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Macromitrium erythrocomum (Bryophyta: Orthotrichaceae), a new species from tropical Queensland, Australia

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Abstract

Macromitrium erythrocomum sp. nov. is described from the Wet Tropics bioregion, Queensland, Australia. It is distinguished mainly by its large size, excurrent red costa, unusual areolation of the upper leaf lamina, short seta, hairy calyptra, peristome absent or reduced to a low basal membrane, and anisomorphic spores. A comparison is made with other *Macromitrium* species in the region.

Introduction

Dixon (1938) noted that the bryophyte flora of tropical Queensland was recognised as being of special interest to botanists, partly because of what had already been found but also because of what was yet to be discovered. Almost 80 years later, new records of bryophyte species are still being added regularly to the tropical Queensland flora. For example, additions have been made in the last few years to the moss flora in the Brachytheciaceae (Huttunen and Ignatov 2010), Stereophyllaceae (Cairns and Meagher 2014), Sematophyllaceae (Meagher and Cairns 2014), and Meteoriaceae (Meagher and Cairns 2016), and to the liverwort flora in the Lejeuneaceae (Renner 2011), Radulaceae (Renner et al. 2013, Renner 2014), and Lepidoziaceae (Brown and Renner 2014).

Here we add the first new species of *Macromitrium* Brid. recorded for the moss family Orthotrichaceae in Australia since the studies of Vitt and Ramsay (1985a,b).

The genus *Macromitrium* is the largest and most diverse in the Orthotrichaceae. The greatest diversity is in the Asia–Pacific region, including Asia and Australasia, extending into tropical Malesia and India, South and Central America, while the genus is less diverse with fewer species in Africa and the temperate forests in the Southern Hemisphere (Vitt and Ramsay 1985b; Ramsay and Cairns 2004) and is absent from Europe. The largest number of species are epiphytes in tropical and subtropical regions of the world, and this is true for Australia, where more than 85% occur in the Wet Tropics of Queensland (Ramsay and Cairns 2004).

The genus includes up to 350 species (Vitt and Ramsay 2012), although more than 800 names have been validly published. While many species described earlier have been reduced to synonyms, new species are still being discovered, as evidenced by Thouvenot and Yong (2015) and Thouvenot and Müller (2016).

Taxonomic revisions in the genus have dealt primarily with geographical regions, including New Zealand (Vitt 1983), Australia (Vitt and Ramsay 1985a, 2012), Papua New Guinea (Vitt et al. 1995), Mexico (Vitt 1994), Central America (Allen 1998, 2002), Africa (van Rooy and van Wijk 1992, Magill and van Rooy 1998, Wilbraham 2007, 2008, 2015, 2016), India (Gangulee 1976), Japan (Noguchi 1967), some Pacific Islands (Miller and Whittier 1990) and Indochina (Tan and Iwatsuki 1993). More recently a series of publications on *Macromitrium* in China (Jing et al. 2007, Guo et al. 2006, 2012) and New Caledonia (Thouvenot and Bardat 2010; Thouvenot and Yong 2015, Thouvenot and Müller 2016) and the Philippines, Malaysia and Indonesia (Guo et al. 2006, Yong 2016) have increased knowledge for Asia and New Caledonia, but so far no world-wide revision has been undertaken. Less is known of the taxa in South America and paleotropical areas to the north and north-west of Australia. The bulk of species in any geographical location at present are endemic to the area, but as studies continue some may be absorbed into synonymy with other taxa.

In Australia *Macromitrium* species are most prominent and diverse in rainforest or forest habitats along the eastern coast and tablelands from northern Queensland to Tasmania, but are absent from the Northern Territory and South Australia, and there is only one species in Western Australia, in the far south-west of that state. The greatest diversity occurs in tropical and subtropical rainforests; fewer species are found in the more temperate forests from New South Wales south to Tasmania (Ramsay et al. 1987). Seventeen of the twenty-one species reported for Australia by Vitt and Ramsay (1985a) occur in tropical Queensland.

