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## KEYS TO THE TASMANIAN FAMILIES AND GENERA OF GILLED FUNGI

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### INTRODUCTION

The taxonomy of the macrofungi of Tasmania has, in comparison with the members of the Plant Kingdom, been largely neglected. The higher flora of Tasmania has had a comprehensive treatment dating back to Rodway (1903). The bryophytes (mosses and liverworts) also received attention in a series of papers and booklets issued by the Royal Society of Tasmania beginning with Bastow (1886-1888); and interest in the study of lichens was also shown in the 19th century (Wilson 1893). There is a conspicuous absence of any concerted taxonomic effort for fungi in both the 19th and 20th centuries. Leonard Rodway, as a keen collector and observer of natural history, might have been expected, as Government Botanist, to study the macrofungi. However, he appears to have confined his written output to about a dozen short papers published between 1898-1929 (see May and Wood, 1997, for a list of these).

A consequence of this neglect of systematics is that there do not appear to be any keys available to Tasmanian macrofungi which would enable interested parties, whether they be amateur naturalists, Landcare project participants or professionals such as ecologists, forest managers, plant pathologists, medical practitioners, etc., to classify a given collection to the level of family and genus. For most collections, it would be difficult to go beyond determining the correct genus, since the vast majority of Australian macrofungi have been neither named nor described. Wood (1979) produced a key to the gilled fungi of Australia (Order Agaricales) but that work was based mainly on material collected in New South Wales and did not group the genera into families.

### BOUNDARIES OF THE FAMILIES AND GENERA OF AGARICS

There has been considerable controversy amongst taxonomists as to which families and genera should be included in the Agaricales. Thus, R. Singer, arguably the most notable agaricologist of his day, included the families Polyporaceae and Boletaceae, which generally have tubes with pores rather than lamellae for their

spore-bearing surfaces (Singer 1986). Other taxonomists vary in the extent to which they agree with him. In addition to this, the study of ribosomal DNA in fungal genes is resulting in profound changes in the taxonomy of the Agaricales. For example, as a result of recent molecular phylogenetic research, the genus *Coprinus* has been reduced to a handful of species and transferred to the Agaricaceae, with the majority of species shifted to three other genera, viz. *Coprinellus*, *Coprinopsis* and *Parasola*, which are part of a newly proposed family Psathyrellaceae (Redhead *et al.* 2001).

Other taxonomic upheavals which are supported by molecular research include the notions that (1) *Lentinus* is more closely related to polypores than to other gilled fungi (Hibbett and Vilgalys 1991), (2) the white-spored family Lepiotaceae is closer to the dark-spored families Agaricaceae and the new Psathyrellaceae (see above) than to other white-spored families (Moncalvo *et al.* 2000), and (3) the Russulaceae is sufficiently far removed from the Agaricales to be placed in a separate order (see Hawksworth *et al.* 1995). In Australia, the use of restriction fragment length polymorphisms and more sophisticated molecular techniques is aiding the clarification of generic and subgeneric relationships, for example, in *Cortinarius* and *Dermocybe* (Chambers *et al.* 1999). Nevertheless, it is still early days in the use of these advanced techniques and there may be surprises yet to come. Redhead (2001) has cautioned against a premature adoption of the proposed name changes, recommending a "wait and see" attitude while data are accumulated and theories are tested. In this study, we choose a conservative taxonomic approach and use, in most instances, the traditionally accepted names for families and genera.

Opinions about the generic positions in families of the Agaricales change continually, making decisions difficult as to which family to include some genera. For example, *Tubaria* has been placed variously in the Crepidotaceae, the Strophariaceae and the Cortinariaceae (Singer 1986; Grgurinovic 1997; Bougher and Syme 1998), depending upon the emphasis placed upon the various macroscopic and microscopic characters. The use of modern techniques of molecular biology may or may not resolve these arguments.

The authors have chosen to adopt, with some minor modifications, the classification scheme for genera within families of Bougher and Syme (1998), who mostly follow the eighth edition of the Dictionary of the Fungi (Hawksworth *et al.* 1995). That limits the Agaricales to 16 families, of which 15 (all but Gomphidiaceae) occur in Australia (see Bougher and Syme 1998, table 10). Mycologists have

described more genera than those dealt with in this paper, some of which may contain only a single species or a handful of species, whereas other mycologists recognise fewer genera in some families. For example, in Entolomataceae, the five genera listed in Table 5 are probably the ones most likely to be encountered. Another genus, *Alboleptonia*, is sometimes used, e.g. by Bougher and Syme (1998, pp. 222-3). On the other hand, some authors (e.g. Singer 1986) recognise only three genera in this family, viz. *Entoloma*, *Clitopilus* and *Rhodocybe*, these genera having widely different spore shape and/or ornamentation.

Hygrophoraceae is another example of disagreement amongst mycologists. Some authors, e.g. Young and Wood (1997), recognise only a few genera, these being *Hygrophorus* (which may be limited to a single species, viz. *H. involutus*, in Tasmania), *Hygrocybe* (for the vast majority of species within the family) and *Camarophyllopsis* (= *Hygrotrama*, which accommodates a small number of species with a pileipellis that is almost cellular in nature). Conversely, some mycologists (e.g. Horak 1990) split *Hygrocybe* into segregate genera such as *Bertrandia*, *Camarophyllus*, *Gliophorus*, *Humidicutis*, and several others.

## THE KEYS

Since the aim here is to provide keys to help the reader identify a given collection to the level of genus, the first step is to determine its correct family. All of the keys are to be seen as "Artificial Keys", i.e. intended to bring the user to the correct family and genus without making any statement about phylogeny. The family and genus to which a species belongs should be recognised primarily by the physical appearance of the fruit body, rather than by the DNA content of the genome. Thus, a *Tricholoma* should be identified by its tricholomatoid habit, its white spore mass, and its lack of an annulus (for almost all species). We recognise, however, that macroscopic features cannot give a complete story, and we have included two microscopic characteristics, viz. the type of pleurocystidia, if present, and whether the spores have a germ pore.

The keys to the families as presented here are summarised in four tables, viz. Table 1 for spore print colour, Table 2 for species having velar remnants, Table 3 for species having an obvious germ pore in the spore wall, and Table 4 for species with pleurocystidia. Use of Tables 1 and 2 relies upon macroscopic characters that may be observed with the naked eye or with a hand lens, while use of Tables 3 and 4 requires a good compound microscope. The taking of a spore print from a mature fruiting body is a routine and important aid in taxonomy both for the novice

and for the experienced. It was at one time almost the sole basis for classification, being the cornerstone of the system devised in the 19<sup>th</sup> century by the “father of mushroom taxonomy”, Elias Fries, who became Professor of Systematic Botany at Uppsala University, Sweden. Although nowadays it is only one of the tools available, it is still an important indicator of the correct family position, recognised by Singer (1986), who devotes the opening pages to this character.

The presence of partial veil remnants such as an annulus on the stipe can be a useful indicator of family, as can the remains of a universal veil, especially if it leaves a volva at the base of the stipe. Whilst spore shape, size and ornamentation are critical aids to correct identification, the presence or absence of an obvious germ pore helps narrow the range of choices. The shape, size and nature of the cheilocystidia and pleurocystidia offer additional tools for correct identification. We choose here to base Table 4 on the pleurocystidia, since these are often more obvious than the cheilocystidia.

After keying to the correct family using Tables 1-4, the reader may then employ Table 5 to determine the correct genus, taking into account the following considerations. Different authors treat Crepidotaceae very variably. Some include *Gymnopilus*, *Galerina* and *Tubaria* in this family (e.g. Courtecuisse and Duhem 1995). In this paper we include only the genus *Crepidotus*, which has a pleurotoid habit, i.e., occurring on wood with a reduced or absent stipe. In the family Paxillaceae, the genus *Tapinella* is sometimes recognised, e.g. by Grgurinovic (1997) and Bougher and Syme (1998), but we follow Singer (1986), who places it in synonymy with *Paxillus*. We have placed the ochraceous-spored *Ripartites* in the family Cortinariaceae, following Largent and Baroni (1988), but other authors (e.g. Courtecuisse and Duhem 1995) put it into the Tricholomataceae. We have also chosen to put *Tubaria* in the Cortinariaceae. Although Largent and Baroni (1988) place *Pseudobaeospora* in the Lepiotaceae, we follow Courtecuisse and Duhem (1995) and Bas (1995) in putting it into the Tricholomataceae.

A glossary of mycological terms is given in the Appendix. Additional definitions may be found in mycological dictionaries, e.g. Snell and Dick (1971) and Ulloa and Hanlin (2000). As the colour of fungi may be an ambiguous character, colour charts are useful. A commonly used one is Kornerup and Wanscher (1978).

TABLE 1

## Key to the families of Agaricales in Tasmania, based on spore print colour

- 1.a) Spore print white (or buff, ochraceous or a shade of lilac) 2
- 1.b) Spore print darker than white (i.e. some shade of pink, brown or black, including purple-brown and purple-black) 7
- 2.a) Universal veil leaving remnants in the form of warts or patches on pileus and/or forming a volva at base of stipe **Amanitaceae**
- 2.b) Neither warts nor volva present 3
- 3.a) Veil present, usually forming an annulus on the stipe, or if not, then stipe scaly below the veil; lamellae typically free from the stipe **Lepiotaceae**
- 3.b) Veil absent, or if present, then lamellae not free 4
- 4.a) Lamellae and/or flesh exuding latex when cut or broken and/or stipe snapping like chalk when pressure is applied; pileus and stipe tissue containing rounded cells called sphaerocysts; spores globose to subglobose with amyloid warts or ridges **Russulaceae**
- 4.b) Not combining the above features 5
- 5.a) Lamellae with a waxy feel or texture, thick and distant; basidia length at least 5.5 times the spore length **Hygrophoraceae**
- 5.b) Lamellae not normally waxy; ratio of basidia length to spore length generally less than 5.5 6
- 6.a) Lamellae decurrent, close, usually forked dichotomously, typically some shade of orange or yellow; pileus and stipe also with some shade of orange or yellow **Hygrophoropsidaceae**
- 6.b) Lamellae various, and if decurrent, not repeatedly forked **Tricholomataceae**
- 7.a) Spore print pink (or may approach sordid reddish) 8
- 7.b) Spore print darker than pink (i.e. some shade of brown or black) 10
- 8.a) Lamellae free at maturity; spores not angled **Pluteaceae**
- 8.b) Lamellae attached at maturity; spores angled or not 9
- 9.a) Spores lacking angles **Tricholomataceae**
- 9.b) Spores angled, either in side view or end view (may be bumpy, warted or ridged when seen in side view) **Entolomataceae**
- 10.a) Lamellae free from stipe; spore print deep brown, chocolate-brown or purple-brown **Agaricaceae**
- 10.b) Lamellae not free; spore print some shade of brown or black, including purple-brown and purple-black 11

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11.a) Stipe absent or much reduced, usually growing shelf-like on wood; spore print brown or cinnamon-brown	<b>Crepidotaceae</b>
11.b) Stipe present; on wood or soil; spore print a darker shade of brown or black	12
12.a) Pileipellis typically cellular; spores usually smooth, typically having a germ pore	13
12.b) Pileipellis typically filamentous (but may be hymeniform, as in <i>Descolea</i> ); spores smooth or ornamented, and may or may not have a germ pore	14
13.a) Spore print medium brown	<b>Bolbitiaceae</b>
13.b) Spore print deep brown to black or purplish brown	<b>Coprinaceae</b>
14.a) Lamellae typically decurrent, often forked or with cross-veins or pores near the stipe; annulus absent	<b>Paxillaceae</b>
14.b) Lamellae rarely decurrent, neither forked nor veined nor with pores near the stipe; annulus sometimes present	15
15.a) Spores mostly elliptical and smooth, typically with a germ pore, although sometimes difficult to discern	<b>Strophariaceae</b>
15.b) Germ pore absent	<b>Cortinariaceae</b>

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TABLE 2

**Key to the families of Agaricales in Tasmania, for species having velar remnants**

1.a) Remnants of partial veil prominent, generally thick, forming a membranaceous annulus on the stipe, sometimes distinctly flaring, persistent	2
1.b) Remnants of partial veil not membranaceous, often fleeting, although they may be prominent, as in various cortinate veils	9
2.a) Spore print white or yellowish cream	3
2.b) Spore print some shade of brown, black, purple-brown or purple-black	6
3.a) Annulus accompanied by a volva in the form of a sack, collar, concentric scales, a free rim or a swollen, spongy base to stipe	<b>Amanitaceae</b>
3.b) Fruiting body lacking a volva at base of stipe	4
4.a) Stipe with lower portion covered by mealy scales	<b>Tricholomataceae: <i>Cystoderma</i></b>
4.b) Stipe without mealy scales	5
5.a) Lamellae typically free	<b>Lepiotaceae</b>
5.b) Lamellae attached	<b>Tricholomataceae: <i>Armillaria</i></b>

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- 6.a) Lamellae free; spore print chocolate brown; pileipellis filamentous  
**Agaricaceae**
- 6.b) Lamellae attached; spore print various shades of brown or black 7
- 7.a) Spores smooth, with a germ pore 8
- 7.b) Spores neither smooth nor with a germ pore  
**Cortinariaceae: *Rozites* and *Descolea***
- 8.a) Fruiting body autodigesting to form an inky residue  
**Coprinaceae: *Coprinus***
- 8.b) Fruiting body not autodigesting **Bolbitiaceae: *Agrocybe* and *Conocybe***
- 9.a) Spores typically with a germ pore, although it may appear to be indistinct  
**Strophariaceae**
- 9.b) Spores lacking a germ pore 10
- 10.a) Spores oblong, walls minimally ornamented  
**Cortinariaceae: *Galerina* and *Tubaria***
- 10.b) Spores amygdaliform, walls variously ornamented, ranging from minimally to coarsely warted  
**Cortinariaceae: *Gymnopilus* and *Cortinarius* (incl. *Democybe*)**
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TABLE 3

Key to the families of Agaricales in Tasmania, for species having spores with an obvious germ pore

- 1.a) Spore print white **Lepiotaceae**
- 1.b) Spore print some shade of brown or black, including purple-brown and purple-black 2
- 2.a) Pileipellis typically filamentous 3
- 2.b) Pileipellis cellular 4
- 3.a) Lamellae free (or nearly free) at maturity **Agaricaceae**
- 3.b) Lamellae attached, usually adnate to adnexed, rarely decurrent  
**Strophariaceae**
- 4.a) Spore print dull brown, medium brown, cinnamon-brown or rusty brown, never a deep brown or purple-brown or purple-black **Bolbitiaceae**
- 4.b) Spore print deep brown to black or purple-brown or purple-black  
**Coprinaceae**



TABLE 4

## Key to the families of Agaricales in Tasmania, for species with pleurocystidia

- 1.a) Pleurocystidia metuloidal 2
- 1.b) Pleurocystidia, if present, not metuloidal 4
- 2.a) Metuloids often with a crown of blunt projections; spore print pink  
**Pluteaceae: *Pluteus***
- 2.b) Metuloids often with apical encrustations of crystals; spore print white or brown 3
- 3.a) Fruiting body lacking a stipe, or with a lateral or strongly eccentric stipe; pileus with a gelatinised layer; spore print white  
**Tricholomataceae: *Hohenbuehelia***
- 3.b) Fruiting body with a central stipe, pileus usually fibrillose, spore print brown  
**Cortinariaceae: *Inocybe***
- 4.a) Pleurocystidia as chrysocystidia (yellowing in alkaline reagents) 5
- 4.b) Pleurocystidia, if present, not chrysocystidia 7
- 5.a) Fruiting body with veil, generally forming an annulus  
**Strophariaceae: *Stropharia***
- 5.b) Veil may be present in young specimens, but not generally forming an annulus 6
- 6.a) Spore print purple-brown to purple-black; germ pore obvious  
**Strophariaceae: *Hypoloma***
- 6.b) Spore print paler, dull brown, cinnamon-brown to rusty brown; germ pore often indistinct  
**Strophariaceae: *Pholiota***
- 7.a) Pleurocystidia may occur in some form, including gloeocystidia (containing oily contents) or pseudocystidia (originating below the hymenium) or thin-walled cystidia, in some species of some genera in the families **Bolbitiaceae, Coprinaceae, Cortinariaceae, Entolomataceae, Lepiotaceae, Paxillaceae, Russulaceae, Strophariaceae and Tricholomataceae.**
- 7.b) Pleurocystidia are generally absent in the families **Agaricaceae, Amanitaceae, Hygrophoraceae, Hygrophoropsidaceae and Crepidotaceae.**

