

A NEW TERRESTRIAL GENUS AND SPECIES WITHIN THE AQUATIC LIVERWORT FAMILY RIELLACEAE (SPHAEROCARPALES) FROM AUSTRALIA¹

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Abstract. A new genus *Austroriella* Cargill & Milne and species *Austroriella salta* Milne & Cargill within the family Riellaceae is described. Known only from the type location at the margins of a saline lake in Western Australia it is the first record and description of a terrestrial species within this typically aquatic family. Female plants are typical of the family with a single reduced wing bearing a row of archegonia; male plants are not typical and are naviculate in form enclosing several rows of enclosed antheridia not unlike the males of *Sphaerocarpos*. Unlike *Sphaerocarpos* this species does bear oil bodies. Differences and affinities are also outlined briefly with closely related genera within the order Sphaerocarpaceae.

Key words: *Austroriella*, *Riella*, Riellaceae, Western Australia, saline lakes, aquatic liverworts

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INTRODUCTION

Riellaceae is a monogeneric family. There are two species of *Riella* Mont. (Riellaceae) currently known from Australia: *Riella halophila* Banwell and *R. spiculata* J. Taylor. The genus *Riella* was first collected in Australia on saline mud at the edge of Lochiel Salt Lake, near the north western mallee town of Dimboola, Victoria in 1948. Although this was the first collection, a subsequent collection found on saline mud at a coastal salt marsh, in 1949 at Port Lonsdale, also in Victoria (Fig. 1b), was used to describe *Riella halophila* (Banwell 1951). *Riella spiculata* was described in 1954, from material collected from a fresh water marsh near the coastal town of Portland in southwest Victoria (Fig. 1b).

Riella, an ephemeral aquatic liverwort, is commonly found growing in clean, shallow fresh or

brackish water; often in ephemeral habitats. It is well documented that the presence of *Riella* can be sporadic (Perold 2000) and often it can be decades before plants are relocated at a particular site (Segarra-Moragues *et al.* 2012b). Some species have been found serendipitously through investigations of other organisms (Wigglesworth 1937) and others are unique collections, not only in number (Segarra-Moragues *et al.* 2012b) but also from unexpected locations, e.g., a seasonal pool in the Sahara Desert (Puche & Boisset 2009).

In 2009 during fieldwork in the Swan Valley Plain bioregion (Anonymous 2013) of Western Australia, numerous salt lakes were visited with the aim of finding material of the thalloid liverwort *Monocarpus sphaerocarpus* D. J. Carr, a rare species known only from a few localities in Australia and a single location in South Africa (Schelpe 1969; Perold 1999).

Whilst searching for *M. sphaerocarpus* at a coastal salt lake north of Perth (Fig. 1a), a population of extremely small bryophytes was

¹ This paper is dedicated to Prof Tamás Pócs, on the occasion of his 80th birthday and for recognition of the enormous contribution he has made to our knowledge of hepatics.

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located on soil in a saline, calcareous sandy rise, near seasonally inundated samphire flats. The vegetation of the sandy rise consists of scattered *Tecticornia indica* (Willd.) K. A. Sheph. & P. G. Wilson subsp. *bidens* (Nees) K. A. Sheph. & P. G. Wilson and *T. pergranulata* (J. M. Black) K. A. Sheph. & Paul G. Wilson, *Melaleuca lanceolata* Otto, *Wilsonia humilis* R. Br., *Lawrencina* sp. and grasses. (Fig. 1c). A collection of this plant was made which on first examination was thought to be either *Sphaerocarpos* sp. or *Monocarpus* sp.

A sample of the plant was sent to David Long and Laura Forrest (RBGE) for molecular analysis, which showed the sample cluster within the *Riella* clade (Forrest *et. al.* pers. com.). A preliminary analysis combining sequences of four DNA regions found that the Australian specimen was sister to *Riella* and *Sphaerocarpos* (Micheli) Boehmer, but was weakly supported. However, in a single region analysis, the sample clustered within the *Riella* clade (Segarra-Moragues pers. com.).

The Western Australian site was revisited in 2010 and additional material was collected. Although fertile, as was the material collected in the previous year, sporophytes were not mature. A subsequent visit to the site in 2012 failed to find any evidence of the plants. However, upon careful observations, the combination of features typical of the family Riellaceae as well as of the family Sphaerocarpaceae support our conclusion that this is not only a new species but also a genus new to science currently placed within the family Riellaceae.