A number of Australian tropical species exist only at elevations above 1200 m, such as *M. dielsii* Broth. ex Vitt & H.P.Ramsay, *M. funiforme* Dixon and our new species *M. erythrocomum* H.P.Ramsay, Cairns & Meagher, and are endemic to the Australian Wet Tropics. This supports the suggestion of Vitt et al. (1995), based on data from New Guinea, that high-elevation species are often narrow endemics.

Collections made recently on the Bellenden Ker Range under the auspices of the Australian Tropical Herbarium, Cairns, yielded two specimens of *Macromitrium* that appeared to be close to *M. involutifolium* (Hook. & Grev.) Schwägr. subsp. *ptychomitrioides* (Besch.) Vitt & H.P.Ramsay. Closer study, together with examination of herbarium collections and consultation with people involved in taxonomic research on the genus *Macromitrium*, including Dale Vitt, Joanna Wilbraham, Bruce Allen and Louis Thouvenot, have led us to agree that these specimens represent an undescribed species, which we have named *Macromitrium erythrocomum*.

Taxonomy

Macromitrium erythrocomum H.P.Ramsay, Cairns & Meagher, sp. nov.

Diagnosis: *Macromitrium* with branches 30–50(–70) mm long, leaves 3.5–4.5 × 0.65–0.8 mm; branch leaves with a prominent red to rusty-red excurrent costa filling the apex; upper leaf cells isodiametric to rounded-quadrata, bulging mammillose, often with a single papilla; marginal cells in mid-leaf and above rectangular with thick outer walls curved inwards into the lumen; a well-developed group of basal leptodermous window cells adjacent to the costa; seta 3.5–4.0(–6.0) mm long; capsule ovoid, mouth strongly puckered when dry, peristome absent or reduced to a low basal membrane; calyptra covered in rigid red hairs and a deeply lacerate base; and anisomorphic spores.

Type: Australia, Queensland, Bellenden Ker Range, on horizontal branch of *Leptospermum wooroonooran* in microphyll fern forest, 17°15'52"S, 145°51'13"E, 1543 m asl, D. Meagher WT-1022 & A. Cairns, 15 Aug 2016 (holo: BRI-AQ858157; iso: CANB).

General description: Pseudautoicous, with dwarf males. Plants medium-sized to robust, somewhat lustrous, light-green above and rusty red to darker red below, forming loose to dense spreading mats. Primary stem creeping, tightly adhering to substrate, 0.3–0.4 mm in diameter, mature leaves ± lanceolate-triangular, 1.9–2.3 mm long × 0.6 mm wide, costa strong, shortly excurrent, leaf basal angles long-decurrent. Rhizoids smooth, red to red-brown, on the ventral side of the stem, often very dense. Branches ascending, erect or slightly curved, axis about 0.35 mm in diameter, 30–50 (–70) mm long and about 2 mm wide when dry, up to 6 mm wide when moist, simple to sparsely branched, not readily separating from the stem. Branch leaves loosely spreading and individually twisted-contorted from an erect adherent base; arranged loosely in a spiral around the branch, with squarrose leaf apices exposed and curved but not usually inrolled, giving an untidy appearance to the upper branch when dry; upper branch leaves pale green, lamina often patchily pigmented dark-red; lower

