Bryophytes and lichens at the Warra LTER Site. I. An inventory of species in *Eucalyptus obliqua* wet sclerophyll forest

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Abstract

A total of 144 bryophytes and 134 lichens was recorded in a pre-logging survey of Eucalyptus obliqua*-dominated wet forest. Most of the species are typical wet forest plants that have been reported previously in Tasmania, but there is also a relatively high number of new and/or interesting records. Based on frequency of occurrence across nine plots, the flora is partitioned into 'core' species, occasional species and uncommon species. A noteworthy feature of the lichen flora is the large number of species represented only by very small, scattered individuals that are relatively uncommon in the study sites. It is among such species that the most interesting records have been found. In a plot by plot comparison, richness of bryophytes compares favourably with that found previously in other wet forest communities in Tasmania but diversity of the lichens is lower. The plots are rather variable in their bryophyte and lichen floras even though they represent the same vascular plant community; some practical implications of this are discussed.*

Introduction

A silvicultural systems trial (SST) established by Forestry Tasmania at the Warra Long-Term Ecological Research (LTER) Site is providing an opportunity to gather basic information on the biodiversity and ecology of *Eucalyptus obliqua* forests. The trial has been set up in wet forest '... to compare potentially feasible alternative systems with the routine clearfell, burn and sow system; to develop sustainability indicators at the coupe level; and to test silvicultural alternatives for areas where habitat, special species timbers or aesthetic values have particular importance' (Hickey *et al.* 1999a). Part of the work involves examining the impact of different logging and regeneration techniques on various biological components of the ecosystem, including mammals, birds, selected invertebrate groups, vascular plants and some non-vascular plant groups (Forestry Tasmania 1998). Sampling for flora and fauna commenced in 1997, and the first coupe was harvested in 1998.

The present paper marks the beginning of a detailed, long-term investigation into the cryptogams (bryophytes and lichens) of *E. obliqua* wet sclerophyll forest at the Warra LTER Site. The results include an inventory of species recorded during pre-logging surveys and a description of the general character of the cryptogamic flora. The data reveal an unanticipated level of floristic richness, underlining the importance of this forest type for plant conservation. Distribution patterns of lichens and bryophytes within the forest and other ecological data will be considered in subsequent papers, as will the impacts of the ongoing silvicultural treatments.

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Methods

Study area

The SST is located within the Warra LTER site about 20 km inland from Geeveston in southern Tasmania. The trial's location and a summary of environmental factors are given in Table 1, the aims and design rationale of the trial are discussed in Hickey *et al.* (2001), and a broad classification and overview of the vegetation are given by Neyland (2001).

Work on cryptogams was contained within five coupes in the SST (Table 2). Throughout the text the coupes will be referred to by the colloquial names shown in the table.

Table 1. Summary details for the silvicultural systems trial at the Warra LTER Site.

Location[1]:	43°04'S, 146°41'E, southern Tasmania
Area[1]:	200 ha
Elevation[1]:	80–240 m
Aspect[1]:	Southerly
Soils[2]:	Mostly derived from Jurassic dolerite
Drainage[2]:	More than half the soils are well or moderately well drained, about a third are imperfectly drained, just over a tenth are poorly drained.
Climate[3]:	Temperate maritime
Winds[3]:	Prevailing north-westerlies

Climate variables from the nearest weather station (Geeveston)[3]

Temperature –	February max.: 16.2°C July min.: 7.6°C
Rainfall –	July max.: 115 mm February min: 56.2 mm

Vegetation[4]

(a) *Eucalyptus obliqua* wet forest with a wet scleropyll understorey

(b) *Eucalyptus obliqua* mixed forest with a thamnic rainforest[5] understorey

(c) *Eucalyptus obliqua* mixed forest with a callidendrous rainforest[5] understorey

[1] Information from Hickey and Neyland (2000)
[2] Laffan (2001)
[3] Packham (1995)
[4] Neyland (2001)
[5] See footnote, p. 206

Sampling

Nine plots were sampled for cryptogams. Eight were 500 m^2 in area and either formed a rectangular block of 50 m x 10 m or a T-shape, with the 'leg' of the 'T' being 30 m x 10 m and the 'bar' being 20 m x 10 m. This latter shape was dictated by other aspects of the study and the need to maintain the same plot size for comparative purposes. One plot (B471) pre-dated the present survey, and was smaller, comprising a 20 m x 20 m (400 m^2) area.

Each of the cryptogam plots, including three in Forestry Tasmania's CFI (Continuous Forest Inventory) plots, coincided with plots established to sample vascular plants in the SST (see Neyland 2001; Table 2). Hence, the location of sampling sites was determined by the design of other SST studies and was not influenced by any aspect of the bryophyte and lichen floras. Eight of the cryptogam plots were subsequently subjected to some form of harvesting as part of the SST and one remained as a control (Table 2; see also Hickey *et al.* 2001).

Bryophyte and lichen inventories for each plot were compiled by thoroughly searching all accessible habitats, including trunks, twigs and leaves to about 2 m above the ground (the practicable, accessible height limit), and logs, rocks and soil. Fallen twigs and branches were examined to obtain floristic data from upper levels of the forest. This approach has been used routinely by us in other Tasmanian vegetation surveys (e.g. Jarman and Kantvilas 1994, 1995a, 1997), and is regarded as an efficient method for capturing species for the purpose of compiling inventories. The method has also been applied in forest studies in the Pacific North-West of North America (Goward and Arsenault 1997) and shown to be the best of those tested for studies on species richness, especially for recording the less common or rare species (McCune and Lesica 1992).

Species not found on the plots but encountered nearby in the same community

Table 2. Location of cryptogam plots within the SST. Plot locations are referrable to vascular plant plots (see Neyland 2001) surveyed for the trial. For treatment details see Hickey et al. *(2001). (Abbreviations: DR = dispersed retention, CBS = clearfell, burn and sow, UI = understorey island)*

Plot code	Coupe *Colloquial name*	Plot location	Plot altitude (m)	Coupe treatment	Plot treatment	Time sampled	Year logged	Year burnt
S	WR001B *Small*	CFI (eastern half)	c. 105	DR	DR	Nov – Dec 1997	1998	1998
T	WR008C *Top*	CFI (western half)	c. 190	DR	DR	Feb – May 1998	1999	2000
M	WR008B *Middle*	164 m on Horseshoe Tr.	c. 130	CBS / UI	CBS	July – Aug 1998	1998	2000
B106	WR008H *Big*	106 m on Bottom Tr.	c. 130	CBS / UI	UI	Feb–June 1999; Dec 1999	2000	2001
B372	WR008H *Big*	372 m on Bottom Tr.	c. 130	CBS / UI	CBS	Nov – Dec 1998	2000	2001
Bn418	WR008H *Big*	near 418 m on Bottom Tr.	c. 130	CBS / UI	UI	Apr – June 1999	2000	2001
B518	WR008H *Big*	518 m on Bottom Tr.	c. 130	CBS / UI	CBS	May – June 1999	2000	2001
C	WR008J *Control*	CFI (eastern half)	c. 100	nil	nil	May 1998 Dec 1999	_	_
B471	WR008H *Big*	471 m on Bottom Tr.	c. 130	CBS / UI	CBS	June 1997 Dec 1998	2000	2001

type were included in the main inventory for the community but were not included in plot analyses.

A more detailed discussion and overview of the methods adopted in the study are given by Kantvilas and Jarman (2001).

Identification

Samples of all species were collected for laboratory examination and identification. Mosses and liverworts were identified using light microscopy; lichens were identified using light microscopy, chemical tests and thin layer chromatography. Australian or overseas specialists who provided information on selected species include Dr K.Yamada (*Radula compacta*), Dr R. Grolle and Dr J. Engel (selected species of *Telaranea* and *Kurzia*), Dr T. Pfeiffer (*Hypopterygium didictyon*), Dr P. McCarthy (*Aspidothelium, Porina, Trichothelium*), Dr B.J. Coppins (*Micarea*) and Dr L. Tibell (*Chaenotheca, Chaenothecopsis*). Voucher material of all lichens is housed in the Tasmanian Herbarium. Vouchers of bryophytes are currently held at Forestry Tasmania but eventually will be lodged in the Tasmanian Herbarium.

Plant nomenclature

Species nomenclature for non-vascular plants generally follows that of Ratkowsky (1987) for liverworts, Dalton *et al.* (1991) for mosses and Kantvilas (1994) for lichens. However, alterations to the names of some species have occurred in accordance with

more recent publications. Classification at the family level is taken from the same sources for the bryophytes whilst that of the lichens mainly follows Hawksworth *et al.* (1995). Vascular plant nomenclature follows Buchanan (1999).

Vegetation

The cryptogam plots were located within vegetation classified as 'G'-type forest by Neyland (2001)(see also 'Tall *Melaleuca squarrosa* swamp' in Corbett and Balmer 2001).

The forest (Photo 1) is dominated by *Eucalyptus obliqua* which occurs as widely spaced oldgrowth trees, some with diameters over 250 cm (Alcorn *et al.* 2001; unpublished data), and as smaller diameter regrowth trees. Canopy height of *E. obliqua* in the trial area is typically from 40 to 65 m (Hickey and Neyland 2000). A layer of understorey trees, 10–20 m tall, occurs below the eucalypts, with the main species being *Nematolepis squamea*, Leptospermum lanigerum, Melaleuca squarrosa* and *Acacia verticillata.* These trees show local variation in their size, distribution and frequency within the plots. The largest are generally less than 20 cm dbh. *Pomaderris apetala, Leptospermum scoparium* and *Banksia marginata* also occur in the low tree layer at some sites.