Descriptions and illustrations of the new genus and species are given here.

TAXONOMY

Austroriella Cargill & Milne, *gen. nov.*

TYPE SPECIES: *Austroriella salta* Milne & Cargill, *sp. nov.*

Plants amphibious, tiny, 0.3–1.2 mm long, procumbent, in scattered patches. Plants dioicous, females bright green, males becoming chestnut red with maturity. Female plants typical of the family

with a single undulating wing bearing oil bodies in individual cells, spherical to pyriform involucre enclosing a beaked calyptra enveloping a spherical capsule. Male plants not typical of the family, naviculate in shape dorsally and falciform in side view. Antheridia in 2 to 5 rows between two wings anteriorly, becoming a single wing posteriorly. Antheridia enclosed within individual involucre appearing dorsally as a uni- or bistratose cover punctuated by an opening above the apex of each antheridium, which are each separated by a wall. Spores released solitary, red-brown, distal face with spine-like protuberances, truncate, rounded or acute at tips.

Austroriella salta Milne & Cargill, *sp. nov.*

Figs 2–4

TYPE: AUSTRALIA. WESTERN AUSTRALIA: Salt lake c. 2 km S from Grigson Lookout. Between Green Head and Jurien Bay, just North of Coastal Road, 29th August 2009, *Jolley 175 & Milne, J* (HOLOTYPE MEL; ISOTYPES CANB, PERTH).

Plants dioicous, procumbent, emergent, growing over subsaline soils, posterior partially embedded in the substrate, anterior creeping along surface of substrate, growing in scattered patches, male and female plants growing closely together or singly as individuals, delicate, consisting of an axis and a dorsal wing. Rhizoids all along ventral surface of stem, hyaline and smooth. Male and female plants dimorphic but of similar size in length only.

Male plants naviculate in dorsal view, falciform in side view 0.6–1.2 mm long, up to 0.4 mm wide (across dorsal surface from one wing to the other) and 0.16–0.50 mm high (from ventral surface of stem to margin of wing), stems simple or furcate. Wing double along most of its length, single posteriorly, geminate, on both sides of axis, plane, \pm rectangular in shape, 125–340 μ m wide (from attachment to stem to margin of wing), unistratose, margins entire, crenate. Wing cells quadrate to hexagonal, isodiametric towards margin of wings, 25–75 \times 20.0–37.5 μ m, becoming elongated towards the stem. Oil cells scattered throughout the wing, each containing a single opaque and rough, oil body. Vegetative scales filamentous or