**TABLE 5**  
**Key to Genera of Agaricales in Tasmania**

**Agaricaceae**

- 1.a) Spores brown under the microscope, smooth *Agaricus*  
 1.b) Spores pale umber or sepia under the microscope, finely punctate; pileus and stipe granular-mealy *Melanophyllum*

**Amanitaceae**

- Pileus usually with warts (remnants of universal veil), dry or slightly viscid; stipe neither viscid nor glutinous *Amanita*

**Bolbitiaceae**

- 1.a) Fruiting body small to medium-sized; pileus often cracked at maturity; stipe usually pliant *Agrocybe*  
 1.b) Fruiting body small; pileus not cracking; stipe usually slender, fragile and hollow 2  
 2.a) Pileus viscid, margins striate; stipe white (rarely pink) throughout; annulus absent *Bolbitius*  
 2.b) Pileus dry, often conical or campanulate; stipe often coloured, sometimes with a moveable annulus *Conocybe*

**Coprinaceae**

- 1.a) Lamellae parallel-sided, crowded, autodigesting *Coprinus*  
 1.b) Lamellae wedge-shaped, close, not autodigesting 2  
 2.a) Spores discolouring in concentrated H<sub>2</sub>SO<sub>4</sub>; usually wood-inhabitants *Psathyrella* and *Lacrymaria*  
 2.b) Spores not discolouring in H<sub>2</sub>SO<sub>4</sub>; usually on dung, enriched soil or grass; lamellae often mottled *Paneolus*

**Cortinariaceae**

- 1.a) Spore print dull brown, tobacco brown, milk-coffee brown or ochraceous brown, but not rusty brown 2  
 1.b) Spore print rusty brown (although some species of *Cortinarius* may have pale brown or yellow-brown spores) 8  
 2.a) Stipe radicating, the base swollen, then gradually tapering; lamellae deeply adnexed to free, often with lilac hues *Phaeocollybia*  
 2.b) Stipe not radicating; lamellae more distinctly attached 3  
 3.a) Spore print ochraceous or some shade of light brown 4  
 3.b) Spore print some shade of dull brown or medium brown 7

- 4.a) Spores globose or subglobose, spiny *Ripartites*  
 4.b) Spores oblong, amygdaliform or phaseoliform, surface smooth or warty 5
- 5.a) Hyphae of the pileipellis forming a cutis *Tubaria*  
 5.b) Pileipellis hymeniform, or of cellular structure to some degree 6
- 6.a) Stipe with a loose, striate annulus; spores warty-rough *Descolea*  
 6.b) Stipe lacking an annulus; spores smooth *Simocybe*
- 7.a) Pileus usually dry, pileipellis fibrillose, radially cracked or with upturned scales; lamella edge usually paler than lamella face due to cystidia; spores smooth or nodulose *Inocybe*  
 7.b) Pileus usually viscid; spores usually warty-rough, with a callus at the apex *Hebeloma*
- 8.a) Typically on wood 9  
 8.b) Terrestrial, rarely or never directly on wood (except for *Galerina patagonica*) 10
- 9.a) Spores minimally ornamented; fruiting body fragile, on twigs and small branches *Phaeomarasmium*  
 9.b) Spores usually distinctly warty; fruiting body more substantial, on logs and stumps *Gymnopilus* (incl. *Pyrrhoglossum*)
- 10.a) Lamellae adnexed to adnate; cheilocystidia always present *Galerina*  
 10.b) Lamellae usually emarginate; cheilocystidia typically absent or inconspicuous 11
- 11.a) Partial veil membranaceous *Rozites*  
 11.b) Partial veil absent, or if present, cortinate 12
- 12.a) Partial veil absent; pileus and stipe usually squamose or squamulose *Cuphocybe*  
 12.b) Partial veil cortinate; pileus rarely squamulose *Cortinarius* and *Dermocybe*

**Crepidotaceae**

- Stipe absent or much reduced, usually growing shelf-like on wood; spore print usually brown or cinnamon-brown *Crepidotus*

**Entolomataceae**

- 1.a) Stipe lateral, reduced or absent; largely wood-inhabitants *Claudopus*  
 1.b) Stipe present, usually central; on soil or wood debris 2  
 2.a) Spores angular in end view only; lamellae usually adnate to decurrent 3  
 2.b) Spores angular in side view; lamellae variously attached 4

- 3.a) Spores longitudinally ridged in side view *Clitopilus*  
 3.b) Spores warty or bumpy in side view *Rhodocybe*  
 4.a) Pileus scaly or hairy and base of stipe strigose *Pouzarella*  
 4.b) Not combining the above features *Entoloma*

### Hygrophoraceae

- 1.a) Pileipellis of inflated hyphae arranged in a hymeniform layer or palisade, usually dry *Camarophyllopsis*  
 1.b) Pileipellis of non-inflated hyphae, viscid or not 2  
 2.a) Pileus viscid, stipe dry; lamellar trama divergent *Hygrophorus*  
 2.b) Pileus and stipe variably dry to viscid; lamellar trama regular to irregular *Hygrocybe*

### Hygrophoropsidaceae

- Spore print white to yellowish white; lamellae decurrent, close, with some dichotomous forking *Hygrophoropsis*

### Lepiotaceae

- 1.a) Pileus and stipe mealy; lamellae attached  
 (see **Tricholomataceae**: *Cystoderma*)  
 1.b) Pileus and stipe may be squamulose or fibrillose, but not mealy; lamellae free 2  
 2.a) Spores lacking a distinct germ pore 3  
 2.b) Spores with a conspicuous germ pore 4  
 3.a) Pileipellis of broadly ellipsoidal or spherical inflated cells *Cystolepiota*  
 3.b) Hyphae of pileipellis not cell-like *Lepiota*  
 4.a) Fruiting bodies large, robust; annulus complex; clamp connections present *Macrolepiota*  
 4.b) Fruiting bodies smaller; annulus simple; clamp connections absent *Leucocoprinus* and *Leucoagaricus*

### Paxillaceae

- 1.a) Spore print white to yellowish white  
 (see **Hygrophoropsidaceae**: *Hygrophoropsis*)  
 1.b) Spore print yellowish brown (clay to ochraceous) or rust-brown 2  
 2.a) Having the habit of a bolete but with lamellae instead of pores *Phylloporus*  
 2.b) Having the habit of a *Clitocybe* or a *Pleurotus*, but with lamellae that are often veined or poroid near the stipe *Paxillus*

**Pluteaceae**

- 1.a) Lacking a universal veil or volva *Pluteus*  
 1.b) Having a membranaceous volva at base of stipe *Volvariella*

**Russulaceae**

- 1.a) Fresh fruiting body exuding latex when cut or broken; lamellulae present *Lactarius*  
 1.b) Not exuding latex when damaged; lamellulae often sparse or absent *Russula*

**Strophariaceae**

- 1.a) Chrysocystidia (sterile cells that turn golden yellow in KOH) often present on lamellae faces 2  
 1.b) Chrysocystidia typically absent 4  
 2.a) Fruiting body never on wood; spores elliptical in profile, with strongly distinct, usually truncate, germ pore; acanthocytes often found in mycelium *Stropharia*  
 2.b) Not combining the above characteristics 3  
 3.a) Lignicolous (on living or dead wood); spore print ranging from deep brown to purple-black; pileus smooth and dry, often with some red colour *Hypholoma*  
 3.b) Mostly on ground or woody debris; spore print dull brown, cinnamon-brown to rusty brown; spore often with indistinct germ pore; pileus usually viscid or scaly *Pholiota*  
 4.a) Stipe poorly developed, eccentric and curved, short; on wood *Melanotus*  
 4.b) Stipe well developed, central, sometimes turning blue-green when handled; on soil, wood or dung *Psilocybe*

**Tricholomataceae**

- 1.a) Fruiting body parasitic on other agarics (usually Russulaceae) *Asterophora*  
 1.b) Not growing on other agarics 2  
 2.a) Basidia with siderophilous granules 3  
 2.b) Not as above 5  
 3.a) Fruiting body collybioid *Tephrocybe*  
 3.b) Fruiting body tricholomatoid, fleshy 4

- 
- 4.a) Fruiting bodies generally dull coloured, often staining when bruised; pigments encrusting hyphae *Lyophyllum*
- 4.b) Fruiting bodies generally brightly coloured, but pigments not situated on hyphal walls *Calocybe*
- 5.a) Edge of lamella conspicuously serrate or eroded; spores amyloid; on wood or soil *Lentinellus*
- 5.b) Not combining all of the above characteristics 6
- 6.a) Fruiting body lacking a stipe, or stipe typically lateral or strongly eccentric, usually on wood 7
- 6.b) Stipe present, central or nearly so, on wood or soil 19
- 7.a) Lamellae appearing to be split lengthwise along the edges and rolled backwards *Schizophyllum*
- 7.b) Lamellae not split 8
- 8.a) Fruiting body luminescent, on wood or near buried decaying wood *Omphalotus*
- 8.b) Not luminescent 9
- 9.a) Pileus with some degree of gelatinisation 10
- 9.b) Pileus lacking a gelatinised context 14
- 10.a) Pileus highly gelatinised, rubbery; lamella face with metuloids *Hohenbuehelia*
- 10.b) Pileus to some degree gelatinised, but lamellae lacking metuloids 11
- 11.a) Spores amyloid (except for *P. ligulatus*) *Panellus*
- 11.b) Spores inamyloid 12
- 12.a) Spores disc-like with spiny ornamentation *Conchomyces*
- 12.b) Spores smooth 13
- 13.a) Fruiting body often grey or fuscous, lamellae well developed *Resupinatus*
- 13.b) Fruiting body often whitish or pale grey, lamellae widely spaced, shallow, running together irregularly *Campanella*
- 14.a) Stipe greatly reduced or absent; pileus often thin-fleshed 15
- 14.b) Fruiting body usually more substantial 17
- 15.a) Fruiting body brick red *Anthracophyllum*
- 15.b) Not as above 16
- 16.a) Fruiting body pure white, on wood *Cheimonophyllum*
- 16.b) Fruiting body off-white, on twigs *Marasmiellus*
- 17.a) Subhymenium very reduced or absent *Panus*
- 17.b) Subhymenium more substantial 18
- 18.a) Hyphae of lamellar trama regularly arranged; lamellae often toothed *Lentinus*
- 18.b) Hyphae of lamellar trama irregularly arranged; lamella edge entire *Pleurotus*

- 19.a) Pileus and part of stipe below the veil covered with mealy granules  
*Cystoderma* 20
- 19.b) Not as above 20
- 20.a) Veil usually forming a distinct annulus on a tough stipe *Armillaria* 21
- 20.b) Veil absent or not forming an annulus on stipe 21
- 21.a) Pileipellis cellular or a hymeniform layer; hymenial cystidia absent  
*Dermoloma* 22
- 21.b) Not combining the above characteristics 22
- 22.a) Lamellae thick, fairly distant, sometimes intervenose or forked; spores globose, spiny and inamyloid *Laccaria* 23
- 22.b) Not combining the above characteristics 23
- 23.a) Stipe fleshy, fruiting body generally stout 24
- 23.b) Stipe thin and hollow, or pithy and tough 29
- 24.a) Spores amyloid 25
- 24.b) Lamellae various; spores inamyloid 26
- 25.a) Hyphae with clamp connections *Leucopaxillus* 26
- 25.b) Hyphae lacking clamp connections *Melanoleuca* 26
- 26.a) Lamellae adnate to decurrent; pileus often centrally depressed  
*Clitocybe* and *Lepista* 27
- 26.b) Lamellae typically notched to adnexed, never decurrent; pileus usually convex, never centrally depressed 27
- 27.a) Spores amyloid; cheilocystidia present *Porpoloma* 28
- 27.b) Spores inamyloid; cheilocystidia present or not 28
- 28.a) Cheilocystidia conspicuous; on wood *Tricholomopsis* 28
- 28.b) Cheilocystidia generally absent; on soil *Tricholoma* 28
- 29.a) Pileus convex, conical or campanulate, with a layer of inflated cells directly beneath the pileipellis, margins often pellucid when wet; stipe usually thin, hollow and fragile; *Mycena* 30
- 29.b) Not as above 30
- 30.a) Fruiting body small to minute, usually centrally depressed; stipe thin but cartilaginous and tough; lamellae typically decurrent 31
- 30.b) Not combining all of the above characters 34
- 31.a) Spores amyloid *Xeromphalina* 32
- 31.b) Spores inamyloid 32
- 32.a) Cystidia conspicuous in the lamellae and pileipellis *Rickenella* 33
- 32.b) Cystidia generally absent 33
- 33.a) Pigment found on or in the hyphal wall *Omphalina* 33
- 33.b) Pigment in hyphae of the pileipellis intracellular (not found on or in the hyphal wall) *Gerronema* 33

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- 34.a) Fruiting body tall with long, slender stipe with radicating base on earth, or on wood; pileus viscid; lamellae white *Oudemansiella* (incl. *Xerula*)
- 34.b) Not as above 35
- 35.a) Pileus and/or stipe covered with hairs, scales or warts; on wood 36
- 35.b) Stipe and pileus not as above 38
- 36.a) Pileus viscid or sticky due to gelatinous filamentous hyphae underlying a pileipellis of inflated cells *Flammulina*
- 36.b) Pileus not as above 37
- 37.a) Pileus and usually stipe covered with dextrinoid or amyloid hairs *Crinipellis*
- 37.b) Pileus dry, covered with brightly coloured scales *Cyptotrama*
- 38.a) Stipe thin but typically tough, pliant and reviving; lamellae usually adnate or, if decurrent, then usually widely spaced; hyphae of pileipellis arranged in a palisade or various other cell-like structures, or containing broom cells or diverticulate-nodulose elements *Marasmius*
- 38.b) Not combining all of the above characters 39
- 39.a) Odour of fish oil or cucumber; pileipellis and lamellae with extremely large cystidia *Macrocystidia*
- 39.b) Not as above 40
- 40.a) Like *Marasmius*, but pileipellis having a rameales-structure *Marasmiellus*
- 40.b) Hyphae of pileipellis arranged in a cutis, lacking a cellular structure 41
- 41.a) Fruiting body with a foetid odour when crushed; trama with some degree of gelatinisation *Micromphale*
- 41.b) Odour, if present, not foetid; trama without gelatinisation 42
- 42.a) Lamellae adnexed to almost free; spores inamyloid *Collybia*
- 42.b) Not as above 43
- 43.a) Lamellae adnexed to sub-free; spores weakly dextrinoid *Pseudobaeospora*
- 43.b) Lamellae adnate to decurrent; spores amyloid *Clitocybula*



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**APPENDIX: A glossary of mycological terms**

- acanthocytes – spine-like or needle-like crystals found amongst the mycelium of *Stropharia*
- adnate – of lamellae that are broadly attached to the stipe, often at a right angle
- adnexed – of lamellae that are narrowly attached to the stipe
- Agaricales – the order of gilled fungi, popularly known as mushrooms and toadstools
- amygdaliform – almond-shaped
- amyloid – of spores or other tissues that become blue in Melzer's solution
- annulus – the ring of tissue left around the stipe after rupturing of the partial veil
- autodigesting – of a fruiting body that becomes liquid with maturity, as in *Coprinus*
- basidium (pl. basidia) – a specialised cell, usually terminal, on which the (basidio-) spores are formed on small pedicels called sterigmata; usually club-shaped (clavate) or almost cylindrical
- bolete – one of the fleshy fungi looking like agarics but with the lamellae replaced by tubes and terminating in pores
- broom cell – a cell, usually terminal, with apical appendages giving it a broom-like appearance
- buff – a pale brownish yellow, yellow-brown or creamy grey
- callus – a broad protuberance found at the distal end of the spores of some species
- campanulate – bell-shaped
- cartilaginous – firm, tough, pliant
- cellular – of hyphae that are globose, subglobose or greatly enlarged, often in the pileipellis
- cheilocystidia – sterile cells situated at the margins of lamellae
- chrysocystidia – cystidia with contents that become golden yellow in alkaline solutions
- clamp connections – a microscopic feature of the cross-walls of hyphae, manifested as swellings, loops or projections linking two adjacent hyphal elements
- collybioid – having the habit or the stature of a *Collybia*, i.e. pileus not very fleshy, with margins initially inrolled, lamellae not decurrent and with a slender, cartilaginous stipe

