Habitat, distribution and the phytogeographical affinities of mosses in the Wet Tropics bioregion, north–east Queensland, Australia.

Helen P. Ramsay[1] and Andi Cairns[2]

[1]National Herbarium of New South Wales, Royal Botanic Gardens, Sydney NSW 2000, AUSTRALIA. [2]School of Tropical Biology, James Cook University, Townsville, Queensland 4811, AUSTRALIA.

***Abstract*:** A checklist of the mosses (Bryophyta) of the Wet Tropics bioregion, north-east Queensland is presented. Included is an update on the taxonomy of species, listing a total of 408 taxa. The habitat and distribution patterns of species within the area and in Australia, together with information on the phytogeographical affinities of these taxa in related areas beyond Australia, are discussed.

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Dedication

The authors present this work as a tribute to the memory of the late **Ilma Stone** (**1913–2001)** and **Heinar Streimann (1938–2001)**, whose work in the area formed the basis for these studies.

The work began in the 1980s, between 1984 and 1998 with Ilma Stone, whose taxonomic studies and data from collections made in the area over many years were immeasurable. Heinar Streimann assisted later in the 1990s, with various taxonomic contributions and data from many collections. Without their assistance and knowledge, the work would not have been written. Their deaths in January 2001 and August 2001 respectively were a serious and tragic blow to Australian bryology.

Introduction

Mosses and liverworts, the major groups of bryophytes, are a significant component of the biodiversity in the Australian wet tropics, in north-east Queensland, occurring in all ecosystems as colonisers of soil, rocks, fallen logs, and as epiphytes and epiphylls. While much attention has been paid to the vascular plants, vegetation types and ecology of tropical north-east Queensland (Tracey & Webb 1975, Kershaw 1978, Tracey 1982), R.M. Schuster (in Keto & Scott 1986) emphasised the importance of bryophytes in the region and criticised the paucity of studies.

Many mosses from north-east Queensland were described and published at the end of the 19th and beginning of the 20th century (Bailey 1893, 1913; Watts & Whitelegge 1902, 1906; Brotherus & Watts 1918; Dixon 1938, 1942; Bartram 1952). Ramsay et al. (1987) estimated the moss flora in the 'wet tropical region of north Australia' (approximately equivalent to the area under discussion) at about 325 species, representing one quarter of the total species for Australia. There were about 114 Australian endemics present, of which 50–60 were thought to be endemic to the region (Ramsay et al. 1987). The areas of greatest species richness were in the rainforests on the high mountain peaks, and on the Atherton Tableland.

Windolf (1987) estimated there were approximately 173 liverwort species in the region, with 20% of these being endemic (Hicks 1986). Recent estimates put the liverwort figure at over 300 taxa (D. Meagher pers. comm.).

Bryophytes in rainforests

For bryophytes, rainforests provide niches largely absent in other communities (Pócs 1982, Richards 1984, Gradstein 1992) including soil, earth banks, rocks, fallen trees and living roots on the forest floor, and further upwards, the bases, buttress roots and trunks of rainforest trees. Habitats in the canopy include lianes, twigs and branches for epiphytic species, while leaf surfaces provide habitats for epiphyllous species. Bryophytes on rotting logs maintain a moist regime that enhances decomposition and recycling through the activities of fungi and other microorganisms. They play an important role in ecological succession by protecting soil from erosion and providing moist beds for seeds to germinate. In all rainforest environments, bryophytes provide microhabitats and refugia for invertebrates and microorganisms, and sites for egg-laying and nurseries for insect larvae. Growth forms such as mats, cushions or pendents provide surfaces important for harvesting water from cloud and storing minute quantities of nutrients from exudates and droppings of insect larvae that are released slowly as leachates over time. Bryophytes control and reduce runoff by gradually releasing moisture during dry periods, maintaining humidity in the forest. They also contribute to humus accumulation, all important to the maintenance of the rainforest as an ecosystem.

History of rainforests in north-east Queensland

The history of rainforest bryoflora is closely associated with the history of Australian rainforests, and in north-east Queensland there is evidence of a long ancestry (Webb et al. 1986, Hill 1994, Webb & Tracey 1994, Martin 1998). Original Gondwanan-derived primitive angiosperm species survive in the rainforests of tropical Queensland. In addition, some of the oldest living forms of our present-day dry-adapted sclerophyllous vegetation and their related ecosystems also survive there. Barlow and Hyland (1988) summarised the important paleogeographic and paleoclimatic events that have led to 'an intricate pattern of humid forest communities which show significant differences in composition, age, endemism, relictuality and richness'. Martin (1998) provided additional evidence, based on palynological studies, of the Tertiary climate in Australia and stated that the precipitation in north-east Australia remained above critical levels for rainforest throughout the Tertiary and most of the Quaternary, enabling the region to be a refuge for many rainforest taxa. Australian rainforests reached their maximum development in the mid Tertiary, thereafter, increasing aridity resulted in reduction of rainforest areas and their retreat to areas of higher rainfall (Frakes 1999).

Rainforests in Australia

In Australia, 'rainforest' is a generic term and includes evergreen forests along the eastern coast (including Tasmania) and seasonally deciduous forests of the north (Lynch & Neldner 2000). Descriptors of rainforests, such as 'tropical', 'sub-tropical', 'monsoonal' and 'temperate' that relate to climate (latitude), and 'montane' and 'sub-montane' that apply to altitude (Beadle & Costin 1952), have application in other regions of the world but do not adequately describe the range of rainforest types found in Australia.

Webb (1959) recognised twenty rainforest structural types and classified Australian rainforests on the basis of structure, based on leaf size, seasonality of leaf fall, presence of other life-forms etc., which he later correlated with environmental factors (climate, soil nutrient status) (Webb 1968). Type descriptions of 'vine forests' and 'vine thickets' (depending on canopy height) are based on leaf sizes (microphyll, notophyll and mesophyll), deciduousness, and structural complexity. The floristic composition of each forest type varies from one locality to another as a result of past rainforest expansions and contractions due to palaeoclimatic events (Martin 1994). Typically, boundaries between structural types are not clear, although distinctions between rainforest and sclerophyll (eucalyptus) communities are generally abrupt, controlled by fire (Adam 1994).

The Wet Tropics bioregion

The Wet Tropics bioregion (Satler & Williams 1999) is situated along the coast of north-east Queensland, extending south from near Cooktown (15° 35' 46"S, 145°15'20"E) to just north of Townsville (19°23'51"S, 146°29' 28"E), a distance of over 500 km along the Australian coast (Goosem et al. 1999). It lies to the east of the Great Dividing Range and consists of a coastal plain dissected by ridges of the Eastern Escarpment and associated coastal ranges. Along its western flank, it borders the Einasleigh Uplands bioregion, and at its southern extremity, the Townsville Plains province of the Northern Brigalow Belt (Sattler & Williams 1999). To the north, the Wet Tropics links to the remote Cape York Peninsula bioregion. The Wet Tropics bioregion covers approximately 1% of Queensland, with an area of 1 849 725 ha (Goosem et al. 1999). A map of the region is shown in Figure 1.

The Wet Tropics is dominated by forested mountains and ranges, with areas of high plateau. Inland from Daintree (lat.16°S) lies the Mt Windsor Tableland (800–1360 m), and extending westwards from the Bellenden Ker Range, the Atherton Tableland (700–1200 m). Transects (see Fig.1, Fig.2 A–C) across Mt Windsor Tableland to the coast, across the Atherton Tableland and the Bellenden Ker Range to the coast, and through Cardwell Range to Hinchinbrook Island, and the south-north profile (Fig.2 D) running through the major peaks and rivers, illustrate the diverse topography of the region (Figs 2 A–D).The Wet Tropics bioregion includes the highest mountains in Queensland — Mt Bartle Frere (1622 m) and Mt Bellenden Ker (1582 m) on the Bellenden Ker Range; Thornton Peak (1374 m), Mt Lewis (1224 m), and Mt Finnigan (1148 m) (Figs. 1 and mountainous Hinchinbrook Island, with Mt Bowen (1142 m) and Mt Diamantina (955 m), is also part of this assemblage. The Cooktown–Ingham massif containing these high peaks covers an area of approximately 360 × 80 km (Webb & Tracey 1981).

Physiography

The coastal massif and associated ranges form a more or less continuous belt along the eastern Queensland coast, and are igneous in origin. Rocky outcrops are common on mountains, and soils of the massif are primarily granitic. The underlying geology comprises mainly marine Silurian, Devonian and Carboniferous sediments of the Hodgkinson Formation (Arnold & Fawckner 1980). Barron River Metamorphics are exposed in valleys around Cairns, and south to Tully, and sandstones predominate near Cooktown (Wilmott & Stephenson 1989). The scoria cones, maars, obvious basalt flows and fertile basaltic soils of the Atherton Tableland represent volcanism dating from the late Tertiary and Quaternary and overlay a mainly metamorphic base. In some areas, basalt flows followed river systems and reached the coastal plain (Stephenson et al. 1980), although coastal lowland soils are mainly of alluvial and colluvial deposits, largely accumulated during the late Quaternary (Nott et al. 2001). Repeated coastal transgressions and retreat during the Quaternary led to the deposition of coastal and estuarine sediments in some areas, with the attainment of the present sea level approximately 6000 years ago. Large rivers — the Daintree, Bloomfield, Barron, Russell, Mulgrave, North and South Johnston, Tully and Herbert drain the region into the Coral Sea, with higher western areas draining south into the Burdekin River, and north to the Mitchell.

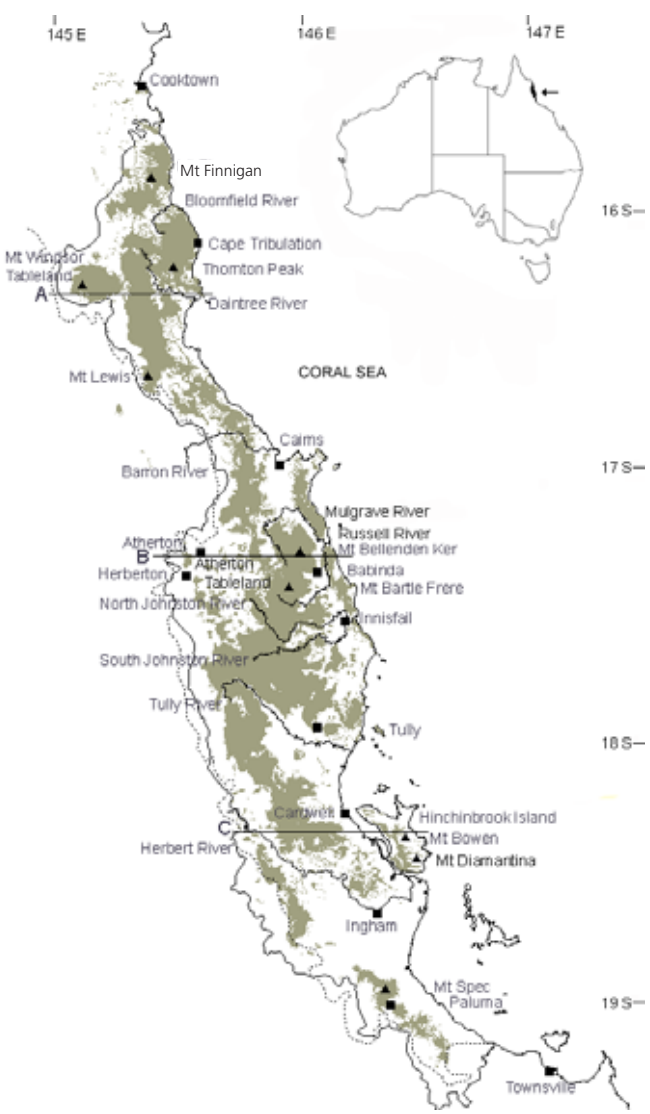


Fig. 1. The Wet Tropics bioregion, north-east Queensland. Dotted line represents the 1250 mm rainfall isohyet; shaded areas represent extant rainforest.

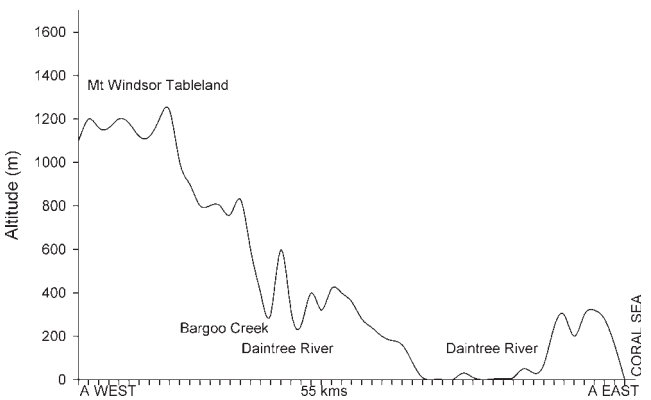


Fig. 2A. Transect across latitude 16°15' S from Mount Windsor Tableland to east coast (55 km) (Division of National Mapping Topographic Map 1:100000 Series R631, Edition 1-AAS: Sheet 7865 South Palmer River and Sheet 7965 Mossman.)

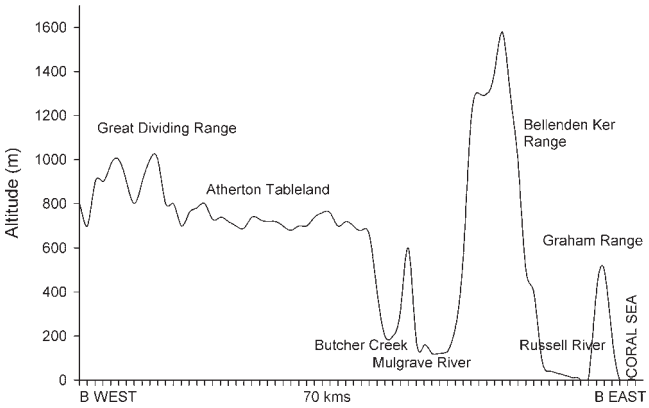


Fig. 2B. Transect across latitude 17 15' 45"S from Great Dividing Range to the east coast (70 km) (Division of National Mapping Topographic Map 1:100000 Series R631, Edition 2-AAS: Sheet 7963 Atherton and Sheet 8063 Bartle Frere).

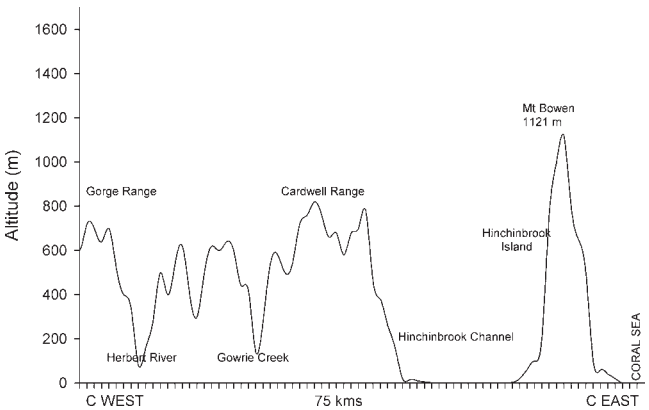


Fig. 2C. Transect across latitude 18°21'S from Gorge Range to Hinchinbrook Island (75 km) (Division of National Mapping Topographic Map 1:100 000 Series R631, Edition 2-AAS: Sheet 8061 Kirrama and Sheet 8161 Cardwell.)

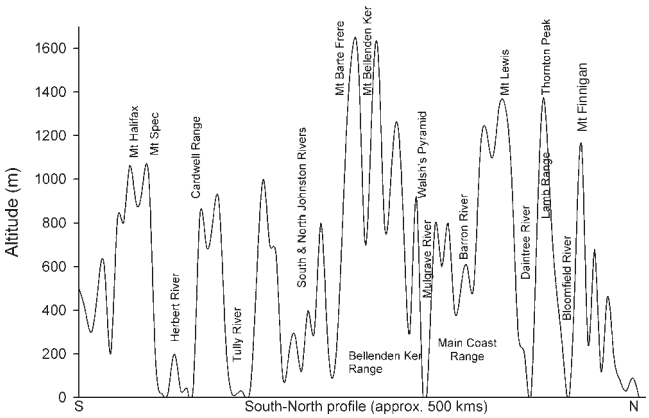


Fig. 2D. South-north profile through the Wet Tropics bioregion, showing major peaks and rivers. (Note the x axis is approximate.)

