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**Hexactinellida (Porifera) from the Drake Passage (Southern Ocean) with a description of three new species.**

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**Abstract**

The Drake Passage has over 20 seamounts and ridges but it is notorious for large waves, fierce storms and strong currents that make benthic sampling difficult and therefore infrequent. Seamounts often have diverse sponge communities and may have high levels of endemism. Hexactinellida from Sars Seamount, an area in which the sponges had not previously been studied, and the Shackleton fracture zone were collected on a research cruise by the Nathaniel B Palmer in the Drake Passage, Southern Ocean. In total, from all cruise stations, 103 specimens of Hexactinellida were collected, however many appeared to be fragments of dead specimens and could not be identified due to missing microscleres. From Sars Seamount 127 sponge specimens were taken and from the Shackleton Fracture Zone 76 sponge specimens were taken; of these 36 and 16 respectively were Hexactinellida. From these two areas three new species of Hexactinellida are described: *Doconesthes robinsoni* sp. nov., *Sympagella walleri* sp. nov. and *Caulophacus palmeri* sp. nov. and new records were made of *Aulocalyx irregularis* and *Rossella antarctica*.

**Introduction**

Hexactinellids are typically regarded as a deep–water class of the Porifera and many species possess long root tufts which enable them to colonise the soft–sediment environments typical of the abyssal plains around the Antarctic continent (Janussen & Tendal 2007). However, they are also found on the Antarctic shelf, and here the representatives of some taxa, including the Rossellidae, are most abundant and sometimes reach very large individual size

(Barthel & Tendal 1994). Due to the load of the huge ice-masses covering this continent, the outer edge of the Antarctic shelf extends down to 400–600m (occasionally 800m). This is deeper than that of other continents and the hydrographic features are deep-sea like with highly stable temperatures, salinity and oxygen concentrations (Janussen *et al.* 2004). No distinct border between the shelf and slope exists in the Antarctic, but a smooth transitional slope which leads to the mixing of shelf and deep-water fauna. This combination of factors appears extremely favourable for sponges: aggregations of Demospongiae and/or Hexactinellida commonly dominate the sessile benthos on the Antarctic shelf; local densities of large sponges may reach several kg per m<sup>2</sup> (Hogg *et al.* 2010) and living hexactinellids and hexactinellid spicule mats can account for more than 90% of the benthic biomass (Barthel & Tendal 1994). Koltun (1968) aptly referred to the Antarctic as the ‘sponge kingdom’.

Over the past 40 years knowledge of the sponge fauna of Antarctica, especially in the deep-sea, has been significantly improved by recent benthos sampling expeditions, such as BENTART (1994,1995 and 2003) ANDEEP I–III (2002, 2005) and SYSTCO (2007, 2012); the number of demosponge records have more than doubled and records of Hexactinellida have tripled during this period (Janussen & Downey 2014). Currently there are 53 hexactinellid species from 21 genera and 7 families recorded from the Antarctic Ocean (Janussen & Downey 2014). However, records from many Antarctic areas remain sparse and further studies are needed.

The Drake Passage is estimated to have opened around 30 mya leading to the geographic isolation of the Antarctic Continent (Barker & Thomas 2004). It contains more than 20 seamounts and ridges, and it is notorious for large waves, fierce storms and strong currents that make benthic research difficult, therefore this sea is largely under-sampled (Waller *et al.* 2011). The sponge fauna of these seamounts has not previously been collected (Downey *et al.* 2012). Currents are amplified around seamounts and these conditions favour suspension feeders, such as sponge and corals, which commonly dominate seamount benthic communities (Samadi *et al.* 2007). Studies of seamounts in other areas have revealed diverse sponge populations, often with high degrees of endemism (Levi, 1969; Xavier & van Soest 2007; Viera *et al.* 2010).

## **Material and Methods**

Samples were collected on the RVIB Nathaniel B Palmer Cruise 11–03 (9<sup>th</sup> May–11<sup>th</sup> June 2011), the principal scientists were Laura Robinson (Woods Hole Oceanographic Institution) and Rhian Waller (University of Maine). This cruise aimed to gain historical perspectives on

climate and biogeography from deep-sea corals in the Drake Passage. Samples were collected from the Burdwood Bank, Shackleton Fracture Zone, West Antarctic Peninsula, Interim Seamount, Sars Seamount and Cape Horn (Robinson and Waller, 2011).

Most sampling of benthos was done by Hein Dredge, some shallower sites were sampled by Otter Trawl. From Sars Seamount 127 sponge specimens were taken and from the Shackleton Fracture Zone 76 sponge specimens were taken; of these 36 and 16 respectively were Hexactinellida. In total 103 specimens of Hexactinellida were taken during the cruise. However, in the majority of these sponges the microscleres were missing and their overall condition gave the impression that they were fragments of dead specimens which had been present on the sea floor for a considerable time. Consequently, species level identification of many of these was not possible. Once collected, dredge/trawl hauls were sorted and examples of recognisable entities removed for preservation. Specimens were photographed and then dried.

