



# ANT XXIV/2 (SYSTCO) Hexactinellida (Porifera) and bathymetric traits of Antarctic glass sponges (incorporating ANDEEP-material); including an emendation of the rediscovered genus *Lonchiphora*

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## ABSTRACT

In this study, we present the hexactinellid sponges sampled in the Weddell-Sea during the ANT 24-2 SYSTCO expedition (30.10.2007–31.01.2008) on the RV Polarstern. All deep-sea stations sampled during this expedition showed comparably modest sponge colonization, with Hexactinellida and Demospongiae occurring in similar numbers of species and individuals. The hexactinellids sampled represent three abyssal species and six species from the deep shelf. Among the deep-sea glass sponges one species new to science was found, *Lonchiphora antarctica* sp. nov., belonging to a poorly known genus, so far represented by only a single specimen known from the Sagami Bay, Japan. Herein we give the first detailed emended diagnosis of the genus and a description of the new species representing the genus as its first well-known specimen. Ecological analysis shows three clearly differentiated associations of hexactinellid sponges in the Antarctic Ocean, which replace each other with increasing depths. Sponge communities on the shelf are dominated by *Rossella* spp., those on the continental slope and in the lower bathyal mostly by *Bathydorus spinosus*, and the abyssal associations by *Caulophacus* spp. No distinct geographical distribution pattern of the Weddell-Sea Hexactinellida could be observed, apart from those caused by their bathyal ranges.

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## 1. Introduction

The benthic fauna of the deep Southern Ocean (SO) is still relatively poorly known. Most contributions from that region date back to the end of the nineteenth century, and a few from the last decade. Biodiversity patterns in the deep Weddell-Sea were the focus of the ANDEEP I–III and SYSTCO-expeditions with RV Polarstern, 2002–2008, and from these expeditions, important knowledge was achieved on the entire benthic communities of the Antarctic deep-sea (Brandt et al., 2007). However, as recent calculations have shown, a large percentage of the existing species is still unknown (Clarke, 2008). Thus, the number of sponge species recorded from the SO is rapidly increasing, since recent studies regularly reveal new sponge taxa (Janussen et al., 2004; Rios, 2006; Plotkin and Janussen, 2008; Janussen and Reischwig, 2009). While in temperate and tropical waters, the sponge class Hexactinellida is almost exclusively confined to deep-sea environments, it plays a major ecological role on the Antarctic shelf, where some species occur in dense populations and reach large individual sizes and thus contribute significantly to the total benthic biomass. But also in the Antarctic we observe that the taxonomic diversity of the Hexactinellida increases remarkably from

the shelf (c. 10 species, 2 genera, 1 family) towards the deep-sea (c. 25 species, 16 genera, 6 families) (Barthel and Tendal, 1994; Janussen and Tendal, 2007). From the ANDEEP I–III collections, all together 76 Porifera species have been identified so far, of which 22% were new to science and 49% new for the SO (Janussen and Tendal, 2007). Within this sponge fauna, the taxon Hexactinellida is well represented, with 21 species, 7 new, from 15 genera and 5 families (Janussen et al., 2004; Janussen and Reischwig, 2009). Here we give a thorough documentation of the Hexactinellida collected during the recent ANT XXIV/2-SYSTCO expedition (2007–08), including the description of a new species and the emendation of the hitherto poorly known genus *Lonchiphora* Ijima, 1927. Bathymetrical and geographical distribution of the Hexactinellida in the deep Weddell Sea, collected during the ANDEEP-SYSTCO campaigns, is evaluated.

## 2. Materials and methods

The material of this study was collected in the Weddell-Sea during the ANDEEP I–III and SYSTCO expeditions (2002–2008) by the RV Polarstern. (See Table 1 for data on the SYSTCO sampling sites. For stations lists and further information on the ANDEEP and SYSTCO stations, see Janussen, 2003, 2006, 2010.) The sponges were sampled at depths between 500 and 5500 m by various benthic sampling

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**Table 1**

Sponges sampled in the deep Weddell-Sea during the Systco-expedition. Numbers give the count of individuals.

Order/Suborder: Family	Genus/Species	Stations/Dates/Depths					
		013–15 06.12.2007 29,976	016–1 17.12.2007 4887	017–10 22.12.2007 21,897	017–11 22.12.2007 20,907	033–14 30.12.2007 53,381	48–1 12.01.2008 6021
Class: Hexactinellida							
Lyssacinosida:							
Rossellidae	<i>Rossella antarctica</i> Carter, 1872						x*
	<i>Rossella fibulata</i> Schulze & Kirkpatrick, 1910						x*
	<i>Rossella levis</i> (Kirkpatrick, 1907)						x*
	<i>Rossella nuda</i> Topsent, 1901						x*
	<i>Rossella racovitzae</i> Topsent, 1901						x*
	<i>Rossella vanhoeffeni</i> (Schulze & Kirkpatrick, 1910)		1				x*
	cf. <i>Bathydorus</i>	1					
	<i>Bathydorus spinosus</i> Schulze, 1886			4	3		
	<i>Caulophacus</i> ( <i>Oxydiscus</i> ) <i>weddelli</i> Janussen et al., 2004					2	
Hexactinosida:							
Farreidae	<i>Lonchiphora antarctica</i> sp. nov.			1			

\* The *Rossella* spp. from station 48–1 are not completely analyzed yet.

gears, especially Agassiz trawl, epibenthic sledge and Rauschert-dredge. All sponges were collected by D. Janussen, sorted and photographed on board, and immediately upon collection, fragments were frozen and fixed in RNA-Later, 96% ethanol, and 6% formalin solution. For study of skeletal architecture and spicules, small parts of the sponge tissue were dissolved in nitric acid (following the standard protocol, Boury-Esnault and Rützler, 1997) and mounted on microscopic slides using Euparal for light-microscopic analysis (LM). For scanning electron microscopy (SEM), spicules were mounted on stubs and sputter-coated. Measurements of spicules were made using high-resolution light microscope with an ocular micrometer. The specimens and slides for this study are deposited in the Porifera collection of the Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main (SMF). A Cluster-analysis based on the Bray-Curtis-similarity for all Hexactinellida from ANDEEP I-III and SYSTCO-expeditions was created by the program past. Zoogeographical analysis was done using a map created via Ocean Data View (Schlitzer, 2004). For further data work and graphic layout we applied SigmaPlot, MS excel and adobe illustrator.

