

Scanning electron microscope studies on four species of *Ulota* from Australia¹

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Abstract: *Ulota* species are difficult to separate to species level on leaf characters alone. In this study, scanning electron microscopy of habit and leaves, capsules, peristomes, and spores proved useful in separating four Australian species. Details of capsule and peristome, particularly distinctive features of the endostome, are shown.

Key words: *Ulota*, Orthotrichaceae, bryophyte, mosses.

Résumé : On arrive difficilement à séparer les *Ulota* espèces au niveau de l'espèce avec les seuls caractères foliaires. L'observation en microscopie électronique par balayage du port et des feuilles, des capsules, des péristomes et des spores permet de distinguer quatre espèces australiennes. L'auteure illustre les détails de la capsule et du péristome, des caractéristiques particulièrement distinctives d'endostome.

Mots-clés : *Ulota*, Orthotrichaceae, bryophytes, mousses.

[Traduit par la Rédaction]

Introduction

The genus *Ulota* closely resembles *Orthotrichum* in growth form, the sulcate capsules hairy calyptras, habitat, and geographic distribution. One species, *Ulota viridis*, shows some growth form resemblance to *Macromitrium*. *Ulota* is distinguished from other genera in the family Orthotrichaceae by the leaves that have a characteristic expanded base with a well-differentiated border of a few to many rows of quadrate to rectangular hyaline cells and very thick-walled, papillose, upper leaf cells (Ramsay 2006).

Venturi (1893) reported a new species of *Ulota* in Australia, *Ulota cochleata*, Weymouth (1894) added species for Tasmania, and Malta (1933) published a revision of the genus in Australasia (Australia and New Zealand). A recent revision of the genus *Ulota* for Australia has been published by Ramsay (2006). In this revision, the following four species and two varieties are recognized for Australia: *Ulota lateciliata* Malta, *Ulota cochleata* Venturi ex Broth., *Ulota lutea* Mitt. ex Hook. f. & Wilson Mitt., *Ulota lutea* var. *robusta* Malta ex Dix., *Ulota viridis* Venturi ex Broth., and *Ulota viridis* var. *dixonii* Malta. These species are difficult to distinguish without a combination of gametophytic and sporophytic characters. Although all are Southern Hemi-

sphere species, only *U. cochleata* is endemic to Australia, the other three being also in New Zealand.

Ulota membranata Malta is a rare epiphyte in Tasmania and New Zealand and a distinct species with large multicellular spores. Another species that occurs in the Southern Hemisphere associated with Australia is *Ulota phyllantha* Brid., a distinct maritime bipolar species that occurs on subantarctic Macquarie Island (Seppelt 2004), remote from Australia, but politically a part of the southernmost Australian State, Tasmania. This latter species has a wide distribution in northern and western Europe, North America, southern South America including Tierra del Fuego, and Southern Africa.

Scanning electron microscope (SEM) studies

In the revision of the genus by Ramsay (2006), illustrations of *Ulota* include drawings of habit studies, leaves, cell structure, capsules, and calyptrae. As mentioned by Ramsay, the species, although often quite similar, e.g., *U. cochleata* and *U. lateciliata*, may grow in mixed colonies but can be distinguished with careful examination. The SEM studies presented here courtesy of Dale H. Vitt illustrate habit and leaves, capsule, peristome structure, and spore surfaces for the four species *U. cochleata*, *U. lutea*, *U. lateciliata*, and *U. viridis* to more clearly demonstrate the differences. The most useful characters for separating species of *Ulota* include plant habit such as tufts, cushions, or creeping; leaves twisted or crisped when dry; capsule shape and neck; spore size and whether unicellular or multicellular; and, in the peristome, particularly features of the endostome.