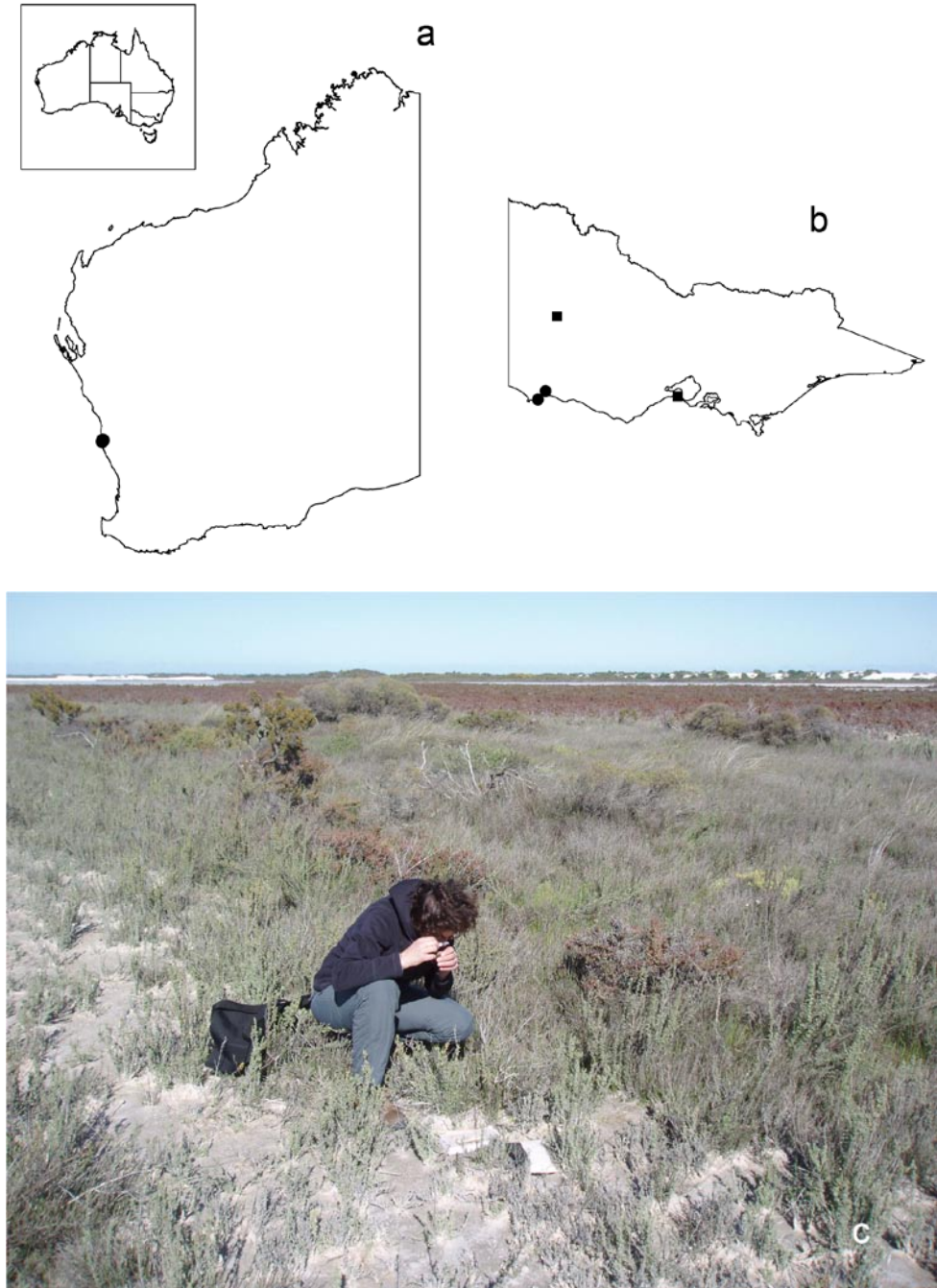


Fig. 1a–c. Distribution of *Riella* Mont. and *Austroriella* Cargill & Milne, *gen. nov.* in Australia. a – Map of Western Australia showing location of coastal salt lake where *Austroriella salta* Milne & Cargill, *sp. nov.* was collected (inset map of Australia). b – Map of Victoria showing collection locations of *Riella halophila* Banwell (squares) and *R. spiculata* J. Taylor (circles). c – Habitat of *Austroriella salta*.