### 3. Results

The Hexactinellida of the SYSTCO-expedition are shown in Table 1. The Demospongiae will be described in an upcoming publication. Diversity and density of the sponges collected on the deep-sea stations were unusually low compared with the ANDEEP results (Janussen et al., 2004; Janussen and Tendal, 2007), only two to three species were present with just one or a few specimens. A counterpoint is made by the station 48–1 on the lower shelf (600 m), which revealed a rich fauna of 6 *Rossella* species with at least 50 specimens, which are currently still under examination (see below). All systematic classifications follow the world porifera database (Van Soest et al., 2008).

#### 3.1. Systematics

Hexactinellida Schmidt, 1870  
Lyssacinosida Zittel, 1877

##### 3.1.1. Rossellidae Schulze, 1885 Rossellinae Schulze, 1897

3.1.1.1. *Rossella* Carter, 1872. Genus *Rossella* was found at the two shelf stations, 016–1 (488 m) and 48–1 (602 m). Especially at 48–1,

they were numerous and diverse, 6 of the 7 currently valid Antarctic species (Barthel and Tendal, 1994) were found at this station (see list below). Nonetheless, the identification of these sponges proved to be difficult. Many specimens are fragmented, and in some cases their spicule content showed differences from what has earlier been described for the particular species. Thus questions occur concerning the correct definition of some *Rossella* species. Therefore, we are working on a thorough revision of the genus *Rossella* on the basis of the SYSTCO material as well as older collections. Here, we prefer to give a list of the species found. Detailed documentation and species descriptions will follow in our upcoming publication.

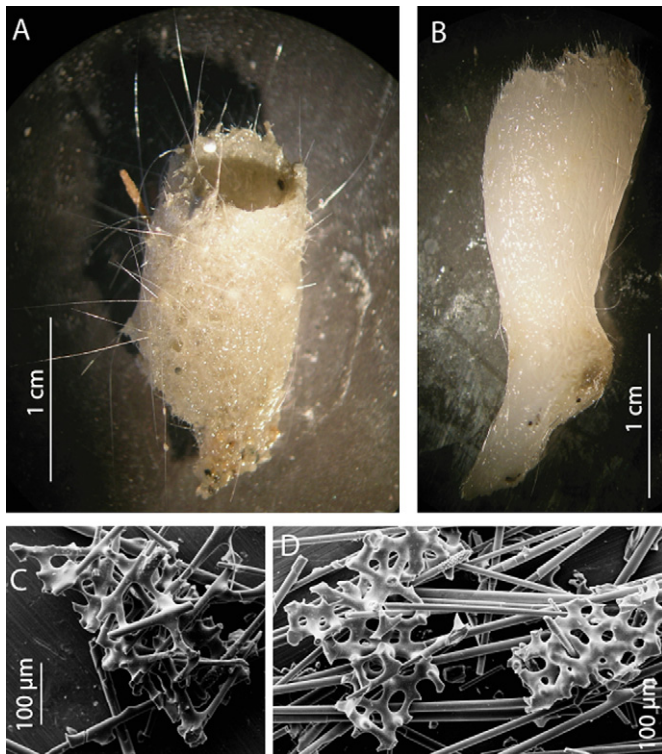
The following *Rossella*-species were identified:

*Rossella antarctica* Carter, 1872  
*Rossella fibulata* Schulze & Kirkpatrick, 1910  
*Rossella levis* (Kirkpatrick, 1907)  
*Rossella nuda* Topsent, 1901  
*Rossella racovitzae* Topsent, 1901  
*Rossella vanhoeffeni* (Schulze & Kirkpatrick, 1910)

##### 3.1.1.2. Genus *Bathydorus* Schulze, 1886. *Bathydorus spinosus* Schulze, 1886

**Material:** 4 specimens from station 017–10 (SMF 10768 SMF 10769, SMF 10773, 70° 4.58'S, 3° 19.66'W, 2189 m, 22.12.2007), 3 specimens from station 017–11 (SMF 10765, SMF 10766, SMF 10767, 70° 4.66'S, 3° 21.37' W, 2090 m, 22.12.2007).

**Description and remarks:** The specimens correspond in their characteristics with earlier records of this well-known and wide-spread species as described by Schulze (1886, 1887), and expanded by several recent studies (e.g. Janussen et al., 2004, Janussen and Reiswig, 2009). Because of its few distinct characters and their wide variances an exact determination of a *Bathydorus* species based solely on morphologic characters seems almost impossible (see also discussion). We therefore chose to determine these sponges as *B. spinosus* until a detailed (genetical) revision of the probable cryptic species of Antarctic *Bathydorus* is done. Most specimens collected are fragments, which were torn apart due to the process of dredging. They are found as pieces of a soft, thin tissue wall with small pores and a fringe of long protruding diactins around the osculum. The tissue is of brown color, both fresh and fixed in ethanol. One juvenile specimen from station 015–11 is almost complete (SMF 10765, Fig. 1A). It is ca. 20 mm high, with a very thin wall, ca. 1 mm, and a large, not contracted osculum of 7 mm width at the top and fringed by long diactins. The basis is missing. One sponge from the station 013–15



**Fig. 1.** A. *Bathydorus spinosus* (SMF 10765), Habitus photo. B–D. *Caulophacus* (*Oxydiscus*) *weddelli* (SMF 10771). B. Habitus photo. C and D. Coalesced spicules of the basal plate (SEM).

(see Table 1), identified as cf. *Bathydorus*, is a very small fragment and did not deliver enough spicules for proper identification.

### 3.1.1.3. *Caulophacus* Schulze, 1885. Subgenus *Caulophacus* (*Oxydiscus*) Janussen et al., 2004

*Caulophacus* (*Oxydiscus*) *weddelli* Janussen et al., 2004

**Material:** 2 Specimens from station 033-14 (SMF 10770, SMF 10771, 62° 0.64'S, 2° 59.33'W, 5338 m, 30.12.2007).

**Description and remarks:** The spiculation of the specimens corresponds to that described by Janussen et al. (2004) for the holotype and for several further specimens by Janussen and Reiswig (2009). One specimen (SMF 10771, Fig. 1B) is an almost complete juvenile sponge. It is about 25 mm high, vase-formed with a distinct basal plate and a narrow inner body cavity with a tight osculum of about 2 mm width. The tissue wall is thick and fibrous with a high density of spicules. The basal plate is wide and flat with irregularly fused spicules (Fig. 1C, D). The color of the sponge in Ethanol is white.

