

# Hypogeous fungi at tree line in the Australian Alps

James M. Trappe & Andrew W. Claridge

## Abstract

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The tree line of the continental Australian Alps yielded eighteen species of hypogeous fungi, all probably forming ectomycorrhizae with *Eucalyptus niphophila*, the tree species characteristic of that habitat. Six of the species were undescribed. These collections represented six families and twelve genera: Boletaceae (with *Chamonixia*), Gallaceaceae (*Gallacea*), Hysterangiaceae (*Hysterangium*), Cortinariaceae (*Cortinarius*, *Dermocybe*, *Descomyces*, *Protoglossum*, *Setchelliogaster*), Russulaceae (*Cystangium*, *Gymnomyces*, *Zelleromyces*) and Tricholomataceae (*Hydnangium*). A key to hypogeous fungi so far found at the Australian Alps tree line is presented.

**Keywords:** hypogeous fungi, sequestrate fungi, tree line, Australia, *Eucalyptus*, Boletaceae, Clathraceae, Cortinariaceae, Russulaceae, Tricholomataceae.

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## Introduction

Australia has a remarkable diversity of hypogeous and other sequestrate fungi. For example, Claridge *et al.* (2000a, b) recorded 209 species, over 150 being undescribed, from 136 forested plots scattered over an area of about 100 x 160 km in eastern Victoria and adjacent New South Wales; this number is close to the total of sequestrate species known from all of Europe. Just how many species might occur Australia-wide is presently unknown. On the basis of existing information, Lebel and Castellano (1999) estimated the figure to be around 600 taxa, a figure upgraded to more than 1,200 and perhaps as many as 2,450 by Bougher and Lebel (2001). Our recent collecting in previously unexplored habitats suggests that the estimate of 1,200 or more likely approaches reality.

Sequestrate fungi, the sporocarps mostly of ectomycorrhizal fungi, not only produce propagules but concomitantly provide a food source for many mammals (Claridge *et al.* 1996, Claridge and Trappe 2005). Tree lines in the Australian Alps provide edge habitats that may accommodate animals of both the alpine and subalpine zones (Fitzherbert *et al.* 1998, Happold 1989). Some of these are known mycophagists (Claridge *et al.* 1996): the broad-toothed rat (*Mastacomys fuscus*), the bush rat (*Rattus fuscipes*), the mountain pygmy-possum (*Burrhamys parvus*), the common brushtail possum (*Trichosurus vulpecula*), the western grey kangaroo (*Macropus fuliginosus*) and the swamp wallaby (*Wallabia bicolor*) (Claridge *et al.* 2001).

No studies of sequestrate fungi living at tree line have been reported for Australia until now. We took advantage of opportunities to collect at tree lines within Kosciuszko National Park in New South Wales and Alpine National Park in Victoria.

## Collection areas and vegetation

Kosciuszko National Park, within the Snowy Mountains of New South Wales, contains approximately 250 km<sup>2</sup> of truly alpine area culminating with Australia's highest summit, Mt. Kosciuszko at 2,228 m above sea level. Its topographic features reflect its history of Pleistocene glaciation and contain a considerable variety of alpine plant communities (Costin *et al.* 1979, Galloway 1989). The tree line, with the overstorey formed exclusively by snow gums, *Eucalyptus niphophila*, varies from about 1,800 m elevation on southern and sheltered slopes up to 2,050 m on exposed northern and western slopes (Slatyer 1989). The uppermost patches of trees are usually on rocky outcrops, perhaps in part because the rocks are effective absorbers of solar energy and provide a microclimate relatively salubrious for tree establishment and growth (Costin *et al.* 1979). Heath plants such as *Epacris* spp. are common in the tree line understory; the vegetation otherwise is described in detail by Costin *et al.* (1979). Generally similar conditions prevail at the Mt. Hotham/Mt. Loch study sites in Alpine National Park, in adjacent Victoria, except that area is not thought to have had Pleistocene glaciers (Peterson 1971) and our collecting was concentrated on relatively gentle slopes with few rock outcrops along the track from Mt. Hotham to Mt. Loch.

## Methods

Tree lines in Kosciuszko National Park were visited four times (April and December 1999, January and April 2000) and, in Alpine National Park, twice (May 1999, April 2000). Collection of fungi was restricted for the most part to within 100 m of the tree line. Four-tined cultivators were used to rake away the litter and a few cm into the soil where most hypogeous sporocarps form. Areas with shrub or herbaceous cover were left alone to avoid disturbing living plants. Sporocarps were bagged and, later on the day of collection, their fresh characters were recorded. Collections were numbered, specimens were cut vertically in half or into several slabs and placed on a portable, forced air food dehydrator set at a temperature of about 40° C. Once dried, specimens were kept in packets for later microscopic study. For that later analysis, thin sections

were cut with a razor blade and mounted in 3% KOH and Melzer's reagent, respectively.

