

## Bryological Herbarium Facilities and Current Research Projects in New Zealand

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**Abstract** The moss and hepatic/hornwort floras of New Zealand are diverse and exhibit a high level of endemism. A current census of New Zealand mosses comprises 516 species distributed in 207 genera, while the known hepatic/hornwort flora includes 607 species in 157 genera. The endemism rate at the species level is c. 24% for indigenous mosses (117 spp.) and c. 53% (319 spp.) for indigenous hepatics/hornworts.

Bryological exploration of New Zealand began in 1769, with the earliest collections made by Joseph Banks. There are now (2005) substantial and well-curated bryophyte collections at three locations in New Zealand: the Auckland War Memorial Museum in Auckland (AK, with c. 34,000 specimens); Te Papa Tongarewa or the Museum of New Zealand in Wellington (WELT, with c. 56,000 specimens); and the Allan Herbarium at Landcare Research in Lincoln (CHR, with c. 110,000 specimens). Overseas, the most significant historical collections are at BM. In the three main New Zealand herbaria, mosses comprise c. 70% of the total bryophyte specimens. This inequality of collection numbers reflects a long-standing historical bias, but may also reflect the restricted distribution of many hepatic taxa in relatively inaccessible parts of the country.

Current research emphasis in New Zealand bryology is on Flora production. At Landcare Research we plan the completion of the final draft of a fully illustrated, single-volume moss Flora by Allan Fife and Jessica Beever in mid-2007, with publication expected in 2008. Line drawing illustrations for all documented species have been completed.

David Glenny (at Landcare Research) and John Engel (in Chicago, USA) are preparing a three-volume hepatic Flora. The first volume is expected to be published by early 2007, with subsequent volumes at 3-year intervals. David Glenny and Bill Malcolm (in Nelson) have recently published an illustrated interactive key to the hepatic and hornwort genera of New Zealand and Australia.

The publication of a modern moss Flora for New Zealand will highlight a wide range of unresolved taxonomic, phytogeographic, and systematic problems, many of which could be profitably approached using molecular methods. Future work could include studies of species relationships and limits in such intractable moss genera as *Sphagnum*, *Hypnum*, and *Racomitrium*, systematic studies of the family Ptychomniaceae or the genus *Blindia*. The indigenous status of some presumed "bipolar" species (e.g., *Climacium dendroides*, *Aulacomnium palustre*) could also be investigated using molecular techniques. The systematists at Landcare Research would welcome proposals for collaborative research projects on New Zealand bryophytes.

**Key words:** bryophyte, moss, hepatic, liverwort, hornwort, New Zealand, Flora, herbaria.

### Introduction

The three main islands of New Zealand have a land area of about 270,000 square kilometres, or about 72% of the land area of Japan. These islands extend from about 34 to 47 degrees south

latitude, and this compares to about 32 to 44 degrees north latitude for the four main islands of Japan. Like Japan, New Zealand is a mountainous country. On the North Island a number of volcanic peaks rise to elevations of nearly 2800 m a.s.l. One of these peaks, Mt. Taranaki (Mt. Egmont), is often compared to Fuji-san because of its remarkable symmetry. On the South Island, a spine of high mountains, collectively known as the Southern Alps, dominates the island. Many Southern Alp peaks exceed 3000 m elevation, with the highest, Aoraki/Mt. Cook, reaching 3764 m. The climate is highly oceanic and largely dominated by moist, westerly air flows and their interaction with the mountainous topography. Average annual precipitation is variable in different regions and ranges from c. 8000 mm in some subalpine localities in the Southern Alps to as low as c. 300 mm in semi-arid areas in the rain-shadow of those mountains.

The interaction of climate, topography, vegetation, and other factors results in diverse habitats for bryophytes and the moss and hepatic/hornwort floras are correspondingly rich. A current census of the New Zealand mosses comprises 516 species distributed in 207 genera and 60 families. Only 33 species of mosses can be termed adventive with any degree of confidence. Of the remaining 483 species, 117 species (approximately 24%) and 10 genera are thought to be endemic. There are no endemic moss families in New Zealand.

The New Zealand hepatic and hornwort flora comprises 607 species distributed in 157 genera and 49 families. Only six species are considered to be adventive. Of this total 319 species (approximately 53%), 17 genera, and 2 families are considered endemic (D. Glenny, pers. comm., Nov. 2005).