Hexactinosida Schrammen, 1912

### 3.1.2. Farreidae Gray, 1872

#### 3.1.2.1. *Lonchiphora* Ijima, 1927. Type species: *Lonchiphora inversa* Ijima, 1927

**Definition:** Farreidae with sceptrules as lonchioles.

**Emended Diagnosis:** Hexactinosida with a rigid framework of fused hexactins that occurs as a monolayer in the periphery and multiple layers in the older skeleton. The specimens recorded so far, show the shape of small, narrow cups, but bigger specimens might grow into an erect framework of anastomosing tubes, as most Farreidae do. Numerous small hexactins are attached to the framework. The dermalia are rough pentactins with slightly bent tangential rays. Numerous oxyhexasters of diverse forms occur throughout the skeleton. Discohexasters are rather rare, uncinates are present. Characteristic are the sceptrules which are

represented by numerous lonchioles. Clavules might be present in some species, but they are not obligatory.

**Remarks:** The genus *Lonchiphora* was erected by Ijima (1927), but never properly described. The text considered as description of *Lonchiphora* is just a brief comparison with another sponge, while a real, full description was said to follow later. The original material is lost, according to Reiswig (2002). As no complete diagnosis exists, there is not much information on the anatomy and spiculation of the type species, *Lonchiphora inversa*. The most profound description given by Ijima is concerning a newly found diagnostic spicule, which he called lonchiole, a sceptrule unique for the genus so far. As Ijima gave no illustration of this spicule, Reid (1958) prepared a drawing completely based on Ijima's description. Here, we describe the first specimen of *Lonchiphora* found since the original. During this study, we have gained profound insight into the morphology and variation of the lonchiole, thus we can confirm that the draft by Reid was very well fitting the real lonchiole (compare with Figs. 2B, 3B). It is a triaxonal monactinal spicule with a long shaft that leads into a distinct knob, which contains the axial cross; sometimes this is replaced by a distal swelling of the central channel. From the apical knob a short, thin secondary ray of slightly irregular shape protrudes in distal direction. In rare cases, a second or even a third secondary ray protruding lateral from the knob may be present. Thus, the lonchiole sometimes resembles the shape of a scopule, although it is a different spicule type (see below). The lonchiole has a distinct inner channel, that widens in the distal knob. It even protrudes into the lateral rays in some of the irregular, derived lonchioles which have more than one secondary ray. Other skeletal elements mentioned by Ijima are only the farreoid framework and numerous small oxyhexactins attached to it. These characters are typical of the farreoid skeleton and they are present in the examined specimen from the Weddell-Sea as well. Reiswig (2002) suggested that apart from the lonchioles, anchorate clavules might be present as dermal sceptrules. However, we in our specimen were not able to find any other sceptrules than the lonchioles and their derivatives. Therefore, the genus *Lonchiphora* is only characterized by possession of one sceptrule type, the lonchioles, but not of additional clavules, which might occur, but are not obligatory for the genus. The co-occurrence of the rare genus *Lonchiphora* in the Antarctic Weddell Sea and in the Japanese Sagami Bay points towards interesting zoogeographical relations between these two, far apart regions (see discussion).

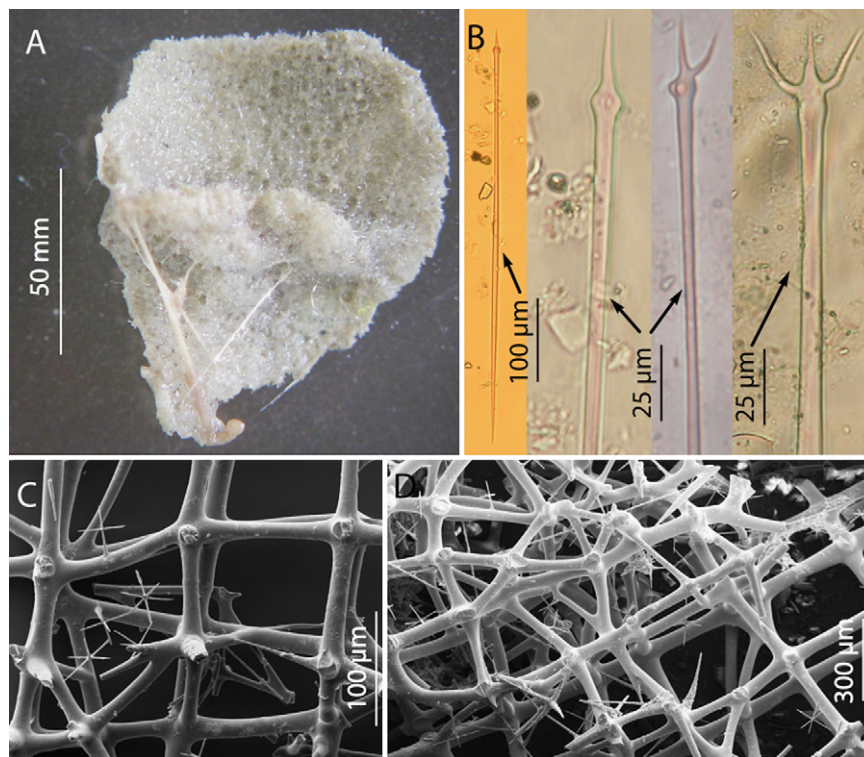
*Lonchiphora antarctica* sp. nov.

**Material:** 1 specimen from the station 17-10 (SMF 10772, holotype, 70° 4.58'S, 3° 19.66'W, 2189 m, 22.12.2007)

**Description:** The holotype is a small Fragment of about 10 mm in diameter and about 1 mm in thickness. It is slightly curved, with the concave side probably representing the inner layer of the sponge, and made up of a rigid framework consisting of fused hexactins (Fig. 2D). In the outer regions, the framework comprises only two parallel layers (Fig. 2C), which demonstrates the farreid nature of the sponge, with a framework that has grown out of a single layer by attaching additional lateral layers of hexactins. From knots of the Framework, a slightly spined ornamentation protrudes, but despite these structures, the framework is generally smooth. Numerous small oxyhexactins, about 120 µm in diameter, are attached to the framework.