Cited collections are variously deposited in these herbaria: the National Herbarium of Australia, Canberra (CANB); National Herbarium of Victoria, Melbourne (MEL); Plant Pathology Herbarium, Orange Agricultural Institute, Orange (DAR); Oregon State University Herbarium, Corvallis (OSC).

## Results

Eighteen basidiomycete species, representing six families and 12 genera, were found in probably ectomycorrhizal association with *Eucalyptus niphophila* at tree line in the Australian Alps; seven of these were undescribed. No ascomycetes were collected. In addition, no epigeous mushrooms were seen on the soil surface, but numerous specimens of small *Cortinarius* subgen. *Telemonia* spp. and *Laccaria* spp. were found under the thick (up to 20 cm.) layer of litter common in these sites. These small mushrooms originated from near the snow gum mycorrhizae and were not robust enough to emerge to the surface of the litter.

A synopsis of differentiating characters of the fungal species found is presented here. More detailed descriptions plus valid publication of the new taxa are to be found in Trappe and Claridge (2003). A key to these hypogeous species of the continental Australian tree line follows the descriptions and discussion.

## Boletaceae

### *Chamonixia* sp.

*Basidiomata* 10-30 mm broad. *Peridium* white or with some blue tinges, slowly staining pale blue in patches or overall when exposed, felty. *Gleba* initially white, often with blue-tinged areas, becoming pinkish brown with maturity. *Odor* initially mild, by maturity unpleasant and resembling dog feces; *taste* not distinctive. *Peridium* of periclinal to interwoven, hyaline hyphae 3-15 µm broad. *Spores* initially hyaline, by maturity pale brown, 10-15 x 5-8 µm including 4-6 obscure to prominent, longitudinal ridges.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24020 and 24022, 25 April 1999 (OSC);

Mt. Guthrie, J. Trappe 25000, 6 Jan. 2000 (DAR). Victoria, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24039 and 24040, 9 May 1999 (MEL).

Species presently assigned to the genus *Chamonixia* are widely distributed in south-eastern Australia on cool sites; they often fruit in or near the mycelial colonies of *Dermocybe globuliformis* (see below). One species has been named from Australia, *Chamonixia vittatispora* G. W. Beaton, Pegler & T. W. K. Young, but it is part of a species complex that needs to be sorted out before a species name can be applied with confidence (T. Lebel, pers. comm.). The generic name *Chamonixia* is European in origin; we have some doubt that the Australian species will remain assigned to that genus once molecular phylogenetic studies are conducted.

## Gallaceaceae

### *Gallacea subalpina* Trappe & Claridge

*Basidiomata* 5-14 mm broad, subglobose. *Peridium* white, slowly staining pale brown when exposed, glabrous. *Gleba* loculate, dark brown, rubbery-firm, with a gray-translucent, dendroid columella 0.5-1.5 mm broad near its base. *Odor* not distinctive; *taste* of peridium bitter, of gleba mild. *Peridiopellis* ca. 50 µm thick, of interwoven-periclinal hyphae 2-4 µm broad, the tissue tinged yellow; subpellis 450-500 µm thick, of hyaline, interwoven hyphae 2-4 µm broad at septa, many cells inflated to 6-10 µm. *Spores* smooth, ellipsoid to broadly subfusoid, 11-14 x 7-9 µm, the walls 0.5-1 µm thick, nearly hyaline in KOH, faintly and erratically dextrinoid, lacking a utricle; sterigmatal attachment cupped, ca. 1.5 x 1.5 µm.

Collections examined: *New South Wales*, Kosciuszko National Park, Mt. Guthrie, Trappe 25003, 6 Jan. 2000 (MEL).

*Gallacea* differs from *Hysterangium* in having relatively broad spores that lack a utricle. *G. subalpina* basidiomata are small and compact compared to other members of the genus, which often reach diameters up to five or six cm and develop large cavities in the gleba (Castellano and Beever 1994). Except for the spores, *G. subalpina* resembles a *Hysterangium*, but the two genera appear to be closely related in any event.

## Hysterangiaceae

### *Hysterangium gardneri* E. Fisch.

*Basidioma* 20 x 30 mm, white, firm, irregular. *Peridium* rough and felty with much clinging debris. *Gleba* grayish olive, loculate, with a gelatinous, dendroid columella. *Odor* rancid-musty; *taste* not recorded. *Peridiopellis* ± 500 µm thick, of hyaline, thin-walled, interwoven hyphae 3-5 µm broad near the gleba, towards the surface inflated to as much as 30-40 µm broad at the surface itself. Spores 8-10 x 3-4 µm, smooth or minutely rugulose, hyaline; utricle absent or inconspicuous.

Collection examined: *New South Wales*, Kosciuszko National Park, Guthega, Mt. Blue Cow, Trappe 25052, 1 April 2000.

