

The lichen genus *Umbilicaria* Hoffm. in Tasmania

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Abstract

The lichen genus *Umbilicaria* Hoffm. in Tasmania comprises six species: *U. cylindrica* (L.) Delise ex Duby, *U. decussata* (Vill.) Zahlbr. (recorded from Tasmania for the first time), *U. nylanderiana* (Zahlbr.) H. Magn. [previously incorrectly referred to as *U. hyperborea* (Ach.) Hoffm.], *U. polyphylla* (L.) Baumg., *U. subglabra* (Nyl.) Harm. and *U. umbilicarioides* (B. Stein) Krog & Swinscow [previously referred to as *U. propagulifera* (Vain.) Llano]. The species are described and illustrated, and their variability, distribution and ecology are discussed.

Introduction

Umbilicaria is a distinctive, easily recognised genus of foliose lichens, widely distributed in areas with cold climates and occurring almost exclusively on siliceous rocks. Characteristics of the genus include a foliose, monophyllous or polyphyllous thallus, attached to the substratum by a central holdfast, termed an umbilicus. The thallus may be smooth, scabrid, pustulate or ridged. Some species develop shaggy, root-like outgrowths termed rhizinomorphs. The black apothecia display a range of morphologies. In most species, they are gyrose, with the disc containing spiral or concentric folds of sterile tissue within the hymenium. The amyloid asci contain eight, mostly hyaline, simple ascospores. Many species reproduce by specialised vegetative diaspores called thalloconidia that are developed on the thallus surface or on the rhizinomorphs; others may develop minute thallus-like propagules called thallyles. Hestmark (2004), Llano (1950) and Purvis (1992) offer excellent summaries of the salient features of the genus.

Estimates of the total number of species of *Umbilicaria* have varied greatly between different authors, although recent workers suggest approximately 70 (Hestmark 2004) to 80 species (Kirk *et al.* 2001). The greatest diversity occurs in the Northern Hemisphere, particularly at intermediate latitudes, whereas in the mid-Southern Hemisphere, *Umbilicaria* appears to be restricted to comparatively small areas in the Andes, New Zealand, Australia and South Africa (Hestmark 1997). It is also relatively diverse in Antarctica (Øvstedal & Lewis Smith 2001). Local endemism is rather uncommon and many species are very widely distributed; this is certainly the case for all the species recorded from Tasmania and Australia. The disjunct distribution reported for some species could be due partly to limited floristic exploration of many high mountain ranges and to difficulties in the identification of some taxa (Codogno 1995).

In the Australasian region, seventeen species of *Umbilicaria* are recognised for New Zealand (Galloway & Sancho 2005; Galloway & Ledingham 2006) whereas seven species are known from mainland Australia (S. Louwhoff in prep.). The first records of *Umbilicaria* from Tasmania were made by the eminent botanist Robert Brown, who accompanied Matthew Flinders in his circumnavigation of the Australian continent in 1801-1803. Brown later visited Tasmania in 1804 and spent several months exploring the environs of Hobart, the Derwent River and Mount Wellington (Moore 2000). He collected two specimens of *Umbilicaria* from Mount Wellington (Crombie 1879), both

now identified as *U. cylindrica* (Groves & Moore 1989). Wilson (1893), in discussing *U. cylindrica*, described the new form *jubata* F. Wilson, also from Mt Wellington. The type of this taxon has never been located (Filson 1984) and subsequently its exact identity remains uncertain. Wilson (1893) also recorded two further taxa: *U. atropurpurea* var. *cinerascens* Ach. and *U. proboscidea* Schrad. The account of the genus in Tasmania by Blackman *et al.* (1974), based mainly on the comprehensive but now dated monograph by Llano (1950) and on extensive field studies by the authors, recognised four species: *U. cylindrica*, *U. hyperborea*, *U. polyphylla* and *U. subglabra*. Since these papers, the taxonomic importance of thalloconidia (Poelt 1977; Hestmark 1990), a character overlooked by Llano, has become widely accepted and has led to a major reassessment of the taxonomy of the genus in general (for example, see Krog & Swinscow 1986; Purvis 1992; Sancho *et al.* 1992; Sipman & Topham 1992; Wei 1993; Øvstedal & Lewis Smith 2001; Krzewicka 2004). On that basis, and as a result of further fieldwork, six species are now recognised for Tasmania.

One major problem with *Umbilicaria* taxonomy in Tasmania (and elsewhere) appears to have been not so much the recognition of individual taxa but the definition of their limits and the application of correct names. Indeed there are even serious problems with the typification of the genus itself (Jørgensen & Santesson 1993), and of several of the more common species (see Wei 1993; Jørgensen 1994; Jørgensen *et al.* 1994). Clearly addressing such problems is outside the scope of the present paper. We have confined ourselves solely to reviewing the large holdings of herbarium specimens available and comparing them with published literature and reference material from other regions of the world, bringing the nomenclature of the Tasmanian species in line with modern concepts and elucidating the diagnostic features of the species. In addition, we examine distribution patterns of the species in Tasmania, particularly in relation to geology and rainfall.

Materials and Methods

The morphology and anatomy of several hundred specimens from BM, BRI, CANB, HO, MEL, NSW and PERTH were examined using light microscopy. This included not only Tasmanian and Australian collections but also comparative material from other regions. Thalloconidia were examined by mounting whole rhizomorphs or thin thallus sections in water, flushed with either 10% KOH or commercial bleach (C). These reagents cause significant swelling of thallus structures and hence measurements were made only on water mounts. Spores and pycnoconidia were examined and measured in hand-cut sections mounted in water, dilute KOH or Lugols Iodine (these structures do not swell noticeably on addition of the reagents used).

Thin layer chromatography (Orange *et al.* 2001) and high performance liquid chromatography (Elix *et al.* 2003) were carried out on a representative selection of specimens. In general, thallus chemistry was not a particularly useful character in the delimitation of Tasmanian *Umbilicaria*, despite the suggestion by Posner *et al.* (1991) that secondary product chemistry of the genus has been overlooked or underestimated (Narui *et al.* 1996). The most common secondary compounds present in Tasmanian *Umbilicaria* are gyrophoric acid, lecanoric acid and umbilicaric acids, or a combination of these, either in major, minor or trace amounts. Some taxa contain no substances.

Key to Species

1. Rhizinomorphs present and typically very abundant on the lower surface and/or margins of the thallus, often forming a shaggy fringe around the lobes2
Rhizinomorphs absent3
2. Rhizinomorphs shrubby and densely dendroid-branched to coralloid, mostly ≤ 1.5 mm long, sparsely to densely beset with clusters of thalloconidia and appearing uneven and lumpy*U. umbilicarioides*
Rhizinomorphs elongate and mostly furcate-branched, never coralloid, 1-4 mm long, mostly smooth, glossy and lacking thalloconidia*U. cylindrica*
3. Upper surface extensively folded, wrinkled or puckered4
Upper surface predominantly smooth5
4. Thallus dark brownish, very fragile and brittle; folds and wrinkles with smooth, rounded edges, sometimes whitish and angular only near the centre*U. nylanderiana*
Thallus black, grey or grey-brown, relatively thick and robust; folds, wrinkles and ridges angular and forming a whitish, reticulate-faveolate pattern across the entire thallus*U. decussata*
5. Thallus polyphyllous, black, epruinose; lobes highly divided and entangled, with margins undulate or \pm deflexed; apothecial disc gyrose*U. polyphylla*
Thallus mostly monophyllous, whitish or greyish pruinose, with margins undulate to upturned; apothecial disc smooth, not gyrose*U. subglabra*

Taxonomy

1. *Umbilicaria cylindrica* (L.) Delise ex Duby

Thallus polyphyllous, 2–10 cm diam., with lobes entire or rather ragged, sometimes fenestrate; upper surface dark brown to dark grey to black, sometimes entirely or in part grey-pruinose, smooth or finely areolate-scabrid; lower surface beige-brown or pinkish, more rarely grey, blackened in the vicinity of the umbilicus, epruinose, mostly smooth but sometimes weakly areolate in older, blacker areas near the umbilicus. *Rhizinomorphs* usually abundant, marginal and laminal on the upper and lower surfaces, 1–4 mm long, usually \pm flat at the point of attachment, then cylindrical and gradually tapered to an acute apex, rarely simple, more commonly sparsely to richly furcate-branched, mostly black or \pm concolorous with the thallus, smooth and glossy, or sometimes with knob-like projections; thalloses uncommon. *Apothecia* numerous, substipitate; disc gyrose, plane or convex. *Ascospores* ellipsoid to oblong-ellipsoid, rarely somewhat bean-shaped, $12\text{--}18 \times 5\text{--}9$ μm . *Thalloconidia* mostly absent (see remarks below). *Pycnidia* scattered, immersed, visible as black dots on the upper surface; conidia bacilliform to fusiform, $3\text{--}4 \times 0.5\text{--}0.7$ μm . *Chemistry*: lacking any substances detectable by t.l.c. For further descriptions see Galloway (1985), Krzewicka (2004), Purvis (1992) and Thomson (1984). (Figs 1A–C)

