

Another bipolar deep-sea anemone: new species of *Iosactis* (Actiniaria, Endomyaria) from Antarctica

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Abstract A new species of deep-sea burrowing sea anemone is described and illustrated from Antarctica. *Iosactis antarctica* sp. nov. is characterised by easily deciduous tentacles with sphincters in the base, smooth column, endodermal marginal sphincter, same mesenteries proximally and distally, 24 perfect mesenteries regularly arranged, diffuse retractor musculature and basilar muscles well developed. *Iosactis antarctica* sp. nov. is the second species of the deep-sea abyssal genus *Iosactis*; it differs from *I. vagabunda* in internal anatomy, cnidae and geographic distribution. The description of *I. antarctica* sp. nov. provides the opportunity to reevaluate the morphology of the proximal end of this genus.

Keywords Anthozoa · Cnidaria · Deep-sea · Scotia Sea · Taxonomy

Introduction

Recent discoveries of sea anemone biodiversity on some of the most unknown areas of the Antarctic deep-sea, such as the Scotia Sea, show more and more examples of deep-sea polar actinarians with a bipolar distribution sensu Stepanjants et al. (2006) (see Rodríguez et al. 2009). Examples of these are the genera *Actinoscyphia* Stephenson, 1920; *Antipodactis* Rodríguez, López-González and Daly,

2009; *Bolocera* Studer, 1879; *Kadosactis* Danielssen, 1890 and *Liponema* Hertwig, 1882 (see Rodríguez et al. 2009). These genera are similar in being relatively homogenous in morphology; species within each tend to differ only slightly in anatomy and are primarily distinguished by geography (see Dunn 1983; Riemann-Zürneck 1986; Rodríguez and López-González 2005).

Here, I describe a new species of sea anemone from polar seas, *Iosactis antarctica* sp. nov., from 16 specimens in the Scotia Sea (Antarctica). This new species makes *Iosactis* Riemann-Zürneck, 1997 the 12th genus of deep-sea anemone with a bipolar distribution. *Iosactis antarctica* sp. nov. is the second species of the genus, differing in internal anatomy, cnidae and geographic distribution from its congener in the Northern hemisphere, *I. vagabunda* Riemann-Zürneck, 1997. Additionally, the description of *I. antarctica* sp. nov. provides the opportunity to re-evaluate the morphology of the proximal end of this genus.

Materials and methods

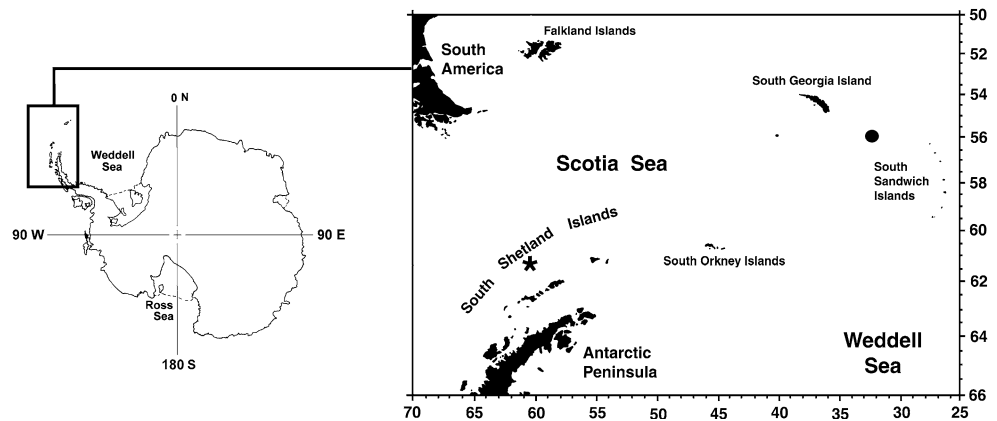
The material studied was collected on the USARP ELT-ANIN 9 cruise in 1974 to the Scotia Sea (Antarctica) (Fig. 1). The material was deposited at the US National Museum of Natural History (USNM), where was discovered by the author during a visit. Additional material was collected on the R/V *Polarstern* cruise ANT XIX/3 (ANDEEP-I) sponsored by the Alfred-Wegener-Institut für Polar-und Meeresforschung, Bremerhaven, during the austral summer of 2002 to the Scotia Sea (Antarctica).

