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ORIGINAL PAPER

Deep-sea glass sponges (Hexactinellida) from polymetallic nodule fields in the Clarion-Clipperton Fracture Zone (CCFZ), northeastern Pacific: Part II—Hexasterophora

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Abstract

The Clarion-Clipperton Fracture Zone (CCFZ) in the northeastern Pacific is a potential area for deep-sea mining, comprises the worldwide largest polymetallic nodule fields and is one of the most difficult to sample and thus unknown ecosystems. Glass sponges (Hexactnellida) represent a main group of benthic deep-sea megafauna, especially hexasterophorid sponges, but only few studies have been published so far. This is the first study focusing on the taxonomy of hexasterophorid sponges from polymetallic nodule fields in the CCFZ and includes descriptions of eight known and six new species: *Hyalostylus microfloricomus* sp. nov.; *Hyalostylus schulzei* sp. nov.; *Docosaccus nidulus* sp. nov.; *Holascus spinosus* sp. nov.; *Caulophacus (Caulophacus) wilsoni* sp. nov.; and *Chonelasma bispinula* sp. nov.

Keywords Deep-sea sponges · Deep-sea mining · Manganese nodules · Caulophacus · Saccocalyx

Introduction

The Clarion-Clipperton Fracture Zone (CCFZ) in the northeastern Pacific comprises the worldwide largest polymetallic nodule fields while further marine deposits are located in the Peru Basin and Penrhyn Basin in the southern Pacific (Petersen et al. 2016). The CCFZ is located in the area between Mexico and Hawaii where it covers 5.2 million km^2 of the sea floor (Petersen et al. 2016). Decreasing output and man-made shortage of terrestrial metal resources create an increasing demand on the world markets and future deep-sea mining of polymetallic nodules in the CCFZ becomes imminent (Gollner et al. 2017). The International Seabed Authority (ISA) subdivided the CCFZ into license areas managed by stakeholders that have permission to scientifically explore this region. The Joint Programming Initiative Oceans (JPIO) working program "Ecological Aspects of Deep-Sea Mining" is focused on studying long-term impacts of deep-sea nodule mining, to predict the ecological consequences and develop future risk assessments and monitoring methods.

Glass sponges (Hexactnellida) represent a main group of benthic deep-sea megafauna (Rex and Etter 2010; Van Soest et al. 2012; Vanreusel et al. 2016) but recent studies focusing on hexactinellid deep-sea sponges from the northeastern

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Pacific are scarce (Kahn et al. 2013; Kersken et al. 2017; Reiswig 2014; Reiswig and Stone 2013). As a consequence, the deep-sea sponge fauna in the CCFZ is only poorly known as well as their ecology that has been investigated in few studies (Beaulieu 2001a, b, Purser et al. 2016). For further information, please check Kersken et al. (2017).

Main objective of this baseline study is to investigate the taxonomy of hexasterophorid sponges living in the CCFZ, including the description of new species. Up-to-date, the occurrence, number, and distribution of deep-sea sponge species in the CCFZ are unknown. Results will be used to contribute to a picture-based species catalog of the CCFZ sponge fauna to allow more precise in-situ species identification and faster monitoring for future purposes, e.g., pre-mining risk assessments by monitoring with camera-based devices. Furthermore, results of this study increase our understanding of adaptations of benthic deep-sea megafauna to life on polymetallic nodule fields in the CCFZ.

Material and methods

Sponges in this study were sampled during expedition SO239 *EcoResponse* (Assessing the Ecology, Connectivity and Resilience of Polymetallic Nodule Field Systems) that took place from 10th March 2015 to 30th April 2015 and was performed by RV *Sonne.* The present study is conducted in the framework of the European programming initiative JPI Oceans (Joint Programming Initiative Healthy Seas and Oceans) including the research program "Ecological Aspects of Deep-Sea Mining". The study area is the Clarion-Clipperton Fracture Zone (CCFZ) in the northeastern Pacific (08° to 18° N and 90° to 130° W) which has been subdivided into license areas by the International Seabed Authority (ISA). Sponges in this study were sampled in the following license areas: BGR license area (Bundesanstalt für Geowissenschaften und Rohstoffe, Germany), GSR license area (G-TEC Minerals Resources NV, Belgium), IFREMER license area (Institut français de recherché pour l'exploitation de la mer, France), and IOM license area (Interoceanmetal, Bulgaria, Cuba, Czech Republic, Poland, Russian Fed., and Slovakia) as well as APEI 3 (Area of Particular Environmental Interest) (Fig. 1). Sponges were collected at nodule fields, reference sites, and seamounts growing on hard substrate (basaltic rock and polymetallic nodules) or soft substrate (sediment).

Thirty-one sponges were collected at 12 sample stations within the CCFZ. The investigated sponge material was sampled with the ROV (Remotely Operated Vehicle) *Kiel 6000* of the GEOMAR—Helmholtz Centre for Ocean Research Kiel, Germany (Table 1). Sponges were collected with a hydraulically operated arm and stored in purpose-built boxes until the ROV was back on deck. After return of the ROV, sponges were transferred into buckets with pre-cooled seawater and further processed in a climate lab (temperature of + 4 °C). Sponges were placed in a dissecting dish, their size was measured, and all specimens were photographed and preserved in denatured ethanol (96%). At the end of the expedition, all material was shipped and deposited at the Senckenberg Research Institute and Nature Museum in Frankfurt am Main, Germany. Spicule preparations were made following the standard procedure described by Boury-Esnault and Rützler (1997) to examine subsamples with light microscope (LM) and scanning electron microscope (SEM). Furthermore, all sponges collected during the expedition SO239 EcoResponse were deposited and inventoried at the Senckenberg Research Institute and Nature Museum. Identified specimens and their metadata were electronically cataloged with SMF numbers and information is available in the SESAM database (Senckenberg Sammlungsmanagement—www.sesam.senckenberg.de).

Results

Hexactinellida Schmidt, 1870
Hexasterophora Schulze, 1886
Lyssacinosida Zittel, 1877
Euplectellidae Gray, 1867
Bolosominae Tabachnick, 2002
***Hyalostylus* Schulze, 1886**

***Hyalostylus microfloricomus* sp. nov.**
Figures 2 and 3 and Tables 2 and 3

Material

Holotype: SMF 12081, collection date 10.04.2015, station SO239/135-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at Heip Mountains (CCFZ), NE-Pacific, 13° 58.69′ N/123° 08.94′ W–13° 59.06′ N/123° 08.64′ W, 3787.6 m; Paratype: SMF 12085, collection date 10.04.2015, station SO239/135-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at Heip Mountains (CCFZ), NE-Pacific, 13° 58.69′ N/123° 08.94′ W–13° 59.06′ N/123° 08.64′ W, 3890.4 m.

Description

Habitus: Basiphytous sponge with slender stalk and cup- to bell-shaped head of white color growing on basaltic rock at a seamount. The head has a side- or upward orientation. Thick body walls surround a central osculum, in the bigger specimen SMF 12081 with sponge-associated amphipod living inside. The stalk forms a peduncle and consists of fused diactins. The oval to conical head is 2.6–5.5 cm high and has a diameter of 2.5–3.4 cm while the stalk measures a length of 45.6 cm (Fig. 2a–c and Table 2).

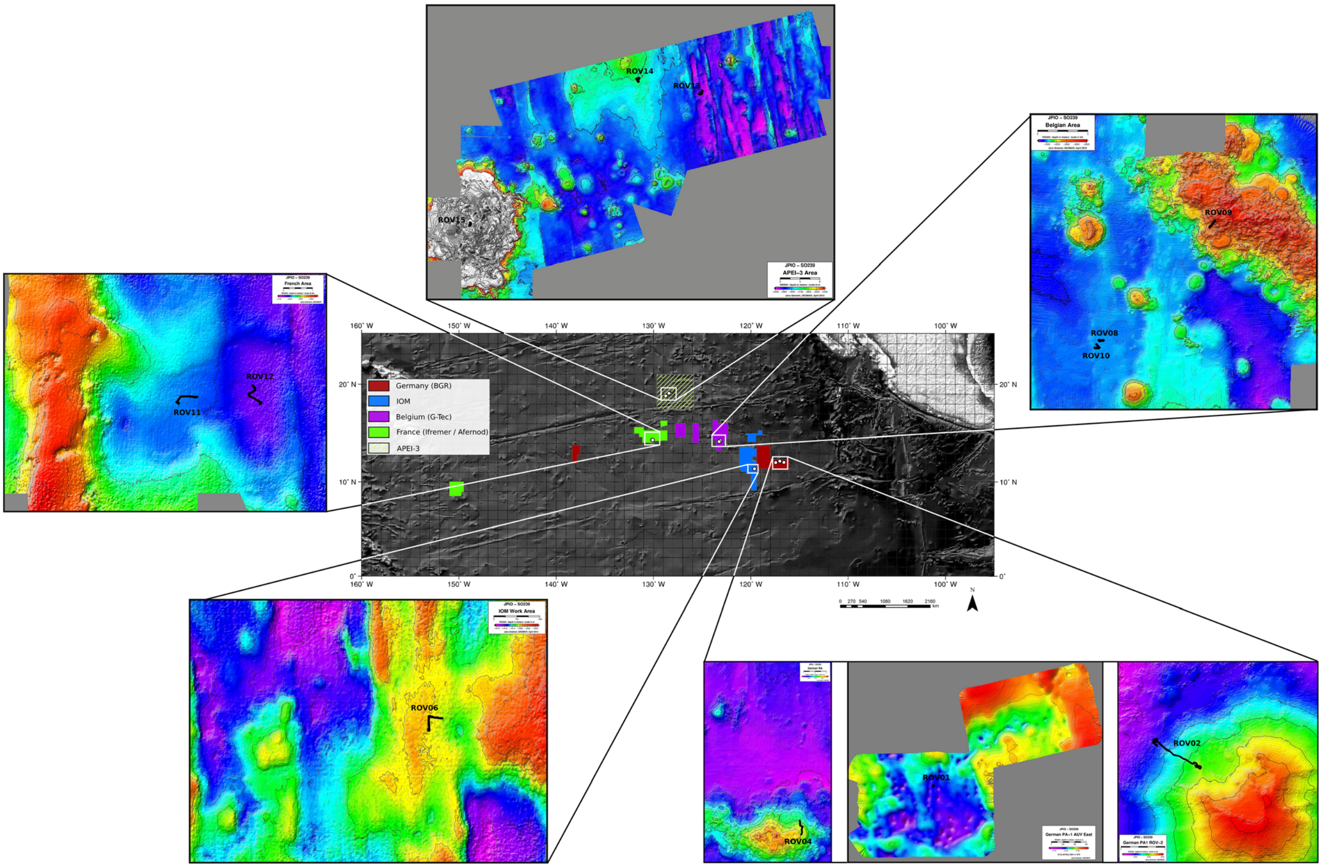


Fig. 1 Map of ROV sample stations within the CCFZ

Megascleres: Choanosomal diactins are common, always curved and smooth with ends covered with small spines that can be round to clavate. A central tubercle is present in most diactins. Choanosomal diactins have a length of 970–1725 μm ($n = 60$) and a width of 5–8 μm ($n = 60$) (Fig. 3a). Tetractins are scarce and also covered with small spines. They have four stout rays slightly bent inwards forming a concave structure. Tetractins have an axis length of 145–310 μm ($n = 20$) and an axis width of 15–25 μm ($n = 12$) (Fig. 3c). Superficial hexactins occur in dermal and gastral surfaces. They have a short distal ray with terminal thickening, a long proximal ray tapering to its tip, and four tangential rays. The ends of distal and tangential rays are cone-shaped and bear small terminal scale-shaped spines while the proximal ray is round and covered with small

Table 1 Sample stations of Hexasterophora from SO239

Station	ROV Dive	License area	Latitude N (start–end)	Longitude W (start–end)
SO239/013-1	1	BGR	11° 51.06′–11° 51.06′	117° 01.97′–117° 01.90′
SO239/029-1	2	BGR	11° 43.04′–11° 42.73′	116° 36.49′–116° 35.94′
SO239/054-1	4	BGR	11° 41.93′–11° 40.75′	117° 27.23′–117° 27.06′
SO239/082-1	6	IOM	11° 03.45′–11° 03.66′	119° 37.89′–119° 37.65′
SO239/131-1	8	GSR	13° 52.39′–13° 52.44′	123° 15.03′–123° 14.88′
SO239/135-1	9	GSR	13° 58.69′–13° 59.06′	123° 08.94′–123° 08.64′
SO239/141-1	10	GSR	13° 52.03′–13° 52.19′	123° 15.33′–123° 15.25′
SO239/157-1	11	IFREMER	14° 02.09′–14° 02.19′	130° 07.13′–130° 06.82′
SO239/161-1	12	IFREMER	14° 02.07′–14° 02.41′	130° 05.60′–130° 05.72′
SO239/189-1	13	APEI 3	18° 47.80′–18° 48.13′	128° 18.53′–128° 18.20′
SO239/200-1	14	APEI 3	18° 49.22′–18° 49.60′	128° 25.55′–128° 25.48′
SO239/212-1	15	APEI 3	18° 32.83′–18° 32.57′	128° 44.88′–128° 44.93′

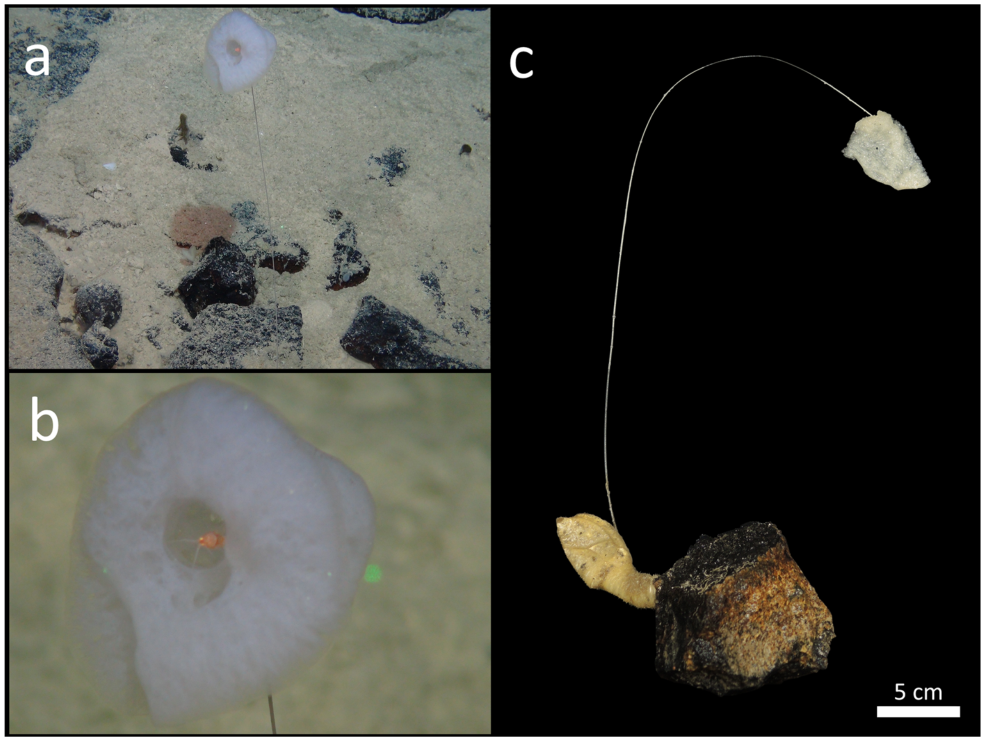


Fig. 2 Habitus of *Hyalostylus microfloricomus* sp. nov.: **a**–**c** SMF 12081 with sponge-associated amphipod living in the central osculum

spines over a length of 30–60 µm. Superficial hexactins have a distal ray with a length of 155–290 µm (*n* = 46), a proximal ray with a length of 275–740 µm (*n* = 46), and tangential rays with an axis length of 345–840 µm (*n* = 50) (Fig. 3b and Table 3).

Microscleres: Microfloricomes are common and look similar to ordinary floricomes except for their size and fragility. Primary rays are smooth and straight, secondary rays are curved and microspined. Each primary ray carries 20–30 secondary rays with claw-like ends bearing usually three marginal teeth. Microfloricomes have a primary rosette diameter of 13–22 µm (*n* = 38) and a diameter of 50–78 µm (*n* = 39) (Fig. 3g). Spherical discohexasters are the biggest microscleres of *H. microfloricomus* sp. nov. but also scarce. Their smooth primary rays carry sometimes 4–5 secondary rays with discoidal ends that have approximately ten pointed teeth. Spherical discohexasters have primary rays that measure 10–24 µm (*n* = 14) and secondary rays that measure 75–136 µm (*n* = 14) in length (Fig. 3f). Anchorate discohexasters are smaller and common in SMF 12081 while scarce in SMF 12085. They are fragile as their secondary rays easily break apart. Primary rays are short, smooth, and straight. Each primary ray carries three to four secondary rays with anchor-shaped discoidal ends. In turn, these ends have six to eight comparably long teeth with rounded ends and smooth teeth edges. Anchorate discohexasters have a primary rosette diameter of 13–18 µm (*n* = 13) and a total diameter of 85–120 µm (*n* = 23) (Fig. 3d). Sigmatocome secondary rays are common in SMF 12081 and scarce in SMF 12085 while primary rosettes were not found. Secondary rays are covered with spines and sine wave-shaped. One end is pointed and the other end looks broken. Sigmatocome secondary rays have a length of 315–455 µm (*n* = 33) (Fig. 3e and Table 3).

Remarks

A characteristic of this *Hyalostylus* is the occurrence of microfloricomes which are particularly more slender and fragile than floricomes of species within this genus as well as slightly smaller. For instance, microfloricomes of *H. microfloricomus* sp. nov. have a max. diameter of 78 µm while floricomes of the type species *Hyalostylus dives* have a max. diameter 97 µm. The habitus with the stalk and cup- to bell-shaped head is typical for representatives of the genus *Hyalostylus*, only the sideward directed orientation in SMF 12081 is unusual. We can only assume the head orientation is caused by environmental conditions as the head of SMF 12085 has a typical upward directed orientation. Furthermore, a sponge-associated amphipod of red to pink color was living in the central osculum of SMF 12081 while the smaller specimen SMF 12085 was free of sponge-associated amphipods and other epizoic invertebrates. Uncommon and characteristic spicule types are microfloricomes while typhoidal hexasters are lacking. The latter characteristics qualify *Hyalostylus microfloricomus* sp. nov. as a new species while the name refers to the occurrence of microfloricomes which is a unique feature.

H. microfloricomus sp. nov. can be confused with *H. dives* and *Hyalostylus schulzei* sp. nov. (see species description in

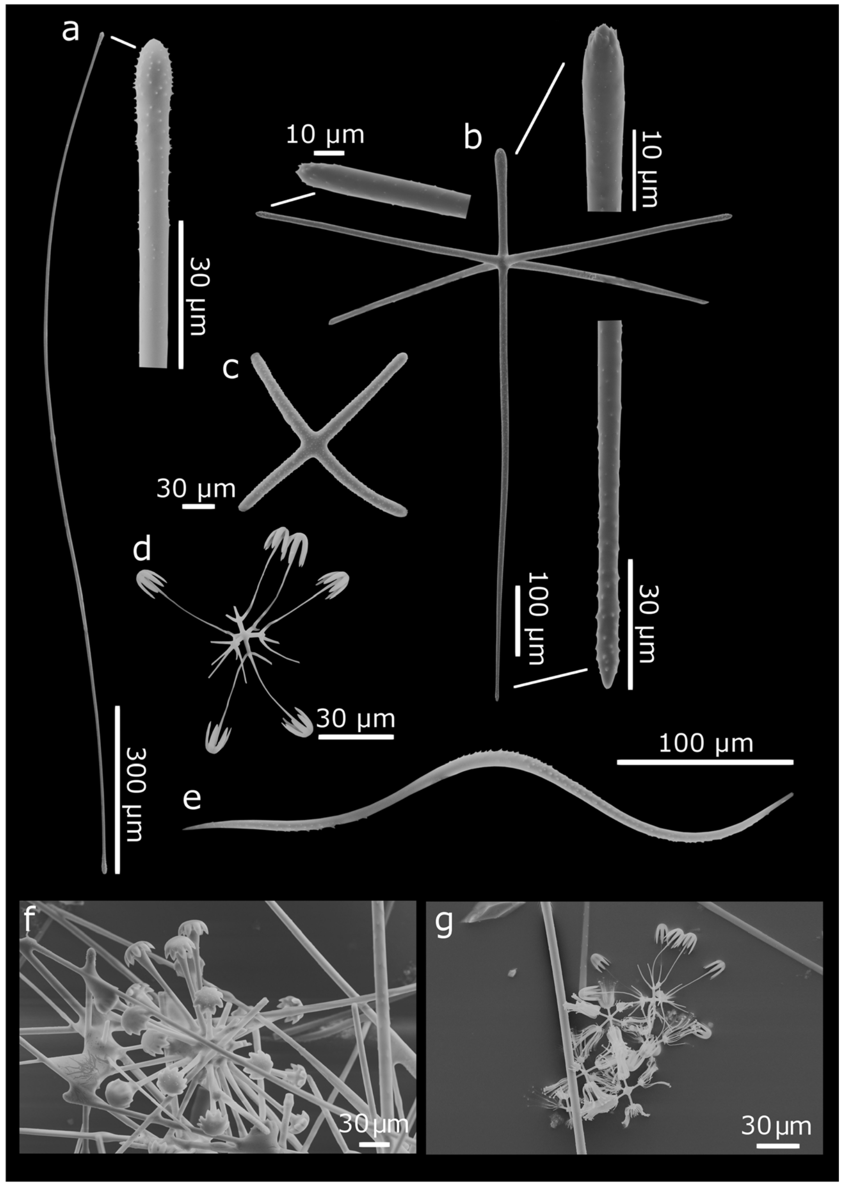


Fig. 3 Spicules of *Hyalostylus microfloricomus* sp. nov.: **a** choanosomal diactin, **b** superficial hexactin, **c** tetractin, **d** anchorate discohexaster, **e** graphiocome secondary ray, **f** spherical discohexaster, and **g** microfloricomes and anchorate discohexaster

this study). All three species have a similar habitus including a long and slender stalk with a cup- to bell-shaped head. However, the body wall of *H. dives* is described to be thin and folded (funnel-shaped head) while *H. schulzei* sp. nov. and *H. microfloricomus* sp. nov. have a thick body wall (cup to bell-shaped head). Furthermore, the spicule inventory of all three species shows characteristic differences, especially their floricomes. Spicules of *H. microfloricomus* sp. nov. include microfloricomes, spicules of *H. dives* typhoidal hexasters, and ordinary floricomes and spicules of *H. schulzei* sp. nov. floricome-like discohexasters and ordinary floricomes with greater size than in *H. dives*.

Table 2 Body size of *Hyalostylus microfloricomus* sp. nov., values in [cm]

	SMF 12081	SMF 12085
Body height	5.5	2.6
Body diameter	3.4	2.5
Stalk length	45.6	–

Hyalostylus schulzei **sp. nov.**

Figures 4 and 5 and Tables 4 and 5

Material

Holotype: SMF 11707, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4914.9 m.

Table 3 Spicule size of *Hyalostylus microfloricomus* sp. nov., values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12081	SMF 12085
Choanosomal diactins		
Length	970–1237–1725 ± 211 (*n* = 30)	975–1276–1625 ± 183 (*n* = 30)
Width	5–6–8 ± 1 (*n* = 30)	5–6–8 ± 1 (*n* = 30)
Tetractins		
Axis length	250–273–310 ± 23 (*n* = 4)	145–217–250 ± 32 (*n* = 16)
Width	15–18–23 ± 3 (*n* = 4)	15–18–25 ± 4 (*n* = 8)
Superficial hexactins		
Distal ray length	155–188–210 ± 16 (*n* = 16)	160–213–290 ± 28 (*n* = 30)
Proximal ray length	275–537–700 ± 109 (*n* = 16)	320–595–740 ± 91 (*n* = 30)
Tangential ray axis length	530–648–760 ± 70 (*n* = 20)	345–653–840 ± 108 (*n* = 30)
Microfloricomes		
Primary rosette diamater	13–16–20 ± 2 (*n* = 30)	13–17–22 ± 3 (*n* = 8)
Total diameter	53–65–78 ± 6 (*n* = 30)	50–57–63 ± 4 (*n* = 9)
Spherical discohexasters		
Primary ray length	10–17–24 ± 5 (*n* = 7)	15–19–23 ± 3 (*n* = 7)
Secondary ray length	105–118–136 ± 10 (*n* = 7)	75–87–103 ± 10 (*n* = 7)
Anchorate discohexasters		
Primary rosette diameter	13–16–18 ± 2 (*n* = 13)	–
Total diameter	85–112–120 ± 8 (*n* = 22)	113 (*n* = 1)
Sigmatocomes		
Primary rosette diameter	–	–
Secondary ray length	315–359–410 ± 23 (*n* = 30)	330–410–455 ± 57 (*n* = 3)

Description

Habitus: Basiphytous white sponge with long slender stalk and cup- to bell-shaped head growing on hard substrate. The head is formed like an inverted bell and has a central osculum. The stalk is thin and solid but still flexible and consists of fused diactins. Epifauna is attached to the stalk, in the case of SMF 11707 small white cirripeds. The bell-shaped head is 12.7 cm high and has a diameter 8.4 cm while the stalk measures a length of 19.2 cm (Fig. 4a–c and Table 4).