Nomenclatural note: Complex nomenclatural problems surround the typification of the name because it is based in part on a specimen of *Parmelia perforata* (Hale 1965). The implications of this have been discussed by Wei (1993) and Wei & Jiang (1993) who proposed a new name, *U. neocylindrica*, for the entity that has generally been regarded by lichenologists as *U. cylindrica*. However, Jørgensen *et al.* (1994) observed that several

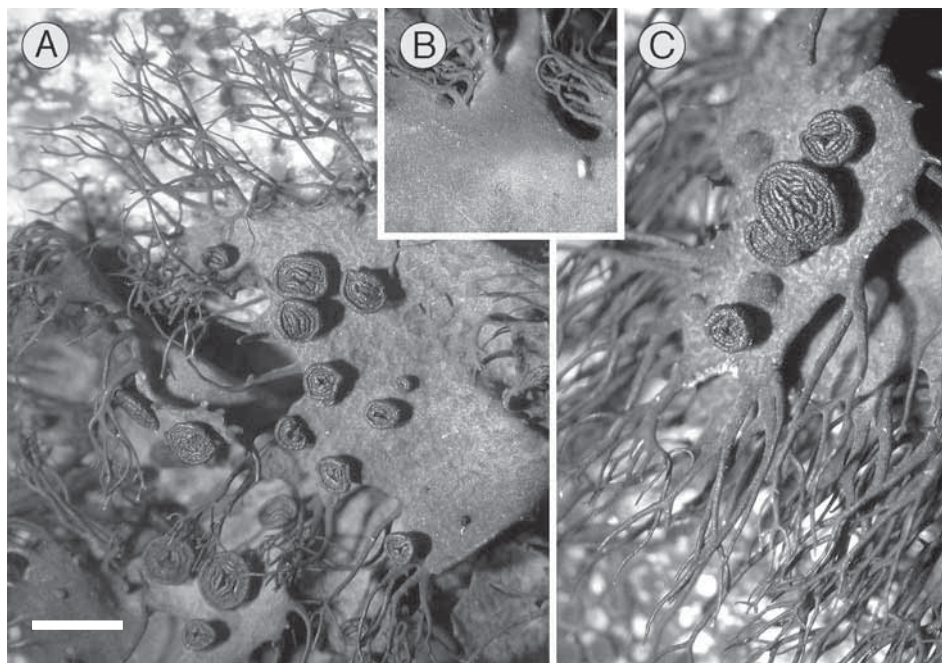


Figure 1. *Umbilicaria cylindrica* (Kantvilas & Jarman 294/00): A- habit (scale = 5 mm); B- detail of lower surface and rhizinomorphs; C- detail of upper surface, rhizinomorphs and gyrose apothecia.

older alternative names were available for this taxon and instead conserved the name *U. cylindrica* with a new type that agreed with its 200-year-long application, thus avoiding an undesirable name change.

Remarks: In Tasmania and mainland Australia, the name *U. cylindrica* has been widely applied (and misapplied) to all specimens of the genus with a polyphyllous thallus, gyrose apothecia and abundant rhizinomorphs. This view derives in part from the monograph of Llano (1950) and was reinforced by Blackman *et al.* (1974). By the 1980s, the presence of thalloconidia and their significance for species-level taxonomy in *Umbilicaria* became broadly accepted, following in part from the work of Poelt (1977) and other workers. For the Australasian region, an additional taxon, subsumed within what had been called *U. cylindrica*, was recognised, at the time called *U. propagulifera* (Vain.) Llano in herbaria (Topham *et al.* 1982), and problems in identifying *U. cylindrica* in the study area became evident.

In this account, the taxon with abundant thalloconidia, developed in irregular clumps on the rhizinomorphs, is referred to as *U. umbilicarioides*. The name *U. cylindrica sens. str.* is applied exclusively to a closely related, superficially similar taxon that mostly lacks thalloconidia and hence the rhizinomorphs appear generally smooth. *Umbilicaria cylindrica* differs further in the form of its rhizinomorphs: these are usually relatively long, in part \pm flattened, tapered extensions of rather lacerate, incised lobed margins, and resemble the tassels that may fringe a rug (Figs 1A–C). In contrast, the rhizinomorphs of *U. umbilicarioides* are shorter (mostly ≤ 1.5 mm), densely dendroid or \pm squarrosely branched and \pm coralloid, and emerge rather abruptly from the lobes like a shrubby fringe (Figs 8A–B). Further discussion is provided under *U. umbilicarioides* (see below).

Tasmanian material of *U. cylindrica sens. str.* falls well within the broad range of variation exhibited by the species elsewhere in the world. The problem in its delineation derives from the apparent presence of sparse, multi-cellular thalloconidia in some specimens, and their taxonomic significance. Recently published descriptions of *U. cylindrica* (e.g. as referred to above) do not mention this character, and indeed Hestmark (1990) specifically states that *U. cylindrica* lacks thalloconidia. On the other hand, Krog & Swinscow (1986) in their discussion of African species imply that, in their concept, the *U. cylindrica* aggregate, at least in Australia, can have thalloconidia. In addition, Poelt & Vězda (1981) include a form of *U. cylindrica* amongst the European species that may have thalloconidia (which they term 'Brutkörnern').

An examination of large numbers of specimens of *U. cylindrica* from many parts of the world (housed mainly in BM, HO and MEL) confirmed that thalloconidia generally do not occur in this species. However, a very small fraction of specimens, mainly Australasian but also from other regions, have occasional, lump-like protuberances on the rhizomorphs that are easily detected under low-power magnification and at first glance look very much like thalloconidia. When viewed under high-power, these lumps may be gall-like outgrowths or superficial colonies of unidentified algal cells. However, they may also be composed of scattered or clumped, brown-pigmented, globose cells of the mycobiont. Some may simply be bulges in the cortex (which is likewise composed of globose, brown-walled cells), perhaps incipient branches or thalloses, and do not form discrete, easily dislodged clusters. However, instances of what seem to be unequivocally clumped, multicellular thalloconidia have also been observed.

Thus the delineation of *U. cylindrica* and *U. umbilicarioides* in the study area remains problematical. We are convinced that two closely related taxa are involved. To apply only one name would be a regression to the past when thalloconidia were not generally regarded as significant or were not even noticed. However, recognising two species requires that we reluctantly include occasional specimens with sparse thalloconidia within *U. cylindrica*, a view that is not generally supported by other authors.

At a practical level, the problem is compounded by the fact that at some locations (mainly on the higher, dolerite peaks of Tasmania's Central Plateau), the two taxa co-occur in closely intermixed colonies. Thus their separation in the field may be tricky, and most sizeable herbarium specimens are mixtures of the two, leading to problems of identification and curation.

Umbilicaria cylindrica is one of the most widespread species of the genus in the world. It is also one of the most variable morphologically and chemically, as indicated by the many infra-specific taxa that have been described (see Llano 1950). For example, Wei & Jiang (1993), Brodo *et al.* (2001) and Thomson (1984) all report that it contains no lichen substances, whereas Krzewicka (2004) reports the presence of lecanoric and gyrophoric acids, and Purvis (1992) and Hestmark (2004) report that it sometimes contains norstictic acid. This chemical variation, as well as the morphological findings discussed above, suggest that the taxonomy of the species world-wide requires further study. Three varieties have been reported for Australia: *U. cylindrica* var. *delisei* (Despr.) Nyl., *U. cylindrica* var. *fimbriata* (Ach.) Nyl. and *U. cylindrica* var. *tornata* (Ach.) Nyl. (McCarthy 2003). None of these is from Tasmania, but at this stage they are considered to fall within our concept of *U. cylindrica sens. str.* (S. Louwhoff, in prep.).