This collection was deteriorated and riddled with larvae, but its microscopic features fit those of the species as described by Castellano (1988) except many of the spores were minutely rugose. The unpleasant odor may reflect the condition of the basidioma and not be typical for the species. *Hysterangium gardneri* was originally described from a collection from under eucalypts in California. It is widely distributed in Australia, although evidently not common, and has been introduced along with eucalypts in many places in the world (Castellano 1988).

## Cortinariaceae

### *Cortinarius debbiae* Trappe & Claridge

*Basidiomata* hypogeous or under humus with the cap adpressed to the soil surface. *Pileus* 2-4 cm broad, convex, the margin inrolled and attached to the stipe by a membranous, persistent, white veil. *Pellis* light orange brown, innately radiate fibrillose, moist when fresh but not viscid, not hygrophanous, sometimes with a white remnant of veil on the disc, the context 3-6 mm thick, white with a slight brown zone beneath the pileipellis. *Lamellae* light brown in youth, becoming cinnamon from spores by maturity, adnate, discharging spores onto the inner surface of the persistent veil. *Stipe* 12-30 x 6-12 mm, white above the velar attachment, brownish white below and light brown at the base, the context concolorous. *Odor* mild, *taste* mild with a slightly astringent aftertaste. *Pileipellis* 3-layered: suprapellis 20-30 µm thick, of pale yellow

hyphae 5-10  $\mu\text{m}$  broad; pellis ca. 50  $\mu\text{m}$  thick, of hyaline hyphae 2-6  $\mu\text{m}$  broad; subpellis 50-60  $\mu\text{m}$  thick, of hyphae 4-7  $\mu\text{m}$  broad at septa but cells mostly inflated to 7-15  $\mu\text{m}$ . *Clamp connections* common. *Spores* ballistosporic, ellipsoid to subamygdaliform in face view, 9-12 x 5.5-6.5  $\mu\text{m}$ , pale yellowish brown, ornamented with minute warts <0.2  $\mu\text{m}$  broad and tall.

Collection examined: *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24047, 9 May 1999 (MEL).

*Cortinarius debbiae* is the second hypogeous species of the genus with ballistospores but a persistent veil to be described from Australia. The other species, now recombined as *Dermocybe globuliformis*, also occurs at tree line in the Australian Alps (see following description). *C. debbiae* is named for Debbie Claridge, accomplished Australian collector of hypogeous fungi, who introduced the senior author to the beauty of the tree line and alpine zones of the Australian Alps.

#### ***Dermocybe globuliformis* (Bougher) Bougher & Trappe**

*Basidiomata* hypogeous or under the humus with the cap adressed to the soil surface, formed in bright yellow mycelial mats. *Pileus* 5-30 mm broad, convex to plane, the margin attached to the stipe by a membranous, yellow veil that persists to late maturity when it may tear and fragment. *Pellis* bright yellow, context 2-4 mm thick, light yellow. *Lamellae* bright yellow in youth, becoming cinnamon from spores by maturity, adnate to subdecurrent, discharging spores onto the inner surface of the persisting veil. *Stipe* 2-7 x 2-4 mm, bright yellow, the context concolorous, exceeding the lamellae only slightly. *Odor* and *taste* mild. *Pileipellis* 3-layered: suprapellis 20-30  $\mu\text{m}$  thick, of pale yellow hyphae 5-10  $\mu\text{m}$  broad; pellis ca. 50  $\mu\text{m}$  thick, of hyaline hyphae 2-6  $\mu\text{m}$  broad; subpellis 50-60  $\mu\text{m}$  thick, of hyphae 4-7  $\mu\text{m}$  broad at septa but cells mostly inflated to 7-15  $\mu\text{m}$ . *Clamp connections* common. *Spores* ballistosporic, ellipsoid to subamygdaliform in face view, 9-12 x 5.5-6.5  $\mu\text{m}$ , pale yellowish brown, ornamented with minute warts <0.2  $\mu\text{m}$  broad and tall.

Collection examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24024, 25 April 1999 (DAR).

This colorful fungus is the only hypogeous *Dermocybe* described to date (Bougher and Trappe 2002).

Bright yellow mycelial mats in the soil with enmeshed ectomycorrhizae of associated eucalypts strongly suggest its presence (Bougher and Malajczuk 1986), but some other *Dermocybe* spp. also produce such mats. The habitat model for *D. globuliformis* (Claridge *et al.* 2000a) indicates that its occurrence is associated with cool but not wet habitats and decreases with time since last fire. Where it occurs, *D. globuliformis* is often abundant, but only one collection was found at tree line, perhaps because the tree line habitats sampled are relatively moist and had not burned for some time.