In the laboratory at National Museums Northern Ireland, the dried specimens were re-hydrated in a 5% solution of decon-90 (Decon laboratories limited) then placed in 70% ethanol. Tissue slides were prepared by sectioning a very thin portion of tissue at a 90 degree angle through the sample. This was dehydrated in absolute ethanol for four minutes and placed in clove oil for another four minutes, to clarify the tissue, before being mounted on a microscope slide in Canada balsam. A coverslip was then placed on the slide and they were kept at 50°C for at least 48h to allow the mountant to dry. Spicule preparations were made by dissolving the tissue in a drop of concentrated nitric acid directly on a microscope slide. The slide was heated over a spirit burner to aid the reaction. Once the acid had burnt off, the remaining spicules were rinsed in distilled water and ethanol and then mounted in Canada balsam as above.

The tissue slide was used primarily for identification to genus level. Spicule measurements were taken from the spicule preparations; at least 20 spicules of each type were measured using ProgRes® CapturePro 2.7 Software (JENOPTIK Optical Systems, Jena, Germany). Type material is deposited (in accordance with the survey permit for work in the Chilean Economic Zone and the Chilean Supreme Decree Number 711) in the Museo Nacional de Historia Natural of Chile, Santiago, Chile (indicated by MNHNCL). Some paratypes are retained in the zoology collections of the Ulster Museum, National Museums Northern Ireland, Belfast (indicated by BELUM.Mc).

Information on extant species was obtained from the World Porifera Database (Van Soest *et al.* 2013). Type specimens examined for comparison were kindly provided by Natural

History Museum, London (BMNH) and Senckenberg Nature Museum, Frankfurt/Main (SMF).

### **The study area (Figure 1)**

The research cruise sampled several sites in the Drake Passage. These specimens were mostly collected from Sars Seamount, but the specimen of *Caulophacus palmeri* sp. nov. was collected from the Shackleton Fracture Zone. The Drake Passage comprises the body of water between the southern tip of South America (Cape Horn) and the South Shetland Islands in Antarctica. The Shackleton Fracture Zone is located at the split between the Scotia and Antarctic tectonic plates, running north–west to south–east from the South American continental shelf to the South Shetland Islands. Sars Seamount lies near the polar front and has a flat top in ~500m and a predominantly gravel seabed (Waller *et al.* 2011). It has an abundant sponge fauna: Waller *et al.* (2011) reported sponges from 99.4% of all images from a towed video survey. Octocorals, stylasterids and other cnidarians were also common (Waller *et al.* 2011).

### **SYSTEMATICS**

Class Hexactinellida Schmidt, 1870

Subclass Hexasterophora Schulze, 1886

Order Aulocalycoida Tabachnick & Reiswig, 2000

Family Aulocalycidae Ijima, 1927

Subfamily Aulocalycinae Ijima, 1927

Genus *Aulocalyx* Schulze, 1886

*Aulocalyx irregularis* Schulze, 1886

### **SPECIMEN**

BELUM.Mc2015.308, cruise sample number NBP1103–DH97–sponge10. 30<sup>th</sup> May 2011  
Sars Seamount, 59° 43.06'S 68° 52.23'W, 620–700m, Hein Dredge.

### *External morphology* (Figure 2A)

Small fragment of pale brown sponge 5 by 2cm. Sponge body formed of an irregular meshwork of connected fibres, giving a lacy appearance. When dried, the sponge is white and the mesh is hard and brittle.

### *Skeleton* (Figure 2B)

Very irregular framework of variable size triangular meshes 554–(713)–819  $\mu\text{m}$  in max. length with a beam width 66–(104)–195  $\mu\text{m}$  (up to 2mm in type), beams are smooth and nodes are smooth, not ornamented.

### *Spicules*

Pentactins (Figure 2C): entirely covered by small spines. Tangential ray 218–(314)–485 by 13–(16)–21  $\mu\text{m}$ . Proximal ray 108–(395)–669 by 10–(16)–20  $\mu\text{m}$ .

Discohexasters (Figure 2D): diameter 44–(54)–70  $\mu\text{m}$ , primary ray 2.9–(5.2)–7.9  $\mu\text{m}$ , secondary ray 12.2–(17.5)–21.4  $\mu\text{m}$ . Initially it seemed that there might be two size categories, measurements revealed that they were fairly evenly spread over the size range. Both spherical (in which the rays are regularly distributed around the radius) and stellate (where the rays form discrete clusters) forms were present, but as there were also intermediate forms we refrained from measuring these separately.

Rhopalasters (Figure 2E): Total diameter 343–(394)–420  $\mu\text{m}$ , primary ray 8.1–(10.7)–15.1  $\mu\text{m}$ , secondary ray 168–(192)–206  $\mu\text{m}$ . Between 5 and 7 (usually 6) secondary rays are present on each primary ray. Rays are spined, with large recurved spines on the second part of their length, and end in a disk.