Distribution and Ecology: *Umbilicaria cylindrica* is the most widespread species of the genus in Tasmania (Figs 2A, 3A), and is typically part of a rich assemblage of macrolichens that includes *Usnea torulosa* (Müll. Arg.) Zahlbr., *Parmelia signifera* Nyl.,

species of *Xanthoparmelia* (including *Neofuscelia*) and additional species of *Umbilicaria*. It occurs on a wide variety of rock types including Jurassic dolerite, Precambrian metamorphosed sediments, Triassic sandstone, Ordovician conglomerate and Devonian granite (Fig. 3A). It also has a very broad altitudinal range, occurring on exposed summits as low as 300 m a.s.l. (Mt Amos, on Tasmania's East Coast) to the highest peaks and plateaux above 1400 m. Its localities at lower altitudes are invariably on very hard, pre-Carboniferous, siliceous rock types, such as predominate in Tasmania's South-West; there it may be common on rock outcrops in lowland, exposed, windswept buttongrass (*Gymnoschoenus*) moorland, as well as in more alpine or subalpine habitats. On the relatively higher, dolerite peaks of the central and north-eastern highlands, it tends to be

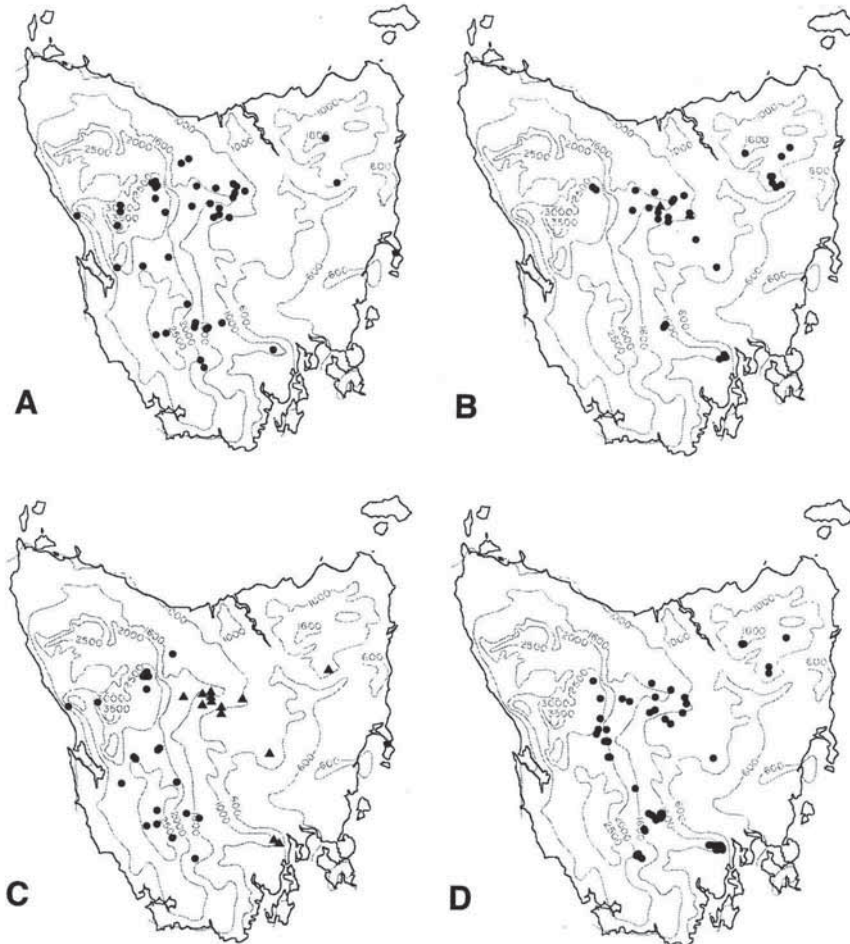


Figure 2. Distribution of *Umbilicaria* species in Tasmania: correlation with mean annual rainfall (mm). A- *U. cylindrica*; B- *U. decussata* (▲) and *U. subglabra* (●); C- *U. nylanderiana* (▲) and *U. polyphylla* (●); D- *U. umbilicarioides*.

exclusively alpine. There it is less abundant and grows together with *U. umbilicarioides*. It is in such habitats that the enigmatic forms with lumpy protuberances and incipient thalloconidia on the rhizinomorphs occur. *Umbilicaria cylindrica* is a cosmopolitan species that in Australia is also known from New South Wales, the A.C.T. and Victoria.

Representative specimens examined: **TASMANIA:** Hansons Peak, 41°40'S, 145°39'E, 24.ii.1968, *R.B. Filson 10715* (MEL); Mt Amos summit, 42°09'S 148°17'E, 300 m alt., 19.ix.1968, *G.C. Bratt & J.A. Cashin 68/1249* (HO); c. 2 km S of Lake Augusta, 41°54'S 146°31'E, 1140 m alt.,

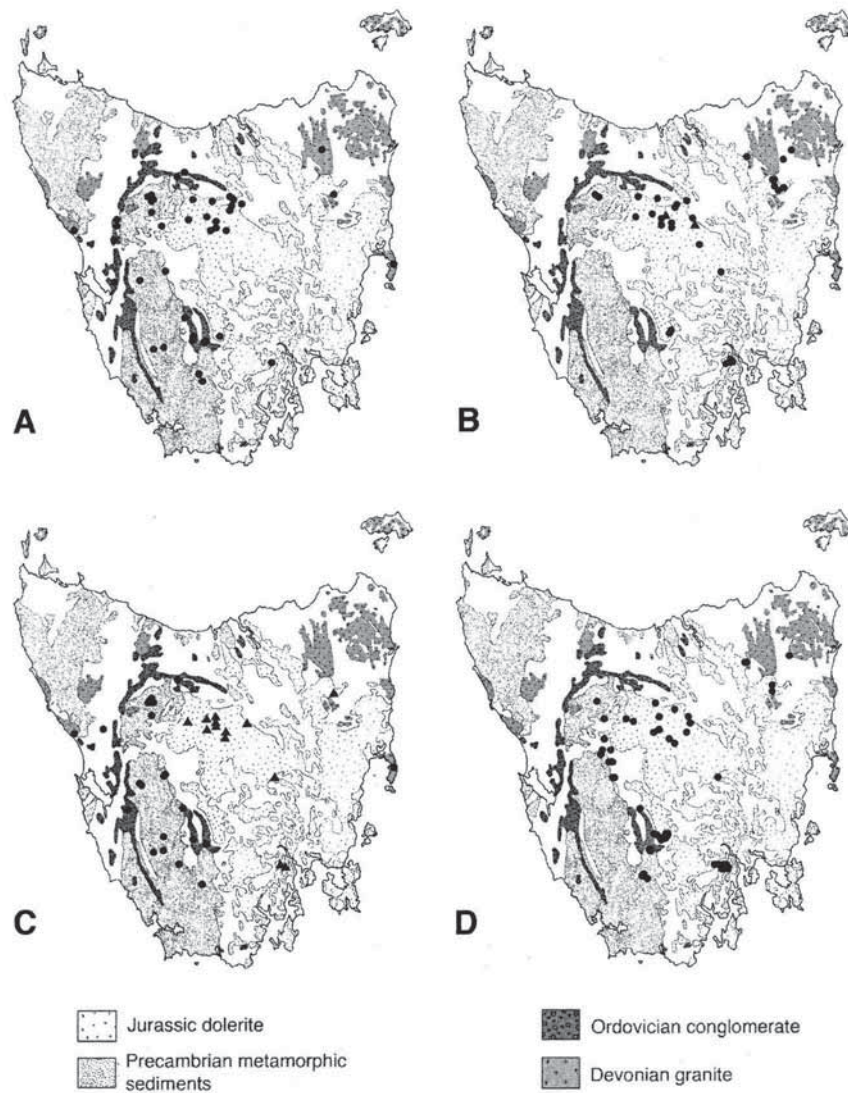


Figure 3. Distribution of *Umbilicaria* species in Tasmania: correlation with geology. A- *U. cylindrica*; B- *U. decussata* (▲) and *U. subglabra* (●); C- *U. nylanderiana* (▲) and *U. polyphylla* (●); D- *U. umbilicarioides*.

14.xii.1999, *G. Kantvilas 448/99* (HO); Schnells Ridge, 43°01'S 146°26'E, 29.vii.1973, *G.C. Bratt 73/881* (HO); Murchison Highway, Hellyer Gorge, 50 m N of Hellyer River, 41°16'S 145°37'E, 300 m alt., 21.i.1989, *F.E. Davies 1101* (CANB); summit of Mt Tim Shea, 42°42'S 145°20'E, 940 m alt., 26.iv.1992, *J.A. Elix 27052* (CANB); Twelvvetrees Range, 42°46'S 146°04'E, 640 m alt., 20.i.1984, *G. Kantvilas 37/84* (HO); Cradle Mountain, 41°41'S 145°57'E, 1080 m alt., 1915, *L. Rodway s.n.* (HO); Frenchmans Cap, 42°16'S 145°50'E, 1400 m alt., 4.i.1981, *G. Kantvilas 17/81* (HO); Lake Cumberland Dam, 41°54'S 145°12'E, 360 m alt., 28.iii.1967, *G.C. Bratt 4011* (HO); Anthony Road, 41°52'S 145°37'E, 640 m alt., 22.v.2000, *G. Kantvilas & J. Jarman 294/00* (HO).

2. *Umbilicaria decussata* (Vill.) Zahlbr.