Megascleres: Choanosomal diactins are curved and have round to clavate ends which can be rough while most of the spicule surface is smooth. They have a central tubercle and a length of 1263–1988 µm (*n* = 30) as well as a width of 5–8 µm (*n* = 30) (Fig. 5a). Tetractins are scarce and they have four spinous rays with round ends that are slightly bent inwards forming a concave structure. Tetractins have an axis length of 200–305 µm and an axis width of 13–18 µm (*n* = 6) (no photograph). Superficial hexactins occur in dermal and atrial surfaces. Their distal ray has in most cases a conical and in rare cases a spherical thickening covered by scale-shaped spines forming a cone-shaped structure. Tangential rays and the proximal ray are smooth with round ends. The distal ray has a length of 210–470 µm (*n* = 30), the proximal ray has a length of 450–1220 µm (*n* = 30), and the tangential rays form an axis with a length of 380–1025 µm (*n* = 30) (Fig. 5b and Table 5).

Microscleres: Floricomes are common and have a typical structure. They have smooth and straight primary rays with 10–15 secondary rays. Secondary rays are curved and microspined in their second half. Their heads are claw-shaped and have three to five pointed teeth. Floricomes have a primary rosette diameter of 15–30 µm (*n* = 30) and a total diameter of 105–190 µm (*n* = 60) (Fig. 5f, g). Floricoid discohexasters are scarce and look very similar to floricomes. Primary rays are straight and smooth. They have nine secondary rays that are curved and microspined over half of their length. Their heads are round caps surrounded by numerous small teeth. Floricoid discohexasters are smaller than floricomes and have a primary rosette diameter of 15–25 µm (*n* = 10) and a total diameter of 100–150 µm (*n* = 11) (Fig. 5d). Anchorate discohexasters are scarce and smaller than floricomes and discohexasters. They have straight and smooth primary rays with four to six secondary rays. Secondary rays are also smooth and curved carrying anchor-shaped heads that have approximately eight to ten long teeth with round ends. Anchorate discohexasters have a primary rosette diameter of 15–20 µm (*n* = 3) and a total diameter of 98–115 µm (*n* = 8) (Fig. 5c). Secondary rays of sigmatocomes are common but not a single primary rosette was found. Spinous secondary rays are sine wave-shaped with one pointed end and one other end that looks broken. They have a length of 380–495 µm (*n* = 30) (Fig. 5e and Table 5).

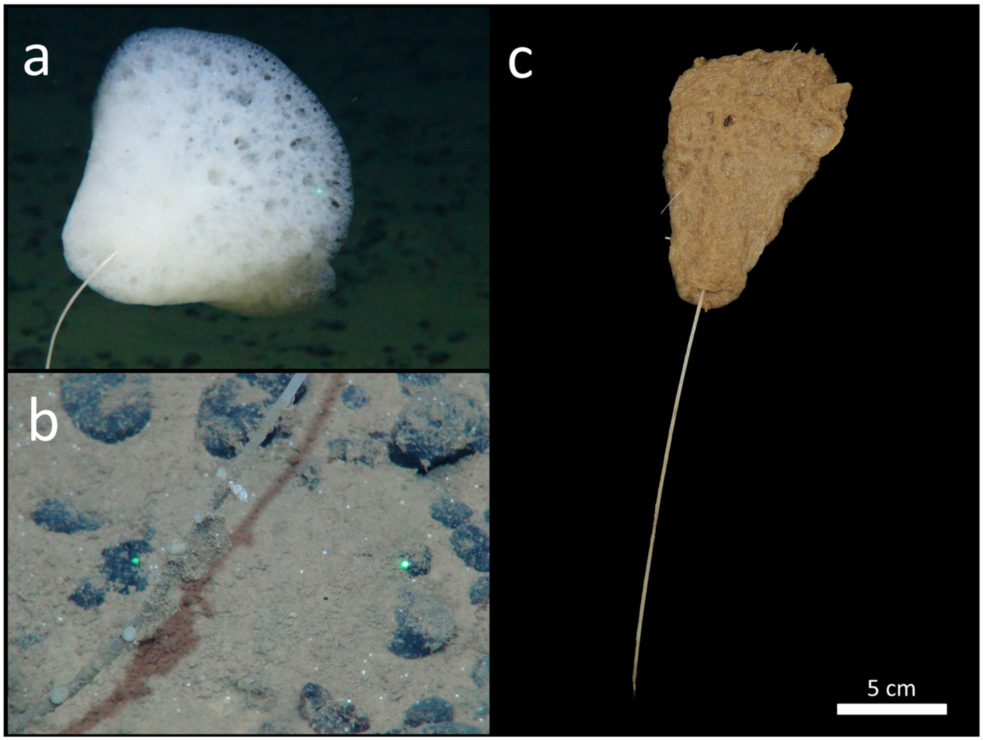


Fig. 4 Habitus of *Hyalostylus schulzei* sp. nov.: **a**–**c** SMF 11707 with epizoic cirripeds growing on the stalk

Remarks

Uncommon features of this representative of the genus *Hyalostylus* are its habitus and inventory of microscleres. In-situ photographs show a fluffy and cup- to bell-shaped head with thick body walls (Fig. 4a–c). The inventory of microscleres is a combination of floricomes, discohexasters, anchorate discohexasters, and graphiocomes while typhoidal hexasters are absent (Fig. 5c–g). Floricome-like discohexasters are characteristic for this species. The latter characteristics qualify *Hyalostylus schulzei* sp. nov. as a new species while the name refers to Franz Eilhard Schulze (*03.22.1840–†11.02.1921) who described the type species *Hyalostylus dives* Schulze, 1886 in the Report on the Hexactinellida collected by *H.M.S. Challenger* during the years 1873–1876.

H. schulzei sp. nov. can be confused with *H. dives* and *H. microfloricomus* sp. nov. (see species description in this study) as all species have a cup- to bell- shaped habitus and several types of spicules in common. A difference to *H. dives* is the habitus. The head of *H. dives* consists of a thin folded body wall while the head of *H. schulzei* sp. nov. is fluffy and consists of a thick body wall. Unfortunately, an in-situ photograph of *H. schulzei* sp. nov. with its central osculum is lacking. The habitus of *H. schulzei* sp. nov. and *H. microfloricomus* sp. nov. are similar. All three species have characteristic microscleres: *H. dives* has typhoidal hexasters, *H. microfloricomus* sp. nov. has microfloricomes, and *H. schulzei* sp. nov. has discohexasters with characteristic heads. Furthermore, the habitus of specimens of *Hyalostylus* can be confused with sponges of the genus *Hyalonema* Gray, 1832. A suitable characteristic to differentiate both genera is the stalk morphology. Stalks of *Hyalostylus* consist of fused diactins and stalks of *Hyalonema* of single spicules (for further information on Amphidiscophora of the CCFZ see Kersken et al. 2017).

***Saccocalyx* Schulze, 1895**

***Saccocalyx pedunculatus* Schulze, 1896**

Figures 6 and 7 and Tables 6 and 7

Saccocalyx pedunculatus: Schulze 1896: 53, pl. V; Tabachnick 2002: 1409, Fig. 14; Muricy et al. 2011: 182; Tabachnick 2014: 234.

Material

SMF 12099, collection date 23.03.2015, station SO239/29-1, ROV *Kiel 6000* from R/V *Sonne* in BGR license area at Rüppell Seamount (CCFZ), NE-Pacific, 11° 51.06′ N/117° 01.97′ W–11° 51.06′ N/117° 01.90′ W, 2884.4 m; SMF 12082, collection date 10.04.2015, station SO239/135-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at Heip Mountains (CCFZ), NE-Pacific, 13° 58.69′ N/123° 08.94′ W–13° 59.06′ N/123° 08.64′ W, 3890.2 m; SMF 12086, collection date 10.04.2015, station SO239/135-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at Heip Mountains (CCFZ), NE-Pacific, 13° 58.69′ N/123° 08.94′ W–13° 59.06′ N/123° 08.64′ W, 3643.7 m; SMF 12096, collection date 24.04.2015, station SO239/212-1, ROV *Kiel 6000* from R/V *Sonne* in APEI

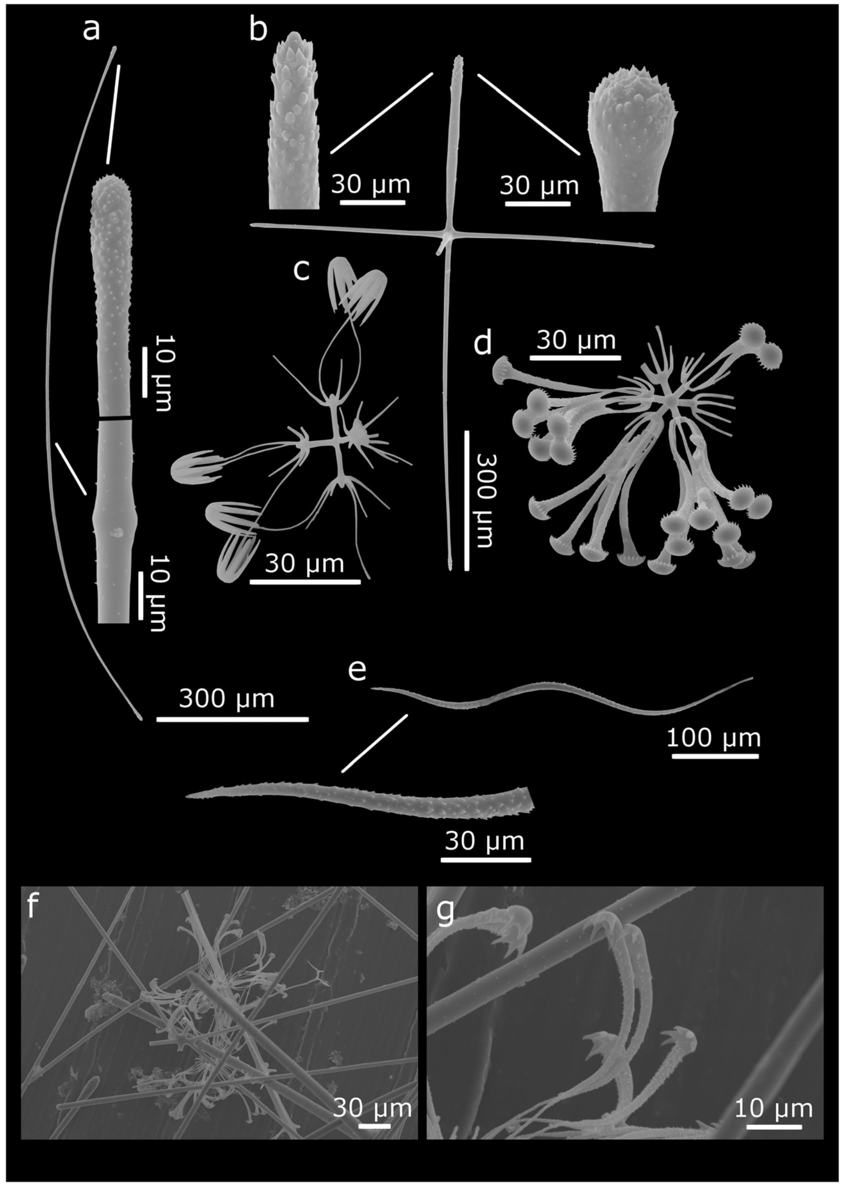


Fig. 5 Spicules of *Hyalostylus schulzei* sp. nov.: **a** diactin, **b** hexactin, **c** anchorate discohexaster, **d** discohexaster, **e** secondary ray of sigmatocome with detail of pointed end, **f** floricome, and **g** floricome detail

3 at Mann Borgese Seamount (CCFZ), NE-Pacific, 18° 32.83′ N/128° 44.88′ W–18° 32.57′ N/128° 44.93′ W, 1782.5 m; SMF 11696, collection date 24.04.2015, station SO239/212-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 at Mann Borgese Seamount (CCFZ), NE-Pacific, 18° 32.83′ N/128° 44.88′ W–18° 32.57′ N/128° 44.93′ W, 1749.2 m.

Table 4 Body size of *Hyalostylus schulzei* sp. nov., values in [cm]

	SMF 11707
Body height	12.7
Body diameter	8.4
Stalk length	19.2

Description

Habitus: Basiphytous white sponge with long stalk and funnel- to cauliflower-shaped head growing on basaltic rock at seamounts (Fig. 6a, b). The head has a rather irregular shape when specimens are small (Fig. 6a). It is spherical to cauliflower-shaped on the outside (dermal surface) while funnel-shaped on the inside (gastral surface) when specimens are big (Fig. 6b). This inner atrial cavity is a central osculum with connections to smaller lateral oscula. The rigid and tubular peduncle forms a flat base on hard substrate where the sponge settles. Small specimens have a thin body wall and big specimens a thick body wall. The body height measures 3.4–24.0 cm, the body width 4.3–16.7 cm, and the stalk length 12.5–30.3 cm while the stalk of the biggest specimen SMF 12096 was ripped off during sampling (Fig. 6a–d and Table 6).

Table 5 Spicule size of *Hyalostylus schulzei* sp. nov., values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 11707
Choanosomal diactins	
Length	1263–1560–1988 ± 188 (*n* = 30)
Width	5–6–8 ± 1 (*n* = 30)
Tetractins	
Axis length	200–237–305 ± 34 (*n* = 8)
Width	13–15–18 ± 1 (*n* = 6)
Superficial hexactins	
Distal ray length	210–383–470 ± 64 (*n* = 30)
Proximal ray length	450–796–1220 ± 159 (*n* = 30)
Tangential ray axis length	380–757–1025 ± 156 (*n* = 30)
Floricomes	
Primary rosette diameter	15–23–30 ± 4 (*n* = 30)
Total diameter	105–150–190 ± 20 (*n* = 60)
Floricoid discohexasters	
Primary rosette diameter	15–20–25 ± 4 (*n* = 10)
Total diameter	100–127–150 ± 18 (*n* = 11)
Anchorate discohexasters	
Primary rosette diameter	15–18–20 ± 2 (*n* = 3)
Total diameter	98–104–115 ± 6 (*n* = 8)
Sigmatocomes	
Primary rosette diameter	–
Secondary ray length	380–461–495 ± 26 (*n* = 30)

Megascleres: Choanosomal diactins are smooth and have a tubercle that can be located in the center but also slightly shifted from the middle being located closer to one end. Diactins are curved and have round ends while their length measures 1530–6525 µm (*n* = 68) and their width measures 5–25 µm (*n* = 68) (Fig. 7i). Choanosomal hexactins have smooth rays which can be straight or extensively curved. Hexactins have an axis length of 300–1875 µm (*n* = 78) (Fig. 7g). Pinular hexactins occur in dermal as well as atrial surfaces but there is no difference in shape. Approximately two thirds of the pinular ray is covered with spines inclined towards the end while all other rays are smooth. Pinular hexactins have a distal pinular ray with a length of 280–570 µm (*n* = 90), a proximal ray with a length of 80–610 µm (*n* = 90) and a tangential ray axis with a length of 250–920 µm (*n* = 90) (Fig. 7a–c and Table 7).

Microscleres: Spirodiscohexasters are common and have primary rays carrying 4–15 smooth and twisted secondary rays with each of them having one discoidal head. The discoidal heads carry numerous small pointed teeth. Spirodiscohexasters have a primary rosette diameter of 13–30 µm (*n* = 90) and a total diameter of 140–195 µm (*n* = 90) (Fig. 7d). Anchorate discohexasters are scarce and fragile, their primary rays have approximately eight secondary rays which can be slightly twisted and their heads have long teeth with smooth teeth edges and round ends. Anchorate discohexasters have a primary rosette diameter of 12–14 µm (*n* = 2) and a total

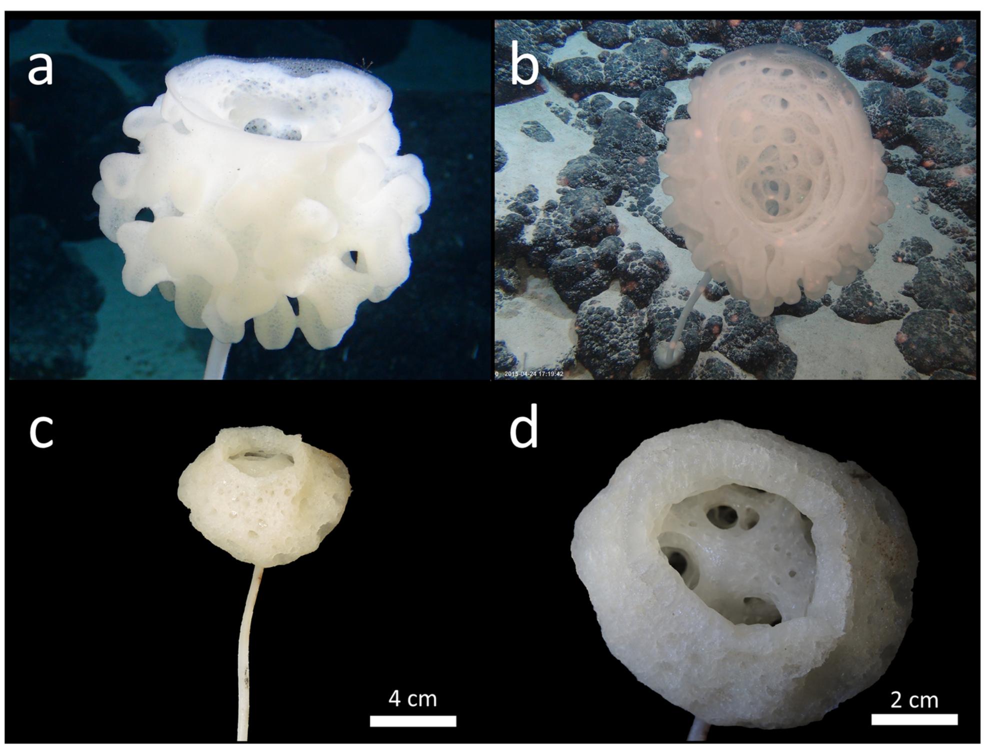


Fig. 6 Habitus of *Saccocalyx pedunculatus*: **a** SMF 12099, **b** SMF 12096, and **c**, **d** SMF 11696

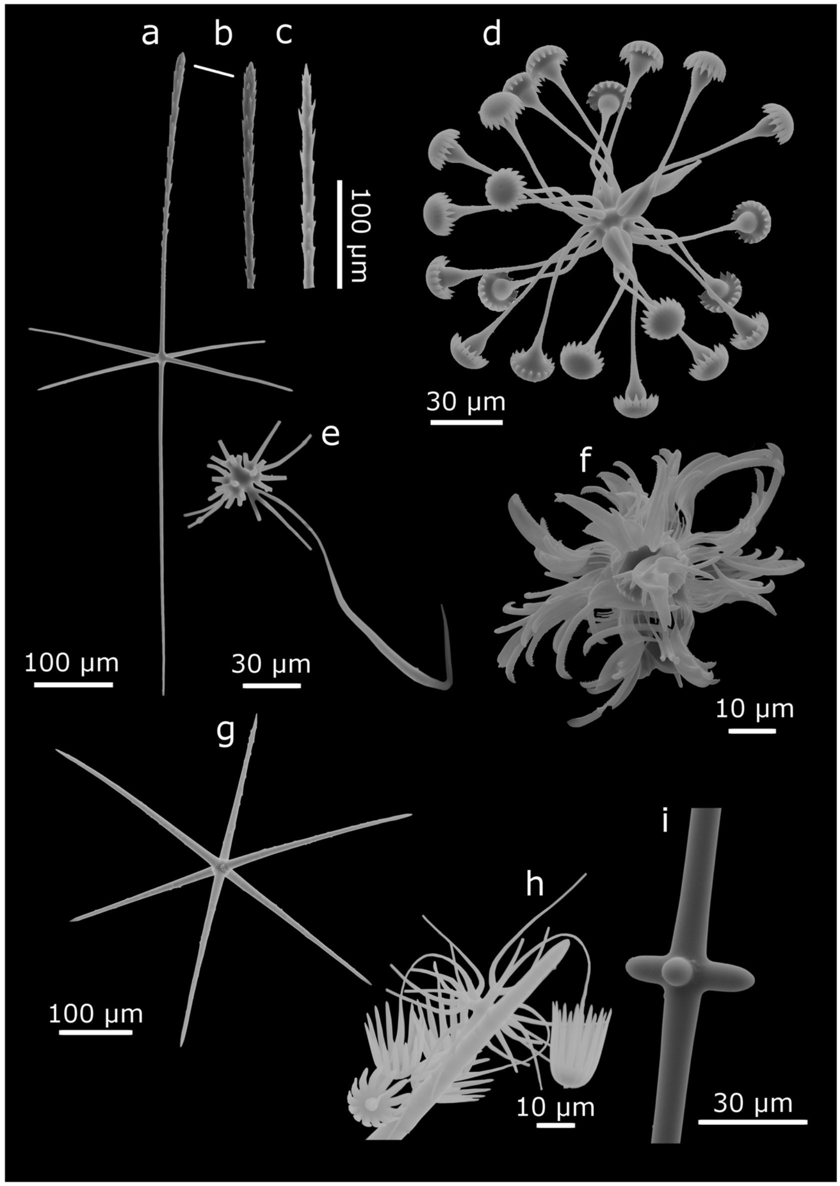


Fig. 7 Spicules of *Saccocalyx pedunculatus*: **a**–**c** pinular hexactin, **d** spirodiscohexaster, **e** drepanocome, **f** plumicome, **g** choanosomal hexactin, **h** anchorate discohexaster, and **i** tubercle of choanosomal diactin

diameter of 113–165 µm (*n* = 2) (Fig. 7h). Plumicomes are scarce and have primary rosettes which are covered with small "s-shaped" secondary rays with curved ends. Plumicomes have a primary rosette diameter of 15–25 µm (*n* = 29) and a total diameter of 48–85 µm (*n* = 28) (Fig. 7f). Drepanocomes are scarce and have short primary rays with scythe-like secondary rays. Drepanocomes have a primary rosette diameter of 13–18 µm (*n* = 12) and a total diameter of 140–300 µm (*n* = 11) (Fig. 7e and Table 7).