Sea anemones were fixed in 10% sea-water formalin. Preserved specimens were examined whole and some were dissected. Parts of five specimens were dehydrated in butanol (Johansen 1940) and embedded in paraffin.

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Fig. 1 Geographic distribution of *Iosactis antarctica* sp. nov. A circle marks the type locality, a star the additional locality



Histological sections 7–10- μ m thick were stained with Ramón y Cajal's Triple Stain (Gabe 1968).

Measurements of cnidae were made from preserved material; small pieces of tissue were smeared on slides and examined using DIC microscopy at 1000 \times magnification. We scanned through the slides and haphazardly measured 20 capsules of each type (when possible) to generate a range: frequencies given are subjective impressions based on all the cnidae seen on the slides. For each type, a mean and standard deviation has been provided to give an idea of the distribution of sizes; these are not statistically significant (see Williams 1998, 2000 for minimal requirements of statistical significance in cnida sizes), but provide some qualitative information about variability in capsule size for each type of nematocyst. Cnida terminology generally follows Mariscal (1974).

The studied material has been deposited in the American Museum of Natural History in New York (AMNH), and the USNM.

Results

Order Actiniaria Hertwig, 1882

Suborder Nynantheae Carlgren, 1899

Superfamily Endomyaria Stephenson, 1921

Family Iosactiidae Riemann-Zürneck, 1997

Diagnosis (Modified from Riemann-Zürneck 1997, modifications in italics)

Endomyaria with well-developed or without basilar muscles. Column undifferentiated, smooth, aboral end rounded, with a central, small, invaginated pedal disc. Endodermal marginal sphincter muscle. Twenty-four (?) tentacles, non-retractile, easily deciduous with sphincter in base. Mesenteries regularly arranged, not differentiated into macro- and microcnemes. Same number of mesenteries proximally and distally. Twenty-four mesenteries, all

perfect and fertile. Column with strong circular endodermal muscles. Mesenteries with strong parietobasilar muscles and weak diffuse retractors. Cnidom: *Robust* spirocysts, basitrichs, microbasic *b*- and *p*-mastigophores.

Type genus *Iosactis* Riemann-Zürneck, 1997, by monotypy.

Genus *Iosactis* Riemann-Zürneck, 1997

Diagnosis

Same as for the family.

Type species *Iosactis vagabunda* Riemann-Zürneck, 1997, by original designation.

Iosactis antarctica sp. nov.
(Figs. 1, 2, 3, 4; Table 1)

Type material Holotype: USNM (1155319), 1 specimen, USARP-Eltanin cruise 9, st. 722, Scotia Sea (Antarctica), 56°04'S–56°00'S 33°59'W–33°57'W, 3,138–3,239 m depth, 08 Sep 1963, 5' Blake trawl. Paratypes: AMNH, 1 specimen; USNM (1155320), 13 specimens; same data as those of holotype for all lots of material.

Additional material AMNH, 1 specimen, Polarstern ANT XIX/3, stn. PS61/114-10, Scotia Sea (Antarctica), 61°43.70'S 60°42.62'W, 2,852.9–2,856.2 m depth, 19 Feb 2002, Agassiz trawl.

Description

External anatomy Body elongate (Fig. 2a, b), undifferentiated; column of preserved specimens to 16 mm diameter and 40 mm height. Proximal end rounded with small, central, invaginated pedal disc, to 4 mm in diameter (Figs. 2b–d, 3g). Scapus smooth (Fig. 2), delicate, with 24 mesenterial insertions strongly marked in preserved specimens.