The subdominant trees produce a shady understorey with scattered, brightly lit openings where canopy gaps occur. The medium to low understorey vegetation is dominated by a layer of the shrub *Bauera rubioides* and / or the sedge *Gahnia grandis,* generally about 1–3 m high (Photos 2, 3). However, some of the tallest clumps of *Bauera* reach much higher into the understorey, their wiry stems trapping fallen eucalypt bark, leaves and branches well above the forest floor. *Bauera* and *Gahnia* grow intermixed or in 'pure' patches, either way producing a very dense, almost impenetrable understorey when they are well developed. However, more typically, the layer is broken by fallen logs (Photo 3), or by small gaps that form a maze of narrow passages through the tangled undergrowth.

Apart from *Bauera,* shrubs are inconspicuous and widely scattered. These vary between the plots but include, for example, *Cyathodes glauca, C. juniperina, Monotoca glauca, Coprosma quadrifida, Pimelea drupacea, Hibbertia empetrifolia, Tasmannia lanceolata, Telopea truncata, Anopterus glandulosus* and *Cenarrhenes nitida.*

Large ground ferns are poorly represented. The main species is *Blechnum wattsii,* present as occasional clumps, and there may be scattered fronds of others such as *Histiopteris incisa, Sticherus tener* or *Gleichenia microphylla.* Small filmy ferns are mostly sparse and inconspicuous but in a few plots they form luxuriant patches on logs, rocks and buttresses intermixed with bryophytes. Several species can be present, including *Hymenophyllum peltatum, H. cupressiforme, H. rarum, H. marginatum* and *H. flabellatum.* Where these species are abundant, numerous fern gametophytes, presumed to belong to these species, can be found amongst the bryophytes. The finger fern *Grammitis billardierei* is also present but not common.

In forest gaps, a thick blanket of eucalypt litter formed of leaves, bark and branches covers the soil surface. Rocks, logs and mounds of inorganic soil raised above the litter provide suitable substrates for cryptogams, providing they are not densely shaded by *Bauera* or *Gahnia.*

Although the understorey of these wet forests is over 60 years old (Hickey *et al.* 1999b), rainforest species (as defined by Jarman and Brown 1983) are rare. Small plants (up to a few metres tall) of rainforest trees such as *Phyllocladus aspleniifolius, Atherosperma moschatum* and *Eucryphia lucida* are present in some plots but are very localised (mainly on logs). Rainforest understorey shrubs (e.g. *Cenarrhenes nitida, Anopterus glandulosus, Tasmannia lanceolata* and *Telopea truncata*) are also very uncommon.

* Formerly *Phebalium squameum* (see Wilson 1998).

Photo 1. A vertical section through the Eucalyptus obliqua *wet sclerophyll forest in the study area. A dense layer of low trees occurs beneath the open eucalypt canopy, and low in the forest there is a layer of* Gahnia *and* Bauera.

Photo 2 (below, left). The forest understorey. A large, oldgrowth eucalypt surrounded by Nematolepis *and* Melaleuca, *with* Gahnia *in the foreground.*

Photo 3 (below, right). An old rotting eucalypt log thickly covered by mosses in a gap within the Gahnia *layer.*

Results

A total of 144 bryophytes (95 liverworts, 49 mosses) and 134 lichens was recorded in the *Eucalyptus obliqua* community. The figures comprise 137 bryophyte species and 132 lichen species from the plots and an additional seven bryophyte and two lichen species from adjacent forest of the same community type. Further taxonomic study of specimens already collected, or additional sampling, is likely to increase species numbers. Some habitats, for example large rocks, exposed inorganic soil on windthrown trees, and wet habitats (small streams, boggy areas), were undersampled and almost certainly support additional species.

The flora is characterised by an abundance of very small, often inconspicuous species, especially among the lichens which are mostly crustose species. The liverworts are represented mainly by leafy species, with only 13 thallose species being recorded.

The number of species per plot ranged from 60 to 90 for bryophytes and from 37 to 64 for lichens. These figures exclude plot B471 from an earlier survey because of its smaller size.

Floristic composition

Floristic composition is summarised in Table 3 (bryophytes) and Table 4 (lichens), with annotated species lists provided in Appendices 1 and 2. The diversity of the liverwort family Lepidoziaceae, with 25 species, is particularly high compared to other families among the bryophytes. It is also high in comparison with other wet forests sampled previously by the authors. For example, the number of Lepidoziaceae species from callidendrous, thamnic and implicate rainforest in Tasmania's west coast forests (five plots in each) was nine, 18 and 17 respectively (Jarman and Kantvilas 1995a).

In the lichens, the richest families are the Micareaceae, with 13 species in the single genus *Micarea*, and the Cladoniaceae, with nine species. This is generally consistent with the relative occurrence of these large lichen families in most wet forest vegetation in Tasmania.

Character of the flora

The most common or widespread mosses are *Dicranoloma billardierei, Distichophyllum pulchellum, Ptychomnion aciculare, Sematophyllum* aggr.* and *Wijkia extenuata*. These are widespread in Tasmanian wet forests in general. The eucalypt colonisers *Rhizogonium novae-hollandiae, Orthodontium lineare* and *O. pallens* are more patchy in occurrence but can be locally common.

The most common liverworts are from the Lepidoziaceae and Riccardiaceae, and include *Kurzia hippurioides, Lepidozia ulothrix, Telaranea patentissima, Zoopsis lietgebiana, Z. argentea, Bazzania involuta, Riccardia aequicellularis, R. cochleata, R. crassa* and *R. lobulata. Heteroscyphus fissistipus* aggr. and the predominantly epiphytic species, *Frullania aterrima, F. rostrata* and *Radula compacta,* are also common.

Lichens characteristic of the forest are the crustose species *Micarea prasina* aggr., the various species of *Thelotrema, Coccotrema* cf. *cucurbitula* and undescribed species of *Arthothelium* and *Mycoblastus.* Typical and common macrolichens include *Cladia aggregata, C. schizopora, Cladonia rigida, Neophyllis melacarpa, Placynthiella icmalea* and *Wawea fruticulosa.*

Tables 5 and 6 indicate the extent to which individual species typify the vegetation. The flora has been partitioned into three groups representing 'core' species (occurring in six or more plots); occasional species (recorded from three to five plots); and uncommon species (occurring in only one or two plots). We consider the first two groups (i.e. frequency ž 33%) as the typical or characteristic flora of the community. The results are summarised

* Includes several species from the Sematophyllaceae, see footnote 6, Appendix 1.

Table 3. A summary of the bryophyte flora in the Eucalyptus obliqua *wet sclerophyll community.*

Family	Genus (no. of species)
Mosses	
Aulacomniaceae	*Leptotheca* (1)
Bryaceae	*Bryum* (1), *Leptostomum* (1), *Orthodontium* (2)
Dicranaceae	*Campylopus* (1), *Dicranoloma* (5), *Dicranum* (1), *Holomitrium* (1)
Fissidentaceae	*Fissidens* (2)
Grimmiaceae	*Grimmia* (1), *Racomitrium* (1)
Hookeriaceae	*Achrophyllum* (1), *Daltonia* (1), *Distichophyllum* (2)
Hypnaceae	*Hypnum* (2), *Isopterygium* (1)
Hypnodendraceae	*Hypnodendron* (1)
Hypopterygiaceae	*Cyathophorum* (1), *Hypopterygium* (1), *Lopidium* (1)
Leucobryaceae	*Leucobryum* (1)
Meteoriaceae	*Weymouthia* (1)
Mitteniaceae	*Mittenia* (1)
Orthotrichaceae	*Macromitrium* (1), *Zygodon* (2)
Polytrichaceae	*Polytrichum* (1)
Pottiaceae	*Calyptopogon* (1)
Ptychomniaceae	*Glyphothecium* (1), *Hampeella* (1), *Ptychomnion* (1)
Racopilaceae	*Racopilum* (1)
Rhizogoniaceae	*Rhizogonium* (2)
Sematophyllaceae	*Rhaphidorrhynchium* (1), *Warburgiella* (2), *Wijkia* (1)
Splachnaceae	*Tayloria* (2)
Thuidiaceae	*Thuidium* (1)
Liverworts (thallose species)	
Aneuraceae	*Riccardia* (7)
Hymenophytaceae	*Hymenophyton* (1)
Metzgeriaceae	*Metzgeria* (2)
Pallaviciniaceae	*Podomitrium* (1), *Symphyogyna* (1)
Treubiaceae	*Treubia* (1)
Liverworts (leafy species)	
Acrobolbaceae	*Acrobolbus* (1), *Marsupidium* (1), *Tylimanthus* (3)
Adelanthaceae	*Adelanthus*(1)
Balantiopsaceae	*Balantiopsis*(1)
Cephaloziellaceae	?*Cephaloziella* sp. (2)
Chaetophillopsidaceae	*Chaetophyllopsis* (1)
Frullaniaceae	*Frullania* (5)
Geocalycaceae	*Chiloscyphus* (5), *Geocalyx* (1), *Heteroscyphus* (7), *?Leptophyllopsis* (1), *Saccogynidium* (1)
Jungermanniaceae	*Cuspidatula* (1), *Jamesoniella* (2)
Lejeuneaceae	*Cheilolejeunea* (4), *Colura* (1), *Drepanolejeunea* (1), *Harpalejeunea* (1), *Lejeunea* (1)
Lepicoleaceae	*Lepicolea* (1)
Lepidolaenaceae	*Gackstroemia* (1), *Lepidolaena* (1)
Lepidoziaceae	*Acromastigum* (3), *Bazzania* (3), *Kurzia* (4), *Lepidozia* (6), *Telaranea* (6), *Zoopsis* (3)
Plagiochilaceae	*Acrochila* (1), *Plagiochila* (3)
Pseudolepicoleaceae	*?Temnoma* (1)
Radulaceae	*Radula* (6)
Schistochilaceae	*Schistochila* (1)
Unknown	Unknown sp. 1