Table 6 Body size of *Saccocalyx pedunculatus*, values in [cm]

	SMF 12099	SMF 12086	SMF 12096	Schulze 1896 (BMNH 1908.09.24.017)
Body height	8.1	2.9	24.0	4–5
Body width	10.4	3.8	16.7	5
Stalk length	30.3	11.4	–	≥ 25

Remarks

S. pedunculatus was described by Schulze (1896) as *Saccocalyx pedunculata* and the first specimen was collected in the middle of the Bay of Bengal, Indian Ocean at 12° 20.00′ N/85° 08.00′ E in a depth of 3297 m. The name of the species refers to its rigid and tubular peduncle. *S. pedunculatus* seems to be a cosmopolitan species as records for the central and southern Atlantic as well as the Southern Ocean, the Indian Ocean and the southern Pacific exist. It was found in depths from 1130 to 3835 m depth (Tabachnick 2014) so that our

Table 7 Spicule size of *Saccocalyx pedunculatus*, values in [µm] are given as follows: minimum–mean–maximum ± standard deviation (number of spicules measured)

	SMF 12099	SMF 12086	SMF 12096	Schulze 1896 (BMNH 1908.09.24.017)
Choanosomal diactins				
Length	1875–2689–3475 ± 444 (*n* = 30)	2050–2541–3388 ± 410 (*n* = 16)	1530–4775–6525 ± 1108 (*n* = 22)	–
Width	8–10–18 ± 2 (*n* = 30)	5–8–10 ± 2 (*n* = 16)	10–14–25 ± 3 (*n* = 22)	–
Choanosomal hexactins				
Axis length	760–1099–1710 ± 266 (*n* = 18)	420–1089–1875 ± 360 (*n* = 30)	300–410–730 ± 95 (*n* = 30)	400
Pinular hexactins				
Distal ray length	280–396–510 ± 70 (*n* = 30)	370–498–540 ± 33 (*n* = 30)	370–486–570 ± 47 (*n* = 30)	200–400
Proximal ray length	80–284–595 ± 140 (*n* = 30)	155–387–540 ± 112 (*n* = 30)	240–427–610 ± 92 (*n* = 30)	100–200
Tangential ray axis length	320–482–895 ± 135 (*n* = 30)	265–374–510 ± 56 (*n* = 30)	250–409–920 ± 121 (*n* = 30)	–
Spirodiscohexasters				
Primary rosette diameter	13–19–25 ± 4 (*n* = 30)	18–23–30 ± 3 (*n* = 30)	13–17–20 ± 2 (*n* = 30)	–
Total diameter	100–147–180 ± 15 (*n* = 30)	140–167–190 ± 14 (*n* = 30)	145–174–195 ± 13 (*n* = 30)	150
Anchorate discohexasters				
Primary rosette diameter	–	–	12–13–14 ± 1 (*n* = 2)	–
Total diameter	–	–	115–140–165 ± 25 (*n* = 2)	–
Drepanocomes				
Primary rosette diameter	–	13–16–18 ± 2 (*n* = 6)	10–13–15 ± 2 (*n* = 6)	–
Total diameter	260–275–290 ± 15 (*n* = 2)	240–279–300 ± 23 (*n* = 4)	140–161–180 ± 16 (*n* = 5)	–
Plumicomes				
Primary rosette diameter	15–17–25 ± 3 (*n* = 10)	20–22–25 ± 2 (*n* = 4)	15–17–20 ± 2 (*n* = 15)	–
Total diameter	60–68–78 ± 6 (*n* = 10)	48–50–53 ± 2 (*n* = 3)	65–74–85 ± 6 (*n* = 15)	80

results do slightly increase the known depth range as SMF 12082 was sampled at 3890.2 m depth. Measurements of the body size in this study and by Schulze (1896) are similar and it can be concluded that Schulze (1896) collected a rather large specimen, similar to SMF 12082. Measurements of the spicule size given by Schulze (1896) are incomplete and rather rough, but we see great accordance for measured microscleres like spirodiscohexasters and plumicomes. Choanosomal hexactins and pinular hexactins were smaller in Schulze's specimen but values are still coincident. Confusion is possible with two other species of *Saccocalyx*: *Saccoclayx careyi* (Reiswig, 1999) and *Saccocalyx microhexactin* Gong, Li & Qiu, 2015. The difference between *S. pedunculatus* and *S. careyi* is the morphology of their dermal pinular hexactins as the pinular rays of *S. careyi* are always clavate and of *S. pedunculatus* only sometimes clavate (Tabachnick 2002). The difference between *S. pedunculatus* and *S. microhexactin* is the presence of microhexactins in *S. microhexactin* (see species description of *S. microhexactin* in this study).

***Saccocalyx microhexactin* Gong, Li & Qiu, 2015**

Figures 8 and 9 and Tables 8 and 9

Saccocalyx microhexactin: Gong et al. 2015, pp. 182–192, Figs. 3 and 4

Material

SMF 12060, collection date 23.03.2015, station SO239/29-1, ROV *Kiel 6000* from R/V *Sonne* in BGR license area at Rüppell Seamount (CCFZ), NE-Pacific, 11° 51.06′ N/117° 01.97′ W–11° 51.06′ N/117° 01.90′ W, 2799.8 m.

Description

Habitus: Basiphytous white sponge with rigid stalk and cup- to cauliflower-shaped head growing on basaltic rock of seamounts (Fig. 8a, b). A central osculum is located on top and the atrial cavity is bearing numerous lateral oscula while the dermal surface is covered with bag-like protrusions. The body wall is soft, only the tubular peduncle is rigid. The body height measures 5.4 cm, the body width 6.4 cm, and the stalk length 13.5 cm (Fig. 8a–c and Table 8).

Megascleres: Choanosomal diactins are smooth, curved with round ends, and have a central tubercle. Their length measures 1150–3650 µm (*n* = 25) and their width measures 8–13 µm (*n* = 14) (Fig. 9a). Choanosomal hexactins have straight or slightly curved rays with blunt ends and a diameter of 480–1313 µm (*n* = 30) (no photograph). Pinular hexactins project from dermal and gastral surfaces. Two thirds of the

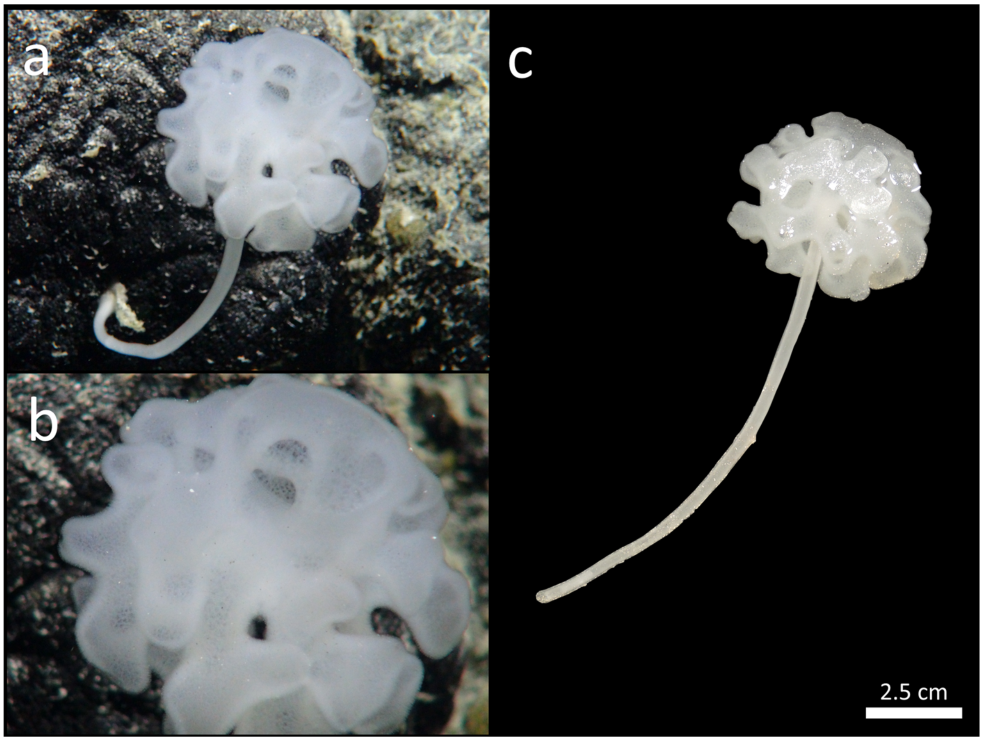


Fig. 8 Habitus of *Saccocalyx microhexactin*: **a**–**c** SMF 12060

pinular ray is covered with spines that distally incline and all other rays are smooth while tangential rays can be straight or curved. Pinular hexactins have a distal pinular ray with a length of 420–510 µm ($n = 30$), a proximal ray with a length of 190–630 µm ($n = 30$), and a tangential ray axis length of 300–740 µm ($n = 30$) while the latter can sometimes exceed the length of the central axis of distal and proximal ray (Fig. 9b and Table 9).

Microscleres: Spirodiscohexasters have 4–19 discoidal heads carrying numerous small teeth with pointed ends. Primary rays are short while secondary rays are long and twisted. Developing spirodiscohexasters look similar to plumicomes and can be confused. Spirodiscohexasters have a primary rosette diameter of 13–20 µm ($n = 30$) and a total diameter of 130–175 µm ($n = 30$) (Fig. 9c, g). Anchorate discohexasters are scarce and have curved secondary rays with bell-shaped heads bearing straight teeth with smooth edges and round ends. They have a primary rosette diameter of 8–13 µm ($n = 14$) and a total diameter of 110–130 µm ($n = 7$) (Fig. 9d). Plumicomes are scarce and have disc-shaped ends of primary rays surrounded by approximately 100–200 smaller microspined secondary rays. Plumicomes have an unknown primary rosette diameter and a total diameter of 35–45 µm ($n = 8$) (Fig. 9h). Drepanocomes are the biggest microscleres and have short primary rays that carry four to six scythe-like secondary rays. Their primary rosette diameter measures 13–20 µm ($n = 16$) and their total diameter measures 260–360 µm ($n = 20$) (Fig. 9f). Microhexactins have straight rays, to some extent covered with spines, and blunt ends. They measure 30–93 µm ($n = 30$) in diameter (Fig. 9e and Table 9).

Remarks

The species *S. microhexactin* was recently described by Gong et al. (2015) and the holotype (MBM 179993) was sampled in the South Chinese Sea (17°33.95′ N, 117°45.67′ E) in 3542 m depth growing on rock of an extinct volcano. This study represents the second record. The specimen SMF 12060 was growing on basaltic rock of a seamount where it was collected in a depth of 2799.8 m. The name of the species refers to the presence of microhexactins (Fig. 9e) that are not known to occur in other species of *Saccocalyx*. The specimen in this study is smaller than the specimen described in Gong et al. (2015), for instance the stalk of SMF 12060 is approximately half as long as the stalk of MBM 179993. Spicule measurements for both specimens (SMF 12060 and MBM 17993) are similar, only choanosomal diactins and hexactins have a different size while anchorate discohexasters are present in our specimen and lacking in the specimen described by Gong et al. (2015). Furthermore, they describe two types of drepanocomes, type I with a mean diameter of 287 µm (similar to drepanocomes of SMF 12060) and the smaller type II with a mean diameter of 128 µm (not found in SMF 12060). Microhexactins of MBM 179993 are bigger than microhexactins of SMF 12060 with a mean diameter of 85 compared to 58 µm (Table 9).

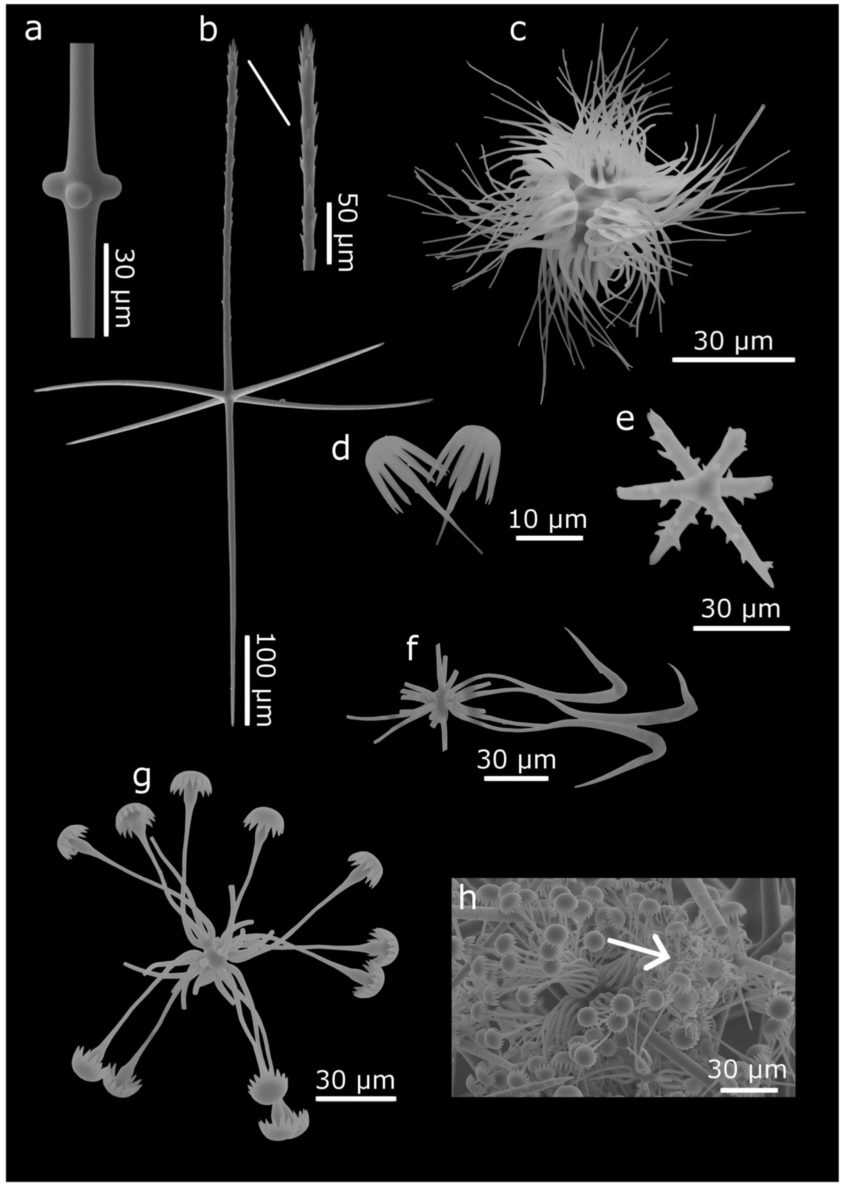


Fig. 9 Spicules of *Saccocalyx microhexactin*: **a** tubercle of choanosomal diactin, **b** pinular hexactin with detail of distal ray, **c** developing stage of spirodiscohexaster, **d** discoidal heads of anchorate discohexaster, **e** microhexactin, **f** fragment of drepanocome, **g** fragment of spirodiscohexaster, and **h** plumicome and spirodiscohexasters

Corbitellinae Gray, 1872

***Corbitella* Gray, 1867**

***Corbitella discasterosa* Tabachnick & Levi, 2004**

Figures 10 and 11 and Tables 10 and 11

Corbitella discasterosa: Tabachnick and Levi 2004: 24, Fig. 9.

Table 8 Body size of *Saccocalyx microhexactin*, values in [cm]

	SMF 12060	Gong et al. 2015 (MBM 179993)
Body height	5.4	–
Body width	6.4	–
Stalk length	13.5	≥ 25.0

Material

SMF 11699, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4906.7 m; SMF 11701, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4905.0 m; SM F 11702, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48,13′ N/128° 18.20′ W, 4905.5 m; SMF 11703, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4905.4 m; SMF 12100, collection date 20.04.2015, station

Table 9 Spicule size of *Saccocalyx microhexactin*, values in [μm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12063	Gong et al. 2015 (MBM 179993)
Choanosomal diactins		
Length	1150–2145–3650 ± 646 (*n* = 25)	2120–2963–3558 ± 397 (*n* = 26)
Width	8–9–13 ± 2 (*n* = 14)	5–9–15 ± 2 (*n* = 26)
Choanosomal hexactins		
Axis length	480–785–1313 ± 229 (*n* = 30)	253–553–712 ± 206 (*n* = 15)
Pinular hexactins		
Distal ray length	420–462–510 ± 23 (*n* = 30)	246–371–451 ± 57 (*n* = 30)
Proximal ray length	190–383–6–30 ± 83 (*n* = 30)	188–392–586 ± 89 (*n* = 30)
Tangential ray axis length	300–522–740 ± 109 (*n* = 30)	347–494–494 ± 63 (*n* = 30)
Spirodiscohexasters		
Primary rosette diameter	13–15–20 ± 2 (*n* = 30)	28–49–66 ± 9 (*n* = 30)
Total diameter	130–157–175 ± 9 (*n* = 30)	112–131–150 ± 25 (*n* = 30)
Anchorate discohexasters		
Primary rosette diameter	8–11–13 ± 2 (*n* = 14)	–
Total diameter	110–120–130 ± 6 (*n* = 7)	–
Drepanocomes I		
Primary rosette diameter	13–17–20 ± 2 (*n* = 16)	61–82–108 ± 19 (*n* = 6)
Total diameter	260–293–360 ± 22 (*n* = 20)	254–287–319 ± 23 (*n* = 6)
Drepanocomes II		
Primary rosette diameter	–	–
Total diameter	–	123–128–138 (7)
Plumicomes		
Total diameter	35–40–45 ± 4 (*n* = 8)	36–49–59 ± 6 (*n* = 17)
Microhexactins		
Total diameter	30–58–93 ± 15 (*n* = 30)	43–85–141 ± 28 (*n* = 33)

SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4905.1; SMF 12051, collection date 22.04.2015, station SO239/200-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 49.22′ N/128° 25.55′ W–18° 49.60′ N/128° 25.48′ W, 4668.8 m; SMF 11694, collection date 22.04.2015, station SO239/200-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 49.22′ N/128° 25.55′ W–18° 49.60′ N/128° 25.48′ W, 4667.2 m.

Description

Habitus: Basiphytous white sponge with saccular habitus, central osculum and protruding fistules with terminal suboscula. The central osculum is covered by prostalia oscularia which protrude from the osculum's margin toward the center, approximately over a length of 0.8 cm. The suboscula have 1–3 openings each. The diameter of the body is smallest close to the base where it is attached to hard substrate. The body wall is soft, thin, and fragile. Furthermore, all collected specimens of *Corbitella discasterosa* were associated with a polynoid polychaete living inside the sponge. The body height measures 6.7–7.1 cm, the body width 3.5–5.5, and the length of prostalia oscularia 0.6–0.8 cm (Fig. 10a–d and Table 10).

Megascleres: Choanosomal diactins are extremely scarce as only one diactin was found in SMF 11699. Diactins are smooth over most of their length, only their round ends are rough. The only measured diactin has a length of 1555 μm (no photograph). A large number of choanosomal hexactins is present in all specimens. Choanosomal hexactins have rays of almost equal length that can be straight in small hexactins or curved in large hexactins. Choanosomal hexactins have an axis length of 470–4775 μm (*n* = 87) (Fig. 1a). Choanosomal tauactins are scarce and only four tauactins were measured in SMF 11701. Their ends have the same appearance as the ends of the choanosomal diactins. Choanosomal tauactins have the shape of a compressed "T." The single ray has a length of 525–975 μm (*n* = 4) and the other two rays form an axis with a total length of 2775–4875 μm (*n* = 4) (no photograph). Gastral pentactins are also scarce and but were measured in all specimens. They have smooth rays and their ends look like ends of choanosomal diactins and tauctins. Gastral pentactins have a proximal ray with a length of 200–800 μm (*n* = 6) and a tangential ray axis with a length of 415–1425 μm (*n* = 6) (Fig. 11b). Dermal hexactins have smooth rays with pointed

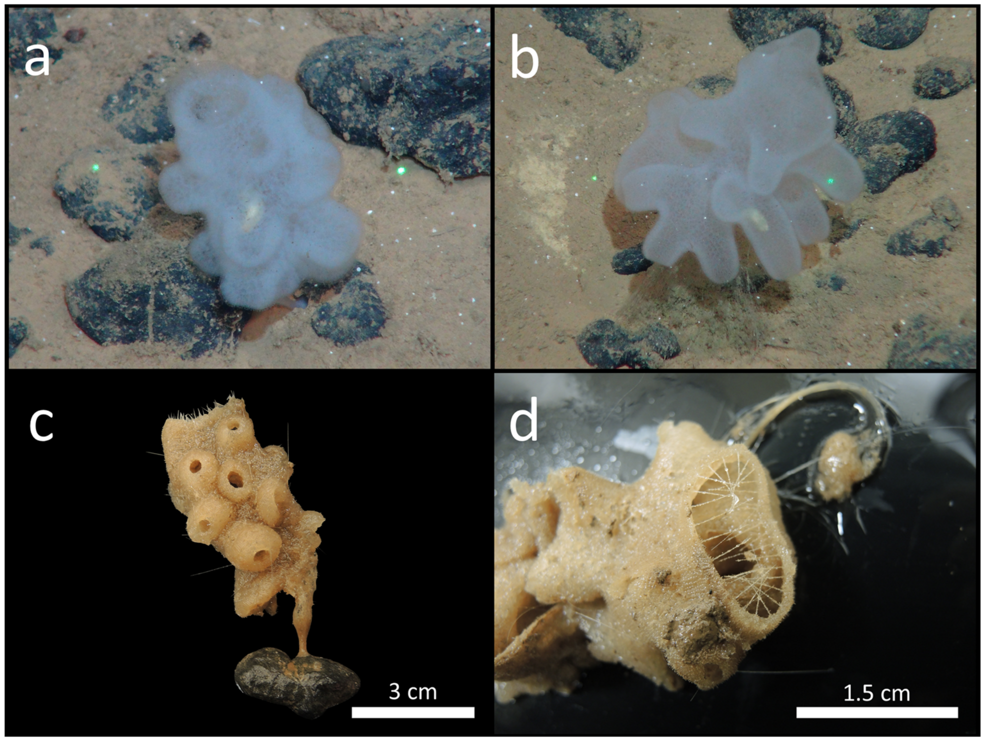


Fig. 10 Habitus of *Corbitella discasterosa*: **a** SMF 11701, **b**, **c** SMF 12100, and **d** SMF 11701

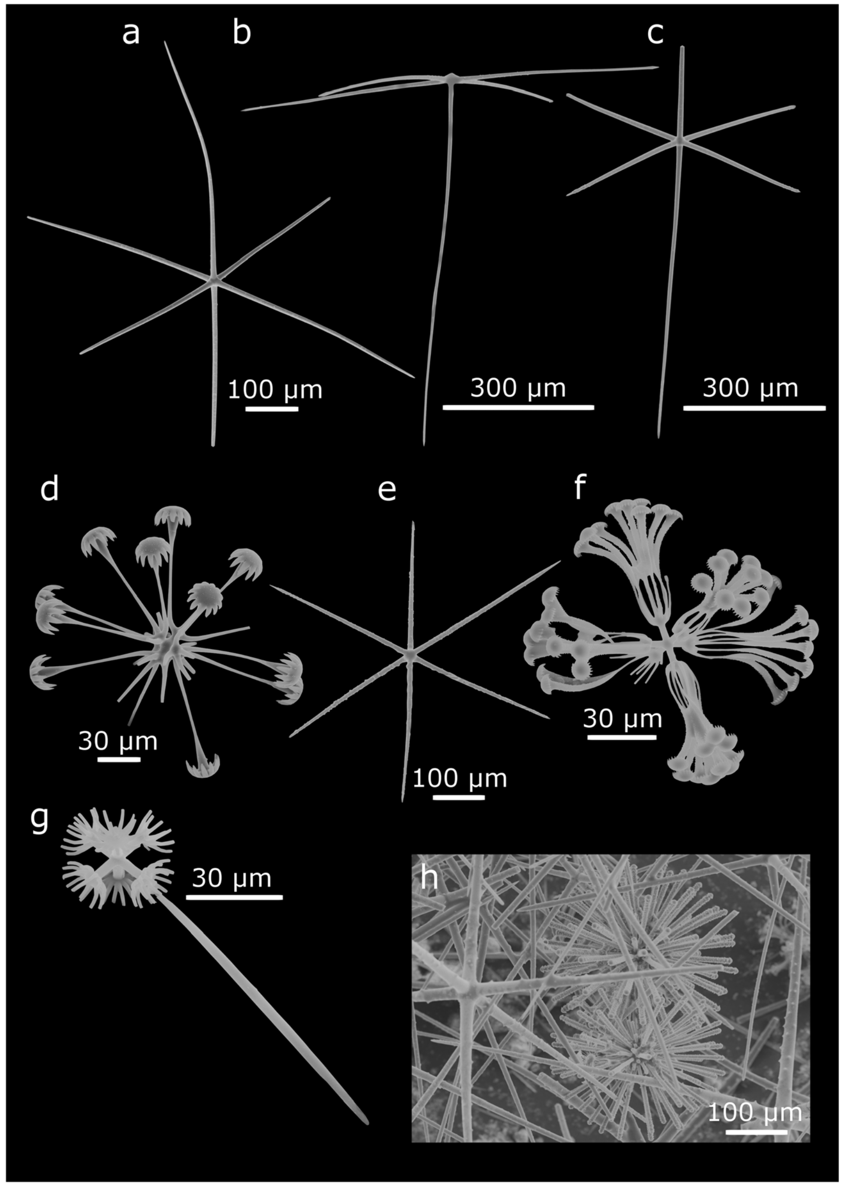
ends while their distal ray is shorter than the proximal ray. Dermal hexactins have a distal ray with a length of 230–820 µm ($n = 13$), a proximal ray with a length of 520–2025 µm ($n = 13$) and tangential rays with an axis length of 420–1350 µm ($n = 33$) (Fig. 11c and Table 11).

