

## *Thelidium robustum* sp. nov. (lichenized Ascomycota, Verrucariaceae) from Kangaroo Island, South Australia

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### Abstract

*Thelidium robustum* P.M.McCarthy & Kantvilas sp. nov. (Verrucariaceae) is described from coastal limestone on Kangaroo Island, South Australia. It is characterized by a grey to dark greyish green, ecorticate, crustose-areolate to pseudosquamulose thallus that is attached to the substratum by hyaline rhizohyphae. The new species is distinguished from other calcicolous taxa of *Thelidium* principally by its comparatively robust thalline morphology in combination with immersed to superficial, simple perithecia and 1-septate ascospores of (16–) 22 (–26) × (9–) 11 (–13) μm. A key is provided to five species of *Thelidium* known from Australia. *Verrucaria papillosa* Ach. (Verrucariaceae) is reported for the first time from South Australia.

**Keywords:** *Thelidium*, Verrucariaceae, lichens, new species, South Australia

### Introduction

*Thelidium* A. Massal. (Verrucariaceae, Verrucariales) grows almost exclusively on calcareous and siliceous rocks in aquatic, semi-aquatic and terrestrial habitats, with approximately 100 species known mainly from northern-temperate to boreal latitudes (Zschacke 1933; Servit 1954; Kopachevskaya et al. 1977; Clauzade & Roux 1985; McCarthy 2001; Galloway 2007; Thüs & Nascimbene 2008; Orange 2009; Thüs & Schultz 2009). The thallus is crustose, usually ecorticate and immersed in the substratum to partially superficial and diffuse, continuous or areolate. Ascومات are perithecioid, immersed in the thallus or directly in the substratum, or semi-immersed to superficial, with or without a dark to black involucrellum, and the asci are fissitunicate, each producing eight colourless, thin-walled ascospores with 1–3 (–7) transverse septa, occasionally with 1–3 longitudinal or oblique divisions. Traditionally, ascospore septation has distinguished *Thelidium* from the simple-spored *Verrucaria* Schrad., while it remains poorly differentiated from *Polyblastia* sens. lat. in which ascospores are submuriform to fully muriform and range from colourless to dark brown. However, molecular studies have shown ascospore septation to be an unreliable diagnostic character among the crustose genera of Verrucariales (Guedian et al. 2007), with a suggestion, as yet unconfirmed, that groups of species currently in *Thelidium* might eventually be segregated as distinct genera (Thüs & Nascimbene 2008).

In this paper, we describe *T. robustum*, a new species from limestone on Kangaroo Island, South Australia. It is characterized by an exceptionally well-developed, grey

to dark green, crustose-areolate to pseudosquamulose thallus that is anchored by hyaline rhizohyphae, as well as comparatively small, non-involucrellate perithecia producing 1-septate ascospores of moderate size. Among the lichens associated with the new species is *Verrucaria papillosa* Ach. which is reported here for the first time from South Australia. We also provide a key to the five known Australian species of *Thelidium*.