Thallus monophyllous or rarely polyphyllous, 1–8 cm diam., rather tough and rigid, with lobe margins entire, incised or somewhat torn, often upturned; upper surface dull, pale to dark grey or brownish grey, scabrid, markedly faveolate-reticulate with sharp ridges radiating from an elevated umbo and decreasing in size towards the margins, with a whitish, coarsely granular necral layer centrally or extending onto the ridges; lower surface grey to pale brown, smooth to bullate, sometimes radially ridged, ± continuously covered with sooty, black thalloconidia except for a narrow peripheral zone. *Rhizinomorphs* absent. *Thalloconidia* single-celled, spherical to ovoid, 6–8 µm diam. *Apothecia* unknown in Tasmanian material, scattered, 1–3 mm diam., initially adnate, becoming substipitate; disc plane, not gyrose, with a central column of sterile tissue (omphalodisc), becoming convex and distorted with age. *Pycnidia* not found. *Chemistry*: gyrophoric acid (major), lecanoric acid (minor). For further descriptions see Filson (1987), Galloway (1985), Hestmark (2004), Krog & Swinscow (1986) and Wei & Jiang (1993). (Figs 4A–B)

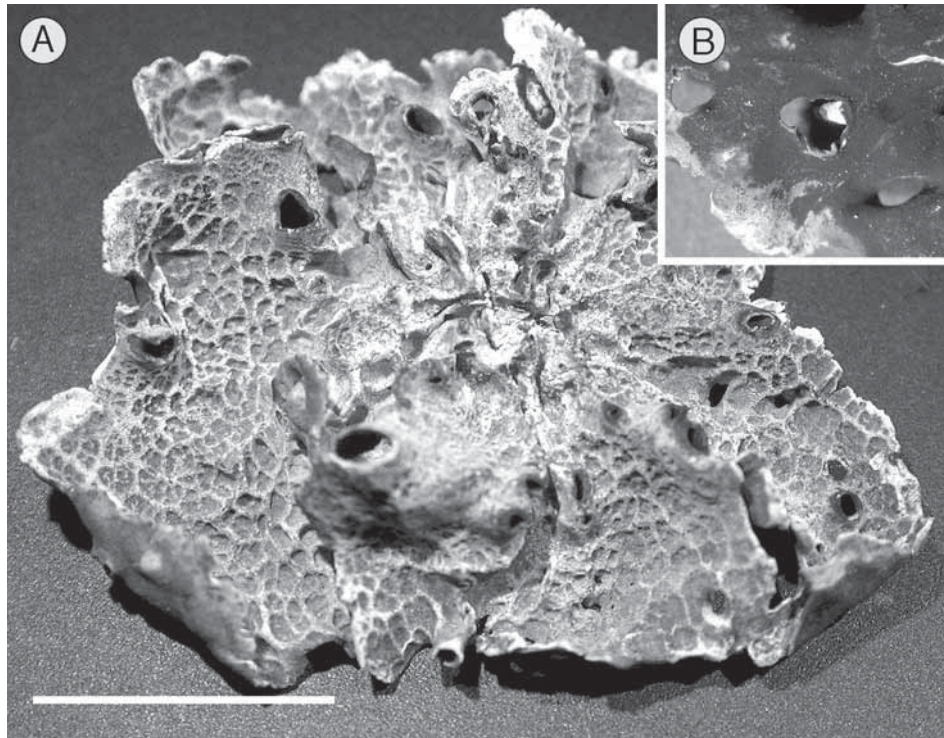


Figure 4. *Umbilicaria decussata* (Kantvilas 329/00): A- habit (scale = 10 mm); B- detail of lower surface showing a ± continuous layer of black thalloconidia.

Remarks: *Umbilicaria decussata* is readily recognisable by the deeply faveolate-reticulate upper surface with sharp ridges, covered by a white, coarsely granular necral layer. It has no confusing species in the Tasmanian flora. *Umbilicaria nylanderiana* also has a puckered and wrinkled upper surface, but its thallus is very fragile, thin and brittle, the wrinkles are rounded rather than ridged, nor are they covered by a whitish layer, except sometimes near the umbo (compare Figs 4A and 5B). The morphological variation that this species displays elsewhere in the world (Filson 1987; Llano 1950; Sancho *et al.* 1992) is not evident in Tasmania.

Distribution and Ecology: *Umbilicaria decussata* is reported here for Tasmania for the first time. It is known from only two localities, from dolerite summits *c.* 1400 m a.s.l. (Fig 3B), where the mean annual rainfall is approximately 1000-1200 mm (Fig. 2B). This is a comparatively dry and cold regime for Tasmania where alpine areas generally experience rainfalls in the order of 1200-3500 mm per annum. It is possible that higher fire frequencies in such drier areas have severely reduced the range of this species. At both sites it is very rare and represented by only a few small thalli on the uppermost parts of rock tors, habitats that are both fire-protected and serve as bird perch sites. This is a cosmopolitan species that in Australia is also known from New South Wales, the A.C.T. and Victoria.

Specimens examined: **TASMANIA:** Summit of Sandbanks Tier, 41°51'S 146°52'E, 1400 m alt., 24.vi.2000, *G. Kantvilas* 329/00 (HO); summit of Wild Dog Tier, 41°47'S 146°35'E, 1390 m alt., 11.iii.2001, *G. Kantvilas* 369/01 (HO).

3. *Umbilicaria nylanderiana* (Zahlbr.) H.Magn.

Thallus mainly monophyllous, 3–5(–15) cm diam., with lobes very brittle, irregularly incised, becoming ragged and often fenestrate; upper surface unevenly ridged, folded, puckered, warty to verruculose, dull grey-brown to brown-black, but usually white-pruinose with an irregular pattern of radiating, \pm sharp-edged ridges in the vicinity of the central umbo; lower surface dull pale brown to grey-brown, mostly smooth, covered continuously or in patches with black, sooty thalloconidia. *Rhizinomorphs* absent. *Thalloconidia* single-celled, brown, \pm roundish, 5–8.5(–10) μ m wide. *Apothecia* frequent, 0.5–1.2 mm diam., sessile to subpedicellate; disc gyrose, plane to convex. *Ascospores* ellipsoid to oblong-ellipsoid, 9–14(–16) \times 5–8 μ m. *Pycnidia* marginal and laminal, visible as minute, glossy, black dots; conidia fusiform (2.5–)3–4 \times 0.8–1.3 μ m. *Chemistry:* gyrophoric acid (major), lecanoric acid (minor/trace), \pm umbilicatic acid (minor/trace). For further descriptions see Galloway (1985), Krzewicka (2004) and Sipman & Topham (1992). (Figs 5A–C)

Remarks: This species is very distinctive, being recognised by the ridged, puckered and folded upper surface, and the smooth undersurface covered with black, sooty thalloconidia. Although the thalloconidia typically form a continuous covering, in some specimens this may be interrupted or very patchy, revealing a pale brown lower surface, perhaps due to the age of the thallus or abrasion by the elements. In the Tasmanian flora, it is easily distinguished from other species of the genus: *Umbilicaria polyphylla* differs by the mostly smooth and black upper surface, whereas *U. decussata* differs by having a reticulate-faveolate pattern of angular ridges across the entire thallus, with the edges of the ridges eroded whitish. *Umbilicaria polyphylla* differs further by having larger (to 16.5 μ m wide), multicellular thalloconidia (Hestmark 1990).

In earlier literature on Tasmanian lichens (Wilson 1893; Wetmore 1963), this species was referred to as *U. proboscidea* (L.) Schrad., a species now recognised as having no thalloconidia, occasional rhizinomorphs and white, central reticulate ridges (Purvis 1992). More recently, it was referred to by most Australian authors (e.g. Blackman *et al.* 1974) as *U. hyperborea* (Ach.) Hoffm., largely as a result of the work of Llano (1950) who considered the two taxa conspecific. However, although *U. hyperborea* has a similarly puckered and folded, essentially dark brown upper surface, it differs chiefly by lacking thalloconidia. Thus whereas the underside of *U. hyperborea* is pale to dark brownish, that of *U. nylanderiana* is typically jet black. The two species are also distinguished by their general morphology, with *U. hyperborea* having a rather more delicate, paler, more olive-coloured thallus with smaller ridges and broader folds, and apothecia that tend to be \pm embedded among the folds and warts.