Microscleres: Anchorate discohexasters are scarce and were only measured in SMF 11699. They have smooth primary rays with usually eight secondary rays while the latter have discoidal ends with umbel-shaped heads and smooth teeth with pointed ends. The only two anchorate discohexasters have a primary rosette diameter of 15 µm ($n = 2$) and a total diameter of 155–168 µm ($n = 2$) (Fig. 11d). Oxyhexactins are common in SMF 11701 but absent in all other specimens. They have straight rays loosely covered with small spines and with pointed ends. Oxyhexactins have a diameter of 200–720 µm ($n = 30$) (Fig. 11e). Floricomes are common and have short and straight primary rays followed by 8–11 long and curved secondary rays with almost discoidal looking ends bearing approximately 20–25 small teeth. They have a primary rosette diameter of 15–25 ($n = 81$) and a total diameter of 98–150 µm ($n = 90$) (Fig. 11f). Graphiocomes are common, especially their secondary rays that tend to break off. Graphiocomes have short and smooth primary rays followed by secondary rays that look like slender blades. Secondary rays of graphiocomes in SMF 11699 were thicker than in all other specimens. The diameter of the primary rosette and the length of the secondary rays were measured separately as complete graphiocomes are rare. Primary rosettes of graphiocomes have a diameter of 15–40 µm ($n = 73$) and secondary rays have a length of 30–125 µm ($n = 77$) (Fig. 11g). Discasters are rare and were found in SMF 11699 as well as SMF 11701. They look like exploding fireworks and have approximately 60–100 acanthous secondary rays with discoidal ends. Discasters have a primary rosette diameter of 53–63 µm ($n = 2$) and a total diameter of 205–300 µm ($n = 11$) (Fig. 11h and Table 11).

Remarks

The species *C. discasterosa* was described by Tabachnick and Levi (2004) and the holotype (MNHN HCL 521) was collected in New Caledonia (22° 43.09′ S/166° 27.19′ E) in a depth from 1590 to 1665 m. The name of the species refers to the occurrence of discasters (Fig. 11h) which is a unique feature in the genus *Corbitella*. Results of this study represent the second record of this species with six collected specimens of which some are complete and others ripped into two fragments, exactly like the holotype. The saccular habitus with rounded lateral oscula, presence of prostalia oscularia and shape of a "venus flower basket" is typical for species of *Corbitella* as well as the spiculation with microscleres having discoidal ends and presence of graphiocomes. Size measurements of specimens from this study and measurements by Tabachnick and Levi (2004) match each other (Table 11). However, there are certain issues that open up space for the following discussion on whether the described specimens really belong to the species *C. discasterosa*: choanosomal spicules of the genus *Corbitella* are mainly

Fig. 11 Spicules of *Corbitella discasterosa*: **a** choanosomal hexactin, **b** gastral pentactin, **c** dermal hexactin, **d** anchorate discohexaster, **e** oxyhexctin, **f** floricome, **g** graphiocome with one secondary ray, and **h** discasters



diactins and hexactin derivates (Tabachnick 2002) but instead of this, we found choanosomal hexactins to be present in all six specimens while diactins are more or less absent (Fig. 11a). Furthermore, choanosomal tauactins are possibly gastral pentactins where two tangential rays broke off, although there were no visible fractures. Gastral pentactins and dermal hexactins are present but rare while gastral and dermal surfaces were subsampled separately to do spicule preparations. However, measurements for both, gastral pentactins, and dermal hexactins match the measurements by Tabachnick and Levi (2004). Spiculation of microscleres is also questionable as some specimens of this study have anchorate discohexasters and lack oxyhexactins, graphiocomes have a different shape in one specimen, and discasters look slightly different than described in the original species description, only floricomes are in good accordance with the data by Tabachnick and Levi (2004), although the number of marginal claws is higher for floricomes of specimens from this study. However, due to major accordance in habitus and characteristic features in spicule morphology do

Table 10 Body size of *Corbitella discasterosa*, values in [cm]

	SMF 11699	SMF 11701	SMF 11694	Tabachnick and Levi 2004 (MNHN HCL 521)
Body height	6.7	7.1	6.8	≥ 5.0
Body width	5.5	3.8	3.5	≥ 1.0
Prostalia oscularia	0.8	0.8	0.6	–

Table 11 Spicule size of *Corbitella discasterosa*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 11699	SMF 11701	SMF 11694	Tabachnick & Levi 2004 (MNHN HCL 521)
Choanosomal diactins				
Length	1550 (*n* = 1)	–	–	600–2000
Width	–	–	–	4–9
Choanosomal hexactins				
Axis length	670–1062–1700 ± 263 (*n* = 30)	635–1332–4775 ± 1052 (*n* = 27)	470–987–1675 ± 329 (*n* = 30)	–
Choanosomal tauactins				
Single ray length	–	525–810–975 ± 171 (*n* = 4)	–	–
Axis length	–	2775–4038–4875 ± 782 (*n* = 4)	–	–
Gastral pentactins				
Proximal ray length	200–210–220 ± 10 (*n* = 2)	240 (*n* = 1)	682–727–800 ± 52 (*n* = 3)	190–684
Tangential ray axis length	415–423–430 ± 8 (*n* = 2)	470 (*n* = 1)	1103–1235–1425 ± 138 (*n* = 3)	684–1460
Dermal hexactins				
Distal ray length	360–380–400 ± 20 (*n* = 2)	230–387–820 ± 165 (*n* = 9)	330–368–405 ± 38 (*n* = 2)	106–274
Proximal ray length	740–920–1100 ± 180 (*n* = 2)	520–990–2025 ± 443 (*n* = 9)	570–710–850 ± 140 (*n* = 2)	190–897
Tangential ray axis length	830–875–920 ± 45 (*n* = 2)	420–754–1350 ± 246 (*n* = 9)	469–686–850 ± 99 (*n* = 12)	288–852
Anchorate discohexasters				
Primary rosette diameter	15–15–15 ± 0 (*n* = 2)	–	–	–
Total diameter	155–161–168 ± 6 (*n* = 2)	–	–	–
Floricomes				
Primary rosette diameter	15–20–25 ± 3 (*n* = 21)	15–20–25 ± 3 (*n* = 30)	15–18–23 ± 2 (*n* = 30)	14–22
Total diameter	114–132–145 ± 7 (*n* = 30)	98–125–143 ± 11 (*n* = 30)	98–130–150 ± 10 (*n* = 30)	108–126
Graphiocomes				
Primary rosette diameter	15–30–40 ± 9 (*n* = 30)	18–22–28 ± 3 (*n* = 30)	15–19–25 ± 3 (*n* = 13)	18–32
Secondary ray length	80–101–125 ± 11 (*n* = 30)	43–59–83 ± 10 (*n* = 30)	30–45–63 ± 8 (*n* = 17)	–
Discasters				
Primary rosette diameter	53–58–63 ± 5 (*n* = 2)	–	–	30–175
Total diameter	241–268–300 ± 22 (*n* = 7)	205–217–226 ± 8 (*n* = 4)	–	137–532
Oxyhexactins				
Total diameter	–	200–469–720 ± 116 (*n* = 30)	–	167–395

specimens of this study most likely belong to the species *C. discasterosa* although there is demand for further research to clarify if *C. discasterosa* is a single species with high variability or rather a species complex.

Euplectellinae Gray, 1867
***Docosaccus* Topsent, 1910**
***Docosaccus maculatus* Kahn, Geller, Reiswig & Smith Jr., 2013**
Figures 12 and 13 and Tables 12 and 13
Doccosaccus maculatus: Kahn et al. 2013, p. 393, Figs. 5, 6, 7, 8, 9

Material

SMF 12094, collection date 15.04.2015, station SO239/161-1, ROV *Kiel 6000* from R/V *Sonne* in IFREMER license area outside OMCO track (CCFZ), NE-Pacific, 14° 02.07′ N/130° 05.60′ W–14° 02.41′ N/130° 05.72′ W, 4997.7 m; SMF 11700, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4905.4 m.

Description

Habitus: Lophophytous white sponge whit flat disc-shaped body growing close to the sediment surface. The body is of irregular shape and inconspicuous oscula as big as pinheads are scattered over the atrial surface. Furthermore, the body is thin and slightly transparent with white spots due to giant prostal hexactins (Kahn et al. 2013). The dermal surface is close to the seabed (approximately 1–3 cm above) with protruding anchorate basalia penetrating into the sediment. The

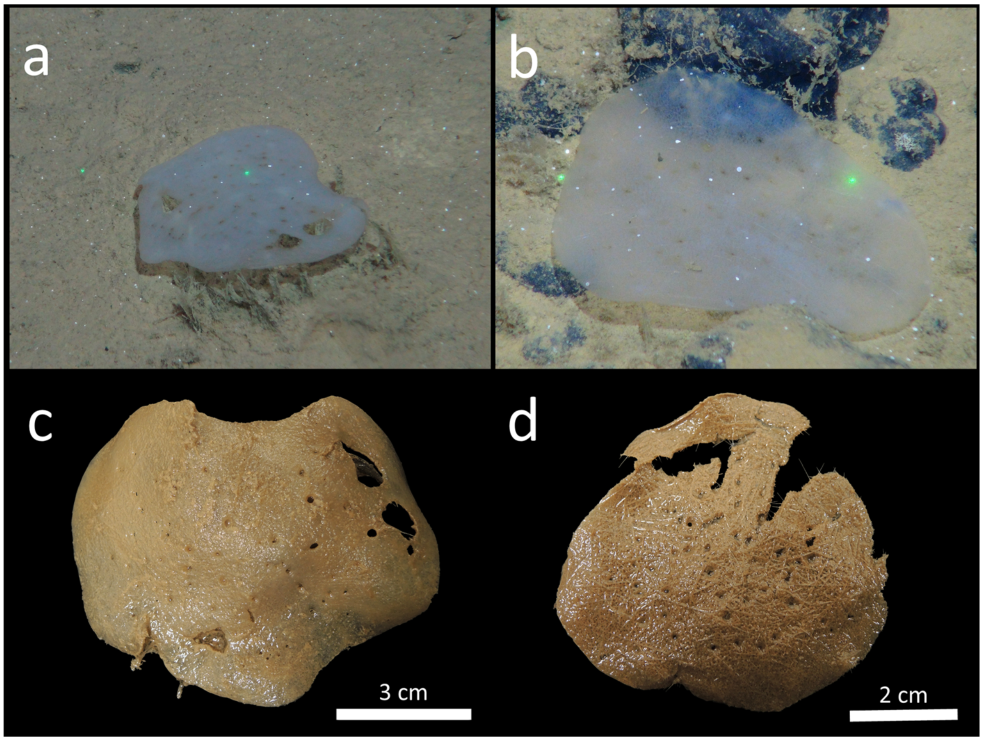


Fig. 12 Habitus of *Docosaccus maculatus*: **a**, **c** SMF 12094 and **b**, **d** SMF 11700

body thickness measures approximately 0.2 cm and the body diameter 6.7–8.6 cm (Fig. 12a–d and Table 12).

Megascleres: Choanosomal diactins are smooth and straight or slightly curved. They have pointed ends and a central tubercle while the latter is the area of maximum width. Choanosomal diactins have a length of 620–4350 μm ($n = 60$) and a width of 10–70 μm ($n = 60$) (Fig. 13a). Choanosomal hexactins are almost smooth, only their ends can be slightly rough. Their rays are straight with pointed ends and the diameter is variable. Choanosomal hexactins have a diameter of 290–1050 μm ($n = 60$) (no photograph). Dermal hexactins have straight rays with pointed ends. The tangential rays and proximal ray are evenly covered with spines while the distal ray is almost smooth. Furthermore, the distal ray is shorter than the proximal ray. The distal ray has a length of 130–390 μm ($n = 34$), the proximal ray has a length of 530–1015 μm ($n = 34$), and the tangential ray axis has a length of 280–1025 μm ($n = 39$) (Fig. 13e). Gastral pentactins have a straight proximal ray and tangential rays that are slightly inclined towards the proximal ray. All rays are covered with spines and have pointed ends. Gastral pentactins have a proximal ray with a length of 105–430 μm ($n = 52$) and a tangential ray axis with a length of 255–510 μm ($n = 60$) (Fig. 13d). Furthermore, basalia are covered with spines and have anchor-shaped four-toothed ends (Fig. 13g and Table 13).

Microscleres: Oxyhexasters are common and completely smooth. Primary rays are straight and of constant thickness while each primary ray carries two to four secondary rays. Secondary rays are almost straight, only their ends are slightly curved. They are thickest at their base and tapering towards their end. Oxyhexasters have a primary rosette diameter of 18–45 μm ($n = 60$) and a total diameter of 76–125 μm ($n = 60$) (Fig. 13b–d and Table 13). Floricomes have a typical structure and morphology. They have straight and smooth primary rays. Each primary ray carries 9–12 secondary rays which are curved and have claw-shaped ends with 4–6 teeth. Floricomes have a primary rosette diameter of 10–23 μm ($n = 31$) and a total diameter of 68–135 μm ($n = 46$) (Fig. 13f and Table 13).

Remarks

This is the second study including a record of *D. maculatus* with data of two specimens (SMF 12094 and SMF 11700). The species was recently described by Kahn et al. (2013) who collected three specimens in the northeastern Pacific in depths from 3953 to 4000 m while our specimens were sampled approximately 1000 m deeper. Specimens in this study have the same body thickness but they are smaller in diameter. Descriptions of habitus and spicule morphology match perfectly, as well as spicule sizes that overlap in almost every case. The only exception is the size of gastral pentactins which are smaller in our specimens. Furthermore, choanosomal diactins have not been mentioned by Kahn et al. (2013).

Docosaccus nidulus **sp. nov**

Figures 14 and 15 and Tables 14 and 15

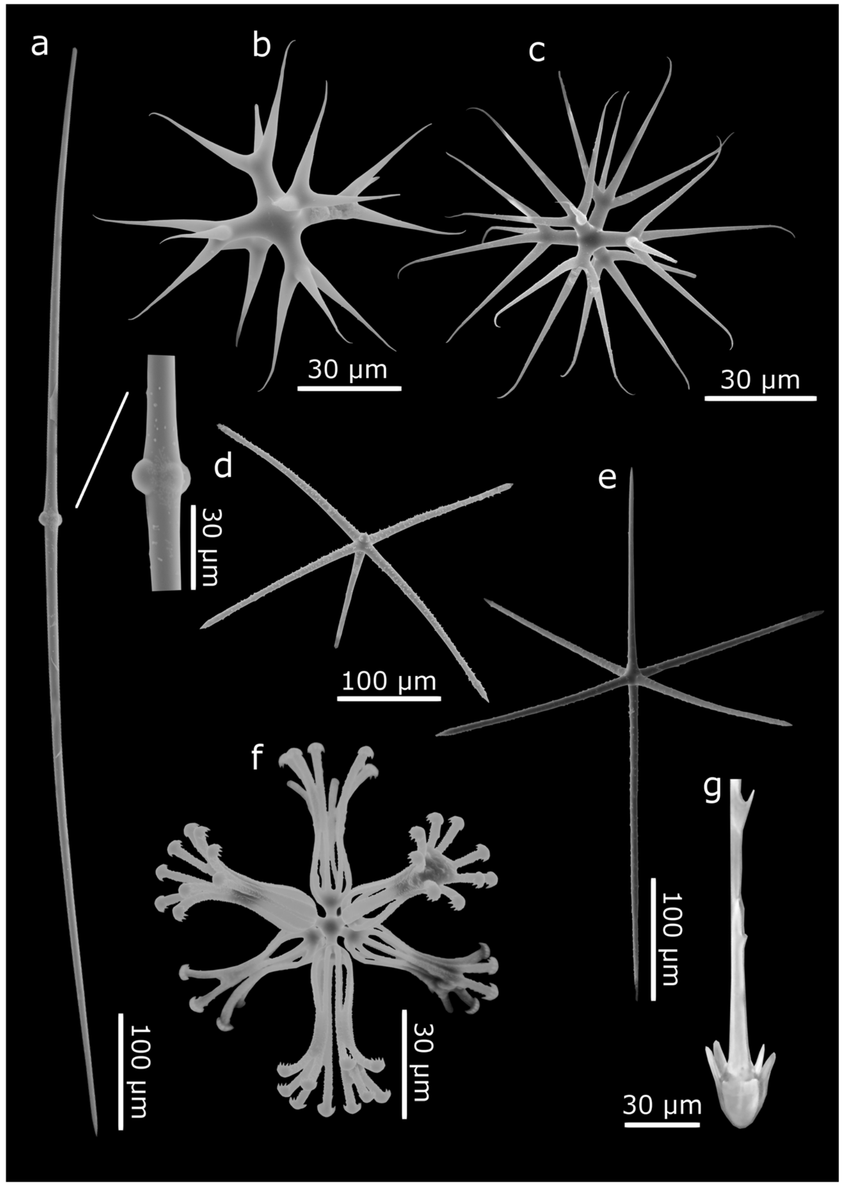


Fig. 13 Spicules of *Docosaccus maculatus*: **a** choanosomal diactins, **b**, **c** oxyhexasters, **d** gastral pentactin, **e** dermal hexactin, **f** floricome, and **g** four-toothed anchorate basalia (light microscopic picture)

Material

Holotype: SMF 12079, collection date 09.04.2015, station SO239/131-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at nodule field (CCFZ), NE-Pacific, 13° 52.39′ N/123° 15.03′ W–13° 52.44′ N/123° 14.88′ W, 4477.8 m.

Table 12 Body size of *Docosaccus maculatus*, values in [cm]

	SMF 12094	SMF 11700	Kahn, Geller, Reiswig & Smith Jr. 2013 (SIO-BIC (P1539))
Body thickness	0.2	0.2	0.1–0.3
Body diameter	8.6	6.7	13.8

Description

Habitus: Lophophytous white sponge with shape of a bird's nest growing on sediment between polymetallic nodules. A central opening with broad margin encloses a flat inner atrial cavity. The body wall is soft and fragile. Anchorate basalia protrude from the dermal surface and penetrate into the sediment. Only a fragment was collected as the specimen was ripped into pieces while sampling. The sponge has a body height of 6.1 cm and a diameter of 21.2 cm (measurements based on in-situ photographs) (Fig. 14a–c and Table 14).

Megascleres: Choanosomal diactins are comparably large and almost smooth, some have a slightly spinous center as well as spinous ends. Diactins are always curved and have a central tubercle or thickening while both ends are pointed. Choanosomal diactins have a length of 1390–7525 µm ($n=$

Table 13 Spicule size of *Docosaccus maculatus*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12094	SMF 11700	Kahn, Geller, Reiswig & Smith Jr. 2013 (SIO-BIC (P1539))
Choanosomal diactins			
Length	820–1401–3100 ± 689 (*n* = 30)	620–961–4350 ± 653 (*n* = 30)	–
Width	10–14–25 ± 4 (*n* = 30)	10–16–70 ± 12 (*n* = 30)	–
Choanosomal hexactins			
Axis length	325–566–830 ± 155 (*n* = 30)	290–678–1050 ± 199 (*n* = 30)	113–360–1192 ± 215 (*n* = 34)
Dermal hexactins			
Distal ray length	130–231–385 ± 69 (*n* = 30)	220–288–390 ± 63 (*n* = 4)	66–142–233 ± 39 (*n* = 50)
Proximal ray length	530–774–1015 ± 119 (*n* = 30)	620–713–770 ± 60 (*n* = 4)	357–597–1135 ± 165 (*n* = 49)
Tangential ray axis length	280–676–875 ± 127 (*n* = 30)	580–835–1025 ± 135 (*n* = 9)	390–682–934 ± 138 (*n* = 27)
Gastral pentacins			
Proximal ray length	120–209–430 ± 107 (*n* = 22)	105–161–260 ± 35 (*n* = 30)	427–653–880 ± 139 (*n* = 17)
Tangential ray axis length	255–361–460 ± 58 (*n* = 30)	340–427–510 ± 41 (*n* = 30)	483–654–802 ± 85 (*n* = 16)
Oxyhexasters			
Primary rosette diameter	30–36–45 ± 4 (*n* = 30)	18–27–33 ± 4 (*n* = 30)	8–15–20 ± 3 (*n* = 50)
Total diameter	76–91–105 ± 7 (*n* = 30)	88–106–125 ± 10 (*n* = 30)	63–79–94 ± 7 (*n* = 50)
Floricomes			
Primary rosette diameter	10–14–15 ± 2 (*n* = 12)	10–16–23 ± 3 (*n* = 19)	10–16–25 ± 3 (*n* = 22)
Total diameter	68–79–88 ± 5 (*n* = 27)	93–107–135 ± 10 (*n* = 19)	63–79–94 ± 7 (*n* = 50)

12) and a width of 10–23 µm (*n* = 12) (Fig. 15a). Choanosomal hexactins are smooth and have curved rays with pointed ends. They have an axis length of 650–1100 µm (*n* = 30) (Fig. 15c). Dermal hexactins are scarce and have straight rays with pointed ends which are getting rough close to the center. The tangential rays and distal ray are spinous over their complete length, the proximal ray approximately over two thirds of its total length. Dermal hexactins have a distal ray with a length of 300–490 µm (*n* = 2), a proximal ray with a length of 640–910 µm (*n* = 2), and a tangential ray axis with a length of 560–835 µm (*n* = 3) (Fig. 15d). Gastral pentactins have slightly curved rays with pointed ends that can be rough. Furthermore, they have a small

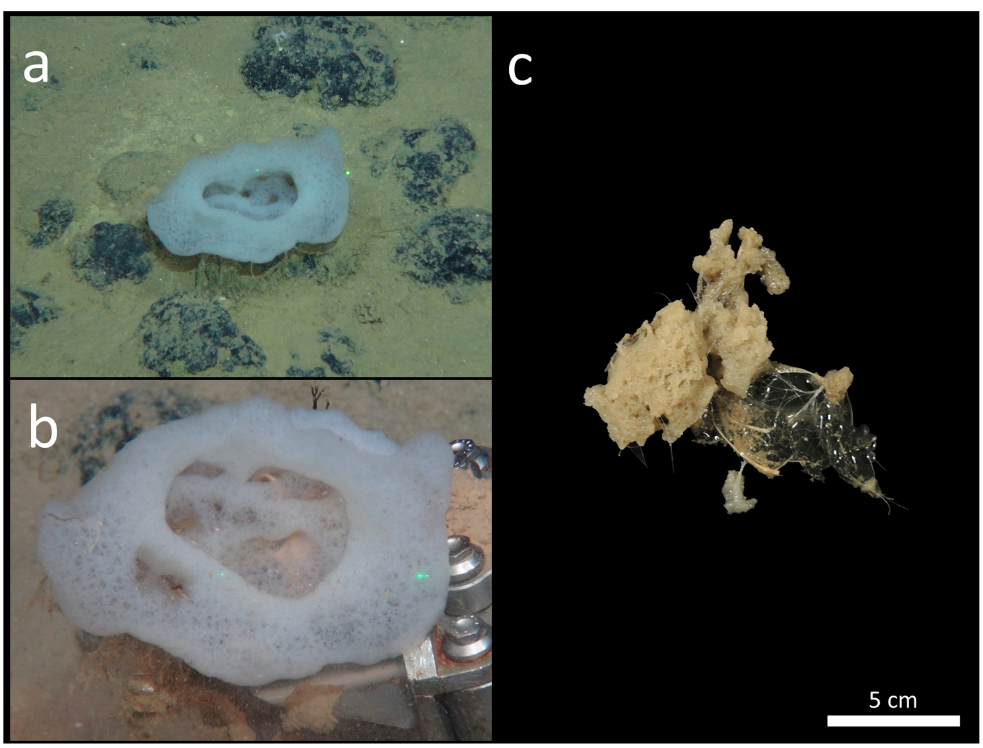


Fig. 14 Habitus of *Docosaccus nidulus* sp. nov.: **a**–**c** SMF 12079

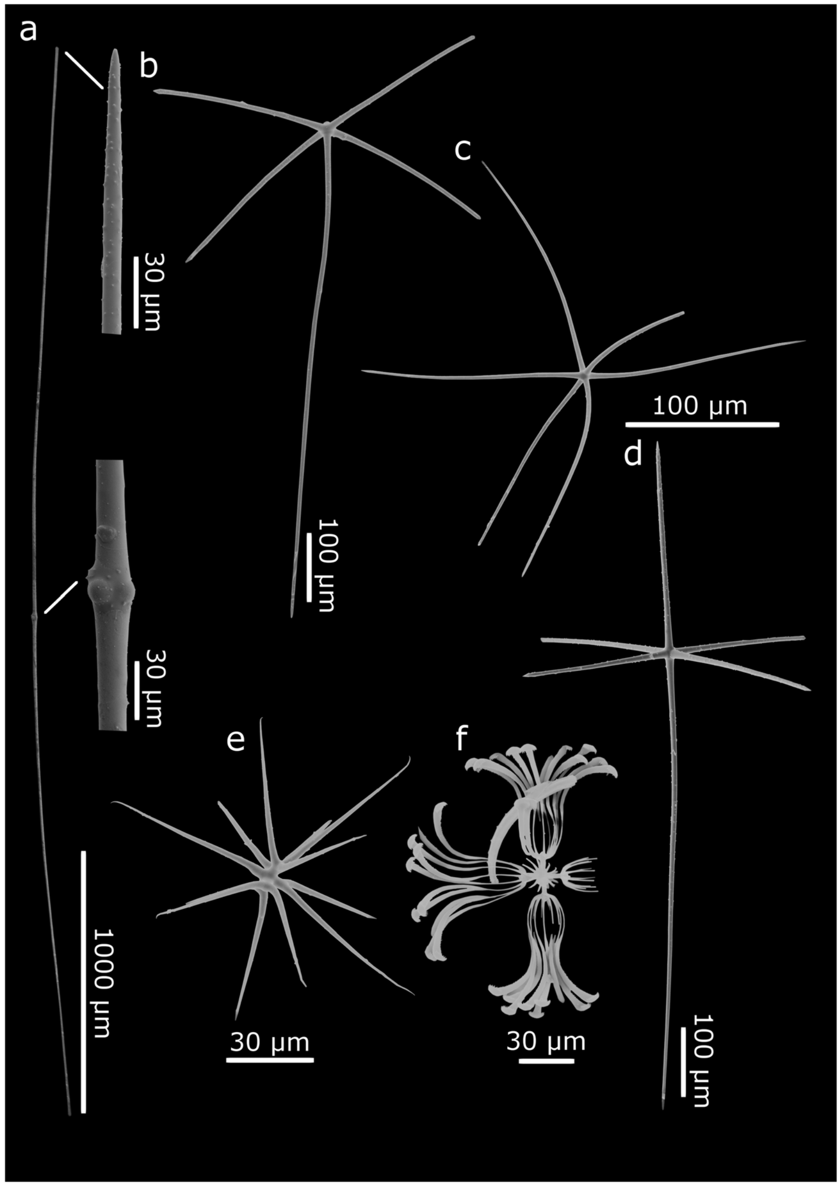


Fig. 15 Spicules of *Docosaccus nidulus* sp. nov.: **a** choanosomal diactins, **b** gastral pentactins, **c** choanosomal hexactin, **d** dermal hexactin, **e** oxyhexaster, and **f** floricome

thickening instead of a distal ray and the length of the tangential ray axis can exceed the length of the proximal ray. Gastral pentactins have a proximal ray with a length of 245–1138 μm (*n* = 28) and a tangential ray axis with a length of 435–780 μm (*n* = 28) (Fig. 15b and Table 15).