- context – the flesh of the pileus or stipe
- cortinate – of a partial veil that is tissue-like or cobwebby
- cutis – the outer layer of the pileipellis, in which the hyphae are repent and arranged more or less parallel to the surface, giving it a smooth appearance macroscopically
- cystidium – a sterile cell of unknown function situated between the basidia of the hymenium or, more generally, any specialised sterile cell different from neighbouring cells in various parts of the fruiting body
- decurrent – of lamellae that extend or descend downwards on the stipe
- dextrinoid – of spores or other tissues that become red-brown or purplish in Melzer's solution
- dichotomous – divided into two approximately equal parts or branches
- divergent – of lamellar trama that has a central strand of parallel hyphae surrounded by rows of hyphae that turn outwards from the medial line
- diverticulate – of hyphae having numerous short, vertical branchlets or protuberances over their surfaces
- eccentric – of a stipe that is not attached to the centre of the pileus
- emarginate – of lamellae that are notched near the stipe
- fibrillose – having thin, threadlike, hairy filaments
- filamentous – of hyphae that are long and narrow
- foetid – ill-smelling, stinking
- free – of lamellae that are not attached to the stipe
- fruiting body – the reproductive unit of a fungus, containing the spore-bearing organs
- fuscous – dusky, a dark grey, grey-brown, or smoky colour
- gelatinous – jellylike
- germ pore – an opening or an area of reduced wall thickness in the apex of the spore
- globose – spherical
- glutinous – exuding gluten made up of gelatinous hyphae
- hyaline – transparent, clear and colourless
- hymeniform – said of a pileipellis, the terminal cells of which are erect, pear-shaped or club-shaped, and are arranged in the form of a palisade
- hymenium – the spore-bearing layer of the fruiting body, situated on the lamellae, containing the basidia as well as various sterile cells such as cystidia
- hypha (pl. hyphae) – the microscopic filament or thread-like structure that is the basic growth unit of a fungus
- inamyloid – of spores or other tissues that do not become blue or red-brown in Melzer's solution

- intervenose – of the condition in which veins are found in the spaces between lamellae
- lamellae – technical name for the spore-bearing “gills” of a gilled fungus; the lamellae usually extend from the pileus margin to the stipe
- lamellar trama – the layer of tissue beneath the hymenium
- lamellulae – shorter than the lamellae, these do not extend all the way to the stipe
- lateral – of a stipe that is attached to the side or the margin of the pileus
- latex – an exuded juice, usually of a milky colour
- macrofungi – fungi that produce a conspicuous fruiting body, such as mushrooms, boletes, bracket and shelf fungi, coral fungi, cup fungi, puffballs, etc.
- mealy – of the surface of a pileus or stipe, covered with flour-like particles
- membranaceous – of a veil that is thin and pliant like a membrane
- metuloids – thick-walled cystidia, usually hyaline, with rounded apices that are often encrusted with crystals
- mycelium – the thread-like or hair-like mass of hyphae that is the vegetative portion of a fungus usually in the substrate beneath the ground
- mycology – the scientific study of fungi
- nodulose – of ornamentation of a knobby kind
- palisade – of a pileipellis having rows of parallel structures arranged next to one another like a picket fence in which the terminal elements are inflated cells that more or less reach the same level
- partial veil – an inner veil extending from the pileus margin to the stipe
- pellucid – of a pileus that is translucent, such that the lamellae are seen as lines when viewed from above
- phaseoliform – bean-shaped
- pileipellis – the outermost layer of the pileus
- pileus – technical name for the “cap” of a fruiting body
- pleurocystidia – large, sterile cells situated on the walls of the lamellae
- pliant – flexible, able to be bent without breaking; not rigid
- poroid – with pores on the underneath surface
- punctate – having small, dot-like spots, hollows or spines
- radicating – of a stipe that has a projection in the soil resembling a root
- rameales-structure – of a pileipellis whose repent outermost hyphae have short, vertical branches, often lacerate or with knobs, or which are irregularly branched
- regular – of lamellar trama which have rows of parallel hyphae
- repent – prostrate
- siderophilous – of basidia that turn purplish black or violet-black in the presence of the reagent acetocarmine

sphaerocysts – rounded cells interspersed amongst the hyphae, found in Russulaceae

spore print – the spore mass obtained by placing the pileus upside down on a glass slide or flat piece of paper or cardboard

squamose – covered with scales

squamulose – minutely squamose

stipe – technical name for the stalk or stem, which supports the pileus

striate – having fine lines or furrows, radiating on the pileus margin, longitudinal on the stipe

strigose – having bristles or coarse hairs

subglobose – almost globose

subhymenium – the layer of hyphae just below the hymenial surface

trama – the flesh or interior tissue of a fruiting body

tricholomatoid – having the habit or the stature of a *Tricholoma*, i.e. mushroom-like with a fleshy stipe, emarginate lamella attachment, and lacking a volva

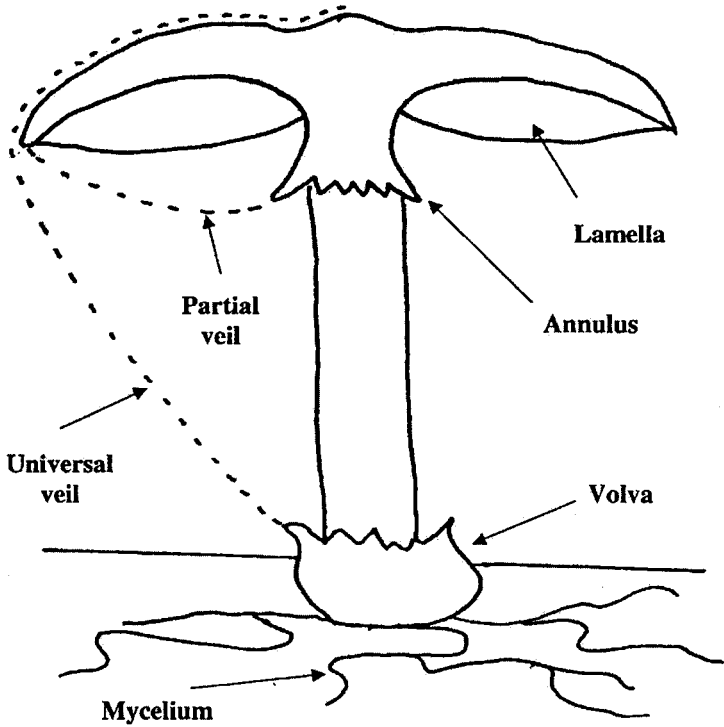
truncate – said of a spore with a flat end, as if it had been abruptly cut off

universal veil – an outer veil that encompasses the entire fungus

velar – referring to a veil

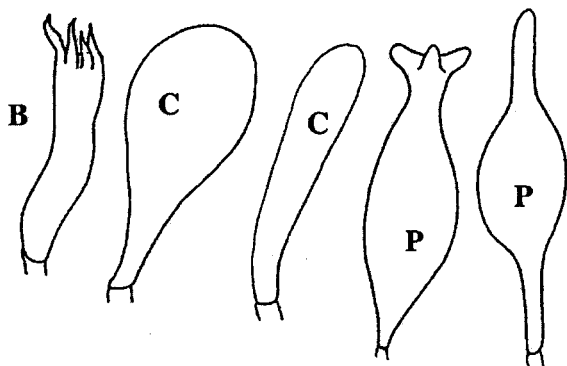
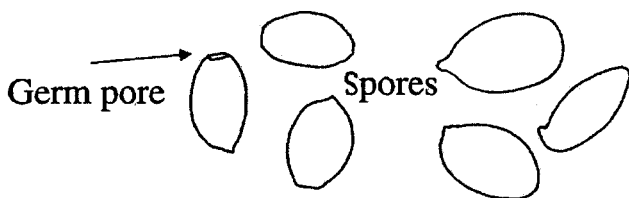
viscid – sticky, but not slimy or glutinous

volva – the remains of the universal veil at the base of the stipe



**A typical mushroom**

## Microscopic Characters



**B=Basidium; C=Cheilocystidium; P=Pleurocystidium**



## MUSINGS OF A NORTHERN NATURALIST IN TASMANIA

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As a newcomer to Tasmania, I would like to offer my thoughts on why I find Tasmanian natural history so special. Part of coming to terms with moving to a new place is trying to relate all the new things one finds around one to how things were back "home". In my case, home was cool temperate England: I spent my first three decades of life there. In my fourth decade, in moving from place to place in the tropics - including Uganda, Indonesia and northeast Queensland, I got used to there being precious few biological similarities with "home", and enormous differences. But Tasmania was described as "cool temperate", so, anticipating our move here at the start of my fifth decade, I had naively believed that I could look forward to a lot more similarities with "home" and a lot fewer differences. But the longer I'm here, the more I appreciate just how wrong I was, and how my preconceptions of what cool temperate ecology means were borne of a Eurocentric view of the natural world that just doesn't work here.

Many outsiders imagine - and I was once one of them - that Tasmania is in the Deep South, and not that far short of the Antarctic. Indeed a glance at an atlas shows that it's closer to the Antarctic continent than it is to my previous home in Cairns. Perhaps it's not surprising, then, that even many Australians expect Tasmania to be cold, dark and dangerous: its mountains brooding and frequently snowbound; its forests impenetrable and silent; its seas stormy but alive with penguins and fur-seals. But I've since discovered that Tasmania is only as far south of the equator as Rome is north of it. To those familiar with Mediterranean Europe, such a latitude gives rise to expectations of warmth and harsh sunshine, of rocky hillsides strewn with aromatic shrubs buzzing with cicadas and crickets, and of clear blue seas harbouring octopus, tuna and seahorses.

As I now know, both descriptions of Tasmania are reasonably accurate, depending on the day and the location. As a naturalist this, for me, is the island's main paradox. How can a native of northern Europe possibly pigeonhole a place that mixes aspects of the climate and nature of England, southern Italy and even the tropics, yet has so many unique aspects that it's clearly like none of these? I guess I had also imagined that the visual similarities between the Tasmanian

farmed countryside and that of England would have extended to their natural history too. But whereas that of England is truly a "living countryside", rich in species for which agroecosystems are their main habitat, that of Tasmania is closer to an ecological desert, with most native species banished to the fringes. By contrast, life is generally far more bounteous in native Tasmanian ecosystems than in any of the sad remnants that pass for native ecosystems in Europe.

I'd like to illustrate my confusion by referring to some of the plant and animal groups whose degree of representation in Tasmania at first surprised me. It's an eclectic list reflecting my own interests, and I'm still on a steep learning curve here, but the closer I look, the more I am amazed. Being a Pom, I'll start with the disappointments - those that seem under-represented.

**Butterflies.** Despite the infamous butterfly-unfriendly weather, England hosts a respectable fifty-plus species, many of them found in "semi-natural" habitats, i.e. agroecosystems. Besides the browns, whites and skippers, there are many colourful blues, hairstreaks, fritillaries and other nymphalids, plus a single swallowtail and a metalmark. In continental Europe at the latitude of Rome, the number of species is several times greater still. Yet Tasmania has no more resident species than England, and nearly all are rather drab-looking browns and skippers - not without their charms, but perhaps not as charismatic as I would have hoped for this latitude. And strangely, the state's only swallowtail is a denizen of cool rainforests, despite belonging to a largely tropical genus and family.

**Land-birds.** These have also been a bit of a disappointment to me, lacking such ubiquitous mainland species as willy-wagtails and magpie-larks. True, there are plenty of endemic species instead and many of these are common, but the diversity is pretty poor, especially in the Europeanised parts of the landscape. England is the opposite - high diversity, arguably higher in the farmed countryside than in the average woodland, but no endemic species at all. Endemic species are scarcely even a feature of the rest of Europe either.

**Palms.** There are some spectacular Phoenix palms in towns and villages around Tasmania, but no native species. Palms are largely tropical, but even Mediterranean Europe has one (admittedly dwarf) species.

**Mistletoes.** Which came first in Australia, the mistletoebird or the mistletoe? More importantly, why are there neither in Tasmania? The common mistletoe of Europe (whose seeds are dispersed by thrushes, in the absence of mistletoebirds) grows throughout lowland Britain, and there are further species towards the Mediterranean.

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Now for the pleasant surprises - those groups that seem over-represented. There are more of these than in the previous category:

**Sea-birds.** The Southern Ocean near Tasmania is teeming with sea-birds, making the most of the strong and predictable winds and the nutrient-rich waters near the Antarctic convergence. This is abundantly clear from the proportion of pages that prions, petrels, sheerwaters, albatrosses etc take up in any Australian bird field-guide. The Atlantic coast of Britain is pretty good for seabirds too, but the number of species is much lower compared to what's potentially twitchable in Tasmanian waters. And the Mediterranean, with its nutrient-poor waters and balmy breezes, is a seabird desert by comparison.

**Beetles.** I did my doctoral research on dead wood associated beetles in the tropical rainforests of northeastern Queensland. I thought I was doing well to be able to include about 350 species in my analyses, but then I come to Tasmania and find that Marie Yee's list, from some 66 eucalypt logs in the Southern Forests, is close to topping 500 species. I can only suppose that the much slower rate of decomposition of logs on the forest floor here (because of lower temperatures) enables more species to occupy them before they decay away. Whatever the reason, it turns on its head the dogma that the tropics represent the pinnacle of biodiversity. Then consider Tasmania's (mostly dead wood associated) stag-beetles. There are thought to be getting on for fifty species here - far more than northeastern Queensland and twelve times the number found in Britain. It seems the state is criss-crossed by "faunal breaks", which delimit the ranges of different stag-beetles; this same pattern is repeated across numerous other invertebrate groups.

**Parrots and honeyeaters.** Europe has no native parrots; the closest member of the order is the ring-necked parakeet whose range extends to the Middle East (though this species has gone feral in England and is now doing fine). I always associated parrots with the tropics, yet even Tasmania boasts nine native species (including the cockatoos). If Tasmania can have migrant parrots (swift and orange-bellied) which leave the island to escape the winter cold, one wonders why there aren't any that similarly migrate between Africa and Europe. If it's a lack of suitable flowering shrubs or trees for flower-feeding species such as swift parrots and honeyeaters to feed at, that begs the question why? And surely there's ample grass-seed around the Mediterranean for an analogue of the grass-parrots?

**Crayfish and amphipods.** There is one native crayfish species in England, and not many more in the rest of Europe. Yet Tasmania boasts more than thirty,

and that's before you count the other strange freshwater and terrestrial decapods that are totally unrepresented in the European fauna. Even terrestrial amphipods, which number about forty species here, are absent from the European fauna (apart from one introduced Australian species in England).

**Marine molluscs.** Tasmania boasts a rich marine mollusc fauna, with subtropical as well as cool temperate elements. To start with, there are four species of cowrie - the quintessential tropical mollusc - though only one is common in the south. No species reaches Britain, though there are a couple in the Mediterranean. Tasmania's volute fauna is also impressive, with several large and colourful species. Elsewhere in the world, large volutes are primarily tropical, but they are a distinctive feature of the Australian marine mollusc fauna nationwide. Each of Tasmania's three abalone species dwarfs the single (and rare) northern European one. The native turban shell is as big as many of the tropical species, and common on any rocky shore. Bonnet shells and cone shells are further largely tropical elements found in Tasmania. And Tasmania's brooch shell is one of very few species globally, the others being found in warmer Pacific waters. Yet Tasmania also shares many mollusc genera with northern Europe, including mussels, piddocks, oysters, topshells, mud-whelks, periwinkles and false cowries.

How can I explain these apparent paradoxes? At the risk of gross oversimplification, they can be better understood in the context of Tasmania's historical and present biogeography, compared to that of Europe. Australia has drifted north over geological time, and its cool-loving endemic or Gondwanan biodiversity has become more and more ousted or "diluted" by tropical infiltrators. Tasmania, as the southernmost outpost of Australia, remains a hospitable refuge for some of this ancient endemic biodiversity that shuns more tropical parts of the continent. Nevertheless, it is still an island, and (all things being equal), islands generally are only able to support fewer species than are larger land-masses nearby. By contrast, Europe has more or less stayed put over comparable geological timescales, but the climate has varied enormously, sometimes being near-tropical, sometimes ice-bound. There may simply not have been sufficient stability for the evolution and survival of a rich pool of endemic cool-loving biodiversity - especially on an island such as Britain.

This difference is evidence in the more recent past too, i.e. in the Pleistocene and Holocene. In Tasmania, climatic conditions during the recent ice ages were never severe enough to smother the land surface with ice, and land bridges connecting Tasmania with Victoria enabled the flow of species north and then

south again, with few north-south mountain barriers. In northern Europe, large chunks of biodiversity were periodically obliterated by ice, and their retreat south was partially blocked by mountains, offering them little refuge. England has since been colonised by the limited number of species that have been able to expand their ranges northwards thousands of kilometres over the past ten thousand years, particularly those that got to the land-bridge before it sank beneath the rising waters of the English Channel. By contrast, in Tasmania, refugia were scattered throughout the island, and range changes over the past ten thousand years may only have been in the order of tens of kilometres.