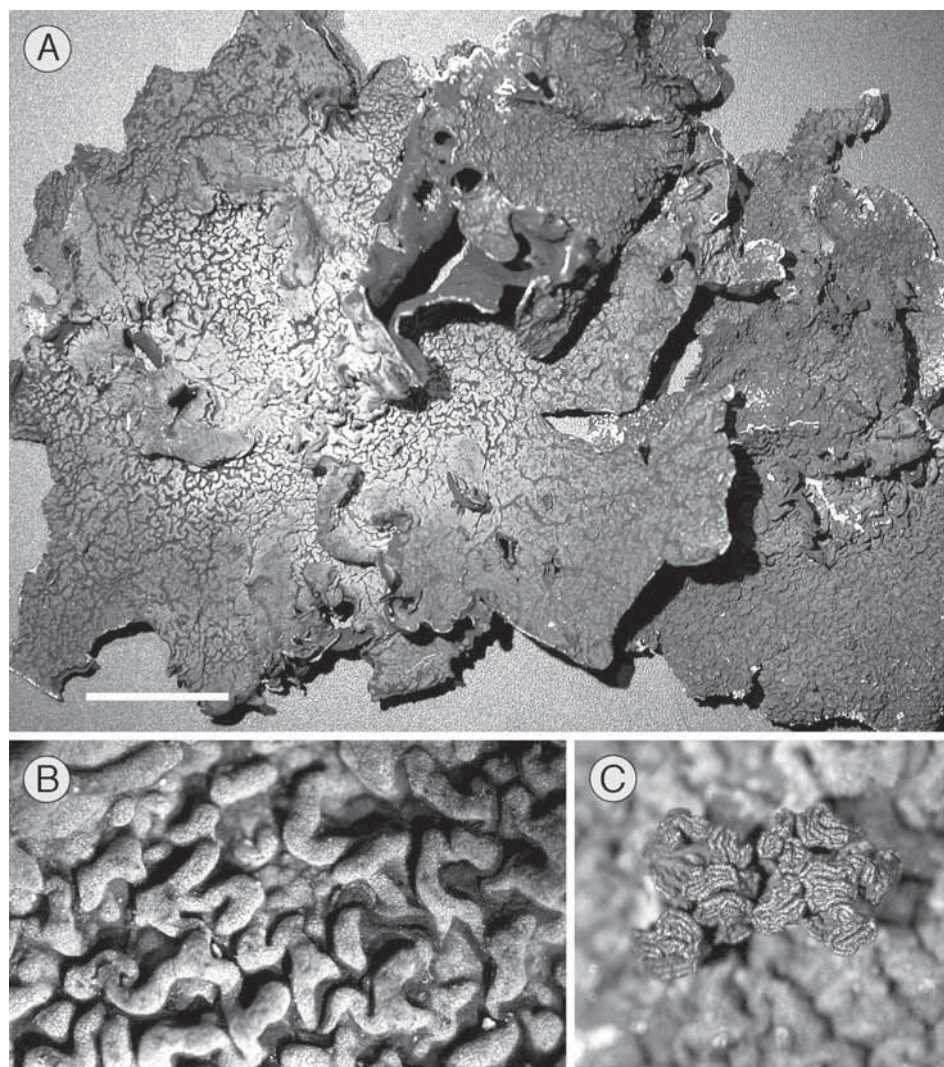


Figure 5. *Umbilicaria nylanderiana* (Kantvilas & Jarman 428/99): A- habit (scale = 10 mm); B- detail of upper surface; C- gyrose apothecia.

Distribution and Ecology: In Tasmania, *Umbilicaria nylanderiana* is restricted to alpine dolerite on the highest peaks and plateaux (above 1000 m) (Fig. 3C). Like *U. decussata*, it is also found mostly in lower rainfall areas (annual rainfall ≤ 1600 mm) (Fig. 2C). Within these areas it is locally common and typically associated with other species of the genus, notably *U. umbilicarioides* and *U. subglabra*, and with tufts of *Usnea torulosa* (Müll. Arg.) Zahlbr. This is a bipolar species, common in the mountains and subpolar regions of the Northern Hemisphere (Sancho *et al.* 1992), and recorded in the Southern Hemisphere from New Zealand (Galloway 1985), South America (Hestmark 1990) and Antarctica (Sancho *et al.* 1992). In Australia, it also occurs in Victoria, New South Wales and the A.C.T.

Representative specimens examined: **TASMANIA:** Pulpit Rock, 42°53'S 147°11'E, 3.vi.1967, G.C. Bratt, M.H. Bratt & J.A. Cashin 4053 (HO); Lake Augusta Quarry, 41°51'S 146°34'E, 20.x.1973, G.C. Bratt 73/1036 (HO); Walls of Jerusalem, 41°49'S 146°18'E, 1967, T. & J. Scott 3975 (HO); S end of Ben Lomond Plateau, 41°37'S 147°42'E, 1360 m alt., 9.iv.1996, G. Kantvilas 19/96 (HO); Table Mountain, 42°14'S 147°08'E, 1095 m alt., 18.vi.1972, G.C. Bratt & J.A. Cashin 72/409 (HO); c. 0.5 km SE of Lake Ada, 41°53'11"S 146°29'16"E, 1150 m alt., 14.xii.1999, G. Kantvilas & J. Jarman 428/99 (HO); Wild Dog Tier, 41°47'S 146°34'E, 1340 m alt., 11.iii.2001, G. Kantvilas 378/01 (HO); Sandbanks Tier, 41°50'S 146°52'E, 5.iv.1969, G.C. Bratt 69/199 (HO); Ouse River, Julian Lakes, 41°48'S 146°29'E, 1.1975, D. & M. Cook 75/159 (HO).

4. *Umbilicaria polyphylla* (L.) Baumg.

Thallus polyphyllous, 2–6 cm diam., with lobes rather elongate and strap-like, ragged, highly divided, overlapping and entangled, sometimes lobulate, forming \pm pulvinate clumps; apices ascending or deflexed, often rather coralloid and very brittle; upper surface dark brown to black, epruinose, smooth to weakly puckered; lower surface black, smooth, \pm continuously covered with a fine layer of black, sooty thalloconidia. *Rhizinomorphs* absent. *Thalloconidia* single-celled or in irregular clusters 10–22.5(–25) μm wide, mostly comprising up to 5 cells; individual cells (5–)6–12 μm diam. *Apothecia* not seen in Tasmanian material; disc gyrose. *Pycnidia* uncommon, immersed, visible as minute black dots in the upper surface; conidia bacilliform, 3–5 \times 0.6 μm . *Chemistry:* containing gyrophoric acid. For additional descriptions see Galloway (1985), Hestmark (1990), Krog & Swinscow (1986), Krzewicka (2004) and Sipman & Topham (1992). (Figs 6A–B)

Remarks: *Umbilicaria polyphylla* is easily recognised in the Tasmanian flora by the mostly black, very lacerate, divided and overlapping lobes that form entangled clumps, and by the absence of rhizinomorphs. The underside is usually uniformly black and covered with sooty thalloconidia. The most typical form of the species in Tasmania comprises short, crowded, ascending lobes with rather rounded, deflexed apices; thalli with ragged, elongate lobes are less common (compare Figs 6A and 6B). The most similar species morphologically is *U. nylanderiana*, although in practice, there are very few instances where these species may be confused. Whereas the thallus of *U. nylanderiana* is predominantly monophyllous, with intensely puckered and verruculose, very thin, flattish, broad and brittle lobes, that of *U. polyphylla* is very clearly polyphyllous, with only slightly puckered, narrow, overlapping lobes in clumps. Hestmark (1990) also describes differences in thalloconidia between the two species, with the former having single-celled and the latter multi-celled thalloconidia. However, in the Tasmanian specimens of *U. polyphylla* studied, the thalloconidia occur in mixtures of few-celled clusters and single cells.

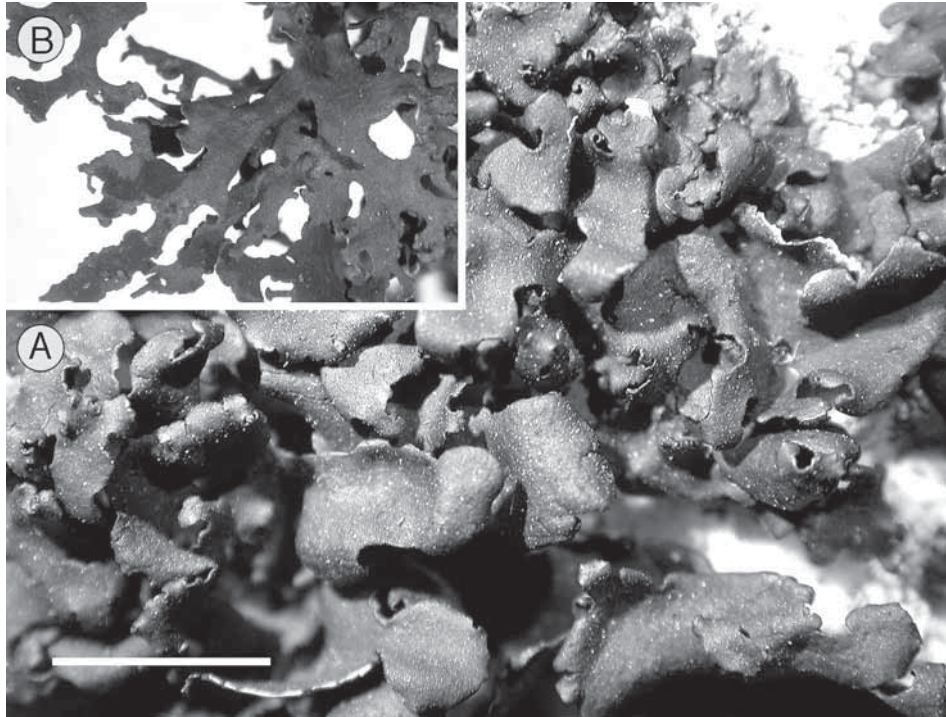


Figure 6. *Umbilicaria polyphylla*: A- typical form with rounded, deflexed lobes (*Kantvilas s.n.*) (scale = 5 mm); B- form with elongate, ragged lobes (*Kantvilas 38/84*).