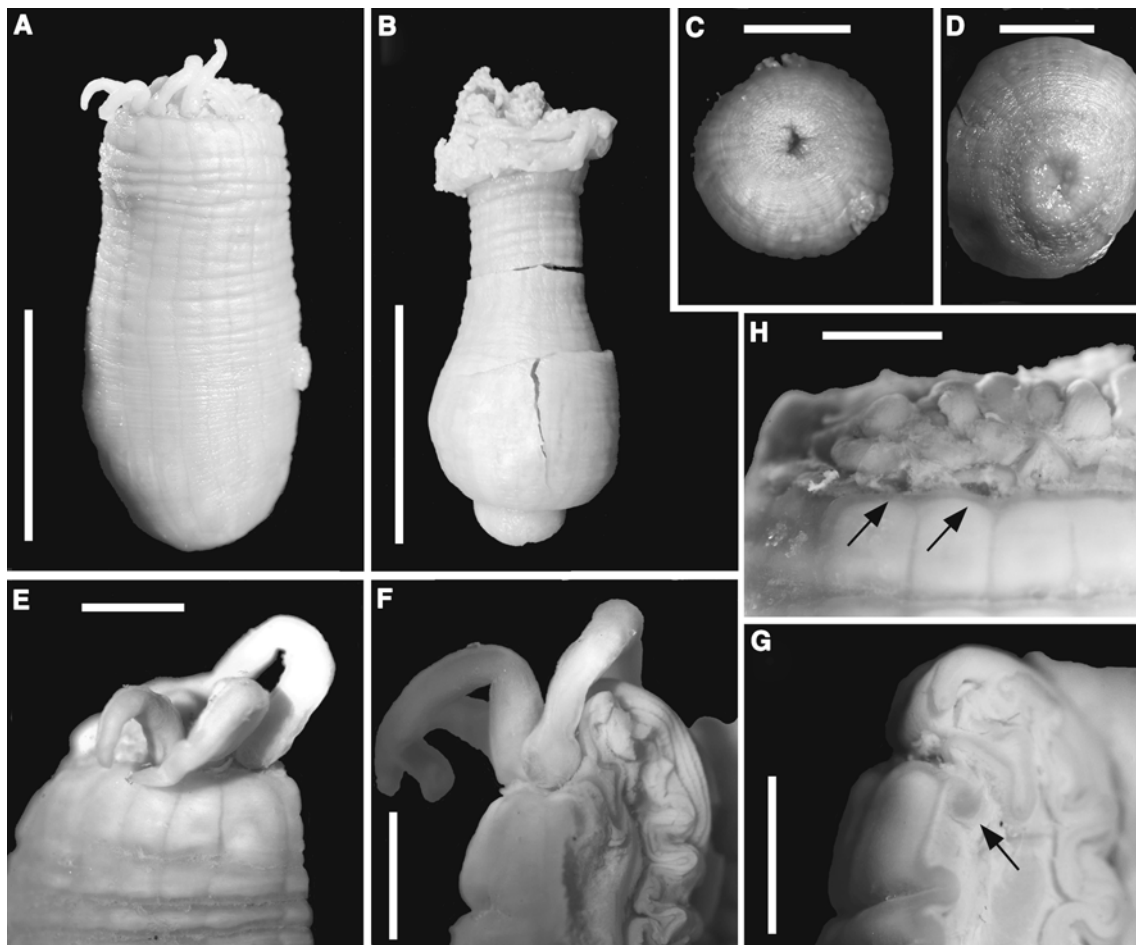


Fig. 2 External anatomy of *Iosactis antarctica* sp. nov. **a** Lateral view of a preserved specimen (USMH 1155319) bearing several tentacles. **b** Lateral view of preserved specimen without tentacles (AMNH); note the damaged oral disc. **c** and **d** Detail of the proximal end showing the invaginated pedal disc. **e** Detail of the tentacles in specimen USMN (1155319); note that each tentacle corresponds with

one endo- or exo-coel. **f** Detail of the base of a tentacle (USMN 1155319); note the anchorage of the tentacle to the margin of the oral disc. **g** Lateral view of the orifice left by a detached tentacle (USMN 1155319); note the endodermal marginal sphincter (*arrow*). **h** Detail of two orifices left by detached tentacles (*arrows*). *Scale bars* **a** 15 mm; **b** 20 mm; **c**, **d** 4 mm; **e**, **f**, **g**, **h** 2 mm

Oral disc of slightly contracted preserved specimens to 15 mm and damaged with internal parts protruding in all specimens examined (Fig. 2b). Tentacles 24(?) in number, easily deciduous (detached—in most specimens), long (to 10 mm) and relatively tough in preserved specimens (Fig. 2a, e, f). Tentacles restricted to margin of oral disc and probably non-retractile, with a well-developed basal sphincter (Fig. 3a, c).

Internal anatomy Mesenteries hexamerously arranged in two perfect cycles (Fig. 3b). Same number of mesenteries proximally and distally. Two pairs of directives each attached to a well-developed siphonoglyph (Fig. 3b, d). All mesenteries fertile, including directives. Gonochoric specimens collected in February and September with gametogenic tissue well developed (oocytes 500–1,300 μm and spermatocysts 190–404 μm in diameter, respectively). Retractor muscles of mesenteries diffuse (Fig. 3d).