Table 4. A summary of the lichen flora in the Eucalyptus obliqua *wet sclerophyll community.*

Family	Genus (no. of species)
Agyriaceae	*Placopsis* (1), *Placynthiella* (1), *Trapeliopsis* (1)
Aphanopsidaceae	*Steinia* (1)
Arctomiaceae	*Wawea* (1)
Arthoniaceae	*Arthonia* (6), *Arthothelium* (1)
Arthopyreniaceae	*Arthopyrenia* (1+)
Aspidotheliaceae	*Aspidothelium* (1)
Bacidiaceae	*Jarmania* (1)
Baeomycetaceae	*Baeomyces* (1)
Biatoraceae	*Cliostomum* (1)
Cladoniaceae	*Cladia* (2), *Cladonia* (6), *Neophyllis* (1)
Clavariaceae	*?Multiclavula* (1)
Coccotremataceae	*Coccotrema* (3)
Collemataceae	*Leptogium* (1), *?Ramalodium* (1)
Coniocybaceae	*Chaenotheca* (1)
Graphidaceae	*Graphis* (1), *Phaeographis* (1)
Gyalectaceae	*Dimerella* (2)
Hypogymniaceae	*Hypogymnia* (3), *Menegazzia* (3)
Hysteriaceae	*Glonium* (1)
Icmadophilaceae	*?Icmadophila* (1)
Lecanactidaceae	*Bactrospora* (1), *Sagenidium* (1)
Lecanoraceae	*Lecanora* (1), *Pyrrhospora* (1), *Ramboldia* (1), *Tephromela* (1)
Lecideaceae s. lat.	*Catillaria* (1), *Hypocenomyce* (2), *Lecidea* s.lat. (4), *Mycoblastus* (2)
Lobariaceae	*Pseudocyphellaria* (2)
Megalariaceae	*Megalaria* (2)
Megalosporaceae	*Austroblastenia* (1), *Megalospora* (1)
Melaspileaceae	*Melaspilea* (2)
Micareaceae	*Micarea* (13)
Microcaliciaceae	*Microcalicium* (1)
Monoblastiaceae	*Anisomeridium* (1)
Mycocaliciaceae	*Chaenothecopsis* (6)
Opegraphaceae	*Opegrapha* (1)
Pannariaceae	*Parmeliella* (1), *Psoroma* (1)
Parmeliaceae	*Hypotrachyna* (1), *Parmelia* (1), *Parmelina* (1)
Peltigeraceae	*Peltigera* (1)
Pertusariaceae	*Ochrolechia* (1), *Pertusaria* (3)
Phlyctidaceae	*Phlyctis* (1)
Pilocarpaceae	*Bapalmuia* (1)
Pleomassariaceae	*Eopyrenula* (1)
Porpidiaceae	*Mycobilimbia* (1)
Pyrenulaceae	*Pyrenula* (2)
Sarrameanaceae	*Loxospora* (1), *Sarrameana* (1)
Solorinellaceae	*Gyalidea* (1)
Sphaerophoraceae	*Bunodophoron* (2), *Leifidium* (1)
Strigulaceae	*Strigula* (2)
Thelotremataceae	*Thelotrema* (4), *Topeliopsis* (1), unknown (1)
Tricholomataceae	*Marasmiellus* (1)
Trichotheliaceae	*Porina* (4), *Trichothelium* (2)
Usneaceae	*Usnea* (1)
incertae sedis	*Dactylospora* (1), *?Lepraria* (1), *?Leprocaulon* (1), unknown taxa (3)

Table 5. Characterisation of the bryophytes in terms of the core flora (6–9/9 plots), occasional species (3–5/9 plots) and uncommon species (1–2/9 plots).

Core flora

Mosses (20+ spp.): *Achrophyllum dentatum, Bryum ?billardierei, Dicranoloma billardierei, D. dicarpum, D. menziesii, D. robustum, D. setosum, Distichophyllum pulchellum, Fissidens tenellus, Hypnodendron comosum, Hypnum chrysogaster, Hypopterygium didictyon, Isopterygium limatum, Macromitrium archeri, Orthodontium lineare, O. pallens, Ptychomnion aciculare, Rhizogonium novae-hollandiae, Sematophyllum* aggr.*, *Wijkia extenuata*

Thallose liverworts (9 spp.): *Metzgeria saccata, Metzgeria* sp., *Podomitrium phyllanthus, Riccardia aequicellularis, R. cochleata, R. crassa, R. ?longiflora, R. lobulata, Symphyogyna podophylla*

Leafy liverworts (32 spp.): *Acromastigum colensoanum, Balantiopsis diplophylla, Bazzania involuta, Cheilolejeunea campbelliensis, Chiloscyphus gippslandicus, Colura saccophylla, Drepanolejeunea aucklandica, Frullania aterrima, F. rostrata, F. ?scandens, Gackstroemia weindorferi, Harpalejeunea latitans, Heteroscyphus fissistipus* aggr., *H. knightii, Kurzia hippurioides, K. fragilifolia, K. sexfida, Lejeunea drummondii, Lepidozia procera, L. ulothrix, Lepidozia* sp. C, *Radula buccinifera, R. compacta, R. ratkowskiana, Telaranea centipes, T. herzogii, T. mooreana, T. patentissima, T. tasmanica, Zoopsis argentea, Z. leitgebiana, Z. setulosa*

Occasional species

Mosses (8 spp.): *Cyathophorum bulbosum, Daltonia splachnoides, Glyphothecium sciuroides, Hypnum cupressiforme, Leucobryum candidum, Mittenia plumula, Rhizogonium pennatum, Zygodon intermedius*

Thallose liverworts (1 sp.): *Riccardia* sp.

Leafy liverworts (18 spp.): *Acrobolbus concinnus, Acromastigum mooreanum, Adelanthus falcatus, ?Cephaloziella* sp. A, *?Cephaloziella* sp. B, *Chaetophyllopsis whiteleggei, Cheilolejeunea mimosa, Chiloscyphus echinellus, C. muricatus, C. semiteres, Chiloscyphus* sp. , *Cuspidatula monodon, Heteroscyphus coalitus, Kurzia tenax, Lepidozia* sp. W, *Radula tasmanica, Schistochila lehmanniana, Tylimanthus tenellus*

Uncommon species

Mosses (16 spp.): *Calyptopogon mnioides, Campylopus* sp., *Dicranum trichopodum, Distichophyllum rotundifolium, Fissidens pallidus, Hampeella alaris, Holomitrium perichaetiale, Leptostomum inclinans, Leptotheca gaudichaudii, Lopidium concinnum, Racopilum cuspidigerum, Tayloria gunnii, T. octoblepharum, Thuidium sparsum, Weymouthia cochlearifolia, Zygodon hookeri*

Thallose liverworts (3 spp.): *Hymenophyton flabellatum, Riccardia wattsiana, Treubia tasmanica*

Leafy liverworts (28 spp.): *Acrochila biserialis, Acromastigum anisostomum, Bazzania monilinervis, B. ?novae-zelandiae, Cheilolejeunea albovirens, C. comitans, Frullania falciloba , F. probosciphora, Geocalyx caledonicus, Heteroscyphus conjugatus, H. decipiens, H. limosus, Jamesoniella tasmanica, Lepicolea scolopendra, Lepidolaena brachyclada, Lepidozia* sp. L, *?Leptophyllopsis laxa, Marsupidium surculosum, Plagiochila ?baileyana, P. ?fasciculata, P. retrospectans, Radula multiamentula, Radula* sp., *Saccogynidium decurvum, Telaranea grossiseta, ?Temnoma* sp., *Tylimanthus diversifolius,* Unknown sp. 1

* See footnote 6, Appendix 1.

in Figure 1. The composition of the flora is greatly influenced by substrate availability (Jarman and Kantvilas 2001), and the low frequencies for several species probably reflect the absence of their preferred substrate rather than a generally unsuitable macroclimate. Abundance has not been considered in delineating the groups.

Conservation and reservation status

New and/or interesting bryophyte records

Most of the bryophytes recorded from the plots are common species that are widespread in Tasmanian wet forests; most are also well represented in secure reserves. However, a

Table 6. Characterisation of the lichens in terms of the core flora (6–9/9 plots), occasional species (3–5/9 plots) and uncommon species (1–2/9 plots).

