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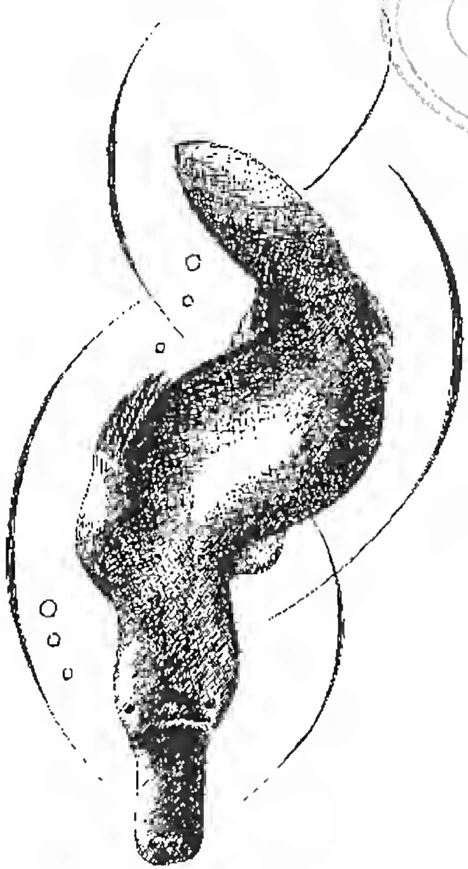

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CONTENTS

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The Tasmanian Naturalist (1998) **120**: 2-8.

MACROPHYTES OF LAKE LEA, NORTH-WEST TASMANIA

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Abstract. Aquatic, semi-aquatic and marginal macrophytes were surveyed at Lake Lea, a sub-alpine lake in north-west Tasmania. The twenty-nine species identified were dominated by monocotyledons. Low growing sedges and herbaceous species were the most common growth forms. The need for further studies of macrophyte ecology in Tasmania is highlighted.

INTRODUCTION

Collection of baseline biological data for individual systems plays a crucial role in allowing the conservation status of areas and the plants they contain to be determined. Despite Tasmania's rich variety of aquatic systems, there have been few surveys of aquatic vegetation, particularly in lakes. The abiotic factors which operate in determining aquatic plant communities are different in lake systems compared to river systems and hence these environments tend to contain different sets of aquatic plants (Brown 1975). Tasmanian wetland vegetation has been studied by Kirpatrick and Harwood (1983ab), Hughes (1987) and Hughes and Davis (1989). Askey-Doran (1993) has documented macrophyte species/communities in eastern Tasmanian rivers and limited descriptions of macrophyte communities were made for coastal dune lakes by Walsh (1997).

This study aimed to describe the macrophyte species in a sub-alpine Tasmanian lake. The survey reported here was completed as part of a study investigating factors influencing usage of the lake by platypus (Otley 1996).

This paper uses a broad definition of the term macrophyte to include aquatic, semi-aquatic and marginal plant species. Aquatic species were considered to be those adapted to growing in and being entirely dependent on permanent water, either completely submerged or emergent (Aston 1977; Hughes 1987). Semi-aquatic species included those that require only periodic inundation for survival (Aston 1977) and can be found anywhere from the exposed shore in summer to permanent but shallow water in winter. Marginal species are typically terrestrial species found only at the lake edge which tolerate temporary inundation in winter.

STUDY SITE

Lake Lea is a relatively undisturbed sub-alpine lake situated in north-western

Tasmania (41030 E, 540330 N) at an altitude of 800 m. The lake has an approximate surface area of 142 ha and an estimated volume of 2.6 Mm^3 (Anon 1992). While it is relatively shallow, at between one to two metres, there is also at least one deep hole of over ten metres (Inland Fisheries Commission 1991).

The lake level rises and falls dramatically, with a fall over the summer 1996/97 of between a half and one metre compared to full winter levels (personal observation). During the study period, the lake flowed north-eastwards into the Lea River. However, it is also known to flow south-west into the Vale River during extremely dry periods, an unusual hydrological phenomena (Australian Heritage Commission 1988).

The lake substrate is predominantly sand, but varies from mud and silt in the western end of the lake to more sand, stone and rocky outcrops in the eastern end.

Despite being dystrophic (i.e. rich in undecomposed organic matter) the waters of Lake Lea are humic, supporting a range of macro-invertebrates including *Parasticoides tasmanicus tasmanicus* (Department of Lands, Parks and Wildlife 1989). Aquatic vertebrates present include platypus (*Ornithorhynchus anatinus*), brown trout (*Salmo trutta*) and from October onwards, water birds including the black swan and grey teal.

The lake is surrounded by five terrestrial vegetation communities: *Poa labillardieri* grassland (Gilfedder 1995), callidendrous rainforest, *Eucalyptus* forest dominated by *Eucalyptus subcrenulata* (Tasmanian Public Land Use Commission 1996), buttongrass blanket moorland (Jarman *et al.* 1988) and paper bark (*Melaleuca ericifolia*) scrub.