Parietobasilar muscles strong, well differentiated on both sides of all mesenteries (Fig. 3b, c); muscle fibres on long and thin mesogleal pennon. Basilar muscles well developed (Fig. 3j).

Endodermal marginal sphincter muscle diffuse to moderately circumscribed (Fig. 3a, e, f, h). Ectodermal longitudinal muscles of tentacles and radial muscles of oral disc not observed, absent (?) (Fig. 3i). Column with strong endodermal circular muscles (3a). Column wall of similar thickness entire length, relatively thin: epidermis 0.06–0.19 mm thick; mesoglea 0.12–0.19 mm thick, and gastrodermis 0.17–0.38 mm thick at level of actinopharynx.

Cnidom Robust spirocysts, basitrichs, and microbasic *b*- and *p*-mastigophores (Fig. 4). See Table 1 for size and distribution.

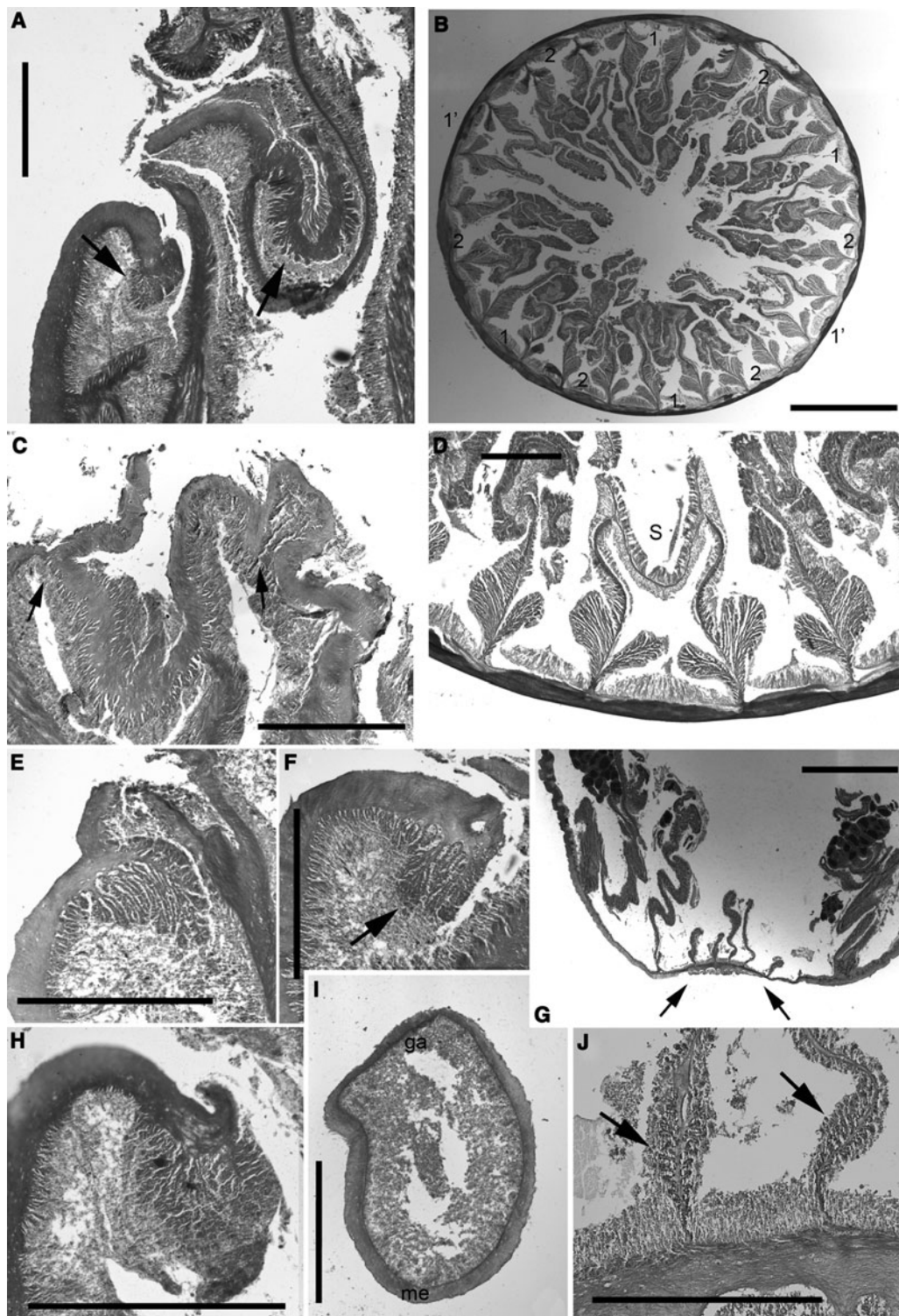
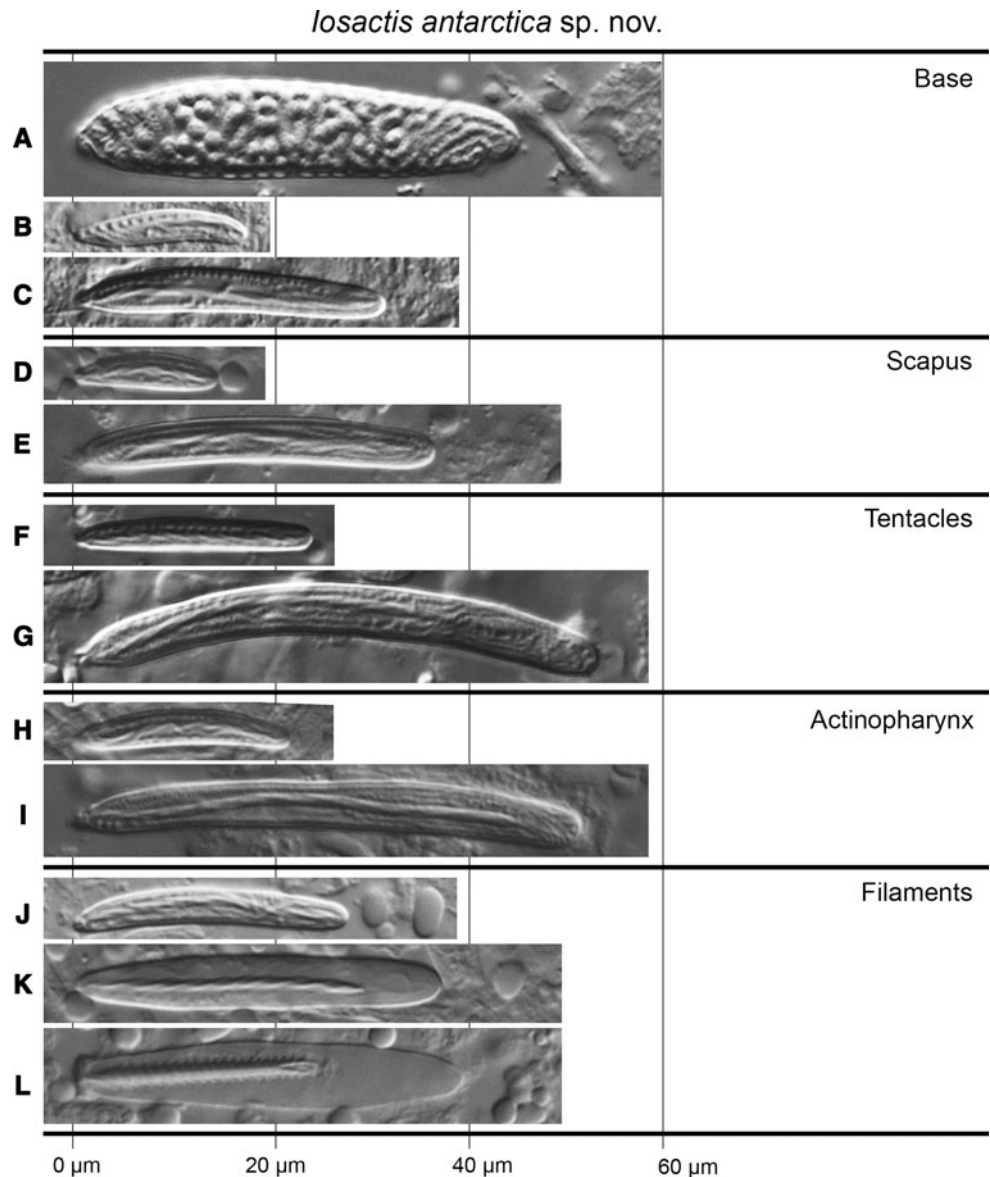


