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A new carnivorous sponge (Porifera) from the Coral Sea

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ABSTRACT

A new species of carnivorous sponge, *Lycopodina coralseaensis* sp. nov., family Cladorhizidae, is described from the Louisiade Plateau, Coral Sea, off the east coast of Australia at bathyal depths of ~2000 m, collected during the RV *Investigator* 2019 voyage. The new species differs from other *Lycopodina* with stipitate morphology by lacking forceps microscleres, similar to *L. nikitawimandi* Ekins *et al.*, 2020a but differing in having only a very small single size class of palmate anisochelae, and most importantly by having a third category of mycalostyle echinating the stem and basal holdfast. This new species is the sixth *Lycopodina* recently described as new from the Australian Exclusive Economic Zone (*L. nikitawimandi, L. helios, L. cassida, L. brochidodroma* and *L. hystrix*), bringing the total number of carnivorous sponges known so far from Australia to 26.

❑ *Porifera, Cladorhizidae, Queensland, Tasmantid, seamounts, Lycopodina, new species.*

Carnivorous sponges (Cladorhizidae, Poecilosclerida) are unique amongst the Porifera, by having a reduced aquiferous system and an ability to capture and digest prey. They are predominantly a deep-water group living in bathyal to abyssal depths (Hestetun *et al.* 2017a) are are frequently found at oceanic ridges and seamount systems, with new species continuously discovered as new areas are explored. While they were first discovered in the mid 19th century, their diversity, taxonomy and geographic distributions are still poorly known due to their deep-sea life-style. However, recent advancements in technology have enabled greater exploration of these deep-sea habitats resulting in the recent escalation in the discovery of a much higher biodiversity than previously thought, leading new expeditions to discover many undescribed species - 23 of which were published in 2020 from Australasian waters alone (e.g. Ekins *et al.* 2020a, 2020b; Vacelet 2020).

The carnivorous sponge family Cladorhizidae Dendy, 1922 currently contains thirteen genera (*Abyssocladia* Lévi 1964, *Abyssosdiskos* Ekins *et al.* 2020b, *Asbestopluma* Topsent, 1901, *Axoniderma* Ridley & Dendy, 1886, *Bathytentacular* Ekins *et al.* 2020b, *Cercicladia* Rios *et al.*, 2011, *Chondrocladia* Thomson, 1873, *Cladorhiza* Sars, 1872, *Eucheliplum*a Topsent, 1909, *Koltunicladia* Hestetun *et al.*, 2016, *Lollipocladia* Vacelet 2008, *Lycopodina* Lundbeck, 1905 and *Nullarbora* Ekins *et al.*, 2020b) and five subgenera (*Asbestopluma (Asbestopluma)* Topsent, 1901, *Asbestopluma (Helophloeina)* Topsent, 1929, *Chondrocladia* (*Chondrocladia)* Thomson, 1873, *Chondrocladia* (*Meliiderma)* Ridley & Dendy, 1887 and

Chondrocladia (*Symmetrocladia)* Lee *et al.,* 2012), with 197 species described up to the present (Van Soest *et al.* 2020).

During August to September 2019, the RV *Investigator* (cruise IN2019_V04) mapped the seafloor and sampled the rocks and biology along the Tasmantid Seamounts, the Louisiade Plateau and Lord Howe Seamounts - one of the world's most extensive intraplate volcanic regions within the Coral Sea (Knesel *et al.* 2008; Richard *et al.* 2018). To date, this is only the second major expedition to sample the deep-sea biology of this general region between ~700 and ~3700 m depth, the first of which being the CIDARIS project from 1986 to 1992 (e.g. Pichon *et al.,* 1986). Specimens collected from the CIDARIS project are still being examined, leading to the descriptions of new species (e.g. Crowther *et al.* 2011), and range expansions of known species of other phyla to the region (e.g. Horowitz *et al.* 2018). A carnivorous sponge *Abyssocladia desmophora* (Hooper & Lévi, 1989) was discovered during the CIDARIS expeditions on the edge of the Australian continental shelf off Queensland at ~1200 m depth. More recently, another carnivorous sponge was found from within the Australian EEZ of the Coral Sea, *Chondrocladia* (*Chondrocladia*) *zygainadentonis* Ekins *et al.,* 2020a, from the edge of the continental shelf at ~1800 m depth. Other carnivorous species recorded from elsewhere in the Coral Sea include *Asbestopluma (Asbestopluma) biserialis* (Ridley & Dendy, 1886), from New Caledonia, *Cladorhiza similis* Ridley & Dendy, 1886, *Cladorhiza schistochela* Lévi, 1993, *Chondrocladia (Chondrocladia) pulvinata* Lévi 1993, *C.(C.) scolionema* Lévi, 1993 and most recently *Abyssocladia kanaconi* Vacelet, 2020, *A. microstrongylata* Vacelet, 2020 and *A. mucronata* Vacelet, 2020. For a list of descriptions including those from the east coast of Australia and the Pacific see Ekins *et al.* (2020a).