Core flora

33 spp.: *Arthonia* sp. A, *Arthothelium* sp., *Cladia aggregata, C. schizopora, Cladonia ramulosa, C. rigida* var. *rigida, C. subsubulata, Coccotrema* cf. *cucurbitula, Dactylospora* sp., *Dimerella* cf. *pineti, Hypogymnia tasmanica, ?Icmadophila* sp., *Lecidea* cf. *botryosa, Megalaria pulverea, Melaspilea* sp. A, *Micarea alabastrites, M. prasina* aggr. (form A), *M. prasina* aggr. (form B), *M. prasina* aggr. (form D), *Mycoblastus* sp.1, *Mycoblastus* sp.2, *Neophyllis melacarpa, Phlyctis* sp., *Placynthiella icmalea, Thelotrema decorticans, T. lepadinum, T. subdenticulatum, T. suecicum, Thelotremataceae* sp.A, *Trapeliopsis granulosa, Usnea* sp., Species A, Species C

Occasional species

26 spp.: *Arthonia tasmanica, Arthopyrenia* spp., *Bactrospora* sp., *Bapalmuia buchananii, Bunodophoron insigne, Chaenotheca hygrophila, Cladonia* cf. *murrayi, C. weymouthii, Gyalidea hyalinescens, Lecidea* sp. B, *Leifidium tenerum, Leptogium victorianum, Loxospora solenospora, Melaspilea* sp. B, *Menegazzia confusa, Micarea cinerea, M. prasina* aggr. (form C), *Opegrapha stellata, Parmeliella nigrocincta, Pertusaria jamesii, P. novaezelandiae, Placopsis* sp., *Ramboldia brunneocarpa, Sarrameana albidoplumbea, Strigula albicascens, Wawea fruticulosa*

Uncommon species

73 spp.: *Anisomeridium* aff. *biforme, Arthonia apteropteridis, Arthonia ilicina, A. subramulosa, Arthonia* sp. B, *Aspidothelium cinerascens, Austroblastenia pauciseptata, Bunodophoron australe, Catillaria* sp.1, *Chaenothecopsis* cf. *nana, C. nigropedata, C. pusilla, C. savonica, C. tasmanica, Chaenothecopsis* sp., *Cladonia ustulata, Cliostomum griffithii, Coccotrema* sp. A, *Coccotrema* sp. B, *Dimerella* cf. *lutescens, Eopyrenula* sp., *Glonium* cf. *stellatum, Graphis* sp., *Hypocenomyce foveata, H. scalaris, Hypogymnia lugubris, H. mundata, Hypotrachyna sinuosa, Jarmania tristis, Lecanora* sp., *Lecidea* cf. *pruinosa, Lecidea* sp. A, *?Leprocaulon* sp., *Marasmiellus affixus, Megalaria* sp., *Megalospora lopadioides, Menegazzia norstictica, M. subpertusa, Micarea* cf. *adnata , M. mutabilis, M.* cf. *mutabilis, M. prasina* aggr. (form E), *M. sylvicola, M. tubaeiformis, Micarea* sp., *Microcalicium disseminatum, ?Multiclavula mucida, Mycobilimbia* sp., *Ochrolechia* sp., *Parmelia protosulcata, Parmelina pseudorelicina, Peltigera dolichorhiza, Pertusaria gibberosa, Phaeographis exaltata, Porina hyperleptalea, P. impolita, P. leptalea, P. subapplanata, Pseudocyphellaria brattii, P. glabra, Psoroma microphyllizans, Pyrenula galactina, Pyrenula* sp., *Pyrrhospora laeta, ?Ramalodium* sp., *Sagenidium molle, Steinia geophana, Strigula indutula, Tephromela atra, Topeliopsis muscicola, Trichothelium assurgens, T. meridionale,* Species B

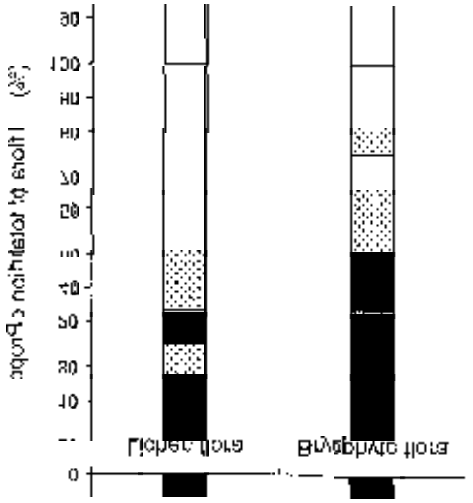

Figure 1. Proportional representation of the core species (6–9/9 plots: ■), occasional species (3–5/9 plots: ▩) and uncommon species (1–2/9 plots: □). Core species and occasional species together are considered as the typical flora of the community.

small group of species are considered rare on the basis of present knowledge.

- ***Cheilolejeunea comitans*:** First recorded for Tasmania (from the north-west) by Grolle (1982); no records at the Tasmanian Herbarium, and not known in any reserve. This liverwort is very similar vegetatively to the apparently widespread *C. mimosa* (which occurs with it at Warra), so it may have been overlooked or misidentified in the past. It is epiphytic on both smooth-barked and papery-barked trunks.
- ***Cheilolejeunea albovirens*:** A mainly alpine liverwort; listed by Moscal and Kirkpatrick (1997) for the Hartz Mountain National Park and the South West National Park; five specimens only at the Tasmanian Herbarium. It is unlikely to be found commonly in wet forest which does not appear to be its optimal habitat.
- ***Colura saccophylla*:** No specimens in the Tasmanian Herbarium; shown in two grid cells by Moscal and Kirkpatrick (1997). Additional records are from the Teepookana area (Jarman and Kantvilas 1995b) and from the Anthony Road on the west coast (Jarman and Kantvilas 1995a). This epiphytic species is one of the smallest liverworts in the forest and collections are likely to be fortuitous unless the species is particularly abundant. It is not known to be reserved.
- ***Orthodontium pallens*:** One specimen in the Tasmanian Herbarium collected from Gordon in 1911; shown in one east coast grid cell by Moscal and Kirkpatrick (1997); one record from Recherche Bay in the revision of *Orthodontium* by Meijer (1952). This moss is very similar in general appearance to the more widespread *O. lineare*, and separation of the the two species in the absence of sporophytes is difficult. It is not known to be reserved. In the study site, it has been found only on the buttresses of oldgrowth eucalypts.
- ***Riccardia* sp.:** This forest floor liverwort could not be ascribed to any published Tasmanian species. It is presently known only from the Warra SST.
- ***Kurzia fragilifolia*:** This tiny liverwort is found most commonly on the rotting leaf bases of decrepit *Gahnia* plants and is presently known only from the Warra SST. It is a new record for Tasmania (Dr J. Engel, pers. comm. 2001), and was previously considered a New Zealand endemic (Schuster 1980, 2000).
- ***?Temnoma* sp.:** This is a small distinctive liverwort, found only once and in a very small quantity. It appears to be a species of *Temnoma* (or a close relative) but does not fit any of those described for Tasmania.
- ***Telaranea tasmanica*:** This is an inconspicuous forest floor liverwort that is widespread in the study area. It was identified by Dr J. Engel (pers. comm. 2001). The species is poorly known in Tasmania and there is little information available on its distribution and ecology.

New and/or interesting lichen records

Crustose lichens are not as well known taxonomically in Tasmania as either the macrolichens or the bryophytes, and distribution data are correspondingly poor. Several species were collected during the study, which represent particularly interesting records. Some are possibly widespread in other eucalypt forests and their discovery may be due solely to the intensity and focus of this study. Others appear to represent genuinely rare and fascinating discoveries. In almost all cases, much more work (taxonomic, ecological and distributional) is needed before a more precise assessment of their conservation and reservation status can be made.

- ***Aspidothelium cinerascens*:** Previously known from tropical South America and the South Island of New Zealand (Malcolm and Vezda 1995), this species was found on living leaves of *Atherosperma moschatum*. It has also been recorded from *Nothofagus cunninghamii* twigs at Cradle Mountain National Park, and appears to be genuinely rare in Tasmania.

- ***Bactrospora* sp.:** In their world monograph of this genus, Egea and Torrente (1993) record only one species for Tasmania, the endemic *B. arthonioides* Egea & Torrente. A related, undescribed species has been discovered in the study area, growing on *Nematolepis squamea* and other small trees with smooth bark. This taxon has also been recorded from rainforest along the Anthony Road.
- ***Chaenotheca hygrophila*:** A new record for Tasmania. This species was previously subsumed within a broad concept of *C. brunneola* (Ach.) Müll. Arg. (L. Tibell, pers. comm.). It is likely to be more widespread in Tasmanian forests than is presently known.
- ***Chaenothecopsis nigropedata*:** A new record for Tasmania. Previously considered endemic to New Zealand (Tibell 1987).
- ***Glonium* cf. *stellatum*:** In Tasmania, the most common species of this genus is *Glonium circumserpens* (Kantvilas and Coppins 1997). A second species has now been found on rocks, bark or soil in the study area and at nearby Arve Loop. Further study is required to ascertain whether it is conspecific with the North American species *G. stellatum* Muhl. ex Fr.
- ***Gyalidea hyalinescens*:** This cosmopolitan species appears to be very uncommon in Tasmania and, prior to this study, was known only from two sites in western Tasmania (both pre-1970 records). It was recorded in the study area on soil and the bases of rotting *Gahnia* leaves.
- ***?Icmadophila* sp.:** An undescribed species confined to the moist buttresses and lower trunks of oldgrowth eucalypts.
- ***Lecidea* cf. *botryosa*:** This taxon is an undescribed species, related to the circumboreal species, *L. botryosa* (Fr.) Th. Fr. It is common on the buttresses of oldgrowth eucalypts in the study area and is probably widespread but overlooked elsewhere.
- ***Melaspilea* sp. 1:** Previously known from a few very small collections from rainforest along the Anthony Road (west coast), this undescribed species has proved to be quite common in the study area.
- ***Micarea sylvicola*:** A new record for Tasmania and the Southern Hemisphere. This inconspicuous species was collected on dry, consolidated soil.
- ***Placynthiella icmalea*:** This represents the first Tasmanian record of this widespread, temperate Northern Hemisphere species. It is common at the study site on oldgrowth eucalypts, on stumps, charred organic soil and wood in burnt coupes, and has since been found to be rather widespread and common in Tasmania.
- ***Porina impolita*:** This species was initially recorded from Tasmania in error (Malcolm *et al.* 1995). All Tasmanian collections referred to by those authors proved to be a related species *P. subapplanata* (Malcolm *et al.* 1999) and *P. impolita s.str.* appeared to be restricted to *Nothofagus moorei* forests of New South Wales. However, *Porina impolita s.str.* has now been discovered in Tasmania, growing on a *Melaleuca squarrosa* tree in the study area, and appears to be very rare.
- ***Steinia geophana*:** A new record for Tasmania and the Southern Hemisphere, discovered on clay soil in Small Coupe following clearing and burning, and on rotting *Melaleuca* in the forest. This species occurs on soil in disturbed sites in the temperate Northern Hemisphere whereas the related species, *S. australis* Kantvilas and McCarthy, is endemic to Tasmania (Kantvilas and McCarthy 1999).
- ***Strigula indutula*:** A new record for Tasmania, collected from *Acacia verticillata* in Small Coupe. It is also known from New Zealand.
- ***Trichothelium meridionale*:** This new species was discovered and described