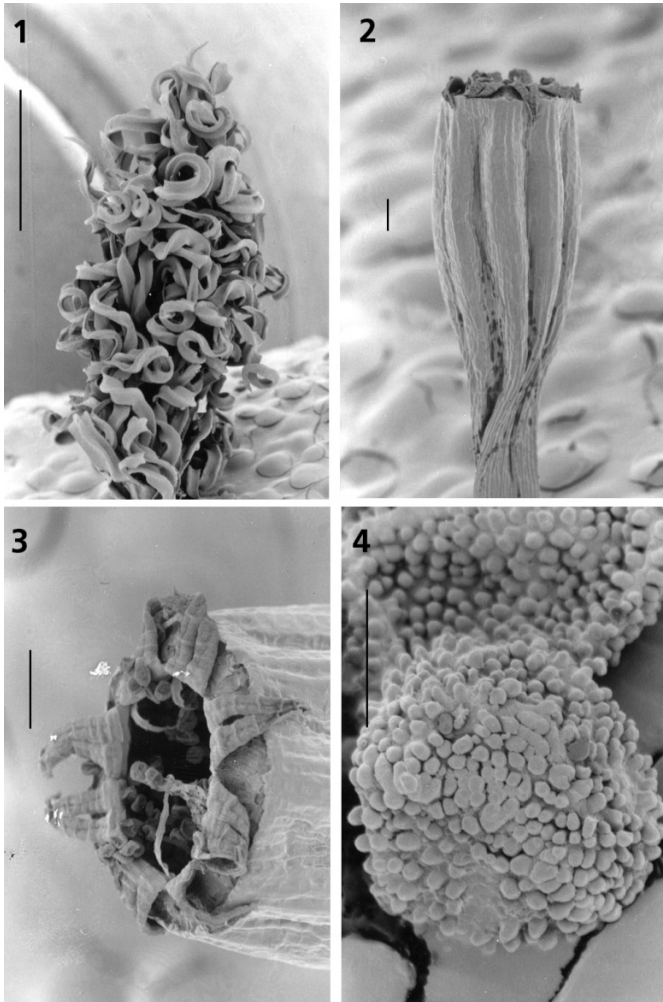
In *U. cochleata* (Figs. 1–4), the leaves are strongly twisted but not crisped when dry and have acute apices (Fig. 1); the

Received 27 March 2009. Accepted 10 September 2009.
Published on the NRC Research Press Web site at botany.nrc.ca on 7 April 2010.

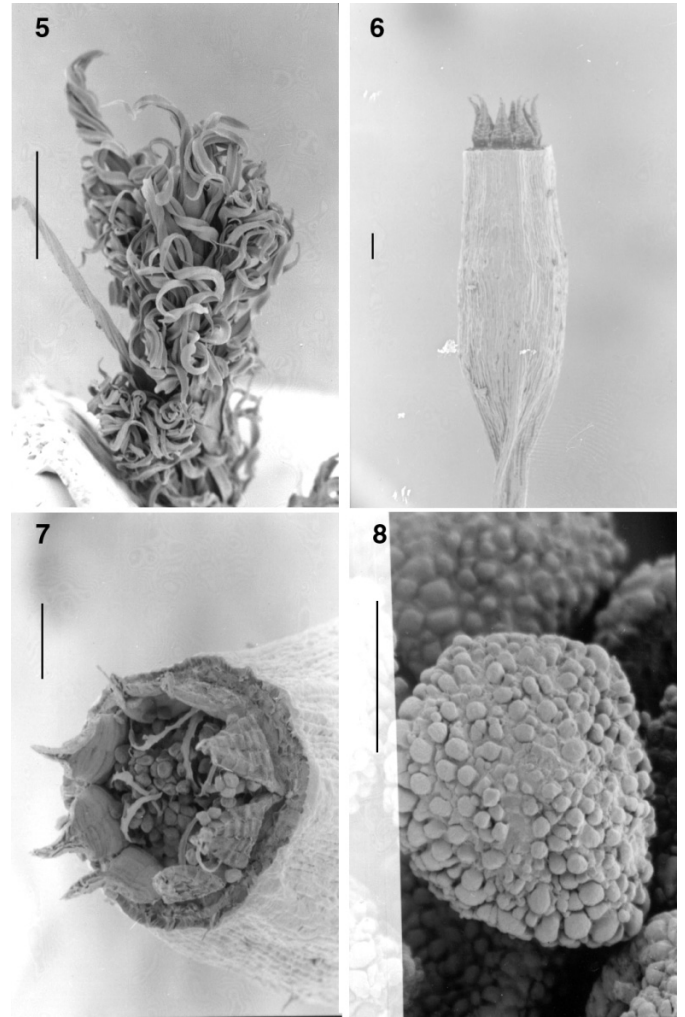
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¹This paper is one of a selection of papers published as part of the special Schofield Gedenkschrift.

Figs. 1–4. *Ulota cochleata* [isotype Weymouth 898 HO] (1) plant showing leaf arrangement (scale bar = 1.0 mm), (2) capsule (scale bar = 100 μ m), (3) peristome (scale bar = 100 μ m), and (4) spores (scale bar = 10 μ m).