This present work describes another new species of Cladorhizidae, collected from the east coast of Australia during the 2019 research expedition of the *RV Investigator* to the Louisiade Plateau in the Coral Sea. The IN2019_V04 voyage collected 42 sponge specimens that have been deposited at the Queensland Museum, among which were three small Cladorhizidae (Figs 1-2). These samples build on recent contributions to the Australian cladorhizid fauna in which 17 new species were described from the east coast of Australia (Ekins *et al.* 2020a), and three new species from Great Australian Bight (Ekins *et al.* 2020b). The current list of species known so far from the Australian Exclusive Economic Zone (EEZ) are listed in Table 1.

MATERIALS AND METHODS

Collection methods. For details of collection methodology refer to Lucieer *et al.* (2020).

Morphological analysis. Scanning Electron Microscope (SEM) spicule preparations were made by dissolving the tissue in 12.5% sodium hypochlorite to remove the soft tissue, and neutralised in distilled water, rinsed twice in 70% ethanol and then finally rinsed twice in 98% ethanol and then air-dried. SEM preparations were sputter coated in gold to improve resolution. The scanning electron micrograph photos and measurements were made using a Hitachi TM-1000 SEM and plates assembled in Adobe Photoshop. Spicule dimensions were measured using SEM tools, and represented as minimum – (mean) – maximum lengths x widths of each spicule category. Nomenclatural acts proposed below are to be understood as authored by Merrick Ekins and John Hooper under ICZN Article 50.1 (ICZN, 1999).

RESULTS

SYSTEMATICS

Phylum PORIFERA Grant, 1836
Class DEMOSPONGIAE Sollas, 1885
Subclass HETEROSCLEROMORPHA
Cárdenas *et al.*, 2012
Order POECILOSCLERIDA Topsent, 1928a
Family CLADORHIZIDAE Dendy, 1922
Cladorhizeae Dendy, 1922:58
Cladorhizidae de Laubenfels, 1936:122.

Genus *Lycopodina* Lundbeck, 1905
Asbestopuma (*Lycopodina*) Lundbeck, 1905: 58.
Lycopodina Lundbeck, 1905: 58.
Cotylina Lundbeck, 1905: 68; de Laubenfels 1936: 122.

***Lycopodina coralseaensis* sp. nov.**
Ekins & Hooper
(Figs 3-4, Tables 1-2)
urn:lsid:zoobank.org:act:2EE2E9CB-F246-4202-8AAE-F68F868B1E5A)

Material Examined. Holotype: QM G339172, Louisiade Plateau, Coral Sea, Australia, IN2019_V04_30, 14°26.6′ S, 155°48.32′ E - 14°27.07′ S, 155°48.5′ E, 1954-2814 m, Rock Dredge, Coll. Jeremy Horowitz, CSIRO on RV Investigator, Cruise IN2019_V04, Sample iv89, 20/VIII/2019. Paratype: QM G339173 same collection data as QM G339172, Sample iv90, 20/VIII/2019. Paratype: QM G339215 same collection data as QM G339172, Sample iv89.

Distribution. Known so far only from the Louisiade Plateau, Coral Sea, Australia, at bathyal depths.

Etymology. *Coralseaensis,* named after the Coral Sea type locality.

DESCRIPTION

Growth form. Erect stipitate, arbuscular, clavate-shaped body, with a very hispid array of filaments arising at all angles from the body, supported by a long stem and a globular basal attachment (Fig. 3A). The holotype, QM G339172, is 8 mm in total length, with the sponge body 4 mm in length and 1.5 mm in diameter including the projecting filaments. Paratype QM G339173 has a total length of 9.6 mm, with the body only 4.3 mm in length, and 1.8 mm in width. Paratype QM G339215 has a total length of 26.2 mm, body 5 mm wide, 11.8 mm long (Fig. 3B).

Colour. Alive on-deck the body, stem, basal disc and base of the filaments were cream. After preservation in ethanol the sponges retained their cream colouration.

Ectosomal skeleton. A thin membranous ectosome covers the sponge with anisochelae embedded in the outer surface of the ectosome, including the terminal end of the basal attachment.