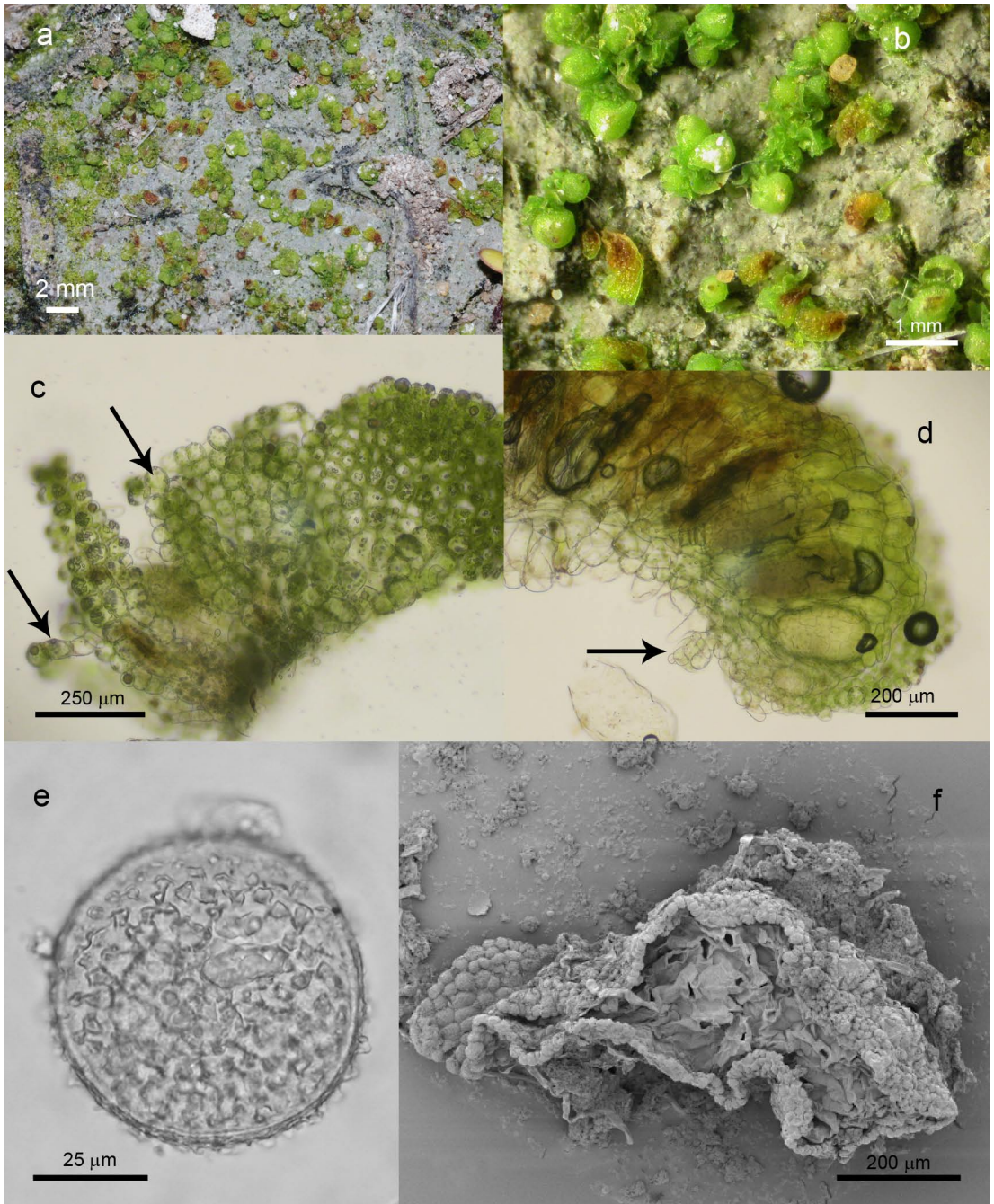


Fig. 2a–f. *Austroriella salta* Milne & Cargill, *sp. nov.* a – population of both male and female plants, b – close up female plants with sporophytes and males with yellow and chestnut coloured antheridia, c – wing of female plant with vegetative scales (indicated by arrows), d – longitudinal section through a male plant showing antheridia and scale (indicated by arrow), e – light micrograph of distal face of spore, f – scanning electron micrograph (SEM) of male plant showing double wing and individual involucres of antheridia.

triangular, along ventral surface of stem or scattered along outside surface of wings, 90–140 μm long and 20–43 μm wide. Propaguliferous scales not seen. Antheridia numerous in two, three or up to five rows between two wings, produced in acropetal sequence, yellow at apex, becoming reddish-orange with maturity. Antheridial body 200 \times 90 μm , stalked, 3 to 4 cells long, jacket cells untiered.

Female plants ruffled in appearance due to the erect, undulating wing, tiny, 0.32–1.20 mm long, 0.34–0.81 mm wide (from anterior margin to posterior margin), stems simple or furcate, linear, axis compressed ovoid in cross-section. Wing single, unistratose, undulate, without lobes and rectangular in outline or bilobed and cordate in smaller, younger plants, 180–500 μm high from insertion on stem, first cell layer and up to first five layers of cells frequently hyaline, overarching stem apex, wing cells quadrate to hexagonal, isodiametric towards margin of wings, 22.5–80.0 \times 22.5–42.5 μm becoming elongated towards stem. Oil cells scattered throughout the wing, each containing a single opaque and rough, oil body. Vegetative scales present and variable in shape from triangular, lanceolate triangular to filamentous, on both sides of wing and surrounding the female involucre, absent along ventral surface of stem, 90–785 μm long and 17.5–133.0 μm wide, with mucilage papillae. Propaguliferous scales not seen. Archegonia at base of wing along stem axis. Involucre 1 or 2 per plant, smooth, no protuberances, but cells bulging giving the surface a papillose appearance, sessile to shortly pedunculate, pyriform to ovoid to \pm spherical, 500–650 μm long and 400–500 μm wide, unistratose, mouth of involucre closed until capsule almost mature, and then open at apex, cells small, quadrate to polygonal in shape, 15.0–57.5 \times 12.5–42.5 μm . Sporophyte completely enclosed by calyptra. Calyptra unistratose, with an apical beak (the remains of the archegonial neck), protruding through involucre when mouth open and a pedicel at its base, 90–150 μm long. Capsule spherical, 315–540 μm in diameter, exceedingly short seta, 42–58 μm long and bulbous foot, capsule wall unistratose, cells quadrate to polygonal, 22.5–57.5 \times 20.0–47.5 μm . Spores red- brown at