The Wet Tropics bioregion is subdivided into nine provinces (Fig. 3), reflecting differences within the landscape, generally associated with geology, geomorphology and climate. Goosem et al. (1999) provide descriptions of provinces (geology, landform, soils and vegetation) and associated regional ecosystems. Much of the bioregion incorporates the Wet Tropics of Queensland World Heritage Area (WTQWHA) (Satler & Williams 1999), recognised by the international community for the richness and diversity of its flora and fauna.

Climate

The climate generally results in two seasons, a separate wet season (December–April), with summer monsoons and occasional tropical cyclones, and an almost dry season (May–November) with occasional showers. Mean annual temperatures vary with topography, from 30°C in the tropical lowland to less than 10°C in montane areas (Webb 1968). Annual rainfall over the region is highly variable, strongly influenced by local topography, and declines towards the north and the south (Adam 1994). There are three locations on and around the high peaks where the rainfall can exceed an average of 3750 mm per annum:

- Thornton Peak, Mt Finnigan, Cape Tribulation (north of the Daintree River), and Mt Lewis (north west of Cairns);
- Mt Bartle Frere, Bellenden Ker and Babinda between the Mulgrave and Russell Rivers;
- lowland areas between the Johnston and Tully Rivers.

Mt Bellenden Ker Centre Peak is the wettest meteorological station in Australia; annual rainfall averages over 8000 mm, peaking at 12 461 mm in 2000 (Bureau of Meteorology 2000). West of the Babinda–Tully area, coastal cloud and rainfall influence extends much further inland, but drops to less than 1300 mm per annum west of the Atherton Tableland (Adam 1994). The approximate position of the 1250 mm rainfall isohyet is indicated on Figure 1.

Tropical cyclones are a signficant feature of the region's climate and these are recognised as being a major factor in shaping the structural and floristic differentiation of the vegetation, particularly in the coastal lowlands (Adam 1994).

Vegetation

The vegetation of the humid tropics (lat. 15–19°S, long. 145–146°30'E) (approximating the Wet Tropics bioregion) was described by Tracey (1982), based on Webb (1959, 1968, 1978) and Tracey and Webb (1975) for rainforests, and Specht (1970) for other vegetation communities. Vegetation descriptions are currently under review (Stanton & Stanton 2000, 2001a, 2001b). Thirteen rainforest structural types (Webb 1968) are recognised within the Wet Tropics bioregion (Tracey 1982).

The Wet Tropics encompasses the most diverse and the largest contiguous area of tropical rainforest in Australia.

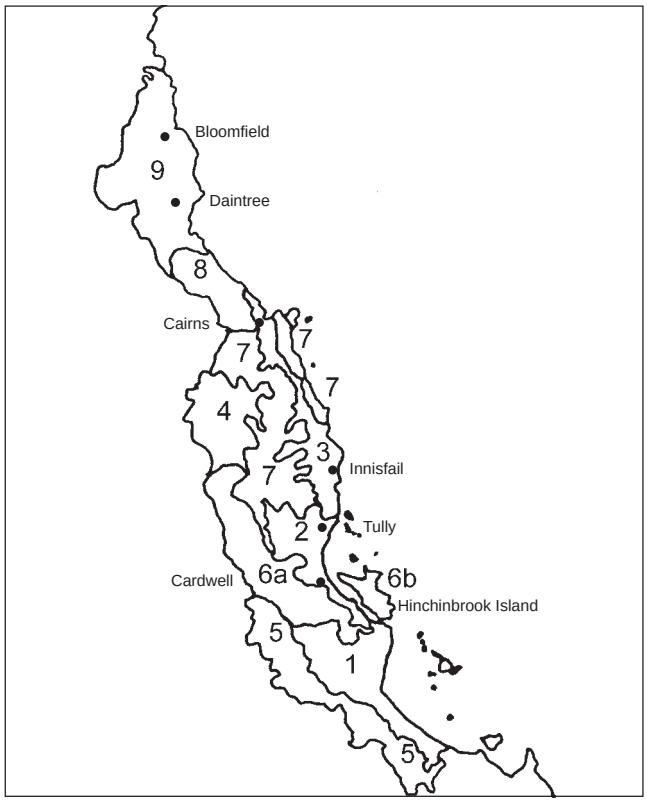


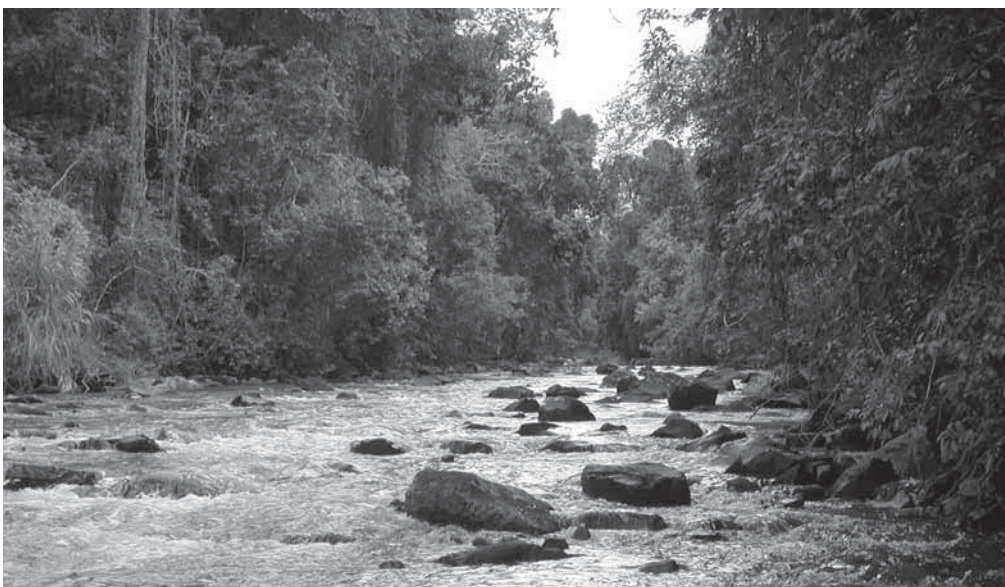
Fig. 3. Provinces of the Wet Tropics bioregion (redrawn from Satler and Williams 1999) showing approximate boundaries. Numbers correspond to the list of provinces in Appendix 1.

Key: 1 = Herbert, 2 = Tully, 3 = Innisfail, 4 = Atherton, 5 = Paluma–Seaview, 6a = Cardwell and Kirrama ranges, 6b = Hinchinbrook Island, 7 = Bellenden Ker-Lamb Range, 8 = Macalister, 9 = Daintree–Bloomfield.

Notophyll vine forest is the major vegetation type on granite uplands across the region, whereas simple microphyll vine-fern forest/thicket predominates on cloudy wet uplands and highlands (Tracey 1982). Rocky granite outcrops on drier areas in lowlands and foothills support deciduous microphyll vine thicket. The best-developed rainforest (complex mesophyll vine forest) that generally occurs in the foothills of the highest mountains and on basaltic soils in upland areas of the Atherton Tableland, has largely been lost by clearing for grazing and agriculture. The few areas of mesophyll rainforest which do remain, including those on cloudy uplands, are mostly preserved in National Parks e.g Mossman Gorge, Daintree, Wooroonooran, Crater Lakes, Tully Gorge, Russell River, Thornton Peak. These areas, and the forest around Cape Tribulation, are extremely rich in bryophytes.

Pockets of wet sclerophyll forests (the tall open-forest of Specht 1970) and eucalypt woodlands occur in the drier areas (1500–2000 mm per annum rainfall) and on western fringes of the Atherton and Windsor Tablelands (Tracey & Webb 1975, Tracey 1982, Kitching 1987). Plant species diversity is particularly high. Vascular plant species in the Wet Tropics number 4 500, of which approximately 3 000 are recorded from the Wet Tropics World Heritage Area (WTMA 2002).

Brachymenium nepalense, epiphytic in pioneer rainforest at edge of cleared area, Longlands Gap, near Atherton (Province 4).
Leaves 0.9–1.6 × 2.4–4.8 mm.



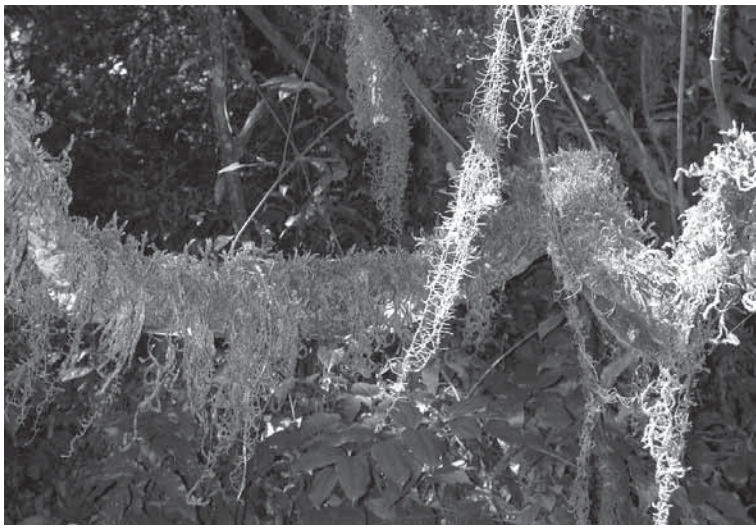
North Johnstone River flowing through mesophyll vine forest near Malanda, Atherton Tableland (Province 4).

Dawsonia polytrichoides growing on tree stump in wet sclerophyll forest dominated by *Syncarpia glomulifera*, Paluma Range, near Ingham (Province 5). Leaves linear, 6–10 mm long.

Dawsonia polytrichoides, Paluma Range, near Ingham (Province 5). Male plants; leaves linear, 6–10 mm long.

Birthday Creek, simple notophyll vine forest, alt. 800 m, Paluma Range, near Ingham (Province 5).

Distichophyllum mittenii growing on filmy fern (*Cephalomanes brassii*) adjacent to creek in simple notophyll vine forest, Paluma Range, near Ingham (Province 5). Leaves 2.0–2.8 × 1.0–1.2 mm.



Epiphytes at Wallaman Falls, near Ingham, Girringun National Park (previously known as Lumholtz National Park) (Province5).

Macromitrium involutifolium, epiphytic on *Alphitonia petrei*, Paluma village, near Ingham (Province 5).

Leucobryum candidum, an epiphyte in simple notophyll vine forest, Paluma Range. Shoots 1–5 cm long.

Surrounded by eucalypt vegetation, Wallaman Falls in Girringun National Park is the longest single-drop waterfall in Australia, falling 305 m to a large pool (Province 5).

Lopidium struthiopteris growing on a sapling in simple notophyll vine forest, alt. 900 m, Paluma Range, near Ingham.

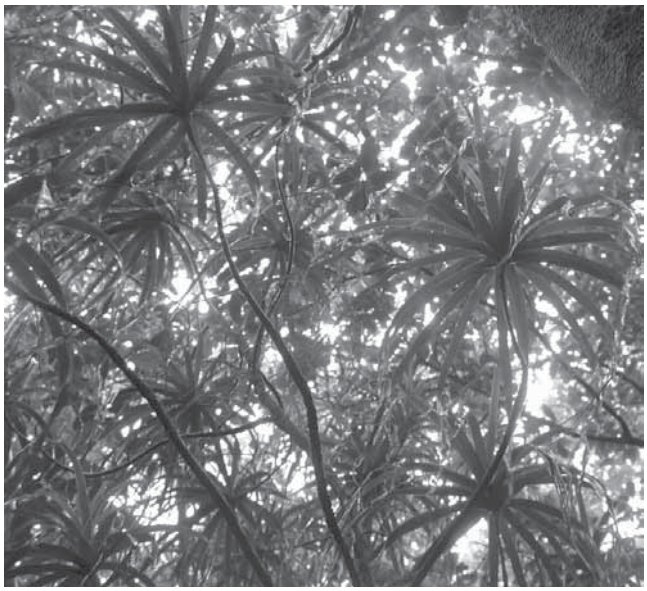
Curran Creek, Kirrama Range, near Cardwell, flowing through simple notophyll vine forest, alt. 650 m. (Province 6a).

Leucobryum aduncum, Kirrama Range, near Cardwell. Leaves 2–4 mm long.

Mesochaete taxiforme growing adjacent to creek, alt. 650 m, Kirrama Range, near Cardwell. (Province 6a)
Leaves 3.4–6.0 × 1.5–2.7 mm.

Hinchinbrook Island from the mainland. (Province 6b).

Creek on the summit of Mt Bellenden Ker, in Wooroonooran National Park, near Babinda, alt. 1550 m. (Province 7).

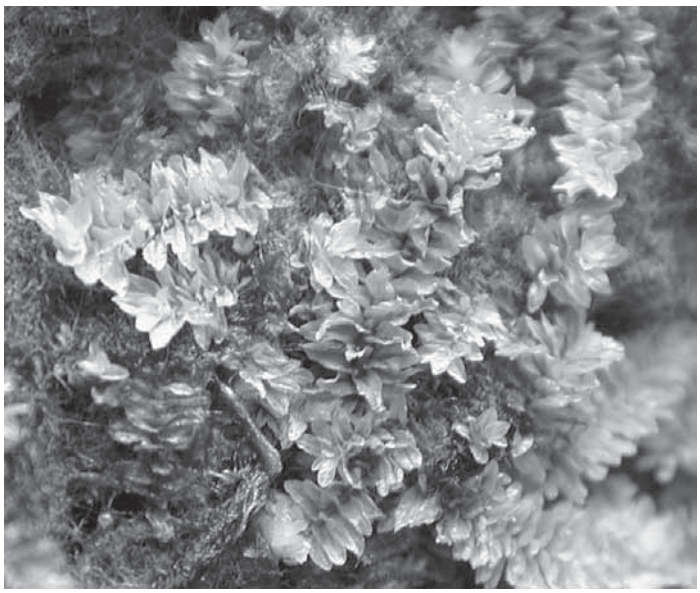


Dracophyllum sayeri (Epacridaceae) understory in simple microphyll stunted vine-fern thicket dominated by *Leptospermum wooroonooran*, on summit of Mt Bellenden Ker, near Babinda. (Province 7).

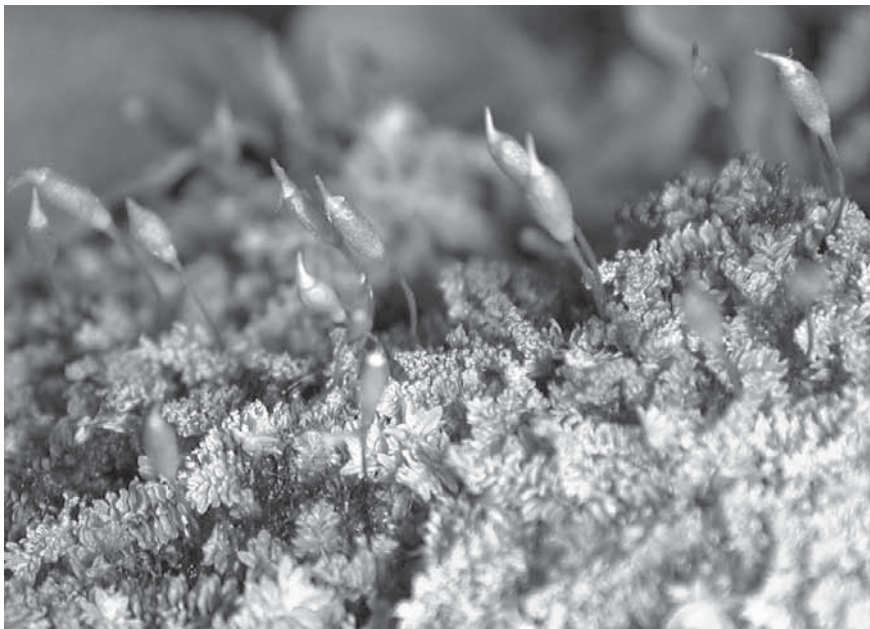
Ectropothecium zollingeri and *Fissidens crispulus* growing on rock, upper Mulgrave River, west of Mt Bartle Frere. (Province 7).

Mossy rocks and *Helmhotzia* sp. (Philidraceae), alt. 1550 m, summit of Mt Bellenden Ker, near Babinda. (Province 7).

Epiphytes at Tchupalla Falls, Wooroonooran National Park, near Innisfail. (Province 7).



Powellia involutifolia. (Province 7).
Leaves 1.5–2 mm × 0.7–1 mm.



Taxithelium merrillii carpeting mangrove mud, Russell River estuary. (Province 7).

Upper Mulgrave River flowing through mesophyll vine forest. (Province 7).

