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A checklist of the hornwort and liverwort flora of the Kermadec Islands, New Zealand Botanical Region

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Abstract

We accept 134 taxa at species rank and below belonging to 25 families as present on the Kermadec Islands, three times the number previously reported. One liverwort, *Lunularia cruciata* is regarded as introduced to the islands. More than half the indigenous species of the Kermadec Islands belong to just three families, Lejeuneaceae, Lepidoziaceae and Lophocoleaceae, which are together represented by 71 species. All but 16 of the hornwort and liverwort taxa that occur on the Kermadec Islands also occur in New Zealand, reflecting strong links to the New Zealand flora via long-distance dispersal.

Introduction

The Kermadec Islands Group (29°15´–31°30´S, 177°55´–179°W) (Fig. 1) is the northernmost extension of the New Zealand Botanical Region (*sensu* Allan 1961; Wardle 1991, but see comments by Trnski & de Lange 2015). The Kermadec Islands (Fig. 1) are mostly andesitic volcanic islands resulting from ongoing subduction between the overriding Indo-Australian Plate and the subducted Pacific Plate (Lloyd & Nathan 1981). The Group comprises three main islands, and several smaller islands and isolated rocks, the largest islands are (from North to South): Raoul Island (2943 ha, c.520 m a.s.l.), Macauley Island (323.75 ha, 238 m. a.s.l.) and Curtis Island (52.6 ha, 137 m a.s.l.) (data from Sykes 1977). Raoul (Fig. 2) is a volcanically active, cliff-girt, heavily forested island whose canopy is dominated by *Metrosideros kermadecensis* W.R.B.Oliv., while Macauley (Fig. 3), also cliff-girt, is currently volcanically quiescent, though often beset by earthquakes. Macauley is mostly vegetated by a dense fernland of *Hypolepis dicksonioides* (Endl.) Hook. (de Lange 2015a). Curtis (Fig. 4) is volcanically active and is mostly vegetated by a low turf of Kermadec ice plant (*Disphyma australe* subsp. *stricticaule* Chinnock). Climate data is available only for Raoul Island, where a meteorological station is maintained by the New Zealand Department of Conservation (DOC). The climate of Raoul Island is humid, subtropical, (data from https://en.wikipedia.org/wiki/Raoul_Island#Climate accessed 19 March 2018), and warm and wet throughout the year, though winter is slightly wetter, with a mean annual precipitation of 1558 mm. Diurnal temperatures (gathered since the 1940s) range from an average high of 22.1°C to an average low of 16.7°C. In the summer months temperatures reach an average daytime maximum of 25.7°C and minimum of 20.5°C, and in winter temperatures may drop to lows of 13.3°C. All of the islands are subjected to infrequent, high intensity tropical cyclones (Morton 1957; Sykes 1977; Revell 1981; Terry 2007; de Lange & Galloway 2015), that have a major impact on island vegetation.

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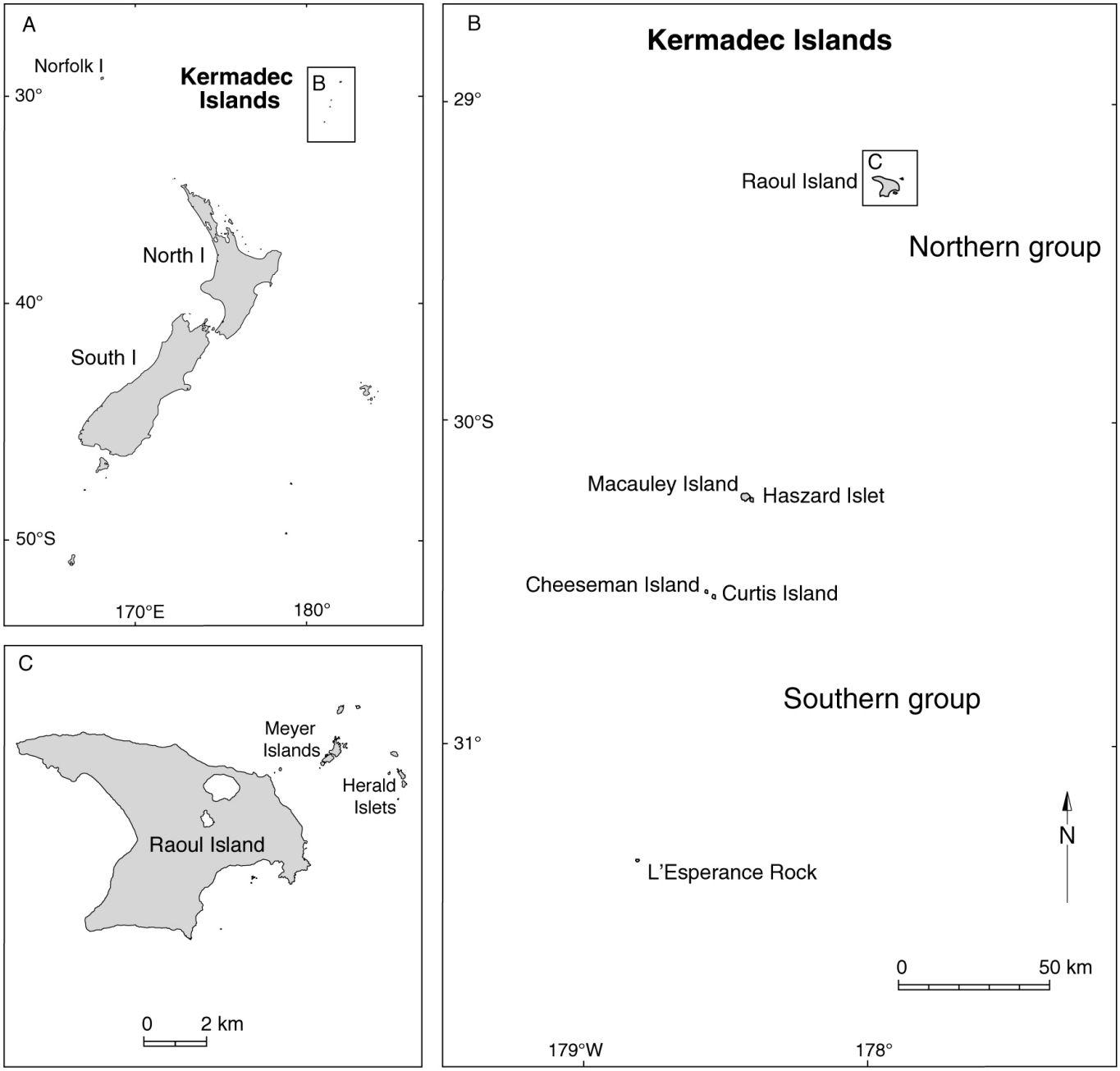

Figure 1. The Kermadec Islands. A. Location of the Kermadec Islands in relation to New Zealand. B. The Kermadec Islands chain, showing the northern group (C – see inset) and southern group, C. Northern group showing Raoul Island, The Meyer Islands and Herald Islets.

The vascular flora of the Kermadec Island Group has been well documented (Sykes 1977; Sykes & West 1996), and there are now 22 formally described plant taxa endemic to the Kermadecs, all at species level or below (Sykes 1977; de Lange et al. 2005; Wilmot-Dear & Friis 2006; Perrie & Brownsey 2012; de Lange et al. 2013; Cameron & Sykes 2015). There are no endemic vascular plant genera and all of the endemic vascular plant species are closely related to taxa on the nearest islands, especially New Zealand to the south west (see Sykes 1977; de Lange et al. 2005; Wimot-Dear & Friis 2006; de Lange et al. 2013).