Prevailing sea temperatures also help explain some of the differences in climate and biodiversity (terrestrial and marine) between Europe and Tasmania. Being exposed to a succession of weather systems originating over the cool waters of the Southern Ocean only increases Tasmania's suitability for terrestrial organisms that like constant and cool conditions. Considerations of daylengths aside, sometimes it seems that the surest way to know what time of year it is in Tasmania is to look at a calendar, since a cool day in summer can easily be colder than a warm day in winter. There is often more variation in temperature between two consecutive days than there is between the average temperatures of two consecutive seasons. On the other hand, the climate of northern Europe is more seasonal due to its higher latitude, even though the winter cold is ameliorated by weather systems originating over the relatively warm waters of the North Atlantic. The enclosed nature of the Mediterranean basin ensures that its waters are also warm compared to oceanic water at similar latitudes, encouraging mild weather over most of that region even during the winter. As we learnt at school, Mediterranean climates are characterised by the four w's: "warm, wet, westerly winds in winter". Tasmania certainly has the wet westerlies in winter (and summer), but they couldn't often be described as warm.

For marine biodiversity, the tables are turned. Warm currents sometimes extend down the East coast of Tasmania, bringing regular sightings of turtles, white pointer sharks, bluebottles and violet snails. They may also explain why so many other "subtropical" forms of life exist in our coastal waters, like the molluscs mentioned earlier. Yet these currents are primarily coastal, and are no more than warm narrow fingers intruding into the vast cold Southern Ocean encircling Antarctica. So while the warm currents enable subtropical species to colonise the coasts, their effect on the regional climate is small compared to that of the colder oceanic water. In summer, it doesn't take much of a warming event over Hobart

for the differences in air temperature over land and sea to be great enough for the development of stiff and cooling afternoon sea breezes. Northern Europe also benefits from warm ocean currents (the North Atlantic Drift), which mean that turtles, bluebottles and seahorses occasionally reach English waters too. However, at this latitude, the warm oceanic water quickly cools as it reaches the coastal shallows, and consequently coastal marine biodiversity has more in common with the Arctic than the Mediterranean.

The more I try and figure out what makes Tasmanian natural history tick, the more I end up questioning my assumptions about what makes European natural history tick, and the more I stray from my usual haunts of hard science towards philosophy. But philosophy hasn't been a big part of natural history for a long, long time and it's probably better that way, which suggests to me that it's time to bring these musings to a close. Nevertheless, I would welcome anyone else's views on what I have written, and look forward to revisiting this subject when I've been in Tasmania a bit longer.

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**VITRINA PELLUCIDA (Muller, 1774) (PULMONATA:  
VITRINIDAE), ANOTHER LAND SNAIL INTRODUCED TO  
TASMANIA**

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*Abstract.* This short paper discusses the presence in southern Tasmania of a widespread but previously unreported introduced land snail, *Vitrina pellucida* (Muller 1774), the first vitrinid recorded from Tasmania. The species is considered moderately invasive in both wet and dry forest but is not considered to be likely to be a severe ecological problem.

## **IDENTIFICATION**

*Vitrina pellucida* has a small shell which is typically 3.5-5mm wide at 3-3.5 whorls. The shell is very thin and fragile, translucent, usually shiny, and yellow to pale green. The spire is low and the body whorl is rounded. The umbilicus is closed and the aperture is subovate and very wide (c.70% of shell width). The shell is smooth with the exception of a microsculpture of low irregular more or less spiral indentations on the protoconch. The animal is vaguely similar to the native *Helicarion* in that it has a small mantle lobe which covers the edge of the shell. Few live Tasmanian specimens of *V. pellucida* have been seen at this stage and the colour of preserved material is unreliable as a guide to actual colour.

No Tasmanian land snail closely resembles *V. pellucida* but some care must be taken in distinguishing it from juvenile *Helicarion cuvieri* Ferussac 1821. *H. cuvieri* is much larger for a similar number of whorls; a shell of 3-3.5 whorls would be 10-15mm wide, and the aperture is considerably wider.

## **V. PELLUCIDA IN TASMANIA**

I first saw *V. pellucida* in Tasmania in 1986 but did not realise what it was at the time, having not considered that it might be something not previously recorded

from Tasmania. Over time, as I increasingly came across what I had assumed (without close study) were either juvenile *Helicarion* or baby *Helix aspersa* Muller 1774, in habitats where neither was present, I realised that these specimens were actually an unrecorded introduced species. Comparisons using pictures and descriptions by Forsyth (1999) and specimens from Slovakia, confirmed that Tasmanian specimens are identical in shell features to European and North American specimens of *V. pellucida*, a species widespread in Europe and introduced widely in North America. This identification is tentative as *V. pellucida* is identical in shell features to *Vitrina angelicae* Beck 1837 and no dissections have been conducted, but *V. pellucida* is most likely due to its frequency in its native range and known ability to be successfully introduced.

*V. pellucida* is widespread on the western shore of Hobart, where it is present (but not especially common) in old gardens (e.g. Fitzroy Gardens), urban wastelands (e.g. the steep weedy areas around the Lynton Avenue underpass in Dynnyrne) and rock walls (e.g. rubble in rock and concrete walls surrounding the Information Systems building at the University of Tasmania campus). It has successfully invaded dry woodlands (e.g. the land between the Mount Nelson Signal Station and Marlborough Street, Sandy Bay) and wet forests (Lambert Park, Truganini Reserve, University Reserve, Hobart Rivulet Reserve, bush margins at Lenah Valley Road) up to a distance of about 300 m from houses.

It was collected from disturbed dry woodland in an invertebrate survey on Hobart's eastern shore at Knopwood Hill, Howrah, by Peter McQuillan in May 1996. Approximately forty specimens were collected in pitfall traps, making it the commonest land mollusc in that survey.

There are two records from outside Greater Hobart. On 24 May 1986, I found a live specimen crawling on the underside of a brick on the margin between dry woodland and pasture at Humphreys Road, New Norfolk (GR 5055 2618, approximately 23km WNW of the Hobart GPO). On 7 May 1995, I recorded the species in degraded sand-dune wattle scrub at Marion Bay (GR 5709 2586, approximately 45km E of the Hobart GPO).

## DISCUSSION

It is likely that increased awareness of this species will lead to more records of it in other parts of the state. The records presented here alone suggest that this species has been present in Tasmania for several decades.



*V. pellucida* is a primarily carnivorous species which "feeds on almost anything but vascular plants" (Ellis 1969) but which prefers dead prey (Grego, pers comm.). The numbers of the species in bushland locations where it has been seen so far in Tasmania are generally modest (a few specimens per hour of sampling) and the size of the species is relatively small. It is more invasive than some other small introduced species, most notably the apparently city-bound *Vallonia pulchella* (Muller 1774), and much commoner than a long-standing introduction *Vitrea crystallina* (Muller 1774). However neither its distance nor its density of invasion are remotely comparable to the ecologically similar *Oxychilus cellarius* (Muller 1774), which also effectively invades both wet and dry environments. Several slug species are also capable of invading over much longer distances and contributing much more to the total exotic biomass.

On this basis *V. pellucida* is considered likely to cause very little or no ecological harm. Most of the bushland sites where it has been recorded are already heavily degraded by weed infestation, overburning and fragmentation. Very few even have moderate native land snail diversities - while the hardy "native tramp" species *Paralaoma caputspinulae* (Reeve 1845) is almost invariably present, Lambert Park and Truganini Reserve are the only *V. pellucida* localities so far recorded where the native snail diversity exceeds five species, and in these cases *V. pellucida* occurs mainly on the disturbed low-diversity fringes of the reserves. The extent to which exotic snails are agents of environmental change rather than merely symptoms of it in Tasmania is an unresolved issue.

At least twenty-three land mollusc species (c.20% of Tasmania's total land mollusc fauna) are now confirmed as having been introduced into Tasmania since European settlement, excluding successful apprehensions in quarantine. Only two of these introductions (*Eobania vermiculata* (Muller 1774) and *Helix aperta* Born 1780) have apparently failed to survive.

## POSTSCRIPT

After this paper was submitted, *V. pellucida* was also found in Launceston and is likely to be widespread there. Several dead specimens were collected along the north side of Cataract Gorge within the first 200m of the track from the West Tamar Highway end on 6 Sept 02, and one live specimen (pictured) was collected along the creekside above the rock fissure in Punchbowl Reserve on 7 Sept 02.

**ACKNOWLEDGEMENTS**

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**INCREASED INCIDENCE OF ENDOPHYTE (*NEOTYPHODIUM LOLII*) INFECTED PERENNIAL RYEGRASS OBSERVED IN TASMANIAN PASTURES**

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Many toxins are produced when the fungal endophyte *Neotyphodium lolii* infects perennial ryegrass. One group, whose predominant activity has been attributed to the compound peramine, acts as anti-feedants for some chewing insects while lolitrem B and related compounds cause perennial ryegrass staggers syndrome in grazing animals. The presence of *N. lolii* in ryegrass also enhances growth, persistence, tolerance to drought stress and resistance to pasture-weed invasion (Siegel *et al.* 1987).

Perennial ryegrass staggers occurs during the summer and autumn and is associated with warm ambient temperatures and close grazing of swards. The concentrations of lolitrem and other alkaloids which affect animal health and plant survival are influenced by environmental conditions and the genotype of both the host and the endophyte (Siegel *et al.* 1987, Reed *et al.* 2000). Guy (1992) showed that Tasmanian pastures with a history of ryegrass staggers had high incidences (79-94%) of *N. lolii* and were at least 4 years old. This study recorded the incidence of *N. lolii* in newly sown perennial ryegrass pastures over a three year period at 4 sites in Tasmania.

Pastures were sown at Cambridge, Hamilton, Kempton (September 1988) and Ross (May 1989) in Tasmania. They were direct drilled with the same seedline of *Lolium perenne* cv. Victorian into unimproved pasture (mainly *Agrostis*, *Hordeum* and *Vulpia* spp.: *Lolium* spp. were rare) which had been killed with glyphosate herbicide.

Tillers were sampled at random every 2-6 months (90 tillers / site / sampling) from Cambridge, Hamilton, Kempton and three times from Ross (Figure 1). Whole tillers were inspected for insect damage and prepared for ELISA (Guy 1992).

Insect damage to the tillers or the pastures as a whole during this study was negligible (P.B. McQuillan, pers. comm. 1989-91). There was little change in incidence in the Hamilton and Kempton pastures during the first 18 months. However during the unseasonally dry period: spring 1989 - autumn 1990 (Hennessy *et al.* 1999), the incidence of *N. lolii* increased steadily to around 80%. Incidence in the newly sown Ross pasture started increasing during the same period suggesting that this was a seasonal effect rather than a function of pasture age. Even though there was between-site variation in aspect, altitude, and soil type there was little between-site variation in the incidence of *N. lolii* at each sampling. The one exception was observed at the Cambridge site during the Sept 1989 sampling when incidence increased markedly ( $\chi^2 = 11.767$ ,  $P < 0.01$ ). This pasture was growing on unconsolidated marine sediments which dried very rapidly after rain. During the final 6 months of the study (spring 1990 - autumn 1991) *N. lolii* incidence increased in the pastures to around 90% (Fig. 1).

Francis and Baird (1989) also observed a sharp rise in *N. lolii* incidence, from 3% to 67 and 83%, in two ryegrass pastures within 3 years in New Zealand. They attributed this directly to an increased competitive ability of endophyte-infected seedlings and discounted infected ryegrass' ability to resist insect attack as not significant during their trial. This study has shown that incidence of *N. lolii* in Tasmanian ryegrass pastures can rise to potentially hazardous levels in 6 -18 months after sowing in the absence of conspicuous insect damage. The increase coincided with unusually dry conditions and may be related to endophyte infected ryegrass' ability to withstand drought stress. This rapid increase highlights the need for good pasture management of younger as well as older pastures to reduce the risk of ryegrass staggers.

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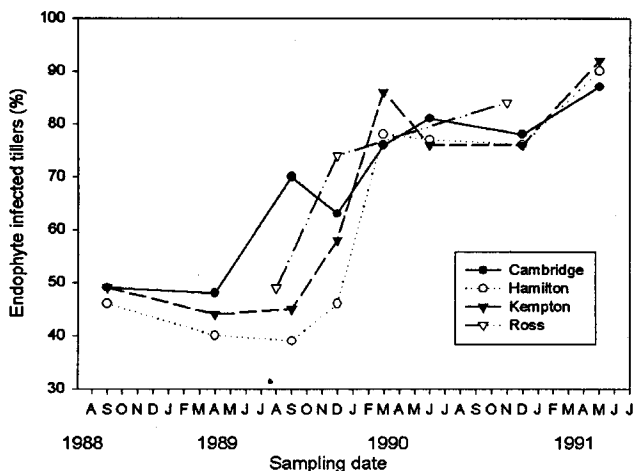


Figure 1. Increase in the incidence of *Neotyphodium lolii* in perennial ryegrass (cv. Victorian) pastures.

## SMALL MAMMAL HABITAT USE IN BUTTONGRASS MOORLANDS, TYNDALL RANGE, WESTERN TASMANIA

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*Abstract.* We conducted a small mammal trapping survey, using 210 aluminium collapsible traps and 30 cage traps, over four nights in three buttongrass moorland sites below the Tyndall Range. We trapped 32 *Rattus lutreolus*, 19 *Antechinus minimus* and 4 *Isoodon obesulus*. We found that small mammals occurred in some buttongrass moorland communities to a greater extent than others and that they were differentiating between buttongrass moorland communities at a level that is lower than the communities described by Jarman *et al.* (1988). Capture rates of small mammals were greatest in areas where there was a dense, tall (0.75m) ground cover (Pure Buttongrass) and often with a sparse overstorey (0.75-2m) (tall Layered Blanket Moor and Wet Copse).

### INTRODUCTION

Buttongrass moorland covers more than one million hectares of Tasmania, mainly in the western part of the State (Jarman *et al.* 1988). It provides habitat for several small mammals, primarily the swamp rat, *Rattus lutreolus*, the broad-toothed mouse, *Mastacomys fuscus* and the swamp antechinus, *Antechinus minimus*. The southern brown bandicoot, *Isoodon obesulus*, the long-tailed mouse, *Pseudomys higginsii* and eastern pygmy possum, *Cercartetus nanus*, have been trapped in moorland but these instances are rare and, for the latter two species, usually in locations adjacent to their more typical habitat.

Buttongrass moorland is a highly variable vegetation type with over 25 communities described and additional ones are likely to be delimited as the vegetation is further investigated (Jarman *et al.* 1988). There is growing evidence that small mammals use some buttongrass moorland communities to a greater

degree than others (Taylor *et al.* 1985; Driessen and Comfort 1991; Slater 1992; Driessen 1998).

Information on habitat use is important for management of small mammals, particularly in relation to fire management. Buttongrass moorland is regularly subjected to fuel reduction burns to prevent fires spreading into fire sensitive vegetation and to protect human life and property. There have been proposals to significantly increase the area of burning in buttongrass moorlands, not only to increase the level of protection of fire sensitive assets but also to manage for biodiversity in buttongrass moorlands (Marsden-Smedley and Kirkpatrick 2000). However, there is very little information on the effects of fire on fauna biodiversity.

*M. fuscus* is one species thought to be at risk from regular firing of buttongrass moorland. In the past the species was trapped only in old growth (>15 years since fire) moorland but, more recently, controlled experiments have shown that it may return three years post-fire in some habitats (Driessen 1999). The conservation status of this species is currently unknown but possibly secure because buttongrass moorland, its primary habitat, is widespread and largely within reserved land.

The original aims of this study were: (1) to identify sites for a study into the impacts of fire on small mammals to complement the work of Driessen (1999), (2) to find new locations where the broad-toothed mouse occurs, and (3) to assess the habitat requirements of small mammals in buttongrass moorlands. However, few captures of small mammals during the study meant that only aim (3) was adequately achieved.

## STUDY AREA

This study was conducted in buttongrass moorlands below Mt Tyndall, 20 km north of Queenstown. Moorlands in this area are accessible by vehicle and are subject to fuel reduction burns to control illegal fires that might escape into fire sensitive vegetation on the Tyndall Range. Three areas of moorland were surveyed, Newton Creek (382300E 5359950N ± 25 m), Upper Langdon (380900E 5355850N ± 25 m) and West Langdon (379150E 5352950N ± 25 m). All sites occur at approximately 500 m above sea level. Taylor *et al.* (1985) conducted an inventory of mammals in the area. They recorded 19 native species including the following small mammals in buttongrass moorland; *R. lutreolus*, *A. minimus*, *P. higginsii* and *I. obesulus*.