Tchupalla Falls surrounded by mesophyll vine forest, Wooroonooran National Park, near Innisfail. (Province 7).

Aims

This study was undertaken to provide an up to date checklist of the mosses of the Wet Tropics bioregion and to determine the distribution of species within the individual provinces of the region. In addition, the distribution of each species listed was compared with its phytogeographical affinities in areas close to Australia such as SE Asia (particularly Malesia, Papua New Guinea), New Zealand, New Caledonia, Norfolk Island etc. A comprehensive listing of published literature relevant to tropical Australian mosses was compiled.

Methods

This present study looks at Wet Tropics mosses in detail, including an update of species taxonomy incorporating data from revisions, new species records, and reports of additional species not previously recorded from the region. The data presented here have been obtained from literature, early collections in Herbaria including BRI, CANB (includes CBG), NSW, as well as the more recent collections made by I.G. Stone (MELU now at MEL), H. Streimann (CANB), D.H. Vitt (ALTA & NSW), H.P. Ramsay (NSW), W.B. Schofield (UBC & NSW), J.R. Spence (NSW), and others made as part of field studies during revisions undertaken for the Flora of Australia (Bryophytes). In addition, some collections made in the 1960s and 1970s e.g. those of B.O. van Zanten (GRO, NSW made in 1968), W.A. Weber (CO made in 1968) and D.H. Norris (HSC made in 1970s) have also provided useful information.

The moss checklist (Appendix 1) contains names in current use. The updated *Catalogue of Australian Mosses* (Streimann & Klazenga 2002) has been particularly useful for checking synonyms and for tracing literature. The *Catalogue* also includes important information on the distribution of the various species in Australian States other than Queensland for comparison and is not repeated here. The checklist (Appendix 1) includes data on location of species within provinces of the Wet Tropics bioregion in Australia, indicates endemics (WT) within the bioregion and those more widespread in Australia (AU), and contains distribution relationships and affinities to areas adjacent to Australia.

During the last thirty years many new species have been described from north-east Queensland and additional species recorded as a result of intensive collecting and revisions. Publications include Allen 1981, 1987; Ando 1972, 1977; Buck 1979, 1980, 1982, 1990; Buck & Crum 1978; Buck & Tan 1989; Catcheside & Frahm 1985; Catcheside & Stone 1988; Crum 1971, 1986, 1991; During 1977; Ellis 1985,1991; Enroth 1991, 1995, 1996; Frahm 1987a,b, 1988, 1990, 1991, 1992, 1993, 1994; Hedenäs 2002; Hyvönen 1989a; Ireland 1992; Isoviita 1986; Klazenga 2003; Koponen 1980, 1982, 1988, 1990; Kruijer 2002; Lai 1992; Lewinsky 1984, 1990; Miller & Manuel 1982; Mohamed 1979; Norris & Robinson 1979; Nowak 1980; Ochi 1970, 1973, 1980, 1982; Ochyra 1986; Ramsay et al. 2002a,b, 2004; Reese1989, 1992; Reese & Stone 1987, 1995; Salazar Allen 1993; Schultze-Motel 1970; Shaw 1985; Spence 1996, 2004; Spence & Ramsay 1996, 2002, 2005 (in press, Flora of Australia for Bryaceae); Stone 1975–1997 [see reference list]; Stone & Catcheside 1993; Stone & Scott 1973; Streimann 1991a,b,c, 1993, 1997, 1999, 2000a, 2001; Syed 1973; Tan et al.1996, 1998; Tangney 1996,1997; Touw 1971, 2001a,b; Touw & Falter-van den Haak 1989; Vitt 1984, 1989; Vitt & Ramsay 1985a,b.

Additional literature of use includes Buck et al. (2002), Crosby et al. (1992), Crosby & Magill (1978), Ramsay (1987), Ramsay and Schofield (1987), Ramsay et al. (1987), and Ramsay & Seur (1994).

Results

Moss Diversity

Of the 1074 accepted species of mosses in Australia, 527 are found in Queensland (Streimann & Klazenga 2002). In the Wet Tropics bioregion the present estimate of diversity is about 408 taxa (398 species, 2 subspecies, and 8 varieties) in 159 genera and 62 families. Data presented here have increased the previous estimate (Ramsay et al. 1987) of the number of species by 83 and added 20 additional families and 29 genera. The checklist (Appendix 1) includes 21 new records for the Wet Tropics and 8 new species for Australia. Lists of genera and their families, and families and their genera are presented in Appendices 2 and 3.

Families with the highest species richness in the area include Bryaceae, Calymperaceae, Dicranaceae (Table 1).

Table 1: Families of mosses with the highest species richness in the Wet Tropics.

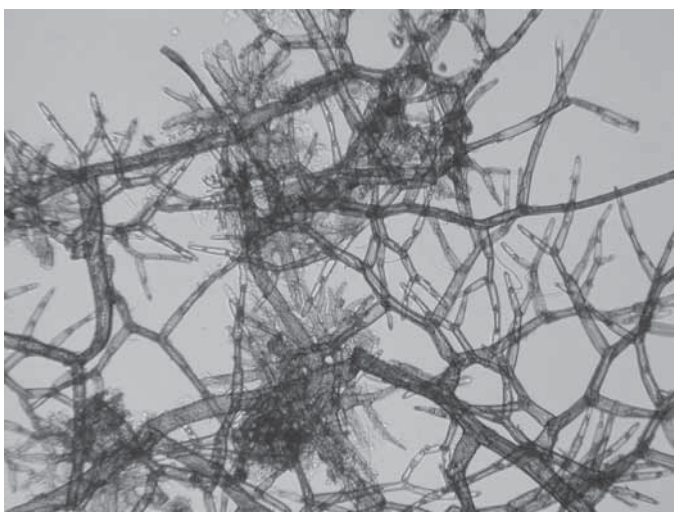
Family	Number of genera	Number of species	
Bryaceae	5	23	
Calymperaceae	7	47	(incl. 2 varieties)
Dicranaceae	7	29	
Meteoriaceae (incl. *Papillaria*)	8	13	
Sematophyllaceae	16	32	

A few genera have many species in the area e.g *Fissidens*, *Macromitrium*, *Syrrhopodon* (Table 2), but many genera (see Appendix 1) are represented by only one to three species.

Table 2: Genera of mosses with the largest species representation in the Wet Tropics

Genus	Number of species	
Fissidens	35	(incl. 2 varieties)
Macromitrium	17	(incl. 2 subspecies)
Syrrhopodon	16	(incl. 2 varieties)
Calymperes	15	
Campylopus	12	
Mitthyridium	9	
Leucobryum	8	(incl. 1 variety)

Creek at Mt Lewis (Province 9), complex notophyll vine forest, alt. 800 m.



Ephemeropsis tjibodensis, an epiphyllous moss, under high power (× 400). (Province 9).

Discussion

Distribution of mosses in the Wet Tropics

Topography and rainfall patterns combine in the region to support a variety of vegetation communities, including mangroves, woodlands and rainforests of different structural types (Tracey 1982) which provide specialised habitats for bryophytes.

Mangrove communities: Mangroves have a disjunct occurrence along the east coast in intertidal areas from Torres Strait to Victoria but reach their maximum diversity in northern Australia (Specht & Specht 1999). Mosses are not common in mangroves but a few terrestrial and epiphytic species have adapted to this habitat. There are no studies of bryophytes, which include mosses, for the mangrove systems of north-east Queensland but Windolf (1989) made a study of bryophytes in an area in south-east Queensland. He recorded three epiphytic mosses and 15 leafy liverworts. Of the mosses, only *Calymperes* was recorded on mangroves, the other two species being on trees at the edges of the mangrove community. A study in Thailand by Thaithong (1984) recorded five moss species (including two species of *Calymperes*) and 21 leafy liverworts. It is clear that mosses are rare in such communities.

One notable exception is *Taxithelium merrillii*, a terrestrial species which is found as extensive mats on mud and exposed mangrove roots, particularly in mangroves that have a high freshwater input e.g. Noah Head NP, Cape Tribulation, and Russell River (Ramsay et al. 2002a). This moss is also recorded in similar communities in the Philippines (Bartram 1939, Iwatsuki & Tan 1979; Tan & Iwatsuki 1991) and South-east Asia (Tan & Iwatsuki 1993). On Hinchinbrook Island, *T. merrillii* carpets sandbars in a heavily shaded intertidal region of Mulligan's Creek, associated with *Melaleuca quinquenervia* forest (R. Lovatt pers. comm.). Unlike *T. merrillii*, species such as *Calymperes* spp., *Syrrhopodon* spp., *Macromitrium aurescens, Leucophanes* sp., and *Octoblepharum albidum*, epiphytic on mangrove trees, are not subject to frequent tidal inundation and are not restricted to this habitat. An ephemeral species with persistent protonema, *Archidium minutissimum* was recorded from sandy soil at the edge of mangroves south of Cooktown where it was submerged at exceptionally high tides (Stone 1985b). Three other collections in the area were not associated with a mangrove habitat. The species has not been seen since 1984 and is worth further investigation in season.

Freshwater habitats: Aquatic mosses are not abundant in streams in the region. Obligate aquatics are more common in cooler climates (Vitt & Glime 1984, Suren 1993); however, many ground-dwelling moss species may also be found growing submerged in freshwater habitats (Scott 1994). In most stream systems, variable current velocities, water levels and humidities contribute to broad environmental gradients from aquatic to terrestrial habitats. In streams at higher elevations where water temperatures are generally lower, some species of genera such as *Bryum, Philonotis, Distichophyllum, Hypnodendron* and *Fissidens* are common both above water and immersed, particularly in areas of low flow. The morphology of certain species appears to be influenced by environmental conditions e.g. fronds of *Hypnodendron vitiense* subsp. *australe* extend much further when growing submerged (A. Touw pers. comm.).

The occurrence of mosses in freshwater habitats in the Wet Tropics may be more common than previously recorded. An unpublished study on the Atherton Tableland (average elevation 700–800 m) showed there is often extensive growth of submerged mosses. In Mazlin Creek, near Atherton, the cosmopolitan moss *Leptodictyum riparium* flourished in a fast-flowing stream where nutrient levels were high. Biggs (1996) determined that bryophytes dominate in steeper headwater streams with stable substrates that promote fast-flowing, turbulent waters, often with high flow variability. However, *Taxiphyllum taxirameum* was also recorded near Atherton, growing abundantly in a permanent spring-fed pool with minimal current velocity, with a constant water temperature of around 22°C. The flow environment of stream bryophytes in the Wet Tropics warrants further attention.

More intensive surveys are clearly needed. The Wet Tropics endemic *Touwia laticostata* is known from only one stream (altitude 300 m) on Mt Bellenden Ker (Ochyra 1986). The aquatic moss *Platyhypnidium muelleri* is also reported from that area (Scott 1994), as is *Platyhypnidium austrinum.* In his overview of the Brachytheciaceae in Australia, Hedenäs (2002) concluded that Australian specimens of *P. muelleri* are more likely to be *P. austrinum*; however, both species have been confirmed in the Wet Tropics. A recent survey (Cairns & Werren 2002, unpublished) of the upper East Mulgrave River revealed extensive submerged beds of *Ectropothecium zollingeri,* previously unrecorded in the Mulgrave catchment, in a shaded riffle. The only record of *Sphagnum* in the area is *Sphagnum perichaetiale* from a *Melaleuca* swamp near Bramston Beach (Stone 1990c).

Terrestrial mosses: Terrestrial bryophytes act as colonisers of soils or in drier areas of south-western Queensland they form an important component of soil crusts (Eldridge et al. 2000). Bryophytes are not abundant on the earth floor of tropical rainforests, perhaps because the continual build-up of leaf litter restricts their development. Nevertheless, in wetter areas in the Wet Tropics, the soil-binding capacity of some terrestrial mosses is significant and they are able to quickly colonise surface soil of newly disturbed steep earth banks and reduce erosion. In the Wet Tropics, *Pogonatum* and *Dawsonia* colonise large areas of the more exposed road cuttings, and *Dicranella* and more rarely *Garckea*, the more protected cuttings. Many species of *Fissidens* are prominent as colonisers of shaded earth banks or forest tracks, some in coastal areas e.g. *F. crispulus, F. perobtusus,* and others at higher altitudes e.g. *F. dietrichiae, F. pallidus.* Tiny earth mosses such as *Archidium, Erpodium,* and *Gigaspermum* are often present but may be hard to find. The families Bryaceae (e.g. *Rosulabryum* spp., *Gemmabryum* spp.), Dicranaceae (e.g. *Dicranella, Campylopus, Dicranoloma*), Funariaceae

(e.g. *Funaria hygrometrica*) and Pottiaceae (e.g. *Barbula*) (Zander 1993) include many taxa of importance in colonising bare soil or shallow soil over rock surfaces.

Epiphytic and epiphyllous mosses: The rainforest presents a range of microhabitats and substrates for bryophytes to colonise, depending on the diversity of microclimates and their individual ecological tolerances. Pócs (1982) observed the zonation of epiphytes in rainforests in Africa, both vertically and horizontally, and differentiated four broad zones on the phorophyte – basal trunk, main trunk, branches, and terminal twigs. The spatial distribution of corticolous bryophytes is therefore determined by a network of fluctuating variables e.g. light intensity, temperature, relative humidity, air currents (Smith 1982, Franks & Bergstrom 2000).

Epiphytic bryophytes contribute significantly to the diversity of tropical rainforests worldwide. In lowland forests in French Guiana, Montfort and Ek (1990) found 154 species of bryophytes, (42% were mosses), on 28 trees representing 22 species. Along an altitudinal gradient in the Columbian Andes, Wolf (1993) found that mosses comprised 36.6% of the 295 epiphytic bryophyte taxa identified.

In south-east Queensland, Franks (2000) and Franks and Bergstrom (2000) found that epiphytic bryophytes formed a significant component of microphyll fern forests. Sampling on *Nothofagus moorei* trunks was carried out from ground level to 2 m on 25 individual trees and showed that the composition and community structure altered with both height above ground level and the direction of exposure (Franks & Bergstrom 2000). Patterns of distribution were thought to reflect changes in moisture availability and degree of desiccation tolerance of the various taxa. Of forty-three bryophyte taxa, 37% were mosses. These represented a range of families and genera including Calymperaceae: *Syrrhopodon armatus*; Dicnemonaceae: *Eucamptodon muelleri;* Dicranaceae: *Dicranoloma* spp.; Hookeriaceae: *Cyathophorum bulbosum*; Hypnaceae: *Hypnum cupressiforme*; Hypopterygiaceae: *Lopidium concinnum*; Lembophyllaceae: *Lembophyllum divulsum;* Leucobryaceae: *Leucobryum candidum*; Orthotrichaceae: *Macromitrium exsertum*; Ptychomniaceae: *Hampeella pallens*; Rhizogoniaceae: *Pyrrhobryum paramattense*; Sematophyllaceae: *Wijkia extenuata*.

No such studies have yet been undertaken for the Wet Tropics, although observations indicate that the species composition of rainforest epiphytes would include some of the species recorded by Franks and Bergstrom (2000), but are also likely to include a range of taxa of tropical origin not found in the south-east forests. Examples include various genera and species in families including Calymperaceae, Sematophyllaceae, Orthotrichaceae and Meteoriaceae.

Epiphyllous mosses occur in the wetter forests and moist rainforest gullies of the Wet Tropics e.g. Mt Bellenden Ker summit, Mt Lewis. Again, no studies have been reported. Worldwide, epiphyllous mosses are uncommon compared with tiny leafy liverworts (Lejeuneaceae), and in tropical America, Africa and Asia are mostly members of the Hookeriaceae (Gradstein 1997, Bates 2000). In the Wet Tropics this does not appear to be the case, although *Distichophyllum mittenii* has been found growing on the leaves of filmy ferns (*Cephalomanes brassii*) (unpublished data). Obligate epiphyllous bryophytes tend to be minute plants, growing appressed to the leaf surface, anchored by bundles of rhizoids (Gradstein 1997). Few mosses fit this description. One notable exception is *Ephemeropsis tjibodensis*, which consists of a protonemal gametophyte and forms dense algal-like patches on the surface of leaves. Most mosses growing on leaves are facultative epiphylls (Gradstein 1997), spreading onto angiosperm leaves from adjacent twigs e.g. members of the Meteoriaceae: *Barbellopsis trichophora*, *Aerobryopsis longissima*, *Meteorium polytrichum*.