**Spiculation** (Table 2): The most common loose spicules are rough pentactins (Fig. 3A) with slightly recurved tangential rays of approximately 190 µm and straight dermal rays of approximately 240 µm. Also very common are oxyhexasters that are usually about 120 µm in diameter. These are found in several different modifications (Fig. 3D), e.g. holoxyhexasters, hemioxyhexasters etc., with one to all rays splitting at half length into two





**Fig. 2.** *Lonchiphora antarctica* n. sp. holotype (SMF 10772) A. Habitus photo. B. Lonchioles and derivatives thereof (LM). C and D. Rigid framework (SEM).

**Table 2**

Spicule dimensions of *Lonchiphora antarctica* n. sp., SMF 10772, dimensions given in µm.

Parameter	Mean	St. dev.	Range	n
Free spicules:				
Pentactin				
Tangential ray	187,5	19,7	140–230	61
Proximal ray	243,0	24,8	200–305	54
Oxyhexaster diameter	118,2	20,1	70–170	71
Discohexaster diameter	124	16,4	105–145	5
Discohexactin diameter	120,6	10,1	105–140	9
Free hexactin diameter	113,9	20,5	60–160	54
Uncinate length	1249	171,8	1115–1550	5
Lonchiole length	368,6	42,1	290–450	64
Lonchiole derivate length	394	25,1	350–410	5
Framework:				
Length between knots	328,6	82,9	162–497	86
Central width of rays	56,7	18,0	16–110	117
Attached hexactin diameter	124,3	21,2	90–190	60

or three secondary rays. Another abundant spicule type is the lonchiole (Figs. 2B, 3B), which is characteristic and unique to the genus *Lonchiphora*. The lonchioles are usually about 370 µm long with a very characteristic knob at the top, from which the short, thin, somewhat irregularly formed terminal ray protrudes. There are also some rather rare derivatives of the lonchioles that are usually of the same length as the regular ones. These derivatives show a second and sometimes a third ray protruding from the side(s) of the knob towards the apical region of the spicule, thus giving it a resemblance of scopules, although they are obviously derivatives of the lonchioles. Another common spicule is the uncinata (Fig. 3G). These are usually more than 1 mm long, but were mostly broken, so that it was not possible to find many specimens for exact measurements. There are also some free oxyhexactins of about 110 µm in diameter, which are probably

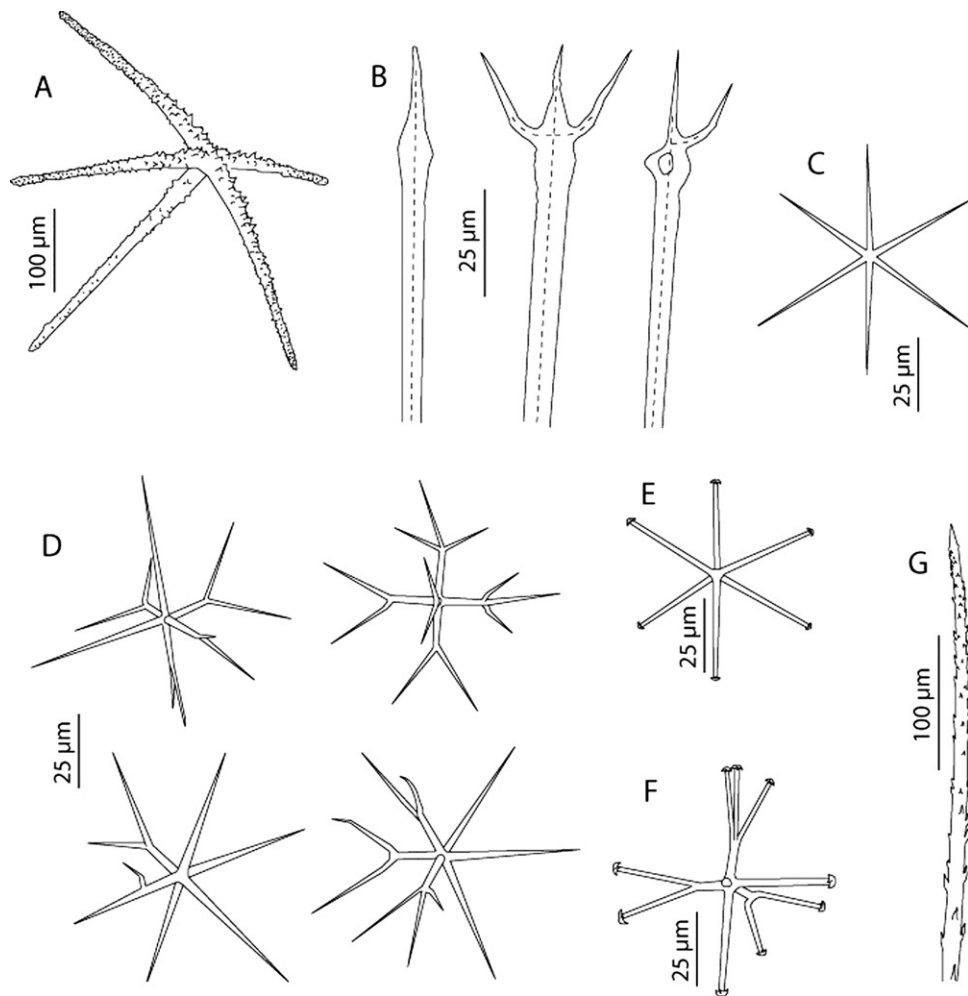
identical with the very numerous ones that are coalesced to the framework. In addition to these more or less regular found spicules, there are two very rare microscleres: discohexactins (Fig. 3E) and discohexasters (Fig. 3F). As these were found very infrequently, one may suggest, that these are foreign material that was washed into the sponge. This hypothesis is supported by the fact, that there is a lot of foreign sedimentary material in the sponge. On the other hand, these disc-bearing scleres are very similar to the oxyhexasters and oxyhexactins of the sponge, in terms of basic bauplan and size. Also, there are no other sponges recorded at that station, which have such discohexasters and discohexactins.