as a result of the present work at Warra (McCarthy and Kantvilas 2000). It is endemic to Tasmania and is very localised in the study area, growing on fronds of the fern *Blechnum wattsii* and on the dead phyllodes of *Phyllocladus aspleniifolius*.

Taxonomically difficult groups requiring further work

In addition to some of the species listed above that require further study, there are other groups that posed particular problems of identification and almost certainly include new species and new records for Tasmania.

- **Arthoniaceae**: This family includes the genera *Arthonia* and *Arthothelium*, and, with seven species, is very well represented in the study area. Considerable further study is required to identify all the species. On the basis of work from Northern Hemisphere forests, species of this family are likely to be good ecological indicators of forest age and continuity.
- ***Coccotrema***: This typical cool temperate genus is represented in the study area by several, probably undescribed species.
- ***Micarea***: Species of this genus appear to be very important as ecological indicators, with several being associated exclusively with oldgrowth trees. Additional taxonomic study is likely to yield several species new to science.
- **The order Caliciales**: Species of this order, especially from the genera *Chaenotheca* and *Chaenothecopsis*, are exclusively associated with oldgrowth trees. Despite the thorough monograph by Tibell (1987), identifying these tiny organisms to species level is a difficult and specialised task. In addition, new taxonomic work (L. Tibell, pers. comm.) has resulted in the segregation of several species previously overlooked in Tasmania.

Discussion

Species composition

Most of the bryophyte and lichen species recorded from the Warra plots have been reported previously from eucalypt forests in Tasmania (Jarman and Kantvilas 1994, 1997; Pharo and Blanks 2000) and are widespread. However, there is also a surprisingly high number of rare species, undescribed species or new records for Tasmania, especially among the lichens.

Many taxa that could be expected in wet eucalypt forest are absent or uncommon in the plots. Bryophytes in this category include, for example, *Thuidium, Racopilum, Weymouthia, Plagiochila, Schistochila, Lepicolea*, several species of *Heteroscyphus* and *Chiloscyphus, Leptoscyphus* and *Tylimanthus*. Macrolichens include taxa such as the lush and prominent, typically foliose genera *Pseudocyphellaria, Psoroma, Menegazzia, Hypogymnia, Nephroma* and *Usnea*. Many species from these genera are strongly associated with rainforest but are also known to be common in certain wet sclerophyll communities, even those where fire may have been a relatively recent phenomenon (e.g. observations from Mount Wellington). The occurrence of some of the rainforest taxa as small, rare components in the community could be interpreted as an indication that with time and lack of catastrophic disturbance the flora might well develop into one more akin to that typical of rainforest. This same trend is apparent among the vascular plants, with the infrequent occurrence of small plants of rainforest species such as *Eucryphia lucida, Atherosperma moschatum, Cenarrhenes nitida* and *Phyllocladus aspleniifolius*.

There is a marked absence or paucity of cyanolichens (i.e. species with a blue-green alga or cyanobacterium as a photobiont) in the flora. Such lichens elsewhere in the world are very strongly associated with oldgrowth forests and serve as indicators or 'flagship' species (e.g. see Rose 1988; McCune 1993).

Despite the age of the oldest trees in the community (several hundred years old: see Hickey *et al.* 1999a; Alcorn *et al.* 2001), the Tasmanian cyanolichen genera, notably *Pseudocyphellaria, Psoroma* and *Nephroma,* are either absent entirely or very uncommon.

Significantly, there are some rather uncommon species present that we have not observed in our previous work on Tasmanian vegetation; for example, the lichens *Dactylospora* sp., *Gyalidea hyalinescens*, *Micarea sylvicola* and *Porina impolita* and the liverworts *Kurzia fragilifolia, Riccardia* sp. and *Telaranea tasmanica.* Given that this forest type, in the absence of disturbance, can be expected to eventually develop into rainforest along the successional pathway described by Gilbert (1959), such species could represent a challenge for ecologically sustainable forest management if their continued existence proves to be dependent on this particular forest community.

Species richness

In spite of its depauperate appearance, the cryptogamic flora of this forest community is rich, supporting at least 144 bryophytes and 134 lichens. In comparison, 77 bryophytes and 66 lichens were reported in a regional study of eucalypt forest in New South Wales (Pharo and Beattie 1997), which sampled a larger area within much broader geographical boundaries and included several forest communities. Species richness reported in other surveys of eucalypt forests (e.g. Ashton 1986; Jarman and Kantvilas 1997; Pharo and Blanks 2000) is difficult to compare meaningfully because, where more species were found than at Warra, the figures have been derived from combining several communities, and where fewer were found, the area sampled was smaller or unspecified.

At the level of individual plots, comparisons are again limited by differences in the area sampled. However, a few of our Warra plots were subdivided to include a sampled area of 400 m^2, enabling direct comparisons with some of our earlier work based on plots of the same size (Table 7). On this basis, bryophyte richness in the Warra community is comparable with that of other wet eucalypt forest communities in Tasmania for which we have data, and is close to or overlaps the range found in rainforest. In contrast, the lichen flora is markedly less diverse (Table 7). Furthermore, the abundance and biomass of lichens is particularly poor, especially when compared to those in rainforest.

Variability within the flora

Species numbers vary widely among the plots (bryophytes 60–90, lichens 37–65), but similar variation has also been observed in callidendrous* and implicate* rainforest (the only vegetation for which we have replicates in the same vascular plant community) (see Table 7). However, a very important difference is that, in comparison to rainforest, the inventory of a single plot from the eucalypt community represents the community's total flora rather poorly, as determined from the replicates. For example, the average number of lichen species per plot, 52, represents only 39% of the total lichen flora. By comparison, in rainforest (Table 7), the average number of lichens per plot represented 54% (implicate) to 59% (callidendrous) of the flora. These figures indicate that the eucalypt plots are quite different from each other with respect to their

* The terms callidendrous, thamnic and implicate apply to the three major groups in Tasmania's lowland cool temperate rainforest. The three groups differ in floristics and forest structure. Briefly, **callidendrous** forest has tall, well-formed trees but few other woody species and there are often abundant ferns, including tree-ferns. Structure of the forest is simple and the understorey is usually open. **Implicate** rainforest is at the opposite extreme: low forest, poorly formed trees, many woody species and few ferns. The forest is a tangle of woody stems, branches and twigs from close to the floor to the canopy. **Thamnic** rainforest occupies a position intermediate between the extremes of callidendrous and implicate forest (see Jarman *et al.* 1994).

Table 7. A comparison of species richness in some wet eucalypt and rainforest vegetation.

Plot	Number of species			
	Bryophytes (500 m^2 plots)	Bryophytes (400 m^2 plots)	Lichens (500 m^2 plots)	Lichens (400 m^2 plots)
Warra (this study)—*E. obliqua* over *Gahnia/Bauera*				
Plot S	90		62	
T	79		52	
M	81		61	
B372	71		65	
B106	82	80	39	35
Bn418	66	61	43	40
B518	60	57	37	30
C	77		54	
B471*		51		28
Total	137†		132†	
Range	60–90		37–65	
Average	76	62	52	33
Wet eucalypt forest (Jarman and Kantvilas 1997)				
S15 (*E. obliqua* regrowth—20 years old)		53		49
S18 (*E. obliqua* with mixed forest understorey)		70		67
W23 (*E. nitida* forest)		55		57
E12 (*E. globulus* forest)		31		51
Rainforest (Jarman and Kantvilas 1995a)				
Callidendrous rainforest§				
Total (5 plots / 1 community)		114		136
Range		66–91		72–89
Average		74		80
Thamnic rainforest§				
Total (5 plots / 3 communities)		128		131
Range		76–92		59–85
Average		83		73
Implicate rainforest§				
Total (5 plots / 1 community)		113		121
Range		66–78		56–69
Average		74		65

* This plot is from an earlier unpublished survey.
† This figure does not include species recorded from just outside the plots in the same community.
§ See footnote, p. 206

lichen composition, in spite of representing the same vascular plant community. Figures for bryophytes are higher than those for lichens in the eucalypt community, with the average number per plot being 76, which represents 55% of the total bryophyte flora. However, in common with the lichens, the bryophytes show greater variability in eucalypt forest than in rainforest where the average number of species per plot for both callidendrous and implicate rainforest is 65% of the total bryophyte flora.