#### ***Descomyces albellus* (Masse & Rodway) Bougher & Castellano**

*Basidiomata* 5-30 mm in diam, globose to subglobose. *Peridium* white to yellow or brownish yellow, with an overlay of abundant to scattered or patchy yellow fibrilles. *Gleba* loculate, brown from the combination of the moderate brown massed spores and white trama, soft, lacking a columella. *Odor* and *taste* mild, pleasant. *Peridiopellis* with a patchy to continuous suprapellis of scattered to abundant, yellow, thick-walled hyphae 4-15  $\mu\text{m}$  broad; subpellis of hyaline, thin-walled hyphae 3-7  $\mu\text{m}$  broad, with occasional cells inflated up to 35  $\mu\text{m}$  broad. *Clamp connections* abundant in all tissues. *Spores* bilaterally symmetric, citriform to subfusiform, 13-19(-20) x 7-11(-13)  $\mu\text{m}$  excluding the ornamentation of scattered warts and short ridges 0.2-1  $\mu\text{m}$  tall, enclosed in a conspicuous, sometimes loose perisporium that does not cover the spore apex; spore walls mostly thin, brown in KOH; sterigmatal attachment smooth, truncate-cupped or torn.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24019, 25 April 1999 (DAR) and 24985, 14 Dec. 1999 (CANB); North slope of Mt. Piper, J. Trappe 25004, 6 Jan. 2000 (DAR).

*Descomyces albellus* is widely distributed across a range of habitats in Australia, from coast to high mountains. It closely resembles *D. albus* (Klotzsch) Bougher & Castellano, but that species has a subpellis of vesiculose to pyriform cells up to 35 x 17  $\mu\text{m}$ . *D. albellus* has been introduced to other continents on roots of eucalypt seedlings (Bougher and Castellano 1986, Giachini *et al.* 2000).

**Protoglossum luteum** Masee

*Basidiomata* 20 x 25 mm, subglobose to globose. *Peridium* with a gelatinous-viscid, grayish yellow to yellowish brown or dark brown, easily separable pellicle 0.5-1 mm thick. *Gleba* loculate, light brown from the combination of the moderate brown massed spores and white trama, the locules 0.2-1 mm broad and rounded to elongate, lacking a columella but sometimes with a small, white basal projection up to 3 x 3 mm. *Odor* and *taste* mild, pleasant. *Spores* bilaterally symmetric, broadly ellipsoid to subglobose, 10-13 x (7-)-8-11 µm excluding the ornamentation of rounded warts and short ridges 0.1-1.5 µm broad and tall, the walls 1-1.5 µm thick, brown in KOH; sterigmal attachment smooth, conical, ca. 2 x 2 µm.

Collections examined: *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24031, 9 May 1999 (MEL).

*Protoglossum luteum* is the type species of the genus. DNA sequence data suggest that the genus *Protoglossum* as conceived by May (1995), though within the Cortinariaceae, is polyphyletic (Peintner *et al.* 2001). Until phylogenetic relationships within the family are further resolved, however, we follow May's approach to the genus at least so far as species with a thick, separable, gelatinous pellicle are concerned.

**Protoglossum niphophilum** Trappe & Claridge

*Basidiomata* 12-20 x 10-30 mm, globose to ellipsoid. *Peridium* with a gelatinous-viscid, easily separable pellicle, silvery white with some slight violet tinged areas to lilac overall, 0.5-1 mm thick. *Gleba* loculate, rusty brown from massed spores, the trama dark brown, the locules 0.2-0.5 mm broad and rounded to elongate, lacking a columella but with a sterile, protruding, white basal pad 2-4 x 2-5 mm; 3% KOH on fresh gleba turning the trama black and spore mass dark brown. *Odor* faintly raphanoid, *taste* not distinctive. *Spores* bilaterally symmetric, ellipsoid, (11-)-12.5-14.5(-16) x 6.5-8(-9) µm excluding the ornamentation of uncrowded, minute warts and short ridges mostly <0.5 µm broad and tall but some up to 1 µm, the walls 0.5 µm thick and yellowish brown in KOH.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24013, 25 April 1999 (DAR). *Victoria*, Alpine National Park, Black Mountain Road 10.8 km E. of Rams Horn track, Claridge Site 84, J. Trappe 18134,

23 May 1996 (MEL); Mt. Hotham, track to Mt. Loch, J. Trappe 24035, 9 May 1999 (MEL).

*Protoglossum violaceum* (Masee & Rodway) T. W. May resembles *P. niphophilum* macroscopically but has smaller spores (8-10.5 x 5-7 µm).

**Protoglossum viscidum** (Masee & Rodway)

T. W. May

*Basidiomata* 8-22 x 10-28 mm, globose to subglobose. *Peridium* with a gelatinous-viscid, light brownish orange to brownish orange, readily separable pellicle 0.5-1 mm thick. *Gleba* loculate, moderate brown from massed spores, the trama dark brown, the locules 0.2-1 mm broad and rounded to elongate, with a white to rusty brown columella 2-4 µm broad terminating near the center of the gleba or sometimes constricted from there to a percurrent strand up to 1 mm broad. *Odor* faintly sweet-spicy, *taste* not distinctive. *Spores* bilaterally symmetric, ellipsoid, (13-)-14-17(-18) x (7-)-8-10 (-12) µm excluding the ornamentation of irregular warts and patches 0.5-1 x 0.2-1(-2) µm, the walls ca. 0.5 µm thick, brown in KOH; sterigmal attachment verrucose, ca. 2 x 2 µm.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge NE of Charlotte Pass, Trappe 24014, 25 April 1999 (MEL).

