Cheilolejeunea rodneyi Bever. & Glenny (Lejeuneaceae, Marchantiopsida), a new species from lowland indigenous forests in New Zealand.

Peter Beveridge¹, David Glenny² and Lara Shepherd¹

¹Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand
²Manaaki-Whenua, PO Box 69-040, Lincoln, New Zealand

Abstract

Cheilolejeunea rodneyi Bever. & Glenny, a new species of liverwort from lowland indigenous forest reserves in the Tararua Ecological District near Wellington in the North Island of New Zealand is described and illustrated. In both morphology and phylogeny, it is closest to the recently-described *C. morganii* Bever. & Glenny, with which it shares monoicy, pycnolejeuneoid innovation leaf sequences, a pentacarinate perianth with long rostrum and absence of large botryoidal oil-bodies, but differs in having a single or two-celled uniseriate second tooth, a large papilla oriented over the lobule exterior surface, a large cylindrical rostrum, the dorsal perianth carina comprising a low-profile ridge, oil-bodies with large, usually homogeneous segments, and the common presence of cladia. Its addition to the New Zealand flora brings the total species of *Cheilolejeunea* to 11, four of which are endemic.

Keywords: *Cheilolejeunea*, Lejeuneaceae, endemic, Marchantiopsida, liverwort, phylogeny, New Zealand, new species

Introduction

*Cheilolejeunea* (Spruce) Steph. is a pantropical genus of about 200 species (Söderström et al. 2016), including a number distributed in sub-tropical and temperate regions (Thiers 1997; Ye et al. 2015). The characters by which *Cheilolejeunea* is distinguished within the Lejeuneaceae include the elaboration of a second lobule tooth oriented away from the stem toward the leaf apex, and overtopping a reduced first tooth, enlarged stem cortical cells, a ventral merophyte two cells wide, the presence of bifid underleaves, cells with 1–5 large usually coarsely botryoidal oil-bodies, absence of vegetative reproductive organs, and (0)1–2 lejeuneoid or pycnolejeuneoid gynoecial innovations (Schuster 1980; Zhu and So 2001; Ye et al. 2015). Exceptions to each of these characters are known to occur. *Cheilolejeunea* is, after *Cololejeunea* (Spruce) Steph. and *Lejeunea* Lib., the third largest genus in Lejeuneaceae, the largest family of liverworts with over 1800 species in about 70 genera (Söderström et al. 2016; Zhu et al. 2017, 2018; Ye and Zhu 2018).

The most recently-published listing for the genus *Cheilolejeunea* in the New Zealand Botanical Region, sensu Allan (1961), (Beveridge et al. 2019) includes ten species: *C. albovirens* (Hook.f. & Taylor) E.A.Hodgs., *C. campbelliensis* (Steph.) R.M.Schust., *C. ceylanica* (Gottsche) R.M.Schust. & Kachroo, *C. hamlinii* Grolle,
C. intertexta (Lindemb.) Steph., C. krakakammae (Lindemb.) R.M.Schust., C. mimoso (Hook.f. & Taylor) R.M.Schust., C. morganii Bever. & Glenny, C. novaezelandiae R.M.Schust. and C. trifaria (Reinw., Blume & Nees) Mizut. As a consequence of recent research (Beveridge and Shepherd 2019), C. comitans has been reinstated as an Australasian endemic species from the synonymy of C. krakakammae (Zhu 2006).