### *Remarks*

The rhopalasters correspond well in size and form with those of the type specimen: 300–400  $\mu\text{m}$  in diameter with 6 terminal rays on short principal terminals. The discohexasters are within the same size range (measured by Reiswig & Kelly 2011 as spherical: 38–93  $\mu\text{m}$  diameter and stellate 31–84  $\mu\text{m}$  in diameter). The pentactins are of similar size (measured by Reiswig & Kelly 2011 as tangential ray length 191–(281)–384  $\mu\text{m}$ , proximal ray length 313–(450)–560  $\mu\text{m}$ ). We did not find any oxyhexactins in our specimen, it is noted in the type description that these occur irregularly and the small size of our specimen may have resulted in them being missing.

*Aulocalyx irregularis* was originally described from 567m near Marion Island (Prince Edward Islands), SE of the Cape of Good Hope in the sub–Antarctic Indian Ocean. Other records are reported in Barthel & Tendal 1994, but Reiswig (2002) noted that they have probably been incorrectly identified due to an earlier assumption that any specimen with an irregular non–euretoid skeletal framework would be *A. irregularis*. In fact, without detailed examination of the full spiculation specimens can only be assigned to the family

Aulocalycidae. The type location is the only previous record of *A. irregularis*, and the genus is also known from two other locations in the Saya de Malha Group, W. Indian Ocean at depths of 567–915m (Reiswig 2002). A new species, *Aulocalyx australis* Reiswig & Kelly 2011 was recently described from Macquarie Ridge, Australia 676–1615m.

Order Lyssacinosa Zittel 1877

Family Rossellidae Schulze 1885

Subfamily Lanuginellinae Gray, 1872

Genus *Doconesthes* Topsent, 1928

*Doconesthes robinsoni* sp. nov.

#### TYPE MATERIAL

Holotype:

MNHNCL POR–15002 Dried sample, small sub–sample rehydrated with Decon–90, tissue section and spicule preparation on slides. Sub–sample of above deposited as BELUM.Mc2015.345 (spicule preparation only). Cruise sample number NBP1103–T0104–sponge20. 31<sup>st</sup> May 2011 Sars Seamount 59° 43.43'S 68° 45.38'W, 570–820m, Otter Trawl.

#### *Etymology*

Named after Dr Laura Robinson who was a principal scientist on RVIB Nathaniel B Palmer Cruise NBP11–03 on which these sponges were collected.

#### *External morphology* (Figure 3A–C)

The single specimen is a flattened sac, cream to light brown in colour (both when fresh and preserved). The sponge was dried after collection and it has only been possible to examine the dried and rehydrated specimen so details of living form may have been lost. The end of the sponge had been removed for preservation in alcohol and has completely disintegrated. The overall form is an oval sac 10 cm in length and 8 cm wide with a thickness of around 2 cm. At the top of a sponge is a single large osculum which opens to a large atrium. Because the specimen has been damaged it is not possible to see the exact form of this but the atrium appears to have a maximum diameter of 5 cm with one thin wall (~4 mm) and one thicker wall (1.5 cm). Presumably the sponge was originally attached at one of the narrow ends of its oval body, but the sample has been detached from its substrate by the trawl. There is no visible root tuft and attachment was basiphytous, directly onto the body. The consistency of the preserved specimen is fairly soft and it fragments easily.

#### *Skeleton*

Confused mass of diactins with a dermal layer of pentactins and rough diactins and an atrial layer of hexactines and pentactines.

### *Spicules*

Hypodermal pentactins (Figure 3D): Pentactins with four long tangential rays and a short proximal ray. From the tip to about 1/3 of the way up the ray is slightly spined. Proximal ray 53–(98)–203 by 22.1–(33.8)–58.7  $\mu\text{m}$ , tangential rays 323–(463)–652 by 16.8–(38.8)–56.3  $\mu\text{m}$ . Hypoatrial pentactines of a similar form but smaller size – proximal ray 33–(63)–128 by 12–(24)–31  $\mu\text{m}$  tangential rays 231–(304)–355 by 17–(22)–27  $\mu\text{m}$ .

Atrial hexactines (Figure 3E). Spined for about 1/2 to 2/3 of their length. Ray length 197–(312)–467/20–(25)–33  $\mu\text{m}$ .

Dermal diactins (Figure 3G): Entirely spined diactins with rounded ends. Centrum marked by a large swelling indicating that spicules are probably derived from hexactins. 206–(251)–295 by 10.0–(13.6)–20.3  $\mu\text{m}$ .

Choanosomal diactins (Figure 3F): Large diactins which are slightly spined at their tips. Tips sometimes tapered and sometimes coming to a fairly abrupt point. Centrum often slightly tylole. 1110–(2118)–3084 by 13.3–(20.7)–28.8  $\mu\text{m}$ .

Oxyoidal microscleres (Figure 3H): Oxyhemihexasters. The majority have six unbranched rays but in a few spicules one or more of the rays is divided in two. The spicules are slightly ornamented with small spines. Total length of rays (measured from centrum) 48–(59)–74  $\mu\text{m}$ .