maturity, hemispherical to tetrahedral, 62.5–75 μm in equatorial diameter including spines. Distal face smooth, covered with short spines, 11–12 across diameter and 30–34 projecting around circumference of spores. Spines 2.50–3.75 μm long, 2.5 μm wide, with truncate, rounded or acute apices, basal membranes at distal pole interconnected, at the equatorial plane absent. Proximal face convex, triradiate mark indistinct, surface of proximal face rugose. Spines fewer than on distal face, smaller, 2.5 μm in diameter, with blunt apices, not interconnected by basal membranes.

ETYMOLOGY. The generic name is from the Latin *Austro-*, meaning south or southern referring to its southern hemisphere locality, and *-riella* in reference to the first genus described for the family Riellaceae.

The species epithet is from the Latin *saltus* (to jump or leap), in reference to the ‘jump’ made by this species from the aquatic habitat shared by all other members of the family and alluding in a pleasingly homophonic manner to the saline conditions in which it now grows as a result.

HABITAT. Found growing on bare saline/subsaline soils in swampy marshlands under *Tecticornia* dominated heathland. Several metres from shore of salt lake, periodically inundated from rainfall only.

DISTRIBUTION. Endemic to Western Australia. Only known from type location.

SPECIMENS EXAMINED: AUSTRALIA. Salt lake c. 2 km S from Grigson Lookout. Between Green Head and Jurien Bay, between Green Head and Jurien Bay, just North of Coastal Road, *Jolley, H.M 176 & Milne, J.*, 29 Aug. 2009 (MEL); Salt lake c. 2 km S from Grigson Lookout, Indian Ocean Road, between Green Head and Jurien Bay, *Milne, J.* 13 Sept. 2010 (MEL).

DISCUSSION. *Austrioriella salta* is characterised primarily by its *Sphaerocarpos*-like male plants, its smooth, \pm spherical involucre, its procumbent habit and terrestrial habitat preference. Plant cells however, contain oil bodies which place it within the family Riellaceae (Montagne 1852). Both the female and male plants are procumbent, but the female plants are typical of the genus with a stem