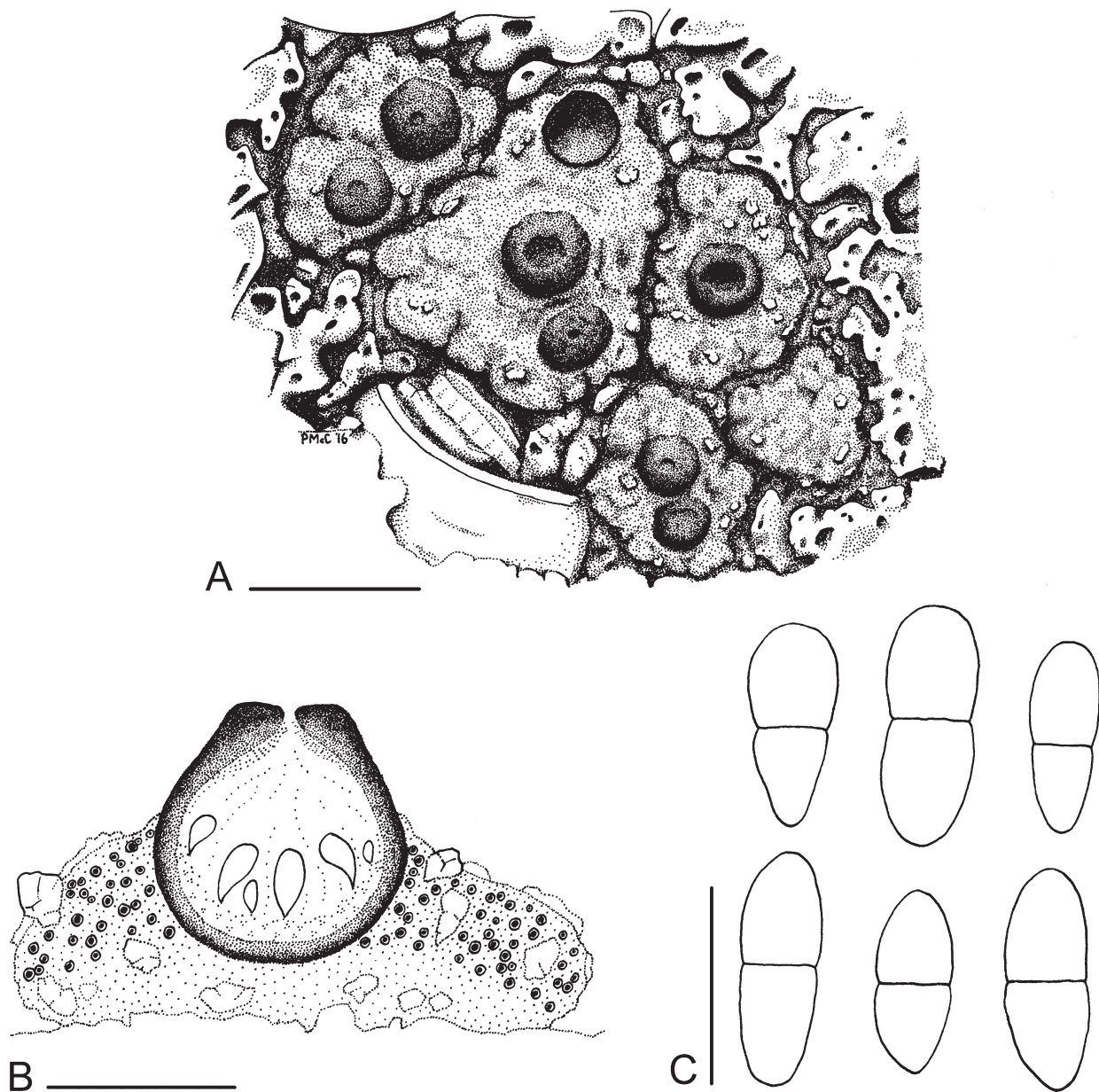
### Methods

Observations and measurements of thallus and ascomatal anatomy, asci and ascospores were made on hand-cut sections mounted in water and dilute KOH (K). Asci were also observed in Lugol's Iodine (I), with and without pretreatment in K.

### Taxonomy

#### *Thelidium robustum* P.M.McCarthy & Kantvilas, sp. nov.

*Thallus calcicola, crustosus aut minute pseudosquamulosus, pallide griseus vel viridiater, 80–300 μm crassus. Pseudosquamulae rotundatae aut elongatae, (0.2–) 0.6 (–1.2) × (0.2–) 0.45 (–0.8) mm, rhizohyphis hyalinis substrato affixae. Algae chlorococcoideae, 8–12 (–14) μm diametro. Perithecia globosa vel pyriformes, immersa aut prominentia, (0.17–) 0.25 (–0.31) mm diametro. Involucrellum destitutum. Excipulum bistratum, superne 40–70 μm crassum, inferne 18–25 (–30) μm, externe fuscoatrum et 8–30 μm crassum, interne pallide vel mediofuscum et 10–40 μm. Paraphyses destitutae. Periphyses simplices, 12–20 × 2–3 (–4) μm. Asci fissitunicati, late clavati, 70–85 × 24–30 μm. Ascosporae incoloratae, 1-septatae, plerumque anguste ellipsoideae, (16–) 22 (–26) × (9–) 11 (–13) μm.*