Richards (1984) noted that different types of forest structure affect levels of light and humidity, providing a range of microclimates within the forest. The bryological diversity of the Wet Tropics bioregion may be a reflection, in part, of differences between rainforest types and the variety of microhabitats they offer. However, to date, few bryologists have listed the rainforest habitat of moss collections according to these classifications (one notable exception is Reese & Stone 1995), and there have been no published analyses of bryophyte communities in relation to rainforest types.

Mosses of other vegetation communities: 'Dry' rainforest (Gillison 1987), *Casuarina* dominated riparian vegetation, and other non-sclerophyll communities have been highlighted as worthy of investigation (Streimann 1994, 2000b). Patches of these vegetation types occur throughout the Wet Tropics, particularly in areas of lower rainfall; nevertheless, an understanding of the bryophyte flora of these habitats is lacking. A survey of the moss flora of dry rainforests to the west of the Wet Tropics revealed a unique assemblage, comprising species from wetter areas and species from drier environments (Fensham & Streimann 1997). Of these habitats, Streimann (1994) commented: 'The species numbers may not be so great, nor the colonies as spectacular, but they do contain an interesting and poorly studied bryophyte flora which may be bryogeographically exciting and significant'.

Mosses with a restricted distribution

Species with restricted distributions include those limited to high mountain peaks and lowland forests. In addition, many Southeast Asian mosses (Appendix 1) are at the limits of their range in the Wet Tropics (Reese & Stone 1995) e.g. *Calymperes porrectum* recorded only from Cape Tribulation, *Macromitrium incurvifolium* recorded from Big Tableland south of Cooktown, Mt Lewis, and the Russell River. Others have restricted altitudinal ranges e.g. *Syrrhopodon prolifer* which has one variety, var. *prolifer*, found above 1200 m, and the other variety, var. *mossmanensis* found below 500 m (Fig. 4c). While this species is pantropical, the varieties are each

represented in Queensland from a single locality, the type variety *S. prolifer* var. *prolifer* from Thornton Peak and the other *S. prolifer* var. *mossmanensis* from Mossman (Reese & Stone 1995).

Mosses restricted to high mountain peaks: Mountain peaks receive high levels of rainfall and high altitude forests ('cloud' forests) may also capture considerable amounts of water from passing clouds (Foster 2001). They therefore offer unique habitats not found elsewhere in the tropics. In tropical regions worldwide, the mass and diversity of both mosses and liverworts increases with altitude (Buck & Thiers 1989). The Wet Tropics is no exception, and bryophytes are particularly abundant in the cloud belt (1200–1600 m) in simple microphyll vine-fern thicket (Webb 1968). Epiphytic mosses are widespread, but some are known only from one or two sites e.g. *Calyptrochaeta rotundifolia, Clastobryum dimorphum, Daltonia contorta, Macromitrium funiforme, Macromitrium dielsii* (Mt Bellenden Ker and/or Mt Bartle Frere), *Meiotheciella papillosa* (Mt Spec near Townsville). Some mosses which are common in lower altitudes in southern Australia and are also in New Zealand e.g. *Calyptrochaeta apiculata, Cyathophorum bulbosum, Daltonia splachnoides*, *Dicranoloma menziesii* and *Warburgiella leucocytus*, are present only on the highest peaks in the Wet Tropics, where cooler temperatures prevail and there is constant mist and cloud. Streimann (2000b) nominated isolated peaks and ranges in the Wet Tropics as 'hot spots' both for endemics, and species with affinities to Southeast Asia and Malesia (see Tan & Iwatsuki 1999).

Contemporary climate change has been nominated by Williams et al. (2003) as a significant threat to the long-term preservation of the biota in the tropical rainforests of the Wet Tropics. Complex notophyll vine forests, simple notophyll and simple microphyll forests and thickets in the wet uplands and highlands have been identified as particularly sensitive to even moderate increases in temperature (Hilbert et al. 2001). On the highest mountains, the cloud base is expected to increase in altitude and consequently reduce mist (Foster 2001, Hilbert et al. 2001). Extinction risks for bryophytes endemic to these unique habitats are high.

Mosses of the lowland coastal belt: Included here, apart from terrestrial mosses, are many epiphytic species in high rainfall areas at lower altitudes: e.g. *Chaetomitrium tahitense*, *Leucophanes* spp., *Octoblepharum albidum*, *Leucobryum* spp. Most taxa in the family Calymperaceae (e.g. *Calymperes*, *Mitthyridium* and *Syrrhopodon*) are well represented at lower altitudes, generally below 500 m (Fig. 4 A–C) (Reese & Stone 1995) with very few restricted to higher altitudes. The family Sematophyllaceae includes species such as *Acanthorrhyncium papillatum, Radulina hamata, Taxithelium instratum, T. nepalense* and *Trismegistia lancifolia*, that are well represented in lowland regions such as Cape Tribulation, Mossman Gorge, Daintree National Park. (Ramsay et al. 2002a).

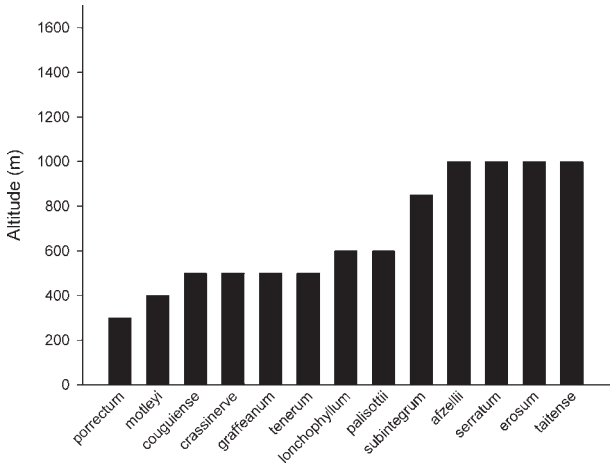


Fig. 4A. Distribution of *Calymperes* species by altitude (Reese and Stone 1995).

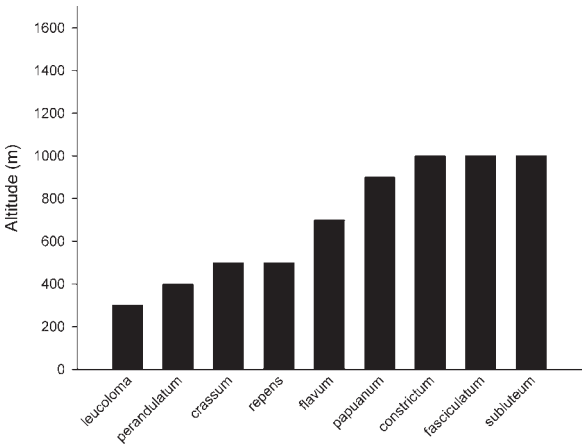


Fig. 4B. Distribution of *Mitthyridium* species by altitude (Reese and Stone 1995).

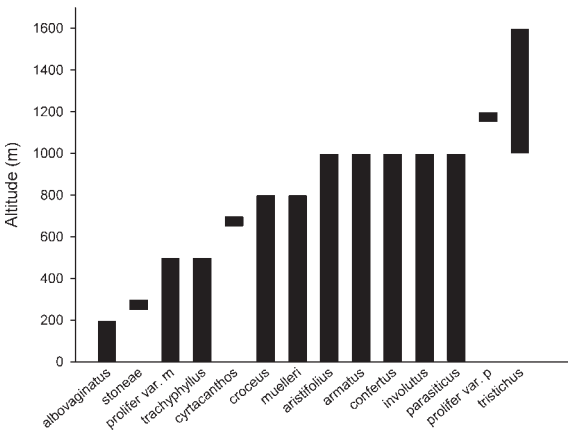


Fig. 4C. Distribution of *Syrrhopodon* species by altitude (Reese and Stone 1995).

Bryophytes are generally thought to be few in lowland tropical forests compared with forests at higher altitudes. Streimann (1994) suggested that bryophyte diversity in these habitats is, in fact, much greater than it appears; many species are restricted to tree canopies and are not easily accessible.

Species widely distributed throughout the area: Some species have wide-ranging geographic distributions throughout the area, at various altitudes. Species such as *Bryobrothera crenulata* and *Callicostella papillata* var. *papillata* are found from Mt Finnigan in the north, to Eungella south of the area (Streimann 2001). *Hookeriopsis utacamundiana* ranges from Mt Bellenden Ker and Mt Bartle Frere to Eungella, some 800 km south. Others that are more widely dispersed in the tropics e.g. *Calymperes erosum*, distributed across northern Australia (QLD, WA & NT), occur as far north as Cape York and extend south to Proserpine (Reese & Stone 1995).

Phytogeographical affinities of mosses in the Wet Tropics

Affinities of the bryoflora of this tropical part of Australia range from endemic species, to species of Gondwanan origin, present primarily in Australia and New Zealand but also in South America and southern Africa. Gondwanan taxa occur frequently in ancient rainforests or montane ecosystems. Many have palaeotropical affinities with species in Malesia and Southeast Asia. Others have relationships to the flora of New Caledonia and/or Oceania and the Pacific. Some cosmopolitan species are also represented e.g. *Funaria hygrometrica.*

Species reported as endemic to area

The Wet Tropics bioregion is well known for the ancient nature and high degree of endemism of vascular plants (Keto & Scott 1986), and has been nominated as a significant centre for endemism (Boden & Given 1995, Crisp et al. 2001). Surprisingly, present studies have found that the number of moss species endemic to the Wet Tropics bioregion is much lower than expected, representing less than 7% of the species present (Appendix 1 as WT). This disparity can perhaps be explained by the comparative ease of dispersal of bryophytes by spores or asexual propagules (Laaka-Lindberg 2003). Similar rates of endemism have been estimated for tropical regions elsewhere e.g. Galapagos Islands 10%, Cuba 12%, Mt Kilimanjaro 6% (Frahm 2003). Taxa formerly considered to be endemic may now be in synonymy under another name or, particularly in the case of small earth mosses, may yet be found in other countries. Others may possibly be synonymous with Southeast Asian mosses at the extremity of their range.

Endemic species of *Fissidens* are associated with moist lowland areas. Isolated mountain peaks are particularly important habitats for some taxa e.g. Mt Finnigan (*Calyptrochaeta brassii*), Mt Bellenden Ker, Mt Bartle Frere and Mt Lewis (*Clastobrum dimorphum*) (Streimann 2000b). Endemic species come from a wide range of families and genera e.g. Brachytheciaceae*: Rhynchostegium nanopennatum* Buxbaumiaceae: *Buxbaumia thorsborneae;* Fissidentaceae: *Fissidens flabellulus*. var. *eachamensis, F. gymnocarpus, F. henryae*; Hypnodendraceae: *Hypnodendron comatulum*; Neckeraceae: *Touwia laticostata*; Orthotrichaceae: *Macromitrium dielsii, M. funiforme.*

More widespread Australian endemics in the area

Many Australian endemic species (AU in Appendix 1) that are found in the Wet Tropics have a pattern of distribution along the east divide, often in pockets of remnant forest e.*g* species belonging to *Dicranoloma, Eucamptodon, Fissidens, Macromitrium, Papillaria, Schlotheimia*. Although this study has added about 83 additional taxa to the total previously recorded from the area, the numbers of Australian endemic species (AU), including those that occur exclusively in the Wet Tropics (WT), has been reduced in this study compared to the earlier estimates made by Ramsay et al. (1987), to about 25% species. The genus with the largest numbers of endemic species is *Fissidens* 14 spp. (including 7 in WT), with *Macromitrium* 12 spp. (2 in WT), *Archidium* 6 spp. (1 in WT); and 12 genera are each represented by a single endemic species.

Moss species occurring across northern tropical Australia

A number of species from the Wet Tropics bioregion also occur throughout northern tropical Australia including north Queensland, the Northern Territory and/or northern Western Australia (Table 3). Little is known about the wetter parts of the Northern Territory, particularly the moist monsoon vegetation of Arnhemland, an area highlighted by Streimann (2000b) as worthy of further exploration. Families well represented across the northern tropics include Archidiacae, Bryaceae, Calymperaceae, Fissidentaceae and Sematophyllaceae. Many of these are also distributed in the palaeotropical regions of Southeast Asia, particularly Malesia. In the Calymperaceae for example, while 42 taxa in three genera occur in Australia (Reese & Stone 1995), the majority are present in the warm humid tropics of the Northern Territory and north-east Queensland. Across this region, *Syrrhopodon* has 18 taxa and *Calymperes* 14, while two species (*C. tenerum* and *C. erosum*) also occur in northern Western Australia. The other genus in the Calymperaceae, *Mitthyridium,* occurs as a single species, *M. flavum,* in the Northern Territory, with the nine Australian representatives all in the Wet Tropics. In the Sematophyllaceae, species such as *Taxithelium* spp. and *Radulina hamata* are present in north-east Queensland and the Northern Territory, while *Papillidiopsis ramulina* has been recorded from north west Western Australia and the Northern Territory but not Queensland (Catcheside & Stone 1988, Stoneburner et al. 1993, Ramsay et al. 2002b, 2004).

Table 3. Representative moss species occurring across northern tropical Australia

Archidium ohioense
Archidium rothii
Brachymenium indicum
Bryum argenteum
Calymperes afzelii
Calymperes erosum
Calymperes graeffeanum
Calymperes motleyi
Calymperes porrectum
Calymperes tenerum
Campylopus laxitextus
Eccremidium minutum
Erpodium coronatum var. *australiense*
Fissidens ceylonensis
Fissidens curvatus
Fissidens gymnocarpus
Fissidens holstii
Fissidens perobtusus
Garckea flexuosa
Gemmabryum apiculatum
Gemmabryum indicum
Hyophila involuta
Leucobryum aduncum
Leucobryum aduncum var. *scalare*
Leucobryum chlorophyllosum
Leucophanes glaucum
Mitthyridium flavum
Octoblepharum albidum
Pelekium investe
Radulina hamata
Taxithelium instratum
Taxithelium kerianum
Taxithelium nepalense
Taxithelium planum
Taxiphyllum minutirameum
Trachyphyllum inflexum

On the Cape York Peninsula, north of the Wet Tropics, Crisp et al. (2001) found significant floristic links between the eastern coastal strip and Trans-Fly and Port Moresby 'dry' areas in Papua New Guinea. Their recent nomination of the Iron Range-McIlraith Range region to the north of the Wet Tropics as an important centre of endemism for vascular plants suggests that this area should be further investigated by bryologists. Patches of vine thicket on Cape York Pensinsula have revealed several previously unreported genera and species (Streimann 2001a); however, bryological surveys of the Cape are few, possibly due to the difficulties of access. Similarly, islands of the Torres Strait, between Australia and New Guinea, are bryologically unknown, although Streimann (2001) suggests that there is no reason why, for example, Hookeriaceae should not occur there.

Afffinities with the mosses of Southeast Asia and New Caledonia

Floristic affinities: Strong affinities exist beween rainforest angiosperms in the Wet Tropics, Malesia and New Caledonia (Morat 1986). Based on cladistic biogeographical analyses, Crisp et al. (1999) reviewed relationships between distribution patterns of angiosperm taxa. They described a northern element of the 'South Pacific track' which appeared to link New Guinea, Queensland, Northern Territory, New Caledonia and Fiji, and concluded that 'the flora of Australia is most closely related to that of its Gondwanan neighbours', noting that there are biogeographical anomalies yet to be resolved. Acknowledgement of tropical flora as 'palaeo-autochthonous, derived from Gondwanan stock' (Webb et al. 1986) is now widely accepted (Specht & Specht 1999). Walker (1990) agreed that the specific interrelationships of some groups of plants [and animals] in rainforests imply a long evolutionary association i.e. the occurrence of species together is more than just chance and is indicative of the maintenance of rainforest assemblages through time (Webb et al. 1986). Re-assembly of tropical forests by expansion from refugia (Webb & Tracey 1981), as has occurred as a result of Quaternary climatic oscillations (Williams et al. 1993), would be a mechanism for increased diversity through random processes. Extrapolation of these conclusions to include all plants should, however, be approached with caution; bryophytes employ significantly different dispersal mechanisms (e.g. spores, fragments, gemmae) compared with flowering plants. Tan and Pócs (2000) emphasised that a regional bryoflora is developed as a result of the complex processes of long-distance dispersal, vicariance events, extinction, and the vicissitudes of climate during the Tertiary and Quaternary.