The New Zealand hepatic flora is recognised for its high species diversity as a liverwort hot spot (von Konrat et al. 2008) and for its high degree of endemism at about 50% (Engel and Glenny 2008). Work on a variety of families over recent years has been informing the production of a four-volume New Zealand liverwort flora, three volumes of which have now been published (Engel and Glenny 2008, 2019a and 2019b). The production of the final volume in the next decade will place New Zealand in the select group of countries with a comprehensive liverwort floral treatment. However, most genera in the Lejeuneaceae including Cheilolejeunea have not been the subject of a comprehensive national or regional revision. Instead there has been an intermittent publication of new species and new records (Grolle 1973; Glenny 1996; Renner 2010; Renner 2013; Renner and Poci 2011; Renner and de Lange 2011; Braggins et al. 2014; Lewington et al. 2013; Beveridge et al. 2019) or inclusion as part of studies of other regions (e.g. Grolle 1982). Within the Lejeuneaceae, the genus Cheilolejeunea may be regarded as particularly neglected with 10 species, including only three endemics, the recent publication of C. morganii (Beveridge et al. 2019) being the first endemic addition since that of C. novaezelandiae (Schuster 1985). A more detailed analysis of the status of the Lejeuneaceae and the genus Cheilolejeunea in the New Zealand hepatic flora may be found in Beveridge et al. (2019). In this study we report a new endemic species of Cheilolejeunea for New Zealand. It was initially recognised as morphologically distinct by comparison with fresh and herbarium material of other New Zealand species. The addition of Cheilolejeunea rodneyi brings the total number of species of Cheilolejeunea in New Zealand to 11, four of which are regarded as endemic.

**Materials and Methods**

Specimens from three locations were available for this study. The type specimen of the new species (WELT H014288) was collected in the Horoeka Reserve, Stokes Valley, close to Wellington during a bioblitz diversity survey. Field collection had previously located similar material in two other Wellington reserves, at Graces Stream in the Remutaka Forest Park (WELT H014291) and Tane’s Track, Pakuratahi Regional Park (WELT H014289). Observations and measurements of gross structures were made using an Olympus TLE stereo microscope with ocular micrometer. Aqueous mounts were made for observation of oil-bodies, and for observation of other vegetative and gametangial structures and hand-cut stem sections, with methylene blue for contrast enhancement, where appropriate. Observations were made using an Olympus CH compound microscope with ocular micrometer. Microscope images were captured with a Canon A630 digital camera, edited using Mac Photos software and printed as tracing table masters. Scanning Electron Microscope (SEM) photographs were taken with a Hitachi TM3030Plus desktop SEM. Specimens were sputter coated with gold before examination. A subsequent collection from the same tree in the Horoeka Scenic Reserve provided material for description of sporophyte and spores, and for SEM images.

The molecular study of the phylogeny of Cheilolejeunea (Ye et al. 2015) has provided a phylogenetic framework for establishing relationships of the new species within Cheilolejeunea. Genomic DNA was isolated from three accessions of C. rodneyi, including the type specimen, and one accession each of the previously unsequenced species C. albovirens and C. campbelliensis using a modified-CTAB DNA extraction method (steps 1, 3–7 from Table 1 in Shepherd and McLay 2011). The two chloroplast loci and one nuclear locus used by Ye et al. (2015) were PCR amplified. The chloroplast transfer RNA Gly (UCC) (trnG) and the trnL (UUA) 5′ exon-trnF (GAA) intergenic spacer (trnLF) were amplified using the primers of Pacak and Szweykowska-Kulinska (2000) and Taberlet et al. (1991), respectively. The nuclear ribosomal internal transcribed spacer 1 and 2 with the intervening 5.8S ribosomal subunit (nrITS) was amplified using the primers of Hartmann et al. (2006).

PCR amplifications were performed in 12 μl reactions with 1× Mytaq buffer (Bioline, Australia), 5 pmol of each primer and 1 M betaine. PCR thermocycling conditions followed Shaw et al. (2005) for trnG and trnLF and Ye et al. (2015) for ITS. Purification of PCR products was performed by digestion with 0.5 U shrimp alkaline phosphatase (SAP, USB Corp.) and 2.5 U exonuclease I (ExoI, USB Corp.) at 37°C for 15 minutes, followed by enzyme inactivation at 80°C for 15 minutes. Sequencing was undertaken on an ABI 3730 DNA sequencer (Massey University Genome Service, Palmerston North, New Zealand) with the ABI Prism Big Dye Terminator cycle sequencing kit version 3.1.
The sequences were edited in Sequencer 5.2.3 (Gene Codes Corporation). The edited sequences were then aligned with selected sequences from Ye et al. (2015), Beveridge et al. (2019) and Beveridge and Shepherd (2019) using MAFFT 6.849 (Katoh and Toh, 2008), at the EMBL-EBI online server, with default settings. Regions of low homology at each locus were detected and removed using Gblocks (Talavera and Castresana 2007), with the least restrictive settings.