**Fig. 1.** *Thelidium robustum*. **A** habit of a fertile thallus; **B** sectioned perithecium and adjacent thallus (semi-schematic); **C** mature ascospores. Scale bars: **A** 0.5 mm; **B** 0.2 mm; **C** 20  $\mu$ m. — **A–C** holotype.

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**Holotype:** South Australia: Kangaroo Island: c. 1.5 km SW of Point Ellen, 36°00'S, 137°11'E, alt. 10 m, on calcarenitic limestone in coastal heathland, 22 Sep. 2015, *G. Kantvilas 444/15* (HO 581507).

Thallus saxicolous on calcarenitic limestone, diffuse and with scattered microthalli in fissures and pits in the substratum, not forming substantial, continuous colonies, dull and pale to medium grey or greyish green or dark green, initially crustose and areolate, becoming pseudosquamulose (i.e. the outwardly squamulose habit at maturity is derived from crustose thallus initials, and the medulla and algal layer are impregnated with minute rock fragments and crystals, thus closely resembling

hemiendolithic crusts), 80–300  $\mu$ m thick, the surface  $\pm$  smooth to minutely uneven and irregularly rugulose, with rock fragments commonly protruding, ecorticate, but with a continuous or patchy, hyaline, necral layer c. 10  $\mu$ m thick which can give the impression of an uneven greyish pruina in surface view; pseudosquamules  $\pm$  isodiametric and rounded to angular, or irregular to elongate, entire or with a minutely lobate-effigurate margin, (0.2–) 0.6 (–1.2)  $\times$  (0.2–) 0.45 (–0.8) mm [ $n = 50$ ], attached to the substratum by 3–5  $\mu$ m thick, hyaline rhizohyphae; rhizines absent. Photobiont cells green, unicellular, chlorococcoid, 8–12 (–14)  $\mu$ m diam., not clustered but scattered throughout thinner thalli, or forming a layer 50–120  $\mu$ m thick below the surface of

thicker pseudosquamules. Medulla nondescript or 50–120 (–150)  $\mu\text{m}$  thick, heavily impregnated with minute rock fragments and crystals (as is the algal layer); cells angular to rounded-irregular, paraplectenchymatous, 5–8  $\mu\text{m}$  wide. Prothallus absent; hypothallus not apparent. Ascomata perithecia, numerous, solitary, usually scattered, (0.17–) 0.25 (–0.31) mm diam. [ $n = 70$ ], 1–3 (–5) per pseudosquamule, outwardly dull blackish, almost completely immersed to semi-immersed in thicker pseudosquamules to almost superficial on thinner, crustose thalli, subglobose to broadly pyriform, not overgrown by the thallus; perithecial apex initially plane, later concave, the ostiole central in a shallow, 60–100  $\mu\text{m}$  wide depression; apices of post-mature ascomata commonly deeply excavate. Involucrellum absent. Excipulum 40–70  $\mu\text{m}$  thick at the apex, 18–25 (–30)  $\mu\text{m}$  thick at the sides and base, bilayered throughout (thin section), K–; outer layer dark olive-brown, 8–30  $\mu\text{m}$  thick, the cells rounded-angular, 5–7  $\mu\text{m}$  wide, comparatively thick-walled; inner layer pale to medium brown, 10–40  $\mu\text{m}$  thick, the cells periclinally elongate, 6–10  $\times$  3–4  $\mu\text{m}$ , thin-walled and closely arranged. Subhymenium 20–30  $\mu\text{m}$  thick. Paraphyses absent. Periphyses unbranched, 12–20  $\times$  2–3 (–4)  $\mu\text{m}$ . Hymenium IKI+ dark orange-brown. Asci fissitunicate, 8-spored, broadly clavate, 70–85  $\times$  24–30  $\mu\text{m}$  [ $n = 15$ ]; wall thickened at the apex; ocular chamber not apparent. Ascospores irregularly arranged in the ascus, colourless, 1-septate, narrowly ellipsoid to oblong-fusiform, straight, with a median or, occasionally, submedian septum and rounded or subacute ends, not or only slightly constricted at the septum, (16–) 22 (–26)  $\times$  (9–) 11 (–13)  $\mu\text{m}$  [ $n = 40$ ]; wall 0.8–1.5  $\mu\text{m}$  thick, to 2  $\mu\text{m}$  thick at the septum, lacking an epispore; contents clear to minutely granulose. Pycnidia absent. **Fig. 1.**