The characteristic or typical flora (species occurring in three or more plots) is also comparatively small for lichens,

representing less than half (c. 45%) of the total lichen flora, whereas with bryophytes, the characteristic flora represents about 65% of the total bryophyte flora (Figure 1). These figures indicate that the lichen flora in this Warra community, as well as containing many small, inconspicuous species, consists very much of scattered, uncommon species (cf. Cooper-Ellis 1998 in her study in USA). This pattern is also apparent within plots, with many of the 'single-plot' species being represented by one or just a few tiny thalli.

In several cases, a single, richly colonised tree (not necessarily large or especially old) was found to be responsible for contributing a very significant proportion of the lichen diversity to a particular plot. Furthermore, such a 'lichen-rich' tree may be extremely significant at the scale of the entire area. This observation was confirmed by the distributions of three species which are of considerable conservation interest: *Aspidothelium cinerascens*, *Porina impolita* and *Trichothelium meridionale*. Despite specific searches for these taxa within the coupes, as well as in adjacent vegetation, they were only ever recorded once in the whole study area.

The variability within single plots, especially in the small size and sporadic occurrences of many species, especially the lichens, is an important factor in deciding on the sampling strategy for cryptogamic work. The rapid, 'grab-anything' approach that is sometimes advocated when resources are low is likely to sample only a small proportion of the diversity, mainly the widespread, common species. However, the best ecological indicators and / or those species with high conservation significance are likely to be among the rarer and more restricted species, and therefore found only by particularly careful and methodical searching.

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Appendix 1. Bryophytes recorded from the Eucalyptus obliqua *community.*

Mosses

Achrophyllum dentatum (Hook.f. & Wilson) Vitt & Crosby
Bryum ?billardierei Schwaegr.[1]
Calyptopogon mnioides (Schwaegr.) Broth.
Campylopus sp.
Cyathophorum bulbosum (Hedw.) C. Muell.
Daltonia splachnoides (Sm.) Hook. & Taylor
Dicranoloma billardierei (Brid.) Paris
Dicranoloma dicarpum (Nees) Paris
Dicranoloma menziesii (Taylor) Paris
Dicranoloma robustum (Hook.f. & Wilson) Paris
Dicranoloma setosum (Hook.f. & Wilson) Paris[2]
Dicranum trichopodum Mitt.
Distichophyllum pulchellum (Hampe) Mitt.
Distichophyllum rotundifolium (Hook.f. & Wilson) C. Muell. & Broth.[3]
Fissidens pallidus Hook.f. & Wilson
Fissidens tenellus Hook.f. & Wilson
Glyphothecium sciuroides (Hook.) Hampe
Grimmia sp.
Hampeella alaris (Dixon & Sainsb.) Sainsb.
Holomitrium perichaetiale (Hook.) Brid.
Hypnodendron comosum (Labill.) Mitt.
Hypnum chrysogaster C. Muell.
Hypnum cupressiforme Hedw.
Hypopterygium didictyon (Hedw.) Brid.[4]
Isopterygium limatum (Hook.f. & Wilson) Broth.
Leptostomum inclinans R. Br.
Leptotheca gaudichaudii Schwaegr.
Leucobryum candidum (P. Beauv.) Wilson
Lopidium concinnum (Hook.) Wilson
Macromitrium archeri Mitt.
Mittenia plumula (Mitt.) Lindb.
Orthodontium lineare Schwaegr.
Orthodontium pallens (Hook.f. & Wilson) Broth.
Polytrichum juniperinum Hedw.
Ptychomnion aciculare (Brid.) Mitt.
Racopilum cuspidigerum (Schwaegr.) Aongstr.
Racomitrium sp.[5]
Rhaphidorhynchium amoenum (Hedw.) Fleisch.[6]
Rhizogonium novae-hollandiae (Brid.) Brid.
Rhizogonium pennatum Hook.f. & Wilson
Tayloria gunnii (Wilson) Willis
Tayloria octoblepharum (Hook.) Mitt.
Thuidium sparsum (Hook.f. & Wilson) Reichdt.
Warburgiella leucocyta (Mull. Hal.) B.C. Tan, Schof. & Ramsay[6]
Warburgiella macrospora (Dixon & Sainsb.) B.C. Tan, Schof. & Ramsay[6]
Weymouthia cochlearifolia (Schwaegr.) Dixon
Wijkia extenuata (Brid.) Crum[7]
Zygodon hookeri Hampe
Zygodon intermedius B.S.G.

1 Possibly two species: *Bryum billardierei* and a similar but unidentified *Bryum* with a more tapered leaf apex.

2 We treat this taxon as a species, following Rodway (1914) and Dixon (1913) (*Dicranum setosum;* syn. *Dicranoloma setosum*), although several later workers, including Sainsbury (1955), Scott and Stone (1976) and Beever *et al.* (1992) regard it as a variety of *Dicranoloma robustum*.

3 A variable taxon and not all collections correspond to typical *D. rotundifolium.* Some specimens resemble *D. crispulum* but, in a recent monograph of the genus in which many Tasmanian specimens were examined, Streimann (1999) states that the latter species does not occur in Tasmania and that determinations under that name are misidentifications of *D. rotundifolium.*

4 Identified by Dr T. Pfeiffer from Germany using DNA sequencing and morphology (T. Pfeiffer *in litt.* 1999). It is likely that all Tasmanian material collected as *H. rotulatum* will prove to be *H. didictyon.*

5 This species resembles *Racomitrium crispulum* but lacks the bi(-tri)-stratose margin described by Frisvoll (1984) for that species.

6 *Rhaphidorrhynchium amoenum*, *Warburgiella leucocyta* and *Warburgiella macrospora* were included in the genus *Sematophyllum* by various workers including Scott and Stone (1976) and Beever *et al.* (1992) but have been re-assessed and placed in different genera by Tan *et al.* (1998). The three species are very difficult to separate in the field and, even in the laboratory, the putative differences are not always easy to determine unambiguously, especially if the material is vegetative and there is no supporting information from sporophytes. At least the first two of these species seem to be widespread and common in the Warra plots. However, verification of their identity was considered too time-consuming to be undertaken for every sample collected, and only selected specimens were identified. For the most part, the samples have been scored simply as *Sematophyllum* aggr., knowing that from one to three (possibly even more) species may be represented.

7 An odd form of *Wijkia extenuata* is very common in the plots. Macroscopically it looks more like the species comprising *Sematophyllum* aggr. (see footnote 6) than the typical form of *Wijkia.* It can be easily misidentified in the field if care is not taken, especially under wet conditions.

Thallose liverworts

Hymenophyton flabellatum (Labill.) Dum. ex Trevis.
Metzgeria saccata Mitt.
Metzgeria sp.[8]
Podomitrium phyllanthus (Hook.) Mitt.
Riccardia aequicellularis (Steph.) Hewson
Riccardia cochleata (Hook.f. & Taylor) Kuntze
Riccardia crassa (Schwaegr.) Carring. & Pears.
Riccardia lobulata (Col.) Hodgs.
Riccardia ?longiflora (Steph.) Hewson
Riccardia wattsiana (Steph.) Hewson
Riccardia sp.[9]
Symphyogyna podophylla (Thunb.) Mont. & Nees
Treubia tasmanica R.M. Schust. & G. Scott

Leafy liverworts

Acrobolbus concinnus (Mitt.) Grolle
Acrochila biserialis (Lehm. & Lindenb.) Grolle
Acromastigum anisostomum (Lehm. & Lindenb.) Evans
Acromastigum colensoanum (Mitt.) Evans ex Reim.
Acromastigum mooreanum (Steph.) Hodgs.
Adelanthus falcatus (Hook.) Mitt.
Balantiopsis diplophylla (Hook.f. & Taylor) Mitt.
Bazzania involuta (Mont.) Trevis.[10]
Bazzania monilinervis (Lehm. & Lindenb.) Trevis.
Bazzania ?novae-zelandiae (Mitt.) Besch. & Mass.
?Cephaloziella sp. A[11]
?Cephaloziella sp. B[11]
Chaetophyllopsis whiteleggei (Carring. & Pears.) R.M. Schust.
Cheilolejeunea albovirens (Hook.f. & Taylor) E.A. Hodgs.
Cheilolejeunea campbelliensis (Steph.) R.M. Schust.
Cheilolejeunea comitans (Hook.f. & Taylor) R.M. Schust.
Cheilolejeunea mimosa (Hook.f. & Taylor) R.M. Schust.
Chiloscyphus echinellus (Lindenb. & Gottsche) Mitt.
Chiloscyphus gippslandicus Engel & R.M. Schust.
Chiloscyphus muricatus (Lehm.) Engel & R.M. Schust.
Chiloscyphus semiteres (Lehm.) Lehm. & Lindenb.
Chiloscyphus sp.[12]
Colura saccophylla Hodgs. & Herz.
Cuspidatula monodon (Taylor) Steph.
Drepanolejeunea aucklandica Steph.
Frullania aterrima (Hook.f. & Taylor) Hook.f. & Taylor
Frullania falciloba (Hook. & Taylor) Lehm.
Frullania probosciphora Taylor
Frullania rostrata (Hook.f. & Taylor) Hook.f. & Taylor ex Gottsche *et al.*
Frullania ?scandens Mitt.[13]
Gackstroemia weindorferi (Herz.) Grolle
Geocalyx caledonicus Steph.
Harpalejeunea latitans (Hook.f. & Taylor) Grolle
Heteroscyphus coalitus (Hook.) Schiffn.
Heteroscyphus conjugatus (Mitt.) Engel & R.M. Schust.
Heteroscyphus cymbaliferus (Hook.f. & Taylor) Engel & R.M. Schust.
Heteroscyphus decipiens (Gottsche) Engel & R.M. Schust.
Heteroscyphus fissistipus (Hook.f. & Taylor) Schiffn. aggr.[14]
Heteroscyphus knightii (Steph.) Grolle
Heteroscyphus limosus (Carringt. & Pears.) Schiffn.
Jamesoniella colorata (Lehm.) Spruce ex Schiffn.
Jamesoniella tasmanica (Hook.f. & Taylor) Steph.
Kurzia fragilifolia R.M. Schust.[15]

8 More than one species may be involved.

9 This pinnate species of *Riccardia* has a distinctive rough cuticle. It does not fit any of the species described by Hewson (1970) for Australia and New Guinea, nor any of those described by Brown and Braggins (1989) for New Zealand. It is possibly a new species.