Choanosomal skeleton. The skeleton consists of several bundles of the larger mycalostyles 1 forming the longitudinal axis extending from the base of the stem to the top of the sponge body (Figs. 3 D-E, 4C). At right angles to the axial core are bundles of medium sized mycalostyles 2 forming bouquets along the length of these tracts (Figs 3F-G, 4B). The stem and basal attachment of the sponge is echinated by the smaller subtylote mycalostyles 3 (Figs 3H-I, 4C-D).

Megascleres. Megascleres consist of three categories of mycalostyles-tylostyles. Mycalostyles 1 of the body and stem are oxeote, having a long tapering point and a tapering rounded basal end, with the thickest part of the spicule approximately in the middle (Fig. 3D-E, Table 2). Dimensions: 507-2820 x 15-45 µm. The medium sized mycalostyles 2 that form the echinating bouquets tangential to the axial skeleton of the body are styles tending towards subtylostyles, with only a slight constriction near or at the basal end, and thickest diameter between the middle and one third towards the base (Fig. 3 F-G). Dimensions: 217-691 x 3-15 µm. The smaller basal styles 3 that echinate the stem and basal attachment are styles or only faintly subtylostyles, with their thickest diameter at the basal end (Fig. 3H-I, Table 2). Dimensions: 69-212 x 2-6 µm.

Microscleres. The microscleres consist only of a single size class of palmate anisochelae (Fig. 3C, Table 2). Dimensions 5.8-10.9 x 2.0-6.3 µm. Forceps found in the majority of other species of *Lycopodina* were absent in all three specimens known so far for this new species. The anisochelae have a single upper large frontal alae nearly completely detached from the two lateral alae which are completely fused to the fimbria, and two smaller lower alae nearly completely fused. The lower alae also has a central dominant tooth with three blunt terminal spines, and the other small alae directly behind it has four blunt teeth, arranged in pairs of unequal sizes.

Remarks. This new species shares similar stipitate morphology with ten other *Lycopodina* species (*L. nikitawimandi* Ekins *et al*., 2020a, *L. brochidodroma* Ekins *et al*., 2020a, *L. drakensis* Goodwin *et al*., 2017, *L. hystrix* Ekins *et al*., 2020b, *L. lycopodium* (Levinsen 1887), *L. microstrongyla* (Lopes *et al*., 2011), *L. novangliae* Hestetun *et al*., 2017b, *L. occidentalis* (Lambe, 1893), *L. tendali* Hestetun *et al*., 2017b and *L. vaceleti* (Van Soest & Baker 2011); see Table 14 in Ekins *et al.* 2020a). However, *L. coralseaensis* sp. nov. differs from

Table 1. Inventory of known Cladorhizidae species recorded from the Australian EEZ