### **Synopsis of New Zealand Bryophyte Herbarium Resources**

The collection of the New Zealand bryophytes has a long history. The earliest described moss species based on New Zealand collections were published by Hedwig (1801) and probably based on material collected by Joseph Banks on James Cook's first voyage of 1769–1771. The earliest hepatic collections appear to be those made by Archibald Menzies at Dusky Sound in Fiordland in 1791 and described in W. J. Hooker's (1818–1820) *Musci Exotici*. All New Zealand bryophyte collections made in the 18th and first half of the 19th-century were placed in British or European herbaria, and most were eventually incorporated into the herbarium of the Natural History Museum in London. The collections made by J. D. Hooker on the main islands of New Zealand and the Auckland and Campbell islands during the *Erebus* and *Terror* Expedition of 1839–1844 are particularly significant. The Natural History Museum (BM) remains the most important repository of early New Zealand moss and hepatic collections.

However, from the latter part of the 19th century an increasing fraction of New Zealand specimens were retained in-country, initially deposited in private herbaria. Eventually these private collections were deposited in public museums within New Zealand, especially those located in Wellington, Christchurch, and Auckland.

At present, three public herbaria in New Zealand maintain major bryophyte collections. All three have modern facilities and are actively curated. Although each of the three major herbaria houses specimens from throughout New Zealand, each exhibits a degree of regional and historical specialisation.

The Museum of New Zealand/Te Papa Tongarewa (WELT), located in the capital city of Wellington, houses some 56 000 bryophytes, of which about 31,000 are databased New Zealand moss specimens. WELT houses more 19th century material than other New Zealand herbaria; it includes the historically important herbarium of Charles Knight and many collections of William



Fig. 1. Portrait of G. O. K. Sainsbury (date and photographer unknown).

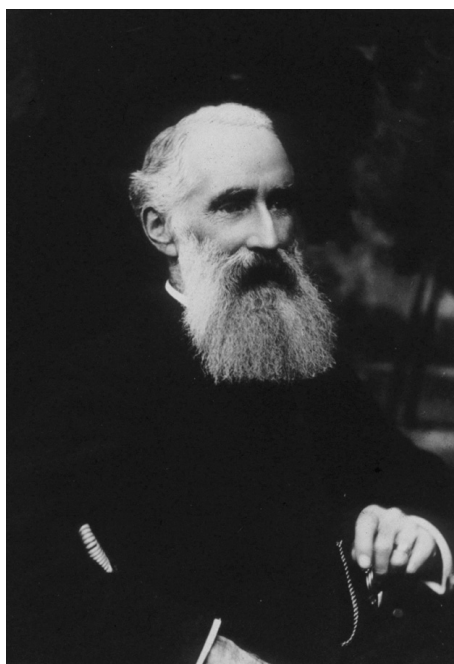


Fig. 2. Portrait of T. W. N. Beckett (date and photographer unknown).

Colenso (but most of Colenso's collections are at BM). Additionally, Te Papa incorporates the highly significant 20th century herbarium of G.O.K. Sainsbury. A modest number of types (135 mosses and 139 hepatics) are present at WELT.

At Landcare Research, near Christchurch, the Allan Herbarium (CHR) contains approximately 75,000 moss specimens, making it the largest collection in New Zealand. Although it is generally a newer herbarium than WELT, the Allan Herbarium incorporates the historically significant and type-specimen-rich herbarium amassed by T.W.N. Beckett during the late 19th and early 20th centuries, the important mid-20th century collections of K.W. Allison and W. Martin, and duplicates from the herbarium of G.O.K. Sainsbury. In addition, CHR houses c. 20,000 hepatics and the entire plant collection at the Allan Herbarium comprises c. 550,000 plant specimens. Databasing of bryophyte specimens is incomplete but ongoing. At least 170 New Zealand moss types are present, and an undocumented but large number (probably 300–400) of "exotic" moss types (mostly isotypes) are present in the Beckett collection, which is retained in separate cabinets from the main collections. There are also 134 hepatic types at CHR.

Finally, the Auckland War Memorial Museum (AK) houses some 34,200 bryophyte specimens, including the late 20th century collections of J. K. Bartlett. The entire herbarium is databased and includes 30 moss type specimens and 16 hepatic type specimens.

### Current Research Projects Involving New Zealand Mosses

Current research on New Zealand mosses is focused on the production of a modern regional Flora. Together with my colleague Jessica Beever and a few overseas colleagues, I am working on an illustrated Flora treatment of the 516 moss species. In the production of this Flora we have



Fig. 3. Exterior of the Allan Herbarium, Lincoln (Nov. 2005, during construction of herbarium addition).