Microscleres: Oxyhexasters are completely smooth. Primary rays are straight and carry two to four secondary rays. Most secondary rays are straight and only a small number has slightly curved ends. Oxyhexasters have a primary rosette diameter of 5–18 μm (*n* = 30) and a total diameter of 103–160 μm (*n* = 30) (Fig. 15e). Floricomes have straight primary rays carrying approximately 10–15 secondary rays each. Secondary rays are curved and have claw-shaped ends. Floricomes have a primary rosette diameter of 8–23 μm (*n* = 24) and a total diameter of 110–170 μm (*n* = 30) (Fig. 15f and Table 15).

Table 14 Body size of *Docosaccus nidulus* sp. nov., values in [cm]

	SMF 12079
Body height	6.1
Body diameter	21.2

Remarks

The genus *Docosacus* includes two species: *Docosaccus ancoratus* Topsent, 1910 and *Docosaccus maculatus* Kahn, Geller, Reiswig & Smith Jr., 2013 but both have different spicule morphology and at least *D. maculatus* also a different habitus. The most uncommon feature of the investigated specimen SMF 12079 is its nest-shaped habitus with a big central opening enclosing the inner atrial cavity. Furthermore,

Table 15 Spicule size of *Docosaccus nidulus* sp. nov., values in [μm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12079
Choanosomal diactins	
Length	1390–3660–7525 ± 1926 (*n* = 12)
Width	10–16–23 ± 4 (*n* = 12)
Choanosomal hexactins	
Axis length	650–912–1100 ± 117 (*n* = 30)
Dermal hexactins	
Distal ray length	300–395–490 ± 95 (*n* = 2)
Proximal ray length	640–775–910 ± (*n* = 2)
Tangential ray axis length	560–688–835 ± 113 (*n* = 2)
Gastral pentacins	
Proximal ray length	245–495–1138 ± 174 (*n* = 28)
Tangential ray axis length	435–551–780 ± 87 (*n* = 28)
Oxyhexasters	
Primary rosette diameter	5–10–18 ± 3 (*n* = 30)
Total diameter	103–126–160 ± 13 (*n* = 30)
Floricomes	
Primary rosette diameter	8–16–23 ± 4 (*n* = 24)
Total diameter	110–136–170 ± 13 (*n* = 30)

proximal rays of dermal hexactins are covered with spines close to their center and secondary rays of oxyhexasters tend to be straight. The latter characteristics qualify this sponge as new species called *Docosaccus nidulus* sp. nov. with the name referring to the shape of a little bird's nest.

Nothing is known about the habitus of *D. ancoratus* because only fragments were collected (Tabachnick 2002) while the habitus of *D. maculatus* is known to be disc-shaped (Kahn et al. 2013). So far, only *D. nidulus sp. nov.* is characterized by a flower- or nest-like habitus what makes it easy to identify. The body size of our specimen was measured via the in-situ photograph. Not only the habitus, also the spicule morphology is different than in other species, e.g., oxyhexasters and dermal hexactins. While secondary rays of oxyhexasters are irregularly curved in *D. ancoratus* and secondary rays have curved ends in *D. maculatus*, they tend to be completely straight in *D. nidulus sp. nov.* (Fig. 15e). Furthermore, dermal hexactins of *D. nidulus* sp. nov. are covered with spines over two thirds of their length starting at their center and have a smooth end. Dermal hexactins of *D. maculatus* have proximal rays which are covered with spines over their total length and dermal hexactins of *D. ancoratus* have proximal rays with spinous ends while most of the ray is smooth. Unfortunately, dermal hexactins are extremely scarce in our fragment.

***Holascus* Schulze, 1886**

***Holascus euonyx* (Lendenfeld, 1915)**

Figures 16 and 17 and Tables 16 and 17

Holascus euonyx: Lendenfeld 1915: 44, pls. 24 and 25

Material

SMF 12057, collection date 01.04.2015, station SO239/82-1, ROV *Kiel 6000* from R/V *Sonne* in IOM license area at

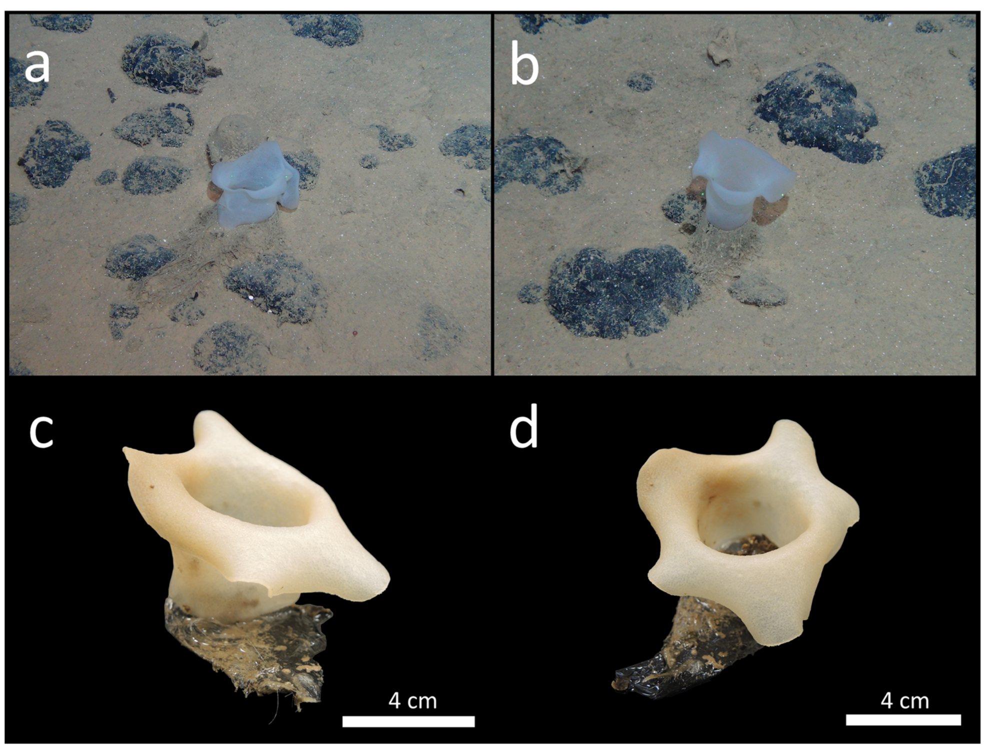


Fig. 16 Habitus of *Holascus euonyx*: **a** SMF 12090 and **b**–**d** SMF 12092

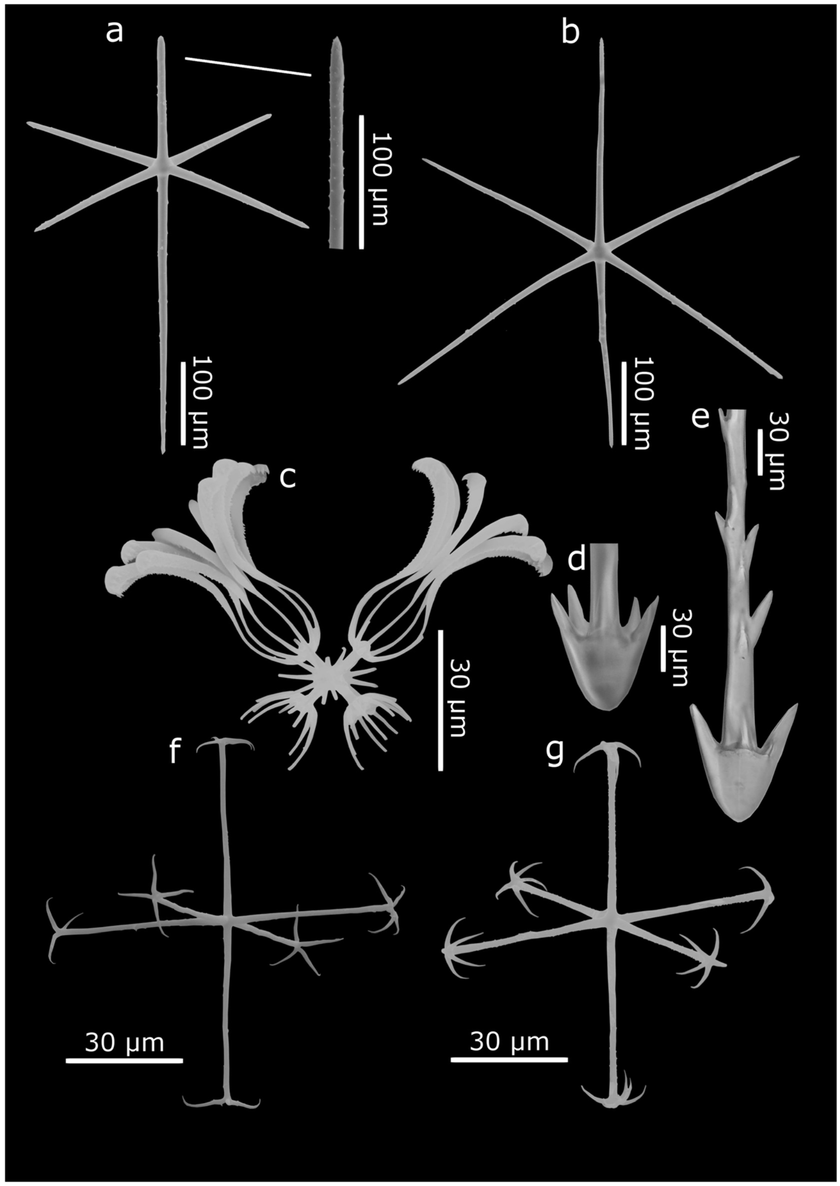


Fig. 17 Spicules of *Holascus euonyx*: **a** superficial hexactin, **b** choanosomal hexactin, **c** fragment of floricome, **d**, **e** anchorate basalia, and **f**, **g** onychohexactins

nodule field (CCFZ), NE-Pacific, 11° 03.45′ N/119° 37.89′ W–11° 03.66′ N/119° 37.65′ W, 4339.2 m, SMF 12090, collection date 14.04.2015, station SO239/157-1, ROV *Kiel 6000* from R/V *Sonne* in IFREMER license area outside OMCO track (CCFZ), NE-Pacific, 14° 02.09′ N/130° 07.13′ W–14° 02.19′ N/130° 07.13′ W, 4951.6 m; SMF 12092, collection date 14.04.2015, station SO239/157-1, ROV *Kiel 6000* from R/V *Sonne* in IFREMER license area outside OMCO track (CCFZ), NE-Pacific, 14° 02.09′ N/130° 07.13′ W–14° 02.19′ N/130° 07.13′ W, 4952.0 m.

Table 16 Body size of *Holascus euonyx*, values in [cm]

	SMF 12057	SMF 12090	SMF 12092	(Lendenfeld, 1915) (PORa-9008)
Body height	5.0	6.6	4.4	–
Body width	7.0	10.4	3.4	–
Tube diameter	3.6	6.9	7.3	–

Description

Habitus: Lophophytous white sponge with cylindrical habitus, thin body wall and fine basalia protruding into the sediment. The body forms a tube with the upper end as overlapping margin. The body height measures 4.4–6.6 cm, the body width 3.4–10.4 cm, and the osculum diameter 3.6–7.3 cm (Fig. 16a–d and Table 16).

Megascleres: Choanosomal hexactins are common and have straight rays with pointed ends slightly covered with

Table 17 Spicule size of *Holascus euonyx*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12057	SMF 12090	SMF 12092	(Lendenfeld, 1915) (PORa-9008)
Choanosomal hexactins				
Diameter	460–602–1010 ± 99 (*n* = 30)	280–504–920 ± 148 (*n* = 30)	320–520–705 ± 93 (*n* = 30)	600–3400
Superficial hexactins				
Distal ray length	100–172–220 ± 23 (*n* = 30)	110–182–255 ± 30 (*n* = 30)	155–176–215 ± 16 (*n* = 15)	235–270
Proximal ray length	230–388–520 ± 77 (*n* = 30)	135–344–500 ± 71 (*n* = 30)	280–339–430 ± 48 (*n* = 15)	400–530
Tangential ray axis length	210–359–590 ± 72 (*n* = 30)	200–304–420 ± 56 (*n* = 30)	300–383–580 ± 75 (*n* = 15)	430–840
Tetractins				
Longitudinal axis length	250–497–835 ± 201 (*n* = 11)	175–413–1000 ± 219 (*n* = 12)	205–282–480 ± 101 (*n* = 5)	≤ 19,000
Transversal axis length	610–4641–8000 ± 2285 (*n* = 11)	1340–4290–8113 ± 1820 (*n* = 12)	775–4035–7850 ± 2393 (*n* = 5)	–
Onychohexactins				
Total diameter	53–74–88 ± 9 (*n* = 30)	56–83–102 ± 12 (*n* = 30)	51–77–95 ± 10 (*n* = 30)	53–95
Floricomes				
Primary rosette diameter	10–13–15 ± 2 (*n* = 30)	10–12–15 ± 2 (*n* = 30)	10–12–15 ± 2 (*n* = 10)	
Total diameter	66–88–108 ± 9 (*n* = 30)	36–85–100 ± 12 (*n* = 30)	75–78–85 ± 3 (*n* = 10)	–
Discohexasters I				
Primary rosette diameter	–	–	–	–
Total diameter	–	–	–	38–44
Discohexasters II				
Primary rosette diameter	–	–	–	–
Total diameter	–	–	–	173–232

spines. They have an axis length of 280–1010 µm (*n* = 90) (Fig. 17b). Superficial hexactins are common and have straight rays which are also covered with small spines. The short distal ray is frequently covered with spines and has a pointed end. The long proximal ray is tapering to its tip which is round. Tangential rays have also round ends. Superficial hexactins have a distal ray with a length of 100–255 µm (*n* = 75), a proximal ray with a length of 135–520 µm (*n* = 75), and a tangential ray axis with a length of 200–590 µm (*n* = 75) (Fig. 17a). Tetractins are common but easily break apart due to their large size. They have two extremely long rays (transversal axis) and two short tangential rays (longitudinal axis) that are both inclined to the same side. Tetractins are straight or curved and have smooth rays. Rays of their longitudinal axis have a length of 175–1000 µm (*n* = 28) and rays of their transversal axis have a length of 610–8113 (*n* = 28) (no photograph). Anchorate basalia are spinous and their heads are anchor-shaped with a round end carrying 5–9 teeth (Fig. 17d, e and Table 17).

Microscleres: Onychohexactins have straight rays with onychoidal ends that have three to five spines and a diameter of 51–102 µm (*n* = 90) (Fig. 17f, g). Floricomes have straight primary rays and curved secondary rays that are serrated over half of their length and have claw-shaped ends with numerous teeth. Floricomes have a primary rosette diameter of 10–15 µm (*n* = 70) and a total diameter of 36–108 µm (*n* = 70) (Fig. 17c and Table 17).

Remarks

The species was described by Lendenfeld (1915) who collected one fragment of a specimen in the East Pacific (00° 03.04′ N/117° 15.08′ W) in a depth of 4243 m and the name of the species refers to the occurrence of onychohexactins and hemionychohexasters. Lendenfeld (1915) described the habitus of the holotype as cylindrically curved plate and already assumes it may have formed a wide tube which can be confirmed by results of this study (Fig. 16a, b). The color of *H. euonyx* is white instead of brown. Due to the fact that Lendenfeld (1915) described a fragment, it is difficult to compare the body size with the complete specimens in this study. The choanosomal hexactins were originally described as small and as large loose hexactins but we found no size classes. Results of this study indicate that choanosomal hexactins seem to have a size range of 280–1010 µm compared to 600–3400 µm given in the original description. Superficial hexactins are characteristic for *Holascus* and results of this study match results of Lendenfeld (1915), although we found also some smaller superficial hexactins. Tetractins measured in this study were smaller than measured by Lendenfeld (1915) but still extremely large with a measured transversal axis length up to 8113 µm. Size measurements of onychohexactins do match each other, although we found only very few hemionychohexasters (no photograph). Floricomes were numerous and their occurrence is at least typical for Euplectellidae but not described by Lendenfeld (1915) who found great numbers of small and large discohexasters instead, but that were in turn, absent in specimens of this study.

***Holascus spinosus* sp. nov.**
Figures 18 and 19 and Tables 18 and 19

Material

Holotype: SMF 12058, collection date 01.04.2015, station SO239/82-1, ROV *Kiel 6000* from R/V *Sonne* in IOM license area at nodule field (CCFZ), NE-Pacific, 11° 03.45′ N/119° 37.89′ W–11° 03.66′ N/119° 37.65′ W, 4335.8 m.

Description

Habitus: Lophophytous white sponge with tubular to collar-shaped habitus and wide central opening to its atrial cavity. The body is band-like and consists of a thin wall forming a collar with two large openings while the upper opening has a smaller diameter than the lower opening. The body wall is smooth and bears a small number of spiny bumps. Furthermore, the upper part of the body wall is slightly curled as well as a smaller second tube next to the main tube. Basalia protrude from the body wall into the sediment while some of them are visible on the sediment surface. *H. spinosus* sp. nov. has a body height of 5.8 cm, a lower body diameter of 13.2 cm (diameter of lower opening), and an upper body diameter of 7.7 cm (diameter of upper opening) (Fig. 18a–c and Table 18).

Megascleres: Large choanosomal diactins are slightly curved, have pointed ends, and a middle part covered with spines which has a slight or distinct central thickening. They have a length of 7450–18,300 µm ($n = 5$) and a width of 20–30 µm ($n = 5$) (Fig. 19a). Small choanosomal diactins are straight or slightly bent and completely smooth while their ends are pointed. They have a central thickening or tubercle. They have a length of 2150–4939 µm ($n = 4$) and a width of 10–15 µm ($n = 4$) (Fig. 19b). Choanosomal hexactins are covered by a small number of spines and have curved rays. Two rays are only slightly curved and give the spicules a characteristic grapnel-like morphology wherefore longitudinal and transversal axis length is given. Choanosomal hexactins have a longitudinal axis length of 330–540 µm ($n = 30$) and a transversal axis length of 160–430 µm ($n = 30$) (Fig. 19d). Choanosomal pentactins are scarce and have straight rays. Close to the center, these rays are covered with spines while their outer parts are smooth. One pentactin with a tangential ray length of 3850 µm ($n = 1$) is present in one of the preparations (no photograph). Superficial hexactins have straight rays. All tangential rays have the same length while the distal ray is longer than the tangential rays but shorter than the proximal ray. All rays of the superficial hexactins are completely or partly covered with spines. The distal ray is completely covered with big spines while all other rays are partly covered with smaller spines. Tangential rays and the proximal ray have spines close to their base and their outer parts are smooth, especially the proximal ray where only one sixth of its total length is covered with spines. Superficial hexactins have a distal ray length of 120–295 µm ($n = 30$), a proximal ray length of 535–1180 µm ($n =$

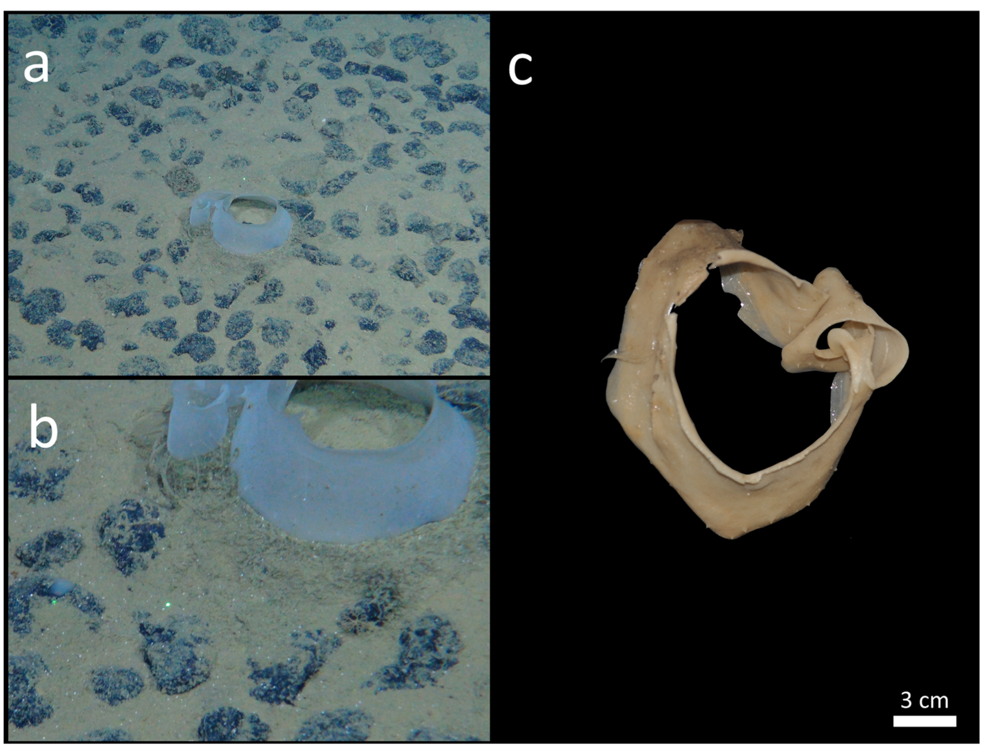


Fig. 18 Habitus of *Holascus spinosus* sp. nov.: **a**–**c** SMF 12058

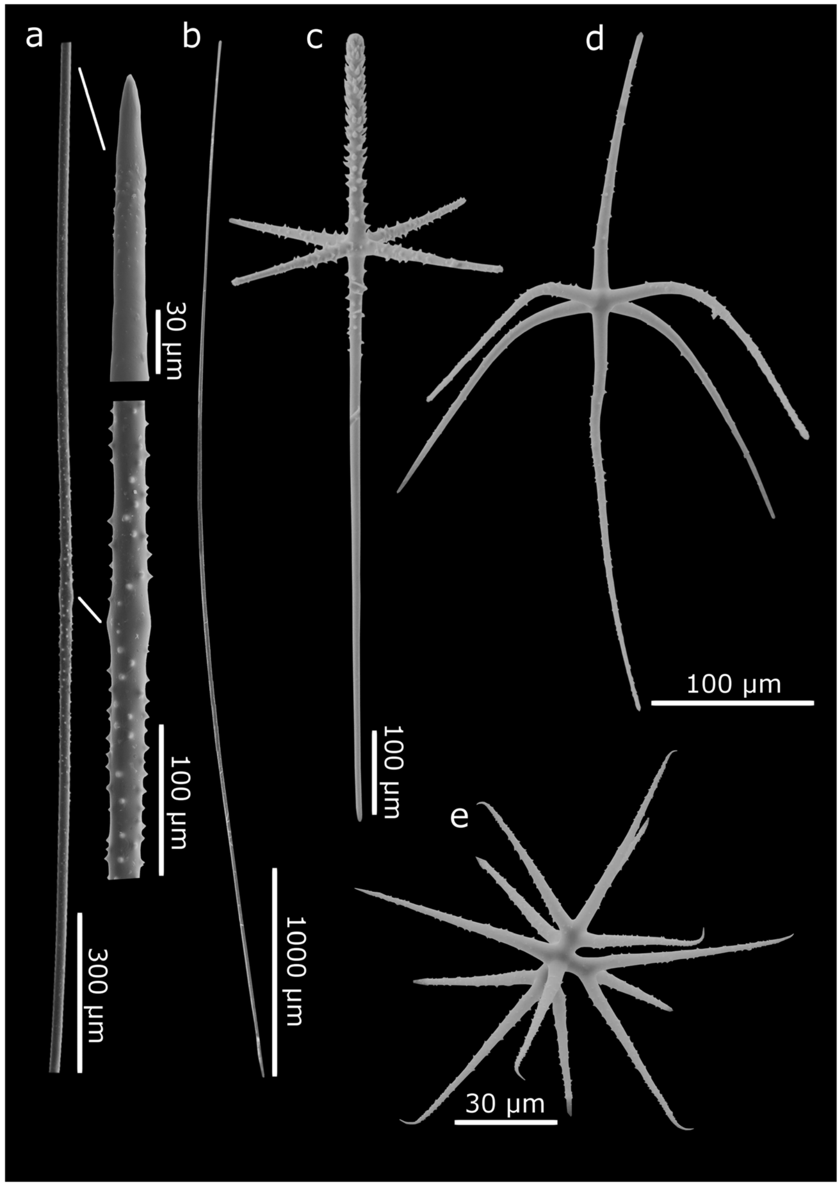


Fig. 19 Spicules of *Holascus spinosus* sp. nov.: **a** large choanosomal diactin, **b** small choanosomal diactin, **c** superficial hexactin, **d** hexactin, and **e** oxyhexaster

30), and a tangential ray axis with a length of 320–975 µm (n = 30) (Fig. 19c and Table 19).