Genus	Species	Distribution	Source
Abyssocladia	*annae* Ekins, Erpenbeck & Hooper, 2020	continental shelf of central New South Wales, Tasman Sea; abyssal	Ekins *et al.* 2020a: 23-25, Fig. 4
	desmophora (Hooper & Lévi, 1989)	continental slope off Townsville, Coral Sea, Queensland; bathyal	Hooper & Lévi 1989: 437-440, Figs 1-4
	escheri Ekins, Erpenbeck & Hooper, 2020	off Fraser Island, Queensland, Coral Sea; abyssal	Ekins *et al.* 2020a: 8,21-23, Fig. 2
	gliscofila Ekins, Erpenbeck & Hooper, 2020	continental shelf adjacent to the Hunter Valley Region, Tasman Sea, New South Wales, and off the Gold Coast, Coral Sea, Queensland; bathyal	Ekins *et al.* 2020a: 25-28, Fig. 5
	oxyasters Ekins, Erpenbeck, Goudie & Hooper, 2020	Nullarbor Canyon, Great Australian Bight, South Australia, Southern Ocean; bathyal	Ekins *et al.* 2020b: 247-251, Figs 4-6
Abyssosdiskos	*pentaeiros* (Ekins, Erpenbeck & Hooper, 2020)	off Bermagui, New South Wales, Tasman Sea; bathyal	Ekins *et al.* 2020a: 86-88, Fig. 17
Asbestopluma (Asbestopluma)	*desmophora* Kelly & Vacelet, 2011	seamounts on the Macquarie Ridge between Australia and New Zealand, Southwest Pacific; mesophotic-bathyal	Kelly & Vacelet 2011: 62-67, Figs 5-6
	maxisigma Ekins, Erpenbeck & Hooper, 2020	continental slope off Jervis Bay, New South Wales, Tasman Sea; bathyal	Ekins *et al.* 2020a: 28-29, 46, Fig. 6
Axoniderma	*australis* (Ekins, Erpenbeck & Hooper, 2020)	off Tasmania and New South Wales, Tasman Sea; abyssal	Ekins *et al.* 2020a: 47-49, 72, Figs 7-8
	poritea (Ekins, Erpenbeck & Hooper, 2020)	off Fraser Island, Coral Sea, Queensland, and Freycinet Peninsula, Tasman Sea, Tasmania; abyssal	Ekins *et al.* 2020a: 72-75, Figs 9-10
Bathytentacular	*moniqueae* (Ekins, Erpenbeck & Hooper, 2020)	off Newcastle, New South Wales, Tasman Sea; abyssal	Ekins *et al.* 2020a: 82-85, Figs 14-15
Chondrocladia (Meliiderma)	*tasmaniensis* Vacelet, Kelly & Schlacher-Hoenlinger, 2009	seamounts south of Tasmania, Tasman Sea; bathyal	Vacelet *et al.* 2009: 63-65, Fig. 4
Chondrocladia (Chondrocladia)	*callistemonex* Ekins, Erpenbeck & Hooper, 2020	off Newcastle, New South Wales, Tasman Sea; abyssal	Ekins *et al.* 2020a: 117-120, Figs 22-23
	clavata Ridley & Dendy, 1886	Fiji, Antarctica, Madagascar, New Zealand, and New South Wales, Tasman Sea; bathyal	Ridley & Dendy 1886:345; Ridley & Dendy 1887: 100, Pl. XX, Figs. 1, 1a, Pl. XXI, Fig. 11; Ekins *et al.* 2020a: 89-114, Figs 18-19
	freycinetensis Ekins, Erpenbeck & Hooper, 2020	off the Freycinet Peninsula, Tasmania, and Jervis Bay, New South Wales, Tasman Sea; bathyal	Ekins *et al.* 2020a: 114-117, Figs 20-21
	zygainadentonis Ekins, Erpenbeck & Hooper, 2020	off Gladstone, Coral Sea, Queensland; bathyal	Ekins *et al.* 2020a:120-123, Figs 24-25
Eucheliplum	*claudochela* Ekins, Erpenbeck & Hooper, 2020	off Central New South Wales, Tasman Sea; abyssal	Ekins *et al.* 2020a: 149-153, Fig. 32
Lycopodina	*brochidodroma* Ekins, Erpenbeck & Hooper, 2020	off Moreton Island, Coral Sea, Queensland; abyssal	Ekins *et al.* 2020a: 148-149, Fig. 31
	calyx Hentschel, 1914	Kaiser Wilhelm Land, Antarctica; Southern and central Eastern Australia, New South Wales and Victoria Tasman Sea; bathyal-abyssal	Hentschel 1914: 66, Pl. IV, Fig. 4, Pl. V, Fig. 11; Ekins *et al.* 2020a: 123-124, 140-141, Fig. 26
	cassida Ekins, Erpenbeck & Hooper, 2020	off Fraser Island, Coral Sea, Queensland; bathyal	Ekins *et al.* 2020a: 146-147, Fig. 30
	helios Ekins, Erpenbeck & Hooper, 2020	off Cape Barren Island, Flinders Central Marine Reserve, Tasman Sea, Tasmania	Ekins *et al.* 2020a: 144-146, Fig. 29
	hystrix Ekins, Erpenbeck, Goudie & Hooper, 2020	Yatala Canyon, Great Australian Bight, South Australia, Southern Ocean; bathyal	Ekins *et al.* 2020b: 252-254, Fig. 7
	nikitawimandi Ekins, Erpenbeck & Hooper, 2020	Central East coast and central Tasmania, Tasman Sea; bathyal-abyssal	Ekins *et al.* 2020a: 141-144, Figs 27-28
	coralseaensis sp. nov.	Louisiade Plateau, Coral Sea, Queensland; bathyal	Present study
Nullarbora	*investigator* (Ekins, Erpenbeck & Hooper, 2020)	off the Freycinet Peninsula, Tasman Sea, Tasmania; bathyal	Ekins *et al.* 2020a: 78-82, Figs 12-13
	heptaxia (Ekins, Erpenbeck, Goudie & Hooper, 2020)	Nullarbor Canyon, Great Australian Bight, South Australia, Southern Ocean; bathyal	Ekins *et al.* 2020b: 244-247, Figs 1-3