**Etymology:** The name “antarctica” is allocated to the species type locality in the Antarctic.

**Remarks:** The genus *Lonchiphora* has never been described properly, but was only mentioned by Ijima (1927) along with a short description of its most characteristic spicule, the lonchiole. The type species *Lonchiphora inversa*, erected by Ijima, is so far the only known species of the genus *Lonchiphora*. As Ijima gave no detailed description of the species and no holotype has been preserved (Reiswig, 2002), it is not possible to exactly determine the type species of the genus. However, since the original specimen was found in the Sagami Bay, Japan, at unknown depth, we suggest, that the specimen now found in the deep Weddell-Sea is very likely to represent another species, assignable to the genus by the possession of the very characteristic lonchioles. Therefore we describe this new specimen as a new species.

### 3.2. Comparison of Hexactinellida associations sampled during ANDEEP-SYSTCO-expeditions

The Cluster-analysis of the associations of hexactinellid sponges sampled during ANDEEP and SYSTCO on the basis of the Bray-Curtis-similarity (Fig. 4) reveals a distinct distribution



**Fig. 3.** Spicules of *Lonchiphora antarctica* n. sp. holotype (SMF 10772) A. Pentactin. B. Top pieces of lonchiole and two different derivatives. C. Free hexactin. D. Different kinds of oxyhexasters. E. Discohexactin. F. Discohexaster, one ray in front is broken. G. Top piece of uncinate.

pattern. Two groups of stations can be identified, which are situated on the deep shelf and upper slope (c. 500 to 1500 m). One of these is dominated by *Rossella* spp. and the other by *Sympagella* spp. Schmidt, 1870. Another distinct group is constituted by stations on the continental slope down to the basin (c. 2000 to 4800 m), which are dominated by *Bathydorus spinosus*. Most stations fall into a cluster, which is the most distinct, reflecting the deepest stations in the Abyssal Weddell Sea (c. 3000 to 5200 m). Within this cluster, three concrete groups are visible: One is dominated by *Caulophacus* spp., the other two are dominated by *Bathydorus spinosus*, and *Lophocalyx* spp. + *Farrea* sp., respectively. The other stations within this abyssal cluster, which are not mentioned here, show very little similarity with any other station and therefore do not play a significant part in this analysis. This is usually due to the fact that only few sponges were found at these stations, mostly fragments which cannot be exactly identified, and thus cannot be related to sponge faunas of the other stations.

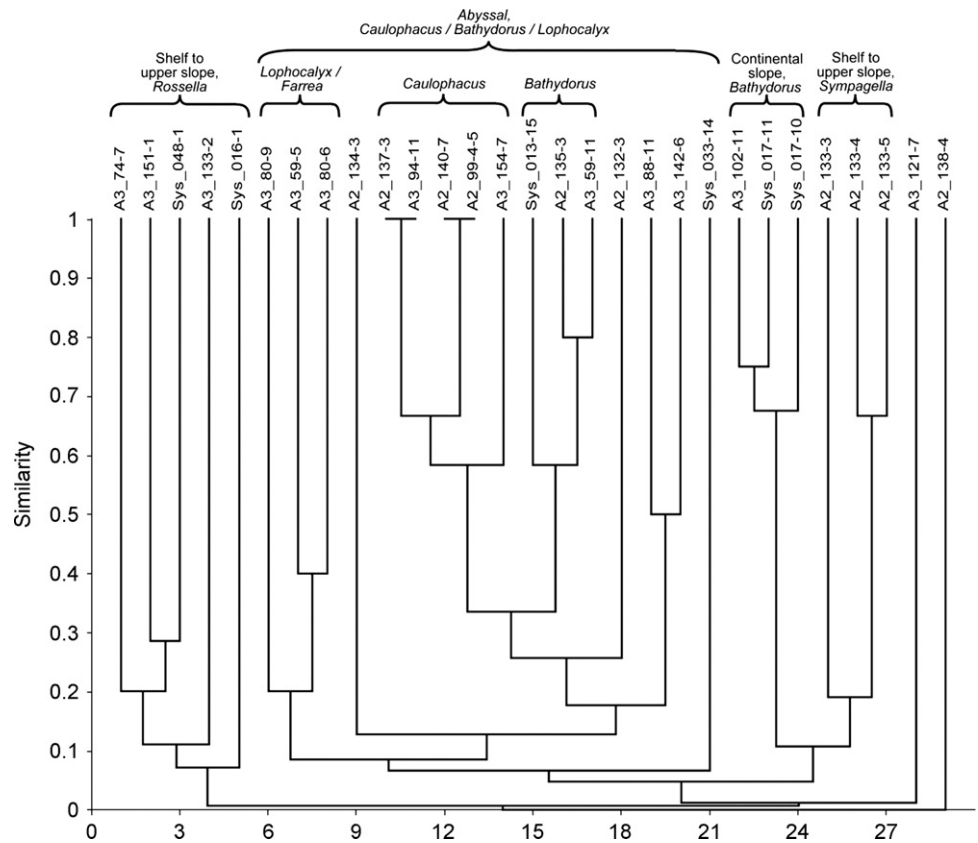
### 3.3. Depth ranges of hexactinellids sampled during ANDEEP-SYSTCO-expeditions

The depth-ranges of all hexactinellid genera and some species sampled during ANDEEP I–III and SYSTCO are given in Fig. 5. Species of the genus *Rossella* generally occurred on the shallower stations of the shelf. Only the species *R. racovitzae* and *R. nuda* were sampled also from deeper stations on the upper slope,