Affinities with the mosses of Malesia and Southeast Asia

Relationships exist between Australian bryophytes and those of the Palaeotropics, particularly Papua New Guinea, the Philippines, Borneo and other parts of Southeast Asia. About 45% of the moss species in the Wet Tropics have affinities with those regions (Appendix 1). Within Malesia, the Malay Peninsula, Sumatra, and Borneo in the west, and New Guinea in the east, form cores of ever-wet climate. These border a mosaic of wet and seasonal areas (the Philippines, Sulawesi, the Moluccas, Java, and the Lesser Sunda Islands), which form a corridor connecting the seasonally dry areas of tropical Southeast Asia and Australia (Touw 1992b). The Moss Flora of Malesiana (Eddy 1988, 1990, 1996) lists many species common to both areas. By comparison affinities of Wet Tropics mosses with those of temperate rainforests of New Zealand is only 15% (Appendix 1).

Klazenga (1999) reported that the genus *Dicranoloma* shows a Malesian-Australasian-Pacific distribution extending marginally into Southeast Asia. The genus *D. braunii* is widespread in Malesia but in Australia occurs only in north-east Queensland, while *D. menziesii* occurs in Papua New Guinea and is found throughout eastern Australia, New Zealand and New Caledonia (Klazenga 2003).

Between Australia and the Lesser Sunda Islands (South Malesia), species such as *Sclerodontium pallidum* and *Thuidiopsis sparsa* are seasonal drought-tolerant plants from more or less exposed habitats (Touw 1992, 2001a). These distribution patterns might be explained by exchange of biota between Malesia and Australasia long before the collision of Gondwana and Laurasia; however, Touw (1992) considered these patterns to be the result of post-glacial establishment during the Miocene. Similarly, *Mittenia plumula*, reported from Mt Spec in the southern Wet Tropics bioregion but more common in eastern Australia, Tasmania, Papua New Guinea and New Zealand, also occurs in Western Malesia, probably as the result of post-glacial colonisation (Tan 1998). Nevertheless, the Australian element is far smaller in the Lesser Sunda Islands than one would expect from their proximity (Touw 1992). The family Thuidiaceae includes species such as *Pelekium gratum* and *P. synoicum* with affinities to Southeast Asia. One species, *P. velatum,* so far reported only from central coastal Queensland by one record (Touw 2001b) but common in Malesia, could well be found in the Wet Tropics.

The same is true of affinities between New Guinea and Australia (Piipo and Koponen 2003). Montane forests in New Guinea and South Malesia include only 12 species of mosses with Australian affinity (Ramsay et al. 1986). In the genus *Macromitrium*, well represented in both New Guinea (29 spp.) (Vitt et al. 1995) and Australia (22 spp.) Vitt and Ramsay 1985a, b), only two species are common to both areas. Examples of species with restricted distribution between north-east Australia and New Guinea include *Acroporium lamprophyllum* var. *percaudatum, Gemmabryum australe, Groutiella tomentosa, Macromitrium incurvifolium, Orthomnium elimbatum, Pogonatum neesii, Sorapilla papuana* (Norris and Koponen 1989a, b; van Zanten and Pócs 1981, Vitt et al. 1995, Tan et al. 1996, Ramsay et al. 1995 Spence & Ramsay 2005, Flora of Australia vol 51 in press). In an analysis of the biogeography of the Bryaceae (subfamily Bryoideae) and its relatives in tropical regions of north-east Queensland, Spence and Ramsay (1996) found that the strongest affinities are with Malesia (including New Guinea). The family Sematophyllaceae has strong affinities with Malesia with many species of the genera found in Australia such as *Acroporium, Acanthorrhynchium, Clastobryum, Meiothecium, Taxithelium, Trichosteleum, Trismegistia, Warburgiella,* and *Radulina* having species common to these areas (Ramsay & Schofield 1987; Ramsay et al. 2002a, b, 2004; Tan et al. 1992).

Gondwanan distributions in temperate rainforest zones of Australasia and South America, as well as in the tropical montane forests of Malesia and Sri Lanka, suggest fragmentation of a continuous area forming a mosaic of wetter and drier environments. Gondwanan families such as Dawsoniaceae (van Zanten 1973), Hypnodendraceae (Touw 1971), Racopilaceae (van Zanten & Pócs 1981, van Zanten & Hofman 1995) and Leptostomataceae (Crum 1989) also occur in New Guinea and the western Pacific. Genera such as *Campylopus* have distribution patterns that include Africa (Frahm 1992) as well as Southeast Asia. Distribution of the genus *Papillaria* (Meteoriaceae) includes both Malesia/Southeast Asia and the Pacific, with greatest diversity in New Caledonia (Streimann 1992). In the Daltoniaceae [Hookeriaceae], *Calyptrochaeta apiculata* has a disjunct distribution, occurring in the Wet Tropics on Mt Bellenden Ker and in southern Australia, but also reported from Chile, Argentina, the Falkland Islands, and New Zealand (Streimann 2000a).

Distunctive patterns of distribution may be difficult to resolve. In the Neckeraceae, *Caduciella marei*, known in Australia from one specimen collected near the Daintree River in 1882 (Enroth 1991), has also been reported from Tanzania, the Comoro Islands, India (Assam), SW China, Indochina, Malesia and Oceania. Tan (1998) considered this widespread distribution to represent either fragmented parts of a former continuous Gondwanan range or the result of chance dispersal between extant populations on three continents.

Commenting on disjunctive patterns of bryophyte distribution between South Malesia/Phillippines and Australasia/Oceania, Tan (1998) attributed the presence of Gondwanan taxa in Malesia e.g. *Bescherellia elegantissima* and *Dawsonia superba* (also present in the Wet Tropics), to their arrival following the collision of SE Asia and the Australian margin in the mid-Miocene; reciprocal invasions into northern Australia could also have occurred during this period. Affinities of moss species across tropical Australia and Malesia/Southeast Asia demonstrate that there are strong phytogeographical relationships between the palaeotropical areas and north-east Queensland. This may be at the family, generic or species level. Taxa come from a wide range of families including Archidiaceae, Bryaceae, Calymperaceae, Daltoniaceae, Fissidentaceae, Meteoriaceae, Orthotrichaceae, Thuidiaceae, and Sematophyllaceae.

Species in the Wet Tropics with affinities to the mosses in Southeast Asia (particularly Malesia) are indicated in Appendix 1. Publications pertaining to the bryoflora of southeast Asia that may also have relevance to the Wet Tropics bioregion include: Akiyama et al. (1991); Enroth (1990); Koponen and Norris (1983); Koponen et al. (1986); Mohamed (1998); Norris and Koponen (1987, 1990a, b); Reese et al. (1986a, b); Tan (1994); Yamaguchi (1993). Index Muscorum (Wijk et al. 1959–1969) has been useful for checking distributions.

Affinities with New Caledonia: All moss families occurring in New Caledonia are also present in Australia. The strong Southeast Asian element in north-east Queensland also extends to the Pacific; further to the west, the diversity of this element decreases. Previously it was thought that relationships between the species in New Caledonia and Australia were not close but recent studies have increased the number of species common to both and reduced the number of endemics in both countries (see Appendix 1). It is expected that this trend will continue.

Knowledge of distributions between the two is still limited for many genera. Pursell and Reese (1982) provided a list of species reported for New Caledonia. Of the 45 names listed in the genus *Macromitrium*, six occur in Australia (Vitt & Ramsay 1985a), in the Meteoriaceae six of the 16 species are found here (Streimann 1991a, b, c; 1992, 1993), in the Bryaceae six of 22 species including *Rosulabryum subfasciculatum* (Pursell & Reese 1982, Spence & Ramsay 1996), and in the Sematophyllaceae 11 of the 63 species reported for New Caledonia occur in Australia (Tan et al. 2002). Yamaguchi and Iwatsuki (1987) reduced the previous figure of 15 species of *Leucobryum*, including seven endemics, to four species with no endemics. Three of these species occur in Australia, including north-east Queensland. Pursell and Reese (1982) listed 39 taxa (also 50 nom. nud.) for *Fissidens*, of which 33 were endemics. A revision of the Fissidentaceae by Iwatsuki (1982) reduced the number of species to 23 including 13 endemics. Additional studies by Iwatsuki and Suzuki (1989) recorded 27 species and further reduced the number of endemics to three. *Nanobryum*

thorsbornei (Stone 1990b) [= F*issidens thorsbornei]*, previously known only from Australia, was added to the list. In a discussion on the origins of the New Caledonian species, Iwatsuki (1990) reported six species of *Fissidens* with an Australian-New Caledonian distribution, but predicted an increase when northern Australian species were investigated. An Australian revision (Stone 1994a) has increased this number to about 23 *Fissidens* species now known to occur in both countries, including *F. rupicola*. Two additional Australian species have recently been added to the total for New Caledonia by Müller et al. (2003).

Ephemerum fimbriatum, previously known only from Australia, has been reported from New Caledonia by Matsui and Iwatsuki (1991). Most, if not all, of the small cleistocarpous mosses (in Pottiaceae, Ditrichaceae, Ephemeraceae and Archidiaceae) present in New Caledonia also occur in Australia. In addition *Viridivellus pulchellum* has also been recorded for New Caledonia (Iwatsuki pers. comm.)

It is evident that a considerable affinity exists between the terrestrial mosses of the north-east region of Australia and those of New Caledonia. While epiphytic pleurocarpous species appear at present to have less affinity in the two areas, further taxonomic studies may increase the relationships.

Affinities with Norfolk Island: Recently a survey of the mosses of Norfolk Island (Streimann 2002) has compared the distribution of species with those in Australia, New Zealand, and New Caledonia. Norfolk Island lies off the coast of Queensland approximately midway between New Caledonia and New Zealand. Affinities of mosses are strongest with Australia (91%) and New Zealand (66%), with only 29% of taxa in common with New Caledonia (Streimann 2002). Sixty nine species of mosses were listed for Norfolk Island, of which 38 (55%) have been recorded in the Wet Tropics bioregion. Just three of these taxa are restricted to Australia and Norfolk Island: *Erpodium hodgkinsoniae*, *Fissidens dietrichiae*, and *F. oblongifolius* var. *hyophilus*, and within Australia none are limited to Queensland (Streimann & Klazenga 2002).

Conclusions

In recent years there has been renewed interest in bryophytes; moss species have been described and their distributions in the Wet Tropics reported, generally associated with revisions of families or genera (e.g. Reese & Stone 1995; Eddy 1988, 1990, 1996, Streimann 1997, 1999, 2000a; Klazenga 2003). The majority of these have been published in dedicated bryological journals outside Australia (exceptions are e.g., Buck 1990, Klazenga 2003, Ramsay et al. 2002a), not easily accessible to general botanists and those involved in vegetation surveys. It is therefore not surprising that bryophytes have been frequently omitted from surveys of vegetation, perhaps because few researchers are familiar with their identification. This study summarises the available data on the mosses of the Wet Tropics bioregion and provides a useful and current checklist of moss species, identifying the areas in which the various species are distributed.

The Wet Tropics is one of the smallest bioregions in Queensland (Satler & Williams 1999), yet the mosses present represent 77.4% of all Queensland mosses. While the greatest number of collections has been made in the rainforests of the Wet Tropics bioregion, the area is still relatively unexplored, particularly in areas of lowland forest (Streimann 2001). Hopefully, publication of these studies will encourage and facilitate more useful investigation of this area. Other important and interesting regions of Queensland adjacent to the area in the north, south and west of the present studies with different rainfall, vegetation and soil types should eventually provide much of interest to bryologists.

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Appendix 1. List of mosses of the Wet Tropics bioregion, north-east Queensland.

Species: The species list includes new records and new species. Some earlier names may be in synonymy and these are listed in Streimann and Klazenga (2002). If more recently published, they are included here.

Distribution: showing relationships in Australia and affinities to areas adjacent to Australia. Distributions in other Australian states and territories are available in Streimann & Klazenga (2002).

WT= Wet Tropics endemics

AU = Australian endemics

NS = New species for Australia

NR = New records for the Wet Tropics

S.E.Asia = species present particularly in parts of Malesia, some in Papua New Guinea.

NZ = New Zealand

OC = Oceania

New Caled. = New Caledonia

Location: within the Wet Tropics bioregion

The Wet Tropics bioregion is subdivided into a series of provinces (Sattler & Williams 1999). The numbers used here relate to the list of provinces according to Goosem et al. (1999).

Province 1. Herbert: Low rainfall, delta of the Herbert River, Quaternary alluvium; alluvial plains with relic stream channels, low stream levees and prior streams associated with the coastal escarpment between the Cardwell Range and Bluewater Creek; open forests and woodlands.

Province 2. Tully: High rainfall, Quaternary alluvium; alluvial plains, channels, levees, lagoons and piedmont fans; mesophyll rainforest.

Province 3. Innisfail: High rainfall, Quaternary alluvium, some basalt and metasediments; undulating low hills, alluvial plains, channels, levees, lagoons; mesophyll rainforest, fan palm and feather palm rainforests, woodlands.

Province 4. Atherton: Moderately high rainfall, 700–1000 m altitude; tableland area dominated by basalt plains, subtropical climate; mainly fragmented mesophyll rainforest.

Province 5. Paluma-Seaview: Relatively low rainfall, 800–900+ m elevation; granitic southern ranges, separated from the northern provinces by the Herbert River Gorge; simple notophyll rainforest

Province 6. Kirrama-Hinchinbrook: Moderately high rainfall. Steep environmental gradients associated with steep slopes, waterfalls, shallow soils and complex vegetation including simple and complex notophyll rainforest, mesophyll vine forest, tall open forest and woodland. Subdivided for the purposes of this study into:

6a. Cardwell and Kirrama Ranges: Rainfall moderate

6b. Hinchinbrook Island: Rainfall variable, to 3500 mm per annum

Province 7. Bellenden Ker-Lamb Range: Very high rainfall, high altitudes to 1600+ m; wet and cloudy upland granitic massifs; mostly rainforest; a major centre of endemism in the bioregion.

Province 8. Macalister (north and west of Cairns): Moderate rainfall; undulating tableland bounded by a steep dissected escarpment falling to a narrow coastal plain; includes the Black Mountain corridor; vegetation mixed.

Province 9. Daintree–Bloomfield: Variable rainfall; a complex province, likely to be subdivided in the future- includes Mt Carbine, Windsor and Big Tablelands, Mount Finnigan, Thornton Peak, Mt Lewis.

Species	Location	Distribution
Acanthorrhynchium papillatum (Harv.) M.Fleisch.	1, 2, 6b	S.E.Asia
Achrophyllum dentatum (Hook. f. & Wilson) Vitt & Crosby	4	S.E.Asia, PNG, NZ
Acroporium lamprophyllum Mitt. var. *percaudatum* (E.B.Bartram) B.C.Tan, H.P.Ramsay & W.B.Schofield	2, 5, 6a, 9	S.E. Asia, **NS**
Acroporium microcladon (Dozy & Molk.) B.C.Tan var. *rhizogemmae* B.C.Tan, W.B.Schofield & H.P.Ramsay (includes specimens identified as *C. conspicuum* M. Fleisch.)	2, 4, 5, 6a, 7, 9	S.E.Asia **NS**
Acroporium stramineum (Reinw. & Hornsch.) M.Fleisch. = *A. erythropodium* (Hampe) Broth. (AU); *Rhynchostegium erythropodium* (Hampe) Mitt.; *Sematophyllum erythropodium* (Hampe) A. Jaeger	4, 5 6a, 7, 9	S.E.Asia