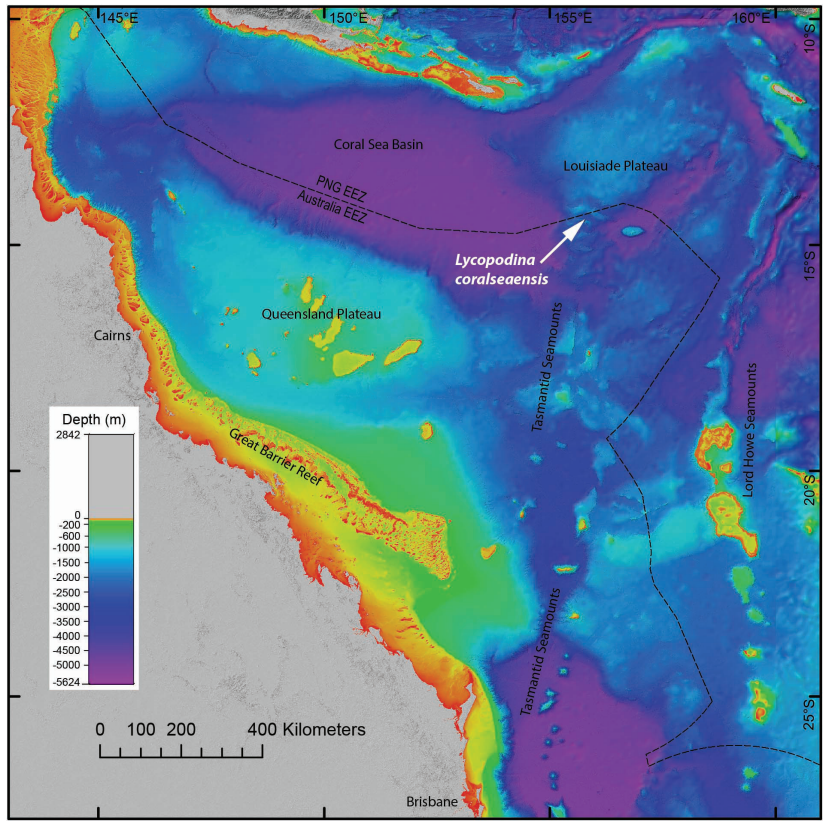

FIG. 1. Location of the *Lycopodina coralseaensis* sp. nov. in the Louisiade Plateau in the Coral Sea.

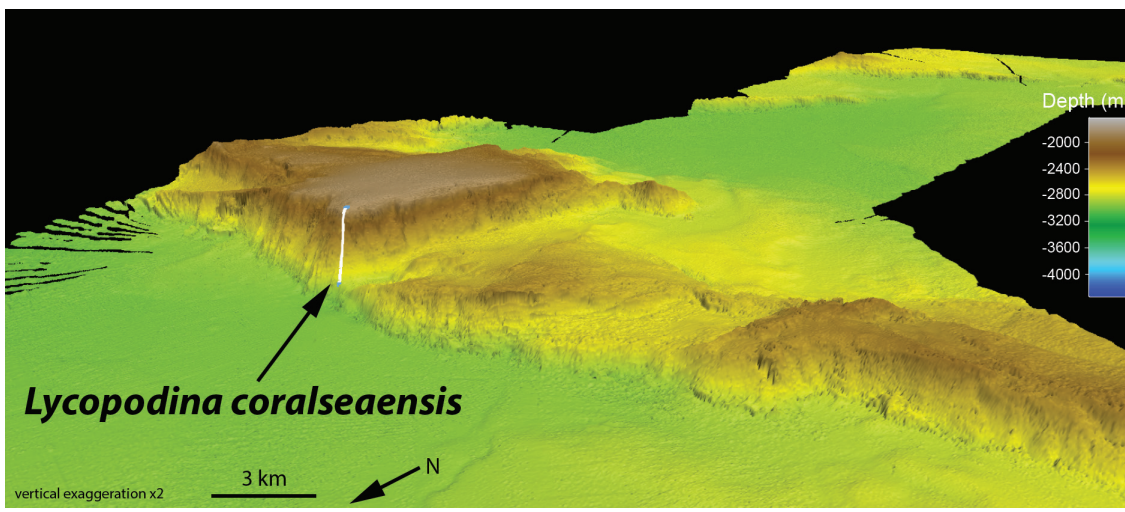

FIG. 2. A 3D view of the dredge 30 site at the crest of a ridge on the Louisiade Plateau, from which all the samples of *Lycopodina coralseaensis* sp. nov. were collected.