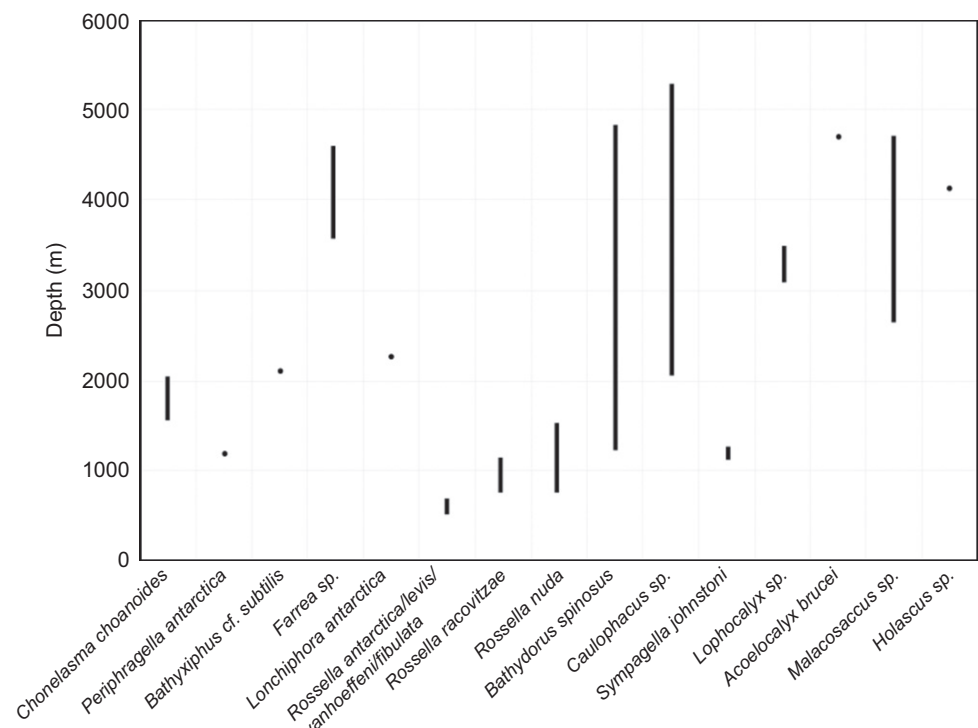
they reached depths of c. 1100 m (*R. racovitzae*) and c. 1500 m (*R. nuda*), respectively. The common deep-sea taxa *Bathydorus spinosus* and *Caulophacus* spp. occur within wide depth ranges. *Bathydorus* (1100 to 4800 m) shows a slight tendency towards shallower water compared with *Caulophacus* (2000 to 5400 m). *Caulophacus* shows a comparable wide bathymetric range due to the fact that we rather commonly find dead stalks on bathyal stations, which cannot be attributed to any species. A wide range of depth was also found for *Malacosaccus* Topsent, 1910 (2600 to 4800 m). The genus *Farrea* was sampled from remarkably deep stations of 3500 to 4700 m, but due to the missing loose spicules in our samples (denuded skeletons), no species assignment was possible.

### 3.4. Geographical distribution of the most common hexactinellid species and genera from ANDEEP-SYSTCO

The most common hexactinellid species/genera (Fig. 6) sampled during ANDEEP and SYSTCO Expeditions are *Caulophacus* spp., *Bathydorus spinosus* and *Rossella racovitzae* (this species co-occurred with most other *Rossella* spp., but was more widespread). All three taxa are widely distributed throughout the entire Weddell-Sea and adjacent areas. The most common genus is *Caulophacus*, which was found at 12 ANDEEP-SYSTCO stations. Most of these stations lie within the deepest regions of the studied area, in the abyssal central Weddell-Sea, but also in the deep-sea areas NW of the Antarctic peninsula. Similarly widespread is the cosmopolitan species



**Fig. 4.** Cluster-analysis of the haxactinellid associations sampled during ANDEEP-SYSTCO-Expeditions. The analysis is based on the Bray-Curtis-similarity. Labels show station name and expedition with the abbreviations: A2: ANDEEP II, A3: ANDEEP III, Sys: SYSTCO. Given genus-names indicate the most dominant taxa in the particular samples.



**Fig. 5.** Depth-range of hexactinellid sponge-taxa from ANDEEP I-III and SYSTCO. Bars show depths range for taxa that have been found on more than one station. Dots show occurrences of taxa sampled on just one station.