Phylogenetic analyses were conducted on both the individual and combined datasets using the PhyML v3.0 web server (http://www.atgc-montpellier.fr/phyml/; Guindon et al., 2010) with maximum likelihood (ML) and MrBayes v3.2.1 (Huelsenbeck and Ronquist 2001) for Bayesian analyses (BA). For the ML analyses, the best-fit model of sequence evolution for each dataset was determined using Smart Model Selection (Lefort et al. 2017). Heuristic searches were performed with 10 random addition sequence replicates and SPR branch-swapping, and branch support assessed with 1000 bootstrap pseudoreplicates. For the BA on each dataset two concurrent analyses were run, each with four Markov chains of five million generations and sampling every 1000 generations. For the combined dataset, each locus was assigned as a separate partition and rates allowed to vary across partitions. For each partition in the combined dataset and for the individual datasets the best-fit model of sequence evolution was determined using the Akaike information criterion (AIC) in jModelTest v2.1.7 (Darriba et al. 2012). The first 20% of samples were discarded as burn-in, after this point the standard deviation of split frequencies was below 0.01 and Tracer v.1.6 (Rambaut and Drummond 2009) also confirmed that stationarity had been reached.

Results

The three Cheilolejeunea rodneyi specimens shared identical DNA sequences across the three loci, which differed from other published sequences. The sequences detected in C. albivirens and C. campbelliensis differed from each other and also any other published sequences. All newly-generated sequences have been deposited in GenBank (Accession numbers MN308469-MN308478, MN316695-MN316699).

The final unambiguous alignment of the three loci was 2335 base pairs (bp) in length, of which 275 bp were parsimony informative. The phylogenies estimated by the different tree building methods and for the individual loci were very similar, differing only in nodes that received low support. The Bayesian phylogeny is shown in Figure 1, with both the ML and BA support values reported. The Cheilolejeunea rodneyi specimens were recovered as sister to C. morganii with strong support (100% BS ML, 1.00 PP). The newly-sequenced C. albivirens and C. campbelliensis were strongly supported as sister taxa (100% BS ML, 1.00 PP), and were in
turn sister to *C. morgani* and *C. rodneyi* (95% BS ML, 1.00 PP). *Cheilolejeunea turgida* and *C. roccatii* grouped with the above species with this clade, which corresponds to Section Paroicae of Ye et al. (2015), also receiving strong support (99% BS ML, 1.00 PP).

Fig. 1. Bayesian phylogram indicating the position of the new species within *Cheilolejeunea* based on comparison with the position of selected indicative species in the phylogeny of Ye et al. (2015), plus the newly sequenced *C. albovirens* and *C. campbelliensis*. Support values higher than 75% maximum likelihood bootstrap (ML BS) and 0.90 posterior probability in the Bayesian analysis (BA PP) are reported in the following order; ML BS / BA PP.

**Discussion**

Both the morphological comparison and molecular analyses demonstrate the distinctiveness of *Cheilolejeunea rodneyi*. The species is closest to the New Zealand endemic *C. morganii* but is not that species, see the recognition section below for details. It does not match any of the currently accepted New Zealand species and does not match species reported for Australia (Thiers 1997; Zhu and Lai 2005; Renner 2012), China, (Zhu et al. 2002) Japan (Mizutani 1982), and North America (Schuster 1980). The New Zealand hepatic flora is closest to that of Australia (Engel and Glenny 2008). About 50% of the c. 640 species are endemic and c. 280 (44%) species are shared with Australia. As all New Zealand non-endemic *Cheilolejeunea* species are found also in Australia (McCarthy 2003), and *C. rodneyi* does not match any of the species described for Australia by Thiers (1997) with additions by Zhu and Lai (2005) and Renner (2012), we propose it as a new species. However, we have not conducted an exhaustive examination of types and synonyms. Thus, the possibility remains that *C. rodneyi* has been previously described. However, in that case, a question of nomenclatural priority will be readily resolved for well circumscribed taxa. It follows that its current provisional status is that of a New Zealand Botanical Region endemic.
Cheilolejeunea rodneyi and the recently-described C. morganii are resolved in Section Paroicae of the Cheilolejeunea phylogeny. Cheilolejeunea albovirens and C. campbelliensis, whose DNA sequences are newly reported here, also group in this section. Further research into the genus Cheilolejeunea in New Zealand is planned to investigate species in the clade including C. mimosa to which most undescribed New Zealand species diversity appears to belong.