Strobiloplumicomes (Figure 3I): Total diameter 65.6–(81.5)–97.7  $\mu\text{m}$ ; Diameter across centrum 1.8–(2.5)–4.0  $\mu\text{m}$ ; Calyx diameter 17.0–(20.2)–22.7  $\mu\text{m}$ ; ray length 18.8–(29.2)–39.6  $\mu\text{m}$ .

### *Diagnosis*

As strobiloplumicome microscleres are present, this specimen is assigned to the subfamily Lanuginellinae. Within the family genera are divided between those which possess only one type of hypodermal pentactin and those which have a second, short toothed, anchorate, category (Tabachnick 2002). As this specimen lacks a second category of hypodermal pentactins and pinular hexactins, pinular pentactins or discohexasters we have assigned it to the genus *Doconesthes*. The genus is poorly known and until recently was represented only by *Doconesthes sessilis* Topsent, 1928. An additional species *Doconesthes dustinchiversi* Reiswig 2015 has recently been recorded from the north-east Pacific. *Doconesthes sessilis* was originally described from a basal fragment so its full complement of spicules may not be represented in the description. Specimens provisionally assigned to this species have also been recorded from the northern mid-Atlantic ridge (Tabachnick & Collins 2008; Tabachnick & Menshenina 2013), however, as noted by Reiswig (2015), there are significant differences in spiculation between the type and these two specimens (e.g. each has a different size class of dermal diactins) and a re-evaluation of their status may be warranted.

Our specimen differs from the type of *D. sessilis* in having smaller dermal and choanosomal diactins, smaller oxyoidal microscleres and strobiloplumicomes almost twice the size of those of the holotype *D. sessilis* and other recorded specimens. Our specimen differs from *D. dustinchiversi* Reiswig 2015 in having smaller oxyhemihexasters and lacking pinular hexactins (Table 1).



*Sympagella walleri* sp. nov.

TYPE MATERIAL

Holotype:

MNHNCL POR-15003 Dried sample, small sub-sample rehydrated with Decon-90, tissue section and spicule preparation on slides. Sub-sample of above deposited as BELUM.Mc2015.365 (spicule preparation on slide only). Cruise sample number NBP1103-DH117-sponge01, 2<sup>nd</sup> June 2011, Sars Long Nose, Sars Seamount, 59° 45.846'S 68° 55.968'W, 930–1030m, Hein Dredge.

Paratypes:

MNHNCL POR-15004 Dried sample, small sub-sample rehydrated with Decon-90, tissue section and spicule preparation on slides, Sub-sample of above deposited as BELUM.Mc2015.273 (spicule slide only). Cruise sample number NBP1103-DH91-sponge08 29<sup>th</sup> May 2011, Sars Seamount, 59° 43.10'S, 68° 52.0'W, 610–680m, Hein Dredge; BELUM.Mc2015.313, cruise sample number NBP1103-DH97-sponge15, 30<sup>th</sup> May 2011, Sars Seamount, 59° 43.06'S 68° 52.23'W, 620–700m, Hein Dredge.

Other specimens (possibly fragments of the above):

BELUM.Mc2015.266, cruise sample number NBP1103-DH91-sponge01 and BELUM.Mc2015.278, cruise sample number NBP1103-DH91-sponge13 both Sars Seamount, 59° 43.10'S, 68° 52.0'W, 610–680m, Hein Dredge; BELUM.Mc2015.299, cruise sample number NBP1103-DH97-sponge01, 30<sup>th</sup> May 2011, Sars Seamount, 59° 43.06'S 68° 52.23'W, 620–700m, Hein Dredge; BELUM.Mc2015.319 cruise sample number NBP1103-DH97-sponge21 Sars Seamount, 59° 43.06'S 68° 52.23'W, 620–700m, Hein Dredge; BELUM.Mc2015.371, cruise sample number NBP1103-DH117-sponge07, 2<sup>nd</sup> June 2011, Sars Long Nose, Sars Seamount, 59° 45.846'S 68° 55.968'W, 930–1030m, Hein Dredge.

*Comparative material examined*

BMNH 1908.9.24.28 *Sympagella gracilis* (Schulze 1903) Holotype specimen.  
BMNH 87.10.20.34 *Sympagella johnstoni* (Schulze, 1886) Holotype specimen  
BMNH1887.10.20.35 *Sympagella nux* Schmidt, 1870 Holotype specimen

*Etymology*

Named after Dr Rhian Waller who was a principal investigator on RVIB Nathaniel B Palmer Cruise NBP11-03 on which these sponges were collected.

*External morphology* (Figure 4A)

The type specimen is a thin walled cup approximately 15cm high with a diameter of 7cm at the osculum. The walls of the cup are 1–2mm thick. The specimen has been damaged during collection and the base is missing. The specimen is cream coloured and has a punctate surface with small pores visible. When preserved (following drying and rehydration) the sponge is in

the form of soft white lumps with a cotton wool like texture. The paratypes are fragments with a similar colour and texture but have been very badly damaged during collection so it is not possible to determine their original form.