**Setchelliogaster australiensis** G. W. Beaton, Pegler & T. W. K. Young

*Basidiomata* 15-25 x 16-25 mm, pileate-stipitate, the margin persistently adpressed to stipe or seceded a few mm. *Peridium* at first enclosed in a thick, felty, orange-brown veil which persists on the stipe but breaks up on the pileus, which may become nearly smooth and brown or retain a patch of veil on the disc. *Gleba* sublamellate to loculate, light brown, the columella usually percurrent, 2-3 mm broad, white, extending below the gleba as a *stipe* 6-10 x 4-8 mm, the base usually broadened to subbulbous, the context white above and brown below. *Odor* and *taste* not distinctive. *Spores* bilaterally asymmetric, subfusoid to amygdaliform, 14-19 x 7-10 µm excluding the ornamentation of fine warts, the mucronate apex smooth, the walls up to 1.5 µm thick and yellowish brown in KOH.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, Trappe 24023, 25 April 1999 (CANB); Rainbow

Lake Track, Trappe 24983, 5 Dec. 1999 (CANB); Guthega, Mt. Blue Cow, Trappe 25051, 1 April 2000 (MEL); Mt. Guthrie, Trappe 25001, 6 Jan. 2000 (DAR) and Trappe 25054, 1 April 2000 (CANB). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24048, 9 May 1999 (MEL).

*Setchelliogaster* spp. can vary considerably macroscopically, from lamellate and agaric-like to loculate and strongly sequestrate (Lago *et al.* 2001). *S. australiensis*, the most frequently encountered hypogeous species at tree line in the Australian Alps, was relatively consistent in its morphology there, however. The broadening of the stipe base was not recorded in the original description by Beaton *et al.* (1985).

## Russulaceae

### *Cystangium polychromum* Trappe & Claridge

*Basidiomata* 5-22 x 7-30 mm, pulvinate to subglobose, the base often radially rugose, the margin of the gleba free of the stipe and initially adpressed to it, later seceded or sometimes becoming plane to upturned. *Peridium* pale yellow to grayish yellow above, concolorous or sometimes white below, in youth blushed rose and becoming mottled rose to reddish purple or very dark purplish red on the disc or those colors overall or mottled with deep yellow, glabrous, context white, thin except on disc, fragile. *Gleba* of contorted and folded lamellae, often intervenose and becoming subloculate, initially white but becoming brownish white to pale yellow by maturity; stipe-columella percurrent, white, 10-20 x 2-4 mm, the stipe exceeding the gleba only slightly or not at all. *Odor* and *taste* mild. *Peridiopellis* 1-2 layered, with an inconspicuous suprapellis overlying an epithelium of 3-6 tiers of cells inflated up to 45 x 25  $\mu\text{m}$ , the pigmented areas initially bright red in KOH but the color soon fading; context with abundant nests of sphaerocysts. *Hymenium* with abundant, conspicuous, clavate to cylindrical or mucronate, hyaline cystidia 75-120 x 12-23  $\mu\text{m}$ , usually containing granules near the apex, greatly exceeding the basidia. *Spores* subglobose to ellipsoid, (7.5-)9-12 x 7-11  $\mu\text{m}$  excluding ornamentation, symmetrical to subsymmetrical, the walls amyloid, the ornamentation of irregularly amyloid, robust, isolated spines 1-2(-3) x 0.2-1  $\mu\text{m}$  tall, sometimes in clusters of 2-3 fused

at the base; plage inconspicuous or absent; sterigmal appendage ca. 2 x 1.5  $\mu\text{m}$ , sometimes with an amyloid collar.

Collections examined: *New South Wales*, Kosciuszko National Park, Guthega, Mt. Blue Cow, J. Trappe 24996, 24999 and 25050, 1 April 2000 (Mel, OSC); Mt. Guthrie, 6 Jan. 2000 (MEL, OSC); Smiggin Holes, J. Trappe 24986, 14 Dec. 1999 (MEL).

*Cystangium polychromum* resembles *C. sessile* in most microscopic respects, but the pileus of *C. sessile* at most secedes only slightly from the stipe and shows only a faint red blush after exposure, in contrast to *C. polychromum*, which has a pileus that may expand to plane or concave and early develops strong, red to purple pigmentation in the pileipellis. Both species were found in Kosciuszko National Park in the same, general localities, and no intergradations in these characters were found between colonies of the two.