Taxonomic Treatment

Cheilolejeunea rodneyi Bever. & Glenny sp. nov.

Diagnosis: Cheilolejeunea rodneyi is most similar to C. morganii Bever. et Glenny with which it shares monoicy, pycnolejeuneoid innovation leaf sequences, obovate pentacarinate perianth and a long rostrum, oil-bodies mainly or frequently with uniseriate segments, and moderately bulging leaf lamina and lobule cells; but differs in having a one- or two-celled lobule second tooth, oil-bodies with few large homogeneous segments, a large lobule papilla oriented over the lobule external surface, usually distant underleaves, a perianth with low profile dorsal carina, and asexual reproduction by cladia.

Type: New Zealand, Tararua Ecological Region, Tararua Ecological District, Stokes Valley, Horoeka Scenic Reserve 41°10.30’S, 174°59.27’E, 12 Dec 2017, P. Beveridge QC-2 (Holotype: WELT H0142881)

Plants pale green, grey-green in herbarium, in procumbent, often parallel, overlapping growth over bark. Branching by Lejeunea-type intercalary branches. Leading shoots c. 0.75–1.0 mm wide by 4–9 mm long, intermingled with a range of suboptimal shoots down to c. 0.2–0.35 mm wide, of variable length, apparently derived from cladia. Stem pale brown, c. 60–70 µm diameter, in cross section (Fig. 2E) with 7 cortical cells, the cells more or less rectangular-elliptical, c. 10 µm wide × 20 µm long, the outer wall 3–7 µm thick, medullary cell rows c. 9–12, variably thick-walled. Stem cells in surface view quadrate to short rectangular, 15.0–22.5 µm wide, 17.5–25.0 µm long with walls c. 2.5 µm thick, c. 10 cells intervening between successive leaves. Rhizoids mostly absent or traces only, sporadically present in clusters of up to 30, arising from underleaf cells adjacent to underleaf bases, hyaline, thick walled, c. 7.5 µm wide × 150 µm long. Leaves (Fig. 2H) incubous, alternate, lobes convex dorsally; imbricate, patent, obliquely spreading, angled to stem axis at about 45°, the lobe apices usually deflexed and obscured in dorsal view. In dorsal view of leading shoots, imbricate leaf lobes completely covering the stem, the antical leaf margin usually extending c. 15–30 µm across stem width. Lobes in leading shoots ovate to elliptic, c. 0.3–0.4 mm wide × 0.5 mm long, usually rounded at the leaf apex, occasionally narrowing to an obtuse-angled point, margins entire or with weak crenulation, weakly to moderately angled at lobule apex. Vitta absent. Mid-lobe cells (Fig. 3) c. 12.5–20.0 µm wide × 17.5–27.5 µm long, walls 1.5–2.0 µm wide, trigones absent or small and concave, usually without intermediate thickening. Dorsal surface of lobe with weakly to moderately bulging cells. Marginal cells c. 12.5 µm wide × 12.5 µm long. Oil-bodies (Fig. 3) 2–4, colourless or grey, homogeneous, occupying 25–75% of cell lumen 3–5 µm wide × 7.5–20 µm long, usually deeply segmented, segments variable in length, 2.5–8 µm long, segmentation in linear sequences or occasionally in short double rows. Chloroplasts peripheral in cell, appearing spindle-shaped, c. 2.5 µm wide × 3 µm long. Lobules (Fig. 2 I, J) before flattening triangular, antical margin inrolled, and the lobule apex constricted with the second tooth normally obscured, but with inflated papilla often visible in profile. Lobule after flattening, ovate triangular, c. 0.08–0.12 mm wide, c. 0.14–0.18 mm long, c. 0.3× lobe length, the keel weakly arched, the free margin of c. 9 cells between stem and second tooth, the lobule apex oblique, the second tooth unicellular or two celled and uniseriate; in the type unicellular c. 20 µm long, 10 µm wide, otherwise two celled, c. 25.5 µm long, 12.5 µm wide, narrowing distally, the papilla when fully expressed c. 8–10 µm diameter, situated at the marginal depression between the second tooth and the slightly prominent rectangular first tooth and oriented over the lobule external surface. Cells of the lobule, including keel, usually weakly bulging. Underleaves (Figs 2A,B, 5) weakly to moderately patent, attached to two-celled ventral merophyte by 4–6-celled sub-transverse insertion, typically distant by about one underleaf length, contiguous only close to shoot apices or gynoecca, very occasionally imbricate, obovate to suborbicular, 0.18 mm wide × 0.18 mm long, sinus V-shaped, 0.05 mm deep. Lobe apices rounded, or pointed with a single apical cell. Lobe base c. 6–8 (–9) cells wide.