branch leaves often dark-red, with apices somewhat more curved but only rarely inrolled; flexuose spreading to wide-spreading when moist; narrowly lanceolate with an ovate base, $3.5\text{--}4.5 \times 0.65\text{--}0.8$ mm, gradually tapering towards an acute to acuminate apex, unistratose, margins plane, entire to minutely crenulate from projecting cell walls. *Costa* prominent, red to rusty-red (often orange-red in young leaves), about $50 \mu\text{m}$ wide, slightly expanded at the leaf apex; in transverse section with a single row of thick-walled ventral stereids and a distinct region of guide cells, shortly exserted to \pm percurrent, abaxial surface with elongate costal cells exposed along the entire length. *Mid-leaf and upper leaf laminal cells* strongly bulging-mammillose, isodiametric to shortly elliptic, 13.0×15.8 (-21) μm , commonly with a single low rounded papilla; arranged in longitudinal rows, 7–8 rows from costa to margin each side near apex expanding to 16–22 rows in the lower part of the leaf; a single row (sometimes patchily two) of short-rectangular marginal cells present in the upper two-thirds of the leaf, $21\text{--}24 \times 7.9\text{--}9.7 \mu\text{m}$, with very thick outer walls curved strongly inwards producing a crescent-shaped lumen; in the mid-lamina often with a row of \pm rhomboid cells between the marginal cells and the inner rounded cells. *Basal laminal cells* gradually delineated from upper laminal cells, thick walled, porose, linear, $(20\text{--}) 37\text{--}58 \times 7\text{--}9 \mu\text{m}$ wide, lumens straight, sometimes with a single low papilla. A well-developed group of laminal leptodermous ‘window’ cells in leaf base adjacent to the costa, $47\text{--}68 \times 6\text{--}8 \mu\text{m}$, thin-walled, usually colourless and only on one side of the costa, occasionally pigmented mid to dark red.

Perigonia not seen. *Perichaetium* on a very short lateral branch. *Perichaetial leaves* triangular-lanceolate, shorter than branch leaves, inner leaves $3.0\text{--}3.17 \times 0.75$ mm; costa excurrent, filling an acumen 0.4 mm long. *Vaginulae* with a few hairs. *Seta* short, $3.5\text{--}4.0$ (-6.0) mm stout, smooth, erect, not twisted. *Capsule* ovoid-globose when young, narrower when mature, $2.4\text{--}3.2$ mm long including operculum, $1.0\text{--}1.1$ mm wide; urn with narrow 4–6 plicate mouth, strongly puckered when dry; operculum conic with upright rostrum $1.0\text{--}1.1$ mm long; peristome lacking or reduced to a basal membrane; exothecial cells rectangular to elongate-rectangular or rhomboidal, smaller and rectangular quadrate near rim, thick-walled, $18\text{--}26 \times 45\text{--}62 \mu\text{m}$. Stomata not seen. *Spores* anisomorphic, $26\text{--}29 \mu\text{m}$, and $13\text{--}16 \mu\text{m}$, surface lightly papillose. *Calyptra* mitrate, about 3 mm long, plicate, covering but not enclosing the capsule, with erect stiff rusty red hairs $58\text{--}62 \mu\text{m}$ thick, arising from base to top of calyptra and denticulate because of protruding cell ends; base lacerate into 8 segments to top of urn, sometimes with one split longer and the calyptra thus appearing cucullate. **Figs 1–3.**



Fig. 1. *Macromitrium erythrocomum* sp. nov. (Meagher WT-1022 & Cairns). Scale bar: 10 mm.