### *Cystangium seminudum* (Masse & Rodway in Masse) T. Lebel & Castellano

*Basidiomata* 10-30 x 10-35 mm, subglobose, the base often radially rugose. *Peridium* completely enclosing the gleba, white to ivory, sometimes with brown patches, minutely pubescent-verrucose but often becoming glabrous. *Gleba* with small, irregular locules, initially white but becoming cream color by maturity; stipe lacking, columella lacking or rudimentary and then white and 1-3 mm broad. *Odor* faintly chlorinateous or mild; *taste* mild. *Peridiopellis* 2-layered, with a narrow suprapellis of tangled, repent to erect, hyaline hyphae 3-5  $\mu\text{m}$  broad overlying an epithelium of 5-8 tiers of cells inflated up to 20 x 17  $\mu\text{m}$ ; context with scattered to abundant nests of sphaerocysts. *Hymenium* with abundant, conspicuous, clavate to cylindrical or ventricose, hyaline cystidia with rostrate to mucronate or obtuse apices, 55-100 x 10-15  $\mu\text{m}$ , often containing granules near the apex, greatly exceeding the basidia. *Spores* globose, 8-11.5(-13.5)  $\mu\text{m}$  broad excluding the ornamentation of strongly amyloid, robust, isolated spines and rods 1-1.5  $\mu\text{m}$  tall, sometimes in clusters of 2-3; plage inconspicuous; sterigmal appendage ca. 2 x 1  $\mu\text{m}$ .

Collections examined: *New South Wales*, Kosciuszko National Park, Guthega, Mt. Blue Cow, Trappe 25052, 1 April 2000 (CANB); Rainbow Lake Track, J. Trappe 24978, 5 Dec. 1999 (MEL); Rainbow Lake, J.

Trappe 24981, 5 Dec. 1999 (CANB). Victoria, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24033, 24036, 24028, 24043 and 24046, 9 May 1999 (MEL).

*Cystangium seminudum* is the most common hy-pogeous member of the Russulaceae in middle to high elevations of south-eastern mainland Australia and Tasmania (Lebel 2003a). At tree line it fruited in summer and autumn at Kosciuszko National Park and autumn in Alpine National Park.

***Cystangium sessile* (Masse & Rodway) Singer & A. H. Sm.**

*Basidiomata* 5-32 x 6-40 mm, globose to subglobose, the base often radially rugose, the margin of the gleba free of the stipe and adpressed to it or slightly seceded. *Peridium* white to ivory or pale yellow, in age sometimes with brown patches or blushed pale red on exposure, glabrous. *Gleba* of contorted and folded lamellae irregularly joined by cross-walls to form elongated to convoluted chambers, initially white but becoming pale yellow by maturity; stipe-columella sometimes lacking but usually truncate to percurrent, white, 0.5-4 mm broad, the stipe exceeding the gleba only slightly or not at all. *Odor* and *taste* mild. *Peridiopellis* 2-layered, with an inconspicuous suprapellis of septate, hyaline hyphae 5-17 µm broad overlying an epithelium of 3-6 tiers of cells inflated up to 39 x 22 µm; context with abundant nests of sphaerocysts. *Hymenium* with abundant, conspicuous, clavate to cylindrical or ventricose, hyaline cystidia 48-133 x 12-25 µm, usually containing granules near the apex, greatly exceeding the hymenium. *Spores* subglobose to globose, 8-11 µm broad excluding ornamentation, symmetrical to sub-symmetrical, the walls amyloid, the ornamentation of irregularly amyloid, robust, isolated spines 1-1.5 µm tall, not crowded, sometimes in clusters of 2-3 fused at the base; plage inconspicuous or absent; sterigmal appendage ca. 2 x 1.5 µm, sometimes with an amyloid collar.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24017, 25 April 1999 (DAR). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24037, 9 May 1999 (MEL).

The type of the genus *Cystangium*, *C. sessile*, is widely distributed in both mainland Australia and Tasmania from near sea level to the upper tree line

(Lebel 2003). A habitat model developed for it (Claridge *et al.* 2000a) indicates an association with relatively cool sites.

***Gymnomyces eburneus* T. Lebel**

*Basidiomata* 10-24 x 10-28 mm, the base often indented and radially rugose. *Peridium* white to ivory, sometimes with brown patches, glabrous to minutely verrucose, completely enclosing the gleba. *Gleba* with small, crowded locules, initially white but becoming pale yellow by maturity; stipe and columella lacking, but an inconspicuous, white basal pad 1 x 1 mm sometimes present. *Odor* faintly raphanoid or mild; *taste* mild. *Peridiopellis* of loosely interwoven hyphal tips emerging from the context of hyaline, interwoven hyphae 2-3.5 µm broad. *Hymenium* with inconspicuous, clavate, hyaline cystidia 20-45 x 10-15 µm, not exceeding the hymenium. *Spores* globose, 8-9.5 µm broad excluding the ornamentation of crowded, amyloid, sometimes curved, isolated spines and rods 1-2.5 µm tall; plage absent.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, Trappe 24016, 25 April 1999 (MEL); Rainbow Lake Track, J. Trappe 24982, 5 Dec. 1999 (MEL). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24034, 24042 and 24044, 9 May 1999 (MEL).