In contrast to the vascular flora, however, the bryophyte flora, including hornworts, liverworts and mosses, has been poorly documented (de Lange & Beever 2015). Over the last two decades the Kermadec Islands moss flora has been carefully scrutinized and published (Beever et al. 1996; de Lange & Beever 2015) but documentation of the hornwort and liverwort flora, the focus of this paper, has scarcely advanced from the preliminary checklist prepared by Ella Campbell and published in Sykes (1977). Campbell's list, based in large part on collections made by Sykes from Raoul and Macauley Islands, reported 20 hornwort and liverwort taxa. Since then there have been several contributions adding species to the Kermadec Islands liverwort and hornwort flora including new records (Campbell 1997; Renner & de Lange 2011; Renner et al. 2013a; Braggins et al. 2014; Renner 2018), descriptions of two supposedly new and endemic taxa (Engel & Merrill 1999; Renner 2005), and reinstatements of previously synonymized taxa (So 2001; Engel & Merrill 2010). However, with few exceptions, these Kermadec reports have been included as part of wider-reaching generic monographs and there is still no single comprehensive listing for all of the hornworts and liverworts of the Kermadec Islands Group. Two liverworts were once thought endemic to the Kermadec Islands, however,

Plagiochila pacifica Mitt. has been found on Rarotonga in the Cook Islands Group (Renner 2018) and *Radula cordiloba* subsp. *erigens* M.A.M.Renner et Braggins is now treated as a synonym of a broadly circumscribed *R. javanica* Gottsche, Lindenb. et Nees (Renner 2014). With these changes, there are now no bryophytes regarded as endemic to the Kermadec Islands.

Figure 2. The northern side of Raoul Island as viewed from Napier Island (image: Peter J. de Lange).

Figure 3. The northern coastline of Macauley Island (image: Malcolm Francis).

Figure 4. Curtis Island as viewed from Cheeseman Island (image: Warren Chinn).

Methods

In May 2009, and May 2011 the senior author (P. J. de Lange, hereafter PdL) undertook field work within the Kermadec Islands. During May 2009 under the auspices of the New Zealand Department of Conservation (hereafter DOC) PdL spent two full days on Raoul Island (Renner & de Lange 2011). The May 2011 visit, conducted as a participant of the Kermadec Biodiscovery Expedition (Trnski & de Lange 2015), was more comprehensive, with landings made by PdL on all the main islands, islets and rock stacks except for Curtis, Haszard, "Haszardette", Milne and the Dougal Rocks (see de Lange 2011a,b,c; de Lange 2012).

As a result of visits in 2009 and 2011 477 packets of hornworts and liverworts were collected. Vouchers are lodged in AK with duplicates in CHR, F, NSW and WELT (herbarium accronyms follow Thiers (2018)). We present a revised checklist of the hornworts and liverworts of the Kermadec Islands based on these collections and supplemented by studies of Kermadec specimens held in other herbaria and literature records. This reflects a more complete knowledge of the hornwort and liverwort flora facilitating comparisons with other island flora in the South Pacific.

Results

In total, 122 formally described and accepted taxa, and 12 taxa that are either potentially new to science or require further critical study are now known for the Kermadec Islands Group (Table 1). Hornwort and liverwort nomenclature follows Söderstrom et al. (2016) and subsequent updates. Authorities for hornworts and liverworts are given in the checklist (see Table 1); those of other plants within the main body of the text. For each record a single representative voucher is cited. Voucher specimens for this list are those that have been personally examined by the authors from collections held in AK (including AKU), F, CHR, MPN, NSW, and WELT including specimens that had been previously examined by E.O. Campbell (Campbell in Sykes 1997; Campbell 1997) and which we have been able to locate. The distribution of hornworts and liverworts within the Kermadec Islands Group is summarised in Table 2.

Discussion

This paper builds on the knowledge of the hornwort and liverwort flora of the Kermadec Islands presented by Campbell in Sykes (1977) and subsequent literature (see introduction). We accept 134 taxa at species rank and below belonging to 25 families as present on the Kermadec Islands, three times the number previously reported. This is perhaps unsurprising, given virtually all past scientific expeditions to these islands have concentrated on the macrofauna (birds especially), and vascular plants (see summary in Gentry 2013).

One liverwort, *Lunularia cruciata* is regarded as probably introduced to the islands, reflecting perhaps on the assumption the source of introduction came from New Zealand (de Lange 2015a).

Table 1. Liverworts and hornworts of the Kermadec Islands, with representative voucher specimens, a generalised distribution that describes species occurrence in the surrounding segment of the globe south of the equator, and whether or not the species occurs on mainland New Zealand. In the table NZ=New Zealand, PNG=Papua New Guinea.

Species	Family	Voucher	Generalised distribution	Mainland NZ occurrence
Acrobolbus knightii (Mitt.) Briscoe	Acrobolbaceae	AK 305070	NZ endemic	Y
Acrolejeunea mollis (Hook.f. & Taylor) Schffin.	Lejeuneaceae	AK 313888	NZ endemic	Y
Acrolejeunea pycnoclada (Taylor) Schiffn. subsp. *pycnoclada*	Lejeuneaceae	AK 325478	Australasian and PNG	N
Acrolejeunea securifolia (Endl.) Steph. subsp. *securifolia*	Lejeuneaceae	AK 305090	Malesia-Pacific-Australasia	Y
Allisoniella recurva R.M.Schust.	Cephaloziellaceae	AK 305311	NZ endemic	Y
Anthoceros sp.	Anthocerotaceae	AK 313858		
Asterella australis (Hook.f. & Taylor) Verd.	Aytoniaceae	AK 325532	Australasian temperate	Y
Balantiopsis diplophylla (Hook.f. & Taylor) Mitt. var. *diplophylla*	Balantiopsaceae	AK 305273	Australasian temperate	Y
Bazzania adnexa (Lehm. & Lindenb.) Trevis.	Lepidoziaceae	AK 305277	Australasian temperate	Y
Bazzania novae-zelandiae (Mitt.) Besch. & C.Massal.	Lepidoziaceae	AK 305215	Australasian temperate	Y
Bazzania tayloriana (Mitt.) Kuntze	Lepidoziaceae	AK 305292	NZ endemic	Y
Ceramanus perfragilis (J.J.Engel & G.L.Merr.) E.D.Cooper	Lepidoziaceae	AK 305304	NZ endemic	Y
Ceratolejeunea belangeriana (Gottsche) Steph.	Lejeuneaceae	AK 329755	Malesia-Pacific-Australasia	N
Cheilolejeunea ceylanica (Gottsche) R.M.Schust. & Kachroo	Lejeuneaceae	AK 325644 p.p.	Malesia-Pacific-Australasia	N
Cheilolejeunea mimosa (Hook.f. & Taylor) R.M.Schust.	Lejeuneaceae	CHR161835	Australasian temperate	Y
Cheilolejeunea parvidens	Lejeuneaceae	AK313943	Australasian temperate	Y
Cheilolejeunea trifaria (Reinw., Blume & Nees) Mizut.	Lejeuneaceae	AK 305163	Malesia-Pacific-Australasia	N
Cheilolejeunea sp. (a)	Lejeuneaceae	AK 287598		
Cheilolejeunea sp. (k)	Lejeuneaceae	AK 313683		
Chiloscyphus excisifolius (Steph.) J.J.Engel & R.M.Schust.	Lophocoleaceae		Australasian temperate	N
Chiloscyphus lentus (Hook.f. & Taylor) J.J.Engel & R.M.Schust.	Lophocoleaceae	AK 305417	NZ endemic	Y
Chiloscyphus rupicola (Steph.) J.J.Engel & R.M.Schust.	Lophocoleaceae	AK 305303	Australasian temperate	Y
Chiloscyphus semiteres (Lehm.) Lehm.	Lophocoleaceae	AK 305777	Australasian temperate	Y
Chiloscyphus subporosus (Mitt.) J.J.Engel & R.M.Schust. var. *subporosus*	Lophocoleaceae	AK 305212	Australasian temperate	Y
Chiloscyphus aff. *bispinosus*	Lophocoleaceae	AK 305211	Australasian temperate	Y
Chiloscyphus aff. *novaezeelandiae*	Lophocoleaceae	AK 305099	Australasian temperate	Y
Cololejeunea cucullifolia (Herzog) E.A.Hodgs.	Lejeuneaceae	AK 325250	NZ endemic	Y
Cryptolophocolea helmsiana (Steph.) L.Söderstr.	Lophocoleaceae	AK 305614	Australasian temperate	Y
Cryptolophocolea mittenianus (Colenso) L.Söderstr.	Lophocoleaceae	AK 305418	NZ endemic	Y
Cumulolejeunea ocellata (Herzog) R.L.Shu & L.Shu	Lejeuneaceae	AK 325257	Australasian temperate	Y
Cuspidatula monodon (Taylor ex Lehm.) Steph.	Jamesoniellaceae	AK305126	Australasian temperate	Y
Dendroceros granulatus Mitt.	Dendrocerotaceae	AK325479	NZ endemic	Y
Dendromastigophora flagellifera (Hook.) R.M.Schust.	Mastigophoraceae	AK 305075	NZ endemic	Y
Dinckleria fruticella (Hook.f. & Taylor) J.J.Engel & Heinrichs	Plagiochilaceae	AK 305074	NZ endemic	Y
Drepanolejeunea aucklandica Steph.	Lejeuneaceae	AK 305415 p.p.	Australasian temperate	Y
Drepanolejeunea vesiculosa Herzog subsp. *vesiculosa*	Lejeuneaceae	CHR 595553	Pacific	N
Drucella integristipula (Steph.) E.A.Hodgs.	Lepidoziaceae	AK 305294	Australasian temperate	Y
Dumortiera hirsuta (Sw.) Nees	Marchantiaceae	AK 325170	Malesia-Pacific-Australasia	Y
Echinolejeunea papillata (Mitt.) R.M.Schust.	Lejeuneaceae	AK 313717	NZ endemic	Y
Frullania apiculata (Reinw., Blume & Nees) Dumort.	Frullaniaceae	AK 306176	Malesia-Pacific-Australasia	N
Frullania falciloba Lehm.	Frullaniaceae	AK 305091	Australasian temperate	Y
Frullania fugax (Hook.f. & Taylor) Gottsche, Lindenb. & Nees	Frullaniaceae	AK 306175	Australasian temperate	Y
Frullania pentalpleura Taylor	Frullaniaceae	AK 305079	Australasian temperate	Y
Frullania spinifera Taylor	Frullaniaceae	AK 306177	Australasian temperate	Y