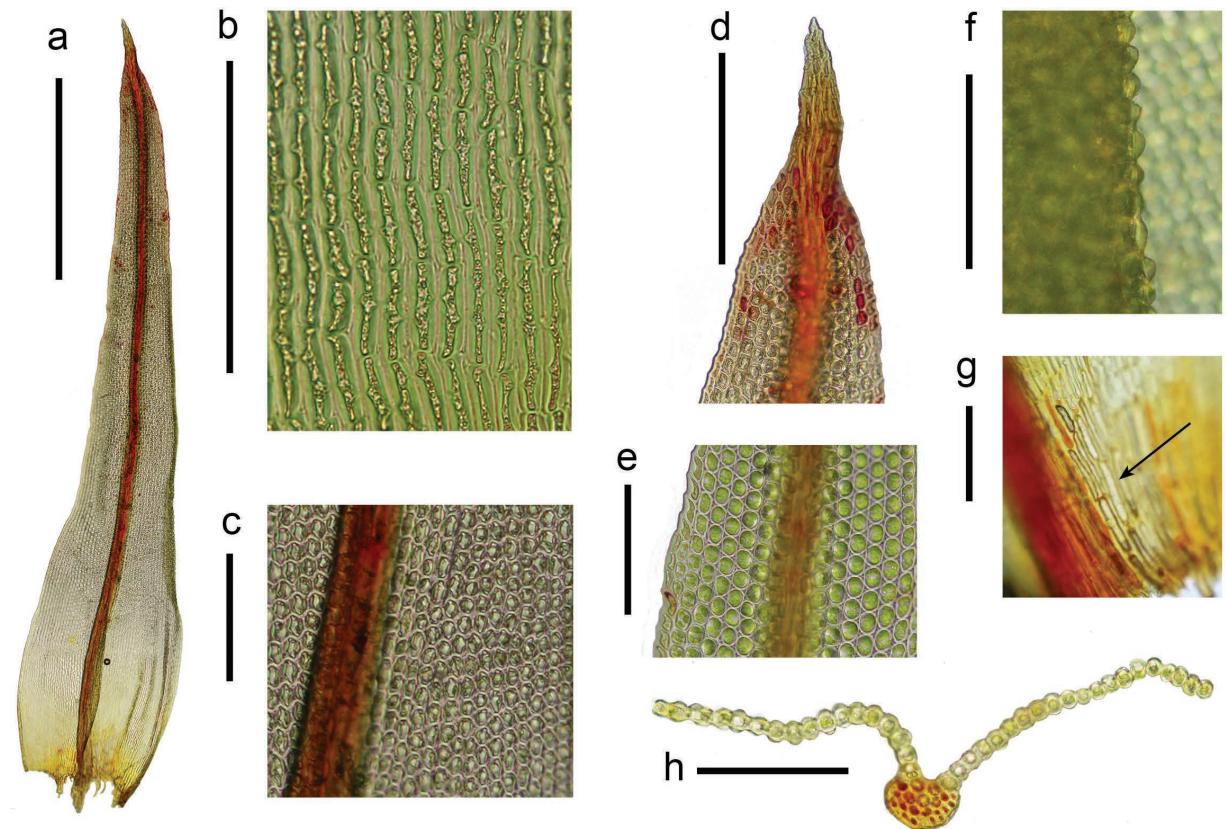


Fig. 2. *Macromitrium erythrocomum* sp. nov. branch leaves: (a) whole leaf, (b) porose linear cells in leaf base, (c) elliptical cells in mid-leaf, (d) leaf apex showing the strongly excurrent costa, (e) cells in upper leaf, showing irregular thick-walled marginal cells (f) bulging papillae of mid-leaf cells, (g) basal leptodermous window cells (arrowed), (h) transverse section of leaf. Scale bars: a = 1 mm, b,d,e–h = 100 µm, d = 200 µm. Photographed from Meagher WT-1022 & Cairns, and Meagher WT-1156 & Cairns.