Acroporium strepsiphyllum (Mont.) B.C.Tan	5, 6a, 9	S.E.Asia, **NS**
Aerobryopsis longissima (Dozy & Molk.) M.Fleisch.	1, 2, 3, 4, 5, 6a, 7, 9	S.E. Asia
Anoectangium aestivum (Hedw.) Mitt.	3	Asia
Archidium brevinerve P. de la Varde	2	Equatorial Africa
Archidium capense Hornsch.	2	Southern Africa
Archidium clarksonianum I.G.Stone	5	AU
Archidium elatum Dixon & Sainsbury	2, 6	**NR**
Archidium microthecium *Dixon & P. de la Varde*	*2*	Southern Africa & India
Archidium minutissum I.G. Stone	9	WT
Archidium ohioense Schimp. ex Müll.Hal.	4	Cosmopolitan, **NS**
Archidium rothii Watts ex G.Roth	1, 2, 3, 8, 9	AU
Archidium species A	2	AU
Archidium species B	3	AU
Archidium species C	2, 3, 8, 9	AU
Arthrocormus schimperi (Dozy & Molk.) Dozy & Molk.	2, 3, 7, 9	S.E.Asia
Barbellopsis trichophora (Mont.) W.R Buck	1, 2, 3, 4, 5, 6a, 7, 8, 9	S.E.Asia
Barbula subcalycina Mull Hal.	4	AU
Bartramia mossmaniana Müll.Hal.	7	South America
Bescherellia elegantissima Duby	2, 4, 5, 6a, 9	New Caled.
Brachymenium nepalense Hook.	2, 3, 4, 5 6a, 7, 9	Paleotrop. S.E. Asia, OC
Brachythecium salebrosum (F.Weber & D.Mohr) Schimp.	4	Southern Africa, NZ,
Braithwaitea sulcata (Hook.) A.Jaeger & Sauerb.	4	NZ
Breutelia affinis (Hook.) Mitt.	6a	NZ
Bryobrothera crenulata (Broth. & Paris) Thér.	5, 6a, 6b, 7, 9	S.E.Asia, Melanesia
Bryum argenteum Hedw**.**	1, 2, 3, 5, 6a, 7, 9	S.E.Asia
Bryum auratum Mitt. Syn: *Anomobryum auratum*	4, 5	S.E.Asia
Bryum lanatum (P.Beauv.) Brid. Syn: *Anomobryum lanatum*	1, 2, 3,4, 5, 6a, 7, 9	S.E.Asia
Buxbaumia colyerae Burges	7	AU
Buxbaumia thorsorneae I. G. Stone	7	WT
Caduciella mariei (Besch.) Enroth	9	S.E.Asia
Callicostella papillata (Mont.) Mitt. var. *papillata*	9	S.E.Asia
Callicostella papillata (Mont.) Mitt. var. *prabaktiana* (Müll.Hal.) Streimann	3, 8, 9	S.E.Asia
Calymperes afzelii Sw.	1, 2, 3, 5, 6a, 9	S.E.Asia, Pantropical
Calymperes boulayi Besch.	8	**NR**, S.E.Asia
Calymperes couguiense Besch.	2, 3, 7, 9	S.E.Asia
Calymperes crassinerve (Mitt.) A. Jaeger	2, 3, 9	S.E.Asia
Calymperes erosum Müll.Hal.	1, 3, 4, 6b, 7, 9	S.E.Asia, Pantropical
Calymperes graeffeanum Müll.Hal.	1, 2, 3, 4, 6a, 6b, 7, 8, 9	S.E.Asia
Calymperes lonchophyllum Schwägr.	2, 9	S.E.Asia
Calymperes moluccense Schwägr.	2, 3, 7, 9	S.E.Asia
Calymperes motleyi Mitt.	1, 2, 5, 9	S.E.Asia
Calymperes porrectum Mitt.	9	S.E.Asia
Calymperes serratum A. Braun ex Müll.Hal.	3, 4, 7, 9	S.E.Asia
Calymperes strictifolium (Mitt.) G. Roth	3	S.E.Asia
Calymperes subintegrum Broth.	2, 6b, 7, 9	S.E.Asia
Calymperes taitense (Sull.) Mitt.	2, 3, 5, 6b, 9	S.E.Asia
Calymperes tenerum Müll.Hal.	1, 2, 3, 4, 5, 7, 9	S.E.Asia
Calyptothecium acutum (Mitt.) Broth.	1, 2	AU
Calyptothecium australinum (Mitt.) Paris	4	AU, **NS**
Calyptothecium humile (Mitt.) Broth.	1, 9	South America
Calyptothecium recurvulum (Broth.) Broth.	7	Melanesia

Calyptothecium subecostatum Dixon	3	WT
Calyptrochaeta apiculata (Hook. f. & Wilson) Vitt	7	S. America, NZ, Antarctic Islands
Calyptrochaeta brassii (E. B. Bartram) Streimann	4, 9	WT
Calyptrochaeta rotundifolia (Nog. & Z. Iwats.) Touw	7	S.E.Asia, **NR**
Camptochaete curvata Tangney	4 (rare)	AU
Camptochaete deflexa (Wilson) A. Jaeger	4, 9	NZ
Camptochaete excavata (Taylor) A. Jaeger	2, 3, 4, 5, 6b, 7, 9	AU
Campylopus catarractilis (Müll.Hal.) Paris	1, 2, 4, 5, 6a	Southern Africa, NZ
Campylopus clemensiae E.B. Bartram	4	S.E.Asia
Campylopus comosus (Schwägr.) Bosch & Sande Lac.	3, 4, 5, 8	S.E.Asia
Campylopus ericoides (Griff.) A. Jaeger	8	S.E.Asia -India
Campylopus flexuosus (Hedw.) Brid.	2, 3, 4, 7, 9	S.E.Asia, NZ
Campylopus flindersii Catches. & J.-P. Frahm	6a	AU
Campylopus introflexus (Hedw.) Brid.	4, 7, 9	Southern Hemisphere
Campylopus laxitextus Sande Lac.	2, 4, 9	S.E.Asia, New Caled
Campylopus pyriformis (Schultz) Brid.	4, 7	NZ, subtropics, N.Caled.
Campylopus robillardei Besch.	4, 6a, 7, 9	Tropical Africa
Campylopus sinensis (Müll.Hal.) J.-P. Frahm	3, 4, 9	S.E.Asia
Campylopus umbellatus (Schwägr. & Gaudichaud ex Arn.) Paris	1, 4, 5, 6a, 7, 9	S.E.Asia
Chaetomitrium tahitense (Sull.) Mitt.	3, 4, 9	S.E.Asia
Claopodium assurgens (Sull. & Lesq.) Cardot	1, 3	S.E.Asia
Clastobryum dimorphum (I. G. Stone) B. C. Tan, Z. Iwats. & D. H. Norris	7, 9	AU
Clastobryum epiphyllum (Renauld & Cardot) B. C. Tan &Touw	5, 6a	S.E.Asia
Cryphaea tenella (Schwägr.) Hornsch. ex Müll.Hal.	4	Tropical Pacific, NZ
Cryptogonium phyllogonioides (Sull.) Isov.	3	S.E.Asia
Cyathophorum bulbosum (Hedw.) Müll.Hal.	7	NZ.
Cyclodictyon blumeanum (Müll.Hal.) O.Kuntze	4, 7, 9	S.E.Asia , Pacific
Cyptodon muelleri (Hampe) M. Fleisch.	3, 4, 8	AU
Daltonia contorta Müll.Hal.	4, 7	S.E.Asia
Daltonia splachnoides (Sm.) Hook. & Taylor	7	NZ
Dawsonia longiseta Hampe?	4, 9	AU
Dawsonia polytrichoides R. Br.	4, 5, 9	AU
Dawsonia superba Grev. var. *pulchra* Zanten	4, 9	AU
Dicnemon calycinum (Hook.) Schwägr.	8	NZ
Dicranella dietrichiae (Müll.Hal.) A. Jaeger	4, 9	NZ
Dicranella euryphylla Dixon	4	WT
Dicranella pycnoglossa (Broth.) Kindb.	3, 4, 7, 8, 9	AU
Dicranoloma austroscoparium (Müll.Hal ex Broth.) Watts & Whitel.	4, 7, 9	WT
Dicranoloma braunii (Müll.Hal. Ex Bosch & Sande Lac.) Paris	9	S.E.Asia
Dicranoloma daymannianum E.B.Bartram	4, 5, 6a, 7	S.E.Asia
Dicranoloma dicarpum (Nees) Paris	4	S.E.Asia, NZ
Dicranoloma leichhardtii (Hampe) Watts & Whitel.	4, 5	AU
Dicranoloma menziesii (Taylor) Renauld	4, 7, 9	NZ, New Caled.
Dicranoloma robustum (Hook.f. & Wilson) Paris	7	NZ, sub-Antarctic Islands
Dicranoloma wattsii Broth.	4	AU
Diphyscium mucronifolium Mitt.	7, 9	S.E.Asia, **NR**
Distichophyllum crispulum (Hook. f. & Wilson) Mitt.	4, 5, 7, 9	NZ
Distichophyllum cuspidatum (Dozy & Molk.) Dozy & Molk.	3	S.E.Asia
Distichophyllum mittenii Bosch & Sande Lac.	4, 5, 6a	S.E.Asia
Ditrichum difficile (Duby) M. Fleisch.	2, 4, 5, 7	S.E.Asia, NZ
Eccremidium brisbanicum (Broth.) I. G. Stone & G. A. M. Scott	2	S.E.Asia, New Caled.
Eccremidium minutum (Mitt.) I. G. Stone & G. A. M. Scott	3	NZ, New Caled.
Eccremidium pulchellum (Hook. & Wilson) Müll.Hal.	2	NZ
Ectropothecium moritzii A. Jaeger	7, 8	S.E.Asia

Ectropothecium riparioides E. B. Bartram	4	AU
Ectropothecium umbilicatum var. *umbilicatum* (Müll.Hal.) Paris	4,7, 8	OC
Ectropothecium zollingeri (Müll.Hal.) A.Jaeger	4, 7,8	S.E.Asia
Entodon mackaviensis Müll.Hal.	4, 5	AU
Entodon plicatus Müll.Hal.	4, 6a, 9	S.E.Asia
Ephemeropsis tjibodensis K. J. Goebel	2, 4, 7, 9	S.E.Asia, NZ
Ephemerum fimbriatum Müll.Hal.	2, 6a	New Caled.
Erpodium coronatum (Hook. f. & Wilson) Mitt. var. *australiense* (I G. Stone) I.G. Stone	5	AU
Erpodium hodgkinsoniae (Hampe & Müll.Hal.)	1	Norfolk Island
Erpodium solmsiellaceum (Müll.Hal. & Broth.) I.G.Stone	2, 3	New Caled.
Eucamptodon muelleri var. *muelleri* Hampe & Müll.Hal.	2, 4, 5, 6a, 6b, 7, 8, 9	AU
Eucamptodon scalarirete (Dixon) B.C. Tan, H.P. Ramsay & W.B. Schofield	4, 5, 7, 9	AU
Euptychium setigerum (Sull.) Broth. subsp. *setigerum*	3	S.E.Asia
Eurhynchium laevisetum Geh.	4	AU
Exostratum blumei (Nees ex Hampe) L.T. Ellis	2, 7, 9	S.E.Asia
Fabronia australis Hook.	4, 9	NZ
Fallaciella gracilis (Hook. f. & Wilson) H.A.Crum	3, 4	NZ, S.E.Asia,
Fissidens altisetus Dix. [= *F. bogoriensis* according to Streimann & Klazenga (2002) but *F. bogoriensis* not known in Australia (pers. comm. I. Stone)]	9	AU ?
Fissidens asplenioides Hedw.	4	Asia
Fissidens autoicus Thér. & Broth.	4, 7	S.E.Asia
Fissidens badyinbarus I. G. Stone & Catches.	6b	WT
Fissidens bryoides Hedw. var. *schmidii* (Mull. Hal.) R.S. Chopra & S.S. Kumar	4	Asia
Fissidens cambewarrae Dixon	2	AU
Fissidens ceylonensis Dozy & Molk.	7	S.E.Asia, NZ
Fissidens crassinervis Sande Lac.	9	Asia
Fissidens crenulatus Mitt.	1, 6a	Indo-Burmese
Fissidens crispulus Brid.	1, 3, 4, 6a, 7, 9	Southern Africa, Japan
Fissidens curvatus Hornsch.	4	S.E.Asia
Fissidens dietrichiae Müll.Hal.	4	New Caled.
Fissidens flabellulus Thwaites & Mitt.	2, 3, 4, 6a	S.E.Asia, New Caled.
Fissidens flabellulus Thwaites & Mitt. var. *eachamensis* I. G. Stone	4	WT
Fissidens gardneri Mitt.	1, 9	S.E.Asia
Fissidens gymnocarpus I. G. Stone	9	AU
Fissidens henryae I. G. Stone	2	WT
Fissidens hollianus Dozy & Molk.	9	S.E.Asia
Fissidens holstii Broth.	8	S.E.Asia
Fissidens hyalinus Hook. & Wilson	4	S.E.Asia
Fissidens leptocladus Müll. Hall ex Rodway	2	NZ
Fissidens linearis Brid. var. *obscurirete* (Broth.) I. G. Stone	9	New Caled.
Fissidens oblatus I. G. Stone & Catches.	4	WT
Fissidens oblongifolius Hook. f. & Wilson	4	WT
Fissidens oblongifolius Hook. f. & Wilson var. *hyophilus* (Mitt.) Beever & I. G. Stone	2, 4, 7	AU
Fissidens pallidus Hook. f. & Wilson var. *pallidus*	4	NZ
Fissidens patulifolius Dixon	2	AU
Fissidens pellucidus Hornsch.	1, 4	Asia
Fissidens perobtusus Dixon (on termite mounds)	2, 9	AU
Fissidens polypodioides Hedw.	5	**NR**
Fissidens pseudopallidus I. G. Stone	8	WT
Fissidens punctulatus Sande Lac.	6a, 9	S.E.Asia

Fissidens rupicola Paris & Broth.	4, 6a, 9	OC
Fissidens serratus Müll.Hal.	9	S.E.Asia, New Caled.
Fissidens sufflatus I. G. Stone	7	WT
Fissidens tenellus Hook. f. & Wilson var. *australiensis* (A.Jaeger) Beever & I.G.Stone	4	AU, **NR**
Fissidens zollingeri Mont.	2, 3	S.E.Asia, OC
Floribundaria floribunda (Dozy & Molk.) M. Fleisch.	2, 4, 7, 9	S.E.Asia
Floribundaria pseudofloribunda M. Fleisch.	4, 9	S.E.Asia
Floribundaria walkeri (Renauld & Cardot) Broth.	4	Southern Africa, S.E.Asia
Funaria hygrometrica Hedw.	5, 6a, 9	Cosmopolitan
Garckea flexuosa (Griff.) Margad. & Nork.	7, 9, 8	S.E.Asia
Garovaglia elegans (Dozy & Molk.) Bosch & Sande Lac. subsp. *dietrichiae* (Müll.Hal.) During	1, 3, 4, 5, 6a, 7, 8, 9	S.E.Asia, OC
Gemmabryum acuminatum (Harv. In Hook.) J.R. Spence and H.P. Ramsay	4,	Pantropical, subtropical
*Gemmabryum apiculatum (*Schwägr.)J.R. Spence & H.P. Ramsay = *Bryum apiculatum* Schwägr.	1, 2, 3, 4, 6a, 7, 8, 9	S.E.Asia, OC, N.Z.
Gemmabryum australe (Hampe) J.R. Spence & H.P. Ramsay = *Bryum australe Hampe*	1,9	NZ, S.E.Asia
Gemmabryum chrysoneuron (M üll Hal.) J.R. Spence & H.P. Ramsay = *Bryum chrysoneuron Müll Hal.*	3,4,6,7	New Caled., Oc, NZ
Gemmabryum clavatum (Schimp.) J.R. Spence & H.P. Ramsay = *Bryum clavatum* (Schimp.) Müll.Hal.	4, 7, 8	S.E.Asia, N.Z., OC
Gemmabryum coronatum (Schwägr.) J.R. Spence & H.P. Ramsay = *Bryum coronatum* Schwägr.; = *B. subatropurpureum* Müll.Hal.	1, 4, 5	New Caled., NZ
*Gemmabryum dichotomum (*Hedw.) J.R. Spence & H.P. Ramsay = *Bryum dichotomum* Hedw; = *B. pimpamae* Müll.Hal.	4, 6a, 8	NZ, Subantarctic
Gemmabryum exile (Dozy & Molk.) J.R. Spence & H.P. Ramsay	4,7, 9	S.E.Asia, OC
Gemmabryum indicum (Dozy & Molk.) J.R. Spence & H.P. Ramsay	2, 3, 8, 9	S.E.Asia, OC
*Gemmabryum pachythecum (*Müll.Hal.) J.R. Spence & H.P. Ramsay =*Bryum pachytheca* Müll.Hal.	9	S.E.Asia, NZ
Gemmabryum preissianum (Hampe) J.R.Spence & H.P. Ramsay	2, 6, 9	AU
Gigaspermum repens (Hook.) Lindb.	4	Southern Africa, NZ
?Glossadelphus hermaphroditus M. Fleisch. [=*Chaetomitrium entodontoides* Broth. & Watts *Glossadelphus* = *Phyllodon* (see Buck 1987)	3	S.E.Asia
Grimmia pulvinata (Hedw.) Sm var. *africana* (Hedw.) Hook. f. & Wilson	8	NZ
Groutiella tomentosa (Hornsch.) Wijk & Margad.	4, 6a, 9	S.E.Asia
Hampeella concavifolia Hattaway & Norris (in prep.)	7, 9	WT, **NR**
Hampeella pallens (Sande Lac.) M. Fleisch.	4, 5, 6b, 7, 9	S.E.Asia
Herpetineuron toccoae (Sull. & Lesq.) Cardot	4, 7	Cosmopolitan
Himantocladium cyclophyllum (Müll.Hal.) M. Fleisch.	7, 9	S.E.Asia
Holomitrium perichaetiale (Hook.) Brid.	1, 2, 3, 4, 5, 6a, 7, 8, 9	NZ
Homaliodendron exiguum (Bosch & Sande Lac.) M. Fleisch.	1, 2, 4, 9	S.E.Asia
Homaliodendron flabellatum (Sm.) M. Fleisch.	4, 9	S.E.Asia
Hookeriopsis utacammundiana (Mont.) Broth.	5, 7, 9	S.E.Asia
Hyophila involuta (Hook.) A. Jaeger	2, 3, 4, 9	S.E.Asia
Hypnodendron comatulum (Geh. ex Broth.) Touw	2, 3, 4, 5, 6a, 7	WT
Hypnodendron spininervium (Hook.) A.Jaeger & Sauerb. subsp. *archeri* (Mitt.) Touw	4, 7, 8	AU
Hypnodendron vitiense Mitt. subsp. *australe* Touw	4, 5, 9	AU
Hypnodendron vitiense Mitt. subsp. *vitiense*	4, 7	S.E.Asia, OC
Hypnum cupressiforme Hedw.	2, 3, 4, 5, 8, 9	Cosmopolitan
Hypnum subchrysogaster (Broth.) Paris	7	AU
Hypopterygium tamarisci (Sw.) Brid. ex Müll.Hal.	4, 5, 6b	NZ
Isocladiella wattsii (Broth.) B.C. Tan, H.P. Ramsay & W.B. Schofield	7	WT