Asexual reproduction by cladia, present in all collections, abundant in the type. Cladia (Fig. 2 AD) short slender fragile branches with reduced leaves and underleaves, produced by Lejeuna-type branching from main stem or branches, by pycnolejeuneoid single or double innovations in the form of cladia, or by shoots narrowing to apical cladia.
Fig. 2. Cheirolejeunea rodneyi Bever. & Glenny sp. nov. (A) Ventral view of leading shoot with unfertilised gynoecium and innovations as cladia. (B) Ventral view of leading shoot with gynoecium and innovation narrowing to lost cladium. (C) Rostrum (D) Cladium (E) Stem section (F) Female bracts and bracteole (G) Androecium (H) Leaves (I) Two-celled second tooth and papilla with exterior orientation (J) Detail of lobule with single celled second lobule tooth and papilla. (K) Sporophyte valve apex, outer layer. (I) Drawn from WELT H014291 (K) Drawn from WELT H014328, the remainder drawn from the type, WELT H014288.
Monoicous. **Androecia** (Fig. 2G) typically short lateral branches from leading shoots and branches, usually proximal on shoots, ovate, c. 0.4 mm wide, 0.5–0.6 mm long, spicate, determinate, projecting beyond the adjacent leaves and visible dorsally, typically 1 male bracteole associated proximally with a sterile bract pair, occasionally with a second bracteole associated with the proximal pair of 2–4 pairs of fertile bracts, the proximal pair of bracts moderately larger than distal pairs, the bracts typically imbricate to contiguous with moderately exposed stems. Androecia diandrous, antheridia c. 12.5 µm diameter, stalk uniseriate, 10 µm diameter. **Gynoecia** (Figs 2F, 4, 5) mostly terminal on long branches with the ultimate subgynoecial underleaf larger than the shoot underleaves not obscuring the innovation first leaf. Female bracts free, bilobed, lobes c. 0.2–0.35 mm wide, 0.45–0.55 mm long, entire, falcate-spathulate, apices rounded, lobule explanate, narrow to moderately broad and lingulate, deflexed, c. 0.07 mm wide, 0.3 mm long. Bracteole free, convex, obovate, cuneate proximally, in distal sector gradually rounded to apex, c. 0.24 mm wide, c. 0.45 mm long, sinus narrow, V-shaped, 0.1 mm deep, with usually single-celled lobe apices. **Perianths** (Figs 2B, 5) terminal on leading or lateral shoots, obovate, rounded to apex, widest close to apex, pentacarinate, the lateral and ventral carinae sharply carinate, the dorsal carina a low profile ridge on a more or less plane dorsal surface. **Rostrum** (Fig. 2C) subcylindrical, often slightly arcuate, (60–) 75–100 µm long of 5–7 cell tiers, the cells sub-quadrate or rectangular with length up to 2× width, with more or less uniform cell thickening. Rostrum apparently fragile. Androecia and gynoecia not often in close proximity. Pycnolejeuneoid innovations, (Figs 2A, B, 5) 1–2 from fertilized and unfertilized gynoecia.