Species	Family	Voucher	Generalised distribution	Mainland NZ occurrence
Frullania aff. *spinifera*	Frullaniaceae	AK 305125		
Frullania aff. *rostellata*	Frullaniaceae	AK 305095		
Frullania aff. *rostrata*	Frullaniaceae	AK 305081		
Frullania aff. *squarrosula*	Frullaniaceae	AK 306174		
Frullania sp. subgenus *Microfrullania*	Frullaniaceae	AK 305101 p.p.		
Frullania sp. subgenus *Trachycolea*	Frullaniaceae	AK 305101 p.p.		
Heteroscyphus allodontus (Hook.f. & Taylor) J.J.Engel & R.M.Schust.	Lophocoleaceae	AK 305186	Australasian temperate	Y
Heteroscyphus ammophilus (Colenso) R.M.Schust. var. *ammophilus*	Lophocoleaceae	AK 313211 p.p.	Australasian temperate	Y
Heteroscyphus argutus (Reinw., Blume & Nees) Schiffn.	Lophocoleaceae	AK 313190	Malesia-Pacific-Australasia	Y
Heteroscyphus cuneistipulus (Steph.) Schffin.	Lophocoleaceae	AK 305607	NZ endemic	Y
Heteroscyphus coalitus (Hook.f.) Schiffn. var. *coalitus*	Lophocoleaceae	AK 305610	Malesia-Pacific-Australasia	Y
Heteroscyphus echinellus (Lindenb. & Gottsche (Lindenb. & Gottsche) J.J.Engel & He-Nygrén var. *echinellus*	Lophocoleaceae	AK 325473	Australasian temperate	Y
Heteroscyphus fissistipus var. *multispinus* (E.A.Hodgs. & Allison) J.J.Engel	Lophocoleaceae	AK 305771	NZ endemic	Y
Heteroscyphus lingulatus (Colenso) J.J.Engel & R.M.Schust.	Lophocoleaceae	AK 305283	NZ endemic	Y
Heteroscyphus supinus (Hook.f. & Taylor) R.M.Schust.	Lophocoleaceae	AK 305618	Australasian and PNG	Y
Heteroscyphus triacanthus (Hook.f. & Taylor) Schiffn. var. *triacanthus*	Lophocoleaceae	AK 305223	Australasian temperate	Y
Hymenophyton flabellatum (Labill.) Trevis.	Hymenophytaceae	AK 305127	Australasian temperate	Y
Isotachis lyallii Mitt.	Balantiopsaceae	AK 305605	NZ endemic	Y
Kurzia moniliformis J.J.Engel	Lepidoziaceae	AK 305308	NZ endemic	Y
Kurzia quinquespina J.J.Engel & G.L.Merr.	Lepidoziaceae	AK 305746	NZ endemic	Y
Lamellocolea granditexta (Steph.) J.J.Engel	Lophocoleaceae	AK 305619	NZ endemic	Y
Lejeunea anisophylla Mont.	Lejeuneaceae	AK 313203	Malesia-Pacific-Australasia	N
Lejeunea exilis (Reinw., Blume & Nees) Grolle	Lejeuneaceae	AK 313699	Malesia-Pacific-Australasia	N
Lejeunea gracilipes (Taylor) Steph.	Lejeuneaceae	AK 313869	Australasian warm temperate and Pacific	Y
Lejeunea apiculata Sande Lac.	Lejeuneaceae	AK 305160	Malesia-Pacific-Australasia	Y
Lejeunea schusteri Grolle	Lejeuneaceae	AK 313187	NZ and Cook Islands	Y
Lejeunea hodgsoniana Grolle ex R.J.Lewington, Bever. & M.A.M.Renner	Lejeuneaceae	AK 313726	NZ endemic	Y
Lejeunea sp. (m)	Lejeuneaceae	AK 315261		
Lembidium nutans (Hook.f. & Taylor) Mitt.	Lepidoziaceae	AK 305276	NZ endemic	Y
Lepidolaena palpebrifolia (Hook.) Trevis	Lepidolaenaceae	AK 305071	NZ endemic	Y
Lepidolaena taylorii (Gottsche) Trevis.	Lepidolaenaceae	AK 305105	NZ endemic	Y
Lepidolejeunea integristipula (Jack. & Steph.) R.M.Schust.	Lejeuneaceae	AK 5644 p.p.	Malesia-Pacific-Australasia	N
Lepidozia elobata R.M.Schust.	Lepidoziaceae	AK 305119	NZ endemic	Y
Lepidozia laevifolia (Hook.f. & Taylor) Gottsche, Lindenb, & Nees var. *laevifolia*	Lepidoziaceae	AK 305616	Australasian temperate	Y
Lepidozia spinosissima (Hook.f. & Taylor) Mitt.	Lepidoziaceae	AK 305217	NZ endemic	Y
Leptolejeunea australis Steph.	Lejeuneaceae	AK 315273	Australasian temperate	Y
Lobatiriccardia coronopus subsp. *australis* (R.M.Schust.) Nebel	Aneuraceae	AK 305087	NZ endemic	Y
Lopholejeunea knightii Steph.	Lejeuneaceae	AK 315277	NZ endemic	Y
**Lunularia cruciata* (L.) Dumort.	Lunulariaceae	AK 305102	Introduced	Y
Marchantia berteroana Lehm. & Lindenb.	Marchantiaceae	AK 305156	Malesia-Pacific-Australasia	Y
Marchantia foliacea Mitt.	Marchantiaceae	AK 325538	Australasian temperate	Y
Marchantia pileata Mitt.	Marchantiaceae	AK 221959	Australasian temperate	Y
Metalejeunea cucullata (Reinw., Blume & Nees) Grolle	Lejeuneaceae	AK 229527	Australasian temperate	Y
Metzgeria furcata (L.) Dumort.	Metzgeriaceae	AK 305280	cosmopolitan	Y
Monoclea forsteri Hook.	Monocleaceae	AK 325476	NZ endemic	Y