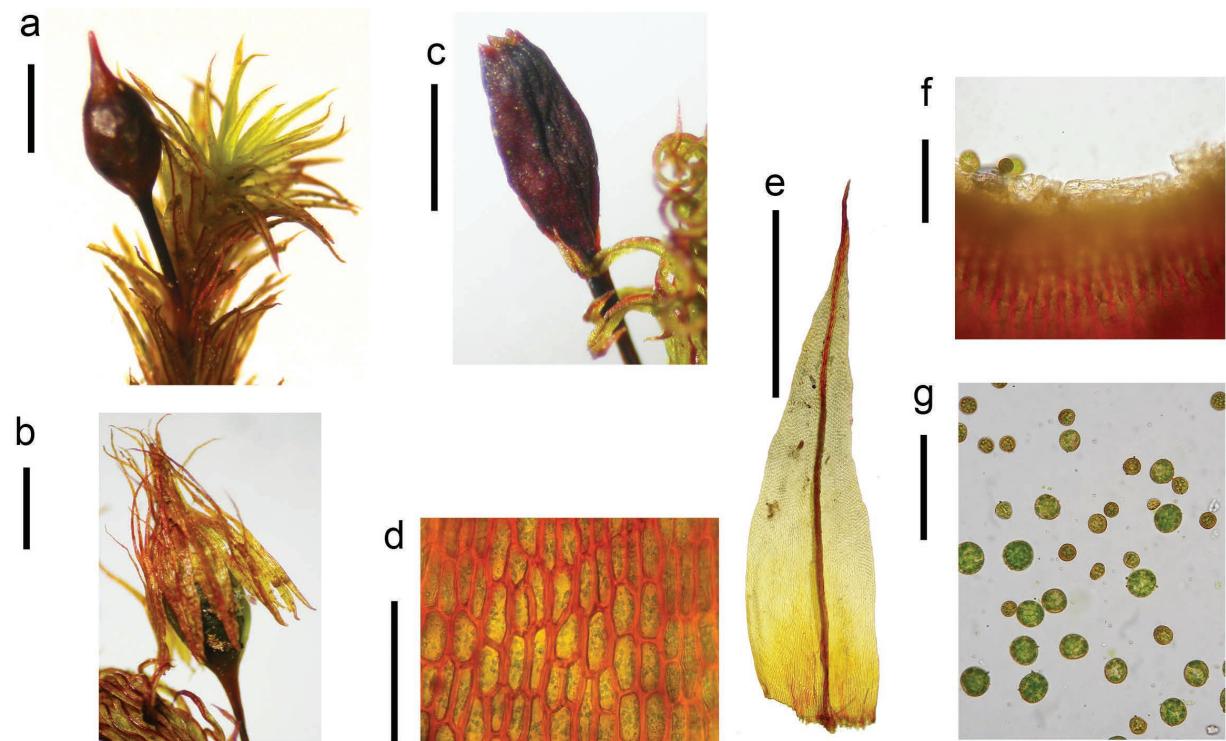


Fig. 3. *Macromitrium erythrocomum* sp. nov. (a) mature capsule, (b) calyptra on immature capsule, (c) mature dry capsule showing the pleated mouth, (d) exothelial cells of urn wall, (e) perichaetal leaf, (f) part of capsule mouth, (g) spores, showing anisomorphy. Scale bars: a–c, e = 1 mm, d,f,g = 100 µm. Photographed from Meagher WT-1022 & Cairns, and Meagher WT-1156 & Cairns.

Other specimens examined: These specimens, which are paratypes, include two collected much earlier that were undetermined and not examined by Vitt and Ramsay (1985a,b).

AUSTRALIA: QUEENSLAND, Bellenden Ker Range, western ridge, on horizontal branches of *Leptospermum wooroonooran*, 17°15'42" S, 145°51'09" E, c. 1571 m asl, D. Meagher WT-1156 and A. Cairns, 18 Aug 2016 (BRI, CNS); Bellenden Ker, near Centre Peak, beside creek in elfin rainforest, c. 17°16' S, 145°51' E, H.P. Ramsay s.n., 2 Nov 1981, NSW; Bellenden Ker summit, Webb & Tracey s.n., 22 Aug 1959 (BRI).

Etymology: The specific epithet is from Greek *erythrocomos*, meaning ‘redhead’, the informal name we gave this species because of the red hairs covering the calyptra. It is to be treated as a noun in apposition.

Notes: The lectotype of *M. involutifolium* subsp. *ptychomitrioides* (as *M. ptychomitrioides* Besch.), from New Caledonia, was examined and photographed for us by Joanna Wilbraham at the Natural History Museum (BM). We also checked several collections from North Queensland identified as *M. involutifolium* subsp. *ptychomitrioides*.