*Fig. 3.* Oil-body image from WELT HO14328, scale bar 25.5 µm.
Fig. 4. Ventral view SEM image of WELT HO14328, gynoecium and pycnolejeuneoid innovation.

Fig. 5. Ventral view SEM image of WELT HO14328 of shoot, gynoecium and innovation.
Spore (based on P. Beveridge QY-1 WELT H014328) shortly emergent from perianth, diameter c. 260 \(\mu m\), seta tiered, width 150 \(\mu m\), tiers 0.1 mm long, c. 0.6 mm between rostrum tip and capsule. Capsule dehiscent into four incompletely separated valves, valve sinus c. 0.70 \(x\) valve length. Valves and valve thickenings pale grey to medially golden. Outer layer (Fig. 2K) cells in the upper half of the valve quadrat at valve margin with marginal dome-shaped thickenings. Upper valve medial cells larger, obscurely hexagonal, 25 \(\mu m\) \(\times\) 25 \(\mu m\), with conspicuous thickenings, mainly irregular dome-shaped thickenings, occasionally becoming confluent and irregularly linear along cell boundaries. Below mid-valve a transition to a field of c. 40 rounded rhomboidal to subrectangular thin-walled cells, the cells c. 17.5 \(\mu m\) \(\times\) 30 \(\mu m\) long or smaller. Inner layer cells near apex and margins larger than outer layer cells, c. 25 \(\mu m\) \(\times\) 45 \(\mu m\) long, each with a small dome-shaped thickening, cells near valve midline becoming rectangular in 3–4 (~5) rows parallel to the mid-line, thin-walled with dome-shaped thickening along longitudinal walls, the thickening becoming continuous, sinuose and with a golden colour. Elaters c. 12.5 \(\mu m\) wide, 250 \(\mu m\) long, with a 2.5 \(\mu m\) wide mono-helical rudimentary thickening, one valve observed with an apical elater and two lateral elaters attached near valve margin, elater complement incomplete and precise pattern of attachment not established. Spores flattened, variable in shape, sub-rectangular 75 \(\mu m\) \(\times\) 50 \(\mu m\) wide with transverse to rounded ends, or shorter and ovate, papillose-granular with 2 or 3 rosettes.

**Additional specimens examined:** New Zealand: North Island: Upper Hutt, Pakuratahi Regional Park, Tunnel Gully, Tane’s Track 41°06’17"S, 174°09’30"E, 220 m, 11 Jun 2017, P. Beveridge PT-1 (WELT H014289); Wainuiomata, Remutaka Forest Park, Catchpool, Graces Stream, 41°20’6.2"S, 174°56’0.0"E, 60 m, 9 Apr 2017, P. Beveridge PR-1 (WELT H014291)

**Distribution and Ecology:** Cheilolejeunea rodneyi has been collected in the Tararua Ecological District, in three lowland forest reserves along the western foothills of the Remutaka Range, east of Wellington and the Hutt Valley. The most southern, Graces Stream in the Remutaka Forest Park, is approximately 20 km S of the type locality, Horoeka Scenic Reserve in Stokes Valley. Tane’s Track, Tunnel Gully in the Pakuratahi Regional Park is a further 15 km ENE of the Horoeka Scenic Reserve. At all the sites, C. rodneyi was present as an epiphyte on the trunk of Nothofagus truncata Colenso.

At the Horoeka SR, the mixed podocarp–broadleaf forest composed of Dacrycarpus dacrydioides (A.Rich.) de Laub., Nothofagus truncata Beilschmiedia tawa (A.Cunn.) Benth. & Hook.f. ex Kirk, Pseudopanax crassifolius (Sol. ex A.Cunn.) K.Koch, Pseudopanax arboreus (L.f.) K.Koch, Knightia excelsa R.Br., Olearia rani (A.Cunn.) Druce, Cyathea dealbata (G.Forst.) Sw., with Dicksonia squarrosa (G.Forst.) Sw., growing in a confined stream gully with closed canopy. Cheilolejeunea rodneyi was growing there as a luxuriant trunk epiphyte from tree base to at least two metres and apparently up to the lowest branches over a metre higher. This growth pattern is likely to be a response to relatively high humidity and asexual reproduction by cladia.