Species	Family	Voucher	Generalised distribution	Mainland NZ occurrence
Neolepidozia patentissima (Hook.f. & Taylor) E.D.Cooper var. *patentissima*	Lepidoziaceae	AK 305612	Australasian temperate	Y
Neolepidozia praenitens (Lehm. & Lindenb.) E.D.Cooper var. *praenitens*	Lepidoziaceae	AK 305611	NZ endemic	Y
Notoscyphus lutescens (Lehm. & Lindenb.) Mitt.	Acrobolbaceae	AK 325635	Tropical	N
Pallavicinia xiphoides (Hook.f. & Taylor) Trevis.	Pallaviciniaceae	AK 305218	Australasian temperate	Y
Paracromastigum furcifolium (Steph.) R.M.Schust.	Lepidoziaceae	AK 305295	NZ endemic	Y
Phaeomegaceros coriaceus (Steph.) R.J.Duff, J.C.Villareal, Cargill & Renzaglia	Dendrocerotaceae	AK 234047	NZ endemic	Y
Phaeoceros carolinianus (Michx.) Prosk.	Anthocerotaceae	AK 313859	Australasian temperate	Y
Phaeoceros delicatus E.O.Campb. & Outred	Anthocerotaceae	AK 325475	NZ endemic	Y
Plagiochasma rupestre (J.R.Forst. & G.Forst.) Steph.	Atyoniaceae	AK 305302	Australasian temperate	Y
Plagiochila alta Steph	Plagiochilaceae	AK 325477	Pacific	N
Plagiochila annotina Lindenb.	Plagiochilaceae	AK 305077	NZ endemic	Y
Plagiochila banksiana Gottsche	Plagiochilaceae	AK 305073	Australasian temperate	Y
Plagiochila pacifica Mitt.	Plagiochilaceae	AK 305197	Pacific	N
Podomitrium phyllanthus (Hook.) Mitt.	Pallaviciniaceae	AK 305286	Australasian temperate	Y
Porella amoena (Colenso) W.Martin	Porellaceae	AK 305106	Australasian temperate	Y
Porella sp. nov.	Porellaceae	AK 325688	NZ and Fiji	N
Psiloclada clandestina Mitt.	Lepidoziaceae	AK 305207	Malesia-Pacific-Australasia	Y
Radula allisonii Castle	Radulaceae	AK 313885	NZ endemic	Y
Radula cuspidata Steph.	Radulaceae	AK 305196	NZ endemic	Y
Radula javanica Gottsche, Lindenb. & Nees	Radulaceae	AK 313206	Malesia-Pacific-Australasia	N
Radula novae-hollandiae Hampe ex Lehm.	Radulacae	AK 315260	Australasian temperate	N
Radula plicata Mitt.	Radulaceae	AK 313882	NZ endemic	Y
Reboulia hemisphaerica subsp. *australis* R.M.Schust.	Aytoniaceae	CHR 595563	Australasian temperate	Y
Riccardia alba (Colenso) E.A.Brown	Aneuraceae	AK 305083	NZ and Lord Howe Island	Y
Riccardia aff. *wattsiana*	Aneuraceae	AK 305772		
Schistochila kirkiana Steph.	Schistochilaceae	AK 313211	NZ endemic	Y
Siphonolejeunea nudipes (Hook.f. & Taylor) Herzog var. *nudipes*	Lejeuneaceae	AK 305167	Australasian temperate	Y
Siphonolejeunea sp. nov.	Lejeuneaceae	AK 313693	NZ endemic	Y
Spruceanthus olivaceus (Hook.f. & Taylor) X.Q.Shi, R.L.Zhu & Gradst.	Lejeuneaceae	AK 315253	NZ endemic	Y
Spruceanthus planiuscula (Mitt.) X.Q.Shi, R.L.Zhu & Gradst.	Lejeuneaceae	CHR 161785	Malesia-Pacific-Australasia	N
Spruceanthus thozetianus (Gottsche & F.Muell.) B.M.Thiers & Gradst.	Lejeuneaceae	AK 313178	Australasian and PNG	N
Symphyogyna hymenophyllum (Hook.) Mont. & Nees	Pallaviciniaceae	AK 305221	Australasian temperate	Y
Symphyogyna subsimplex Mitt.	Pallaviciniaceae	AK 305158	NZ endemic	Y
Symphyogyna undulata Colenso	Pallaviciniaceae	AK 305220	NZ endemic	Y
Targionia hypophylla L.	Targioniaceae	AK 305116	Australasian temperate	Y
Telaranea herzogii (E.A.Hodgs.) E.A.Hodgs.	Lepidoziaceae	AK 305107	Australasian temperate	Y
Triandrophyllum subtrifidum (Hook.f. & Taylor) Fulford & Hatcher	Herbertaceae	AK 313889	Australasian temperate	Y
Trichocolea mollissima (Hook.f. & Taylor) Gottsche	Trichocoleaceae	AK 305274	Australasian temperate	Y
Trichocolea rigida R.M.Schust.	Trichocoleaceae	AK 305281	Australasian temperate	Y
Tricholepidozia lindenbergii var. *complanata* (J.J.Engel & G.L.Merr.) E.D.Cooper	Lepidoziaceae	AK 305305	Australasian temperate	Y
Tricholepidozia lindenbergii (Gottsche) E.D.Cooper var. *lindenbergii*	Lepidoziaceae	AK 305309,	Australasian temperate	Y
Tricholepidozia tetradactyla (Hook.f. & Taylor) E.D.Cooper	Lepidoziaceae	AK 305617	NZ endemic	Y
Zoopsidella caledonica (Steph.) R.M.Schust.	Lepidoziaceae	AK 305219	NZ and New Caledonia	Y
Zoopsis argentea (Hook.f. & Taylor) Gottsche, Lindenb. & Nees var. *argentea*	Lepidoziaceae	AK 305208	Australasian temperate	Y
Zoopsis leitgebiana (Carrington & Pearson) Bastow	Lepidoziaceae	AK 305165	Australasian temperate	Y

Table 2. Occurrences of hornwort and liverwort species on islands of the Kermadec Islands group.