### *Skeleton*

The specimens were dried on collection and then rehydrated for examination. Consequently the tissue is not well preserved and it is difficult to see exact skeletal structure. There is a confused choanosomal skeleton of large diactins. Pinular hexactins are present at the surface of the sponge (it was impossible to determine if atrial and dermal categories differed as preservation was not good enough to determine location of these regions in the sponge). Strobiloplumicome and discohexaster microscleres are present throughout the tissue.

### *Spicules*

Measurements unless specified are from the type specimen – measurements from the paratypes are given in Table 2 for comparison.

Choanosomal diactins (Figure 4B): 1441–(2601)–3736 by 11.3–(15.5)–26.7  $\mu\text{m}$  abruptly pointed ends densely ornamented with small spines.

Hypodermal/hypoatrial pentactins (Figure 4C): With long proximal ray (495–(715)–1006 by 18.2–(25.0)–32.2  $\mu\text{m}$ ) and shorter tangential rays (232–(333)–415 by 15.9–(25.2)–33.2  $\mu\text{m}$ ). Ends densely ornamented with small spines.

Choanosomal hexactins (Figure 4D): Proximal ray (396–(625)–742 by 19.0–(26.2)–31.2  $\mu\text{m}$ ), distal ray (148–(449)–665 by 18.2–(26.6)–32.6  $\mu\text{m}$ ), tangential rays (231–(407)–594 by 15.9–(23.0)–33.2  $\mu\text{m}$ ) Ends densely ornamented with small spines.

Surface pinular hexactins (Figure 4E): Pinular ray (107–(125)–136 by 11.3–(19.2)–25.1  $\mu\text{m}$ ), proximal ray (56–(83)–113 by 6.4–(9.8)–13.5  $\mu\text{m}$ ), tangential rays (53–(95)–120 by 4.8–(9.2)–12.2  $\mu\text{m}$ ).

Discohexasters (Figure 4F): with usually two, sometimes three secondary rays per primary ray. 81–(92)–103  $\mu\text{m}$  total diameter, centrum diameter 3.4–(5.2)–7.0  $\mu\text{m}$ .

Strobiloplumicomes (Figure 4G,H): Rare in all of the specimens. The hook-like ends of the strobiloplumicomes are very fragile and often lost during spicule preparation (Fig 4g), a lateral view of a strobiloplumicome rosette with these hooks in place can be seen in Figure 4H. No strobiloplumicomes were found to measure in the spicule preparations of the type specimens and those on the SEM preparations were at the wrong angle for measurements to be taken. Strobiloplumicomes of the paratypes are 11.0–20.9  $\mu\text{m}$  total diameter with a centrum diameter of 1.9–2.9  $\mu\text{m}$ .

### *Diagnosis:*

As these specimens possess strobiloplumicomes they are assigned to the sub-family Lanuginellinae. The lack of a second class of anchorate dermal pentactins, the possession of pinular hexactins and discoidal microscleres assigns them to the genus *Sympagella*. There are currently ten valid species in the genus (Table 3), one of these *Sympagella johnstoni* (Schulze, 1886) was described from the southern Indian Ocean, between the Cape of Good Hope and the Kerguelen Islands, and has also been recorded from the Weddell Sea (Janussen *et al.* 2004).

There are only three other species of *Sympagella* which do not possess oxyoidal microscleres: *Sympagella ecomari* Tabachnick & Menshenina, 2013, *Sympagella johnstoni* (Schulze, 1886) and *Sympagella nux* Schmidt, 1870 (Table 3). *S. ecomari* has much longer and thinner pinular rays on its surface hexactins (up to 267  $\mu\text{m}$ ) and larger strobiloplumicomes (29–58  $\mu\text{m}$ ); *S. johnstoni*, from examination of the type specimen, has more robust discohexasters and the pinules of its surface hexactins have a much larger width to length ratio, giving them a very bushy appearance; *S. nux* can be distinguished as it possesses pinular pentactins and its surface hexactins have much longer and more slender pinular rays .

Genus *Caulophacus* Schulze, 1885

Subgenus *Caulophacus* Schulze, 1885

*Caulophacus palmeri* sp. nov.

Note: We have followed Boury–Esnault *et al.* 2014 who, due to molecular phylogenetic evidence, transferred the genus *Caulophacus* from Rossellinae to Languinellinae. They emend Tabachnick’s (2002) definition of Languinellinae as ‘Rossellidae with strobiloplumicomes or if these are absent the concerned group(s) share so many morphological characters with a group bearing strobiloplumicomes that their common ancestry with loss of that spicule is most parsimonious...’.

#### TYPE MATERIAL

MNHNCL POR\_15001. Dried sample, small sub-sample rehydrated with Decon–90, tissue section and spicule preparation on slides. Sub-sample of above deposited as BELUM.Mc2015.176 (spicule slide only). Cruise sample number NBP1103–DH59–sponge03. 20<sup>th</sup> May 2011 Shackleton Fracture Zone, 60° 32.25’S, 56° 49.07’W, 1810–1820m, Hein Dredge.