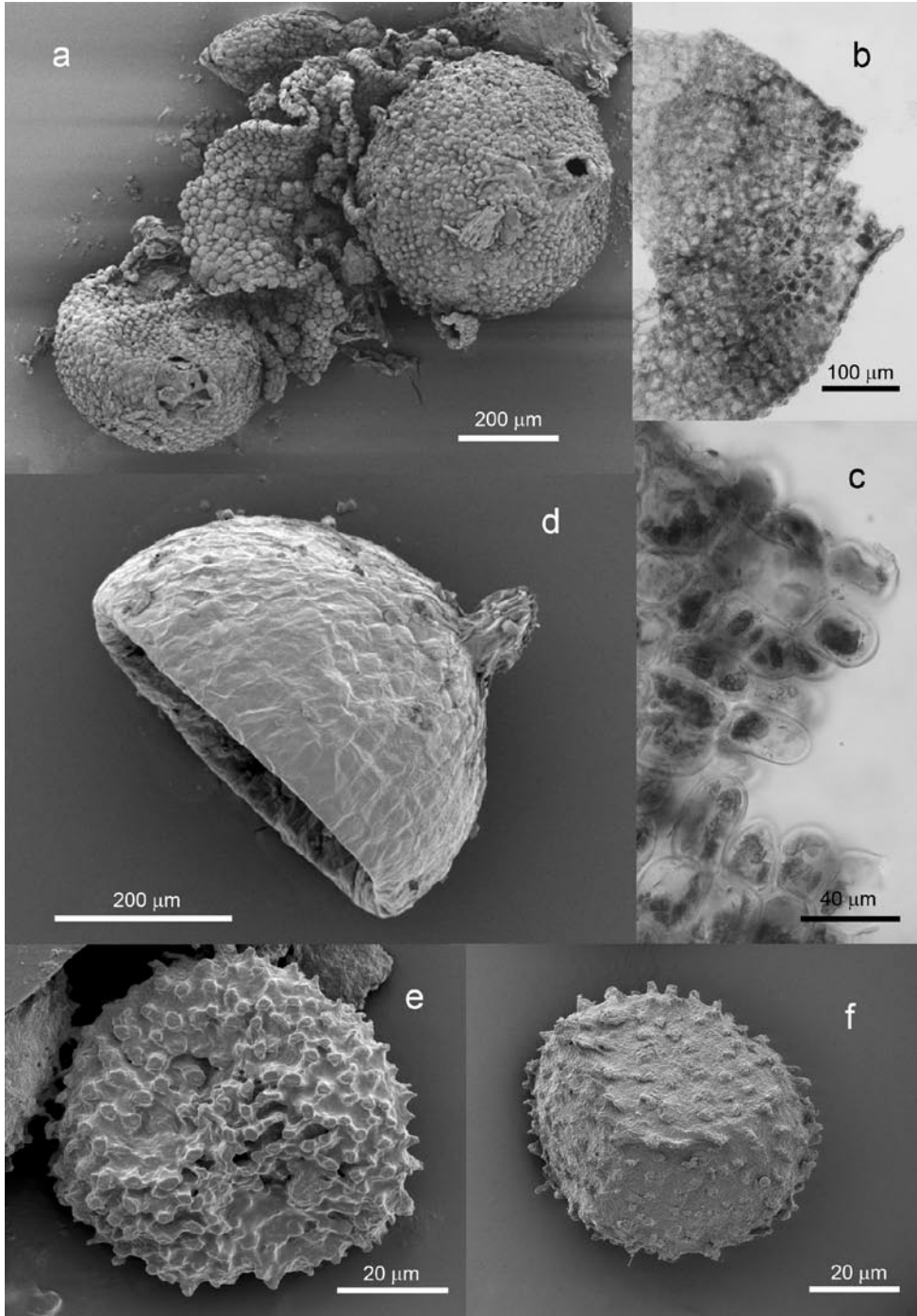


Fig. 3a–f. Female plants of *Austroriella salta* Milne & Cargill, *sp. nov.* a – SEM of whole female plant with sporophyte showing maturing involucre with oriface, b – light micrograph of apex of involucre, c – close up of opening of involucre. d – SEM of calyptra. e – SEM of distal face of spore, f – proximal face of spore.