Kermadec Hornwort and Liverwort Distribution						
	North Meyer	**South Meyer**	**Raoul**	**Macauley**	**Cheeseman**	**L'Esperance**
Altitude (m)	122	99	518	238	61	70
Area (ha)	12	12	2943	324	8	5
Acrobolbus knightii			+			
Acrolejeunea mollis			+			
Acrolejeunea pycnoclada subsp. *pycnoclada*			+			
Acrolejeunea securifolia subsp. *securifolia*			+			
Allisoniella recurva			+			
Anthoceros sp.			+			
Asterella australis				+		
Balantiopsis diplophylla var. *diplophylla*			+			
Bazzania adnexa			+			
Bazzania novae-zelandiae			+			
Bazzania tayloriana			+			
Ceramanus perfragilis			+			
Ceratolejeunea belangeriana			+			
Cheilolejeunea ceylanica			+			
Cheilolejeunea mimosa			+			
Cheilolejeunea parvidens			+			
Cheilolejeunea trifaria			+			
Cheilolejeunea sp. (a)			+			
Cheilolejeunea sp. (k)			+			
Chiloscyphus excisifolius			+			
Chiloscyphus lentus			+			
Chiloscyphus rupicola			+			
Chiloscyphus semiteres			+	+		
Chiloscyphus subporosus			+			
Chiloscyphus aff. *bispinosus*			+			
Chiloscyphus aff. *novae-zeelandiae*			+			
Cololejeunea cucullifolia		+				
Cryptolophocolea helmsianus			+			
Cryptolophocolea mittenianus			+			
Cumulolejeunea ocellata			+			
Cuspidatula monodon			+			
Dendroceros granulatus			+			
Dendromastigophora flagellifera			+			
Dinckleria fruticella			+			
Drepanolejeunea aucklandica			+			
Drepanolejeunea vesiculosa subsp. *vesiculosa*			+			
Drucella integristipula			+			
Dumortiera hirsuta			+	+		
Echinolejeunea papillata			+			
Frullania apiculata			+			
Frullania falciloba			+			
Frullania fugax			+			
Frullania pentapleura			+	+	+	+
Frullania spinfera			+			
Frullania aff. *spinfera*			+			
Frullania aff. *rostellata*			+			
Frullania aff. *rostrata*			+			
Frullania aff. *squarrosula*			+			
Frullania sp. subgenus *Microfrullania*			+			
Frullania sp. subgenus *Trachycolea*			+			
Heteroscyphus allodontus			+			
Heteroscyphus ammophilus			+			
Heteroscyphus argutus			+			

Kermadec Hornwort and Liverwort Distribution						
	North Meyer	South Meyer	Raoul	Macauley	Cheeseman	L'Esperance
Heteroscyphus cuneistipulus			+			
Heteroscyphus coalitus			+			
Heteroscyphus echinellus			+			
Heteroscyphus fissistipus var. *multispinus*			+			
Heteroscyphus lingulatus			+			
Heteroscyphus supinus			+			
Heteroscyphus triacanthus var. *triacanthus*			+			
Hymenophyton flabellatum			+			
Isotachis lyallii			+			
Kurzia moniliformis			+			
Kurzia quinquespina				+		
Lamellocolea granditexta			+			
Lejeunea anisophylla			+			
Lejeunea exilis			+			
Lejeunea gracilipes			+			
Lejeunea apiculata			+			
Lejeunea schusteri			+			
Lejeunea hodgsoniana	+		+			
Lejeunea sp. (m)			+			
Lembidium nutans			+			
Lepidolaena palpebrifolia			+			
Lepidolaena taylorii			+			
Lepidolejeunea integristipula			+			
Lepidozia elobata			+			
Lepidozia laevifolia var. *laevifolia*			+			
Lepidozia spinosissima			+			
Leptolejeunea australis			+			
Lobatiriccardia coronopus subsp. *australis*			+			
Lopholejeunea knightii			+	+		
**Lunularia cruciata*			+	+		
Marchantia berteroana			+	+		
Marchantia foliacea				+		
Marchantia pileata			+	+		
Metalejeunea cucullata			+			
Metzgeria furcata			+			
Monoclea forsteri			+			
Neolepidozia patentissima var. *patentissima*			+			
Neolepidozia praenitens var. *praenitens*			+			
Notoscyphus lutescens			+			
Pallavicinia xiphoides			+			
Paracromastigum furcifolium			+			
Phaeomegaceros coriaceus			+			
Phaeoceros carolinianus			+			
Phaeoceros delicatus			+			
Plagiochasma rupestre			+	+		
Plagiochila alta			+			
Plagiochila annotina			+			
Plagiochila banksiana			+			
Plagiochila pacifica			+			
Podomitrium phyllanthus			+			
Porella amoena			+			
Porella sp. nov.			+			
Psiloclada clandestina			+			
Radula allisonii			+			
Radula dentifolia			+			
Radula javanica			+			

Kermadec Hornwort and Liverwort Distribution						
	North Meyer	South Meyer	Raoul	Macauley	Cheeseman	L'Esperance
Radula novae-hollandiae			+			
Radula plicata			+			
Reboulia hemisphaerica subsp. *australis*.			+	+		
Riccardia alba			+			
Riccardia aff. *wattsiana*			+			
Schistochila kirkiana			+			
Siphonolejeunea nudipes			+	+		
Siphonolejeunea sp. nov.			+			
Spruceanthus olivaceus			+			
Spruceanthus planiusculus			+			
Spruceanthus thozetianus			+			
Symphyogyna hymenophyllum			+			
Symphyogyna subsimplex			+			
Symphyogyna undulata			+			
Targionia hypophylla			+	+		
Telaranea herzogii			+			
Tricholepidozia lindenbergii var. *complanata*			+			
Tricholepidozia lindenbergii var. *lindenbergii*			+			
Tricholepidozia tetradactyla			+			
Triandrophyllum subtrifidum			+			
Trichocolea mollissima			+			
Trichocolea rigida			+			
Zoopsidella caledonica			+			
Zoopsis argentea var. *argentea*			+			
Zoopsis leitgebiana			+			
134 taxa	1	1	130	10	1	1

Islands and rocks lacking hornworts and liverworts

Hornworts and liverworts are apparently absent from the Herald Islets, Napier, Nugent, Milne, Dougal and Egeria Rocks, Hazard Islet, "Hazardette", and Curtis Island. As expected, the much larger, physiographically diverse and densely forested Raoul Island has the largest flora (130 taxa) and is also the only island to support any hornworts, followed by the next largest island Macauley (14 taxa). Interestingly, despite their forested state, North and South Meyer collectively supported only two liverworts, whilst the sparsely vegetation Cheeseman Island and L'Esperance Rock had one species (*Frullania pentapleura*). With the exception of Curtis Island which was not landed on (see de Lange 2012) and which may support hornworts and liverworts because it does have a small moss flora, the survey coverage of the Kermadec Islands is now fairly complete. Nevertheless, several key parts of Raoul Island still need critical investigation, particularly the caldera floor, fumaroles and craters, locations which for safety reasons remained out of bounds during the 2009 and 2011 visits.

The Northern Kermadec Island Group

The Meyer Islands and Herald Islets

The Meyer Islands (Fig. 5) and Herald Islets (Fig. 6) comprise a cluster of 13 vegetated islands, islets and rock stacks and a further 21 low-lying non-vegetated rock stacks and associated exposed reefs. The largest islands are The Meyers, which support a forest cover dominated by Kermadec pohutukawa (*Metrosideros kermadecensis*) and Kermadec ngaio (*Myoporum rapense* subsp. *kermadecensis* (W.R.Sykes) Chinnock) (Fig. 7). Napier, Nugent and Dayrell have a similar though very much smaller vegetation cover. The vegetation of the Chanters was described as one dominated by Kermadec ngaio (reported as *M. obscurum*) by Sykes (1977). However, when PdL visited these outer islands and islets in 2011, the vegetation was only just starting to recover from the passage of Tropical Cyclone Bune (de Lange 2011b). Consequently, much of the plant cover was either dead, or the trees and shrubs stripped completely of their foliage, while the ground cover had mostly been washed, blown or burned off leaving mostly bare earth. It seems likely that this cyclone damage will have contributed to the depauperate liverwort flora recorded from these islands and islets during the 2011 visit.