METHODS

Sampling was conducted in July 1996 and February 1997. Plants were collected by hand at various sites around the entire lake with sampling restricted to a water depth of less than one metre. Specimens were identified to species level where possible. Identifications were undertaken by Mr. A. Buchanan (Tasmanian Herbarium), with assistance from Mr. D. Morris (Tasmanian Herbarium, grasses) and Dr. P. Dalton (Botany Department, University of Tasmania, mosses and hepatics). Nomenclature followed Buchanan *et al.* (1989) for dicotyledons, monocotyledons and ferns and Jarman and Fuhrer (1995) for mosses and liverworts. The habitat (i.e. low growing, water column, marginal) and presence of flowering parts were recorded for each species.

RESULTS

Twenty-nine macrophyte species were identified from Lake Lea of which 17 were monocotyledons, eight dicotyledons, two mosses, one hepatic and one was a fern (Table 1). Seven of these species were marginal macrophytes, inundated (but

Table 1. Macrophyte species collected from Lake Lea.

Family	Species	Habitat	Flowering#	Conservation status*
Monocotyledons				
Centrolepidaceae	*Centrolepis sp.*	low growing		common
Cyperaceae	*Baumea rubiginosa*	water column		common
	Carex gaudichaudiana	low growing	February	common
	Carex sp.	water column		
	Eleocharis gracilis	low growing		common
	Isolepis alpina	low growing		common
	Isolepis crassiuscula	low growing	February	common
	Isolepis fluitans	water column		common
	Isolepis montivaga	low growing		unknown or indeterminate
Iridaceae	*Diplarrena moraea*	marginal	February	common
Juncaceae	*Juncus australis*	marginal	February	common
	Juncus bassianus	marginal	February	common
Poaceae	*Agrostis lacunarum*	marginal	February	endemic, common
	Amphibromus recurvatus	water column	February	common
	Glyceria australis	water column		common
Restionaceae	*Restio complanatus*	marginal	February	common
	Restio hookeri	marginal		endemic, common
Dicotyledons				
Campanulaceae	*Pratia surrepens*	low growing	February	common
Drosaceae	*Drosera binata*	marginal		common
	Drosera pygmaea	marginal		common
Haloragaceae	*Myriophyllum pedunculatum*	low growing	February	common
Lentibulariaceae	*Utricularia dichotoma*	low growing	February	common
Menyanthaceae	*Liparophyllum gunnii*	low growing	February	endemic, rare
Scrophulariaceae	*Gratiola nana*	low growing		common
Umbelliferae	*Centella cordifolia*	marginal		common
Mosses				
Dicranaceae	*Campylopus sp*	low growing		common
Sphagnaceae	*Sphagnum sp.*	low growing		common
Hepatics				
Jungermaniaceae	*Cryptochila grandiflora*	low growing		common

Table 1. (cont.)

Ferns			
Isoetaceae	*Isoetes gunnii*	low growing	endemic, common

*Source - Flora Advisory Committee (1993)
#Specimens collected or observed with flowering parts
Rare = located in 20 or less 10 x 10 km grid squares

not submerged) during high lake levels. These were typically larger clump sedge and rush species including *Restio complanatus, R. hookeri, Agrostis lacunarum, Diplarrena moraea, Juncus bassianus* and *J. australis*.

Half of the species present were rooted low growing plants, submerged at normal lake levels and emergent during summer, during which time flowering occurred. Five of these species were sedges and rushes (narrow leafed) and nine were broad leafed species.

Five species were rooted water column inhabiting species, three completely submerged (*Carex* sp., *Isolepis fluitans* and *Glyceria australis*) and two emergents (*Baumea rubiginosa* and *Amphibromus recurvatus*). No free-floating unattached species were present.

Three species present were found only on the exposed sandy lake edge over summer. The sundews, *Drosera pygmaea* and *D. binata*, and *Centella cordifolia* are not aquatic species (Curtis, 1963, 1975) but colonisers of the drier margins.

All but one species (*Gratiola nana*) were common at Lake Lea. The most dominant species were *Isoetes gunnii, Pratia surrepens, Isolepis alpina* and *Carex* sp. *Liparophyllum gunnii, Utricularia dichotoma* (particularly obvious in summer with a conspicuous purple flower), *Myriophyllum pedunculatum* and *Restio complanatus* (at the lake margin) dominated to a lesser extent.

DISCUSSION

Lake Lea supports a wide variety of macrophyte species dominated by representatives from the monocotyledonous families, particularly Cyperaceae (sedges). Non-angiosperm diversity was low. However, the quillwort, *Isoetes gunni*, appeared particularly dominant. Most of the species found at Lake Lea have also been found in or near lowland streams or poorly drained habitats (Askey-Doran 1993; Hughes 1987), suggesting that Tasmanian plant communities in lakes may be similar to those found in river systems.