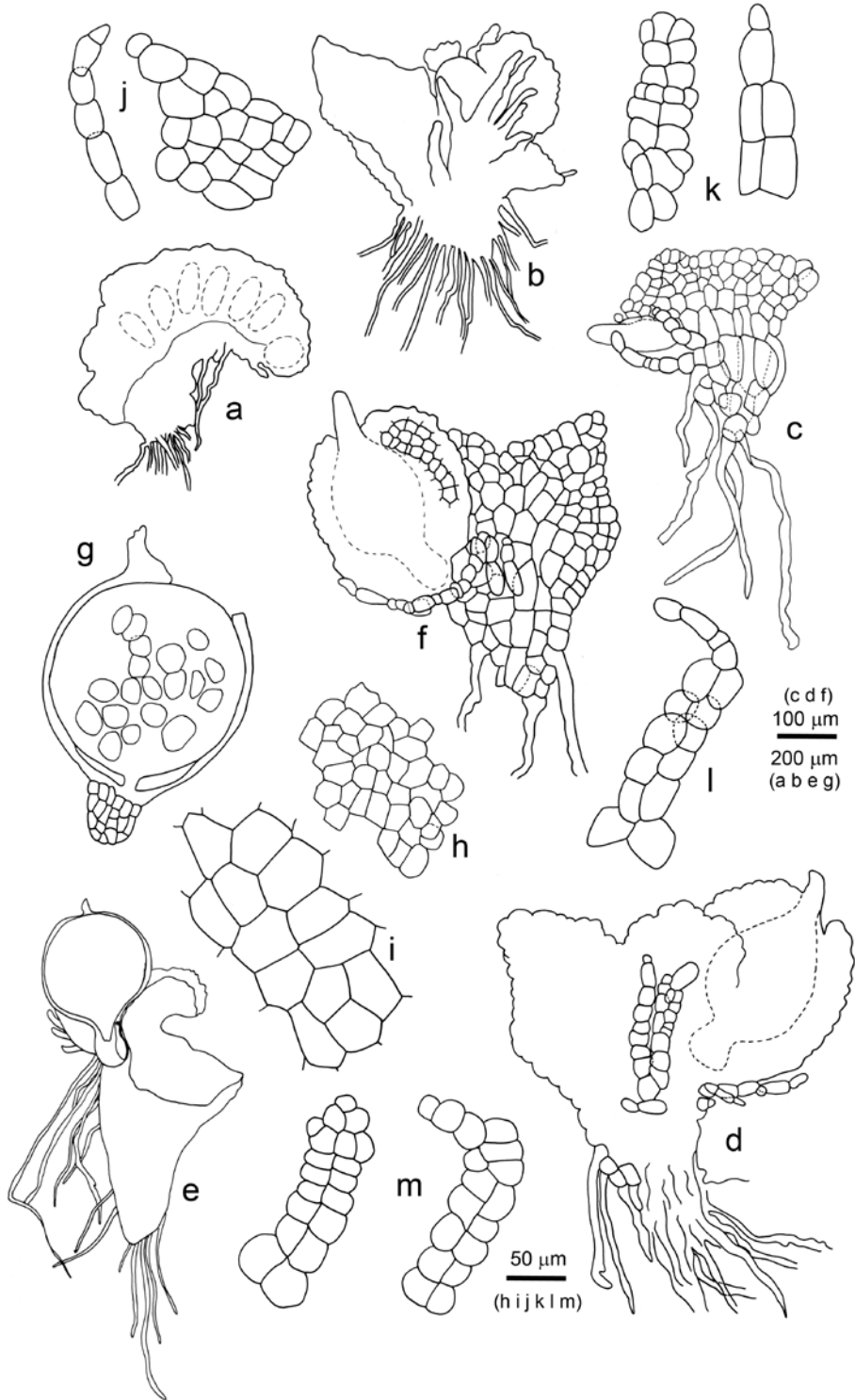
Table 1. Comparison of *Austroriella salta* Milne & Cargill, *sp. nov.* with Australian *Riella* species. Most characters for *R. halophila* Banwell and *R. spiculata* J. Taylor were taken from protologues. *Actual measurements or observations made by authors when absent from protologues.

Characters	<i>Riella halophila</i>	<i>Riella spiculata</i>	<i>Austroriella salta, sp. nov.</i>
Plant length	10–20 mm	5–9 mm	0.3–1.2 mm
Wing width	1.5–3.0 mm	1.4–3.0 mm	0.125–0.810 mm
Vegetative leaf scales	2–3 mm long	present, 0.3–0.5 mm long	0.090–0.785 mm long
Sexual state	dioicous	monoicous	dioicous
Antheridia	antheridia not in single row; embedded in free margin	immersed in wing, and grouped in marginal sinuses in single row	two to five rows between two wings
Involucre			
shape	pyriform – subglobose	ovoid acuminate	pyriform to ovoid
size	2.0–3.0 mm long	2.0–2.5 mm long	0.50–0.65 mm long
ribbed or smooth	smooth	smooth	smooth
Stalk	pedunculate	sessile	sessile to shortly pedunculate
Seta length	*300–470 μm	*250 μm	42–58 μm
Foot shape	* \pm bulbous, slightly broader than seta	*slight flaring of base of seta	bulbous
Capsule			
shape	spherical	spherical	spherical
size	*~ 550 μm	* 660–850 μm	315–540 μm
Spores			
diameter	62–72 μm excluding spines, *65–76 μm including spines	80 μm excluding spines, 99 μm including spines	60.0–72.5 μm in equatorial diameter, excluding spines, 62.5–75.0 μm including spines
wing	*absent	*absent	absent
shape	subelliptical	subtriangular - circular	hemispherical to tetrahedral
ornamentation of distal face	*short spine-like protuberances	central reticulation and truncated spines	short, spine-like protuberances
length of spines	3–4(–5) μm	*7.5–12.5 μm	2.50–3.75 μm
apices of spines	obtuse or truncate	truncate	apex rounded, truncate or acute
basal membrane	*present at distal pole, absent at equatorial plane	*distinct across distal face	\pm distinct, present at distal pole, absent at equatorial plane
# of spines across diameter	*7–9	*9–11	11–12
ornamentation of proximal face	*scattered irregular papillae	*finely papillate	small scattered papillae
triradiated mark	*absent	faint	indistinct