	Mycalostyle 1	Mycalostyle 2	Basal style	Anisochelae	Large basal style	Basal tylostyle	Basal strongyles	Forceps	Sigmancistra
Lycopodina coralseansis sp. nov. Holotype QM G337172	507-(954)-1430 x 14.5-(26.0)-36.0, *n*=21	262-(426)-691 x 4.0-(6.9)-9.7, *n*=53	69-(126)-212 x 2.1-(3.8)-6.0, *n*=52	5.8-(8.4)-9.9 x 2.0-(3.8)-5.6, *n*=73 Large alae 2.1-(2.7)-4.9, Small alae 1.3-(2.1)-2.7, *n*=25	Absent	Absent	Absent	Absent	Absent
Lycopodina coralseansis sp. nov. Paratype QM G337173	741-(989)-1320 x 19.4-(25.8)-35.0, *n*=11	217-(434)-581 x 3.4-(7.6)-14.5, *n*=62	69-(126)-159 x 2.0-(3.3)-4.6, *n*=40	6.9-(8.6)-10.0 x 3.1-(4.2)-5.1, *n*=49 Large alae 1.9-(2.4)-3.2, Small alae 1.3-(2.0)-2.8, *n*=17	Absent	Absent	Absent	Absent	Absent
Lycopodina coralseansis sp. nov. Paratype QM G337215	563-(1453)-2820 x 15.1-(32.2)-44.7, *n*=20	276-(399)-565 x 5.6-(9.2)-14.9, *n*=53	98-(141)-188 x 1.7-(3.4)-5.3, *n*=51	7.1-(9.4)-10.9 x 3.0-(4.6)-6.3, *n*=52 Large alae 2.1-(2.8)-3.5, Small alae 1.6-(2.2)-2.7, *n*=24	Absent	Absent	Absent	Absent	Absent
Lycopodina nikitawimandi Ekins *et al.*, 2020a (mean of all types)	1040-(1449)-1910 x 12-(22)-37, *n*=186	209-(577)-992 x 3-(11)-19, *n*=338	Absent	10.4-(14.3)-17.8 x 2.8-(3.9)-6.0, *n=312* Large alae 2-6 Small alae 3-4	Absent	Absent	Absent	Absent	Absent
Lycopodina hystrix Ekins *et al.*, 2020b (mean of all types)	496-(1145)-2170 x 4-(17)-28, *n*=109	107-(168)-258 x 3-(6)-9, *n*=76	106-(215)-322 x 4-(7)-12, *n*=93	*10.5-(13.1)-16.1 x 5.0-(6.2)-8.0, n=267* Large alae 2.6-(3.9)-5.0 Small alae 2.0-(2.6)-3.4 *n*=135	348-(547)-1480 x 3.6-(8.7)-18.5, *n*=51	107-(168)-258 x 2.9-(6.2)-9.1, *n*=76	36-(59)-81 x 3.3-(5.1)-6.7, *n*=44	15.5-(41.6)-50.8 x 3.3-(7.6)-11.4, *n*=26	7.7-(10.2)-12.6 x 0.4-(0.8)-1.3, *n*=16

TABLE 2. A comparison of spicule measurements (µm) between the different specimens of *Lycopodina coralseaensis* sp. nov. and comparison of spicule dimension with its sister species *L. nikitawimandi* from the east coasts of New South Wales and Tasmania (Ekins *et al.* 2020a) and *L. hystrix* from South Australia (Ekins *et al.* 2020b).

