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, Tasmanid, 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 (Abyssoclada Lévi 1964, Abyssosdiskos Ekins et al. 2020b, Asbestopluma Topsent, 1901, Axoniderma Ridley & Dendy, 1886, Bathyentactular Ekins et al. 2020b, Cercycladia Rios et al., 2011, Chondroc cladia Thomson, 1873, Cladorhiza Sars, 1872, Euchetipluma Topsent, 1909, Koltunicladia Hestetun et al., 2016, Lollipocladia Vacelet 2008, Lycopodina Lundbeck, 1905 and Nullabora Ekins et al., 2020b) and five subgenera (Asbestopluma (Asbestopluma) Topsent, 1901, Asbestopluma (Helophloeina) Topsent, 1929, Chondrocладia (Chondrocладia) Thomson, 1873, Chondrocладia (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 Tasmanid 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 from within the Australian continental shelf ~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
Cladorhizaeae Dendy, 1922:58
Cladorhizidae de Laubenfels, 1936:122.

Genus Lycopodina Lundbeck, 1905
Asbestopluma (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)
vrn: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                                 |
|                        | eschiri Ekins, Erpenbeck & Hooper, 2020 | off Fraser Island, Queensland, Coral Sea; abyssal                           | Ekins et al. 2020a: 8:21-23, Fig. 2                                   |
|                        | glycyfila 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                                    |
|                        | oxysters Ekins, Erpenbeck, Goudie & Hooper, 2020 | Nullarbor Canyon, Great Australian Bight, South Australia, Southern Ocean; bathyal | Ekins et al. 2020b: 247-251, Figs 4-6                                  |
| Abyssoclidios          | pentaeiros (Ekins, Erpenbeck & Hooper, 2020) | off Bermagui, New South Wales, Tasman Sea; bathyal                        | Ekins et al. 2020a: 86-88, Fig. 17                                    |
| Abestopluma (Abestopluma) | desmophora Kelly & Vacelet, 2011 | seamounts on the Macquarie Ridge between Australia and New Zealand, Southwest Pacific; mesophasic-bathyal | Kelly & Vacelet 2011: 62-67, Figs 5-6                                  |
| Axoniderma             | australis (Ekins, Erpenbeck & Hooper, 2020) | continental slope off Jervis Bay, New South Wales, Tasman Sea; bathyal         | Ekins et al. 2020a: 28-29, 46, Fig. 6                                  |
| Batygentectular        | moniqueae (Ekins, Erpenbeck & Hooper, 2020) | off Newcastle, New South Wales, Tasman Sea; abyssal                         | Ekins et al. 2020a: 82-85, Figs 14-15                                 |
| Chondrocladia (Meliderma) | tasmaniensis Vacelet, Kelly & Schlacher-Hoenlinger, 2009 | seamounts south of Tasmania, Tasman Sea; abyssal                         | 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                                |
|                        | zpppinnatifidus Ekins, Erpenbeck & Hooper, 2020 | off Gladstone, Coral Sea, Queensland; bathyal                             | Ekins et al. 2020a:120-123, Figs 24-25                                |
| Euchelipluma           | claudachile Ekins, Erpenbeck & Hooper, 2020 | off Central New South Wales, Tasman Sea; abyssal                           | Ekins et al. 2020a: 149-153, Fig. 32                                  |
| Lycopodina             | brachidoloma 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                                  |
|                        | helos 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                                   |
|                        | nikitsinimandi 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                                                         |
| Nullarborra           | investigator (Ekins, Erpenbeck & Hooper, 2020) | off the Freycinet Peninsula, Tasman Sea; 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                                  |
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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 | Anisochele | Large basal style | Basal tylostyle | Basal strongyles | Forceps | Sigmancistra |
|----------------|---------------|---------------|-------------|------------|------------------|-----------------|-----------------|---------|--------------|
| **Lycopodina coralseaensis**| 5.07-9.9 x 145-(28.0)-56.0,  n=21| 26.24-69.1 x 4.0-(6.9)-9.7,  n=53| 21.68-212 x 2.1-(3.8)-6.0,  n=52| 5.8-(8.4)-9.9 x 2.0-(3.8)-5.6,  n=73| Absent| Absent| Absent| Absent| Absent |
| **Holotype QM G337172**| | | | | | | | | |
| **Lycopodina coralseaensis**| 7.41-(8.9)-13.2 x 19.4-(25.8)-35.0,  n=11| 21.74-(34.8)-58.1 x 3.4-(7.6)-14.5,  n=62| 6.9-(12.6)-15.9 x 2.0-(3.3)-4.6,  n=40| 6.9-(8.6)-10.0 x 3.1-(4.2)-5.1,  n=49| Absent| Absent| Absent| Absent| Absent |
| **Paratype QM G337173**| | | | | | | | | |
| **Lycopodina coralseaensis**| 5.63-(14.5)-28.0 x 15.1-(32.2)-44.7,  n=20| 27.64-(39.9)-56.5 x 5.6-(9.2)-14.9,  n=53| 9.8-(14.1)-18.8 x 1.7-(3.4)-5.3,  n=51| 7.1-(9.4)-10.9 x 3.0-(4.6)-6.3,  n=52| Absent| Absent| Absent| Absent| Absent |
| **Paratype QM G337215**| | | | | | | | | |
| **Lycopodina nikitawimandi**| 10.40-(14.49)-19.10 x 12-(22)-37,  n=186| 20.96-(57.77)-99.2 x 3-(11)-19,  n=338| Absent| 10.4-(14.3)-17.8 x 2.8-(3.9)-6.0,  n=312| Absent| Absent| Absent| Absent| Absent |
| **Ekins et al., 2020a** (mean of all types)| | | | | | | | | |
| **Lycopodina hystrix**| 4.96-(14.5)-21.70 x 4-(17)-28,  n=109| 10.76-(168)-23.8 x 3-(6)-9,  n=76| 10.5-(13.1)-16.1 x 5.0-(6.2)-8.0,  n=267| 34.8-(54.7)-148.0 x 3.6-(8.7)-18.5,  n=51| 107-(168)-238 x 29-(6.2)-91,  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)-13,  n=16|
| **Ekins et al., 2020b** (mean of all types)| | | | | | | | | |

**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).
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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.
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 Tasmanid 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
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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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