*Etymology.* The epithet *robustum* refers to the comparatively stout thalline morphology of the new species.

*Remarks.* *Thelidium robustum* is characterized by having ecorticate pseudosquamules that are attached to the substratum by hyaline rhizohyphae, small, often prominent, blackish perithecia with a dark, bilayered excipulum and lacking an involucrellum, combined with moderately large, 1-septate ascospores. For the purposes of comparison with broadly similar taxa, once exclusively aquatic and/or silicolous taxa are excluded from consideration, as well as those with a predominantly endolithic thallus or involucrellate perithecia, species producing significantly smaller or larger, 1-septate ascospores, and those with propagules having 3 or more septa, very few remain. Thus, the common, northern-temperate to boreal *T. minutulum* Körb. has perithecia and ascospores of similar dimensions to those of the South Australian lichen. However, this is an unambiguously crustose species with a continuous, rimose or granular thallus that rarely exceeds 150  $\mu\text{m}$  in thickness, it has clustered algal cells 4–9  $\mu\text{m}$  wide and a perithecial

excipulum that is considerably thinner towards the apex and colourless in its basal half (Thüs & Nascimbene 2008; Orange 2009; Thüs & Schultz 2009). *Thelidium rehmi* Zschacke, from moist sandstone in central Europe and Great Britain and sometimes very similar to *T. minutulum*, has paler and even thinner thalli with scattered algal cells, but the excipulum is colourless towards the base, and ascospores are 20–30  $\mu\text{m}$  long (Thüs & Nascimbene 2008; Thüs & Schultz 2009). Finally, *T. calcareum* (Muell.Arg.) Hellb., which appears to be endemic to New Zealand, has a very thin, dark olive to blackish brown, effuse or abraded thallus and ascospores 14–18  $\mu\text{m}$  long (Galloway 1985, 2007).

The generic position of the new species is a little ambiguous insofar as the thallus is initially crustose and areolate, and it either maintains that morphology or becomes pseudosquamulose at maturity, being attached to the substratum by hyaline rhizohyphae. Such thalli might suggest a more appropriate placement in *Placidiopsis* Beltr., an almost exclusively Northern Hemisphere genus of temperate to boreal latitudes and arid or semi-arid regions (Breuss 1996). However, the outwardly squamulose morphology at maturity is derived from crustose thallus initials, and the medulla and algal layer are impregnated with minute rock fragments and crystals, a feature typical of hemiendolithic Verrucariaceae (such as *Thelidium*) and not of taxa in which squamules develop on the substratum (e.g. *Placidiopsis*). Indeed, it can also be argued convincingly that separating genera of Verrucariaceae solely on thallus morphology (crustose and areolate as opposed to squamulose) is artificial and requires additional supporting characters, such as molecular data. Those data are beyond the scope of the present morphological study, and our principal purpose is to bring a clearly unusual and novel taxon from a remote, relatively rarely studied area to the attention of lichenologists and land managers.