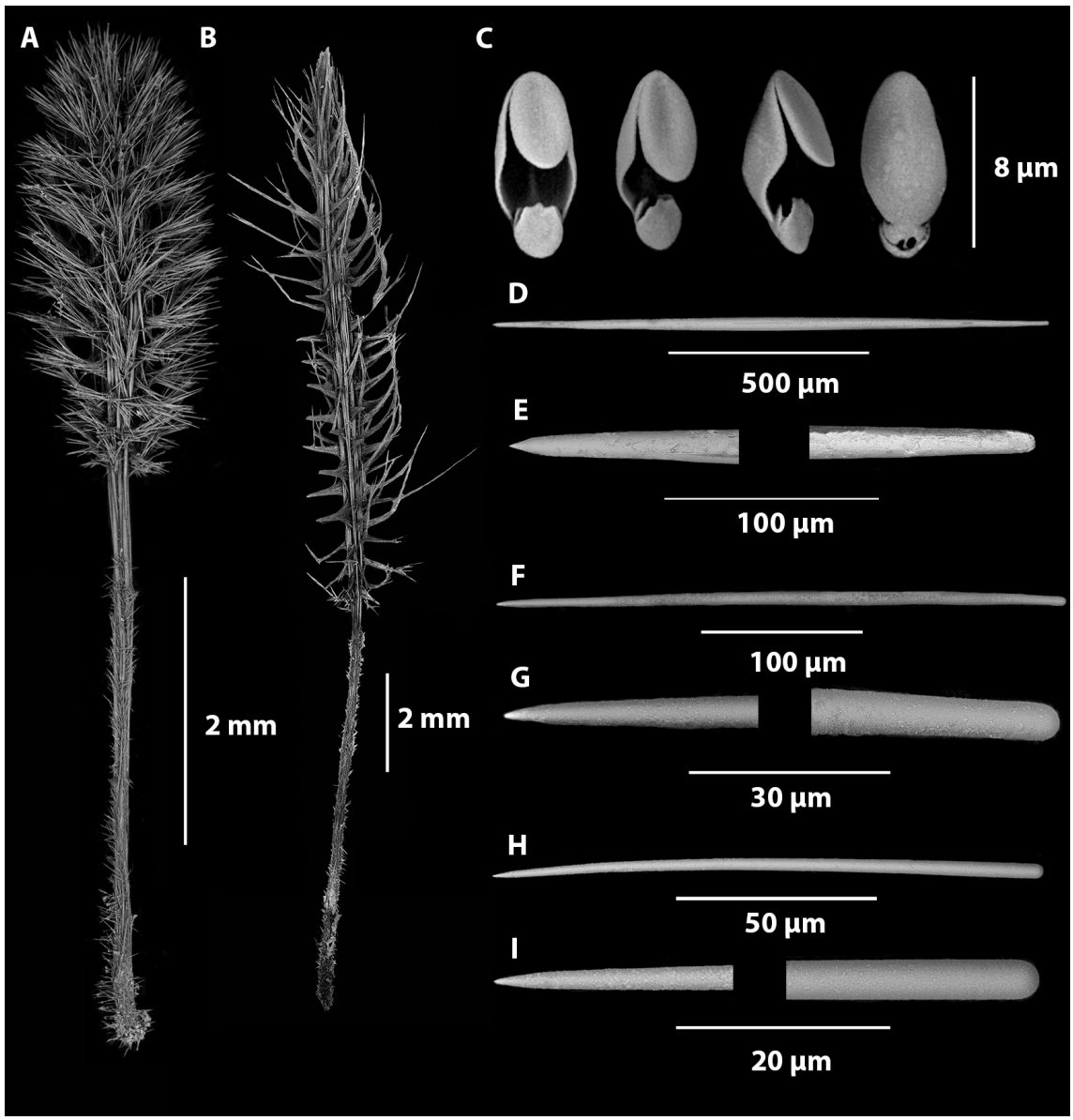

FIG. 3. *Lycopodina coralseaensis* sp. nov. **A**, Holotype QM G339172; **B**, Paratype QM G339215; **C**, Abyssochelae; **D**, Larger mycalostyle 1 that forms axial skeletal tracts in both the stem and body; **E**, Magnified ends of the mycalostyle 1 depicted in D; **F**, Medium sized mycalostyle 2 from the body; **G**, Magnified ends of the mycalostyle 2 depicted in F; **H**, Smaller basal style 3 echinating the stem; **I**, Magnified ends of the basal style 3 depicted in H.