#### *Etymology*

Named after the research vessel Nathaniel B Palmer which in turn is named after the merchant mariner and ship builder Nathaniel Brown Palmer (8<sup>th</sup> August 1799 – 21<sup>st</sup> June 1877) who was amongst the first people to discover Antarctica.

#### *External appearance* (Figure 5A)

Hispid cream-coloured sponge with bulbous mushroom-like top and narrow stalk. The width of the top is 25mm and height 14mm, the stalk is 4mm maximum diameter. Preserved appearance: Delicately hispid pale peach lump with firm texture and distinct but not detachable, slightly hispid, dermal surface.

#### *Skeleton*

The specimen has been poorly preserved (dried then rehydrated) and skeletal structure is hard to see clearly. Confused choanosomal skeleton of diactines and non-pinnular hexactines.

Hypodermal layer of pentactines and pinular hexactines with pinular ray facing outwards.  
Atrial layer of pinular hexactines. Microscleres are present throughout tissue.

### *Spicules*

Choanosomal diactins with rounded, slightly tylote, spined ends and a small central swelling. 903–(1517)–3502 by 9.3–(18.4)–33.8  $\mu\text{m}$  (Figure 5B). Some larger examples were also present but as these broke in both the section and spicule preparations it was not possible to measure them.

Choanosomal hexactins: Tangential ray 304–(614)–851  $\mu\text{m}$ , proximal ray 310–(724)–988  $\mu\text{m}$ , distal ray 304–(592)–892  $\mu\text{m}$

Hypodermal spicules are pentactins (Figure 5C) and hexactins (Figure 5D) with spined tips. Proximal ray 476–(761)–1541  $\mu\text{m}$ , tangential ray 241–(310)–421  $\mu\text{m}$ .

Pinular hexactins (Figure 5E). Dermal pinular hexactin: Pinular ray 167–(187)–203 by 15.9–(28.6)–40.1  $\mu\text{m}$ , proximal ray 69–(77)–87 by 7.4–(8.5)–11.5  $\mu\text{m}$ , tangential ray 61.8–(74.1)–88.2 by 6.3–(8.3)–12  $\mu\text{m}$ . Atrial pinular hexactin: Pinular ray 118–(164)–193 by 20.1–(28.3)–47.4  $\mu\text{m}$ , proximal ray 33–(73)–98 by 5.4–(8.6)–12.6  $\mu\text{m}$ , tangential ray 55.2–(68.3)–81.6 by 6.4–(8.1)–11.3  $\mu\text{m}$ .

Discohexactins (Figure 5F). Ray length: 55–(63)–79  $\mu\text{m}$ , total diameter 116–(135)–169  $\mu\text{m}$ , centrum diameter 5.0–(8.3)–11.2  $\mu\text{m}$ .

### *Diagnosis*

*Caulophacus* is defined as a stalked fungus or cup-like Rossellidae with pinular hexactine dermalia and atrialia (Tabachnick 2002). The four sub-genera which are included in the genus are defined by the type of microscleres present: *Caulophacus (Caulodiscus)* Ijima, 1927 has microscleres with various terminations (discoidal, onychoidal, oxyoidal); *Caulophacus (Caulophacus)* Schulze, 1885 has mainly discoidal microscleres; *Caulophacus (Oxydiscus)* Janussen, Tabachnick & Tendal, 2004 has numerous oxyhexasters, discohexasters may also be present and *Caulophacus (Caulophacella)* Lendenfeld, 1915 has microscleres with exclusively oxyoidal endings. (Janussen *et al.* 2004). This specimen possesses only discoidal microscleres and consequently is assigned to *Caulophacus (Caulophacus)*.

There are 20 currently valid species of *Caulophacus (Caulophacus)* of which ten species have been recorded from the Southern Ocean and surrounding areas (Table 4). The majority of these possess discohexaster as well as discohexactin microscleres; the only species which do not are *C. basispinosus* Levi 1964 and *C. galathea* Levi 1964. However, both of these species have oxy-tipped microscleres which are not present in our specimen.

Sub-family Rossellinae Schulze 1885

Genus *Rossella* Carter 1872

*Rossella antarctica* Carter 1872

### *Specimens*

BELUM.Mc2015.284, cruise sample number NBP1103–DH95–sponge04, Sars Seamount 59° 43.76'S, 68° 53.93'W, 740–820m, Hein Dredge. BELUM.Mc2015.329, cruise sample number NBP1103–TO104–sponge04 and BELUM.Mc2015.335, cruise sample number NBP1103–TO104–sponge10, both Sars Seamount 59° 43.43'S, 68° 45.38'W, 570–820m, Otter Trawl.

#### *Comparative material examined*

*R. antarctica* specimens from station the ANT XXIV/2 (SYSTCO I) expedition (SMF 11734, 11735, 11908–11915, 11916–11930).

#### *External appearance* (Figure 6A, B)

The three sponges are sacciform with a basal attachment and a terminal oscule. The largest specimen is 15cm long and 9cm wide and the smallest 5cm long and 2cm wide. All were cream coloured when collected and have a veil of projecting diactins which protrude up to 1.5cm from the body. No dense velum of protruding pentactins is present in the specimens.