Figure 5. The Meyers as viewed from Fishing Rock, Raoul Island. North Meyer (left hand side of image), South Meyer (right hand side of image) with Egeria Rock in foreground (image: Peter J. de Lange).

Figure 6. A portion of the Herald Islets (The Chanters) as viewed looking north from North Meyer (image: Peter J. de Lange).

Figure 7. Forest interior, South Meyer. The dominant forest tree is *Metrosideros kermadecensis* followed by *Myoporum rapense* subsp. *kermadecense* with occasional *Corynocarpus laevigatus*. The bare ground in this image is the result of seabird activity, though acerbated by the impact of Cyclone Bune (image: Peter J. de Lange).

Only two liverwort species were found on The Meyers; *Lejeunea hodgsoniana*, found only on North Meyer in a few locations on shaded rocks and the basal portion of the trunks of Kermadec pohutukawa and ngaio, and *Cololejeunea cucullifolia* which was found near the summit of South Meyer growing on the sheltered portion of the trunk of a very large Kermadec pohutukawa. A notable and unexplained absence was *Frullania*, so much a feature of similar forested vegetation on nearby Raoul Island. Despite the likely impact of Cyclone Bune on the liverwort flora of these outer islands, these islands and islets may naturally have a depauperate hepatic flora, as 22 moss species were recorded from the islands and islets during the same survey (de Lange & Beever 2015).

Raoul Island

Raoul Island has a vegetation cover entirely dominated by Kermadec pohutukawa. However, based on differences in the canopy and subcanopy composition of mostly vascular plants (and also the abundance of epiphytic mosses), Oliver (1910) partitioned the island's forest cover into two main types, a 'dry' and a 'wet' forest type (Fig. 8, 9). Sykes (1977) maintained this distinction. The 'dry' forest was typified by the local dominance of *Myrsine kermadecensis* Cheeseman within the understory (and at times canopy) of the otherwise dominant Kermadec pohutukawa forest, and also by the absence of hutu (*Ascarina lucida* var. *lanceolata* (Hook.f.) Allan) and of the epiphytic moss *Papillaria crocea* (see comments by Sykes 1977). Conversely the 'wet' forest type has mahoe (*Melicytus ramiflorus* J.R.Forst. et G.Forst.), and hutu, with abundant *Papillaria crocea,* and *Myrsine* notably scarce. These basic forest types are still recognised today, despite changes in forest composition following the successful goat eradication in 1983, and rising dominance of nikau (*Rhopalostylis baueri* (Seem.) H.Wendl. et Drude) (Parkes 1984; de Lange & Stanley 1999; de Lange & Havell 2009) (Fig. 10).

With 130 taxa (Table 1) Raoul Island supports the greatest liverwort diversity in the archipelago. It is also the only island known to support hornworts (five taxa, *Anthoceros* sp. indet. *Dendroceros granulatus Phaeomegaceros coriaceus, Phaeoceros carolinianus*, *Phaeoceros delicatus*). Of the 134 recorded liverworts, all but 4 are known in the archipelago only from Raoul (Table 1). One of the liverworts reported from Raoul *Lunularia cruciata* is regarded as naturalised. This species is abundant on Raoul Island, along the various tracks and roads maintained by DOC, and around the accommodation buildings and huts. It is also reasonably common within those areas visited by people undertaking weed control and track maintenance. *Lunularia* also occurs locally on Macauley Island, and it seems that it was introduced to that island from Raoul Island (de Lange 2015a,b,c).

Figure 8. 'Dry' forest interior, near the base of Ravine 8, Raoul Island. The forest canopy is almost exclusively *Metrosideros kermadecensis* with a subcanopy of *Myrsine kermadecensis* (image: Peter J. de Lange).

Figure 9. 'Wet' forest interior, upper slopes of Moumoukai, Raoul Island. The forest canopy here though still dominated by *Metrosideros kermadecensis* has other canopy emergents including *Ascarina lucida* var. *lanceolata*, *Melicytus ramiflorus* subsp. *ramiflorus*, and increasingly *Alsophila kermadecensis* and *Pseudopanax kermadecensis* (image: Peter J. de Lange).

Figure 10. *Rhopalostylis baueri*, mid slopes of Moumoukai, Raoul Island, has, especially following the eradication of browsing animals, increased its presence across the island, and indications are that it is forming its own distinct vegetation association (image: Peter J. de Lange).

Despite the high liverwort diversity of Raoul Island, in a pattern comparable to the mosses (de Lange & Beever 2015) only a few of the liverworts recorded from there are common, most seem to be naturally scarce. Again, as with the mosses (de Lange & Beever 2015) there also appears to be a shift in liverwort assemblages moving north to south across the island. The most common (or at least visually obvious) liverworts on Raoul are *Chiloscyphus semiteres* var. *semiteres*, an as yet unnamed segregate of *Frullania rostrata* (Hook.f. et Taylor) Hook.f. et Taylor treated as "*Frullania* species B" in Carter et al. (2017), *Heteroscyphus argutus* (Fig. 11), *Lejeunea gracilipes*, *Lepidozia elobata*, *Lopholejeunea knightii, Plagiochila pacifica* (Fig. 12) and *Tricholepidozia lindenbergii*. However, some liverworts, such as *Marchantia pileata* and the two species of *Riccardia* are also common, though only in the ravines of the northern part of the island. The upper 'wet' forest running along the crater walls and toward Mahoe and Smiths Bluff is where *Radula javanica* (Fig. 13) is especially common, though it also resides around the seepages and small natural springs located within the ravines scattered along the north-western portion of the island.

Figure 11. *Heteroscyphus argutus* near Prospect, Raoul Island. This species is one of the more conspicuous of the Lophocoleaceae on account of its size, and characteristically 'washed' out colour. This species is common throughout both 'dry' and 'wet' forest associations on the island (image: Peter J. de Lange).

Figure 12. *Plagiochila pacifica* on the lower trunk of *Rhopalostylis baueri*, Moumoukai, Raoul Island. This species, seen here growing with *Radula javanica*, was once considered endemic to Raoul Island, is probably the most obvious of the island's liverworts by virtue of its size and abundance in the 'wet' forest of that island (image: Peter J. de Lange).

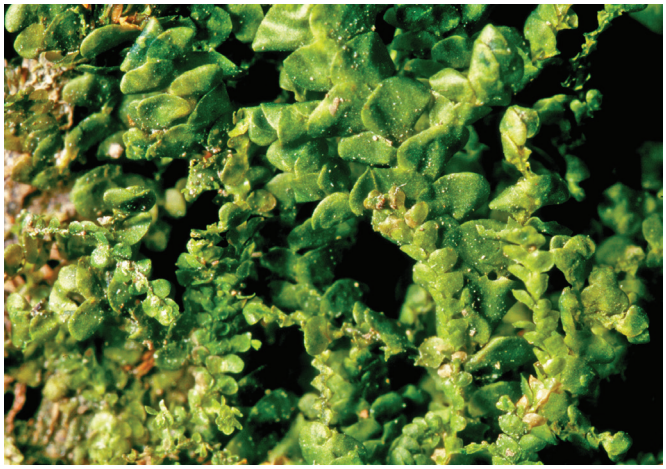

Figure 13. *Radula javanica* (as *R. cordiloba* subsp. *erigens*) was once considered very uncommon on Raoul Island. It is now known to be quite widespread, often growing with *Plagiochila pacifica* (image: John E. Braggins).