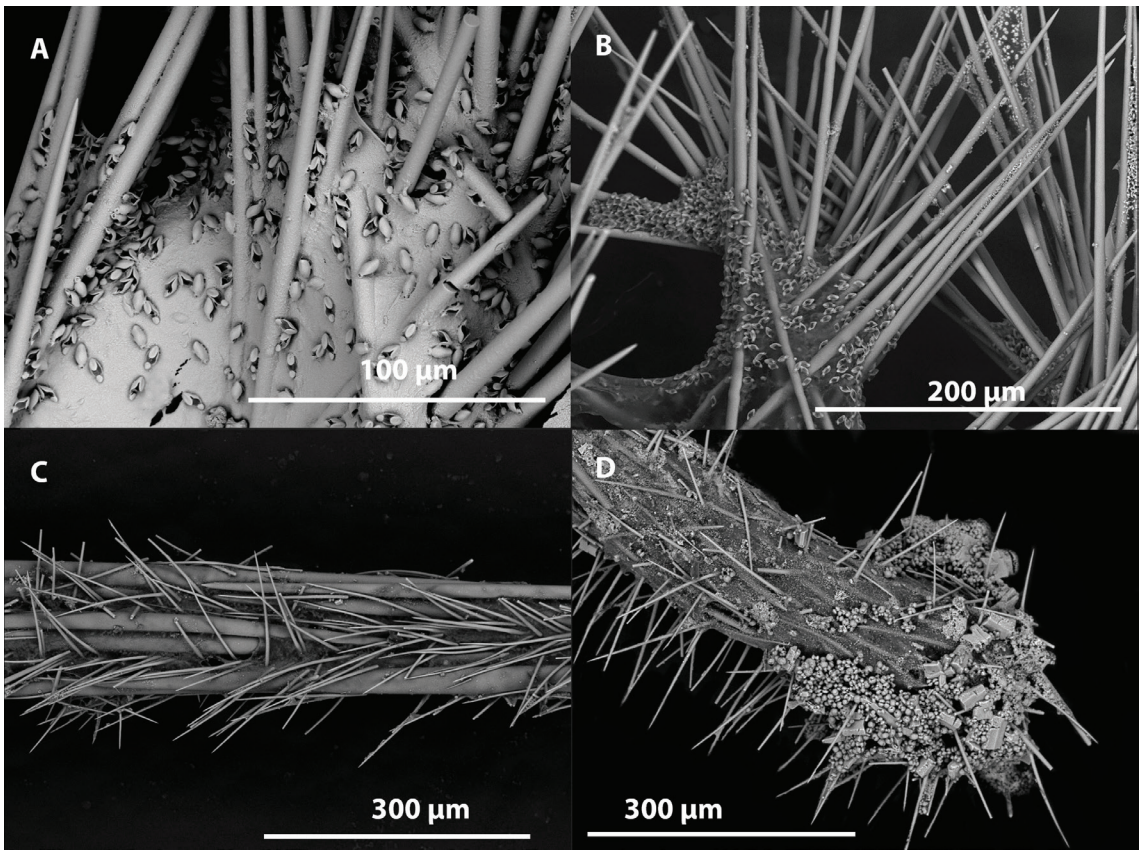

FIG. 4. *Lycopodina coralseaensis* sp. nov. **A**, Close-up of the sponge body, showing the embedded mycalostyles 2 forming erect bouquets projecting from the surface, and the anisochelae embedded on the thin ectosome; **B**, Mycalostyles 2 projecting from the longitudinal tracts of mycalostyles 1 in the sponge body, and anisochelae encrusting the soft tissue surrounding those tracts; **C**, Stem of the sponge showing the large tracts of mycalostyles 1 forming the axial skeleton of the stem, and the smaller mycalostyles 3 echinating those tracts; **D**, The slightly globular basal attachment with echinating mycalostyles 3 and soft tissue encrusted by anisochelae at its termination.

nine of these stipitate species in lacking forceps microscleres. Forceps however, appear to be associated with sexually reproducing individuals (e.g. Riesgo *et al*. 2007) and are often rare or absent. This new species is similar in this regard to *L. nikitawimandi* from bathyal-abyssal depths off the east coasts of New South Wales and Tasmania, from which it differs in having only a very small single size class of palmate anisochelae and a third category of mycalostyle echinating the axis of the stem and basal holdfast. *Lycopodina hystrix* from Southern Australia has a much larger palmate anisochelae, forceps and at least two extra classes of styles.

DISCUSSION

With the discovery of *Lycopodina coralseaensis* sp. nov. from bathyal depths on the Louisiade Plateau, lying north of the Tasmantid Seamounts off Queensland, Australia, the present study brings the total number of cladorhizid carnivorous sponges described from Australia's Exclusive Economic Zone to 26 species in 9 genera, occurring from deep mesophotic to

abyssal depths (Table 1). This species has morphological similarities to two other species, occurring around Australia i.e. *L. nikitawimandi* and *L. hystrix*. Due to the minute size of these sponges, they can easily be overlooked during sampling of deep-sea rocks using dredges, where the main focus is geological sampling. It is only due to the presence of the biologists on board who were able to secure these fragile carnivores of the deep. To date, only three samples of this new species have been recovered, and all three were used in the manufacture of SEM stubs. Future explorations, including the use of remote operated vehicles, will determine if the distributions of these rare species are restricted to particular seamounts or plateaus, or have more widespread distribution across the oceans. In this case, all three samples were collected from the same rock dredge. Some carnivorous species have wide distributions, such as *Chondrocladia (Chondrocladia) clavata* Ridley & Dendy, 1886, found on the continental slopes of Fiji (Ridley & Dendy 1887), Australia (Ekins *et al.* 2020a), Antarctica (Dressler-Allame *et al*. 2017) and Madagascar (Lévi 1964), and *Lycopodina calyx* (Hentschel, 1914) found in Antarctica (Goodwin *et al*. 2017) and Australia (Ekins *et al.* 2020a). Like many known sponge species, the majority of carnivorous sponges have been recovered only once. Molecular results in the future may discover whether the widespread species such as *C. (C.) clavata* are genetically separated. But because of the higher than expected gene flow that occurs in deep sea sponges (Ekins *et al*. 2015), perhaps the bathyal and abyssal carnivorous fauna are all more connected than we presently assume.

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