### Newton Creek

This site sloped gradually away from the Anthony Highway south-east to Newton Creek. Adjacent to the highway the vegetation consisted of 2 m tall scrub dominated by *Leptospermum nitidum* and *Melaleuca squamea* over a dense cover of *Gymnoschoenus sphaerocephalus*, *Empodisma minor* and *Lepyrodia tasmanica*. There was a small dry copse with a sparse overstorey of *Eucalyptus nitida* over a dense scrub layer of *Leptospermum nitidum*, *Melaleuca squamea*, *Acacia mucronata* with some *Gahnia grandis*. About 20 m from the highway, the shrub layer became lower and then graded into buttongrass moorland with a height of less than one metre. Large areas of buttongrass moorlands occurred to the east and southeast of the survey area (>100 ha). A small creek flowed under the Anthony Highway, through the survey area and into Newton Creek. The low buttongrass moorland was last burnt in 1987, it is not known when the taller vegetation near the highway was last burnt.

The following buttongrass communities, described by Jarman *et al.* (1988) were present at Newton Creek; Layered Blanket Moor, Standard Peat, Pure Buttongrass and Dry Copse. We subdivided Layered Blanket Moor into three sub-communities based on vegetation height and dominant plant species. Cover and height for plant species in each community at Newton Creek are given in Table 1.

### Upper Langdon

This site was located in a 40 ha buttongrass moorland plain surrounded by dense tea tree scrub, rainforest and mixed forest. The moorland was connected to a larger band of moorland that paralleled the Tyndall Range. A small creek flowed into the middle of the survey area and then dispersed. A second creek passed through the southeastern corner of the survey area. The buttongrass moorland communities were less than 1.5 m in height although there were a few patches near to scrub that had taller shrubs. The survey area was last burnt in 1985.

The following buttongrass communities, described by Jarman *et al.* (1988) were present at Upper Langdon; Layered Blanket Moor, Standard Peat, Pure Buttongrass and Southwestern Sedgely. We subdivided Layered Blanket Moor into three sub-communities based on vegetation height and dominant plant species. Cover and height for plant species in each community at Upper Langdon are given in Table 2.



**Table 1. Cover (C, %) and Height (Ht, cm) of Vegetation at Newton Creek.**  
 LBM = Layered Blanket Moor, Gs = *Gymnoschoenus sphaerocephalus*, Em = *Empodisma minus*, Lta = *Lepyrodia tasmanica*, p = present.

Taxon	Low LBM		Medium LBM		Tall LBM		Pure Buttongrass		Standard Peat		Dry Copse	
	Gs/Em/Lta		Gs		Em/Lta/Gs							
	Ht	C	Ht	C	Ht	C	Ht	C	Ht	C	Ht	C
<i>G. sphaerocephalus</i>	50	30	60	45	50	20	50	80	30	55	40	5
<i>E. minus/L. tasmanica</i>	30	25	30	5	30	30	30	5	20	10	40	5
<i>Lepidosperma filiforme</i>	30	5									40	p
<i>Gahnia grandis</i>	100	p									150	10
<i>Eurychorde complanata</i>	30	p										
<i>Balostion tetraphyllum</i>					100	p	150	5			100	p
<i>Leptocarpus tenax</i>	30	15	30	p	30	p	40	p	30	p		
<i>Ehrharta tasmanica</i>					10	p	20	p	20	p		
Poaceae							20	p			40	p
<i>Astelia alpina</i>							50	p				
<i>Diplazene latifolia</i>	30	p	30	p	30	p	30	p	20	p		
<i>Eucalyptus nitida</i>											500	15
<i>Melaleuca squamea</i>	75	5			200	20	100	p			350	25
<i>Melaleuca squarrosa</i>					120	p						
<i>Leptospermum nitidum</i>	75	15	120	35	200	20	150	5	40	25	350	25
<i>Leptospermum scoparium</i>	75	p			200	p					350	p
<i>Sprengelia incarnata</i>	75	p	120	20	60	p	60	p	40	5		
<i>Epacris lanuginosa</i>	20	p							30	p		
<i>Bauera rubioides</i>	40	p			60	5			20	p	40	p
<i>Banksia marginata</i>	70	p							60	p		
<i>Acacia mucronata</i>	180	p			150	p					350	10
<i>Pultenaea juniperina</i>	40	p	30	p	50	p	60	p			100	p
<i>Gleichenia</i> sp						20	p		20	p		
<i>Lycopodiella</i> sp	10	p										
Coral lichen	30	p			30	p						
Sphagnum						p						
Bare rocky ground		p										

## West Langdon

This site consisted of a square pocket of buttongrass moorland that was surrounded on three sides by dense tea tree scrub grading into *Eucalyptus nitida* forest. On the fourth side it became part of a larger (>100 ha) area of buttongrass moorland. The site was relatively flat and vegetation height was mostly less than 1 m tall. A small creek flowed through one half of the survey area and the banks of the creek comprised dense *Melaleuca* scrub over *Bauera rubioides*, *Gymnoschoenus sphaerocephalus* and *Gahnia grandis*. It is not known when the site was last burnt.

The following buttongrass communities, described by Jarman *et al.* (1988) were present at West Langdon; Pure Buttongrass, Southwestern Sedgey, Wet Standard and Wet Copse. Cover and height for plant species in each community at West Langdon are given in Table 3.



Table 3. Cover (C, %) and Height (Ht, cm) of Vegetation at West Langdon.  
p = present.

Species	Pure Buttongrass		Southwestern Sedgey		Wet Copse		Wet Standard	
	Ht	C	Ht	C	Ht	C	Ht	C
<i>G. sphaerocephalus</i>	50	80	30	30	50	10	30	10
<i>E. minor</i> <i>tasmanica</i>	30	10	30	5	100	5	30	30
<i>Gahnia grandis</i>					150	15		
<i>Eurychorda complanata</i>	30	p						
<i>Balioskion tetraphyllum</i>	100	p			150	10		
<i>Leptocarpus tenax</i>			40	30			30	15
<i>Ehrharta tasmanica</i>					20	10	30	p
<i>Astella alpina</i>	20	p						
<i>Diplazene latifolia</i>	30	p			p		30	p
<i>Eucalyptus nitida</i>					p			
<i>Melaleuca squamea</i>	75	5	50	5	200	20	75	20
<i>Melaleuca squarrosa</i>					200	p		
<i>Sprengelia incarnata</i>	75	5	50	15			60	5
<i>Speocris lanuginosa</i>	80	p			150	5		
<i>Bauera rubioides</i>	20	p	20	p	150	25	50	30
<i>Boronia</i> sp	30	p	40	10				
<i>Gleichenia</i> sp	10	p						
sphagnum		p						

## RESULTS

We caught three mammal species during the survey (Table 4). *R. lutreolus* was the most commonly caught animal (32 captures) followed by *A. minimus* (19 captures) and *I. obesulus* (4 captures). The swamp rat was caught at all three sites, whereas the swamp antechinus was caught only at Upper Langdon and Newton Creek, and the southern brown bandicoot was caught only at Upper Langdon.

*R. lutreolus* was caught in all buttongrass moorland communities, as defined by Jarman *et al.* (1988) except Southwestern Sedgey, Wet Standard and Dry Copse. Capture rates in Layered Blanket Moor, Standard Peat and Pure Buttongrass were variable both within and between sites. *R. lutreolus* was trapped in pure buttongrass at Upper Langdon and West Langdon (although all captures at this site were immediately adjacent to Wet Copse) but not at Newton Creek. Capture rates were highest in Layered Blanket Moor but only where there was tall *Melaleuca squamea* and *Leptospermum nitidum* over dense *Gymnoschoenus sphaerocephalus*, *Empodisma minus* and *Lepyrodia tasmanica*. In all other layered blanket moor sub-communities *R. lutreolus* was

Table 4. Number of animals trapped in each vegetation type at each site. n = total number of captures, % = total number of captures expressed as a percentage of total trap nights except *Isodon obesulus* where captures are expressed as a percentage of total number of cage trap nights only. Traps were set for 3 nights at Newton Creek and West Langdon and 4 nights at Upper Langdon. Superscript values indicate number of *Rattus lutreolus* caught in cage traps. LBM = Layered Blanket Moor, Gs = *Gymnoschoenus sphaerocephalus*, Em = *Empodisma minus*, Lta = *Lepyrodia tasmanica*, Lte = *Leptocarpus tenax*.

Vegetation Type	No. of	No. of	Total	<i>Rattus</i>		<i>Antechinus</i>		<i>Isodon</i>	
	Elliot	Cage	Trap	<i>lutreolus</i>	<i>minimus</i>	<i>minimus</i>	<i>obesulus</i>	<i>obesulus</i>	<i>obesulus</i>
	Traps	Traps	Nights	n	%	n	%	n	%
Newton Creek									
Low LBM (Gs/Em/Lta)	10	0	30	0	0.0	1	3.3	-	-
Medium LBM (Gs)	4	0	12	0	0.0	0	0.0	-	-
Tall LBM (Em/Lta/Gs)	14	9	69	6 <sup>3</sup>	5.8	5	7.2	0	0.0
Pure Buttongrass	6	0	18	0	0.0	1	5.6	-	-
Standard Peat	5	1	18	0	0.0	0	0.0	0	0.0
Total	40	10	150	6 <sup>3</sup>	4.0	7	4.7	0	0.0
Upper Langdon									
Low LBM (Gs)	6	0	24	0	0.0	0	0.0	-	-
Low LBM (Lte/Gs/Em/Lta)	15	0	60	3	5.0	1	1.7	-	-
Tall LBM (Gs)	5	1	24	4	16.7	0	0.0	0	0.0
Pure Buttongrass	23	5	112	7	6.3	5	4.5	0	0.0
Standard Peat	32	1	132	5	3.8	4	3.0	0	0.0
Southwestern Sedgely	19	3	88	0	0.0	2	2.3	4	4.5
Total	100	4	440	19	4.3	12	2.7	4	4.0
West Langdon									
Pure Buttongrass	38	5	129	2	1.6	0	0.0	0	0.0
Southwestern Sedgely	19	0	57	0	0.0	0	0.0	-	-
Wet Copse	10	5	45	5 <sup>2</sup>	11.1	0	0.0	0	0.0
Wet Standard	3	0	9	0	0.0	0	0.0	-	-
Total	70	10	240	7 <sup>2</sup>	2.9	0	0.0	0	0.0
Total all sites	210	30	830	32 <sup>5</sup>	3.9	19	2.3	4	10.0

either absent or caught in low numbers. At Newton Creek *R. lutreolus* was trapped only in one vegetation type, tall Layered Blanket Moor, which formed a distinct band parallel to the highway.

The sex and age for *R. lutreolus* at all sites were eight adult females, four adult males, two juvenile females and two juvenile males. Only adult females were trapped at West Langdon. All juveniles and only one adult female were trapped at Newton Creek.

There was no clear pattern of *A. minimus* captures in the buttongrass moorland communities surveyed. It was trapped in small numbers in several moorland communities at Newton Creek and Upper Langdon, but was absent from West

Langdon. At Newton Creek *A. minimus* was captured most frequently in tall Layered Blanket Moor but absent from this community at Upper Langdon. At Upper Langdon most captures were in Pure Buttongrass, Standard Peat and Southwestern Sedgely.

All nine *A. minimus* were adult females and 5 of these had pouch young (litter sizes were 3, 5, 5, 6, 6, average = 5).

*I. obesulus* were trapped only at Upper Langdon and all captures occurred adjacent to a small creek in pure buttongrass. One adult male and one juvenile female were trapped.

## DISCUSSION

The results of this trapping survey support previous observations (Driessen and Comfort 1991; Slater 1992; Driessen 1998) that not all buttongrass moorland communities are suitable habitat for small mammals and that some communities are used to a greater extent than others. Further, we found that small mammals are differentiating between buttongrass moorland communities at a level that is lower than the communities described by Jarman *et al.* (1998). For example, at the sites surveyed Layered Blanket Moor varied in terms of the overall height of the vegetation and in terms of dominant species in the ground layer and overstorey. Jarman *et al.* (1988) recognised that there was variability within their communities and that further communities may be delimited with further investigation.

Capture rates of small mammals in buttongrass moorlands in the present study were similar to previous surveys (Table 5) although we did not trap *M. fuscus*. The lack of *M. fuscus* captures was disappointing as each of the sites had evidence indicating their presence. Their characteristic green scats, which go white when dry, were present at all sites particularly along creek banks. *M. fuscus* typically have low capture rates (Driessen 1998; Table 5) but given the amount of trapping effort it was reasonable to expect one or two captures. Further trapping of these areas should confirm their presence.

### *Rattus lutreolus*

*R. lutreolus* was the most frequently caught animal during the present survey and this is typical of most small mammal trapping surveys in buttongrass moorlands (Table 5). In all likelihood, this reflects the abundance of this species in this habitat, but also its willingness to enter traps.

We found that *R. lutreolus* was most common in buttongrass moorland communities that had a dense, tall (0.75 m) ground cover (Pure Buttongrass) and often with a sparse overstorey (0.75-2 m) (tall Layered Blanket Moor and Wet Copse). Similar results have been found in previous studies (Taylor *et al.* 1985; Driessen and Comfort 1991; Slater 1992; Taylor and Comfort 1993; Driessen 1998). We found that these habitats were often adjacent to creeks, as did Slater (1992), presumably because of the better drainage. These habitats are used probably because they provide dry nesting sites that are well protected from predators. This is supported by the observation that all captures of females at West Langdon and half of female captures at Upper Langdon were adjacent to the creeks. The results for Newton Creek are less clear as there were only a few captures and these were mostly juveniles.

#### *Antechinus minimus*

We found no clear pattern of habitat use by *A. minimus* in the buttongrass moorland communities surveyed. In general the species appeared to prefer the same communities as *R. lutreolus* with the exception of its absence from tall Layered Blanket Moor at Upper Langdon. The absence *A. minimus* from West Langdon was unusual and not easily explained. It may be related to habitat as, with the exception of south western sedge which does not appear to be suitable habitat, the communities present at West Langdon were mostly different from the two other sites. Although pure buttongrass was present at all three sites, it was a different from that at West Langdon, being much lower in height and forming a dense mat over the ground. Only near the wet copse vegetation was the pure buttongrass similar to other sites.

Only adult female *A. minimus* were trapped during the survey and over half of these had young. This is consistent with adult males dying immediately after breeding.

#### *Isoodon obesulus*

*I. obesulus* occurs primarily in dry sclerophyll forest, scrub and heathland communities throughout Tasmania (Hocking 1990) and has been reported in buttongrass moorlands on only two previous occasions (Table 5). Hocking and Guiler (1983) and Taylor *et al.* (1985) each caught two *I. obesulus* in the Gordon

**Table 5 Comparison of capture rates (total captures per 100 trap nights) of small mammals in buttongrass moorlands in previous surveys.** Capture rates for *I. obesulus* are for cage traps, all other capture rates are for Elliott traps. '-' indicates cage traps were not used in survey.

Survey	Location	<i>Rattus lutreolus</i>	<i>Antechinus minimus</i>	<i>Mastacomys fuscus</i>	<i>Isoodon obesulus</i>
Taylor <i>et al.</i> (1985)	Upper Henty	5.9	0.1	0.0	4.0
Driessen & Comfort (1991)	McPartlan Pass	5.1	1.7	0.4	-
Slater (1992)	Norfolk Range	1.9	1.9	0.6	0.0
Driessen (1998)	Pellon Plains	5.0	0.0	0.5	-
Driessen (1999)	Lake St Clair	2.7	2.0	1.1	0.0
Present study	Tyndall Range	4.4	2.6	0.0	4.0

River and Upper Henty regions respectively. In both surveys *I. obesulus* was caught in closed moorland (moorland with shrubs greater than 1.3 m in height) which led Taylor *et al.* (1985) to suggest the species may prefer this habitat to open moorland (shrubs less than 1.3 m in height or absent). In the present study, all four *I. obesulus* were trapped in open moorland. Their presence on the trapping grid at Upper Langdon was restricted to a narrow band of open moorland adjacent to a small creek. Based on the low number of captures in buttongrass moorlands it seems likely that this species uses this habitat as part of a wider range of habitat use.