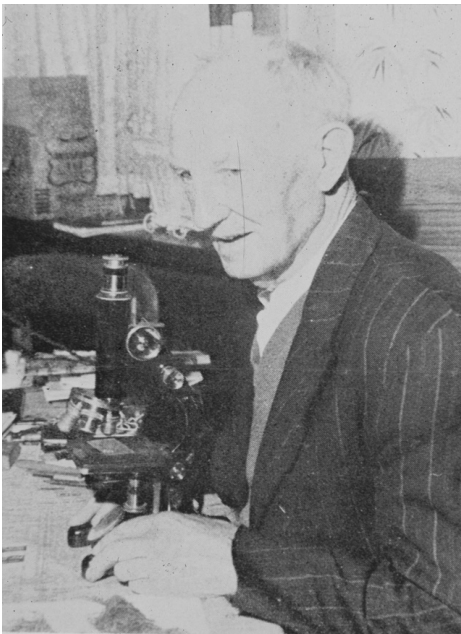


Fig. 4. Portrait of K. W. Allison (1974, photo by J. Child).



Fig. 5. Portrait of W. Martin (1970, photo by J. Child).

built upon the excellent “Handbook” of G.O.K. Sainsbury (1955), as well as studies by Dixon (1913–1929) and earlier workers.

The illustrations for this book have been completed by Rebecca Wagstaff, excluding those for the Pottiaceae, which are currently being drawn by Dr. Rod Seppelt of Hobart, Tasmania. The text for the moss Flora is c. 75% completed. Draft texts have been completed for most of the larger and more difficult families, including the Bartramiaceae, Brachytheciaceae, Bryaceae, Dicranaceae, Fissidentaceae (by J. Beever), Grimmiaceae, Polytrichaceae (by R. S. Tangney), and



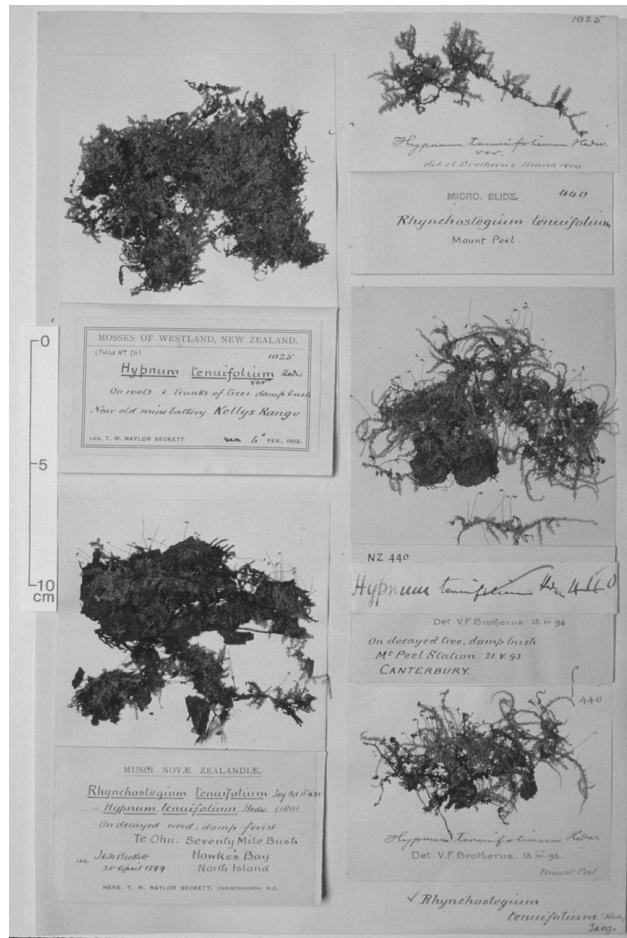


Fig. 6. A typical specimen sheet from the Beckett herbarium at CHR.

Sphagnaceae. Some family treatments are based on modern monographic treatments covering the Australasian region and these include the Ditrichaceae (Seppelt, 1982), Orthotrichaceae (Vitt, 1976, 1983; Lewinsky, 1984, 1990), Hypnodendraceae (Touw, 1971), Hypopterygiaceae (Kruijer 2002), Meteoriaceae (Streimann, 1991a-c), and Thuidiaceae (Touw & Falter-van den Haak, 1989). Larger families for which partial drafts require further work include the Seligeriaceae, Daltoniaceae, Ditrichaceae, Hypnaceae, and Mniaceae. In the Hypnaceae, species have been assigned to genera (especially genera allied to *Isopterygium*) with some reservation. Also in that family the varieties of *Hypnum cupressiforme* remain poorly understood. Two large families still require considerable revision. The Pottiaceae are currently being reviewed by Jessica Beever, who continues to discover undocumented New Zealand taxa, and the Amblystegiaceae (in the wide and traditional sense) continues to provide taxonomic difficulties at both the species and generic level. We aim to complete the text in 2007 and to publish the Flora, as either one or two volumes, during 2008.

The moss Flora project has been supported by a large number of both professional and amateur botanists throughout the country with a strong interest and good working knowledge of the New Zealand mosses. A high level of interest in mosses (and hepatics) in New Zealand has been



Fig. 7. Jessica Beever (Oct. 2005, photo by R. Beever).