Isopterygium acuminatum Bosw.	4, 7, 8	AU, **NR**
Isopterygium albescens (Hook.) A. Jaeger	2, 4	S.E.Asia, OC, NZ
Isopterygium minutirameum (Müll.Hal.) A. Jaeger var. *brevifolium* (M.Fleisch.) E.B.Bartram	7	S.E.Asia, OC
Isopterygium minutirameum (Müll.Hal.) A. Jaeger var. *minutirameum*	2,3,6b,9	NZ
Isopterygium novae-valesiae Broth.	2,4,7	AU
Lembophyllum divulsum (Hook. f. & Wilson) var. *clandestinum* (Hook. f. & Wilson) Wijk & Margad.	7, 9	NZ
Leptobryum pyriforme (Hedw.) Wilson	5	NZ
Leptodictyum riparium (Hedw.) Warnst.	4	**NR**
Leptostomum erectum R. Br.	1, 2, 4	AU
Leptotrichella tenax (Müll.Hal.) Ochyra var. *longipes* (Müll.Hal.) Ochyra	9	AU
Leucobryum aduncum Dozy & Molk. var. *aduncum.*	2, 3, 4, 6a, 8, 9	S.E.Asia
Leucobryum aduncum Dozy & Molk. var. *scalare* (Müll.Hal.ex M.Fleisch) A.Eddy	1, 2, 4, 6a, 9	S.E.Asia, New Caled.
Leucobryum ballinense Broth.	3, 4, 5	AU
Leucobryum candidum (Brid. ex P. Beauv.) Wilson	2, 3, 4, 5, 6a, 6b, 7, 8, 9	Asia, New Caled., NZ,
Leucobryum chlorophyllosum Müll.Hal.	1, 4, 9	S.E.Asia, New Caled. **NR**
Leucobryum sanctum (Brid.) Hampe	2, 3, 4, 6a, 7, 8, 9	S.E.Asia
Leucobryum subchlorophyllosum Hampe	4, 6a, 7, 9	**NR**
Leucobryum wattsii Broth.	1, 2, 6a, 6b, 9	AU
Leucoloma [various undetermined species]	4, 6a, 7, 9	WT
Leucoloma molle (Müll.Hal.) Mitt.	4, 7	AU
Leucomium strumosum (Hornsch.) Mitt.	3, 4	S. Amererica, **NR**
Leucophanes angustifolium Renauld & Cardot	1, 3, 5, 7	Madagascar
Leucophanes candidum (Schwägr.) Lindb.	9	S.E.Asia, OC
Leucophanes glaucum (Schwägr.) Mitt.	2, 3, 7, 8, 9	S.E.Asia, OC
Leucophanes octoblepharoides Brid.	3, 4, 6b, 7, 8, 9	S.E.Asia, OC
Lopidium concinnum (Hook.) Wilson	2, 6b, 7, 9	South America, NZ
Lopidium struthiopteris (Brid.) M. Fleisch.	4, 5, 7	S.E.Asia, OC
Macgregorella indica (Broth.) W.R. Buck	4	S.E.Asia
Macrohymenium mitratum (Dozy & Molk.) M. Fleisch.	6b	S.E.Asia
Macromitrium archeri Mitt.	4, 7, 9	AU
Macromitrium aurescens Hampe	1, 4, 6a	AU
Macromitrium caloblastoides Müll.Hal.	1, 2, 4	AU
Macromitrium diaphanum Müll.Hal.	4	AU
Macromitrium dielsii Broth. ex Vitt & H.P. Ramsay	7	WT
Macromitrium exsertum Broth.	4, 7, 9	AU
Macromitrium funiforme Dixon	7, 9	WT
Macromitrium hemitrichodes Schwägr.	4, 9	AU
Macromitrium hortoniae Vitt & H.P. Ramsay	5	AU, **NR**
Macromitrium incurvifolium (Hook. & Grev.) Schwägr.	3, 9	OC
Macromitrium involutifolium (Hook. & Grev.) Schwägr. subsp. *involutifolium*	4, 5, 7	New Caled.
Macromitrium involutifolium (Hook. & Grev.) Schwägr. subsp. *ptychomitrioides* (Besch.) Vitt & H.P. Ramsay	4, 5, 6a, 7, 9	OC
Macromitrium leratii Broth. & Paris	4, 6a, 6b, 7, 9	AU
Macromitrium ligulaefolium Broth.	2, 3, 4, 5, 6a, 7, 8, 9	NZ, New Caled., OC.
Macromitrium microstomum (Hook. & Grev.) Schwägr.	1, 2, 3, 4, 7, 9	NZ, OC
Macromitrium repandum Müll.Hal.	1, 4, 5, 6a, 7, 8, 9	AU
Macromitrium stoneae Vitt & H.P. Ramsay	4	AU
Meiotheciella papillosa (Broth.) B.C. Tan, H.P. Ramsay & W.B. Schofield	5	S.E.Asia, New Caled. **NS**
Meiothecium secundifolium Dixon	2	WT, **NS**

Meiothecium microcarpum (Hook.) Mitt. = *Meiothecium wattsii* (Broth.) Broth. [Australian specimens of *Meiothecium jagorii* (Müll.Hal.) Broth are this, earlier missidentified]	2, 6b, 9	S.E.Asia, New Caled., Oc.
Meiothecium tenellum Broth. & Paris	3, 4, 8	S.E.Asia
Mesochaete taxiforme (Hampe) Watts & Whitel.	4, 5, 9	AU
Mesochaete undulata Lindb.	1, 5	AU
Mesonodon flavescens (Hook.) W.R. Buck	4	S.E.Asia
Meteoriopsis reclinata (Müll.Hal.) M. Fleisch. ex Broth.	3, 4, 7, 8, 9	S.E.Asia
Meteorium polytrichum Dozy & Molk	3, 4, 5, 6a, 7, 9	S.E.Asia
Mittenia plumula (Mitt.) Lindb.	5	NZ, PNG, **NR**
Mitthyridium constrictum (Sull.) H.Rob.	3, 7, 9	S.E.Asia
Mitthyridium crassum (Broth.) H.Rob.	2, 9	S.E.Asia
Mitthyridium fasciculatum (Hook. & Grev.) H.Rob.	2, 3, 4, 7, 9	S.E.Asia
Mitthyridium flavum (Müll.Hal.) H.Rob.	1, 2, 3, 6a, 7, 8, 9	S.E.Asia
Mitthyridium leucoloma (Müll.Hal.) H.Rob.	3	S.E.Asia
Mitthyridium papuanum (Broth.) H.Rob.	2, 3, 7, 9	S.E.Asia
Mitthyridium perundulatum (Broth.) H.Rob.	3, 7, 9	S.E.Asia
Mitthyridium repens (Harv.) H.Rob.	2, 3, 7, 9	S.E.Asia
Mitthyridium subluteum (Müll.Hal.) H.K. Nowak	1, 2, 3, 5, 9	S.E.Asia
Muellerobryum whiteleggei (Broth.) M. Fleisch.	1, 2, 3, 4, 5, 6b, 7, 9	AU
Myurium rufescens (Reinw. & Hornsch.) M. Fleisch. subsp. *purpuratum* (Mitt.) Maschke [*Oedicladium* — no combination available]	4, 7, 9 .	S.E.Asia, Oc
Nanobryum thorsbornei I. G. Stone = *Fissidens thorsbornei* (I. G. Stone) Brugg.-Nann.	3, 5, 6a, 9	New Caled.
Neckeropsis lepineana (Mont.) M. Fleisch.	1, 4, 9	S.E.Asia
Neckeropsis nanodisticha (Geh.) M. Fleisch.	1, 2	S.E.Asia
Neolindbergia vitiensis (E.B.Bartram) Enroth	9	S.E.Asia
Notoligotrichum australe (Hook. f. & Wilson) G.L.Sm.	4	NZ
Octoblepharum albidum Hedw.	1, 2, 4, 6a, 6b, 9	S.E.Asia
Oedicladium rufescens (Reinw. & Hornsch.) M. Fleisch. subsp. *rufescens* [see *Myurium* also]	4, 6b, 9	S.E.Asia, OC
Orthomnion elimbatum (Nog.) T. J. Kop.	3, 4, 9	PNG
Orthorrhynchium elegans (Hook. f. & Wilson) Reichhardt subsp. *cymbifolioides* (Müll.Hal.) Lin.	7	S.E.Asia, NZ
Papillaria crocea (Hampe) A. Jaeger	4, 5, 6a, 8, 9	S.E.Asia, NZ
Papillaria flexicaulis (Wilson) A. Jaeger	4, 5	S.E.Asia, New Caled.
Papillaria leuconeura (Müll.Hal.) A. Jaeger	6a, 9	S.E.Asia
Papillaria nitens (Hook. f. & Wilson) Sainsbury	3, 4, 5, 6a, 6b, 7, 9	NZ, New Cal.
Pelekium gratum (P.Beauv.) Touw	1, 6b, 7	S.E.Asia
Pelekium investe (Mitt.) Touw	4	S.E.Asia, **NR**
Pelekium synoicum (Touw) Touw	4,7,8	S.E.Asia
Philonotis hastata (Duby) Wijk & Margad.	3, 4, 8, 9	S.E.Asia, NZ
[Philonotis pseudomollis (Müll.Hal.) A. Jaeger (? *P. tenuis*)]	4, 7	AU
Philonotis tenuis (Taylor) Reichardt	4, 7	NZ
Philonotis thwaitesii Mitt.	9	Asia, S.E.Asia, S.America, **NR**
Pinnatella alopecuroides (Mitt.) M. Fleisch.	7, 9	S.E.Asia
Pinnatella kuehliana (Bosch & Sande Lac.) M. Fleisch.	2, 4, 6a	S.E.Asia, OC
Platyhypnidium austrinum (Hook. f. & Wilson) M. Fleisch.	7	NZ
Platyhypnidium muelleri (A. Jaeger) M. Fleisch.	7	PNG, Hawaii, **NR**
Pogonatum neesii (Müll.Hal.) Dozy	4	S.E.Asia, OC
Pogonatum tubulosum Dixon	9	S.E.Asia
Polytrichum juniperinum Hedw.	4	S.E.Asia
Powellia breviseta (E. B. Bartram) Zanten	1, 2 (in Flora)	New Caled., OC, **NR**
Powellia involutifolia Mitt.	2, 5, 7	S.E.Asia, OC

Pseudohypnella verrucosa (Dozy & Molk.) M. Fleisch.	3, 7	S.E.Asia
Pseudospiridentopsis horrida (Mitt. ex Cardot) M. Fleisch.	7	WT
Pseudosymblepharis bombayensis (Müll.Hal.) P. Sollman	9	Asia, S.E.Asia, **NR**
Pterobryella breviacuminata Besch.	4, 9	OC
Pterobryidium australe Broth. & Watts	4	AU
Ptychomitrium australe (Hampe) A. Jaeger	4	NZ
Ptychomnion aciculare (Brid.) Mitt.	7	NZ, **NR**
Pyrrhobryum latifolium (Bosch. & Sande Lac.) Mitt.	4, 5, 6a, 9	S.E. Asia
Pyrrhobryum medium (Besch.) Manuel	4, 5, 7	S.E.Asia, OC
Pyrrhobryum paramattense (Müll.Hal.) Manuel ?doubtful species (Frahm 2003)	1, 3, 4, 6b, 7, 9	S.E.Asia, NZ
Pyrrhobryum spiniforme (Hedw.) Mitt.	1, 4, 6a, 7, 9	S.E.Asia
Racopilum cuspidigerum (Schwägr.) Ångstr. var. *convolutaceum* (Müll.Hal.) Zanten & Dijkstra	3, 7	OC, NZ
Racopilum cuspidigerum (Schwägr.) Ångstr. var. *cuspidigerum*	7	S.E.Asia, OC
Radulina hamata (Dozy & Molk.) W.R.Buck & B.C. Tan	1, 3, 5, 8, 9	S.E.Asia, OC
Rhaphidorrhynchium amoenum (Hedw.) M. Fleisch. var. *amoenum*	9	NZ
Rhizogonium graeffeanum (Müll.Hal.) A. Jaeger	4, 7, 9	S.E.Asia
Rhodobryum aubertii (Schwägr.) Thér.	4, 6a, 7, 9	S.E.Asia
Rhynchostegium distratum (Hampe) A. Jaeger	4	AU
Rhynchostegium nanopennatum (Broth.) Kindb.	7	WT
Rhynchostegium tenuifolium (Hedw.) Reichhardt var. *tenuifolium*	4	S.E.Asia, OC, NZ
Rosulabryum albolimbatum (Hampe) J.R. Spence	2, 4,	AU
Rosulabryum billarderi (Schwägr.) J.R. Spence	1, 4, 5, 6a, 7, 9	OC
Rosulabryum capillare (Hedw.) J.R. Spence	9	Cosmopolitan
Rosulabryum epiphyticum J.R. Spence & H.P. Ramsay	2	AU, **NS**
Rosulabryum lamingtonicum J.R. Spence & H.P. Ramsay	3	AU
Rosulabryum leptothrix (Mull. Hal.) J.R. Spence	2, 9	AU
Rosulabryum subfasciculatum (Hampe) J.R. Spence	1, 2, 3, 4, 5, 6a, 8, 9	New Caled.
Rosulabryum subtomentosum (Hampe) J.R. Spence	2, 4	NZ
Rosulabryum torquescens (Bruch ex De Not) J.R.Spence	1	Cosmopolitan
Rosulabryum tuberosum (Mohamed & Damanhuri) J.R. Spence	3	S.E.Asia
Rosulabryum wightii (Mitt.) J.R. Spence	1, 2, 4, 5, 6a, 7, 8, 9	India
Schlotheimia brownii Schwägr.	4, 6a, 7, 9	AU
Schlotheimia funiformis Taylor ex Dixon	4, 6a	AU
Schoenobryum concavifolium (Griff.) Gangulee	4	S.E.Asia
Sclerodontium clavinerve (Müll.Hal.) H.A.Crum	3, 4	AU
Sclerodontium pallidum (Hook.) Schwägr. subsp. *pallidum*	4, 9	NZ
Sematophyllum homomallum (Hampe) Broth.	2 (rare)	S.E.Asia, OC
Sematophyllum subhumile (Müll.Hal.) M. Fleisch. var. *subhumile*	2, 4, 5, 6, 7, 8, 9	S.E.Asia, NZ, OC
Sematophyllum subhumile (Müll.Hal.) M. Fleisch. var. *contiguum* (Mitt.) B.C. Tan, W.B. Schofield & H.P. Ramsay	6,7	OC, NZ
Sematophyllum subpinnatum (Brid.) E. Britton	1, 2, 3, 4, 5, 6, 9	S.E.Asia, OC
Sorapilla papuana Broth. & Geh.	9	S.E.Asia
Sphagnum perichaetiale Hampe	3	S.E.Asia, NZ
Stereophyllum radiculosum (Hook.) Mitt.	4, 5	AU
Syrrhopodon albovaginatus Schwägr.	7, 9	S.E.Asia
Syrrhopodon aristifolius Mitt.	2, 9	S.E.Asia
Syrrhopodon armatus Mitt.	2, 3, 4, 6a, 7, 8, 9	S.E.Asia
Syrrhopodon ciliatus (Hook.) Schwägr.	'rare' (Reese & Stone 1995)	S.E.Asia, OC
Syrrhopodon confertus Sande Lac.	3, 7, 9	S.E.Asia
Syrrhopodon croceus Mitt.	3, 7, 9	S.E.Asia
Syrrhopodon cyrtacanthos Reese	9	WT
Syrrhopodon involutus Schwägr.	2, 3, 6a	S.E.Asia

Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.	3, 4, 7, 8, 9	S.E.Asia
Syrrhopodon parasiticus (Brid.) Besch.	6a, 7, 9	S.E.Asia
Syrrhopodon platycerii Mitt.	2, 4, 9	AU
Syrrhopodon prolifer Schwägr. var. *mossmanensis* Reese	9	WT
Syrrhopodon prolifer Schwägr. var. *prolifer*	9	S.E.Asia
Syrrhopodon stoneae Reese	6b, 7	WT
Syrrhopodon trachyphyllus Mont.	1, 6a, 6b, 8, 9	S.E.Asia
Syrrhopodon tristichus Nees ex Schwägr.	7, 9	S.E.Asia
Taxiphyllum taxirameum (Mitt.) M. Fleisch.	4	S.E.Asia, OC
Taxithelium instratum (Brid.) Broth.	1,5, 7, 9	S.E.Asia
Taxithelium kerianum (Broth.) Broth.	3, 6a, 7, 9	S.E.Asia
Taxithelium merillii Broth.	3, 6b, 7, 8, 9	S.E.Asia
Taxithelium muscicola (Broth.) B.C.Tan, H.P.Ramsay & W.B.Schofield	2, 7, 9,	AU
Taxithelium nepalense (Schwägr.) Broth.	4, 5, 7	S.E.Asia, tropical Africa
Taxithelium planum (Brid.) Mitt.	4, 5	S.E.Asia, tropical Africa
Thamnobryum ellipticum (Bosch & Sande Lac.) W. Schultze-Motel	3	S.E.Asia
Thamnobryum pandum (Hook. f. & Wilson) I. G. Stone & G.A.M. Scott	9	NZ
Thamnobryum pumilum (Hook.f. & Wilson) Nieuwl.	7	NZ,
Thuidiopsis sparsa (Hook. f. & Wilson) Broth.	4, 9	NZ,
Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.	1, 3, 4, 6b, 9	New Caled., OC,NZ
Touwia laticostata Ochyra	7	WT
Trachycarpidium brisbanicum (Mull. Hal.) I.G. Stone	1, 2	AU
Trachyloma diversinerve Hampe	4, 9	NZ
Trachyloma indicum Mitt.	4	S.E.Asia
Trachyloma planifolium (Hedw.) Brid.	4, 5, 9	NZ
Trachyphyllum inflexum (Harv.) A. Gepp.	1, 8	S.E.Asia
Trachypus humilis Lindb.	4	S.E.Asia, OC
Trachythecium verrucosum (A.Jaeger) M.Fleisch.	4	S.E.Asia, OC
Trematodon baileyi Broth.	9	AU
Trematodon longescens Müll.Hal.	7, 8	AU
Trematodon longicollis Michx.	8	**NR**
Trematodon suberectus Mitt.	4	NZ
Trichosteleum boschii (Dozy & Molk.) A. Jaeger	7	S.E.Asia, O
Trichosteleum ruficaule (Thwaites & Mitt.) B.C. Tan	2, 4, 7, 9,	S.E.Asia, OC
Trichosteleum subfalcatulum (Broth. & Watts) B.C. Tan, W.B. Schofield & H.P. Ramsay	1, 2, 4, 6a,	AU
Trichosteleum wattsii (Paris) B.C. Tan, W.B. Schofield & H.P. Ramsay	2, 6b	AU
Trichostomum brachydontium Bruch.	4	S.E.Asia
Trismegistia rigida (Mitt.) Broth.	9	S.E.Asia
Vesicularia rivalis Broth.	5, 9	AU
Viridivellus pulchellum I. G. Stone	3, 5, 7	AU
Warburgiella leptorhynchoides (Mitt.) M.Fleisch.	7, 9	S.E.Asia
Warburgiella leucocytus (Müll.Hal.) B.C. Tan, W.B. Schofield & H.P. Ramsay	1, 4, 7	NZ
Weissia balansae (Müll.Hal.) R.H.Zander	1, 2	New Caled.
Weissia controversa Hedw.	4	Cosmopolitan
Weissia platystegia (Dixon) A. Eddy = *Astomum platystegium* reported by Norris & Koponen (1989)	5	S.E.Asia
Wijkia extenuata (Brid.) H.A.Crum	1, 2, 4, 6a 7, 9	New Caled. NZ
Wilsoniella karsteniana Müll.Hal.	8	WT
Zygodon intermedius Bruch & Schimp.	4	NZ

Note: For one taxon, *Gemmabryum*, we are using the name to be published in the Flora of Australia treatment in volume 51 (in press 2005).

Appendix 2. Alphabetic list of genera with families

Acanthorrhynchium	Sematophyllaceae
Achrophyllum	Hookeriaceae
Acroporium	Sematophyllaceae
Aerobryopsis	Meteoriaceae
Anoectangium	Pottiaceae
Archidium	Archidiaceae
Arthrocormus	Calymperaceae
Barbellopsis	Meteoriaceae
Barbula	Pottiaceae
Bartramia	Bartramiaceae
Bescherellia	Cyrtopodaceae
Brachymenium	Bryaceae
Brachythecium	Brachytheciaceae
Braithwaitea	Trachylomataceae
Breutelia	Bartramiaceae
Bryobrothera	Adelotheciaceae
Bryum	Bryaceae
Buxbaumia	Buxbaumiaceae
Caduciella	Neckeraceae
Callicostella	Pilotrichaceae
Calymperes	Calymperaceae
Calyptothecium	Pterobryaceae
Calyptrochaeta	Daltoniaceae
Camptochaete	Lembophyllaceae
Campylopus	Dicranaceae
Chaetomitrium	Symphyodontaceae
Claopodium	Leskeaceae
Clastobryum	Sematophyllaceae
Cryphaea	Cryphaeaceae
Cryptogonium	Pterobryaceae
Cyathophorum	Hookeriaceae
Cyclodictyon	Pilotrichaceae
Cyptodon	Cryphaeaceae
Daltonia	Daltoniaceae
Dawsonia	Polytrichaceae
Dicnemon	Dicnemonaceae
Dicranella	Dicranaceae
Dicranoloma	Dicranaceae
Diphyscium	Diphysciaceae
Distichophyllum	Daltoniaceae
Ditrichum	Ditrichaceae
Eccremidium	Ditrichaceae
Ectropothecium	Hypnaceae
Entodon	Entodontaceae
Ephemeropsis	Daltoniaceae
Ephemerum	Ephemeraceae
Erpodium	Erpodiaceae
Eucamptodon	Dicnemonaceae
Euptychium	Garovagliaceae
Eurhynchium	Brachytheciaceae
Fabronia	Fabroniaceae
Fallaciella	Lembophyllaceae
Fissidens	Fissidentaceae
Floribundaria	Meteoriaceae
Funaria	Funariaceae
Garckea	Ditrichaceae
Garovaglia	Garovagliaceae
*Gemmabryum**	Bryaceae
Gigaspermum	Gigaspermaceae
Glossadelphus	Hypnaceae
Grimmia	Grimmiaceae
Groutiella	Orthotrichaceae
Hampeella	Ptychomniaceae
Herpetineuron	Anomodontaceae
Himantocladium	Neckeraceae
Holomitrium	Dicranaceae
Homaliodendron	Neckeraceae
Hookeriopsis	Pilotrichaceae
Hyophila	Pottiaceae
Hypnodendron	Hypnodendraceae
Hypnum	Hypnaceae
Hypopterygium	Hypopterygiaceae
Isocladiella	Sematophyllaceae
Isopterygium	Hypnaceae
Lembophyllum	Lembophyllaceae
Leptobryum	Meesiaceae
Leptodictyum	Amblystegiaceae
Leptostomum	Leptostomataceae
Leptotrichella	Dicranaceae
Leucobryum	Leucobryaceae
Leucoloma	Dicranaceae
Leucomium	Leucomiaceae
Leucophanes	Calymperaceae
Lopidium	Hypopterygiaceae
Macgregorella	Myriniaceae
Macrohymenium	Sematophyllaceae
Macromitrium	Orthotrichaceae
Meiotheciella	Sematophyllaceae
Meiothecium	Sematophyllaceae
Mesochaete	Rhizogoniaceae
Mesonodon	Entodontaceae
Meteoriopsis	Meteoricaeae
Meteorium	Meteoriaceae
Mittenia	Mitteniaceae
Mitthyridium	Calymperaceae
Muellerobryum	Pterobryaceae
Myurium	Myuriaceae
Nanobryum	Nanobryaceae
Neckeropsis	Neckeraceae
Neolindbergia	Pterobryaceae
Notologotrichum	Polytrichaceae
Octoblepharum	Calymperaceae
Oedicladium	Myuriaceae
Orthomnion	Mniaceae
Orthorrhynchium	Orthorrhynchiaceae
Papillaria	Meteoriaceae
Pelekium	Thuidiaceae
Philonotis	Bartramiaceae
Pinnatella	Neckeraceae
Platyhypnidium	Brachytheciaceae
Pogonatum	Polytrichaceae
Polytrichum	Polytrichaceae
Powellia	Racopilaceae
Pseudohypnella	Sematophyllaceae
Pseudospiridentopsis	Meteoriaceae
Pseudosymblepharis	Pottiaceae
Pterobryella	Pterobryellaceae
Pterobryidium	Pterobryaceae
Ptychomitrium	Ptychomitriaceae
Ptychomnion	Ptychomniaceae
Pyrrhobryum	Rhizogoniaceae
Racopilum	Racopilaceae
Radulina	Sematophyllaceae
Rhaphidorrhynchium	Sematophyllaceae
Rhizogonium	Rhizogoniaceae
Rhodobryum	Bryaceae
Rhynchostegium	Brachytheciaceae
Rosulabryum	Bryaceae
Schlotheimia	Orthotrichaceae
Schoenobryum	Cryphaeaceae
Sclerodontium	Dicranaceae
Sematophyllum	Sematophyllaceae
Sorapilla	Sorapillaceae
Sphagnum	Sphagnaceae
Stereophyllum	Stereophyllaceae
Syrrhopodon	Calymperaceae

Taxiphyllum	Hypnaceae
Taxithelium	Sematophyllaceae
Thamnobryum	Neckeraceae
Thuidiopsis	Thuidiaceae
Thuidium	Thuidiaceae
Touwia	Neckeraceae
Trachycarpidium	Pottiaceae
Trachyloma	Trachylomataceae
Trachyphyllum	Pterigynandraceae
Trachypus	Meteoriaceae
Trachythecium	Hypnaceae
Trematodon	Bruchiaceae
Trichosteleum	Sematophyllaceae
Trichostomum	Pottiaceae
Trismegistia	Sematophyllaceae
Vescicularia	Hypnaceae
Viridivellus	Viridivelleraceae
Warburgiella	Sematophyllaceae
Weissia	Pottiaceae
Wijkia	Sematophyllaceae
Wilsoniella	Ditrichaceae
Zygodon	Orthotrichaceae

Appendix 3. Index to genera and families (Shaw & Goffinet 2000, earlier classification in square brackets. * = new taxonomy).

Adelotheciaceae [Hookeriaceae]	*Bryobrothera*
Amblystegiaceae	*Leptodictyum*
Anomodontaceae	*Herpetineuron*
Archidiaceae	*Archidium*
Bartramiaceae	*Bartramia* *Breutelia* *Philonotis*
Brachytheciaceae	*Brachythecium* *Eurhynchium* *Platyhypnidium* *Rhynchostegium*
Bruchiaceae	*Trematodon*
Bryaceae	*Brachymenium* *Bryum* *Gemmabryum** *Rhodobryum* *Rosulabryum*
Buxbaumiaceae	*Buxbaumia*
Calymperaceae	*Arthrocormus* *Calymperes* *Exostratum* *Leucophanes* *Mitthyridium* *Octoblepharum* *Syrrhopodon*
Cryphaeaceae	*Cryphaea* *Cyptodon* *Schoenobryum*
Cyrtopodaceae	*Bescherellia*
Daltoniaceae [Hookeriaceae]	*Calyptrochaeta* *Daltonia*
[Hookeriaceae]	*Distichophyllum* *Ephemeropsis*
Dicnemonaceae	*Dicnemon* *Eucamptodon*
Dicranaceae	*Campylopus* *Dicranella* *Dicranoloma* *Holomitrium* *Leptotrichella* *Leucoloma* *Sclerodontium*
Diphysciaceae	*Diphyscium*
Ditrichaceae	*Ditrichum* *Eccremidium* *Garckea* *Wilsoniella*
Entodontaceae	*Entodon* *Mesonodon*
Ephemeraceae	*Ephemerum*
Erpodiaceae	*Erpodium*
Fabroniaceae	*Fabronia*
Fissidentaceae	*Fissidens*
Funariaceae	*Funaria*
Garovagliaceae	*Euptychium* *Garovaglia*
Gigaspermaceae	*Gigaspermum*
Grimmiaceae	*Grimmia*
Hookeriaceae	*Achrophyllum* *Cyathophorum*
Hypnaceae	*Ectropothecium* *Glossadelphus* *Hypnum* *Isopterygium* *Taxiphyllum* *Trachythecium* *Vescicularia*
Hypnodendraceae	*Hypnodendron*
Hypopterygiaceae	*Hypopterygium* *Lopidium*
Lembophyllaceae	*Camptochaete* *Fallaciella* *Lembophyllum*
Leptostomataceae	*Leptostomum*
Leucobryaceae	*Leucobryum*
Leucomiaceae	*Leucomium*
Meesiaceae	*Leptobryum*
Meteoriaceae	*Aerobryopsis* *Barbellopsis* *Floribundaria* *Meteoriopsis* *Meteorium* *Papillaria* *Pseudospiridentopsis* *Trachypus*

Mitteniaceae	*Mittenia*
Mniaceae	*Orthomnion*
Myriniaceae	*Macgregorella*
Myuriaceae	*Myurium* *Oedicladium*
Nanobryaceae [Fissidentaceae]	*Nanobryum*
Neckeraceae	*Caduciella* *Himantocladium* *Homaliodendron* *Neckeropsis* *Pinnatella* *Thamnobryum* *Touwia*
Orthorrhynchiaceae	*Orthorrhynchium*
Orthotrichaceae	*Groutiella* *Macromitrium* *Schlotheimia* *Zygodon*
Pilotrichaceae [Hookeriaceae]	*Callicostella* *Cyclodictyon* *Hookeriopsis*
Polytrichaceae	*Dawsonia* *Notologotrichum* *Pogonatum* *Polytrichum*
Pottiaceae	*Anoectangium* *Barbula* *Hyophila* *Pseudosymblepharis* *Trachycarpidium* *Trichostomum* *Weissia*
Pterigynandraceae	*Trachyphyllum*
Pterobryaceae	*Calyptothecium* *Cryptogonium* *Muellerobryum* *Neolindbergia* *Pterobryidium*
Pterobryellaceae	*Pterobryella*
Ptychomitriaceae	*Ptychomitrium*
Ptychomniaceae	*Hampeella* *Ptychomnion*
Racopilaceae	*Powellia* *Racopilum*
Rhizogoniaceae	*Mesochaete* *Pyrrhobryum* *Rhizogonium*
Sematophyllaceae	*Acanthorrhynchium* *Acroporium* *Clastobryum* *Isocladiella* *Macrohymenium* *Meiotheciella* *Meiothecium* *Pseudohypnella* *Radulina* *Rhaphidorrhynchium* *Sematophyllum* *Taxithelium* *Trichosteleum* *Trismegistia* *Warburgiella* *Wijkia*
Sorapillaceae	*Sorapilla*
Sphagnaceae	*Sphagnum*
Stereophyllaceae	*Stereophyllum*
Symphyodontaceae [Ho okeriaceae]	*Chaetomitrium*
Thuidiaceae	*Pelekium* *Thuidiopsis* *Thuidium*
Trachylomataceae	*Braithwaitea* *Trachyloma*
Viridivelleraceae	*Viridivellus*