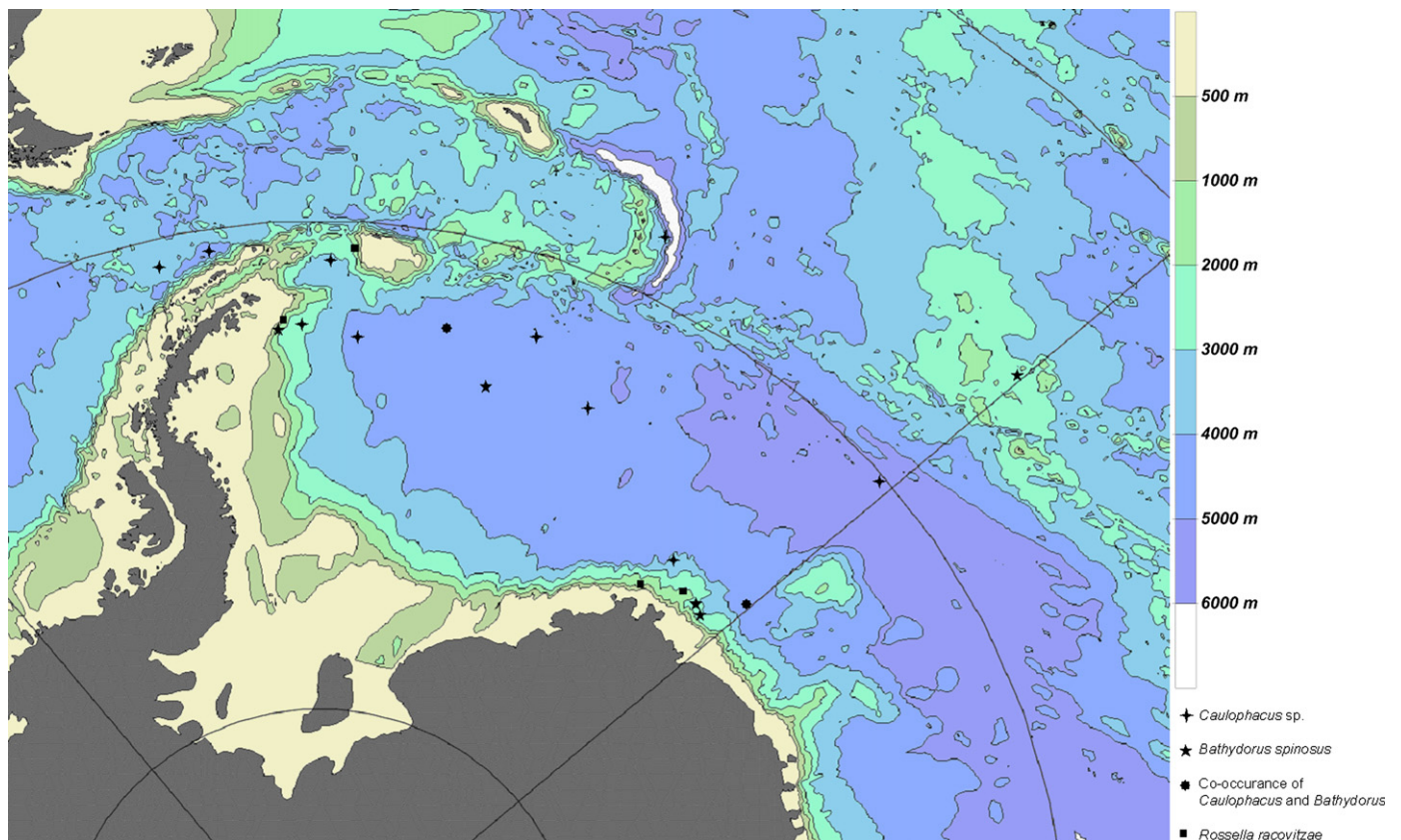


Fig. 6. Distribution of the most common hexactinellids sampled during ANDEEP-SYSTCO-Expeditions. Map created with Ocean Data View (Schlitzer, 2004).

*Bathydorus spinosus*, which often occurs in slightly shallower waters and is most common in bathyal habitats near the coasts, but is also found in the open Weddell-Sea, where we have two co-occurrences of *Caulophacus* and *B. spinosus*. *Rossella racovitzae* was found at 4 stations, which are far apart but all on the coastal slope or continental shelf.

#### 4. Discussion

Several studies (e.g., Brandt et al., 2007; Gage, 2004) have shown, that the Antarctic deep-sea hosts a very rich and diverse zoobenthos. According to Janussen and Reischwig (2009), more than 30 hexactinellid species have been described from the Antarctic deep-sea. However, the deep-sea stations of the SYSTCO-expedition showed comparably low diversity and abundance of both hexactinellids and demosponges. Also, no gigantism within the Rossellidae could be recorded, as it was the case among the bathyal ANDEEP III specimens of *Rossella nuda* and *Rossella racovitzae* (Janussen and Reischwig, 2009). Therefore it seems that all the areas sampled during SYSTCO represent regions of low colonization by suspension feeders, which according to Gutt and Koltun (1995) may alternate with zones of rich communities. But still it has to be pointed out that in spite of the relatively few specimens collected during SYSTCO, the number of species known from the Antarctic is significantly increased, as one out of three hexactinellid species (1 out of 11 specimens) found in the deep-sea, was new to science. Also the demosponges show this tendency, where at least two out of nine species (2 out of 29 specimens) are new to science (yet unpublished data). This strongly supports the hypothesis, that about half the sponge species occurring in the deep Weddell-Sea are still undescribed

(Janussen and Tendal, 2007), although proper calculations on this are still missing. Upcoming analysis of these results together with the final identification of the ANDEEP-SYSTCO Demospongiae will lead to a better understanding of the patterns of benthic colonization in the southern ocean deep-sea.

*Lonchiphora* is so far a poorly described genus, therefore it was still necessary to differentiate its diagnostic characters from those of other genera with similar features. Lonchiole-like spicules are known from the genus *Laocoetis* Pomel 1872, which is a foremost fossil genus with only one known extant species, *Laocoetis perion* Lévi 1986. However, the “lonchioles” reported from this species by Tabachnik and Lévi (1997), bear little resemblance to the lonchioles of *Lonchiphora*, as described by Ijima (1927), figured by Reid (1958) and now photographically documented from the new species *Lonchiphora antarctica* (Fig. 2B). Furthermore, several other spicule types are reported from *Laocoetis*, like stout scopules, several irregular discohexasters and massive swellings of the outer layers of the dictyonal framework, which are very much unlike those of *Lonchiphora*. Therefore, no close relationship seems likely for *Lonchiphora* and *Laocoetis*. The documented farreoid structure of the dictyonal framework, including the attached oxyhexactins, strongly suggests the position of the genus *Lonchiphora* within the family Farreidae. Also, all the further documented spicules fit well within the diagnosis of the family, as it was emended by Duplessis and Reischwig (2004). The 2- and 3-rayed derivatives of the lonchioles bear some resemblance to the aspidoscopules, as reported for *Aspidoscopulia* sp. (Reischwig, 2002). But the aspidoscopules have much more massive and numerous rays, than the lonchiole-derivates. This resemblance however might suggest a closer relationship between *Aspidoscopulia* and *Lonchiphora*. However, this case can only be studied under

consideration of much more material and especially by the inclusion of genetic data, which is a bigger task for a possibly upcoming revision of the family Farreidae that will be difficult to obtain due to the relative rareness of farreid sponges.

A very interesting aspect of the genus *Lonchiphora* is its geographic distribution. The holotype of *Lonchiphora inversa* was found in the Sagami Bay, Japan, whereas our species *Lonchiphora antarctica* was sampled in the Weddell-Sea, almost on the other side of the Earth. This distribution might be explained by a concept on the evolution of Cenozoic seaways developed by Lawver and Gahagan (2003). According to this concept, a circumglobal current existed throughout almost the entire Cenozoic from equatorial waters near the region of Japan southwards through a wide passage east of Africa straight into Antarctic waters near the Weddell-Sea. From there, the current went north again and re-entered the Pacific near the equator, in the region of recent middle America. According to this concept, there was a strong inflow from the Pacific Ocean towards the Antarctic Weddell-Sea throughout a long period of time, and it is likely that *Lonchiphora* followed this current. Therefore we suggest that the Antarctic *L. antarctica* is the younger one and may be derived from the Japanese *L. inversa*, or another (still unknown) related Pacific species.

Our ecologic evaluation of the ANDEEP-SYSTCO hexactinellids via cluster-analysis (Fig. 4), depth (Fig. 5) distribution, and distribution map of the most common taxa (Fig. 6) shows a clear bathymetric zonation within the sponge communities. These are mainly made up by *Rossella* spp. in the shallower regions, followed by *Bathydorus spinosus* in the bathyal and *Caulophacus* spp. in the abyssal depths. Furthermore, another two sponge associations have been found repeatedly, which are quite different from the above mentioned, but which occur at different locations within the same depth ranges. These are three stations on the lower shelf to upper slope dominated by *Sympagella* spp. and three stations on the abyssal characterized by *Lophocalyx* spp. and *Farrea* spp. It is a task for future investigations to point out, whether these are two distinct sponge communities existing at certain depth ranges in ecologically defined environments, different from the “usual” ones, or whether these are mere coincidences. As the deep-sea sponges are generally not abundant, an answer to this question will only be found by further sampling effort combined with detailed ecological monitoring of the sponges environments.