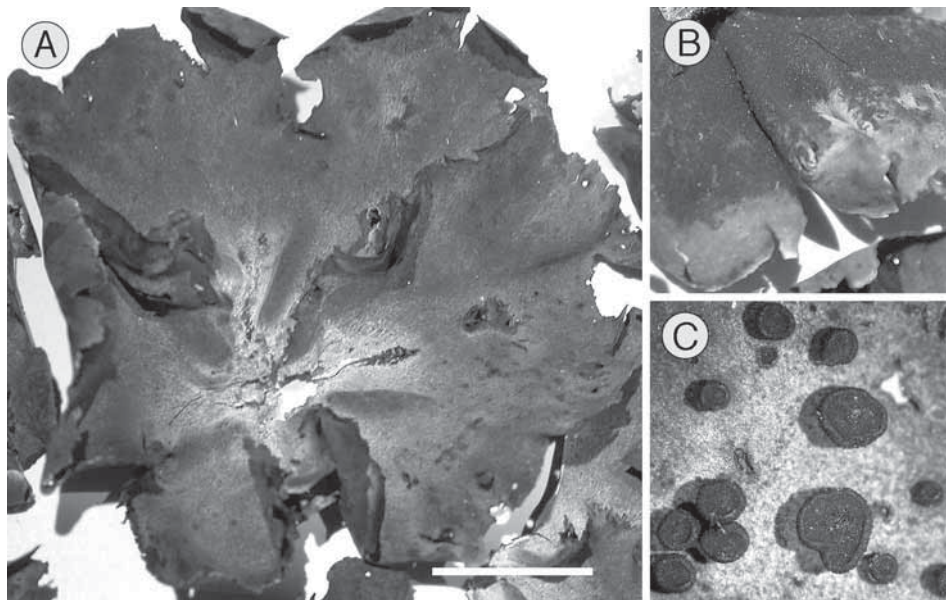


Figure 7. *Umbilicaria subglabra* (*G.C. Bratt 69/36*): A- habit (scale = 10 mm); B- detail of lower surface with patchy thalloconidia; C- leiodisc apothecia.

Distribution and ecology: *Umbilicaria polyphylla* is part of the ‘south-western’ element of Tasmania’s lichen flora (Kantvilas 1995) and is restricted to the highly siliceous, pre-Carboniferous rock types such as Precambrian quartzite and Ordovician conglomerate that dominate the western half of the island (Fig. 3C). The outlying record from Devonian granite on Tasmania’s East Coast is not unusual in that this area, which is subject to coastal mists, supports many other, mainly ‘south-western’ plants. Unlike several other species of the genus, for example *U. decussata*, *U. nylanderiana* and *U. subglabra*, *U. polyphylla* is also found in the wettest areas, where the annual rainfall exceeds 2000 mm (Fig. 2C). Like *U. cylindrica*, with which it typically occurs, *U. polyphylla* has a broad altitudinal range (c. 400–1370 m), extending from low elevation buttongrass moorlands to alpine and subalpine heathlands. This is a cosmopolitan species that in Australia also occurs in New South Wales, the A.C.T., Victoria and Western Australia.

Representative specimens examined: **TASMANIA:** Cradle Plateau, 41°40’S 145°55’E, 1040 m alt., 8.i.1972, G.C. Bratt 72/37 (HO); Sentinel Ridge, northern slopes, 42°52’S 146°13’E, 900 m alt., 16.iii.1968, G.C. Bratt & J.A. Cashin 68/202 (HO); Hansons Peak, 41°40’S 145°39’E, 24.ii.1968, R.B. Filson 10707 (MEL); summit of Mt Tim Shea, 42°42’S 145°20’E, 940 m alt., 26.iv.1992, J.A. Elix 27053 (CANB); Moores Pimple summit, 41°52’S 145°29’E, 880 m alt., 3.i.1974, G.C. Bratt 74/55 (HO); Crater Peak, 41°39’S 145°56’E, 1200 m alt., 16.ii.1984, G. Kantvilas & P. James 411/84 (BM, HO); N foothills of Denison Range, 42°27’S 146°15’E, 750 m alt., 13.x.1981, J. Jarman 842/81 (HO); The Thumbs, 42°39’S 146°18’E, 1080 m alt., 3.ii.1973, G.C. Bratt & K.M. Mackay 73/44 (HO); Elliot Range, 42°28’S 145°43’E, 880 m alt., 12.i.1985, G. Kantvilas s.n. (HO); Schnells Ridge, 43°01’S 146°26’E, 29.vi.1973, G.C. Bratt 73/882 (HO); Ben Lomond National Park, 41°32’S 147°30’E, ii.1967, D. McVean 6775 (HO).

5. *Umbilicaria subglabra* (Nyl.) Harm.

Thallus monophyllous or, less commonly, polyphyllous, 2–6(–10) cm diam., thin and fragile to rather tough, occasionally with scattered, irregular perforations and with margins ± torn, often white-crisped, inrolled or ascending, occasionally becoming lacinate; upper surface dull, smooth or minutely scabrid, pale to dark grey or brown-grey, with a white necral layer often extending over the entire thallus, minutely radially or reticulately cracked to striate at the umbo; lower surface smooth, dull, pale or dark grey, continuously or patchily covered with sooty, black thalloconidia. *Rhizinomorphs* absent. *Thalloconidia* single-celled, roundish, (5–)6–8(–10) µm diam. *Apothecia* occasional, 0.5–2.5(–4.5) mm diam., black, substipitate to stipitate; disc not gyrose, smooth (leiodisc), plane, becoming convex with age; margin persistent, elevated above the level of the disc. *Ascospores* hyaline, ellipsoid, 10–16(–20) × (3–)5–9 µm. *Pycnidia* laminal, mostly towards the lobe margins; conidia fusiform, 2.5–3.5(–5) × 0.8–1 µm. *Chemistry:* gyrophoric acid (major), lecanoric acid (minor), ± umbilicic acid (minor). For further descriptions see Galloway (1985), Hestmark (2004), Krog & Swinscow (1986) and Krzewicka (2004). (Figs 7A–C)

Remarks: This species is characterised by the pale to dark grey upper surface that commonly has a white necral layer centrally or extending over the entire thallus, and fine, thin cracks radiating from the central umbo. The lobe margins are frequently torn, ragged and eroded whitish. This is the only Tasmanian species of the genus with leiodisc apothecia (Fig. 7C); the others are gyrose (Figs 1C, 5C and 8C) or, in the case of *U. decussata*, omphalodisc. However, some apothecia may rarely have a contorted, flexuose margin that may appear almost gyrose. Of the other *Umbilicaria* species that lack rhizinomorphs, *U. nylanderiana* and *U. decussata* differ from *U. subglabra* by their ridged and/or puckered upper surface, whereas *U. polyphylla* differs by its ± uniformly dark thallus of

overlapping lobes; furthermore, in this species, the single-celled thalloconidia frequently coalesce into roundish clusters. Earlier records of *U. atropuina* var. *cinerascens* Ach. from Tasmania (Wilson 1893) refer to *U. subglabra* (Blackman *et al.* 1974).

Distribution and Ecology: This is a locally common alpine species, mostly found on dolerite and only very rarely on Precambrian quartzite (Fig. 3B). Its known altitudinal range is *c.* 1000–1470 m, and although some records are from wetter, western areas of Tasmania, most are from lower rainfall regions (< 2000 mm per annum) (Fig. 2B). This species is best developed on steeply inclined or vertical rock surfaces, mostly with a sunny, exposed aspect, where competition from other macrolichens and from bryophytes is minimal. *Umbilicaria subglabra* is a bipolar species, also reported from Europe, Asia and North America (Hestmark 2004) and New Zealand (Galloway 1985). In Australia, it also occurs in New South Wales, the A.C.T. and Victoria.

Representative specimens examined: **TASMANIA:** Mt Jerusalem, 41°49'S 146°19'E, 8.xii.1987, *G. Kantvilas 109/87* (HO); summit of Drys Bluff, 41°42'S 146°49'E, 1290 m alt., 23.vi.2002, *G. Kantvilas 356/02* (HO); Windy Moor, 42°40'S 146°39'E, 1180 m alt., 30.xii.2001, *G. Kantvilas 1346/01* (HO); summit of Bent Bluff, Ben Lomond Plateau, 41°37'S 147°45'E, 25.v.1997, *P. Buchanan s.n.* (HO); Liawenee, 41°54'S 146°40'E, 1020 m alt., 2.v.1980, *G. Kantvilas 159/80A* (BM, HO); Split Rock, 41°52'S 146°40'E, 1280 m alt., 6.xii.1991, *G. Kantvilas 423/91* (HO); Devil's Gullet, *c.* 54 km S of Devonport, 41°40'S 146°21'E, 1148 m alt., 14.xi.1971, *G.C. Bratt & J.A. Cashin 71/1557* (HO); Coalmine Crag, 41°33'S 147°39'E, 1470 m alt., 28.iv.1998, *G. Kantvilas 89/98* (HO); Lake Augusta, 41°50'S 146°34'E, 840 m alt., 1970, *G.C. & M.H. Bratt 70/250* (HO); summit of Mt Victoria, 41°20'S 147°50'E, 1200 m alt., 8.i.1997, *G. Kantvilas 11/97* (HO); Mt Penny West, 42°02'S 146°56'E, 1150 m alt., 4.iv.1969, *G.C. Bratt & K.M. Mackay 69/159* (HO).