## ACKNOWLEDGEMENTS

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## PARASITISM OF SCORPIONS BY MITES

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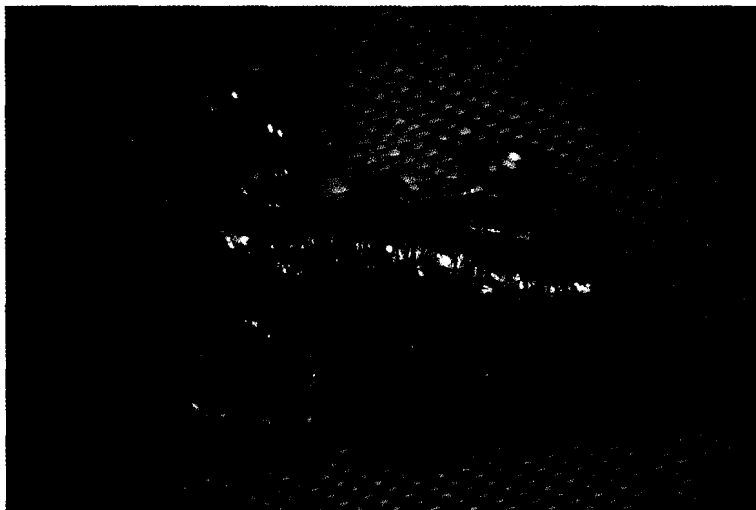
**Abstract.** Mites were found on the Tasmanian scorpion *Cercophonius squama* from December to March 2001-02. Mites were most abundant during late summer, and 100% mite-infestation of scorpions was observed in late February. Two species of mites were collected from the scorpions. One was identified as the parasitic larvae of *Leptus charon* (Erythraeidae), the other as the phoretic nymphs of an unidentified species of Acaridae. The occurrence of *Leptus* on scorpions is, to our knowledge, the first record of parasitism of scorpions by mites in Tasmania.

### INTRODUCTION

Scorpions are among the best-known invertebrates, invoking fear in those that loathe them but fascination in others. In Tasmania, the native *Cercophonius squama* is our only species of scorpion (Figure 1), although sometimes this species has been confused with the similar species *Cercophonius michaelsoni* which occurs in Western Australia (Miller 2002). However, what Tasmania lacks in diversity, we seem to make up for in abundance, as scorpions are commonly found in and around buildings in most northern and eastern areas of the state. These scorpions can sting, but pain from the venom's effects usually lasts only a short while, and we are unaware of any serious reactions to the venom of *C. squama* (McGowan and Pielage 1996).

When removing a scorpion from a household, an observant person may notice small (1-2 mm) bright-red blobs attached to the scorpion's body. Looking closer, one may also notice that these blobs have three pairs of legs and appear to be covered in hairs. These tiny creatures are the larvae of mites, an extraordinarily diverse group of organisms found in every imaginable habitat. We are unaware

of any Tasmanian records of mites associated with scorpions. Therefore, our goal was to identify these mites and provide some observations on their seasonal abundance. Information on their unusual life-histories is also provided.



**Figure 1.** The common Tasmanian scorpion *Cercophonius squama*. Body length from tip of stinger to front of head is about 25 mm.

## MATERIALS AND METHODS

Scorpions were captured in Hobart by ALM and returned to the laboratory for further observation. The number of mites per scorpion was counted and a general summary is presented here.

Representatives of these mites were collected and placed into tubes of 70-80% ethanol. Mites were prepared for slide mounting by clearing them in Kono's fluid and mounting them, on glass slides, in Hoyer's medium (Krantz 1978). Mites were viewed with the aid of a phase-contrast microscope (magnification x 5 to x 1200), and identified with the aid of several unpublished keys and Krantz (1978). The Erythraeidae were identified to species with the aid of Southcott (1961, 1991, 1993,

1999) and a spreadsheet designed to allow simultaneous comparisons of all *Leptus* species in Australia (Seeman, unpublished). Copies of this Excel<sup>®</sup> spreadsheet are available from the senior author, via e-mail, at no charge. This spreadsheet also includes a description of each of Southcott's codes given in Table 1. Each of these codes refers to a specific characteristic of the mite: for example, AW is the width in micrometres of the mite's prodorsal shield. For more information, consult Southcott (1961) for an explanation of the characters used.

## RESULTS

Two species of mite were associated with Tasmanian scorpions. A bright-red species was the larva of *Leptus charon* Southcott (Erythraeidae). The measurements of our specimens ( $n = 7$  measured) are within 10% of all measurements for *L. charon* (Table 1). A second species of mite was also detected: a tiny, brown mite (0.4 mm) proved to be the phoretic deutonymphs of an unknown species of Acaridae.

Collections of scorpions began in early spring, and the first incidence of *L. charon* on scorpions occurred on 18 Dec 2001, with one mite on each of two scorpions of a total of 12 collected. However, by January 80% of scorpions had mites, and by February 100% of scorpions were parasitised by *L. charon*. The incidence of mites then dropped off rapidly, and by the end of March only 15% of scorpions had mites, and by April mites were once again absent.

The average number of mites (both *L. charon* and Acaridae) per scorpion was 10, and the range was 1 to 35 mites per scorpion. Mites were frequently found on the pectinal teeth (comb-like structures behind the fourth pair of legs), but they did occur all over the scorpion's body. Scorpions did not attempt to groom mites off their body, even though scorpions with many mites appeared to have poor body condition.

## DISCUSSION

Parasitism of scorpions seems to be uncommon. A search of recent literature (1984 - present) revealed only one species of nematode (Poinar and Stockwell 1988) and several species of *Leptus* (Southcott 1999). We are aware of only one other species of mite on scorpions: larvae of *Leptus pyrenaicus* Andre parasitise scorpions in Europe (Andre 1953). We have also compared *L. charon* to *L. pyrenaicus* and determined them to be different.

**Table 1.** Comparison of *Leptus charon* described by Southcott (1991, 1993) with *Leptus charon* collected from the Tasmanian scorpion *Cercophonius squama* (n = 7) measured. All measurements for Tasmanian *L. charon* are within the range of other *L. charon*, except for those marked with a \*, which are within 10% of the known range. Abbreviations as of Southcott(1961).

Southcott's Code	Range in $\mu\text{m}$		Southcott's Code	Range in $\mu\text{m}$	
	<i>L. charon</i>	Scorpion <i>L. charon</i>		<i>L. charon</i>	Scorpion <i>L. charon</i>
AW	86-98	84-90	TIII/GelI	1.28-1.46	1.30-1.39
PW	99-113	95-106	GelII	107-119	98-106*
SBa	11-15	14-16	TIII	187-207	164-172*
SBp	12-16	10-15	TaII(L)	110-145	112-126
ASBa	25-32	20-24*	TaII(H)	20-27	21-26
ISD	51-62	54-66	TIII/GelII	1.70-1.82	1.63-1.72
L	84-107	80-93	AW/ISD	1.46-1.66	1.34-1.67
W	100-125	105-114	ISD/A-P	2.95-4.64	3.35-4.56
A-P	11-20	14-16	AW/A-P	4.89-7.36	5.53-6.18
AL	52-66	53-63	StI	30-43	39-50
PL	61-69	61-68	StII	30-45	38-46
ASE	34-55	44-46	CxI	73-85	76-83
PSE	60-86	83-94	CxII	20-36	26-30
DS	45-60	46-56	CxIII	26-60	41-45
Gel	110-127	104-112	TII/AW	1.74-1.91	1.57-1.71*
TII	147-182	132-148	TIII/AW	2.02-2.22	1.91-2.00*
TaI(L)	118-145	120-130	AW/AL	1.42-1.78	1.33-1.70
TaI(H)	22-29	22-26	TIII/TII	1.14-1.27	1.16-1.24
TII/Gel	1.31-1.49	1.27-1.36	TIII/PW	1.21-1.41	1.13-1.24
GelI	94-102	88-92*	L/W	0.78-0.93	0.70-0.86
TIII	123-145	118-125	PW/AW	1.07-1.22	1.13-1.19
TaII(L)	100-125	104-117	AL/PL	0.83-0.87	0.85-0.93
TaII(H)	20-31	22-23			

R.V. Southcott was an Australian acarologist who published extensively on the Erythraeidae, and his final work (Southcott 1999, published posthumously) provides the most extensive work on Australian *Leptus*. In his final paper, he dealt with *Leptus* associated with arachnids, where he reports ten *Leptus* spp. from scorpions. Of these, only *L. charon* was reported from *C. squama*: in this case, from a single Victorian scorpion. *L. charon* was also found on various spiders, including a *Delena cancerides* from Tasmania. Therefore, we were not surprised to find that the common *Leptus* on Tasmanian scorpions is *L. charon*.

The life history of *L. charon* is bizarre, but one it shares with several thousand members of the Parasitengona, a diverse assemblage of aquatic and terrestrial mites (Walter and Proctor 1999, pp. 43-44). The primitive life history of a mite involves an egg, prelarva, larva, protonymph, deutonymph, tritonymph and adult. However, this life history is variously modified in every possible way: for example, many species skip the prelarval stage, and a few mites give birth to adults!

For the family Erythraeidae, including *Leptus*, life begins as an egg, from which a tiny six-legged prelarva emerges. The prelarva then moults into a six-legged red or orange larva and begins searching for a suitable host, which may be any animal greater than about 3 mm in size. For *L. charon*, this may be a scorpion (this study), but this species has also been recorded from a fly in Canberra (Southcott 1991), beetles and moths in New South Wales and South Australia (Southcott 1993), and spiders in South Australia (Southcott 1999). Lack of specificity in *Leptus* is common: for example, the European species *L. ignotus* is known from nine orders of insects and arachnids (Wendt *et al.* 1992). The tiny larva embeds its mouthparts into its host's soft cuticle and begins to slowly suck out its internal juices, gradually swelling in size. A fully swollen larva looks somewhat like a hairy, red, miniature football.

When the tiny mite has had its fill, it drops off its host and enters a resting stage that is called a calyptostase. This resting stage is the protonymph, and after completion of this stage a deutonymph will emerge. The deutonymph is a free-living predator that usually runs about in leaf litter searching for eggs and small invertebrates to eat. Being free-living, it looks nothing like the larva. Nymphs of *Leptus* are cream-yellow or red mites with numerous stout black hairs (looking quite like beard-stubble); they also tend to have patches of white hairs, giving them an attractive spotted or patterned appearance. After feeding, the deutonymph then enters a second calyptostase (the tritonymph) before emerging into the adult life stage. The free-living adult mites are usually large for a mite (about 3 mm long) and look like large versions of the deutonymph.

The completely separate habit of the parasitic larva and free-living adults has made the taxonomy of these species extremely difficult. Species are named from larvae collected from animals, but are also named from the free-living adults. Consequently, some species are known only from larvae, others only from adults, and in some cases different names are given to the larvae and adults of the same species. In the case of *L. charon*, the adults of this species have never been described (Southcott 1999). However, their sheer abundance as larvae on

scorpions indicates that the adult life stage must be living in the backyards of almost every Tasmanian resident. Finding the adult of this mite will require collection, careful rearing of *Leptus* adults, and harvesting of larvae as they hatch from eggs. However, the world is one filled with myriad unknown mites, and it will probably be many years until the adults are matched with their young.

The other tiny mite captured on scorpions belonged to the family Acaridae. This mite is vastly different from *Leptus*, and their life history is similarly bizarre. These mites begin as eggs, but the larvae, protonymphs, tritonymphs and adults are free-living. These mites feed on fungi or decaying plant or animal matter. However, if conditions are poor, something switches on within the mite, and they add the deutonymph life-stage. This deutonymph is no ordinary mite: it can walk, but it cannot feed. The mouthparts almost disappear, and the anus is replaced by a plate of suckers that the mite uses to attach to anything passing its way (Krantz 1978, pp. 371-379; Walter and Proctor 1999, pp. 36-42). This act of using another animal for transport is called phoresy, and it is an important means of dispersal for thousands of species of mite. Although we do not know what species of Acaridae was attached to the Tasmanian scorpions, we do know that they are on them for a ride only. Only detailed study could tell us if they are specific to scorpions and, like *Leptus*, it will probably be many lifetimes before this particular mite-mystery is solved.

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**BIOLOGICAL DIFFERENCES BETWEEN MAINLAND AND  
TASMANIAN *CHRYSOPHTHARTA AGRICOLA*, A  
EUCALYPTUS LEAF BEETLE**

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*Abstract.* *Chrysophtharta agricola* collected from Tasmania and mainland Australia in December 2000 and January 2001, respectively, were compared for adult length, egg and larval batch size, and egg, larval and adult parasitism. Beetles originating from both regions were crossed and their offspring were reared to adulthood and assessed for fertility to confirm that collections were conspecific. 100 years of collection data from several state collections were collated to observe the frequency of collection across seasons, and relate this to the species' differing voltinism in each region. Overall, the size of beetles, egg batches, larval batches and rate of larval parasitism did not differ significantly between regions. Larval parasitoids collected from Tasmania were the tachinid flies *Paropsivora* sp. and an undescribed tachinid species, and the braconid wasp *Eadya paropsidis*. The tachinid flies were also collected parasitising *C. agricola* larvae from mainland Australia. Egg parasitism rates differed significantly between mainland Australia and Tasmania: the pteromalid species *Enoggera nassau* and *Neopolycystus* sp. developed from *C. agricola* eggs. Adult beetles were infected by the mites *Leptus* sp. and an undescribed genus of podapolipid mites in Tasmania, and by *Chyzeria* sp. in mainland Australia. Collection data revealed that the frequency of collection of adult *C. agricola* was similar between regions in spring and summer, but that beetles were collected more frequently in autumn in mainland Australia than in Tasmania.



## INTRODUCTION

*Chrysophtharta agricola* (Chapuis) (Coleoptera: Chrysomelidae) is an endemic pest of commercial eucalypt plantations in Tasmania (de Little 1989; Ramsden and Elek 1998) and Victoria (Elliott *et al.* 1998; Collett 2001). Its geographic distribution extends from the eastern NSW-Qld border to southern Tasmania, and it is oligophagous, with a host range of more than 20 Eucalyptus species from two sub-genera. In Tasmania, *C. agricola* usually has only one generation each year (Ramsden and Elek 1998), while in Victoria the species undergoes two generations (Naumann 1991; Collett 2001).

Specimens of *C. agricola* were collected from mainland Australia and Tasmania for a study using allozyme electrophoresis, one of the objectives of which was to determine whether genetic differences occur between Tasmanian and mainland Australian populations. These specimens also provided the opportunity to compare additional parameters between populations, the results of which are presented here. Additionally, an attempt was made to correlate data from collection records from mainland Australia and Tasmania with the recorded number of generations *C. agricola* undergoes in a year in each region.

## MATERIALS AND METHODS

*Chrysophtharta agricola* were collected from four sites in mainland Australia (Picadilly Circus (PIC), *E. dalrympleana*, Jindabyne (JIN) *E. dalrympleana*, Mt Buller (BUL) *E. viminalis*, and Marysville (MAR) *E. viminalis*) and Tasmania (Florentine Valley (FLO) *E. nitens*, Frankford (FRA) *E. nitens*, Geeveston (GEE) *E. globulus* and Scottsdale (SCO) *E. globulus*) in December-January 2000-2001 (Fig. 1). Specimens were collected as eggs, larvae and adults. Egg and larval batches were collected into separate vials or plastic bags and transported in a cooled esky to the laboratory. The number of eggs or larvae in each batch was counted, and each egg/larval batch was placed into a separate plastic petri dish, and egg batches were monitored for the emergence of beetle larvae or parasitoid wasps. The number of egg batches from which parasitoids emerged was recorded. Field-collected larvae were fed fresh juvenile *E. nitens* foliage and petri dishes were cleaned and foliage added or replaced twice each week until parasitoid fly or wasp pupal cases or beetle pupae developed. For larval batch size and larval parasitism rates, batch sizes of <6 and >20 were excluded from analysis to standardise the composition of instars. That is because larger batch sizes usually represented early instars that had not been exposed to

parasitoids for as long as older larvae, and smaller batch sizes usually represented final instars (author's unpubl. data). Thus, batches used for analysis comprised mostly second and third instars. The number of parasitised larvae in each batch was determined, and the average intra-batch parasitism rate for each site was calculated.