Macromitrium erythrocomum is most similar to *M. involutifolium* (Hook. & Grev.) Schwägr, particularly *M. involutifolium* subsp. *ptychomitrioides*. Both subspecies of *M. involutifolium* occur in northern Queensland, often growing together at the same locality. Like *M. erythrocomum* they are relatively large for the genus, have strongly bulging, rounded upper leaf cells, a short seta, a hairy calyptra, and in *M. involutifolium* subsp. *ptychomitrioides* a reduced or absent peristome.

The red colouration and its location in this new species, *M. erythrocomum*, is distinctly different from that found in other species of *Macromitrium*. *Macromitrium erythrocomum* differs from *M. involutifolium* subsp. *ptychomitrioides* in a number of characters. The red colouration in *M. erythrocomum* is distinctly different: Vitt and Ramsay (1985a) described *M. involutifolium* subsp. *ptychomitrioides* as ‘dark-green to olive-green, more rarely golden green’. Although some collections of *M. involutifolium* subsp. *ptychomitrioides* have golden to orange colouration in the costa and in the calyptra and its hairs, none have the distinct deep red colouration found in *M. erythrocomum*.

The new species also differs from *M. involutifolium* subsp. *ptychomitrioides* in having leaves with an excurrent red costa that fills the apex, leaves at branch apices curved-squarrose with leaf apices exposed, not usually inrolled when dry, a smaller ovate capsule, and a deeply lacerate calyptra with rigid red hairs. Older leaves appear dark red because of pigments in the cell walls, or because the cell lumens are filled with red pigment even though the walls may not have the red colouration. The red colour and location in this species differs from the colouration and its location seen in most other *Macromitrium* species. The presence of accessory pigments such as yellow, orange, red and rusty-brown is an important adaptation in mosses, providing physiological protection in a number species. These pigments defend plants against ultraviolet radiation damage (Campanella et al. 2014). Such pigments are a feature of certain species only, usually those that are genetically adapted to grow in high light habitats even though they may also grow in shade.

Most studies of photosynthesis and desiccation in mosses and the importance of pigments for protection have been derived from a limited number of species. No such studies have so far included tropical moss species such as *Macromitrium*. Marshall and Proctor (2004) studied the proportions of chlorophyll *a*, chlorophyll *b* and total carotenoids in 39 moss species in the United Kingdom and found that light values of chlorophyll: carotenoid ratios were highest in deep shade, but almost no similar work has been carried out for tropical forest species. Red, orange and yellow pigments are most pronounced in *Macromitrium* species adapted to high light habitats (Vitt 1994). Accessory pigments are frequently associated with plastids in vascular plants, but in mosses they occur predominantly in the cell walls of species.

Macromitrium erythrocomum exhibits some differences from the accepted concepts for red colouration in mosses. The specimens seen grew in dense shade protected from high light damage. Pigmentation must be genetically determined and that would explain a plant adapted to high light retaining this feature when growing in shade. There is an interesting progression in the leaf colour from the young to oldest leaves in *M. erythrocomum*. When young, the leaf is light green because the cells are packed with chloroplasts and the walls are not coloured, although the costa is bright red. As the leaf ages it loses the chloroplasts and the lumen becomes yellowish in colour, but still with a distinctively red costa. Eventually red pigments fill the cells and the walls become coloured, making the leaf entirely red.

The marginal cells are also distinct in *M. erythrocomum*: short-rectangular, with a thick outer wall curved inwards, giving a crescent-shaped lumen. Dale Vitt (pers. comm. November 2016) suggested they are similar to leaf marginal cells in some South American species.