Fig. 3 Internal anatomy of *Iosactis antarctica* sp. nov. **a** Longitudinal section of the distal column showing the endodermal marginal sphincter muscle and the sphincter in the base of the tentacle (*arrows*); note the well-developed circular musculature in the column. **b** Cross section of the column through the mesenteries at the level of the actinopharynx showing the cycles of mesenteries; numbers between pairs indicate the cycle of mesenteries. **c** Detail of the sphincter of a tentacle; note the muscle fibres along the entire base of the tentacle.

d Detail of the directive mesenteries, the retractor and the parietobasilar muscles. **e**, **f** and **h** Detail of the marginal column showing the endodermal diffuse to moderately circumscribed marginal sphincter in different specimens. **g** Longitudinal section of the proximal column showing the invaginated pedal disc (*arrows*). **i** Cross section of a tentacle. **j** Detail of a longitudinal section of the proximal end showing the well-developed basilar muscles. *ga* gastrodermis, *me* mesoglea, *s* siphonoglyph. *Scale bars a, c, d, e, f, h, i, j 0.5 mm; b, g 2 mm*

Fig. 4 Cnidae of *Iosactis antarctica* sp. nov. **a** Robust spirocyst. **b** Basitrich 1. **c** Basitrich 2. **d** Basitrich 1. **e** Basitrich 2. **f** Basitrich 1. **g** Basitrich 2. **h** Basitrich 1. **i** Basitrich 2. **j** Basitrich 1. **k** Microbasic *b*-mastigophore. **l** Microbasic *p*-mastigophore



Colour Preserved material uniform pink to peach.

Etymology

The specific epithet refers to the place where specimens have been collected (Antarctica).

Geographic and bathymetric distribution

Iosactis antarctica sp. nov. has been collected from abyssal waters (2,852–3,239 m) in the Scotia Sea, off the South Sandwich and South Shetland Islands (see Fig. 1). *Iosactis antarctica* sp. nov. co-exists with other actinarians: *Actinocyphia plebeia* (McMurrich, 1893); *Antipodactis scotiae* Rodríguez, López-González and Daly, 2009; *Aulactinia sulcata* (Clubb, 1902) and *Kadosactis*

antarctica (Carlgren, 1928). In the South Sandwich Islands (type locality), *I. antarctica* sp. nov. has been collected with the three former species, whereas in the South Shetlands Islands, it was collected together with all species but *A. sulcata* (Dunn 1983; Fautin 1984; Rodríguez and López-González 2005; Rodríguez et al. 2009).

Discussion

Differential diagnosis of *Iosactis* species

As is true for other deep-sea actinarians, *Iosactis antarctica* sp. nov. and *I. vagabunda* are morphologically relatively similar species; however, they differ in size, internal anatomy, cnidae and geographic distribution. Although

Table 1 Size ranges of the cnidae of *Iosactis antarctica* sp. nov. and *I. vagabunda* (data for *I. vagabunda* from Riemann-Zürneck, 1997)