At Tane’s Track, Tunnel Gully, at an elevation of 220 m, a mixed podocarp-broadleaf forest of Dacrydium cupressinum Sol. ex G.Forst., Nothofagus truncata Beilschmiedia tawa, Knightia excelsa and Pseudopanax crassifolius is located on a steep slope with a western aspect and moderate to strong insolation. Cheilolejeunea rodneyi was found there on the lower trunk and base of N. truncata.

At Graces Stream, Remutaka Forest Park, at 60m elevation, the mixed broadleaf forest with dominant Nothofagus truncata and N. solandri Hook.f. has moderate to strong insolation with evidence of maturity and windfall. Cheilolejeunea rodneyi there was in scattered patches on the trunk of N. truncata with other bryophytes including Drepanolejeunea aucklandica Steph., Frullania aterrima (Hook.f. & Taylor) Gottsche, Linderb. & Nees, F. pentapleura Taylor, Radula sp. and Hypnum chrysogaster Müll.Hal.

**Recognition:** Although within the New Zealand Cheilolejeunea flora, there are a few species that can be identified with confidence on vegetative features alone, for most, gynoecial material is required with innovations, and ideally with perianths, to determine whether gynoecial innovations are lejeuneoid or pycnolejeuneoid and facilitate identification. Examination of the key below will show that the pycnolejeuneoid condition is shared by 7 species, C. albovirens, C.ceylanica, C. intertexta, C. campbelliensis, C. novaezealandiae, C. morganii, and with this paper, C. rodneyi. Some of these species are readily distinguished from C. rodneyi and C. morganii by their vegetative features. Cheilolejeunea albovirens and C. ceylanica differ by being small with narrow shoots, less than 500 \(\mu m\) wide and with long, rectangular lobules at least 0.5 lobe length. Cheilolejeunea campbelliensis and C. novaezealandiae are distinguished by their having papillose leaf cells. The remaining pycnolejeuneoid species was formerly known as Pycnolejeunea glauca and recognised in New Zealand at present as C. intertexta, is distinguished from C. morganii and C. rodneyi by its short rostrum and underleaves that are large, up to four times stem width, orbicular with a narrow sinus and with underlobe apices commonly crossing each other.

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Cheilolejeunea rodneyi is most similar to C. morganii but is able to be distinguished by a number of features. The perianths of C. rodneyi have a rounded apex and a low-profile dorsal carina ridge in contrast to the truncate or retuse perianth apex and sharply carinate dorsal carina in C. morganii. Underleaves are usually obovate to suborbicular and distant in C. rodneyi while typically obovate and contiguous in C. morganii. The distinctive oil-body features in C. rodneyi of linear sequences of mainly single large homogenous segments up to 4 µm wide x 20 µm long contrast with the spherical segments, 2.5 µm diameter, in C. morganii. The lobule features of C. rodneyi include a single or two-celled second tooth and a large papilla oriented over the lobule external surface. The papilla is erect on the lobule margin in C. morganii and the second tooth 4–5-celled. Cladia, sometimes conspicuous, are present only in C. rodneyi.

A summary of these and other features by which Cheilolejeunea rodneyi can be distinguished from C. morganii may be found in Table 2.