10 The name *B. involuta* follows Scott (1985) but more than one species may be involved.

11 These two minute species are probably from the genus *Cephaloziella* (Cephaloziellaceae). They are rather similar but species A has papillose leaves that are somewhat spiny in appearance whereas species B is not papillose. Species A may be more than one taxon.

12 Bilobed species having affinities with *C. perpusillus* (Hook.f. & Taylor) Engel.

13 This species has a distinctive flat perianth, and is likely to be either *F. deplanata* or *F. scandens* but there seems to be some confusion in the literature about which one occurs in Tasmania (Hattori 1983; Scott 1985; Ratkowsky 1987).

14 Very variable, and probably more than one species.

15 A minute, very fragile species with leaves consisting of two lobes that readily lose the middle and apical cells. Its identity was suggested by Dr R. Grolle (pers. comm. 1999) and subsequently confirmed by Dr J. Engel (pers. comm. 2001).

Appendix 1. Continued.

Kurzia hippurioides (Hook.f. & Taylor) Grolle[16]
Kurzia sexfida (Steph.) Grolle[17]
Kurzia tenax (Grev.) Grolle
Lejeunea drummondii Taylor
Lepicolea scolopendra (Hook.) Dum. ex Trevis.
Lepidolaena brachyclada (Taylor ex Lehm.) Trevis.
Lepidozia glaucophylla (Hook.f. & Taylor) Taylor ex Gottsche *et al.*
Lepidozia procera Mitt.
Lepidozia ulothrix (Schwaegr.) Lindenb.
Lepidozia sp. C
Lepidozia sp. L
Lepidozia sp. W
?Leptophyllopsis laxa (Mitt.) R.M. Schust.
Marsupidium surculosum (Nees) Schiffn.
Plagiochila ?baileyana Steph.
Plagiochila ?fasciculata Lindenb.
Plagiochila retrospectans Nees
Radula buccinifera (Hook.f. & Taylor) Taylor ex Gottsche
Radula compacta Castle[18]
Radula multiamentula E.A. Hodgs.
Radula ratkowskiana Yamada
Radula tasmanica Steph.
Radula sp.[19]
Saccogynidium decurvum (Mitt.) Grolle
Schistochila lehmanniana (Lindenb.) Carring. & Pears.
Telaranea centipes (Taylor ex Gottsche *et al.*) R.M. Schust.
Telaranea grossiseta (Steph.) Engel & R.M. Schust.
Telaranea herzogii (E.A. Hodgs.) E.A. Hodgs.[20]
Telaranea mooreana (Steph.) R.M. Schust.
Telaranea patentissima (Hook.f. & Taylor)[21]
Telaranea tasmanica (Steph.) Engel & Merrill[22]
?Temnoma sp.[23]
Tylimanthus diversifolius E.A. Hodgs.
Tylimanthus pseudosaccatus Grolle
Tylimanthus tenellus (Hook.f. & Taylor) Mitt.
Zoopsis argentea (Hook.f. & Taylor) Hook.f. ex Gottsche *et al.*
Zoopsis leitgebiana (Carring. & Pears.) Bastow
Zoopsis setulosa Leit.
Unknown sp. 1[24]

16 Determined by Dr R. Grolle (pers. comm. 1999).

17 Determined by Dr J. Engel (pers. comm. 2001)

18 Determined by Dr K. Yamada (pers. comm. 1999). *Radula compacta* is present in two forms: the typical large-leafed form and a much smaller but very common form with leaves at maturity having a more rounded shape resembling the shape of the microphyllous leaves of the large-leafed form. Some plants occur with shoots of both forms. The type description of *R. compacta* (Castle 1963) cites the species as having 3–4 bracts on the male inflorescence, but the small form has been found with very long male inflorescences with more than 40 pairs of bracts.

19 An unidentified species resembling *R. buccinifera* but with the lobule somewhat longer.

20 Determined by Dr R. Grolle (pers. comm. 1999) and Dr J. Engel (pers. comm. 2001).

21 Determined by Dr J. Engel (pers. comm. 2001).

22 Determined by Dr J. Engel (pers. comm. 2001).

23 This does not fit the known *Temnoma* species reported for Tasmania; very rare.

24 A small species with bilobed leaves, resembling a *Chiloscyphus* species in dorsal view but lacking underleaves; very rare.

Appendix 2. Lichens recorded from the Eucalyptus obliqua *community. The HO number is the unique number of the voucher specimen in the Tasmanian Herbarium collection.*

Anisomeridium aff. *biforme* (Borrer) R.C. Harris[1]
Arthonia apteropteridis Kantvilas & Vezda
Arthonia ilicina Taylor
Arthonia subramulosa Müll. Arg.
Arthonia tasmanica Kantvilas & Vezda
Arthonia sp. A[2]
Arthonia sp. B[3]
Arthopyrenia spp.[4]
Arthothelium sp.[5]
Aspidothelium cinerascens Vain.
Austroblastenia pauciseptata (Shirley) Sipman
Bactrospora sp.[6]
Baeomyces heteromorphus Nyl. ex C. Bab. & Mitt.
Bapalmuia buchananii (Stirt.) Kalb & Lücking
Bunodophoron australe (Laurer) Massal.
Bunodophoron insigne (Laurer) Wedin
Catillaria sp.1[7]
Chaenotheca hygrophila Tibell
Chaenothecopsis cf. *nana* Tibell
Chaenothecopsis nigropedata Tibell
Chaenothecopsis pusilla (Ach.) A.F.W. Schmidt
Chaenothecopsis savonica (Räsänen) Tibell
Chaenothecopsis tasmanica Tibell
Chaenothecopsis sp.[8]
Cladia aggregata (Sw.) Nyl.
Cladia schizopora (Nyl.) Nyl.[9]
Cladonia cf. *murrayi* W. Martin[10]
Cladonia ramulosa (With.) Laundon[11]
Cladonia rigida (Hook.f. & Taylor) Hampe var. *rigida*
Cladonia subsubulata Nyl.
Cladonia ustulata (Hook.f. & Taylor) Leighton
Cladonia weymouthii F. Wilson ex A.W. Archer
Cliostomum griffithii (Sm.) Coppins
Coccotrema cf. *cucurbitula* (Mont.) Müll. Arg.[12]
Coccotrema sp. A[13]
Coccotrema sp. B[14]
Dactylospora sp.[15]
Dimerella cf. *lutescens* Vezda & Malcolm
Dimerella cf. *pineti* (Ach.) Vezda
Eopyrenula sp.[16]

1 This genus is still very poorly understood in Tasmania, and the identification at species rank is provisional; HO 502881.

2 Characterised by having 1-septate spores, 10–14 x 4–6 mm with uneven-sized locules; occurs mainly on smooth bark; HO 502884, 325979, 443000.

3 Characterised by having 3-septate, fusiform-ellipsoid spores, 12–15 x 4–5 mm; occurs on eucalypt bark; HO 323445, 500718, 500945.

4 *Arthopyrenia* is a difficult genus of pyrenolichens. Several species may be present in the study area; HO 502877, 502882.

5 A common and widespread, undescribed species in Tasmanian forests, characterised by having densely muriform spores and apothecia that react vivid K+ magenta; HO 323430, 503367.

6 An undescribed species related to *Bactrospora arthonioides* Egea & Torrente; HO 502876, 325980.

7 A widespread, as yet undetermined species in wet forest in Tasmania, mainly found on twigs in the canopies of trees; HO 502943.

8 This genus is poorly known in Tasmania; HO 323429.

9 On very old, dry eucalypt trunks, this normally squamulose-sorediate species may become entirely sorediate and form a thick, powdery crust resembling a species of *Lepraria*. Such forms can be determined by their chemistry which comprises protocetraric and fumarprotocetraric acids.

10 A species with red apothecia, squamules with an orange underside and containing thamnolic acid and skyrin; HO 325983, 501546.

11 Specimens containing fumarprotocetraric acid with or without homosekikaic acid occur in the study area. Although the latter have been called *Cladonia adspersa* Mont. & v.d. Bosch by Elix *et al.* (1992), there appear to be no morphological, ecological or biogeographical arguments for the segregation of the two chemical variants at species level: their ranges overlap and they are morphologically indistinguishable.

12 Differs from 'typical' *Coccotrema cucurbitula* by consistently containing an unidentified UV+ substance in addition to stictic and constictic acids; HO 445013, 443003, 502987.