Fig. 8. Rebecca Wagstaff (Nov. 2005, photo by S. Wagstaff).

maintained by a series of annual field workshops that have been held at different locations since 1983. Collections made during these “John Child Workshops” have contributed greatly to our knowledge of the moss distributions throughout New Zealand and have encouraged professional botanists/ecologists to incorporate bryophytes into their research projects.

Another factor in the high profile of mosses, and cryptogams in general, in New Zealand has been the availability of a field guide to the common moss species (Beever et al., 1992) and a number of beautifully illustrated semi-popular identification guides produced by the photographers Bill and Nancy Malcolm (e.g., Malcolm & Malcolm, 2003).

### After the Moss Flora: What Next?

Ongoing work towards the completion of the moss Flora in 2007 continues to highlight unanswered questions concerning species relationships. Many of these questions could be profitably approached using modern molecular techniques, but there is no ongoing molecular systematics research focused on New Zealand mosses. The systematists at Landcare Research would welcome proposals for collaborative research projects on New Zealand bryophytes. A few examples of outstanding questions are given below.

A number of genera/families in the New Zealand moss flora exhibit variation that cannot be adequately interpreted using conventional morphological/descriptive techniques. *Racomitrium*, *Hypnum*, *Hypopterygium*, *Distichophyllum*, *Calyptrochaeta*, and *Plagiothecium* are six genera where regional species limits could profitably be explored using molecular techniques, such as the use of AFLPs. *Sphagnum* is another genus where species limits (particularly in sections *Sphagnum*, *Cuspidata*, and *Subsecunda*) are inadequately understood. The species in these sections have received various taxonomic interpretations; the “taxonomic stance” adopted for the



Fig. 9. David Glenny (Nov. 2005).

Flora is to apply a broad species concept and to note morphological variations.

In *Racomitrium* six of the seven documented New Zealand species are clearly defined by morphological characters. The seventh species, *R. crispulum*, exhibits a confusing array of morphotypes, only some of which appear to be correlated with environmental factors, and requires more detailed study. It is likely that additional species of *Racomitrium* will be added to the flora. *Racomitrium fasciculare* and *R. aquaticum* have been recorded incidentally from New Zealand in northern hemisphere Floras (Crum & Anderson, 1981; Noguchi, 1988) and their possible occurrence in New Zealand requires special investigation.

Many problems of southern hemisphere/New Zealand moss systematics and historical geography would benefit from a non-traditional molecular approach. These include questions of plant migration at a range of taxonomic levels. At the species or near-species level an examination of the colonisation of southern hemisphere landmasses, including subantarctic islands of recent volcanic origin, would be profitable. *Entosthodon laxus*, *Brachythecium paradoxum*, and *Holodontium strictum* are three species occurring in New Zealand, South America and several oceanic island groups. Molecular studies of isolated populations of these species could reveal migration patterns relevant to other southern hemisphere plant groups. At the generic level, *Blindia* is a genus of c. 16 species (seven occurring in New Zealand). All but one species occurs only in the southern hemisphere and several species are of very restricted distribution. The genus would be a fascinating one to study using molecular techniques. At a higher taxonomic level the Ptychomniaceae are a family of seven genera and c. 15 species. The Ptychomniaceae are primarily distributed in temperate southern hemisphere regions and have maximum generic diversity in New Zealand (six of seven genera) but maximum species diversity in South America. The Rhizogoniaceae are a moderate-sized family (c. 10 genera with six occurring in New Zealand) of predomi-

nantly southern hemisphere distribution. Cladistic and phylogeographic studies of these families using molecular methods would seem particularly worthwhile.

A feature of the New Zealand moss flora unique to the southern hemisphere is the large number of bipolar species present at high elevations. For the most part these species are widespread in temperate to cold regions in the northern hemisphere and present in one or more southern hemisphere region. Some 69 species in the New Zealand flora exhibit this pattern of distribution. Future studies, using molecular techniques, may show that some of these species are introductions to New Zealand. *Climacium dendroides* and *Aulacomnium palustre* are two species that have been interpreted as indigenous in New Zealand but which exhibit some characteristics (e.g., single-sex, non-fruiting populations and their collection history) suggesting they may be early introductions.

### Current Research Projects Involving New Zealand Hepatics

The other major ongoing research project concerns the hepatics; because of my lack of direct involvement in this project, I will comment only briefly about it. My colleague David Glenny and Dr. John Engel (of the Field Museum, Chicago, USA) are preparing a three-volume hepatic Flora. The first volume is expected to be published by early 2007, with subsequent volumes at 3-year intervals. Also, an illustrated interactive key to the hepatic and hornwort genera of New Zealand and Australia has been recently published by David Glenny and Bill Malcolm (Glenny & Malcolm, 2005).

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