The depths ranges reported here for *Rossella* spp. begin at 500 m, because these were the shallowest stations sampled during the ANDEEP and SYSTCO expeditions. The complete spectrum for the occurrence of this genus begins at much shallower depths from 5 m, as reported by several authors (e.g. Schulze and Kirkpatrick, 1911; Burton, 1929; Barthel and Tendal, 1994). The known depth-ranges for most of the investigated *Rossella* species is extended considerably towards larger depths. This is especially true for *R. nuda*, which was formerly known to occur down to 900 m (Barthel and Tendal 1994), but has now been found at more than 1400 m. The reservation has to be made though that the diagnostic differentiation of species within the genus *Rossella* is currently under revision by the authors. This will be part of an upcoming publication including detailed descriptions and possibly revisions of all the SYSTCO *Rossella* spp. mentioned above. We can confirm the earlier reported distribution of *Rossella racovitzae* (distribution map, Fig. 6), which is considered circumantarctic on the Antarctic shelf (Barthel and Tendal, 1994). Most probably, further near shore samplings will reveal a much denser distribution of this species.

Our findings of *Bathydorus spinosus* extend its geographical distribution patterns recorded so far by Tabachnick (2002)

and Barthel and Tendal (1994), who reported findings of the genus only from the eastern part of the Weddell-Sea (relatively near the shore). We have now recorded it from all parts of the Weddell-Sea, from open waters as well as from shallower stations (see Janussen et al., 2004; Janussen and Reischwig, 2009; Fig. 6). Based on the data presented here, it seems obvious, that *Bathydorus spinosus*, beside *Caulophacus* spp., is the most common hexactinellid sponge in the deeper regions of the Southern Ocean. Compared to *Caulophacus*, *Bathydorus* shows a slight tendency of occurring in bathyal regions closer to the shelf, whereas *Caulophacus* generally occurs in the abyssal, open deep-sea habitats. *Bathydorus* is highly abundant, and also due to its large individual size it grants high amounts of biomass. To some degree it takes over the ecological role of *Rossella* spp. and *Anoxycalyx* (*Scolymastra*) *joubini* Topsent, 1916 on the shelf as the most common hexactinellid sponges, which also provide habitats and food for a wide range of associated organisms (Janussen and Tendal, 2007). The wide distribution of *Bathydorus spinosus* may at least partly be due to the fact that this taxon probably covers a complex of several cryptic species. Its few diagnostic features that are highly variable make a morphological differentiation within this complex problematic or even impossible (Barthel and Tendal, 1994; Janussen, unpublished observations). With the application of molecular methods on many specimens from different areas and depth ranges within the Southern Ocean, it may be possible in the future to obtain a deeper insight into the distribution, relation and zoogeography of *Bathydorus* and its Antarctic species.

*Caulophacus* is the most common hexactinellid genus in the abyssal SO, the Antarctic distribution of *Caulophacus* has been illustrated earlier by Barthel and Tendal (1994) and by Tabachnick (2002). As a result of the intensive sampling effort of the ANDEEP-SYSTCO projects, we can now document a much denser distribution of this genus than previously known within the Weddell-Sea. More accurate taxonomic identifications may bring further insight into its colonization of the Antarctic deep-sea, but in many cases this is impossible because of the bad shape of many *Caulophacus* specimens, which are often collected only as isolated dead stalks. *Caulophacus* (*Oxydiscus*) *weddelli* has to date been recorded twice from the Weddell-Sea (Janussen et al., 2004; Janussen and Reischwig, 2009), both times from depths of about 5000 m. The specimens described here were sampled a little deeper at c. 5300 m, which can be considered within the depth spectrum of this species. As we have found it three times during the ANDEEP-SYSTCO campaign, *Caulophacus* (*Oxydiscus*) *weddelli* may be regarded a rather common sponge in the deep Weddell-Sea. The new specimen shown herein (Fig. 1B) is the first reported juvenile of this species. It differs from the yet described adult ones by a lighter, almost white color and a more firm and fibrous tissue.

Genus *Malacosaccus* has now been recorded for a wider bathymetric range than previously known (2580 m, Barthel and Tendal, 1994), here ca. 2800 to 4800 m. *Farrea* sp. is recorded from stations much deeper than in previous studies (450–2000 m according to Barthel and Tendal, 1994), here ca. 4650 m, but these specimens were found as dead skeletal fragments impossible to identify to a species level, and it cannot be excluded that they have been washed into the depth after death.

So far, we cannot report any distinct faunal provinces within the Weddell-Sea sponge fauna, as the common species are found throughout the entire study area, whereas the uncommon species are so rare, that it is impossible to decide, whether they have a very limited distribution or are just under-sampled. Thus, the subdivision of the Weddell-Sea into two faunal provinces (Scotia Sea and Continental High Antarctic) by Spalding et al. (2007) cannot be confirmed by our results, but future investigations and increased sampling effort in the deep Weddell-Sea are needed to



bring about new insights concerning the sponge fauna. The more distinct zoogeographical map of the Antarctic by Clarke (2008), which divided the so far known Antarctic fauna into six faunal zones, can be extended in the sense that the zone called “Weddell-Sea”, which on this map covered only the eastern part of the Weddell-Sea, in fact includes the entire Weddell-Sea, including the adjacent areas to the west.

## 5. Conclusion

A distinct shift in the composition of the hexactinellid sponge fauna exists from the shelf towards the open and deeper sea. The shelf and upper slope communities are dominated by *Rossella* spp., which is replaced by *Bathydorus spinosus* in the bathyal and followed by *Caulophacus* spp. in abyssal depths. Nonetheless, these “sponge zones” show distinct overlaps. This study offers a first insight into the distribution and taxonomy of the sponge fauna collected during the ANDEEP-SYSTCO-expeditions. Publications to follow will deal with the SYSTCO Demospongiae, including several new species, and the very rich sponge association sampled at station 48-1, Bergström Shelf in 600 m depth. This material also includes a rich assemblage of sponge-associated invertebrate macro- and meiofauna yet to be studied.

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