There are several other large species of *Macromitrium* in North Queensland, but only *M. funiforme* and *M. leratii* Broth. & Paris are outwardly similar to *M. erythrocomum*. However, in both these species the colour

is rusty-brown, the costa is orange, there is no red colouration in the cell walls or lumens, the leaves are smaller and more widely lanceolate, the branches are shorter, the calyptora is hairless, the seta is longer, and the capsule has a peristome. No other Australian species of *Macromitrium* has a patch of leptodermous tissue in the leaf base. However, Joanna Wilbraham (pers. comm. Dec. 2016), who suggested the term ‘basal window cells’ for this tissue, noted that these cells occur in other *Macromitrium* species such as *M. sulcatum* (Hook.) Brid. and *M. soulae* Renaud & Cardot. In the macromitrioid *Groutiella tomentosa* (Hornschr.) Wijk & Marg. these cells occur as 2–5 rows on the leaf margin, not near the costa. When the leaves of *M. erythrocomum* are removed from the stem, the leaf often tears above these cells, so that they are not visible in the dissected leaf.

Individual characters listed here may be present in various tropical *Macromitrium* species in Papua New Guinea and New Caledonia. Characters include large size with branches more than 30 mm tall, strong secondary pigmentation, a hairy lacerate calyptora, lanceolate leaves narrowing gradually to a short-acuminate apex, stem leaves smaller than branch leaves, costa shortly excurrent and filling the acumen, upper cells bulging with a single papilla, basal cells elongate and porose with straight lumens, capsule ovoid, peristome lacking, and spores anisomorphic. In *M. erythrocomum* this full combination of characters is present but does not occur in any other known species.

Other species from Papua New Guinea with a reddish-brown or rusty red pigmentation are (1) *M. erubescens* Bartr., (2) *M. macrosporum* Broth., (3) *M. megalocladon* Fleisch. and (4) *M. yuleanum* Broth. & Geh. (Vitt et al. 1995). Each differs from *M. erythrocomum* in three or more features, such as a different cell structure (1,2,3), costa not excurrent (2,3,4), longer seta (1,3), capsule mouth not puckered when dry (1,2,3,4), and hairless calyptora (2,4) or calyptora hairs basal (1). Other species with some characters shared with *M. erythrocomum* include *M. austrocirrosum* Bartr., *M. acuminatum* (Reinw. & Hornsch) Müll.Hal. [syn. *M. elongatum* Dozy & Molk.] and *M. ochraceum* (Dozy & Molk.) Müll.Hal. In *M. austrocirrosum* and *M. archboldii* Bartr. similarities shared are basal cells porose, elongate with straight lumens, costa excurrent and spores anisomorphic, but differences from *M. erythrocomum* include absence of red colour, naked calyptrae, a peristome and longer setae. *Macromitrium erubescens* shares a hairy calyptora, spores anisomorphic, stem leaves smaller than branch leaves, leaves lanceolate, basal cell lumens long and straight but it differs in the 5-ranked leaves, colour, calyptora hairs restricted to base, the seta is longer and it has a peristome.

The Malesian species *M. ochraceum* (Dozy & Molk.) Müll.Hal. has a longer seta, lacks the red colour and has a longer leaf apex, the calyptora is not lacerate with hairs mainly at base, and it has a distinct peristome (Yong pers. comm. November 2016). Thouvenot (pers. comm. November 2016) suggested that the only species with a red costa from New Caledonia is *M. rufipilum* Cardot, which has a long seta and a long-excurrent costa forming a piliferous leaf apex. Two recently described new species from New Caledonia, *Macromitrium larrainii* Thouvenot & K.T.Yong (Thouvenot and Yong 2015; Müller et al. 2016), and *Macromitrium humboldtense* Thouvenot & Frank Müll. (Thouvenot and Müller 2016) do not have the combination of short seta, red hairy calyptora, leaves with red excurrent costa, porose basal laminal cells with straight lumens, and rectangular marginal cells with curved lumens and no peristome.

It is clear from this discussion that a molecular study of *Macromitrium* is needed to establish phylogenetic and biogeographic relationships between species. In addition, it might be valuable to analyse the biochemistry of red pigments in *Macromitrium* should suitable material become available in the future.

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