Figs. 5–8. *Ulota lateciliata* [isolecotype Weymouth 2487 HO] (5) plant showing leaf arrangement (scale bar = 1.0 mm), (6) capsule (scale bar = 100 μ m), (7) peristome (scale bar = 100 μ m), and (8) spores (scale bar = 10 μ m).



capsule is oblong, ovoid to cylindrical and deeply 8-ribbed to the base (Fig. 2) with the peristome recurved, exostome wide with an acuminate apex, and often split vertically, with a filiform endostome (Fig. 3); the spores are 20 μ m with a papillose surface, the papillae evenly shaped and regularly arranged, dense, and tall (Fig. 4).

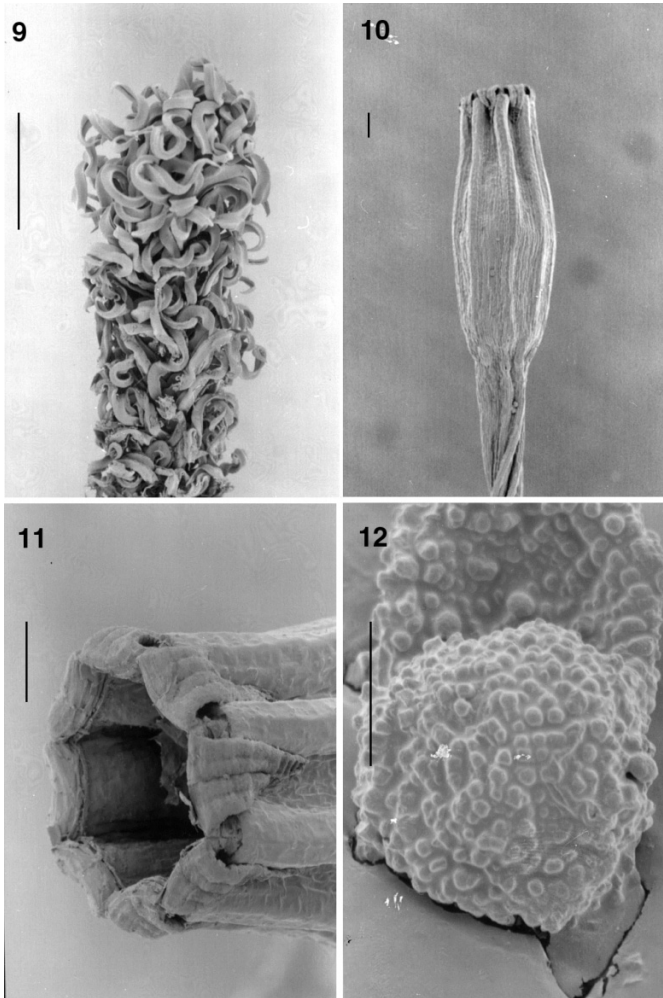
In *U. lateciliata* (Figs. 5–8), the leaves are loosely arranged curled, twisted, and acuminate (Fig. 5); capsules are long, ovoid to subcylindrical when dry, slightly contracted below the mouth, and shallowly 8-ribbed to the base (Fig. 6); the peristome is upright, not recurved as in other species (Fig. 7) with the 8 exostome segments, broad at the base, and tapering abruptly as seen in Figs. 6 and 7, while the spores are 25 μ m with large but short globular papillae densely arranged that are relatively uniform in size (Fig. 8).

In *U. lutea* (Figs. 9–12), the leaves are strongly crisped, twisted, and contorted when dry (Fig. 9); the capsules have a long smooth tapering neck, deeply 8-ribbed to the base, the neck often twisted with the seta (Fig. 10); the peristome is recurved, with exostome teeth broad and tapering gradually to an acute apex (Fig. 11); spores are 20 μ m with large

and small papillae (Fig. 12) irregularly and densely arranged. Two varieties are noted with the new variety *robusta* in Ramsay (2006) but previously a separate species in Malta (1933). They differ in plant size, leaf length, and capsule size. Only the type species is illustrated here (refer to Ramsay 2006).