bearing a single lateral wing. The male in contrast is a curved stem bearing two wings, which enclose several rows of antheridia, (Figs 2d, 4a) more typically seen in male plants of *Sphaerocarpos*. In *Riella*, they occur in single rows along the margin of the wing (Perold 2000; Segarra-Moragues *et al.* 2012a, b). Little is known of the complete life cycle of this species as it has only been collected twice over two consecutive years

from its type locality and is not yet in cultivation. Very little is known of the vegetative state of the male plants before they become fertile, if indeed there is a vegetative state.

Austroriella salta differs from both *R. halophila* and *R. spiculata* by the shape of its involucre which is \pm spherical to pyriform to ovoid and sessile to very shortly pedunculate, (Figs 3a, 4e, f) while that of *R. halophila* is pyriform-subglobose



and distinctly pedunculate (Banwell 1949) and *R. spiculata* is ovoid-acuminate or tear-drop-shaped and also in the monoicous sexual condition of the latter (Taylor 1954).

Other prominent differences between the three species can be seen in the spore patterning which is considered an important character for distinguishing species. *Riella spiculata* has the most distinct spores, with the distal face displaying a macro-ornamentation of long slender protuberances which flare at the tips, and a fine reticulated patterning in between the interconnected basal membranes. (Taylor 1954). The spores of *R. halophila* and *A. salta* are similar with a distal macro-ornamentation of low spine-like protuberances however, *A. salta* has many more across the diameter of the distal face (Figs 2e, 3e). (Table 1).

Members of the Riellaceae are elusive plants within the hepatic flora of Australia. The family is considered to include obligate aquatic species found in swamps and marshlands, often in brackish, subsaline or saline conditions around the edges of salt lakes or saltpans. As noted by Segarra-Moragues, these habitats occupied by this genus are not readily sort out by bryologists (Segarra-Moragues *et al.* 2012a) because of the paucity of bryophytes. *Austroriella salta* is unusual in the sense that it appears to be a terrestrial species, its life cycle ephemeral and probably triggered by seasonal inundation from rain. Fertile plants to date were collected in Spring following a wet Winter. Its prostrate habit also indicates that this species does not grow to maturity when under water as is typical of the genus (Segarra-Moragues *et al.* 2012a & b). The habitat is situated in scrubby heathland within the Swan Coastal Plain bioregion (Anonymous 2013) on saline soil, however *A. salta* is at a significant distance from the edge of the more permanent water of the saline lake (Fig. 1c), hence the assumption that it is not an obligate aquatic species within the genus but a terrestrial species.

Recent molecular multi-locus analyses have supported a clade containing all members of the order Sphaerocarpaceae (*Sphaerocarpos*, *Geothallus*, *Riella* and *Austroriella*) plus *Monocarpus* in a sister relationship to this group (Forrest *et al.* 2012). Characters which unite members of the Sphaerocarpaceae are the absence of air chambers, air pores and elaters, presence of only smooth rhizoids, antheridia in perigonial involucre or pockets, a very short seta and cleistocarpous capsules (Crandall-Stotler *et al.* 2009). *Monocarpus*, which is currently classified within the order Marchantiales (Crandall-Stotler *et al.* 2009), does bear air pores. It does share with *Sphaerocarpos* and *Geothallus* the absence of oil bodies, absence of ventral scales and the absence of specialized asexual structures all of which are found in *Riella* and *Austroriella*.

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Fig. 4a–m. Line drawings of *Austroriella salta* Milne & Cargill, *sp. nov.* a – male plant, b – vegetative plant with lateral scales, c – whole female plant, d–f – whole female plants with lateral scales and developing sporophytes, g – sporophyte covered by calyptra, h – cells of involucre, i – cells of capsule, j–m – vegetative scales.

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