Microscleres: Oxyhexasters have straight primary rays carrying two to four secondary rays covered with small spines. Secondary rays are completely straight or their tips are curved. Oxyhexasters have a primary rosette diameter of 18–28 (n = 30) and a total diameter of 108–158 µm (n = 30) (Fig. 19e and Table 19).

Table 18 Body size of *Holascus spinosus* sp. nov., values in [cm]

	SMF 12058
Body height	5.8
Lower body diameter	13.2
Upper body diameter	7.7

Remarks

The tubular habitus with two openings and a thin body wall with very fine protruding basalia are common characteristics for the outer morphology of species within the genus *Holascus*. In this genus, most characteristic spicule types for species identification are superficial hexactins and the inventory of microscleres, e.g., discohexasters, oxyhexasters, and/or onychohexasters. The herein investigated species has superficial hexactins densely covered with spines, especially the distal ray, and also choanosomal diactins covered with spines in the area close to their central thickening. Furthermore, the only microscleres are acanthous oxyhexasters with two to four secondary rays arising from each primary ray. The latter characteristics, especially the strong spination of spicules, qualify the specimen as the new species *Holascus spinosus* sp. nov.

Table 19 Spicule size of *Holascus spinosus* sp. nov., values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12058
Large choanosomal diactins	
Length	7450–12,840–18,300 ± 3733 ($n = 5$)
Width	20–25–30 ± 3 ($n = 5$)
Small choanosomal diactins	
Length	2150–3122–4939 (4)
Width	10–13–15 ± 2 ($n = 4$)
Choanosomal hexactins	
Longitudinal axis length	330–434–540 ± 48 ($n = 30$)
Transversal axis length	160–320–430 ± 71 ($n = 30$)
Choanosomal pentactins	
Tangential ray axis length	3375 ($n = 1$)
Superficial hexactins	
Distal ray length	120–231–295 ± 37 ($n = 30$)
Proximal ray length	535–838–1180 ± 163 ($n = 30$)
Tangential ray axis length	320–423–975 ± 111 ($n = 30$)
Oxyhexasters	
Primary rosette diameter	18–23–28 ± 3 ($n = 30$)
Total diameter	108–133–158 ± 9 ($n = 30$)

The genus *Holascus* includes 15 species and 4 of them that were described by Lendenfeld (1915) are known to occur in the northeastern Pacific. Two of them are included in this study: *Holascus euonyx* and *Holascus taraxacum*. The other two species are *Holascus ancoratus* (Lendenfeld, 1915) and *Holascus edwardsi* Lendenfeld, 1915. Both have a tubular body that is similar to the habitus of *H. taraxacum* rather than *H. spinosus* sp. nov. Furthermore, the spiculation of both species is different: a good characteristic to differentiate between *H. ancoratus* and *H. spinosus* sp. nov. are microscleres, because *H. ancoratus* has floricomes and onychohexasters while *H. edwardsi* has oxyhexasters, graphiocomes, and sigmas. Anchorate basalia were not found in the preparations as most of them were ripped off during sampling.

***Holascus taraxacum* (Lendenfeld, 1915)**
Figures 20 and 21 and Tables 20 and 21
Holascus taraxacum: Lendenfeld 1915: 29, pls. 21–23

Material:

SMF 12059, collection date 01.04.2015, station SO239/82-1, ROV *Kiel 6000* from R/V *Sonne* in IOM license area at nodule field (CCFZ), NE-Pacific, 11° 03.45′ N/119° 37.89′ W–11° 03.66′ N/119° 37.65′ W, 4337.1 m; SMF 11693, collection date 22.04.2015, station SO239/200-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-Pacific, 18° 49.22′ N/128° 25.55′ W–18° 49.60′ N/128° 25.48′ W, 4670.6 m.

Description

Habitus: Lophophytous white sponge with tubular habitus, central opening to its atrial cavity, and several root tufts. The diameter of the tubular body increases from the base to approximately two thirds of its total length and slightly decreases in its last third again. The tube can be irregular in shape, probably depending on the environmental conditions, e.g., with a thickening (Fig. 18b). The body wall is soft and collapses after collection. Three to four root tufts are located at the base and penetrate into the sediment where a second opening is located. The collected specimens have a body height of 12.9–29.9 cm, a body width of 3.9–5.1 cm, and basalia with a length of 3.4–8.4 cm (Fig. 20a–c and Table 20).

Megascleres: Megascleres in *H. taraxacum* are choanosomal diactins, chaonosomal hexctins, and numerous hexactin derivates like pentactins, tetractins and triactins, as well as superficial hexactins. Choanosomal diactins are numerous but difficult to measure due to their size. Diactins are smooth and curved, have a thickening or a tubercle close to but not necessarily at their center, and their ends can be round to clavate. Choanosomal diactins have a length of 2558–11,100 µm ($n = 15$) and a width of 10–23 µm ($n = 15$) (Fig. 21b). Choanosomal hexactins have smooth and curved rays of equal length with rounded ends. Measured hexactins have a diameter of 700–2140 µm ($n = 15$) (Fig. 21c). Choanosomal pentactins, tetractins, and triactins look similar than hexactins, only their number of rays is reduced. Only a small number (pentactins and triactins) or none (tetractins) of these spicules were measured as they are comparably large and easily break apart. The measured pentactins has a single ray length of 1975 µm ($n = 1$) and a tangential ray axis length of 7925 ($n = 1$) (Fig. 21d). Measured triactins have a single ray with a length of 490–3838 µm ($n = 6$) and a tangential ray axis length of 2850–9100 µm ($n = 6$) (Fig. 21f). Superficial hexactins have smooth and straight rays with round or pointed ends. They have one long proximal ray, four tangential rays, and one distal ray with a clavate thickening and a small number of terminal scale-shaped spines forming a cone. Superficial hexactins are numerous and have a distal ray length of 270–490 µm ($n = 60$), a proximal ray length of 710–1975 µm ($n = 30$), and a tangential ray axis length of 540–1150 µm ($n = 60$) (Fig. 21a and Table 21).

Microscleres: Oxyhexasters are numerous in SMF 12059 and absent in SMF 11693. They have straight primary rays that carry usually two or three straight and conical secondary rays covered with small spines. Oxyhexasters have a primary rosette diameter of 18–30 µm ($n = 30$) and a total diameter of 94–160 µm ($n = 30$) (Fig. 21j). Discohexasters are spherical and have primary rays with approximately 20–30 secondary rays. Primary and secondary rays are straight and microspined while secondary rays have discoidal ends with small teeth. Discohexasters have a primary rosette diameter of 15–

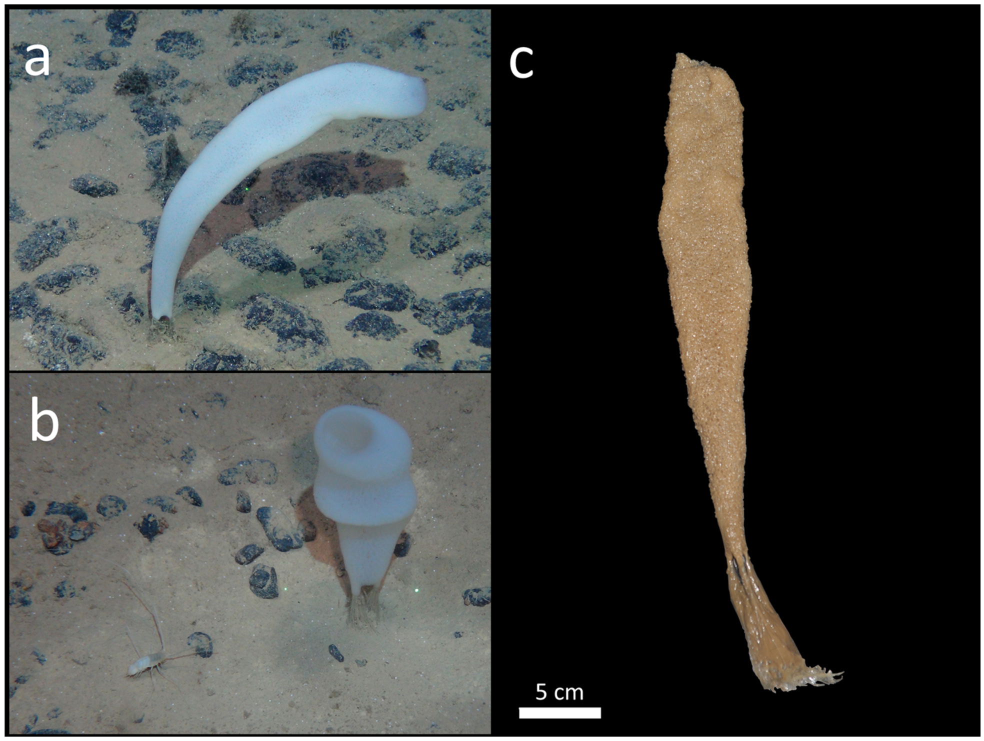


Fig. 20 Habitus of *Holascus taraxacum*: **a** SMF 12059, **b** SMF 11693, and **c** SMF 12059

40 μm ($n = 60$) and a diameter of 157–475 μm ($n = 60$) (Fig. 21g). Graphiocomes are numerous and tend to break apart, thus, primary rosettes and secondary rays have to be measured individually. Primary rosettes have straight rays of constant thickness and a constant diameter 24–38 μm ($n = 43$) (Fig. 21i). Secondary rays are smooth and straight while they have a length of 118–355 μm ($n = 60$) (Fig. 21h and Table 21).

Remarks

The species *H. taraxacum* was described by Lendenfeld (1915) who collected the lower body of one incomplete specimen and three more fragments of the upper body in the Tropical East Pacific (05° 17.00′ S/85° 19.05′ W) in a depth of 4086 m. The name of the species refers to the presence of discohexasters which look similar to seed heads of a dandelion flower (genus *Taraxacum*). Lendenfeld (1915) already assumed the sponge body consists of a continuous tube which can now be confirmed. The root tufts are the most characteristic feature of the habitus and protrude a few centimeters above the sediment surface (Fig. 20a, b). The color of *H. taraxacum* is white instead of brown. The inventory of megascleres described by Lendenfeld (1915) and this study is similar but size and fragility of the megascleres of *H. taraxacum* are a problem for exact spicule measurement. What Lendenfeld (1915) described as principal hexactins, pentactins, and tetractins have not been observed in the specimens SMF 12059 and 2079, although it is possible that these spicule types have been overlooked for certain reasons, e.g., a rare number of these spicules or because they were broken or both. Choanosomal diactins where originally described as comital rhabds, long slender rhabds, and minute rhabds. They are common but difficult to measure due to their size and fragility. Choanosomal hexactins were originally described as intermediate hexactins and their derivates like pentactins, tetractins, and triactins are common but also difficult to measure due to their size and fragility. Superficial hexactins are the only type of megascleres which are common and simple to measure. Measurements of length and diameter match each other as well as the spicule morphology which shows that superficial hexactins in both studies are identical. The inventory of microscleres in the study by Lendenfeld (1915) and our study is different. Oxyhexasters are only present in SMF 12059 and can be a contamination, although spicule morphology and size measurements are matching the original description. Discohexasters are the most characteristic type of microscleres in *H. taraxacum* and their morphology and size are equal to measurements of the study by Lendenfeld (1915). Microhexactins and pentactins as well as onychohexasters are absent in SMF 12059 and SMF 11693. Graphiocomes of the same type are described in both studies and probably identical although only primary rays were measured in the original description. Although most types of megascleres have been observed in SMF 12059 and SMF 11693, it was difficult to measure them. The inventory of microscleres is different in both studies although the most characteristic microscleres like discohexasters are present. We think it is possible that one of the upper body parts

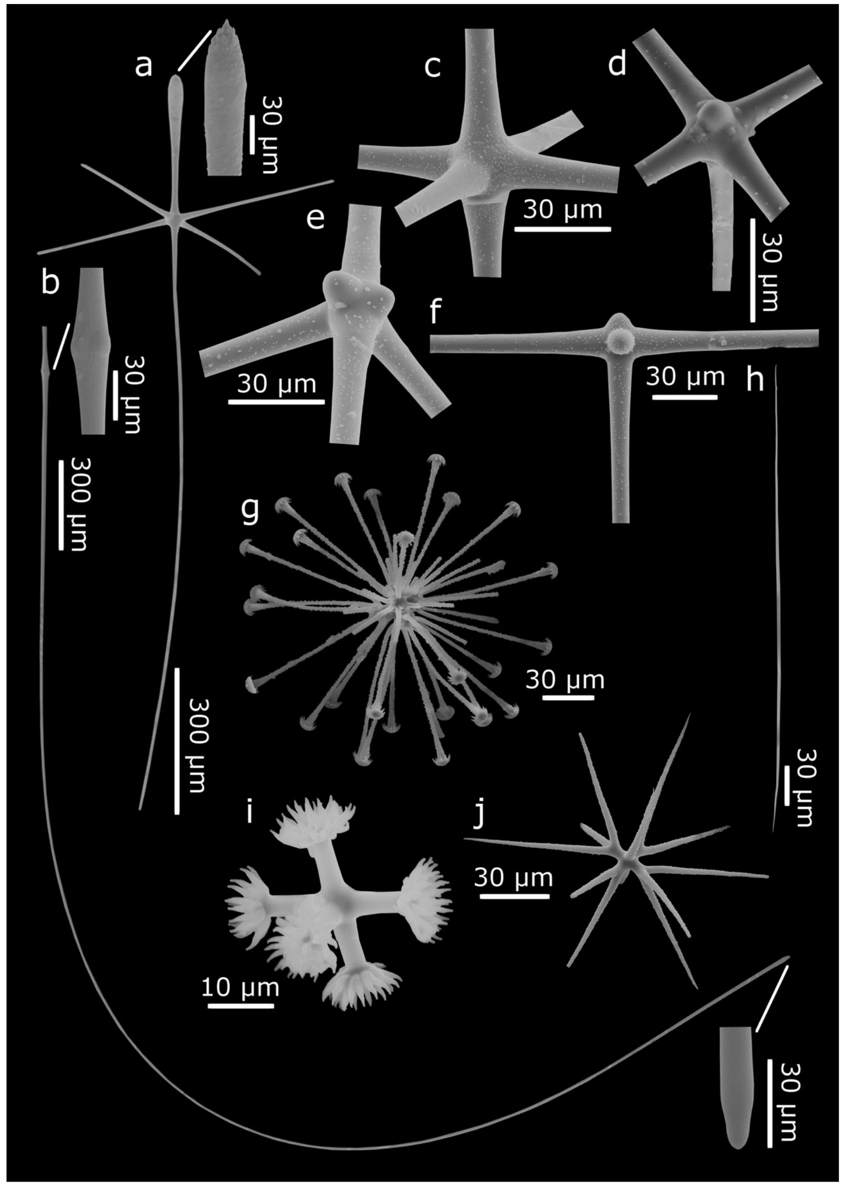


Fig. 21 Spicules of *Holascus taraxacum*: **a** superficial hexactin with detail of distal ray, **b** part of choanosomal diactin with central thickening and detail of rounded end, **c** center of choanosomal hexactin, **d** centre of choanosomal pentactin, **e** centre of choanosomal tetractin, **f** centre of choanosomal triactin, **g** discohexaster, **h** secondary ray of graphiocome, **i** primary rosette of graphiocome, and **j** oxyhexaster

collected by Lendenfeld (1915) was part of a different species or that some of his material was contaminated because due to the great accordance of the sponge habitus and the most characteristic spicule types of *H. taraxacum* (superficial hexactins and discohexasters), it is definitely the same species. Furthermore, anchorate basalia were not found in the preparations but were described by Lendenfeld (1915) who differentiated smooth and spined anchorate basalia.

Table 20 Body size of *Holascus taraxacum*, values in [cm]

	SMF 12059	SMF 11693	(Lendenfeld, 1915) (PORa-6840-A)
Body height	29.9	12.9	12.0
Body width	5.1	3.9	7.0
Basalia length	8.4	3.8	8.0–12.0

Sceptrulophora Mehl, 1992
Euretidae Zittel, 1877
Chonelasmatinae Schrammen, 1912
***Bathyxiphus* Schulze, 1899**
***Bathyxiphus subtilis* Schulze, 1899**

Figures 22 and 23 and Tables 22 and 23

Bathyxiphus subtilis: Schulze 1899: 82, pl. XVII and XVIII; Reiswig and Wheeler, 2002: 1319, Fig. 12

Material

SMF 11706, collection date 20.04.2015, station SO239/189-1, ROV *Kiel 6000* from R/V *Sonne* in APEI 3 (CCFZ), NE-

Table 21 Spicule size of *Holascus taraxacum*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12059	SMF 11693	Lendenfeld, 1915 (PORa-6840-A)
Choanosomal diactins			
Length	2558–7635–11,100 ± 2978 (n = 8)	2600–5175–7625 ± 1785 (n = 7)	5000–15,000
Width	13–18–23 ± 4 (n = 8)	10–12–15 ± 2 (n = 7)	11–45
Choanosomal hexactins			
Diameter	700–705–710 ± 5 (n = 2)	885–1622–2140 ± 363 (n = 13)	2000–5000
Choanosomal pentactins			
Single ray length	1975 (n = 1)	–	1000–2500
Tangential ray axis length	7925 (n = 1)	–	2000–5000
Choanosomal triactins			
Single ray length	1740–2257–3550 ± 753 (n = 4)	490–2164–3838 ± 1674 (n = 2)	–
Tangential ray axis length	2850–5725–9100 ± 2766 (n = 4)	3463–5406–7350 ± 1944 (n = 2)	–
Superficial hexactins			
Distal ray length	270–366–430 ± 43 (n = 30)	275–325–490 ± 54 (n = 30)	160–500
Proximal ray length	710–1418–1975 ± 378 (n = 30)	830–1204–1675 ± 259 (n = 30)	800–1800
Tangential ray axis length	540–727–900 ± 85 (n = 30)	775–941–1150 ± 100 (n = 30)	400–2000
Oxyhexasters			
Primary rosette diameter	18–23–30 ± 3 (n = 30)	–	38
Total diameter	94–126–160 ± 17 (n = 30)	–	95
Discohexasters			
Primary rosette diameter	25–34–40 ± 3 (n = 30)	15–20–23 ± 3 (n = 30)	28
Total diameter	168–226–475 ± 67 (n = 30)	157–193–394 ± 54 (n = 30)	180–290
Graphiocomes			
Primary rosette diameter	24–34–38 ± 3 (n = 30)	26–32–38 ± 3 (n = 13)	22–26
Secondary ray length	118–300–345 ± 42 (n = 30)	248–308–355 ± 25 (n = 30)	–

Pacific, 18° 47.80′ N/128° 18.53′ W–18° 48.13′ N/128° 18.20′ W, 4914.7 m.

Description

Habitus: Basiphytous white sponge with upright blade-shaped habitus growing on hard substrate. The body is blade- or lamella-shaped with a thin but firm body wall due to the rigid skeleton. The lower body arises from the peduncle forming a round basis that opens up into the upper body which looks like a slightly involute leaf or double-edged sword with a distinct midrib. The upper end of the body is round again. The specimen in this study has a body height of 9.2 cm and a body width of 1.5 cm (Fig. 22a, b and Table 22).

Skeletal framework: The rigid skeleton is a dictyonal framework with several layers and beams covered by small spines. Mostly rectangular meshes are formed by fused regular hexactins that form also some loose ends. Uncinates do often lie parallel to single beams. Overall, a fan-like skeletal structure in growth direction is visible (Fig. 22c, d).

Megascleres: Superficial pentactins have rays with round to slightly clavate ends that are covered with small spines. All five rays are thickest at their base and taper towards their ends. The length of the tangential ray axis exceeds the length of the proximal ray. On the distal side, a small tubercle is present. Superficial pentactins have a proximal ray length of 190–260 µm (n = 6) and a tangential ray axis with a length of 540–890 µm (n = 30) (Fig. 23e, f). Uncinates are straight or slightly crescent-shaped with indistinct spination as barbs are lacking. Uncinates have a length of 725–1325 µm (n = 30) (Fig. 23a). Tyloscopules are present while subtyloscopules are lacking. Scopules are straight and covered with small spines. The head consists of a capitulum carrying four diverging tines with small caps that have serrated margins. The shaft is usually straight and has a pointed end. Tyloscopules have a head length of 90–130 µm (n = 30) and a total length of 360–520 µm (n = 30) (Fig. 23b and Table 23).

Microscleres: Hemioxyhexasters are common and completely covered with small spines. They have short straight primary rays carrying one to four straight secondary rays with pointed ends. Hemioxyhexasters have a primary rosette diameter of 23–45 (n = 30) a total diameter of 70–114 µm (n = 30) (Fig. 23c). Hemidiscohexasters are also completely covered with small spines. They have short straight primary rays and each of them carries one to five straight secondary rays with discoidal ends. Hemidiscohexasters are smaller and less

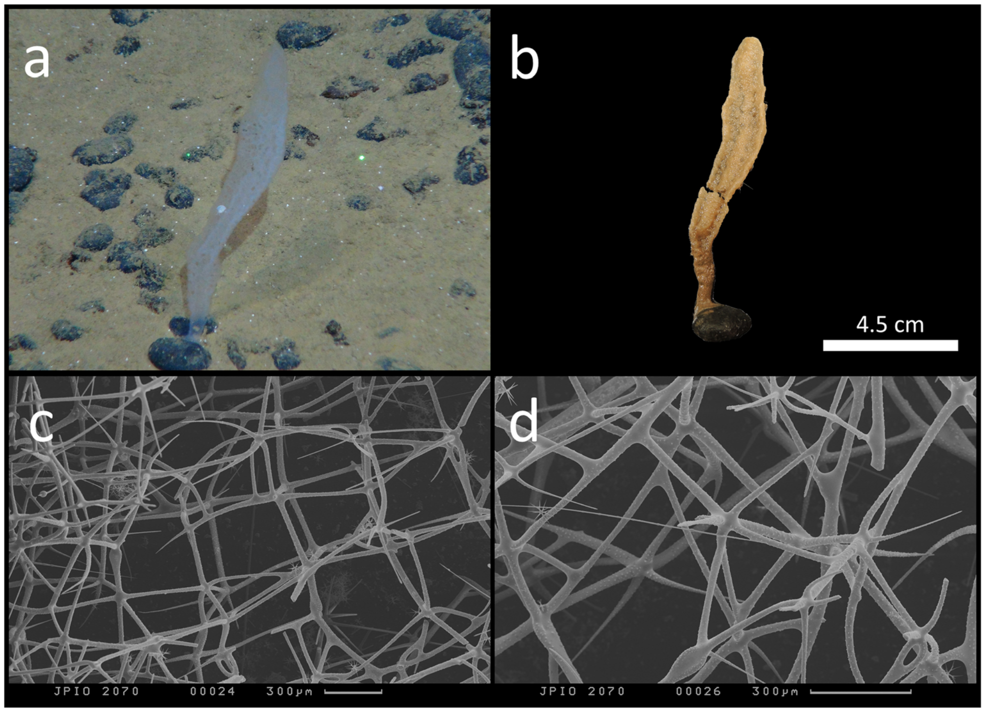


Fig. 22 Habitus of *Bathyxiphus subtilis*: **a**–**d** SMF 11706

common than hemioxyhexasters. They have a primary rosette diameter of 10–25 μm ($n = 30$) and a total diameter of 28–48 μm ($n = 30$) (Fig. 23d and Table 23).