#### *Spicules:*

Measurements are taken from BELUM.Mc2015.284, figures are restricted to spicules of high taxonomic value.

Dermal spined pentactin: Very large spicules – tangential rays of the one specimen measures were 3750/117  $\mu\text{m}$ . The spicules are covered with large, fairly widely spaced spines.

Rough pentactin tangential ray 90–(122)–184  $\mu\text{m}$ , proximal ray 80–(117)–110  $\mu\text{m}$

Rough hexactin diameter 149–(268)–403  $\mu\text{m}$

Oxyhexactin diameter 89–(115)–142  $\mu\text{m}$

Oxyhexaster diameter 86–(102)–116  $\mu\text{m}$

Calycocone (Figure 6C) diameter 85–(99)–109  $\mu\text{m}$ , number of secondary rays 4(5)6  $\mu\text{m}$ , Complete ray length 43–(48)–55  $\mu\text{m}$ , Primary ray length 6–(11)–13  $\mu\text{m}$ , Centrum length 6–(10)–13  $\mu\text{m}$ , Secondary ray length 20–(28)–33  $\mu\text{m}$ .

Microdiscohexaster (Figure 6D) diameter) 22–(33)–36  $\mu\text{m}$

#### *Remarks*

This species differs from other Antarctic *Rossella* species by its distinctive spined dermal pentactins. It has relatively small (~100  $\mu\text{m}$ ) calycocones with 3–8 secondary rays and primary and secondary rays of a similar length; this distinguishes it from many other species of *Rossella* which tend to have calycocones with short primary and long secondary rays. The microdiscohexasters found in this species are characterised by the lack of a capitulum at the end of the primary rays, the secondary rays originate directly from the endings of the primary rays; this feature is shared only with *R. levis* (Kirkpatrick 1907). See Göcke & Janussen (2013) for a full discussion.

The spicule dimensions of our specimens are generally in good correspondence with those given by Kirkpatrick (1907) and Göcke & Janussen (2013). The dimensions of the middle piece of the calycocones are longer (6–(10)–13 in our specimens, 2–4 in Kirkpatrick, 2.5–5.5 in Göcke & Janussen 2013), however, this may be due to a variation in how these were measured, proportions in images look similar.

The genus *Rossella* is currently in a very problematic state as many of the described species are suspected to be synonyms. Attempts to install synonymies nevertheless were so far not fully successful (see Barthel & Tendal 1994, Göcke & Janussen 2013). *Rossella antarctica* nonetheless is a very well defined and accepted species. The species is widely distributed all around the Southern Ocean with Antarctic records from the Amundsen/Bellingshausen Sea, Antarctic Peninsula and South Shetland Islands, East Antarctic Dronning Maud Land, East Antarctic Enderby Land, East Antarctic Wilkes Land, the Ross Sea and the Weddell Sea. It has also been recorded from the sub-Antarctic from Kerguelen, Prince Edward Islands and South Georgia and from Namaqua (Barthel & Tendal 1994; Göcke & Janussen 2013; Van Soest *et al.* 2015). The Sars Seamount sites may be at the lower end of the depth range for this species, the majority of Antarctic specimens have been recorded between 90 and 600m. Göcke & Janussen (2013) note that during the SYSTCO-I expedition the deepest records of *R. antarctica* were in 600m with deeper stations yielding no specimens. However, Barthel & Tendal (1994) do note one record from off Patagonia in 1100m.

## Discussion

Janussen *et al.* 2004 estimate that potentially only half of Hexactinellida species are currently known to science and note that many specimens collected during recent expeditions are new. Here we describe three hexactinellid species new to science from the Drake Passage region and report *Aulocalyx irregularis* which was only previously known from the type locality (Marion Island, sub-Antarctic Indian Ocean). The genus *Doconesthes* is also new for the region, adding to the 21 genera of Hexactinellida hitherto recorded from the Antarctic (Janussen & Downey 2014). Samples from the research cruise also included undescribed species of demosponges, including several species of Cladorhizidae new to science (manuscript in prep). This study demonstrated the Drake Passage region has a rich sponge fauna and the potential for additional surveys to enhance our knowledge of sponge biodiversity.

*Caulophacus palmeri* sp. nov. was recorded from the Shackleton Fracture Zone at 1820m. A third of Antarctic hexactinellid species are thought to be restricted to abyssal depths and nearly half of all abyssal endemic species are currently found within this deep-sea hexactinellid genus (Janussen & Downey 2014). This species was not recorded at the shallower Sars Seamount and is likely, like other species in the genus, to be restricted to abyssal depths. Again, additional sampling is required to determine its distribution. Auscavitch (2011) reports from a visual analysis of the areas sampled by the cruise that the fauna of the Shackleton Fracture Zone bore similarities to the soft seafloor communities of the deep Antarctic shelf whereas on Sars Seamount and other Drake passage seamounts Magellanic and cosmopolitan faunas were dominant.