Some of these patterns may reflect that the vegetation of Raoul Island, natural volcanic, earthquake and cyclonic perturbations aside, is still recovering from over one hundred years of modification by humans and introduced browsing animals (Sykes 1969; Parkes 1984; de Lange & Galloway 2015). Browsing animals undoubtedly had a tremendous impact on the cryptogamic flora of Raoul Island through opening up habitats, thereby increasing evapotranspiration and available light; through the physical destruction of colonies, and by decreasing soil nutrient levels and soil cycling through the loss of seabird-induced pedoturbation following the eradication of seabird nesting colonies. Therefore, the removal of goats 28 years ago (see Parkes 1984), and later both cats and rats in 2002 (de Lange & Havell 2009), will have had and will continue to have long-term consequences for the flora, fauna, and vegetation recovery of Raoul (Sykes 1969; Parkes 1984; de Lange & Beever 2015).

Aside from animal eradications, the extirpation of a range of environmentally damaging weed species, and the ongoing intensive long-term management of others, mean that major disturbance to the indigenous vegetation of Raoul is likely to be affected only by the aforementioned natural stochastic events (earthquakes, volcanism, and tropical cyclones). While these are potentially very destructive to standing vegetation, such events have undoubtedly contributed to the evolving flora of the islands in the past by creating new, sometimes novel, habitats for colonisation, releasing fresh nutrients, and in the case of tropical cyclones "seeding" the Kermadecs with the propagules of fungi and plants (de Lange & Galloway 2015). Lastly, the role of seabirds in the vegetation recovery and enrichment of the Raoul Island cryptogamic flora needs further consideration, as in the past the island was covered in an array of ground nesting and burrowing seabirds (Cheeseman 1889, 1891; Iredale 1910, 1913, 1914; Bell 1911, 1912; Oliver 1912; Bacon 1957; Sorenson 1964; Straubel 1954; Merton 1970), which not only facilitated soil turn-over and nutrient enrichment but also potentially acted as dispersal agents for plants and fungi from other island groups (see comments by de Lange et al. 2004; de Lange & Galloway 2015).

The Southern Kermadec Island Group

Macauley Island

The largest island of the Southern Kermadec Island Group, Macauley once had a low forest cover of what was probably Kermadec ngaio (Sykes 1977; Barkla et al. 2008; de Lange 2015a). Fairly early on in the island's recorded history pigs and goats were liberated there, and, while the pigs did not thrive, the goats had a serious impact on that island's vegetation cover before they were at last eradicated in 1970 (Sykes 1977). As such the vegetation of Macauley Island is still recovering; currently it is mostly vegetated by dense, almost impenetrable *Hypolepis* fernland and *Cyperus* sedgeland (Fig. 14), with small pockets of Kermadec ngaio shrub land and 'forest' present on the cliff faces and ravines near Mt Haszard (Fig. 15), the highest part of that island (see Barkla et al. 2008; de Lange 2015a). Although most of the plateau is now choked by a dense, monospecific fernland, the ravines (Fig. 16), gullies and canyons which drain the plateau are mostly free of *Hypolepis*. Also on the steep, eroding scoria cliffs of the Mt Haszard crater system, *Hypolepis* is less common, and it is in these places where liverworts have been found.

Figure 14. Macauley Island looking across the inland crater and the plateau to Hazard Island. The dominant vegetation during the May 2011 survey of the island was *Hypolepis dicksonioides* fernland. The vegetation forms a dense, almost impenetrable mass in places 3 m deep through which land and sea birds are unable to travel. This vegetation probably in part explains the paucity of hepaticae on this island (image: Peter J. de Lange).

Figure 15. The seaward crater below Mt Hazard, Macauley Island has all but eroded. However, the rubble slopes and tuff cliffs support a range of hepatics of which the most common is *Plagiochasma rupestre*. Surprisingly the dense *Myoporum* forest supported only occasional specimens of *Siphonolejeunea nudipes* var. *nudipes* (image: Peter J. de Lange).

Figure 16. Access Gully – the main route to the plateau of Macauley Island when making sea landings had a small population of *Lunularia cruciata* that we surmise was probably introduced from Raoul or New Zealand by past landing parties (image: Peter J. de Lange).

Fourteen liverworts have now been recorded from Macauley (de Lange 2015a) which next to Raoul Island is the largest number for any of the islands (Table 1). Of the 14 liverworts recorded there, *Asterella australis*, and *Marchantia foliacea* are so far known in the Kermadec Islands only from Macauley Island (Table 2; de Lange 2015a). The most commonly encountered species is *Plagiochasma rupestre* var. *rupestre* which is abundant along the scoriaceous dacitic-tholeiitic basalt cliff faces, and overhangs on the seaward side of Mt Haszard. In these places it is sometimes found in association with *Frullania pentapleura* and *Siphonolejeunea nudipes* var. *nudipes*. *Lunularia cruciata* is locally common along the walls of Access Gully. This species was not reported from Macauley Island until May 2011, and as it was only seen in sites used to access the island by recent landing parties it is likely a recent introduction to the island, possibly even from Raoul Island (see above). Three species of *Marchantia* (*M. berteroana*, *M. foliacea* and *M. pileata*) have now been recorded from Macauley Island though none is common. Perhaps more surprising is the occurrence of the moisture-loving *Dumortiera hirsuta* a species first reported for the island in collections made by Sykes during visits to the island in 1966 and 1970 (see Campbell in Sykes 1977), and which is still found there in the Grand Canyon ravine.

Cheeseman Island

One liverwort, *Frullania pentapleura* was collected from Cheeseman Island (Table 2) where it was extremely uncommon (de Lange 2015b). Bryophytes had not been previously reported from Cheeseman Island which has only been occasionally visited on account of its difficult landing (de Lange 2015b). Despite the paucity of visits it does not seem likely that Cheeseman Island (Fig. 17) would ever have had a diverse liverwort flora; the island is too dry, poorly vegetated, and low in microhabitat diversity. Nevertheless, 11 species of moss were recorded from the island during the same landing (de Lange 2015b; de Lange & Beever 2015) and, in that context it is perhaps surprising that none of the more drought-resistant thalloid liverworts common on nearby Macauley Island (particularly *Marchantia pileata* and *Plagiochasma rupestre*) were found on Cheeseman Island (de Lange 2015b). As the vegetation of Cheeseman Island had also been severely damaged by the passage of Tropical Cyclone Bune some 45 days prior to the islands visit (de Lange 2012, 2015a,b,c), it is possible that liverworts may have been temporarily eliminated from the island, or reduced to such small numbers that they were overlooked.

Figure 17. Cheeseman Island as viewed from the north (image: Peter J. de Lange).

L'Esperance Rock

Rising to 70 m a.s.l L'Esperance Rock (Fig. 18) is the most isolated of the Kermadec Islands Group and the least vegetated (de Lange 2015c). Only ten vascular plants make up its flora, including *Senecio esperensis* which is endemic to that rock (Sykes 1971, 1977; de Lange et al. 2015). Despite being sparsely vegetated, and at the time of landing (May 2011) even more so because of cyclone damage (de Lange 2012), one liverwort, *Frullania pentapleura*, was found near the northern end of the main summit saddle of the rock (Table 1).

Figure 18. L'Esperance Rock as views from the north-west (image: Peter J. de Lange).

Biogeographic considerations

More than half the indigenous species of the Kermadec Islands belong to just three families, Lejeuneaceae, Lepidoziaceae and Lophocoleaceae, which are together represented by 71 species. The strong representation of Lejeuneaceae is consistent with floras of lowland forest habitats in tropical and subtropical climates globally, but the relatively high representation of Lepidoziaceae and Lophocoleaceae are anomalous, particularly the generic diversity represented on the Kermadec Islands within

Lepidoziaceae, with 13 genera present. The Kermadec Island flora is relatively depauperate in Frullaniaceae, a family usually co-dominant with Lejeuneaceae in terms of species diversity. These features of the Kermadec flora may be explained to some degree by the contributions surrounding land masses have made to the Kermadec Islands flora by long-distance dispersal. Indeed, the entire Kermadec Islands flora is derived by long-distance dispersal, as befits the relatively young age of the group which dates to the late Pleistocene (c. 0.5–1.5 mya, Brothers & Searle 1970; Lloyd & Nathan 1981). Notably there are no liverworts or hornworts endemic to the Kermadec Island Group.