In *U. viridis* (Figs. 13–16), the leaves are only slightly twisted with projecting apices when dry, the apex is narrowly acuminate (Fig. 13), and capsules are short, ovate, grooves continuing into seta (Fig. 14); the exostome is strongly recurved when dry, slightly narrower than other species and tapering gradually to an acute apex, and the endostome is filiform and smooth (Fig. 15); spores are smaller, 10–15 μ m (note the different scale), with short, dense, irregularly arranged large papillae (Fig. 16). The two varieties reported for *U. viridis* differ in the leaf size and leaf border as well as spore surface. In the type variety illustrated here, the leaf is somewhat smaller with a border of 4–6 cell rows and the capsule is larger with a recurved exostome, while in variety *dixonii* (not illustrated here), the leaf is larger with a border of one to three rows only and the capsule is smaller

Figs. 9–12. *Ulotia lutea* [isotype of synonym *Ulotia weymouthi*, Weymouth 615 HO] (9) plant showing leaf arrangement (scale bar = 1.0 mm), (10) capsule (scale bar = 100 μ m), (11) peristome (scale bar = 100 μ m), and (12) spores (scale bar = 10 μ m).



with a longer operculum and exostome teeth less recurved. The spores are verrucose in variety *dixonii* and papillose with large papillae in variety *viridis* (refer to text and illustrations in Ramsay 2006).

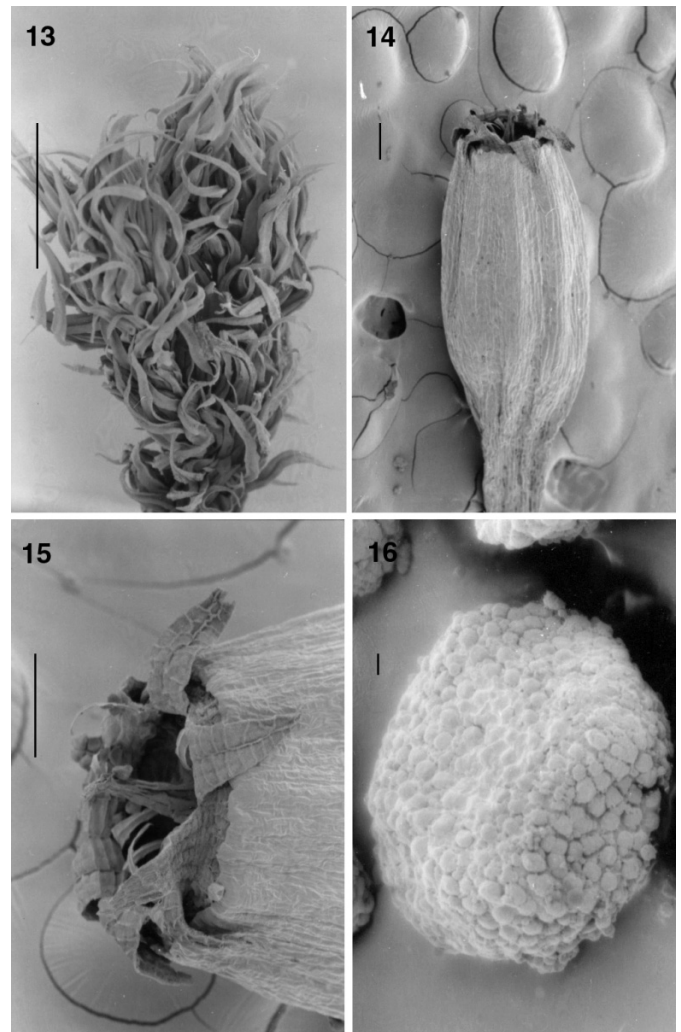
Discussion

SEM for clarifying morphological characteristics is now used with success for bryophyte taxonomy. The data presented here have shown clearly the differences between the four species investigated and added to our understanding of these character differences between species as well as showing the similarities and characteristics shared in various species of the genus *Ulotia*.

Acknowledgements

The author is deeply indebted to Wilf Schofield with whom I collected and studied the cytology of some western North American mosses in 1978 and who sent me from Vancouver to Edmonton to meet Dale Vitt. Both Wilf and Dale later visited Australia and worked with me at different times on a number of projects on Australian mosses, e.g.,

Figs. 13–16. *Ulotia viridis* [isotype Weymouth 901 HO] (13) plant showing leaf arrangement (scale bar = 1.0 mm), (14) capsule (scale bar = 100 μ m), (15) peristome (scale bar = 100 μ m), and (16) spores (scale bar = 1.0 μ m). Note different scale for spores on this plate.



Dale on *Macromitrium* and Wilf on the family Sematophyllaceae. Whilst in Australia, Wilf Schofield collected hundreds of moss specimens to add to collections at NSW, some being *Ulotia* species. Dale Vitt kindly read and suggested improvements to the manuscript on *Ulotia* for the “Flora of Australia” and provided the SEMs included in this publication. For this help, I acknowledge the great assistance of them both. The many hours spent working with each, in the field and in the laboratory, the many discussions, and their support at different times have been both enjoyable and productive.

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