Molecular studies of *T. robustum*, perhaps in conjunction with additional, more informative collections, and leading to a transfer to *Placidiopsis*, would not diminish the integrity of the Australian lichen, as the five known saxicolous species of *Placidiopsis* are certainly distinct from *T. robustum*. Thus, the Brazilian *P. hypothallina* Aptroot (Aptroot 2002), *P. porinoides* Aptroot from China (Aptroot & Seaward 1999) and *P. minor* R.C.Harris from eastern U.S.A. and Greenland (Harris 1979; Alstrup 1991; Breuss 1996) have diminutive perithecia up to 0.1 mm in diameter and ascospores 8–13  $\mu\text{m}$  long. Two other species, *P. sbarbaronis* (Servít) Clauzade & Cl.Roux from Italy and *P. cavicola* Etayo & Breuss from Spain, have perithecia of broadly similar size to those of the Australian lichen. However, the former has perithecia with an apical involucrellum (Servít 1953; Clauzade & Roux 1985), while *P. cavicola* has a hyaline excipulum and ascospores of 13–17  $\times$  6–7  $\mu\text{m}$  (Etayo & Breuss 1994; Prieto et al. 2010).

**Distribution & habitat.** The new species is known only from calcarenitic limestone at the type locality, near Point Ellen on the south coast of Kangaroo Island, South Australia. The site is in coastal heathland, just a few hundred metres from the shoreline, where the *Thelidium* grew on exposed, low, undulating bedrock in gaps amongst the dense shrubbery. Associated lichens on the rocks included *Circinaria contorta* (Hoffm.) A.Nordin, S.Savic & Tibell, *Sarcogyne meridionalis* P.M.McCarthy & Kantvilas, *Sarcogyne* sp., *Toninia australis* Timdal and *Verrucaria papillosa* Ach., the last a new record for South Australia (G.Kantvilas 445/15; HO 581508). The substratum is very coarse and crumbly, with the composite shell and sand fragments readily discernible, and is of early Pleistocene origin (Milnes et al. 1983). The general vegetation and geology of the site (heathland on shallow, sandy soils over limestone) is widespread along the southern coast of Kangaroo Island, the southern mainland of Australia and, to a lesser extent, on Flinders Island. Lichen distribution is patchy in such places, with the soil generally unstable, the shrubbery dense and sand-blasted by wind, and much of the rock surface easily eroded.

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### Key to *Thelidium* in Australia (after McCarthy 2001, 2014)

1. Ascospores 3 (–4)-septate, 30–60 × 14–22 µm; perithecia prominent, involucrellate, 0.3–0.75 mm diam. [N.S.W., Tas., Vic.] ..... ***T. papulare*** (Fr.) Arnold
- 1: Ascospores 1-septate
  2. Thallus semi-aquatic; perithecia prominent, 0.24–0.41 mm diam., the involucrellum partly overgrown by the thallus; ascospores 21–31 × 12–16 µm [Tas.] ..... ***T. pluvium*** Orange
  - 2: Thallus growing on terrestrial rocks; perithecia with or without an involucrellum
    3. Perithecia with a thin involucrellum that is contiguous with the hyaline to pale brown excipulum; thallus rimose to areolate, dark olive-brown, 20–50 µm thick [Vic.] ..... ***T. olivaceum*** (Fr.) Körb.
    - 3: Perithecia lacking an involucrellum; thallus endolithic or epilithic, 80–300 µm thick
      4. Thallus endolithic, inconspicuous; perithecia immersed in pits in the rock, 0.25–0.45 mm diam.; ascospores 25–40 × 10–17 µm [N.S.W.] ..... ***T. decipiens*** (Hepp) Kremp.
      - 4: Thallus epilithic, areolate to pseudosquamulose; perithecia immersed in or superficial on the thallus, 0.17–0.31 mm diam.; ascospores 16–26 × 9–13 µm [S.A.] ..... ***T. robustum***