Remarks

This is the second official record of *B. subtilis* which is the only species of the genus *Bathyxiphus*. Schulze (1899) sampled the holotype south of Isla Guadalupe close to the coast of California, USA (28° 57.00′ N/118° 14.30′ W) in a depth of 1251 m. The specimen by Schulze (1899) was bigger than the specimen in this study, but due to the detailed description of the habitus and the spicule inventory, there is no doubt that this is the second official record. Schulze's (1899) description of a habitus similar to a double-edged sword with wavy edges is precise and matches our results perfectly and especially the midrib is a unique characteristic. The original description of the skeletal framework does also match our results, but not perfectly. Described is a dictyonal framework with regular and mostly rectangular meshes consisting of smooth beams while only the loose ends are covered with small spines. In contrast, all beams in the skeletal framework of SMF 11706 are covered with small spines and nothing is smooth. Since the first record was made in 1899, there is a great discussion about the true spicule inventory of this species and Schulze already mentioned in the original description that his results are uncertain because the holotype was in a bad condition. Pinulate hexactins are absent in SMF 11706 and our results confirm, what Schulze (1899) did already mention in the original description: pinulate hexactins in the holotype are a contamination. Furthermore, this is true for the pileate clavules which are definitely a contamination and maybe also true for the subtyloscopules, although we found many tyloscopules what increases the probability to have findings of subtyloscopules. In contrast, pentactins are mentioned in the original description but it was doubtful if they really were part of *B. subtilis*. As pentactins were common in the preparations of SMF 11706, we can confirm their presence and furthermore assume that these occur in both, dermal and gastral surfaces. Furthermore, hemioxy- and hemidiscohexasters are common while hemidiscohexasters are smaller than hemioxyhexasters. Uncinates in SMF 11706 are lacking barbs, but we have additional material from the DISCOL area in the southern Pacific that look like our specimens and have uncinates with barbs (in preparation).

***Chonelasma* Schulze, 1886**
***Chonelasma bispinula* sp. nov**
Figures 24 and 25 and Tables 24 and 25

Material

Holotype: SMF 12073, collection date 01.04.2015, station SO239/82-1, ROV *Kiel 6000* from R/V *Sonne* in IOM license area at nodule field (CCFZ), NE-Pacific, 11° 03.45′ N/119° 37.89′ W–11° 03.66′ N/119° 37.65′ W, 4346.6 m; Paratype: SMF 12084, collection date 10.04.2015, station SO239/135-1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at Heip Mountains (CCFZ), NE-Pacific, 13° 58.69′ N/123° 08.94′ W–13° 59.06′ N/123° 08.64′ W, 3855.5 m; Paratype: SMF 12087, collection date 11.04.2015, station SO239/141-

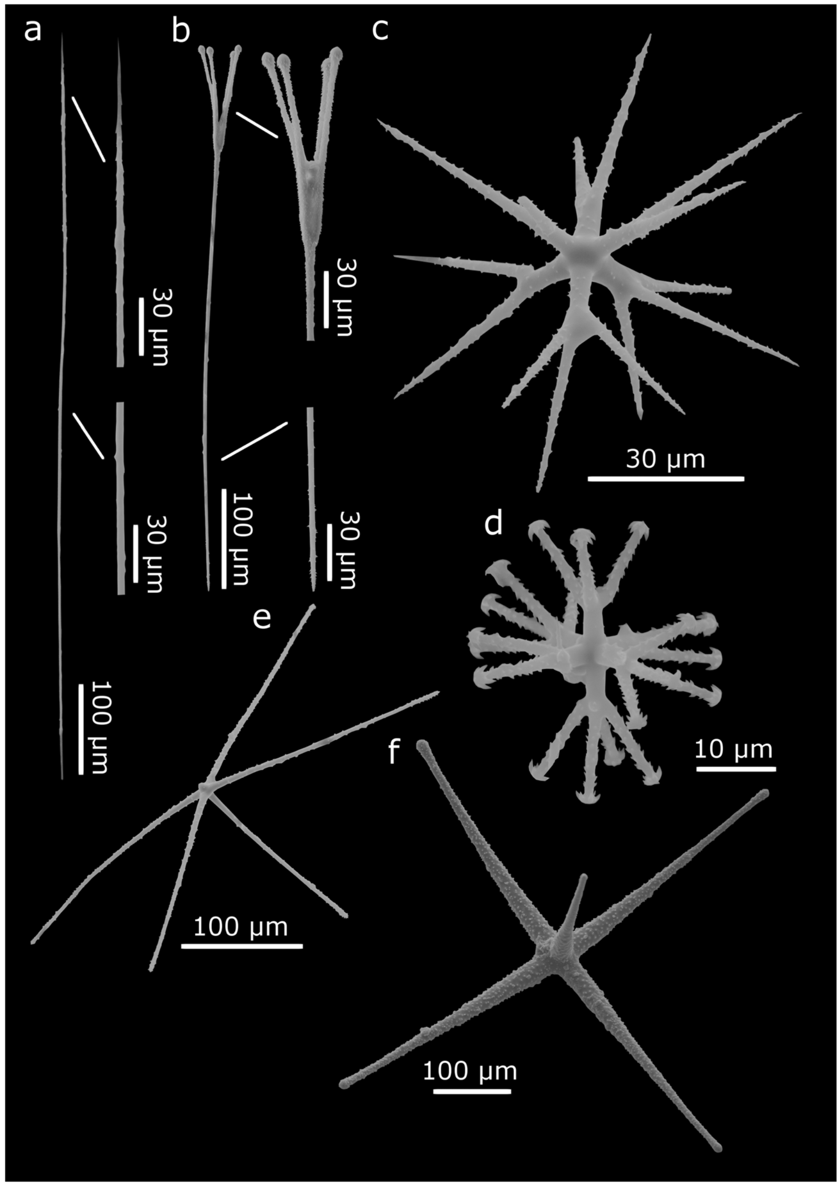


Fig. 23 Spicules of *Bathyxiphus subtilis*: **a** uncinate, **b** tyloscopule, **c** hemioxyhexaster, **d** hemidiscohexaster, and **e**, **f** superficial pentactins

1, ROV *Kiel 6000* from R/V *Sonne* in GSR license area at reference site (CCFZ), NE-Pacific, 13° 52.03′ N/123° 15.33′ W–13° 52.19′ N/123° 15.25′ W, 4474.8 m.

Description

Habitus: Basiphytous white sponge with upright cup- to funnel-shaped body growing on nodules and other hard

Table 22 Body size of *Bathyxiphus subtilis*, values in [cm]

	SMF 11706	Schulze, 1899 (USNM 7528)
Body height	9.2	30
Body width	1.5	5–10

substrate. The funnel-shaped body protrudes from a short central basis and body walls are thin but firm due to the dictyonal skeletal framework. White rings are visible within the funnel, possibly due to the ranking of dictyonalia and their center into macroscopically visible septa. The body height measures 2.9–5.2 cm and the body width 2.6–6.4 cm and the wall thickness 0.1–0.2 cm (Fig. 24a–d and Table 24).

Skeletal framework: The skeleton is a dictyonal framework and consists of a dermal cortical layer forming irregular meshes and an inner primary layer forming rectangular meshes. Beams within the framework are spinous and have a constant thickness (Fig. 25f, g).

Megascleres: Superficial pentactins have one proximal and four tangential rays roughly covered by big spines, especially the tangential rays. Furthermore, tangential rays are slightly inclined toward the proximal ray. Superficial pentactins have a

Table 23 Spicule size of *Bathyxiphus subtilis*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 11706	Schulze, 1899 (USNM 7528)
Superficial pentactins		
Proximal ray length	190–235–260 ± 24 (n = 6)	–
Tangential ray axis length	540–685–890 ± 70 (n = 30)	–
Uncinates		
Length	725–1053–1325 ± 115 (n = 30)	1025 ± 234
Tyloscopules		
Head length	90–108–130 ± 10 (n = 30)	–
Total length	360–458–520 ± 36 (n = 30)	298–313
Subtyloscopules		
Head length	–	57 ± 16
Total length	–	308–403
Hemioxyhexasters		
Primary rosette diameter	23–35–45 ± 5 (n = 30)	–
Diameter	70–94–115 ± 11 (n = 30)	76 ± 20
Hemidiscohexasters		
Primary rosette diameter	10–17–25 ± 3 (n = 30)	–
Diameter	28–38–48 ± 5 (n = 30)	–

proximal ray length of 104–290 µm (n = 5) and a tangential ray axis length of 355–805 µm (n = 90) (Fig. 25e). Scopules are completely covered with small spines and consist of a straight shaft with two different ends, one is pointed and the other one is a head consisting of a capitulum and tines. Four to seven diverging tines protrude from the capitulum and have small serrated caps as heads. Scopules have a head length of 33–63 µm (n = 69) and a total length of 230–485 µm (n = 65) (Fig. 25a). Uncinates are straight or curved and have two pointed ends while only one end is covered with bracket indications. Uncinates have a length of 690–1540 µm (n = 19) (Fig. 25b and Table 25).

Microscleres: Hemioxyhexasters are common, covered with small spines, and have six primary rays, whereof four are carrying secondary rays while the other two are rudimentary. The four "complete" primary rays are lying in two axes, they are

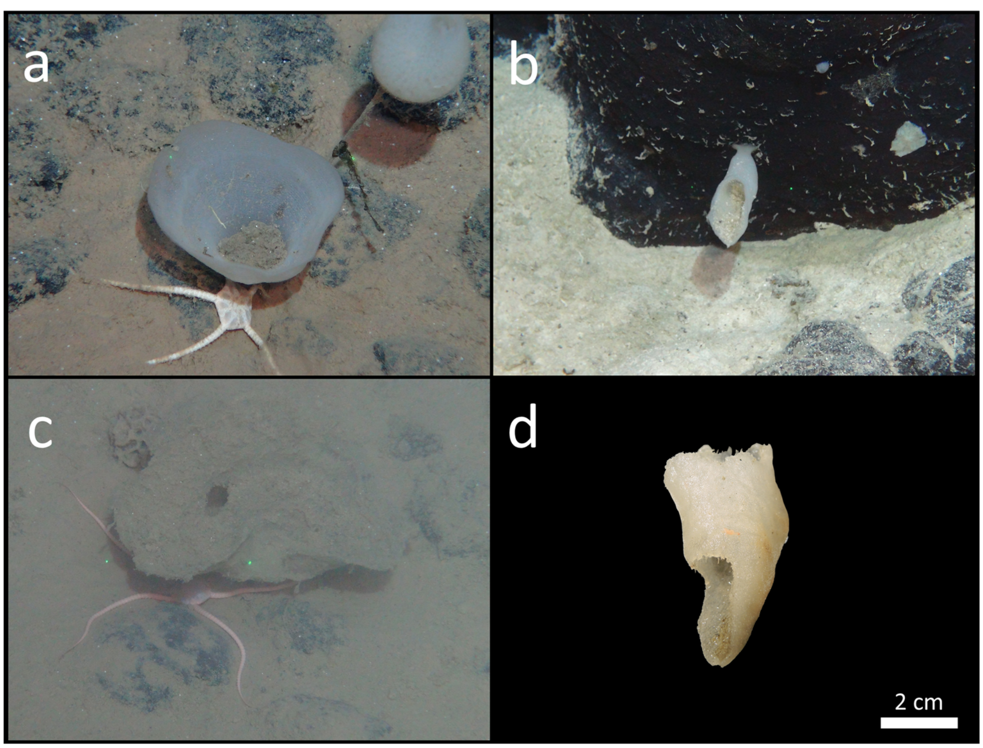


Fig. 24 Habitus of *Chonelasma bispinula* sp. nov.: **a** SMF 12073, **b** SMF 12084, **c** SMF 12087, and **d** SMF 12084

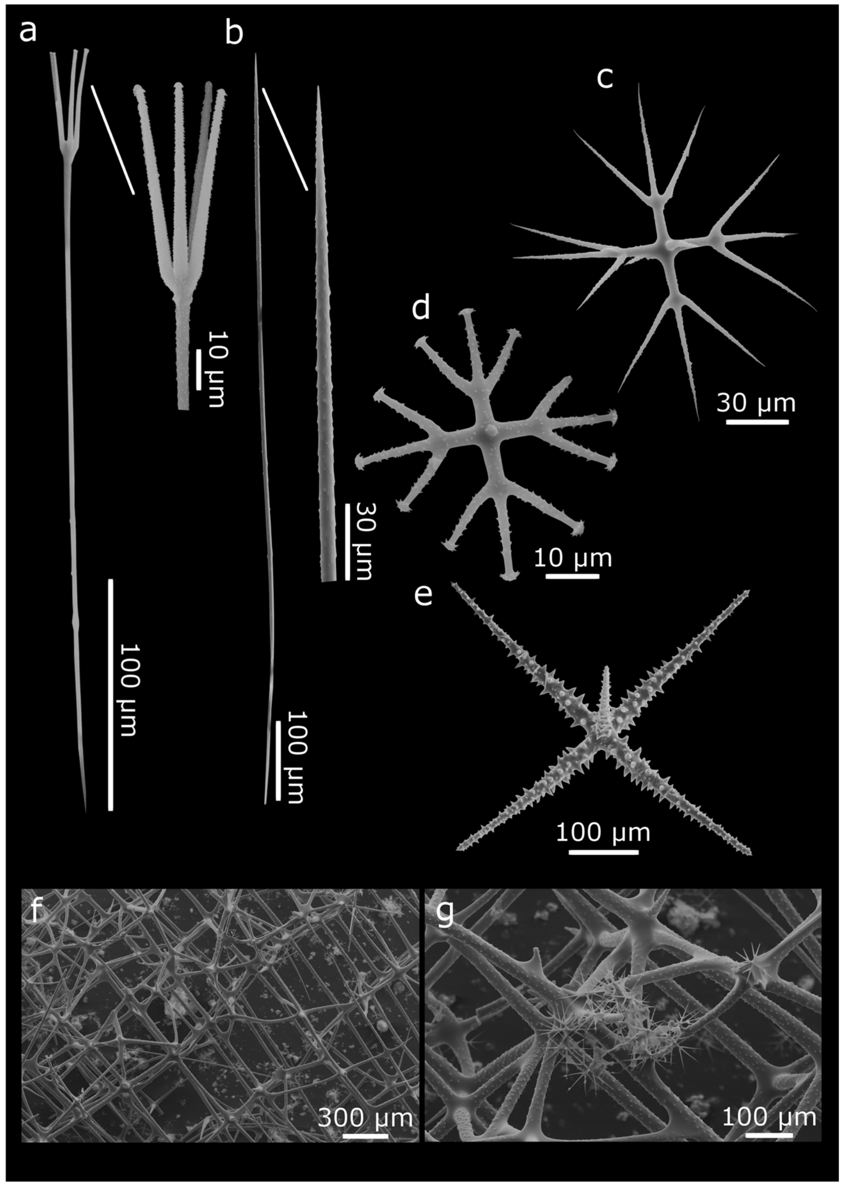


Fig. 25 Spicules of *Chonelasma bispinula* sp. nov.: **a** scopule with detail of head, **b** uncinate with detail of end, **c** oxyhexaster, **d** discohexaster, **e** pentactin, and **f**, **g** framework of dermal cortical layer (irregular meshes) covering inner primary layer (rectangular meshes)

straight and each of them carries three secondary rays with pointed ends. Secondary rays do always diverge in an angle of ca. 45°. The two rudimentary primary rays are lying in one axis and have pointed ends. Secondary rays can also be slightly curved. Hemioxyhexasters have a primary rosette diameter of 23–53 µm ($n = 90$) a diameter of 105–165 µm ($n = 90$) (Fig. 25c). Hemidiscohexasters are scarce and covered with small spines. They have four primary rays carrying secondary rays with discoidal ends and two rudimentary rays present as thickenings. The four complete primary rays carry three secondary rays that diverge in an angle of ca. 45°. Discoidal ends of secondary rays are caps with approximately four to eight marginal teeth. The two rudimentary rays are thickenings lying in one axis. Hemidiscohexasters have a primary rosette diameter of 18–38 µm ($n = 36$) and a diameter of 54–78 µm ($n = 38$) (Fig. 25d and Table 25).

Table 24 Body size of *Chonelasma bispinula* sp. nov., values in [cm]

	SMF 12073	SMF 12084	SMF 12087
Body height	3.6	5.2	2.9
Body width	6.4	2.6	4.5
Wall thickness	0.1	0.2	0.1

Remarks

The most uncommon feature of these three specimens is the morphology of their microscleres. Hemioxyhexasters have one axis with rudimentary primary spines which are straight or curved with pointed ends and hemidiscohexasters have small round tubercles. Uncinates are not typical for *Chonelasma* as they are lacking barbs. Apart from that, habitus, skeletal

Table 25 Spicule size of *Chonelasma bispinula* sp. nov., values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12073	SMF 12084	SMF 12087
Superficial pentactins			
Tangential ray axis length	355–621–805 ± 111 (n = 30)	510–585–670 ± 38 (n = 30)	465–638–780 ± 71 (n = 30)
Proximal ray length	104–141–179 ± 37 (n = 2)	140–150–160 ± 10 (n = 2)	290 (n = 1)
Scopules			
Head length	33–48–63 ± 7 (n = 30)	38–46–53 ± 4 (n = 30)	33–44–50 ± 5 (n = 9)
Total length	295–389–485 ± 49 (n = 30)	310–380–450 ± 37 (n = 30)	230–279–350 ± 45 (n = 5)
Uncinates			
Length	890–1233–1540 ± 182 (n = 13)	690–1265–1450 ± 261 (n = 6)	–
Hemioxyhexasters			
Primary rosette diameter	23–32–38 ± 3 (n = 30)	33–45–53 ± 4 (n = 30)	25–33–40 ± 3 (n = 30)
Total diameter	105–121–138 ± 9 (n = 30)	110–142–165 (n = 30)	105–123–148 ± 11 (n = 30)
Hemidiscohexasters			
Primary rosette diameter	20–25–30 ± 4 (n = 30)	–	18–30–38 ± 8 (n = 6)
Total diameter	54–66–78 ± 8 (n = 30)	–	58–70–80 ± 7 (n = 8)

framework, and spicule inventory are typical for a representative of the genus *Chonelasma*. The latter characteristics, especially the unique morphology of hemioxy- and hemidiscohexasters, qualify these specimens as representatives of the new species *Chonelasma bispinula* sp. nov.

The genus *Chonelasma* includes ten species, whereof only one is known to be present in the eastern to northeastern Pacific: *Chonelasma oreia* Resiwig, 2014. Fortunately, *C. oreia* is easy to differentiate from *C. bispinula* sp. nov. The body of *C. oreia* is more massive, rugose, and the dermal surface is covered with a blood vessel-like network, whereas the body walls of *C. bispinula* sp. nov. are thin, more regular, and smooth. The spiculation is also different as *C. oreia* has hemioxyhexasters which are typical for *Chonelasma* as well as uncinates with barbs. The habitus of SMF 12073 and SMF 12087 is funnel-shaped and similar to *Chonelasma choanoides* Schulze & Kirkpatrick, 1910 while the habitus of SMF 12084 is cup-shaped. Superficial pentactins are common but easily break apart making it difficult to measure their length. The size of spines covering superficial pentactins varies, as they were bigger in SMF 12084. Hemidiscohexasters are extremely scarce and were lacking in preparations of SMF 12084 as well as uncinates which were lacking in preparations of SMF 12087. Apart from that, all spicules, especially hemioxyhexasters, had a very consistent shape and size in all three specimens.

Rossellidae Schulze, 1885
Lanuginellinae Gray, 1872
***Caulophacus* Schulze, 1886**
***Caulophacus* (*Caulophacus*) Schulze, 1886**
***Caulophacus* (*Caulophacus*) *variens* Tabachnick, 1988**
Figures 26 and 27 and Tables 26 and 27
Caulophacus variens: Tabachnick, 1988, p. 55, Fig. 2

Material

SMF 12067, collection date 27.03.2015, station SO239/54-1, ROV *Kiel 6000* from R/V *Sonne* in BGR license area at Senckenberg Mountains (CCFZ), NE-Pacific, 11° 41.93′ N/117° 27.23′ W–11° 40.75′ N/117° 27.06′ W, 2852.7 m.

Description

Habitus: Basiphytous white sponge with disc-shaped head and rigid stalk growing on basaltic rock of a seamount. The smooth head is disc-shaped with a sharp edge separating dermal and gastral surfaces. The dermal surface comprises an artery-like network and the gastral surface is completely smooth but openings of oscula underneath it are visible. The transition from head to stalk is distinct, the stalk is rigid and hollow probably forming a peduncle at its base. The head of *C.* (*C.*) *variens* is 2.7 cm thick and has a diameter of 8.5 cm while the stalk measures a length of 112.0 cm and a width 0.9 cm (Fig. 26a–c and Table 26).

Megascleres: Choanosomal diactins are straight or curved and have round or clavate ends. Both ends are rough and covered with spines while the main part is smooth with a central thickening. Choanosomal diactins have a length of 1038–2913 µm (n = 30) (Fig. 27a). Choanosomal hexactins are scarce and have straight rays with round ends. Close to the base, their rays are covered with spines. Choanosomal hexactins have a diameter of 1063–2050 µm (n = 7) (Fig. 27e). Dermal pinular hexactins are common and have a fusiform to clavate pinular ray covered with spines. Close to the base, the pinular ray is smooth while the diameter increases until it reaches approximately four fifths of its total length. The end of the distally directed pinular ray is an apical cone. Tangential rays and the proximal ray are shorter and

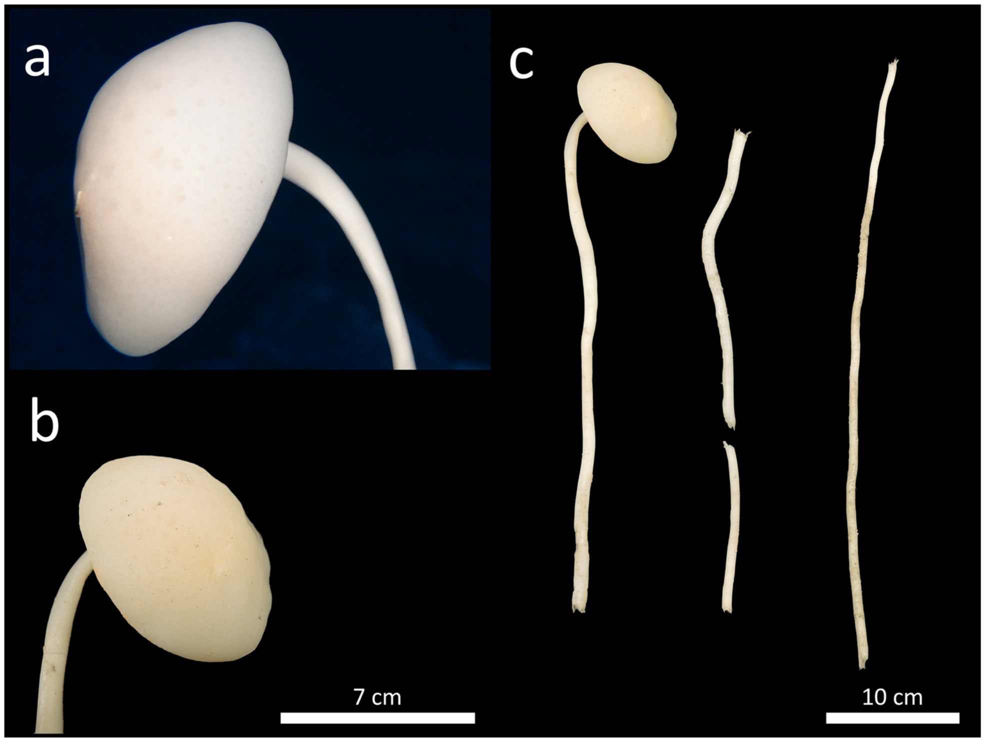


Fig. 26 Habitus of *Caulophacus variens*: **a**–**c** SMF 12067

covered with small spines. Dermal pinular hexactins have a distal ray length of 350–520 µm ($n = 30$) with a diameter of 50–75 µm ($n = 30$). The proximal ray has a length of 70–125 µm ($n = 30$) while the tangential ray axis measures a length of 120–290 µm ($n = 30$) (Fig. 27c). Gastral pinular hexactins are very similar to dermal pinular hexactins. The pinular ray is longer and more slender while tangential rays and proximal ray are equal. Gastral pinular hexactins have a distal ray length of 465–570 µm ($n = 30$) with a diameter of 40–60 µm ($n = 30$). The proximal ray has a length of 75–130 µm ($n = 30$) while the tangential ray axis measures a length of 105–280 µm ($n = 30$) (Fig. 27b and Table 27).