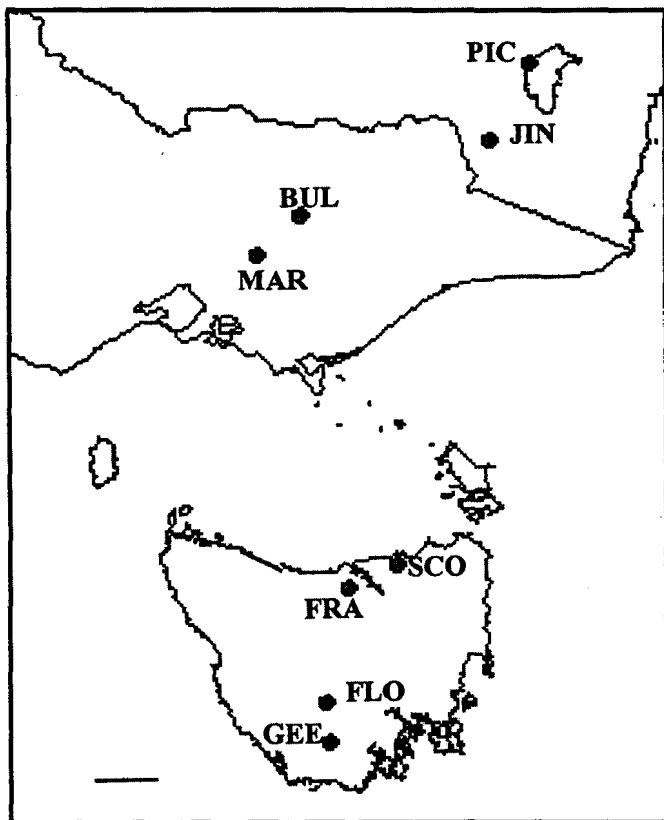


Figure 1. Map showing the localities from which *Chrysophtharta agricola* were collected for this study. Scale bar represents approximately 80 km.

Field-collected beetles were sexed based on tarsal differences (Baly 1862), and their maximum body length was measured using a digital calliper ( $\pm 0.1$  mm). Adults exhibited a striking colour difference between mainland Australia and Tasmania. One male beetle collected from mainland Australia was mated with a previously unmated female from Tasmania, and one male beetle collected from Tasmania was mated with a virgin female beetle from mainland Australia. The offspring of these crosses were reared, mated, and their offspring was reared to confirm that beetles from each region were the same species.

Collection records for adult *C. agricola* were collated to try to determine a relationship between the number of specimens collected with the number of generations between mainland Australia and Tasmania. Collection details were sourced from the Australian National Insect Collection (ANIC), the Victorian Museum, NSW State Forests, NSW Agriculture, the Tasmanian Department of Primary Industries Water and Environment, de Little (1979) and G. Maywald (Queensland Department of Primary Industries, Indooroopilly) (pers. comm). The proportion of collection records from spring, summer and autumn was compared between regions. Only collection dates, and not actual beetle numbers were used for the comparison because collections on each date were made by the same person. For example, if 3 beetles were collected on 14 January, and 1 on 4 February, this was scored as two records for summer.

## RESULTS AND DISCUSSION

In mainland Australia and Tasmania, egg batches were parasitised by *Enoggera nassau* Girault (Hymenoptera: Pteromalidae), and one egg batch from Marysville contained *Neopolysystus* (identified by B.D. Murphy, Forest Research Institute, New Zealand). Parasitoids that developed in *C. agricola* larvae from mainland Australia and Tasmania were the tachinid fly *Paropsivora* sp. and an unidentified tachinid species from an undescribed genus (identified by A.D. Rice, CRC for Sustainable Production Forestry). The braconid wasp *Eadya paropsidis* Huddleston & Short emerged from larvae collected only in Tasmania (Table 2).

An undescribed species of podapolipid mite was found infecting beetles from Frankford, while *Leptus* sp. (Erythraeidae) were found infecting beetles from the Florentine Valley and Frankford. Beetles from mainland Australia were infected only with a mite species from the family Chyzeriidae, probably *Chyzeria* sp. (all mites identified by O.D. Seeman, Department of Primary Industries, Water and Environment, Tasmania). The podapolipid mite data support the results of an

**Table 1.** Mean  $\pm$  s.e. field-collected egg and larval batch sizes and parasitism rates, and male and female sizes for *Chrysophtharta agricola* collected from four sites in mainland Australia and Tasmania. Egg parasitism rates are the percentage of parasitised batches per site. Different letters within columns denote significant differences between means at  $P < 0.05$  (ANOVA for individual sites, t-test for regions; lower case letters refer to differences between sites, upper case letters refer to differences between regions (mainland Australia and Tasmania). N.d. = no data.

Site	Egg batch size	Egg parasitism	Larval batch size	Larval parasitism	Male size (mm)	Female size (mm)
Picadilly Circus	28.2 $\pm$ 5.9 (14–39) <i>n</i> = 9	55 % a	11.6 $\pm$ 1 (6–20) <i>n</i> = 17	22.3 $\pm$ 5 % (0–47) ac	8.1 $\pm$ 0.1 (7.4–8.9) <i>n</i> = 14	8.9 $\pm$ 0.2 (8.1–9.5) <i>n</i> = 12
Jindabyne	26.9 $\pm$ 2.1 (14–39) <i>n</i> = 18	50 % a	13.2 $\pm$ 0.9 (6–20) <i>n</i> = 20	32.5 $\pm$ 4.8 % (0–67) bc	8.5 <i>n</i> = 1	9.2 $\pm$ 0.1 (8.7–9.5) <i>n</i> = 6
Mt Buller	29.1 $\pm$ 5.5 (18–57) <i>n</i> = 7	0 b	8.4 $\pm$ 0.7 (6–12) <i>n</i> = 8	34.6 $\pm$ 7.4 % (0–57) bc	7.8 $\pm$ 0.2 (6.4–8.7) <i>n</i> = 9	8.6 $\pm$ 0.2 (7.7–9.3) <i>n</i> = 12
Marysville	36.6 $\pm$ 3.5 (21–54) <i>n</i> = 6	33 % a	n.d.	n.d.	8.6 $\pm$ 0.2 (8.4–9) <i>n</i> = 4	8.9 $\pm$ 0.2 (8.1–9.5) <i>n</i> = 6
<b>Mainland overall</b>	<b>30.3 <math>\pm</math> 1.7</b>	<b>34.5 % A</b>	<b>11.8 <math>\pm</math> 0.6</b>	<b>29.0 <math>\pm</math> 3.1 %</b>	<b>8.1 <math>\pm</math> 0.1</b>	<b>8.8 <math>\pm</math> 0.1</b>
Florentine Valley	32.6 $\pm$ 1.4 (17–60) <i>n</i> = 54	0 b	11.4 $\pm$ 1.1* (3–24) <i>n</i> = 20	n.d.	8.2 $\pm$ 0.1 (6.7–9.2) <i>n</i> = 65	8.9 $\pm$ 0.1 (7.2–9.9) <i>n</i> = 97
Frankford	29.9 $\pm$ 1.2 (13–67) <i>n</i> = 60	1.6 % b	n.d.	n.d.	8.1 $\pm$ 0.1 (7.5–9.3) <i>n</i> = 44	8.8 $\pm$ 0.2 (7.9–10.1) <i>n</i> = 60
Geeveston	n.d.	n.d.	12.7 $\pm$ 1.2 (6–20) <i>n</i> = 18	10 $\pm$ 4.5 % (0–66) a	n.d.	n.d.
Scottsdale	n.d.	n.d.	11.6 $\pm$ 0.9 (6–17) <i>n</i> = 19	33.9 $\pm$ 4.8 % (6.7–71) b	n.d.	n.d.
<b>Tasmania overall</b>	<b>31.1 <math>\pm</math> 0.9</b>	<b>0.8 % B</b>	<b>12.2 <math>\pm</math> 0.7</b>	<b>23.2 <math>\pm</math> 3.7 %</b>	<b>8.2 <math>\pm</math> 0.07</b>	<b>8.8 <math>\pm</math> 0.1</b>

\* data from Anthony Rice, CRC-SPF

**Table 2.** Larval parasitoid complex of *Chrysophtharta agricola* at seven sites in mainland Australia and Tasmania from larval batches collected between 19 December 2000 and 14 January 2001. + = species present, - = species absent.

site	Tachinid sp 1	<i>Paropsivora</i> sp	<i>Eadya paropsidis</i>
Picadilly Circus	+	+	-
Jindabyne	+	+	-
Mt Buller	+	+	-
Florentine Valley	+	-	+
Frankford	+	-	+
Geeveston	+	-	+
Scottsdale	+	+	+

allozyme electrophoresis study that examined geographic variation between populations separated by at least 20 km, and suggested that gene flow between *C. agricola* populations is limited (Nahrung and Allen a, unpublished). Podapolipid mites spend their entire lifecycle on their host, and are only transmitted during copulation. Therefore, if beetle populations were mixing equally amongst each other, we would expect mites to be more evenly distributed throughout the sampled beetle populations.

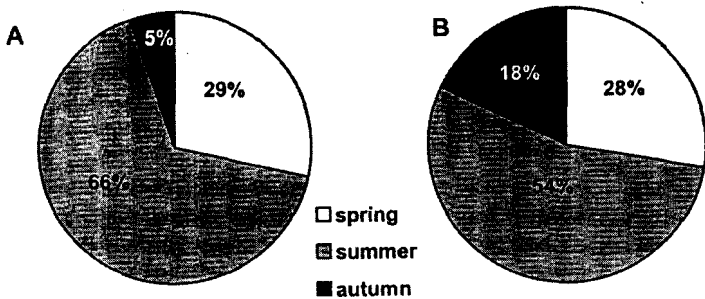
There was a significant difference in egg parasitism rates between mainland Australia and Tasmania (Nahrung and Murphy 2002). Overall, egg batch size, larval batch size, larval parasitism rates and male and female beetle lengths did not differ between mainland Australia and Tasmania (t-tests,  $P < 0.05$ ). However, there were some differences in larval parasitism rates between sites (ANOVA,  $F_{4,77} = 5.6$ ,  $P = 0.001$ ) (Table 1).

Adult *C. agricola* collected in mainland Australia and Tasmania also differed their elytral colouration: beetles from Tasmania were green-brown, while beetles from mainland Australia were yellow-green. Black morph beetles are found in Tasmania and mainland Australia (Nahrung and Allen b, in press), and one black female beetle was reared from a larval batch collected at Jindabyne. Adult beetles collected from mainland Australia and Tasmania mated readily with beetles of opposite origin, and produced viable, fertile offspring, providing further evidence confirming that they were the same species. The elytral colouration of mainland x Tasmanian progeny was more similar to the brown of Tasmanian beetles,

although yellow colouration was apparent in some specimens. Pure lines of Tasmanian and mainland beetles maintained the elytral colouration of their origin, although teneral beetles of either origin were indistinguishable from each other (dark grey with red elytral margins).

Within regions, *C. agricola* collected from Mt Buller contained no egg parasitoids. Data for sites within Tasmania are less comparable because of missing values, but Geeveston exhibited a significantly lower larval parasitism rate than Scottsdale.

One hundred and nineteen independent *C. agricola* collection records from Tasmania and 623 from mainland Australia contained sufficient information to use in determining temporal collection frequency. Collection records dated from 1900 to 1999. Beetles were collected more frequently in autumn from mainland Australia than from Tasmania (Figure 2). This suggests that beetles begin overwintering later in mainland Australia than in Tasmania, or that there is indeed a second generation, or that adults in mainland Australia are longer-lived than their Tasmanian counterparts. However, conclusions drawn from data such as these can be misleading: differences in collection frequencies may simply reflect a greater collection effort at one time of year over another.



**Figure 2.** *Chrysophtharta agricola* adult beetle collection frequency for spring, summer and autumn in Tasmania (A) and mainland Australia (B).

Generally, *C. agricola* originating from Tasmania and mainland Australia shared a number of biological characteristics. Egg and larval batch sizes were similar between regions, as were adult beetle lengths and larval parasitism rates. Regional differences included egg parasitism rates and the elytral colouration of mature beetles. While two species of egg parasitoid were associated with *C. agricola* eggs in mainland Australia, only *E. nassau* was recorded from Tasmanian *C. agricola*. Larval parasitism by *Ea. paropsides* was not detected from mainland Australia in this study, but the parasitoid has previously been recorded from the ACT from *Paropsis atomaria* Olivier (Tanton & Epila 1984). The erythraeid mite species *Leptus* and the undescribed species of podapolipid mite was recovered only from Tasmania, while chyzerid mites were only found in association with *C. agricola* in mainland Australia.

#### ACKNOWLEDGMENTS

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## OPPORTUNISTIC COUNTS OF HOODED PLOVERS ON TASMANIAN BEACHES

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It has been suggested that Tasmania holds large numbers of the Vulnerable Hooded Plover *Thinornis rubricollis* (Garnett and Crowley 2000). Counts or population estimates of this species in Tasmania include Antos (in press), Bryant (2002), Collier and Collier (1995), Cooper (1994, 1997), Holdsworth and Park (1993), Moore (1994), Newman (1982, 1986), Newman and Patterson (1984), Schulz (1990, 1993a,b), Schulz and Kristensen (1993, 1994), Schulz and Menkhorst (1984) and Woehler and Park (1997). However, count data from the state are not complete, with many areas hitherto uncounted. Additionally, there are seasonal variations in the number of Hooded Plovers counted along coasts (Heislors and Weston 1993), meaning that additional counts may serve to document some of these variations. I counted a handful of beaches (totalling 44.6 km) on a "non-birding" holiday to Tasmania during the 2000/2001 breeding season. I recorded whether information (e.g., brochures, signs) on the species was available at each beach. I also collated some information on counts made by other visitors to the State (I. Hance *in litt.*, A. Silcocks and J. Starks pers. comms).

Opportunistic counts can never compare with the utility of major surveys (e.g., Holdsworth and Park 1993, Schulz 1993a, Bryant 2002) or regular counts (e.g., Cooper 1997). Opportunistic counts tend not to be published in the mainstream ornithological literature, but they may provide useful site-specific information for land managers, provide some baseline information for future comparison or aid planning for more thorough counts.

Many opportunistic reports of Hooded Plovers suffer from not adequately describing how much of a beach or a section of coastline was actually searched. Thus, I have presented the distance covered in each instance.

I merely offer the results in the hope that they may be useful to locals or in the future (Tables 1 and 2). Birds were located on all coasts. The ratio of adults to nests (0.08) was the same as the ratio of adults to broods. Of the 25 beaches I visited, 12% had information signs and 4% had brochures available on the species; 16% of beaches visited had some kind of information available. I also checked all

birds for leg bands, and the only bands I detected were at Orford Spit and these birds were probably locally banded (P. Park pers. comm.) .

### ACKNOWLEDGMENTS

Thanks to the ever patient D.P. Hart and to P. Park for her excellent work on Hooded Plovers in Tasmania. Thanks also to I. Hance, O. Seeman, A. Silcocks and J. Starks.

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Table 1. Opportunistic counts carried out by the author in Tasmania, and the availability of information on Hooded Plovers at each site. A = Adult, JUV = juveniles and CH = Chick (flightless young). Counts are in chronological order.

Date	Beach	Area	General	Long.	Lat.	Number of Plovers	Distance (km) Information available?	Comments (see below)
21/12/2000	Gregory's Beach	Stanley	North Coast	149°17'	40°43'	0	1.0	No
21/12/2000	East Inlet to Town	Stanley	North Coast	149°16'	40°46'	2A	3.5	No
22/12/2000	Arthur River mouth to point to north.	Arthur River	North West Coast	149°39'	41°03'	5A	1.8	No
22/12/2000	Adventure Bay	Bruny Island	South East Coast	147°19'	43°21'	2A, 1 CH	2.3	No
26/12/2000	Cloudy Bay	Bruny Island	South East Coast	147°14'	43°26'	7A	7A	No
29/12/2000	Western side of isthmus	Bruny Island	South East Coast	147°19'	43°17'	1A, 2 CH	7.0	No
29/12/2000	Neck camping area south to rocks	Bruny Island	South East Coast	147°19'	43°18'	NA	2.0	No
30/12/2000	Neck camping area north to Shearwater colony	Bruny Island	South East Coast	147°20'	43°16'	1A	3.0	No
31/12/2000	Blowhole Beach	Tasman Peninsula	East Coast	147°56'	43°02'	2A	0.1	No
31/12/2000 and 1/1/2001	Port Arthur	East Coast	East Coast	147°57'	43°08'	2A	1.1	No
1/1/2001	Orford Spit	East Coast	East Coast	147°32'	42°33'	2A	0.7	Yes
1/1/2001	Muir Beach	Coker Bay	East Coast	148°16'	42°07'	0	1.8	No
2/1/2001	Winglass Bay (northern half)	Frycinet National Park	East Coast	148°17'	42°10'	2A, 3 Eggs	0.7	No
2/1/2001	Hazard Beach (northern end)	Frycinet National Park	East Coast	148°16'	42°10'	0	1.0	No
2/1/2001	Richardson's Beach	Frycinet National Park	East Coast	148°17'	42°07'	0	1.6	No
2/1/2001	Sherry Bay	Frycinet National Park	East Coast	148°20'	42°07'	0	0.1	No
3/1/2001	Friendly Beaches, bases P1 to Butler's Point	Frycinet National Park	East Coast	148°17'	41°58'	3A	3.0	No
3/1/2001	Dore Point camping area to point.	Blindfold Bay	East Coast	148°17'	41°13'	0	1.0	No
4/1/2001	Deep Creek north to Point	Mt William National Park	East Coast	148°18'	40°58'	2A, 2 CH	3.3	No
4/1/2001	Deep Creek south to Point	Mt William National Park	East Coast	148°18'	40°58'	4A	0.5	No
5/1/2001	South Choppers Point Beach	Waterhouse Conservation	North Coast	147°33'	40°50'	2A, 3 Eggs	0.5	No
5/1/2001	Waterhouse Point to east	Waterhouse Conservation	North Coast	147°40'	40°49'	2A	2.1	No
6/1/2001	East Beach	Low Head	North Coast	148°49'	41°03'	2A, 2 Eggs	1.0	No
6/1/2001	Baker Beach (except easternmost 1 km)	Adobase Range National Park	North Coast	148°35'	41°08'	1A	5.0	No
7/1/2001	Beach west of town	Devonport	North Coast	148°20'	41°09'	0	0.5	No

200 m of beach not counted; a local reported that birds were commonly seen in East Inlet.