Suspension feeders such as sponges and corals usually dominate seamount megabenthos, currents tend to be amplified around seamounts which favours suspension feeders (Samadi *et al.* 2007). Wilson & Kaufmann (1987) estimate that 15–36% of the local invertebrate faunas of seamounts are endemic. However, seamount biodiversity is understudied: Samadi *et al.* (2007) noted that of the estimated 100,000 Seamounts worldwide only 232 had been

biologically sampled and for these many species had not been identified due to a lack of taxonomic resources. The difficult conditions in the Drake Passage mean that seamounts in this area have been infrequently sampled (Waller *et al.* 2011). This is the first taxonomic study of their sponge fauna. Whilst *Sympagella walleri* sp. nov. and *Doconesthes robinsoni* sp. nov. are currently only known from Sars Seamount, additional sampling is required to determine if they are restricted to this area or have a wider distribution in the Southern Ocean.

Most of the material described in this paper is from Sars Seamount from depths of 610–970m. This site had a very high sponge biomass and biodiversity (Figure 2) Auscavitch (2011) describes the seamount as having a rich community of sponges and stylasterid hydrocorals encrusting on stylasterid and sponge rubble. Interestingly the sponge communities here were more diverse than on the nearby Interim Seamount which was dominated by echinoderms.

It has been proposed that seamounts have highly localised species distributions with high degrees of endemism; significant differences were found between species composition of seamounts of different ridge systems in the southwest Pacific (Richer de Forges *et al.* 2000). Maud Rise Seamount in the eastern Weddell Sea despite being deeper than both of those we sampled (1700–3500m) has a community dominated by the genera *Polymastia* and *Tentorium* and completely lacking Hexactinellida and Cladorhizidae (Brandt *et al.* 2011) which were present at both Interim and Sars Seamounts. Whilst a more recent study has shown that for groups such as crustaceans gene flow between seamounts is not limited (Samadi *et al.* 2006), further research is required to determine if this is true for groups with limited dispersal capacities such as Porifera.

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## Figure legends.

Figure 1 – Sampling locations. A, Sars Seamount, B Shackleton Fracture Zone. Inset: box indicates the area shown in larger figure.

Figure 2. *Aulocalyx irregularis*, specimen BELUM.Mc2015.308. A. Collected specimen, scale in cm; B. Skeletal framework, Scale bar 1000  $\mu\text{m}$ , SEM; C. Pentactin, scale bar 100  $\mu\text{m}$ , SEM, D. Discohexaster, scale bar 10  $\mu\text{m}$ , SEM; E. Rhopalaster, scale bar 100  $\mu\text{m}$ , SEM.

Figure 3. *Doconesthes robinsoni* sp. nov. Type specimen MNHNCL POR–15002. A. Freshly collected specimen, scale in cm; B. Rehydrated specimen, scale in cm; C. Atrium of rehydrated specimen, scale in cm; D. Hypodermal pentactin, illustration traced from light microscope image, scale 100  $\mu\text{m}$ ; E. Atrial hexactine, illustration traced from light microscope image, scale 100  $\mu\text{m}$  F. End of choanosomal diactin, scale 200  $\mu\text{m}$ , light microscope; G. Dermal diactin, scale 100  $\mu\text{m}$ , light microscope; H. Hemioxyhexaster, scale 10  $\mu\text{m}$ , SEM; I. Strobiloplumicome, scale 10  $\mu\text{m}$ , SEM, the frontal ray is missing.

Figure 4. *Sympagella walleri* sp. nov. Type specimen MNHNCL POR-15003, strobiloplumicome image G from BELUM.Mc2015.313. A. Collected specimen; B. End of diactin, scale bar 200  $\mu\text{m}$ , light microscope; C. Dermal pentactin, scale bar 100  $\mu\text{m}$ , illustration traced from light microscope image; D. Dermal hexactin, scale bar 100  $\mu\text{m}$ , illustration traced from light microscope image; E. Pinular hexactin, scale bar 10  $\mu\text{m}$ , SEM; F. Discohexaster, scale bar 10  $\mu\text{m}$ , SEM; G, H. Strobiloplumicome, scale bar 10  $\mu\text{m}$ , SEM.

Figure 5. *Caulophacus palmeri* sp. nov. Type specimen MNHNCL POR\_15001. A. collected specimen, scale in cm; B. end of diactin, scale bar 10  $\mu\text{m}$ , SEM; C. pentactin, scale bar 100  $\mu\text{m}$ , illustration traced from light microscope image; D. hexactin, scale bar 100  $\mu\text{m}$ , illustration traced from light microscope image; E. pinular hexactin, scale bar 10  $\mu\text{m}$ , SEM; F. discohexactin, scale bar 10  $\mu\text{m}$ , SEM.

Figure 6. *Rossella antarctica*: A. Collected specimen BELUM.Mc2015.284; B. Specimen BELUM.Mc2015.335; C. Rays of a calycocome from BELUM.Mc2015.284 (scale bar 10 $\mu\text{m}$ ); D. Microdiscohexaster from BELUM.Mc2015.284 (scale bar 10  $\mu\text{m}$ ).