*Gymnomyces eburneus* is widely distributed in south-eastern mainland Australia (Lebel 2003b).

***Zelleromyces claridgei* Trappe**

*Basidiomata* 5-20 mm broad, subglobose, even to lobed and furrowed. *Peridium* medium orange to dark brownish orange, glabrous. *Gleba* loculate, pale orange to brownish orange, when fresh and moist exuding a whey-like latex. *Odor* and *taste* mild to slightly farinaceous. *Peridiopellis* with a weakly to well developed epithelium of 3 to 5(-6) tiers of cells inflated up to 20 µm broad; subpellis of interwoven hyphae 3-5 µm broad with scattered to abundant laticiferous hyphae. *Hymenium* with scattered to rare cystidia up to 50 x 6 µm, tapered to an obtuse tip, often not exceeding the hymenium. *Spores* subglobose to globose, 6-9 µm broad excluding ornamentation, the walls weakly amyloid, the ornamentation mostly 1 µm tall at maturity, zebroid, of more or less parallel ridges 0.2-0.7 µm broad, some of which encircle the spore, others

being short lines, usually one or two of the encircling ridges more prominent than the others, often with some short lines at angles to the main ornamentation; plage inconspicuous or absent; sterigmal appendage ca.  $1 \times 1 \mu\text{m}$ , often with amyloid spots or an amyloid collar.

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24015, 25 April 1999 (DAR). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24030, 24032 and 26124, 9 May 1999 (MEL).

This species, one of several glabrous, orange members of the genus, resembles *Zelleromyces striatus* (G. H. Cunningham) G. W. Beaton, Pegler & T. W. K. Young in its combination of orange coloration and distinctive, zebroid spore ornamentation. However, *Z. striatus* has a peridiopellis of narrow, interwoven hyphae (Beaton *et al.* 1984) rather than the epithelium of inflated cells characteristic of *Z. claridgei*, which is widely distributed in eastern Victoria and south-eastern New South Wales (Trappe and Claridge 2003). The species is named in honor of Dr. Andrew Claridge, who collected the holotype and many other collections of this species in the Australian Alps.

#### ***Zelleromyces corkii* Trappe & Claridge**

*Basidiomata* 3-20 mm broad, subglobose. *Peridium* pale to medium orange, glabrous. *Gleba* loculate, pale orange, when fresh and moist exuding a whey-like latex. *Odor* and *taste* mild. *Peridiopellis* of interwoven, hyaline hyphae 2-5  $\mu\text{m}$  broad, at the surface loosely tangled and with occasional cells inflated up to  $12\mu\text{m}$ ; laticiferous hyphae present but inconspicuous. *Cystidia* scattered, tapered and often acicular, 40-55  $\times$  2-5  $\mu\text{m}$ , substantially exceeding the hymenium. *Spores* globose, 6-7(-9)  $\mu\text{m}$  broad, the walls weakly amyloid, the ornamentation a complete to mostly complete, irregular, amyloid reticulum ca. 0.2  $\mu\text{m}$  tall, with some isolated amyloid spots and short side branches; plage inconspicuous or absent; sterigmal appendage ca.  $2 \times 1 \mu\text{m}$ .

Collection examined: *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 26126, 9 May 1999 (MEL).

Another member of the "orange complex" of *Zelleromyces* spp. in Australia, *Z. corkii*, differs from the others in having small, reticulate spores and an epithelial peridiopellis. It is named in honor of Dr.

Steven J. Cork, a collector of hypogeous fungi, who has particularly studied the value of these fungi in the nutrition of small mammals in Australia and the United States.

#### ***Zelleromyces daucus* G. W. Beaton, Pegler & T. W. K. Young**

*Basidiomata* 5-20 mm diam, subglobose. *Peridium* pale to medium orange, glabrous, translucent when moist. *Gleba* loculate, pale orange to light brownish orange, when fresh and moist exuding a whey-like latex. *Odor* and *taste* mild. *Peridiopellis* with a well developed epithelium of 4 to 6 tiers of rounded cells 10-30  $\mu\text{m}$  broad; subpellis of interwoven hyphae 3-5  $\mu\text{m}$  broad with scattered to abundant laticiferous hyphae. *Cystidia* lacking. *Spores* subglobose to globose, 6-10  $\mu\text{m}$  broad, the walls amyloid, the ornamentation a complete to mostly complete, strongly amyloid reticulum 1-2.5  $\mu\text{m}$  tall; plage inconspicuous or absent; sterigmal appendage ca.  $2 \times 1 \mu\text{m}$ .

Collections examined: *New South Wales*, Kosciuszko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24018 and 24021, 25 April 1999 (CANB). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 24029 and 26126, 9 May 1999 (MEL).

Yet another of the "orange complex" of *Zelleromyces*, *Z. daucus*, differs from the others by its tall, strongly amyloid, completely reticulate spore ornamentation. It is widely distributed in eastern Victoria and south-eastern New South Wales (Claridge and Trappe, unpubl.).