6. *Umbilicaria umbilicarioides* (B. Stein) Krog & Swinscow

Thallus polyphyllous, 3–10(–20) cm diam.; upper surface grey to black, often patchily or continuously pale grey-pruinose, typically finely areolate-scabrid; lower surface pinkish to beige-brown to black (especially near the umbilicus), epruinose or occasionally with patchy, sparse, grey pruina, mostly smooth but sometimes weakly areolate, especially in blackened areas near the umbilicus. *Rhizinomorphs* very abundant, laminal on the upper and lower surfaces, and marginal where they frequently form a dense fringe, 0.5–1.5(–3) mm long, black, mostly terete, richly branched, shrubby to ± coralloid; thalylles frequent. *Thalloconidia* abundant to sparse, occurring near the apices of rhizinomorphs, multicellular, roundish, (15–)20–40(–60) µm wide; individual cells 5–10 µm wide. *Apothecia* occasional to frequent, substipitate; disc gyrose, plane to convex. *Ascospores* ellipsoid to oblong-ellipsoid, 12–18 × 6–9 µm. *Pycnidia* scattered, immersed, visible as black dots on the upper surface; conidia bacilliform to fusiform, 3–4 × 0.5–0.7 µm. *Chemistry:* lacking any substances detectable by t.l.c. For additional descriptions, see Hestmark (1990), Krog & Swinscow (1986) and Krzewicka & Smykla (2004); also Galloway (1985) as *U. propagulifera*. (Figs 8A–C)

Remarks: This species is very similar to *U. cylindrica*, sharing with that species a polyphyllous thallus, abundant rhizinomorphs, gyrose apothecia and the absence of lichen substances. *Umbilicaria umbilicarioides* differs chiefly in developing thalloconidia in irregular clumps on the rhizinomorphs. However, in some thalli, the number of thalloconidia becomes very few and the species appears to grade into *U. cylindrica* (see under that species). The problem is further complicated by the fact that these two species frequently co-occur and are intermixed in large numbers of herbarium collections. The morphology of the rhizinomorphs also aids in the separation of the two species. Whereas

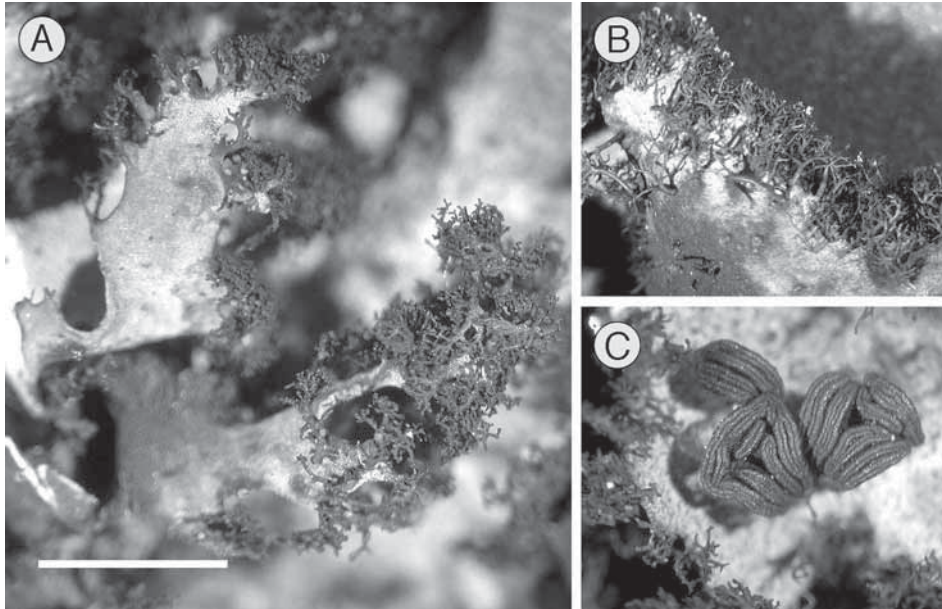


Figure 8. *Umbilicaria umbilicarioides* (Kantvilas 83/05): A- detail of upper surface with shrunken rhizomorphs (scale = 5 mm); B- detail of lower surface and rhizomorphs; C- gyrose apothecia.

in *U. cylindrica*, these occur as tapered, smooth, furcate extensions of rather lacerate, incised lobes margins (Fig. 1C), in *U. umbilicarioides* they tend to form shrunken, densely ± squarrosely branched, ± coralloid, discrete outgrowths from the thallus lobes (Fig. 8A). In addition, thalloyles are abundant in *U. umbilicarioides* but less so in *U. cylindrica*.

Tasmanian and Australian specimens of *U. umbilicarioides* in BM were named *U. propagulifera* by P. Topham in the early 1980s (P. James *in litt.*) and this name has persisted in various Tasmanian and Australian checklists (e.g. Kantvilas 1994; McCarthy 2003). Krog & Swinscow (1986) synonymised *U. propagulifera* under *U. umbilicarioides*, described from the East African highlands, but cautioned against the widespread extrapolation of all world records of *U. propagulifera* to *U. umbilicarioides*. They specifically cite Australasian material, which they include within *U. cylindrica*. However, as discussed under *U. cylindrica* above, it is a poor option to broaden the concept of a widespread, well-defined taxon like *U. cylindrica* to include specimens with abundant thalloconidia. European specimens of *U. propagulifera* (Topham *et al.* 1982) are now referable to a related, exclusively Northern Hemisphere taxon, *U. dendrophora* (Hestmark 1993).

Examination of a wide range of herbarium material of *U. umbilicarioides sens. str.* revealed some differences with Tasmanian material. Thalloconidia on specimens from Africa and Antarctica tend to be more abundant and prominent. Likewise, the rhizomorphs on the lower surface are often very abundant and form a rather shaggy 'tomentum'. The thallus of Antarctic material is also often markedly grey-pruinose, contrasting sharply with the black rhizomorphs, whereas Tasmanian specimens, even when partly pruinose, appear uniformly grey to black. In African material, the lower surface is also quite markedly scabrid-areolate (a character highlighted by Krog & Swinscow 1986), whereas Tasmanian material has a mostly smooth underside, except in the vicinity of the umbilicus. This particular character, whilst helping to distinguish *U. cylindrica*

and *U. umbilicarioides* in New Zealand (D.J. Galloway *in litt.*) appears to be of limited use in Tasmanian specimens. Although some African specimens of *U. umbilicarioides* are \pm identical with Tasmanian specimens, in general the species in Africa exhibits a far wider range of variation, grading from robust thalli with dense rhizinomorphs to rather thin thalli with few rhizinomorphs. Thus further study of Tasmanian (and Australian) populations, and of their relationship with *U. cylindrica sens. str.*, is required and our determinations of this species at this stage are tentative.

Topham *et al.* (1982) suggested that there is an inverse link between the production of apothecia and of thalloconidia, but this is not generally evident in Tasmanian specimens of *U. umbilicarioides*. Apothecia with well-developed asci and spores are common and, if anything, well-developed ascospores appear to be less common in the exclusively sexually reproducing *U. cylindrica*. Krog & Swinscow (1986) also did not observe any suppression of apothecial production in abundantly thalloconidiate specimens.

Distribution and Ecology: In Tasmania, *U. umbilicarioides* is a very common species on the dolerite peaks of the central and north-eastern highlands, ranging from subalpine to alpine elevations (Fig. 3D). Its distribution appears to be determined by altitude and rock type rather than rainfall (Fig. 2D). It typically grows on the apices of large boulders and rock outcrops where it forms extensive associations with *Usnea torulosa* (Müll. Arg.) Zahlbr., *Parmelia signifera* Nyl. *Pseudephebe pubescens* (L.) M. Choisy, *Protoparmelia badia* (Hoffm.) Hafellner, species of *Xanthoparmelia* (incl. *Neofuscelia*), and other species of *Umbilicaria*. On peaks where fires have occurred frequently, it tends to be confined to more sheltered, fire-protected niches. As with other species of *Umbilicaria*, its post-fire recovery appears to be very limited; for example, on Mt Wellington, even nearly 40 years after a severe fire, no signs of recovery of this species have been observed (see also Blackman *et al.* 1974). This species appears to be confined to the Southern Hemisphere and has been reported from Africa, South America and the Antarctic region (Krog & Swinscow 1986), as well as from New Zealand (D.J. Galloway *in litt.*). In Australia, *U. umbilicarioides* also occurs in Victoria, New South Wales and the A.C.T.