Microscleres: Discohexactins are common and have a distinct spination. Their rays are completely covered with spines and usually straight, sometimes slightly bend. Discoidal ends are caps with four to six teeth. Discohexactins have a diameter 120–263 µm ($n = 30$) (Fig. 27d). Discohexasters are spherical and have numerous straight secondary rays covered with spines and round cap-shaped ends. Discohexasters have a diameter of 133–239 µm ($n = 30$) (Fig. 27f and Table 27).

Remarks

This is the second study with data of the species *C.* (*C.*) *variens* which has been described by Tabachnick (1988). He collected two specimens of the subspecies *C.* (*C.*) *variens variens* Tabachnick, 1988 and one specimen of the subspecies *C.* (*C.*) *variens juvenilis* Tabachnick, 1988 while all three specimens were sampled at the same station in 3800–4270 m depth. Subspecies were described as specimens with mushroom-shaped head and brown color, thus being similar to SMF 12067 which has a mushroom-shaped head but white color. The brown color does most likely originate from contamination with fine sediment particles that were resuspended during sampling. *C.* (*C.*) *variens variens* has a head diameter of 3–4 cm and *C.* (*C.*) *variens juvenilis* of 2 cm while SMF 12067 is bigger with a head diameter of 8.5 cm. *C.* (*C.*) *variens variens* has a stalk length of 70 cm and the stalk of SMF 12067 is even longer with 112 cm. Tabachnick (1988) considered the variability of spicule morphology in both subspecies is high and *C.* (*C.*) *variens juvenilis* might be a juvenile specimen of *C.* (*C.*) *variens variens.* Due to the latter suggestions and the reason that both subspecies are officially accepted as *C.* (*C.*) *variens*, we combine data of spicule sizes measured by Tabachnick (1988) and compare these with measurements in this study. Size measurements of megascleres match each other, only choanosomal diactins were absent in *C.* (*C.*) *variens juvenilis*. Microscleres are more difficult to compare as discohexactins and spherical discohexasters of *C.* (*C.*) *variens juvenilis* are smaller than in all other specimens and stellate discohexasters are only present in *C.* (*C.*) *variens variens.* However, the presence of spherical discohexasters is characteristic and the main reason why SMF 12067 has been identified as *C.* (*C.*) *variens.*

***Caulophacus* (*Caulophacus*) *wilsoni* sp. nov.**
Figures 28 and 29 and Tables 28 and 29

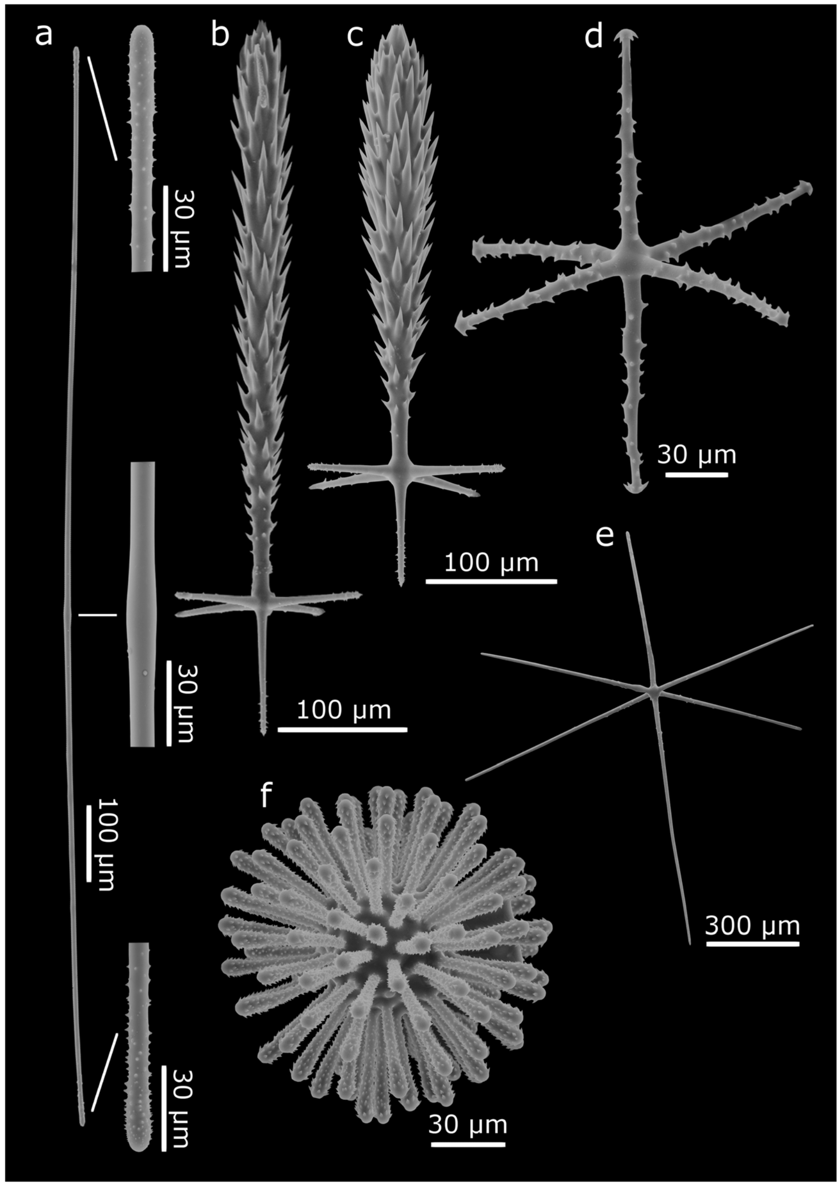


Fig. 27 Spicules of *Caulophacus variens*: **a** choanosomal diactins, **b** gastral pinular hexactin, **c** dermal pinular hexactin, **d** discohexactin, **e** choanosomal hexactin, and **f** spherical discohexaster

Material

Holotype: SMF 12061, collection date 20.03.2015, station SO239/13-1, ROV *Kiel 6000* from R/V *Sonne* in BGR license area at nodule field (CCFZ), NE-Pacific, 11° 51.06′ N/117° 01.97′ W–11° 51.06′ N/117° 01.90′ W, 4125.9 m.

Table 26 Body size of *Caulophacus* (*Caulophacus*) *variens*, values in [cm]

	SMF 12067	*C. (C.) variens variens* Tabachnick, 1988	*C.* (*C.*) *variens juvenilis* Tabachnick, 1988
Head thickness	2.7	–	–
Head diameter	8.5	3.0–4.0	2.0
Stalk length	112.0	70.0	–
Stalk width	0.9	–	–

Description

Habitus: Basiphytous white sponge with rigid stalk and soft discoidal head growing on polymetallic nodules. Its dermal surface (bottom side of head) is rugose and covered by a net mainly consisting of hypodermal pentactins while its gastral surface (top side of head) is covered with numerous oscula. Head and stalk are separated by a clear transition. The stalk consists of fused diactins. Furthermore, two juvenile specimens of *C.* (*C.*) *schulzei* are growing on the stalk. The head of *C.* (*C.*) *wilsoni* sp. nov is 2.9 cm thick and has a diameter of 7.7 cm while the stalk measures a length of 35.8 cm and a width of 0.5 cm (Fig. 28a–d and Table 28).

Table 27 Spicule size of *Caulophacus* (*Caulophacus*) *variens*, values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12067	*C. (C.) variens variens* Tabachnick, 1988	*C. (C.) variens juvenilis* Tabachnick, 1988
Choanosomal diactins			
Length	1038–1910–2913 ± 519 (*n* = 30)	1200	–
Choanosomal hexactins			
Diameter	1063–1635–2050 ± 389 (*n* = 7)	300–1800	700–2200
Dermal pinular hexactins			
Distal ray length	350–416–520 ± 37 (*n* = 30)	–	–
Distal ray max. diameter	50–62–75 ± 7 (*n* = 30)	–	–
Proximal ray length	70–100–125 ± 12 (*n* = 30)	–	–
Tangential ray axis length	120–204–290 ± 39 (*n* = 30)	60–120	160–200
Gastral pinular hexactins			
Distal ray length	465–538–570 ± 25 (*n* = 30)	–	–
Distal ray max. diameter	40–50–60 ± 6 (*n* = 30)	–	–
Proximal ray length	75–106–130 ± 10 (*n* = 30)	–	–
Tangential ray axis length	105–202–280 ± 39 (*n* = 30)	70–120	140–200
Hypodermal/-gastral pentactins			
Length	330 (*n* = 1)	–	
Diameter	1050 (*n* = 1)	–	
Discohexactins			
Diameter	120–179–263 ± 30 (*n* = 30)	140–320	90–120
Stellate discohexasters			
Diameter	–	220–460	–
Stylasters			
Diameter	133–187–239 ± 30 (*n* = 30)	210–560	88–116

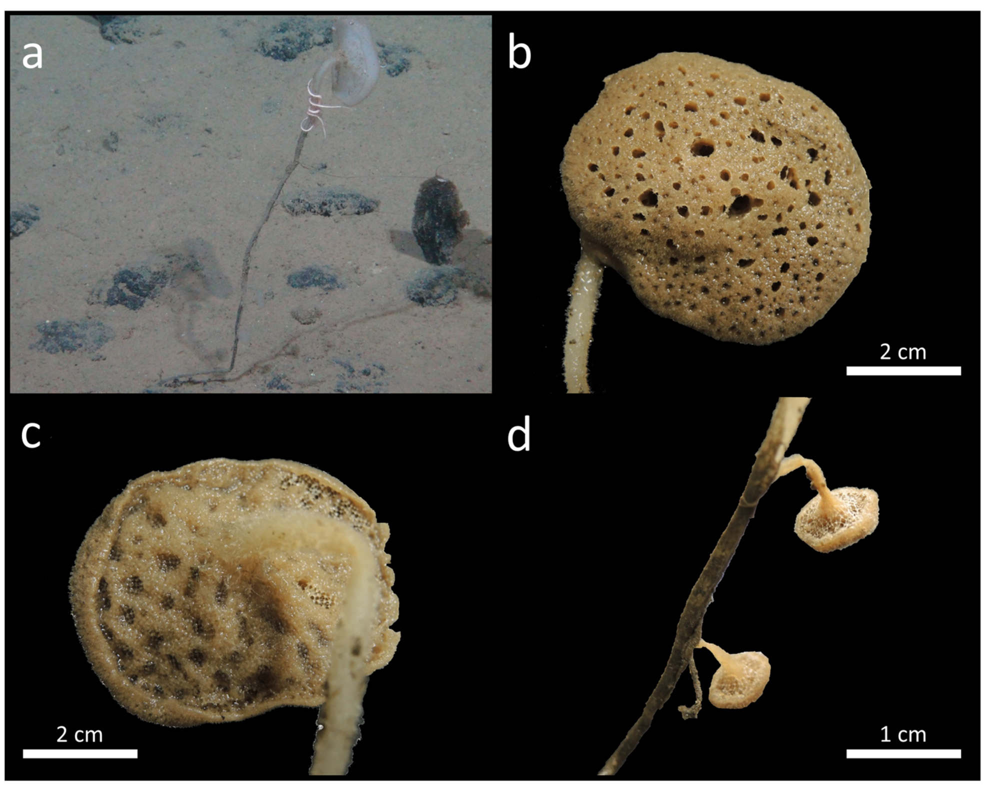


Fig. 28 Habitus of *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov.: **a**–**c** SMF 12061 and **d** SMF 12061 young specimens of *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov. growing on the stalk of SMF 12061

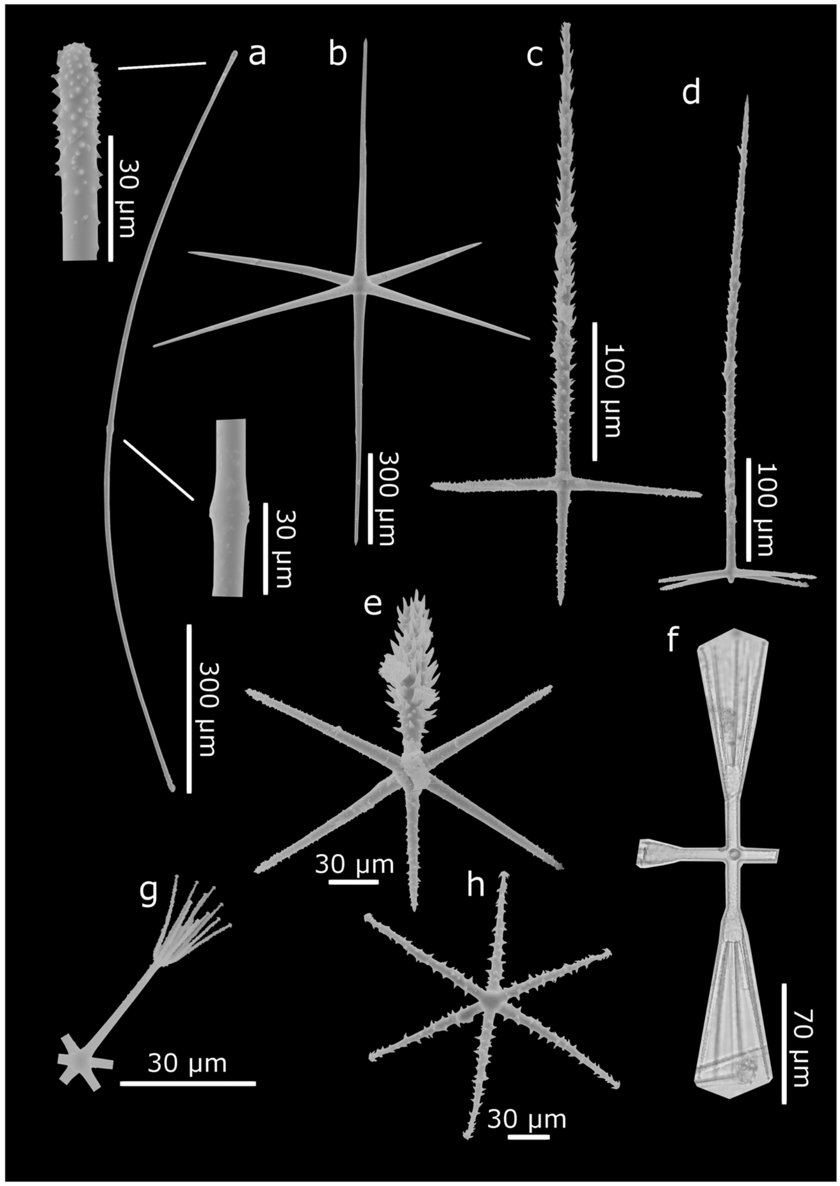


Fig. 29 Spicules of *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov.: **a** choanosomal diactin, **b** choanosomal hexactin, **c** gastral pinular hexactin, **d** gastral pinular pentactin, **e** dermal pinular hexactin, **f** big discohexaster (picture from light microscope), **g** small discohexaster, and **h** discohexactin

Megascleres: Choanosomal diactins are curved and have round ends. The main part of the diactins is smooth while their ends are rough. The spicule thickness is constant over its total length. Choanosomal diactins have a length of 1225–1975 μm (Fig. 29a). Choanosomal hexactins have smooth and straight rays with pointed ends. They have a diameter of 1084–2350 μm (Fig. 29b). Dermal pinular hexactins are rare and present in the dermal surface. Their pinular ray is spindle-like and covered with spines inclined towards the end. Tangential rays and the proximal ray are straight and covered with smaller spines. Dermal pinular hexactins are smaller than gastral pinular hexactins but their pinular ray is thicker. They have a pinular ray length of 75–174 μm with a diameter of 23–33 μm. The proximal ray has a length of 67–130 μm while the tangential ray axis measures a length of 93–245 μm (Fig. 29e). Gastral pinular hexactins are present in the gastral surface at the top of the discoidal head. They have a pinular ray with a length exceeding the tangential ray diameter. The pinular ray is covered by spines and slightly tapering toward the end. Tangential rays and the proximal ray are covered with smaller spines. Gastral pinular hexactins have a pinular ray length of 180–345 μm and a diameter of 5–15 μm. The proximal ray has a length of 75–105 μm while the tangential ray axis measures a length of 170–230 μm (Fig. 29c). Gastral pinular pentactins look similar to the before mentioned hexactins

Table 28 Body size of *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov., values in [cm]

	SMF 12061
Head thickness	2.9
Head diameter	7.7
Stalk length	35.8
Stalk width	0.5

Table 29 Spicule size of *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov., values in [µm] are given as follows: minimum–mean–maximum (number of spicules measured)

	SMF 12061
Choanosomal diactins	
Length	1225–1585–1975 ± 182 ($n = 30$)
Choanosomal hexactins	
Diameter	1084–1752–2350 ± 415 ($n = 18$)
Dermal pinular hexactins	
Distal ray length	75–111–174 ± 34 ($n = 5$)
Distal ray max. Diameter	23–29–33 ± 3 ($n = 5$)
Proximal ray length	67–93–130 ± 22 ($n = 5$)
Tangential ray axis length	93–183–245 ± 56 ($n = 5$)
Gastral pinular hexactins	
Distal ray length	180–303–345 ± 62 ($n = 5$)
Distal ray max. diameter	5–8–15 ± 4 ($n = 5$)
Proximal ray length	75–89–105 ± 10 ($n = 5$)
Tangential ray axis length	170–186–230 ± 22 ($n = 5$)
Total length	–
Gastral pinular pentactins	
Distal ray length	345–479–610 ± 80 ($n = 13$)
Tangential ray axis length	140–207–250 ± 29 ($n = 13$)
Hypodermal/-atrial pentactins	
Proximal ray length	975–984–1013 ± 19 ($n = 2$)
Angential ray axis length	950–956–963 ± 6 ($n = 2$)
Discohexactins	
Diameter	200–254–300 ± 25 ($n = 30$)
Dermal discohexasters	
Diameter	83–104–150 ± 15 ($n = 30$)
Gastral discohexasters	
Diameter	165–197–280 ± 48 ($n = 4$)

but they are lacking a proximal ray, only a small tubercle is present. They have a pinular ray length of 345–610 µm and a tangential ray axis length of 140–250 µm (Fig. 29d and Table 29). Hypodermal and atrial pentactins are rare and have rays with pointed ends. The tangential rays are smooth while the proximal ray is partly acanthous close to its base. Hypodermal and atrial pentactins have a proximal ray length of 975–1013 µm and a tangential ray axis length of 950–963 µm (no photograph).

Microscleres: Discohexactins are common and have a conspicuous spination. Their rays are completely covered with spines and usually straight, sometimes slightly bend. Discoidal ends are caps with four to six teeth. Discohexactins have a diameter 200–300 µm (Fig. 29h). Dermal discohexasters have secondary rays half as long or as long as the primary rays. Their primary rays are straight and smooth while their secondary rays are straight and microspined with small cap-like ends. Dermal discohexasters have a diameter of 83–150 µm (Fig. 29f). Gastral discohexasters are rare, also in gastral surfaces. They have secondary rays minimum as long or twice as long as the primary rays. Exactly like the dermal discohexasters, their primary rays are straight and smooth while their secondary rays are straight and microspined with small cap-like ends. Gastral discohexasters have a diameter of 165–280 µm (Fig. 29g and Table 29).

Remarks

A characteristic habitus combined with the spicule morphology, especially of dermal pinular hexactins and gastral pinular pentactins as well as two size classes of discohexasters, qualifies this specimen as representative of the new species *Caulophacus* (*Caulophacus*) *wilsoni* sp. nov. The species name honors Henry Van Peters Wilson (*02.16.1863–†01.04.1939) who spent almost 10 years on the taxonomic study of the sponges sampled during the *Albatross* expedition.

The subgenus *Caulophacus* (*Caulophacus*) includes 21 species whereof 4 are known to be present in the northern to northeastern Pacific: *Caulophacus* (*Caulophacus*) *adakensis* Reiswig & Stone, 2013; *Caulophacus* (*Caulophacus*) *cyanae* Boury-Esnault & De Vos, 1988; *Caulophacus* (*Caulophacus*) *schulzei*, and *Caulophacus* (*Caulophacus*) *variens*. However, only *C.* (*C.*) *schulzei* can be confused with *C.* (*C.*) *wilsoni* sp. nov. Although their habitus is different, their spicule inventory and morphology are similar. While specimens of *C.* (*C.*) *schulzei* have a trumpet-shaped body with smooth transition from stalk to head have specimens of *C.* (*C.*) *wilsoni* sp. nov. a disc-shaped body with distinct transition. Furthermore, the dermal surface of *C.* (*C.*) *wilsoni* sp. nov. is rugose and covered by a network mainly consisting of hypodermal pentactins while the gastral surface is full of oscula. Dermal pinular hexactins, discohexactins, and discohexasters are larger than in *C.* (*C.*) *schulzei.* Gastral pinular pentactins are present in this specimen and lacking in *C.* (*C.*) *schulzei*. Furthermore, the pinular rays of dermal and gastral pinular hexactins of *C.* (*C.*) *schulzei* have almost the same length (only few dermal pinular hexactins have short pinular rays) while dermal and gastral pinular hexactins in *C.* (*C.*) *wilsoni* sp. nov. have pinular rays of different length (Fig. 29c–e).

Discussion

Most Amphidiscophora in the CCFZ grow on sediment between polymetallic nodules (Kersken et al. 2017) while most Hexasterophora grow directly on top of polymetallic nodules or other hard substrate, e.g., basaltic rock. Results of this study show that 9 of 14 identified sponge species grow exclusively on hard substrate. Both identified species of *Saccocalyx* and *Hyalostylus microfloricomus* sp. nov. grow on basaltic rock of seamounts while *Hyalostylus schulzei* sp. nov., *Corbitella discasterosa*, *Bathyxiphus subtilis*, *Chonelasma bispinula* sp. nov., and both identified species of *Caulophacus* grow on polymetallic nodules or small rocks lying on the sediment surface of abyssal plains within the CCFZ. Only species of *Holascus* and *Docosaccus* have anchorate basalia and root in the sediment to grow between the polymetallic nodules. Deep-sea nodule mining would not only damage these sponges by dredging and sediment resuspension and redeposition processes but also by substrate removal (for further information on impact by dredging and sediment plumes see Kersken et al. 2017). Other studies focusing on the ecology of deep-sea sponges have shown how complex ecological interdependencies can be, for instance, if other invertebrates grow on sponge stalks (Beaulieu 2001a, b) or use them for brooding and reproduction (Purser et al. 2016). Unfortunately, it is impossible to predict what damage decimation or loss of deep-sea sponges would mean to the benthic community. Furthermore, the number of unknown sponge species in the abyssal northeastern Pacific is high: Kahn et al. (2013) described two new species sampled at 4100 m depth at a single station in the northeastern Pacific, Reiswig and Stone (2013) described one new genus and eight new species sampled at the central Aleutian Islands, Alaska, and Reiswig (2014) described six new species sampled at the west coast of North America (Washington, British Columbia and Gulf of Alaska). Including data of this study, at least 1 new genus and 22 new species were described within the last 5 years. Further collection of sponges from the northeastern Pacific, especially polymetallic nodule fields and adjacent areas within the CCFZ, will help to expand our knowledge on species richness and occurrence. Thus, we have a better understanding of the ecological impact created by deep-sea mining in the CCFZ and can far better contribute to future risk assessments and monitoring actions, e.g., picture-based techniques like ROV and AUV surveys.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed by the authors.

Sampling and field studies All necessary permits for sampling and observational field studies have been obtained by the authors from the competent authorities and are mentioned in the acknowledgements, if applicable.

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