13 An undescribed species with apically red apothecia, containing norstictic acid; HO 329309, 324448, 325345.

14 A densely isidiate species containing stictic and constictic acids plus a UV+ unknown substance; HO 324449.

15 An inconspicuous, unidentified species occurring on papery bark; HO 502945, 329003, 325988.

16 This species is the first record of the genus *Eopyrenula* for Australia. It has greyish, 3-septate spores, 12–14 x 4–5 mm and simple paraphyses; HO 329305.

Appendix 2. Continued.

Glonium cf. *stellatum* Mühlenb. ex Fr.[17]
Graphis sp.[18]
Gyalidea hyalinescens (Nyl.) Vezda
Hypocenomyce foveata Timdal
Hypocenomyce scalaris (Ach.) M. Choisy
Hypogymnia lugubris (Pers.) Krog
Hypogymnia mundata (Nyl.) Rassad.
Hypogymnia tasmanica Elix
Hypotrachyna sinuosa (Sm.) Hale
?Icmadophila sp.[19]
Jarmania tristis Kantvilas
Lecanora sp.[20]
Lecidea cf. *botryosa* (Fr.) Th. Fr.[21]
Lecidea cf. *pruinosa* Müll. Arg.
Lecidea sp. A[22]
Lecidea sp. B[23]
Leifidium tenerum (Laurer) Wedin
?*Lepraria* sp.
?*Leprocaulon* sp.[24]
Leptogium victorianum F. Wilson
Loxospora solenospora (Müll. Arg.) Kantvilas
Marasmiellus affixus (Berk.) Singer
Megalaria pulverea (Borrer) Hafellner & Schreiner
Megalaria sp.[25]
Megalospora lopadioides Sipman
Melaspilea sp. A[26]
Melaspilea sp. B[27]
Menegazzia confusa P. James
Menegazzia norstictica P. James
Menegazzia subpertusa P. James & D.J. Galloway
Micarea cf. *adnata* Coppins[28]
Micarea alabastrites (Nyl.) Coppins
Micarea cinerea (Schaerer) Hedl.
Micarea mutabilis Coppins & Kantvilas
Micarea cf. *mutabilis*[29]
Micarea prasina Fr. aggr.; form A[30]
Micarea prasina Fr. aggr.; form B[30]
Micarea prasina Fr. aggr.; form C[30]
Micarea prasina Fr. aggr.; form D[30]
Micarea prasina Fr. aggr.; form E[30]

17 A species superficially similar to *Glonium circumserpens* (Nyl.) Kantvilas & Coppins, but with larger spores, (16–) 20–23 x 6–8 mm; HO 324457, 329005, 325341.

18 Only a minute fragment of a thallus was collected. It had a totally carbonised exciple, and 7–9-locular spores, 32–50 x 8–12 mm; HO 503019.

19 A very distinctive, small squamulose lichen, resembling the primary thallus of a *Cladonia*. It contains thamnolic acid. It has not been seen with apothecia and, as a result, its generic placement is uncertain; HO 324452, 443009, 500712.

20 A species with yellow, lecideine apothecia, *Lecanora*-type asci and spores 11–13 x 3.5–5 mm, probably related to *Lecanora symmicta* (Ach.) Ach. from the Northern Hemisphere; HO 325989.

21 A very common undescribed species on old eucalypt buttresses, differing from *Lecidea botryosa* by the larger spores, (10–) 12–16 x (4–) 6–8 mm, and by containing homosekikaic acid; HO 500805, 329416, 324462.

22 This species occurs on *Melaleuca* and is characterised by the brown epithecium, red-brown hypothecium and simple spores, 8–12 x 4–5 mm; HO 323162.

23 A species characterised by the greenish hymenium and the (0–) 1 (–2)-septate spores, 10–15 x 4–5 mm; HO 326000, 503602, 503236.

24 A species characterised by a minutely fruticulose, woolly thallus which reacts C-, KC+ red, UV-; HO 325990.

25 A species characterised by a pale blue exciple, ± greenish in K; a blackish epithecium, unchanged in K; a ± colourless hypothecium, K+ pale greenish; spores 40–46 x 16–18 mm; HO 329006.

26 A common species on smooth bark, with elongate, black, lirelliform apothecia and brown, 1-septate, ellipsoid spores, 9–13.5 x 3.5–5.5 mm; HO 443002, 325991, 324463.

27 Occurs on charred eucalypt bark and is characterised by black, lirelliform apothecia and simple, brown to colourless spores, 8–10 x 4 mm; HO 500728, 500727.

28 Similar to species of the *Micarea prasina* group but with a smooth, waxy thallus; HO 50995, 501548.

29 Differs from *Micarea mutabilis s.str.* by the well-developed, squamulose thallus; HO 329302, 500802.

30 The *Micarea prasina* group is characterised by a granular green thallus, tiny, rather tuberculate apothecia and ovoid-ellipsoid, 0–1-septate spores. Several distinct entities from this complex are present in the study site: form A, with mainly whitish, translucent apothecia, C- in section (HO 325995, 324454); form B, differing from form A by a K+ greenish blue pigment in the upper part of the hymenium (HO 503364, 503356); form C, which has a greyish thallus and apothecia reacting C+ faint pink in section (HO 500708, 501579); form D with orange-brown apothecia that react C+ orange in section (HO 445011, 329482); and form E with an epithecium that reacts K+ violet (HO 324458).

Appendix 2. Continued.

Micarea sylvicola (Flotow) Vezda & V. Wirth
Micarea tubaeiformis Coppins & Kantvilas *ined.*
Micarea sp.[31]
Microcalicium disseminatum (Ach.) Vainio
?*Multiclavula mucida* (Fr.) R.H. Petersen
Mycobilimbia sp.[32]
Mycoblastus sp. 1[33]
Mycoblastus sp. 2
Neophyllis melacarpa (F. Wilson) F. Wilson
Ochrolechia sp.[34]
Opegrapha stellata Knight
Parmelia protosulcata Hale
Parmeliella nigrocincta (Mont.) Müll. Arg.
Parmelina pseudorelicina (Jatta) Kantvilas & Elix
Peltigera dolichorhiza (Nyl.) Nyl.
Pertusaria gibberosa Müll. Arg.
Pertusaria jamesii Kantvilas
Pertusaria novaezelandiae Szatala
Phaeographis exaltata (Mont. & v.d. Bosch) Müll. Arg.
Phlyctis sp.[35]
Placopsis sp.
Placynthiella icmalea (Ach.) Coppins & P. James
Porina hyperleptalea McCarthy & Kantvilas
Porina impolita McCarthy
Porina leptalea (Durieu & Mont.) A.L. Smith
Porina subapplanata Malcolm, Vezda, McCarthy & Kantvilas
Pseudocyphellaria brattii D.J. Galloway & Kantvilas
Pseudocyphellaria glabra (Hook.f. & Taylor) Dodge
Psoroma microphyllizans (Nyl.) D.J. Galloway
Pyrenula galactina (Shirley) Kantvilas
Pyrenula sp.
Pyrrhospora laeta (Stirton) Hafellner
?*Ramalodium* sp.
Ramboldia brunneocarpa Kantvilas & Elix
Sagenidium molle Stirton
Sarrameana albidoplumbea (Hook.f. & Taylor) Farkas
Steinia geophana (Nyl.) B. Stein
Strigula albicascens (Nyl.) R.C. Harris
Strigula indutula (Nyl.) R.C. Harris
Tephromela atra (Huds.) Hafellner
Thelotrema decorticans Müll. Arg.
Thelotrema lepadinum (Ach.) Ach.
Thelotrema subdenticulatum (Zahlbr.) G. Salisb.
Thelotrema suecicum (H. Magn.) P. James
Thelotremataceae sp. A[36]
Topeliopsis muscicola Kantvilas & Vezda
Trapeliopsis granulosa (Hoffm.) Lumbsch
Trichothelium meridionale McCarthy & Kantvilas
Trichothelium assurgens (Cooke) Apteroot & Lücking
Usnea sp.
Wawea fruticulosa Henssen & Kantvilas
Species A[37]
Species B[38]
Species C[39]

31 Characterised by the dark brown epithecium, becoming pale greenish or colourless in K, colourless hymenium, dark brown hypothecium, becoming dark greenish in K, and the simple ellipsoid spores, 8–10 x 4–5.5 mm; HO 503374, 503373.

32 Occurs on soil and is characterised by 0–1-septate spores, 18–24 x 6–9 mm; HO 324690, 325339.

33 The genus *Mycoblastus* is poorly known in Tasmania. Both of the species recorded are common and widespread in Tasmania, and differ mainly by the internal pigmentation of their apothecia. See Kantvilas (1985) for descriptions.

34 A common and widespread twig species; HO 503392, 324464.

35 Similar to the common *Phlyctis subuncinata* Stirton, but differing by containing norstictic acid; HO 503385, 329308.

36 A widespread species of wet forest, described and illustrated by Kantvilas and Vezda (2000).

37 A possibly non-lichenised ascomycete growing on bryophytes, with brown, marginate apothecia, amyloid asci and ellipsoid 1-septate spores, 18–20 x 7–8 mm; HO 501581.

38 A sterile sorediate crust, C+ red-orange, UV+ red-orange, occurring on *Melaleuca*; HO 503603.

39 A sterile species with a yellow powdery thallus and indeterminate chemical composition. Its habitat and habit suggest affinities with the order Caliciales; HO 500721, 329413, 500786.