Representative specimens examined: **TASMANIA:** summit plateau, Mother Cummings peak, 41°41'S 146°32'E, 1250 m alt., 3.iii.2002, G. Kantvilas 154/02 (HO); Table Mountain, 42°14'S 147°08'E, 1095 m alt., 18.vi.1972, G.C. Bratt & J.A. Cashin 72/410 (HO); Pine Lake, 41°45'S 146°42'E, 1050 m alt., 14.vi.1965, G.C. Bratt & J.A. Cashin 2339 (HO); Mt Mueller, western peak, 42°46'S 146°28'E, 1150 m alt., 16.xii.1998, G. Kantvilas 259/98 (HO); Wylds Craig summit, 42°28'S 146°23'E, 1330 m alt., 28.xii.1998, G. Kantvilas 276/98 (HO); Mt Marian near Trestle Mountain, 42°53'S 147°06'E, 5.ix.1967, G.C. Bratt & F.N. Lakin 67/74 (HO); Great Lake Plateau, 41°57'S 146°40'E, 1000 m alt., 18.i.1969, G.C. & M.H. Bratt & K.M. Mackay 69/28 (HO); Wild Dog Tier, 41°47'S 146°34'E, 1340 m alt., 11.iii.2001, G. Kantvilas 279/01 (HO); Hansons Peak, Cradle Mountain, 41°40'S 145°58'E, 1150 m alt., G.C. Bratt & J.A. Cashin 3625 (HO); Mt Field East moor, 42°39'S 146°38'E, 30.v.1970, G.C. Bratt & F.N. Lakin 70/708 (HO).

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References

- Blackman, A.J., Bratt, G.C. and Cashin, J.A. (1974). Umbilicariaceae in Tasmania. *Lichenologist* **6**, 112–114.
- Brodo, I.M., Duran Sharnoff, S. and Sharnoff, S. (2001). *Lichens of North America*. Yale University Press: New Haven and London.
- Codogno, M. (1995). The problem of geographic disjunctions in the Umbilicariaceae (lichens). *Nova Hedwigia* **60**, 479–486.
- Crombie, J.M. (1879). Enumeration of Australian lichens in Herb. Robert Brown (Brit. Mus.), with descriptions of new species. *Botanical Journal of the Linnean Society* **17**, 390–401.
- Elix, J.A., Giralt, M. and Wardlaw, J.H. (2003). New chloro-depsides from the lichen *Dimelaena radiata*. *Bibliotheca Lichenologica* **86**, 1–7.
- Filson, R.B. (1987). Studies in Antarctic Lichens 6: further notes on *Umbilicaria*. *Muelleria* **6**, 335–347.
- Galloway, D.J. (1985). *Flora of New Zealand Lichens*. P.D. Hasselberg, Government Printer: Wellington.
- Galloway, D.J. and Ledingham, J. (2006). Additional lichen records from New Zealand 43. *Umbilicaria deusta* (L.) Baumg. *Australasian Lichenology* **58**, 14–16.
- Galloway, D.J. and Sancho, L.G. (2005). *Umbilicaria murihikuana* and *U. robusta* (Umbilicariaceae: Ascomycota), two new taxa from Aotearoa (New Zealand). *Australasian Lichenology* **56**, 16–19.
- Groves, E.W. and Moore, D.T. (1989). A list of the cryptogams and gymnospermous plant specimens in the British Museum (Natural History) gathered by Robert Brown in Australia 1801–1805. *Proceedings of the Linnean Society of New South Wales* **111**, 65–102.
- Hale, M.E. (1965). A monograph of *Parmelia* subgenus *Amphigymnia*. *Contributions from the U.S. National Herbarium* **36** (5), 193–358.
- Hestmark, G. (1990). Thalloconidia in the genus *Umbilicaria*. *Nordic Journal of Botany* **9**, 547–574.
- Hestmark, G. (1993). *Umbilicaria dendrophora*. *Mycotaxon* **46**, 211–215.
- Hestmark, G. (1997). Species diversity and reproductive strategies in the family Umbilicariaceae on high equatorial mountains- with remarks on global patterns. *Bibliotheca Lichenologica* **68**, 195–202.
- Hestmark, G. (2004). ‘*Umbilicaria*’, in T.H. Nash III, B.D. Ryan and F. Bungartz (eds), *Lichen Flora of the Greater Sonoran Desert Region* Volume 2, pp. 548–556. Lichens Unlimited: Tempe.
- Jørgensen, P.M. (1994). (1094-1097) Proposals to reject four species names of lichenized fungi. *Taxon* **43**, 462–464.
- Jørgensen, P.M. and Santesson, R. (1993). (1074-1082) Nine proposals to conserve generic names of lichenized fungi. *Taxon* **42**, 881–887.
- Jørgensen, P.M., James, P.W. and Jarvis, C.E. (1994). (1112-1137) Proposals to reject or conserve 26 Linnaean names of lichenized ascomycetes. *Taxon* **43**, 646–654.
- Kantvilas, G. (1994). A revised checklist of the Tasmanian lichen flora. *Muelleria* **8**, 155–175.
- Kantvilas, G. (1995). Alpine lichens of Tasmania’s South-West wilderness. *Lichenologist* **27**, 433–449.
- Kirk, P.M., Cannon, P.F., David, J.C. and Staplers, J.A. (2001). *Ainsworth & Bisby’s Dictionary of the Fungi*. 9th edition. CAB International: Wallingford.
- Krzewicka, B. (2004). The lichen genera *Lasallia* and *Umbilicaria* in the Polish Tatra Mts. *Polish Botanical Studies* **17**, 1–88.
- Krzewicka, B. and Smykla, J. (2004). The lichen genus *Umbilicaria* from the neighbourhood of Admiralty Bay (King George Island, maritime Antarctic), with a proposed new key to all Antarctic taxa. *Polar Biology* **28**, 15–25.
- Krog, H. and Swinscow, T.D.V. (1986). The lichen genera *Lasallia* and *Umbilicaria* in East Africa.

- Nordic Journal of Botany* **6**, 75–85.
- Llano, G.A. (1950). *A Monograph of the Lichen Family Umbilicariaceae in the Western Hemisphere*. Office of Naval Research: Washington D.C.
- McCarthy, P.M. (2003). *Catalogue of Australian Lichens*. Flora of Australia Supplementary Series 19. Australian Biological Resources Study: Canberra.
- Moore, D.T. (2000). Some aspects of the work of the botanist Robert Brown (1773-1858) in Tasmania in 1804. *Tasforests* **12**, 123–146.
- Narui, T., Culberson, C.F., Culberson, W.L., Johnson, A. and Shibata, S. (1996). A contribution to the chemistry of the lichen family Umbilicariaceae (Ascomycotina). *The Bryologist* **99**, 199–211.
- Orange, A., James, P.W. and White, F.J. (2001). *Microchemical Methods for the Identification of Lichens*. British Lichen Society: London.
- Øvstedal, D.O. and Lewis Smith, R.I. (2001). *Lichens of Antarctica and South Georgia*. Cambridge: University Press.
- Poelt, J. (1977). Die Gattung *Umbilicaria*. Khumbu Himal. *Ergebnisse des Forschungsunternehmens Nepal Himalaya* **6**, 397–435.
- Poelt, J. and Vězda, A. (1981). *Bestimmungsschlüssel europäischer Flechten*. Ergänzungsheft II. J. Cramer: Vaduz.
- Posner, B., Feige, G.B. and Huneck, S. (1991). Studies on the chemistry of the lichen genus *Umbilicaria* Hoffm. *Verlag der Zeitschrift für Naturforschung* **47**, 1–9.
- Purvis, O.W. (1992). ‘*Umbilicaria* Hoffm. (1789)’, in O.W. Purvis, B.J. Coppins, D.L. Hawksworth, P.W. James and D.M. Moore (eds), *The Lichen Flora of Great Britain and Ireland*, pp. 616–620. Natural History Museum Publications: London.
- Sancho, L.G., Kappen, L. and Schroeter, B. (1992). The lichen genus *Umbilicaria* on Livingstone Island, South Shetland Islands, Antarctica. *Antarctic Science* **4**, 189–196.
- Sipman, H.J.M. and Topham, P. (1992). The genus *Umbilicaria* (lichenized ascomycetes) in Colombia. *Nova Hedwigia* **54**, 63–75.
- Thomson, J.W. (1984). *American Arctic Lichens. 1. The Macrolichens*. Columbia University Press: New York.
- Topham, P.B., Seaward, M.R.D. and Bylinska, E.A. (1982). *Umbilicaria propagulifera* new to the Northern Hemisphere. *Lichenologist* **14**, 47–52.
- Wei, J. (1993). The lectotypification of some species in the Umbilicariaceae described by Linnaeus or Hoffmann. *Mycosystema, Supplement* **5**, 1–17.
- Wei, J. & Jiang, Y. (1993). *The Asian Umbilicariaceae*. Mycosystema Monographicum Series No. 1. International Academic Publishers: Beijing.
- Wetmore, C.M. (1963). Catalogue of the lichens of Tasmania. *Revue Bryologique et Lichénologique* **32**, 223–264.
- Wilson, F.R.M. (1893). Tasmanian lichens. Part 1. *Papers and Proceedings of the Royal Society of Tasmania* (1892), 133–178.