Categories	Range of length and width of capsules (μm) <i>I. antarctica</i> sp. nov.	$\bar{X} \pm \text{SD}$	<i>S</i>	<i>N</i>	<i>F</i>	Range of length and width of capsules (μm) <i>I. vagabunda</i>
PEDAL DISC						
Robust spirocysts	(23.0–44.0) \times (7.0–10.0)	37.6 \pm 4.2 \times 8.1 \pm 0.6	4/4	45	+ / + +	(27–33) \times (7–8.5)
Basitrichs 1	(13.0–16.0) \times (3.0–4.0)	14.7 \pm 1.0 \times 3.0 \pm 0.2*	4/4	23	--- / + + +	(11–12) \times (2.5–3)
Basitrichs 2	(25.0–35.0) \times (3.0–5.0)	28.8 \pm 2.2 \times 4.0 \pm 0.2	4/4	71	+ + / + + +	(21–26) \times (3.5–4)
SCAPUS						
Basitrichs 1	(13.4–19.3) \times (2.8–4.1)	16.4 \pm 1.3 \times 3.3 \pm 0.4	4/4	68	+ + / + + +	(10.5–13.0) \times (2.5–3)
Basitrichs 2	(29.0–40.0) \times (4.0–5.7)	35.4 \pm 2.2 \times 4.5 \pm 0.4	4/4	62	+ / + + +	(23.5–30.0) \times (3.5–4.5)
TENTACLES						
Basitrichs 1	(19.0–31.0) \times (3.0–4.4)	22.9 \pm 3.2 \times 3.3 \pm 0.5*	3/3	36	+ / + +	(19–25) \times (3–3.5)
Basitrichs 2	(44.0–55.0) \times (4.0–5.0)	48.7 \pm 2.5 \times 4.7 \pm 0.5	2/3	40	+ + / + + +	(39–45) \times (3.5–4.5)
ACTINOPHARYNX						
Basitrichs 1	(17.0–29.0) \times (2.7–4.0)	22.3 \pm 2.8 \times 3.4 \pm 0.5	4/4	62	+ / + + +	(13.5–26) \times (3–3.5)
Basitrichs 2	(39.0–57.0) \times (4.0–5.0)	47.0 \pm 3.9 \times 4.8 \pm 0.4	4/4	69	+ + / + + +	(33–43) \times (4–4.5)
FILAMENTS						
Basitrichs	(17.0–32.0) \times (3.0–5.0)	25.8 \pm 2.7 \times 3.6 \pm 0.5	4/4	66	+ + +	(15–22) \times (3)
<i>M b</i> -mastigophores	(31.0–45.0) \times (5.6–7.0)	40.3 \pm 3.6 \times 6.1 \pm 0.3*	4/4	32	+ / + + +	(33–40) \times (5–6)
<i>M p</i> -mastigophores	(29.0–41.0) \times (4.0–7.0)	36.6 \pm 3.0 \times 5.8 \pm 0.7*	4/4	37	+ / + +	(30–35) \times (4.5–6)

\bar{X} mean length by mean width of capsules. *SD* standard deviation. *S* ratio of number of specimens in which each cnidae was found to number of specimens examined. *N* total number of capsules measured. *F* frequency, +++ = very common, ++ = common, + = rather common, --- = sporadic. *M* Microbasal. Mean values marked with an asterisk are based on fewer than 40 capsules. Values from pooled samples of similar sizes

differences in size (especially in the tentacles) might be an artefact between the two species and are highly dependent on preservation conditions in sea anemones (Stephenson 1920), *I. antarctica* sp. nov. is almost twice the size of *I. vagabunda* (to 400 μm length and to 250 μm , respectively). Furthermore, although *I. antarctica* sp. nov. is relatively larger than *I. vagabunda*, tentacles are considerably longer in the latter (to 10 mm vs. 25 mm, respectively). Specimens of both species were preserved similarly and their shapes are very similar (see Fig. 1 and Riemann-Zürneck 1997, Fig. 2), suggesting that preservation artefacts should pertain equally and uniformly to both species. Furthermore, Riemann-Zürneck (1997) described the tentacles of *I. vagabunda* as ‘probably non-retractile’; the fact that her specimens lack longitudinal muscles in the tentacles might be related with the lack of capacity to retract the tentacles; however, her specimens were missing the epidermis and so might be expected to lack epidermal musculature. Some of the tentacles of *I. antarctica* sp. nov. still retained the epidermis, but even in these, no longitudinal muscles have been detected; the tentacles of *I. antarctica* sp. nov. are also probably non-retractile. Thus, there is no evidence to expect that the differences in body and tentacle size are an artefact of preservation in this case.

The deciduous tentacles each bearing a sphincter in the base is probably the most distinctive character of *Iosactis*.

Both species of *Iosactis* differ in the morphology of the tentacular sphincter: in *I. antarctica* sp. nov., the muscle fibres of the sphincter are distributed along the entire base of the tentacle, whereas in *I. vagabunda*, the fibres are restricted to the central part of the base of the tentacle (see Fig. 3a, c and Riemann-Zürneck 1997, Fig. 6b). Although there are other endomyarian (*Bolocera*; *Leipsoceras* Stephenson, 1918; *Liponema*) and related actiniarian genera (*Boloceractis* Panikkar, 1937; *Bolocerooides* Carlgren, 1899 and *Bunodeopsis* Andres, 1881; within the infraorder Bolocerooidaria Carlgren, 1924) with a sphincter in the tentacles, it is not a common feature within Actiniaria (only 6 genera of the 430 genera within the order). Like *Iosactis*, *Bolocera* and *Liponema* are deep-sea bipolar genera; however, molecular data suggest that not all genera with tentacular sphincters are closely related (ER unpubl. data), supporting Riemann-Zürneck’s (1997) contention that this might be an adaptation to the deep-sea environment.