Table 2. Features for distinguishing between Cheilolejeunea rodneyi and C. morganii.

| Character                  | Cheilolejeunea rodneyi                          | C. morganii                                      |
|----------------------------|------------------------------------------------|--------------------------------------------------|
| Leaf lobe apices           | rounded                                        | rounded to obtuse-angled point                   |
| Oil-bodies                 | homogeneous, 2–4, 3–5 µm wide 7.5–20 µm long, segments 2.5–8 µm long in linear sequences | botryoidal, 2–3, 3–4 µm wide, 10–12.5 µm long, segments spherical, ca 2.5 µm in diam., moniliform or double rows |
| Underleaves (typically)    | distant x length of an underleaf               | contiguous                                       |
| Underleaf shape            | obovate to suborbicular                        | obovate                                          |
| Lobule second tooth        | 1–2 cells                                      | 4–5 cells                                        |
| Lobule papilla             | large marginal extending onto lobule external surface | small marginal erect                             |
| Rostrum shape              | cylindrical                                    | truncate-conical                                 |
| Rostrum cell tiers         | 5–7 (75–100 µm long)                           | 5–7 (ca 65 µm long)                              |
| Perianth dorsal carina      | low profile ridge                              | sharply carinate                                 |
| Cladia                     | commonly present                               | not seen                                         |

Conservation Status: Cheilolejeunea rodneyi is known at present from only three locations in the Wellington area and was not previously represented in the herbaria at CHR and WELT. The species was unknown at the last published threat classification (de Lange et al. 2014). Its classification in the meantime, according to the New Zealand Threat Classification System (Townsend et al. 2008) should be 'Data Deficient'.

Etymology: The name honours the late Rodney Lewington (1935–2018), a long-time member of the Wellington Botanical Society, supporter of the Otari-Wilton’s Bush Trust, and student of the New Zealand liverwort flora, generous in sharing his knowledge and enthusiasm, and a frequent companion in the field.

Key to species of Cheilolejeunea in New Zealand

The following key to the New Zealand species of Cheilolejeunea is modified from that for Australia in Thiers (1997), with additional modifications after Zhu and Lai (2005).

1. Leaves ovate; lobule rectangular, 2.0–3.5 times longer than wide, at least 0.5 lobe length; innovation leaf sequences pycnolejeuneoid ................................................................. 2
2. Leaves ovate, ovate-acute or orbicular; lobule ovoid, 1–2 times longer than wide, 0.25–0.5 lobe length; innovation leaf sequence lejeuneoid or pycnolejeuneoid ........................................... 3
3. Shoots less than 500 µm wide; stem cortex of less than 5 cells in cross-section; leaves erect, innovations usually absent ........................................................................................................ 3. C. albovirens
4. Shoots at least 500 µm wide; stem cortex of at least 7 cells in cross-section; leaves widely spreading; innovations usually present .................................................................................. C. ceylanica
3. Underleaf insertion straight or moderately arched, bases cuneate to rounded ........................................ 4
4. Underleaf insertion strongly arched (∩-shaped), bases cordate .............................................................. C. trifaria
5. Innovation leaf sequence lejeuneoid ........................................................................................................ 5
4. Innovation leaf sequence pycnolejeuneoid ................................................................................................. 7
5 Perianths sharply 5-keeled.........................................................................................................................6
5 Perianth keels completely lacking........................................................................................................... C. comitans
6 Leaf apex acute; lobule apex attenuate, lobule teeth subequal, composed of single cells, isodiametric .............................................................................................................................................. C. hamlinii
6 Leaf apex obtuse; lobule apex not attenuate, lobule teeth not equal in size and shape, second tooth pointed towards leaf apex........................................................................................................................................................................... C. mimosa
7 Rostrum (intact) >4 cell tiers tall .........................................................................................................................8
7 Rostrum (intact) <4 cell tiers tall .........................................................................................................................9
8 Second tooth composed of 1 or 2 cells, if 2 then uniseriate .............................................................................. C. rodneyi
8 Second tooth composed of 4–5 cells, uniseriate or not ................................................................................. C. morganii
9 Dorsal leaf cell surfaces smooth .......................................................................................................................C. intertexta
9 Dorsal leaf cells each bearing a single dome-shaped papilla...........................................................................10
10 Leaf apices rounded-acute to obtuse, underleaves remote, papillae on lobule carina, lobe margins, but not on underleaves, dioicous .......................................................................................................................... C. campbelliensis
10 Leaf apices acute, narrowly triangular, underleaves contiguous or slightly imbricate, papillae on dorsal lobe surface and margins and underleaf disc, autoicous............................... C. novaezelandiae

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