The liverwort flora of the Kermadec Islands has strong links to New Zealand. Of the 122 taxa now recorded for the Kermadecs whose distribution has been documented, 105 also occur on the New Zealand mainland, and 42 are endemic to the New Zealand Botanical Region (Table 1), with occurrences on Raoul Island reflecting northern-most distributional outliers. These patterns strongly suggest that most of the Kermadec Island flora has been sourced from New Zealand to the south-west, which is reflected in the contribution made by the families Lepidoziaceae and Lophocoleaceae, both of which are diverse in lowland forest habitats of New Zealand, to the Kermadec Island flora (Table 1). Occurrences of some species on Raoul Island are unusual, particularly for those associated with cool hyperhumid forest environments whose distribution contracts upward in elevation with decreasing latitude, including *Dendromastigophora flagellifera, Echinolejeunea papillata, Lepidolaena palpebrifolia,* and *Lepidozia spinosissima*. In the northern part of their distributions on New Zealand these species are more or less confined to higher elevation sites associated with summits and elevated plateau. Most of the other New Zealand endemic species are widespread in lowland forest habitats, their occurrence on Kermadec Islands is supported by similar microhabitats and indeed similar assemblages of species. Why these species have dispersed as far as the Kermadec Islands but not further into the Pacific Region may warrant investigation and explanation once their absence from islands further to the north has been confirmed. The confinement of these species to the New Zealand Botanical Region does not seem to be for want of dispersibility, given they have traversed just over half the distance separating New Zealand from the Tonga group, and Fiji.

In contrast to the contribution of species from the south, there has been only limited contribution of species from the west or the north of the Kermadec Islands. Only 16 of the species on the Kermadec Islands occur either nowhere else in the New Zealand Botanical Region, or only on the Chatham Islands (Table 3). Another, *Heteroscyphus argutus*, also occurs on Mayor Island, off the Bay of Plenty coast, and the Chatham Islands but is not yet recorded from the North Island though its occurrence there should be anticipated. Because of its occurrence proximate to the North Island we have not included it in Table 3, below. A similar number of moss species occur on the Kermadec Islands, but not on the New Zealand mainland (de Lange & Beever 2015).

Table 3. Tropical liverworts of the Kermadec Islands. The two species marked with an asterisk also occur on the Chatham Islands.

Acrolejeunea pycnoclada (Taylor) Schiffn. subsp. *pycnoclada*
Ceratolejeunea belangeriana (Gottsche) Steph.
Cheilolejeunea ceylanica (Gottsche) R.M.Schust. & Kachroo
Cheilolejeunea trifaria (Reinw., Blume & Nees) Mizut.
Drepanolejeunea vesiculosa Herzog subsp. *vesiculosa*
Frullania apiculata (Reinw., Blume & Nees) Dumort.
**Lejeunea anisophylla* Mont.
Lejeunea exilis (Reinw., Blume & Nees) Grolle
Lepidolejeunea integristipula (Jack. & Steph.) R.M.Schust.
Notoscyphus lutescens (Lehm. & Lindenb.) Mitt.
Plagiochila alta Steph
Plagiochila pacifica Mitt.
Porella sp. nov.
**Radula javanica* Gottsche, Lindenb. & Nees
Spruceanthus planiuscula (Mitt.) X.Q.Shi, R.L.Zhu & Gradst.
Spruceanthus thozetianus (Gottsche & F.Muell.) B.M.Thiers & Gradst.

Of the 16 species in Table 3, the Lejeuneaceae dominate, followed by minor contributions from the Frullaniaceae, Plagiochilaceae and Radulaceae. Most of these families are generally widespread in the tropical regions of Australasia, Malesia, and the Pacific and beyond and could have dispersed from any northerly quarter. Two have dispersed from the west, and warrant comment. *Radula novae-hollandiae* is confined to Australia south of the tropic of Capricorn, except for occurrences on Norfolk Island and Raoul Island (Pócs & Renner 2021). This species has dispersed to Raoul Island either directly from the Australian mainland, or from Norfolk Island.

Spruceanthus thozetianus is another species that has dispersed from the west, it occurs up the east coast of Australia, in Papua New Guinea and on Norfolk Island, and like *Radula novae-hollandiae* may have dispersed to Raoul Island from either the Australian mainland or Norfolk Island. In this checklist *Spruceanthus thozetianus* replaces *Thysananthus spathulistiulus*, recorded for the Kermadec Islands by Renner & de Lange (2011), who struggled to identify the single male specimen correctly. Field experience on the east coast of Australia since 2011 has made the identity of the Kermadec specimen clearer, and we update our determination accordingly. *Spruceanthus thozetianus* is variable in size and morphology on the Australian mainland

(Thiers & Gradstein 1989), and the scattered stems fall within this range, however without perianths our determination is qualified by caution.

Linkage with the flora of Norfolk Island, suggested by the shared occurrence of these two species may become stronger and clearer once the flora of Norfolk Island is documented. As yet there is no comprehensive treatment of the liverwort and hornwort flora for Norfolk Island.

Linkage between the Kermadec Islands and north-eastern Australia are evident in the moss flora of Kermadec Islands (de Lange & Beever 2015), but are not so evident in the liverwort and hornwort flora, it is possible that some of the under-determined entities included in our checklist will prove to be poorly known species that are shared with tropical Queensland, which has a more distinctive and diverse liverwort flora than generally appreciated from herbaria in the northern hemisphere from where much of the documentary work was, until relatively recently, produced. There are 12 under-determined taxa in our checklist, including six *Frullania*, two *Cheilolejeunea* and one *Lejeunea*. *Frullania* of Australasia have been subject to more than two decades of ongoing revision (e.g., von Konrat & Braggins 2001, 2003), which follow the studies of Hattori (1979a, 1979b, 1983). *Cheilolejeunea* are poorly documented for Australia, and the real diversity on the Australian continent will prove higher than the 24 species currently known from Australia (Renner et al. 2024). *Lejeunea* is also poorly documented, especially in the Tropical Biome of Australia, where further investigation of species boundaries is warranted.

That the Kermadec liverwort flora has such a strong affinity with the rest of New Zealand, and yet has a minor but biogeographically interesting tropical Pacific component, may reflect the main avenues for propagule dispersal to the islands. During winter the Kermadec Islands experience strong south-westerly air flows, while during the summer the wind direction changes to the north-east (Bannister & Blanchon 2003; Blanchon et al. 2012). Further, the seemingly anomalous eastern Australian liverwort occurrences on the Kermadecs may reflect uplift of propagules by tropical cyclones which are generated in that part of Pacific, and whose tracking regularly crosses the Kermadec Islands Group (Revell 1981; Terry 2007). But it is unusual that the contribution made by tropical liverwort and hornwort species to the Kermadec Islands flora is not greater. On that element comparison with other small islands at similar latitude, particularly Norfolk Island and Lord Howe Island will be particularly interesting.

Although further bryological survey of the islands will no doubt reveal overlooked taxa, there is now a sufficiently robust base line to enable examination of a changing bryophyte flora in relation to ongoing vegetation recovery of the islands, long distance dispersal of propagules from New Zealand and the wider Pacific, and the impact of the extreme natural disturbance events which periodically occur.

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