Riemann-Zürneck (1997) commented that the central pit at the proximal end in *Iosactis vagabunda* seemed as a small, invaginated pedal disc; however, she did not find basilar muscles in *I. vagabunda* or provided any picture of the aboral end of *I. vagabunda*. Thus, according to Riemann-Zürneck’s (1997) description, the well-developed basilar muscles in *I. antarctica* sp. nov. (Fig. 3j) distinguish it from *I. vagabunda*. Additionally, these basilar

muscles confirm that, although small, *Iosactis* species have a pedal disc. Thus, the diagnosis of the family and genus has been modified accordingly.

Both species of *Iosactis* are the same in having 12 pairs of perfect and fertile mesenteries and diffuse retractor muscles but strong parietal muscles. However, the morphology of the endodermal marginal sphincter differs: in *I. antarctica* sp. nov., the sphincter is diffuse to moderately circumscribed (with a few relatively thin mesogleal processes) (Fig. 3a, e, f, h), whereas in *I. vagabunda*, the sphincter is circumscribed-pinnate, with the muscle fibres sited on a well-developed and relatively thick branch of mesoglea (see Riemann-Zürneck 1997, Fig. 6b). The variation of the sphincter shape depends on the species; on some of them, the sphincter shape is of uniform appearance, whereas in others, the sphincter varies depending on the contraction of the specimen (England 1987). The variability of the sphincter within *I. antarctica* sp. nov. has been checked by sectioning four specimens in different states of contraction.

The types and size ranges of cnida are very similar in the species of *Iosactis* (Table 1; Fig. 4). However, there are slight differences: the basitrichs in the filaments and the basitrichs 1 in the base and scapus of *I. antarctica* sp. nov. are larger than those of *I. vagabunda*. Furthermore, despite the overlap in size ranges for most types of nematocysts, the cnidae of *I. antarctica* sp. nov. are notably larger than those of *I. vagabunda*; in most cases the size ranges overlap only slightly (e.g. basitrichs 2 in the base, scapus and tentacles overlap only in 1 µm, see Table 1). Although three specimens of *I. antarctica* sp. nov. had few undamaged tentacles (with epidermis still present) attached, spirocysts were not found in the tentacles, as occurs in *I. vagabunda*. As in *I. vagabunda*, robust spirocysts were found in the pedal disc of *I. antarctica* sp. nov. The presence of spirocysts in the pedal disc ('aboral pit' in *I. vagabunda*), but not in the column of the species of *Iosactis*, supports the interpretation that the aboral end is a pedal disc in this genus.

Iosactis antarctica sp. nov. has been found in deep Antarctic seas; *I. vagabunda* has been found in the abyssal Porcupine planes in the North Atlantic Sea. Both species have been collected from abyssal soft bottoms. Riemann-Zürneck (1997) considered *I. vagabunda* endemic to the abyssal Porcupine planes based on the particularity of this habitat (see Rice et al. 1994) and her own observations. *Iosactis antarctica* sp. nov. has been found in two localities, with relatively large distance between them; this suggests that *I. antarctica* sp. nov. has a less restricted distribution than *I. vagabunda*. Because of the restricted distribution of *I. vagabunda*, genetic connection between both species of *Iosactis* is unlikely, further supporting the distinction between *I. antarctica* sp. nov. and *I. vagabunda*.

Deep-sea bipolar sea anemones

As is true for other bipolar deep-sea species of sea anemones, in *Iosactis* species, the differences between anatomy and cnidae are relatively small (e.g. *Antipodactis*, *Bolocera*, *Kadosactis*, *Liponema*, see Dunn 1983; Riemann-Zürneck 1986; Rodríguez and López-González 2005; Rodríguez et al. 2009). Furthermore, some of these genera have some morphological characters in common (e.g. deciduous tentacles with sphincters, cnidom, etc.). However, the most significant common feature is their life in deep-water habitats on unconsolidated sea floors. This suggests that although there may be a strong selection for certain adaptations in the deep-sea, cnida size is not under strong selective pressure in deep and polar seas. Increasing our knowledge on some areas of deep-sea in Antarctica, such the Scotia and the Weddell seas, will slowly help discerning broader patterns of distribution and evolution of this particular actiniarian fauna.

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