Cattle are permitted to graze the foredune just north of the mouth.

The rangers, Bernard Edwards, had signposted the breeding area.

Not counted; some problems exist with vehicles driven during high tide.

The habitat was sand flats, not typical Hooded Plover habitat. When disturbed one chick ran across the bitumen road (100 kph speed limit).

This adult flew over the isthmus to the western side of Bruny Island.

Birds were below a busy boat ramp within 10m of parked vehicles.

False scrape located; P. Park counts this area frequently.

Not counted, but locally banded birds present.

A well-known fenced area is maintained on the spit.

This beach appears not to be suitable habitat.

Table 2. Some opportunistic counts made by others. See the legend of Table 1 for the key to abbreviations. Counts are in chronological order.

Date	Beach	Area	General	Long.	Lat.	Number	Distance	Observer
20/01/1999	Cox's Blight	Near Melaleuca	South West Coast	146°14'	43°29'	2A	1.0	Andrew Sillocks
12/04/1999	Un-named beach	Woolnorth	North Coast	144°42'	40°58'	2A	1.0	Jon Starks
17/04/1999	Arthur River mouth to north	Arthur River	West Coast	144°29'	41°03'	0	1.0	Jon Starks
23/03/2000	Penguin Beach	Swansea	East Coast	148°04'	42°07'	2A, 1 JUV	N/A	Ian Hance
24/03/2000	Friendly Beaches, Ilesca Pt to Butler's Point	Frycienet National Park	East Coast	148°17'	41°58'	2A, 2 JUV	0.0	Ian Hance
24/03/2000	Cressy Beach	Near Spilkey Bridge	East Coast	148°04'	42°10'	2A, 1 JUV	N/A	Ian Hance

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## THE SPIDER FAUNA UTILISING *EUCALYPTUS OBLIQUA* AT THE WARRA LTER SITE IN SOUTHERN TASMANIA

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### INTRODUCTION

The Warra Long Term Ecological Research (LTER) site in southern Tasmania (146°40'E, 43°04'S) provides the opportunity to conduct ecological work on a wide range of arthropods both at the ordinal and species level. One result is the development of a catalogue of the insects and associated arthropods of Warra. In this paper we record the species of spiders utilising habitat niches on the dominant eucalypt at the site, *Eucalyptus obliqua* L'Herit. A total of 74 species in 22 families are recorded.

### METHODS

Sampling different parts of a tree requires different sampling techniques to be employed. In this study we used canopy fogging, trunk spraying, caged log sections, hand collection and beating of foliage. Details of the collection techniques used are described in Bashford *et al.* (2001).

We sampled four mature *E. obliqua* trees at the mid-upper canopy level (35-40 m) and the lower to mid canopy level (20-30 m). Sampling was conducted in October 2001 and February 2002.

The lower trunks of ten *E. obliqua* trees of a range of diameter sizes were sprayed with aerosol synthetic pyrethrin insecticide to a height of 2.5 metres. Invertebrates were collected using aspirators and forceps from orange plastic sheets sealed to the base of each tree.

Spiders emerging from cages placed on six old growth and six regrowth *E. obliqua* trees were collected over a one-year period. Only emergence from cages which were placed on the logs as soon as the trees were felled were used to obtain records of spiders utilising bark.

In February 2002, ten 6 year old *E. obliqua* regeneration trees were fogged from the ground and the catch collected from plastic sheeting placed under the trees. One of us (LJB) sampled adjacent same age regeneration by beating and hand collecting in September 2001.

## RESULTS

Table 1 lists the species of adult spiders collected from different habitat niches on *E. obliqua* at Warra. As expected the caged logs, which were sampled monthly over a one-year period, provided the richest source of species. Many of these were duplicated in other sampling on different parts of the tree. This indicates the use of the tree trunk as a 'highway' linking all parts of the tree with the ground. The bark ribbons provided spider species not collected elsewhere but since these were collected from the base of the tree may represent sheltering litter species. Only six adult species were collected as listed but many juvenile and immature specimens were also collected which could not be identified. Similar numbers of species were collected from upper canopy (14), lower canopy (12), and regeneration (20). Only 3 species were common to all three samples.

Table 2 shows the relationship between spiders and other arthropod orders associated with the *E. obliqua* habitat.

Spiders constitute a consistent proportion of the invertebrates present on *E. obliqua*. Spiders are evenly distributed on the foliage and branches throughout the canopy. The highest assemblage was on the young regeneration trees but this comprised mostly of juvenile and immature individuals, which could not be identified to species. The young dense regeneration seems to be a 'nursery' area for many arboreal spider species.

One study (Heterick *et al.* 2001) records, at the species level, the spiders on several Western Australian eucalypts. Sampling for canopy and bark invertebrates were conducted seasonally over a one-year period at a range of sites. The number of spider species found on each of those eucalypts was similar but markedly different from our results on *E. obliqua* due to the difference in sampling frequency. However the number of spider species caught on bark was similar when sampling was conducted over a one-year period. The bark species for jarrah, marri, paperbark wandoo and wandoo were 23, 25, 32 and 37 respectively compared to 34 species from fogged *E. obliqua* bark.

## COMMENTS

In 1948, Musgrave stated that only 100 species of spiders were recorded from Tasmania. In 1987, Raven in a list compiled from the Queensland Museum database, recorded 180 species from Tasmania. It has been estimated that only 30% of Australian spider species have been described (Davies 1985). It can be interpreted that there may be up to 600 species in Tasmania. However Tasmania has been well serviced by arachnologists over the years, for example, Hickman in the late 1920's, produced a series of descriptive papers "Studies in Tasmanian Spiders" describing 87 species. (Hickman 1926). In recent times Tracy Churchill's sampling of coastal heathland in northeast Tasmania (1993) and Raven and Gallon's (1987) examination of the spider fauna of the South West World Heritage areas have continued to increase the knowledge of the Tasmanian spider fauna. Local studies at specific sites have helped expand the distribution records of some species (Bashford 1992).

There have been a number of studies looking at the diversity of invertebrates on eucalypts at an ordinal level. (Recher *et al.* 1996; Majer *et al.* 2000). In this project we have taken a species level approach which enables ecological data to be obtained. Future analysis will determine which spider species are either dependant on part of the tree structure as a habitat or reliant on specific prey species which themselves are dependent on the tree structure.

## ACKNOWLEDGMENTS

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Table 1. Species of spiders collected from *Eucalyptus obliqua* at Warra LTER site.

Family	Genus	Species	Sex	Upper canopy	Lower canopy	Bark fogging	Bark ribbons	Caged logs	Regen fogging	Regen beating
UNKNOWN- Amaurobioti			F					x		
UNKNOWN- Amaurobioti			F					x		
AMAUROBIDAE	A1		M					x		
AMAUROBIDAE	A2		MF			x		x		
AMAUROBIDAE	Stenopsoma		MF					x		
ANAPIDAE	<i>Rodonius</i>	<i>pervus</i>	F					x		
ARANEIDAE	<i>Araeus</i>	<i>eburnus</i>	MF					x		x
ARANEIDAE	<i>Arya</i>	<i>cleavelus</i>	M	x					x	x
ARANEIDAE	<i>Dolophanes</i>		M	x	x				x	x
ARANEIDAE	Novale 7	<i>trihirculela</i> ?	F							x
ARANEIDAE	sp C		MF	x	x					
AUSTROCHLODAE	<i>Hickmania</i>	<i>tygoides</i>	M					x		
CLUBIONIDAE	<i>Clubiona</i>	A	MF			x		x		
CLUBIONIDAE	<i>Clubiona</i>	B	MF	x	x			x		
CLUBIONIDAE	<i>Clubiona</i>	D	MF		x	x		x		
CLUBIONIDAE	<i>Clubiona</i>	E	M						x	
CLUBIONIDAE	<i>Clubiona</i>	J	M	x						
CLUBIONIDAE	<i>Clubiona</i>	"variana"	M					x		
CORINNIIDAE	<i>Suponus</i>	<i>picta</i>	MM				x			x
CYCLOCTENIDAE	<i>Cycloctenus</i>	<i>cryptophilus</i>	MF			x		x		
CYCLOCTENIDAE	<i>Cycloctenus</i>		1 MF				x	x		
CYCLOCTENIDAE	D2	sp A	MF			x	x	x		
CYCLOCTENIDAE	D2	sp B	MF			x		x		
DESIDAE			D1					x		
DESIDAE	near <i>Manganatis</i>		F			x		x		
DESIDAE	<i>Nemantia</i>	<i>periscalis</i>	M					x		
DESIDAE	<i>Nemantia</i>	B	MF			x		x		
DESIDAE	<i>Torops</i>	<i>montanus</i>	MF					x		
DESIDAE	D3		MF			x		x		
DESIDAE	D4	sp B	M			x		x		
DESIDAE	D6		M			x		x		
DESIDAE	D7		M			x		x		
DICTYNIDAE			imm			x		x		
GNAPHOPSIDAE			F					x		
GNAPHOPSIDAE	poss <i>trivula</i>		M					x		
LAMPONIDAE	<i>Lampona</i>	<i>cylindrata</i>	M					x		
LAMPONIDAE		NEW	MF					x		
LINYPHIDAE	L1		MF			x		x		
LINYPHIDAE	L2		MF			x		x		
LINYPHIDAE	L5		MF			x		x		
LINYPHIDAE	L8		M					x		
LYCOSIDAE					x	x	x			
MIMETIDAE	<i>Australonimetus</i>		F					x		
MIMETIDAE	<i>Ero</i>	<i>tasmanensis</i> ?	MF			x		x		
NICODAMIDAE	<i>Liodamus</i>	<i>olga</i>	MF					x		
ORSOLOBIIDAE	<i>Tasmanoonops</i>		MF			x	x	x		
ORSOLOBIIDAE	<i>Cornifex</i>	<i>insignis</i>	MF			x		x		
PARARCHAEIDAE	<i>Pararchaea</i>	<i>caribola</i>	M					x		
SALTICIDAE	<i>Myrmarchna</i>	<i>cognata</i>	F							x
SALTICIDAE	<i>Prostheclina</i>	<i>pallida</i>	MF			x	x	x		
SALTICIDAE	SB					x		x		
SALTICIDAE	SF2		F			x		x		

Table 1 cont. Species of spiders collected from *Eucalyptus obliqua* at Warra LTER site.

Family	Genus	Species	Sex	Upper canopy	Lower canopy	Bark fogging	Bark ribbons	Caged logs	Regen fogging	Regen beating
SEGESTRIDAE			Imm			x				
STPHIDIIDAE	<i>Stiphidium</i>	<i>facatum</i>	MF					x		
STPHIDIIDAE	ST1					x		x		
SYNOTAXIDAE	<i>Typus</i>	<i>biactosa</i>	F			x		x		
TETRAGNATHIDAE	<i>Erycinola</i>		MF							x
TETRAGNATHIDAE	<i>Orsone</i>		MF					x		
TETRAGNATHIDAE	<i>Tetragnatha</i>		Juv		x					
THERIDIIDAE	<i>Achearanea</i>	<i>varuculata</i>	F	x						
THERIDIIDAE	<i>Achearanea</i>	A	MF					x		
THERIDIIDAE	<i>Dipoena</i>	A	M					x		
THERIDIIDAE	<i>Dipoena</i>	B	M						x	
THERIDIIDAE	<i>Enoplognatha</i>		M	x	x					
THERIDIIDAE	<i>Euryops</i>	<i>ebogens</i>	F			x				
THERIDIIDAE	<i>Euryops</i>	sp A	MF	x	x					
THERIDIIDAE	<i>Euryops</i>	sp D		x						
THERIDIIDAE	<i>Phoroncidia</i>	<i>hibberculata</i> ?	MF		x					x
THERIDIIDAE	<i>Phoroncidia</i>	sp 2	F	x	x					x
THERIDIIDAE	<i>Phoroncidia</i>	sp 3			x					
THERIDIIDAE	<i>Statola</i>	<i>ilvens</i>	MF			x		x		x
THERIDIIDAE	SWF		F	x						x
THERIDIIDAE	RB		MF							x
THERIDIIDAE	T1		M	x						x
THERIDIIDAE	T2		MF			x				
THERIDIIDAE	T3		M					x		
THERIDIIDAE	T4		F			x				
THERIDIIDAE	T5		MF	x						
THERIDIIDAE	T6		MF					x		
THERIDIIDAE	T8		F							x
THERIDIIDAE	T9		F							x
THOMISIDAE	<i>Disea</i>	<i>inornata</i>	MF							x
THOMISIDAE	<i>Disea</i>		MF	x	x	x			x	
THOMISIDAE	<i>Sidyrella</i>		Imm			x		x	x	
THOMISIDAE	<i>Stephanopis</i>	<i>cambridgei</i>	MF			x		x		

**Table 2.** The number of spider individuals collected compared to some other invertebrates collected from *Eucalyptus obliqua* at Warra LTER site.

Site	Date	ACARI	ARANEAE	BLATTODEA	COLEOPTERA ADULTS	COLLEMBOLA	DIPTERA ADULTS	HEMIPTERA	HYMENOPTERA FORMICIDAE	HYMENOPTERA	LEPIDOPTERA LARVAE	PSEUDOSCORPIONS	% SPIDERS
upper canopy	Oct-01	30	27	14	93	58	48	192	29	35	10	0	9
lower canopy	Oct-01	41	27	29	378	101	136	331	129	58	18	0	2
upper canopy	Feb-02	9	24	9	15	12	48	63	9	15	0	0	12
lower canopy	Feb-02	3	29	10	31	44	58	50	1	28	3	1	11
bark fogging	Apr-02	8	39	223	328	6	104	23	5	86	4	73	4
Regen fogging	Mar-02	13	46	0	53	13	86	286	1	23	6	0	9
Total		104	192	285	898	234	480	945	174	245	41	74	5

## BOOKREVIEW

*Snakes and Lizards of Tasmania. Fauna of Tasmania Handbook No. 9.*

By Mark Hutchinson, Roy Swain and Michael Driessen

Published by the Nature Conservation Branch (DPIWE) and University of  
Tasmania

Reviewed by Sue Baker

"Snakes and lizards of Tasmania" is a great field guide to the identification of Tasmania's 3 species of snake and 18 species of lizard. For each species there is an excellent colour photograph, a distribution map and written description of identification features, distribution and interesting details of its natural history. The book lends itself well to flicking through photos for making an identification, and also contains scientific keys. The keys are a little difficult for the non-biologist to use, but many of the couplets have helpful diagrams which explain the text. However, several enthusiastic non-biologist colleagues did have some difficulty with terms such as "vent", "dorsal", "lateral", and "tubercles", which are not defined in the glossary. Some prior knowledge in biological nomenclature is therefore recommended.

Nevertheless, the book is of broad appeal, being loved not only by myself as a biologist, but also by a group consisting of an engineer, excavator operator and an asbestos removalist. The book is made more interesting by descriptions about the biology, how to catch lizards by "fishing" with a mealworm, as well as useful things like how to treat snakebite and a bibliography of further reading. The book is available at most Tasmanian bookstores, and is an essential item for any keen naturalist.

## Warrugang

Monochromatic arms

Body wrapped in Federation colours,

suspended in an invisible vortex

- greying when crepuscular

Signs of a more sinister agenda

Wary passers-by hurry home

at sun's finale

as it begins to thaw

Hurriedly continuing its nocturnal dance

- a convulsing, anastomosing silhouette

Almost free

so close

But not tonight

it must give up

as aurora freezes the pathetic frame once more

Chris Palmer