### **Tricholomataceae**

#### ***Hydnangium carneum* Wallr.**

*Basidiomata* 5-25 mm in diam., subglobose to irregular, with a basal attachment of hyphae and clinging soil. *Peridium* pale to medium pink or brownish pink, felty. *Gleba* loculate, pink, often with a white sterile basal pad or irregular columella. *Odor* and *taste* mild. *Peridiopellis* of interwoven hyphae 2-12  $\mu\text{m}$  broad, clamp connections present. *Spores* subglobose to globose, hyaline, 12-17  $\mu\text{m}$  broad excluding the ornamentation of hyaline cones and spines 0.5-1  $\mu\text{m}$  broad and tall; sterigmal appendage 1.5-2  $\times$  0.5-1  $\mu\text{m}$ .

Collections examined: *New South Wales*, Kosciusz-



zko National Park, Kangaroo Ridge SW of Charlotte Pass, J. Trappe 24021, 25 April 1999 (CANB). *Victoria*, Alpine National Park, Mt. Hotham, track to Mt. Loch, J. Trappe 22029, 9 May 1999 (MEL).

*Hydnangium carneum* is a widely distributed,

ectomycorrhizal hypogeous fungus associated with eucalypts in Australia, although it is not common everywhere (Claridge *et al.* 2000a and 2000b and unpublished data). *Hydnangium* is a sequestrate relative of the mushroom genus *Laccaria*.

## Key to hypogeous fungi at tree line

- |   |                                 |
|---|---------------------------------|
| 1. Peridium a gelatinous-viscid pellicle 0.5-1 mm thick   | 2                               |
| 1. Peridium dry to moist but not a gelatinous-viscid pellicle   | 4                               |
| 2. Peridium silvery white to violet   | <i>Protoglossum niphophilum</i> |
| 2. Peridium grayish yellow to dark brown or orange brown  | 3                               |
| 3. Spores 10-13 x (7-)8-11 µm excluding ornamentation   | <i>Protoglossum luteum</i>      |
| 3. Spores (13-)14-17(-18) x (7-)8-10(-12) µm excluding ornamentation  | <i>Protoglossum viscidum</i>    |
| 4 (1). Peridium pink to grayish pink; spores nonamyloid, ornamented with hyaline spines   | <i>Hydnangium carneum</i>       |
| 4. Peridium white to yellow, orange or brown, if pink tinged, the spores amyloid, variously ornamented or smooth                            | 5                               |
| 5. Peridium orange and glabrous; gleba exuding a whey-like latex; spore ornamentation amyloid   | 6                               |
| 5. Peridium white, yellow, red, purple or brown; gleba not exuding a latex; spores smooth or with either amyloid or inamyloid ornamentation | 8                               |
| 6. Spores ornamented with ±parallel ridges (zebroid)  | <i>Zelleromyces claridgei</i>   |
| 6. Spores ornamented with a reticulum   | 7                               |
| 7. Peridium an epithelium of inflated cells; spore ornamentation 1-2.5 µm tall  | <i>Zelleromyces daucinus</i>    |
| 7. Peridium of interwoven hyphae, with scattered, inflated cells; spore ornamentation ca. 0.2 µm tall                                       | <i>Zelleromyces corkii</i>      |
| 8 (5). Peridium white, often with blue-tinged areas and slowly turning light blue overall when exposed                                      | <i>Chamonixia</i> sp.           |
| 8. Peridium some other color or, if white, not staining blue  | 9                               |
| 9. Spores with amyloid ornamentation  | 10                              |
| 9. Spores smooth or ornamentation nonamyloid  | 13                              |
| 10. Peridium grayish yellow with pink, red, or purple mottling or those colors overall  | <i>Cystangium polychromum</i>   |
| 10. Peridium white to yellow or tinged at most faintly red  | 11                              |
| 11. Gleba of crowded and contorted lamellae   | <i>Cystangium sessile</i>       |
| 11. Gleba of small locules  | 12                              |

12. Peridium an epithelium of inflated cells *Cystangium seminudum*  
 12. Peridium of interwoven hyphae *Gymnomyces eburneus*
- 13 (9). Basidiomata with a stipe 14  
 13. Basidiomata lacking a stipe 16
14. Basidiomata bright yellow *Dermocybe globuliformis*  
 14. Basidiomata brown 15
15. Spores 9-12 x 5.5-6.5 µm; basidiomata lamellate *Cortinarius debbiae*  
 15. Spores 14-19 x 7-10 µm; basidiomata sublamellate to loculate *Setchelliogaster australiensis*
- 16 (13). Spores brown, the ornamentation of scattered warts and short ridges 0.2-1 tall *Descomyces albellus*  
 16. Spores hyaline or nearly so, smooth or minutely rugulose 17
17. Gleba brown; spores 11-14 x 7-9 µm *Gallacea subalpina*  
 17. Gleba grayish olive to green, spores 8-10 x 3-4 µm *Hysterangium gardneri*

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