In terms of growth form, Lake Lea was dominated by low growing or ground cover species. Species representing free-floating and floating-leafed growth forms

(Sainty and Jacobs 1988) were not present. The make up of the communities may be controlled by a number of factors including shore physiography, substrate, exposure to wave action, temperature, water depth and water nutrient level (Brown 1975; Hughes 1986; Humphries 1996). The trend of dominance by low growing species and an absence of tall emergent species found in this survey was also found in sub-alpine lakes in New Zealand by Michaelis (1983). She suggested there was possibly an upper altitudinal limit for tall-growing macrophytes relating to factors such as water temperature, substrate, lake depth and degree of exposure. This is supported in this study and by the observation of Walsh (1997) that the majority of Tasmanian coastal dunes lakes sampled had extensive fringes of tall-growing species. Further investigation and comparison of macrophtye communities in Tasmanian coastal, sub-alpine and alpine lakes is required.

Due to the seasonal fluctuation of water level it is difficult to determine the importance of aquatic versus semi-aquatic species at Lake Lea. However the dominance of low-growing species which flowered during the summer suggests that the majority of the species at Lake Lea are semi-aquatic.

All but two species at Lake Lea are common and/or have a secure reservation status (Kirkpatrick and Harwood 1983b; Moscal and Kirkpatrick 1992; Duncan and Isaac 1986), with *Liparophyllum gunnii* being considered rare and *Isolepis montivaga* with an unknown or indeterminate status (Flora Advisory Committee 1993). Only four species *Isoetes gunnii, Restio hookeri, Agrostis lacunarum* and *Liparophyllum gunni* are endemic to Tasmania (although *L. gunni* is also found in New Zealand) and all are well represented throughout Tasmania (Kirpatrick and Harwood 1983a). None of the species present at Lake Lea are introduced (Buchanan *et al.* 1989). Despite the lack of rare or vulnerable species Lake Lea is considered a wetland of high conservation significance because of its unusual hydrology and geomorphology (Kirkpatrick and Tyler 1988).

This study provides a basic description of the macrophyte community present at a sub-alpine Tasmanian lake. The lack of comparative studies highlights the need for further investigative studies of macrophyte ecology in Tasmanian and Australian lake systems in general.

ACKNOWLEDGEMENTS

I wish to acknowledge the expertise of the botanists who identified the plants, particularly Alex Buchanan. To the platypus project supervisor, Sarah Munks, who organised the initial environmental survey and suggested I write this, thanks for letting me freeze my arm off collecting samples! I also appreciated her criticisms of an early draft. My appreciation also goes to Mike Askey-Doran for his helpful comments of the paper. I also acknowledge the assistance of various volunteers who were involved in the sampling including Bill, Lexie and Aaron.

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SASSAFRAS SEEDLING ESTABLISHMENT ON RAINFOREST MARGINS IN EASTERN TASMANIA

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Abstract. The numbers of sassafras seedlings present in fenced and unfenced paired plots at six sites on the edge of remnant rainforest patches in eastern Tasmania were monitored over a period of nine years. The numbers of seedlings present in the unfenced plots declined with no established seedlings found at the last measurement. The average pattern of numbers of seedlings present in the fenced plots was an increase over the first eighteen months and a subsequent decline to lower levels which were still significantly greater than in the unfenced plots. Browsing and soil disturbance from mammals appeared to be responsible for the differences between fenced and unfenced plots. However, competition for moisture was probably influencing mortality rates of seedlings in fenced plots and differences between sites with respect to their susceptibility to drought produced different patterns of recruitment and mortality over time.

INTRODUCTION

Seedling regeneration of sassafras in rainforest is rare (Read and Hill 1988) with most regeneration appearing to arise from coppice shoots from existing stems. Read (1985) attributed the failure of sassafras seedling regeneration to the high drought susceptibility of young seedlings. Hickey (1982) noted that the survival of seedlings in unfenced planting trial areas was significantly lower than their survival in fenced areas and attributed this differential survival to the effects of browsing animals. The present study was undertaken in order to determine the impact of browsing animals on seedling establishment in relict rainforest patches in eastern Tasmania. The results after eighteen months of protection from browsing are presented in Neyland (1991). This paper reports the results after nine years of protection.

METHODS

Ten paired one metre square plots, one fenced and an adjacent one unfenced, were established in a range of remnant rainforest sites from Eaglehawk Neck to St Helens across eastern Tasmania. The fenced plots were completely enclosed with wire mesh placed over and around metal star pickets. The base of the fence was secured to the ground with logs and rocks to prevent animals from digging under the wire. All mammals above the size of a rat would have been excluded. The plots were subjectively located on the edges of rainforest patches in spots where, at the time of establishment of the trial, sassafras cotyledons were abundant. The plots were established between 25th October and 18th November 1988 and were subsequently remeasured on 31st June - 1st July 1989, 6th February - 1st May 1990, 11th October 1990 and 10-11th November 1997. At the initial measurement, all cotyledons and established seedlings were counted. At subsequent measurements only seedlings with at least one pair of true leaves were counted. For the last measurement, nine years after initial establishment of the trial, only six of the plots were remeasured. The other four plots were either unable to be relocated or accessed. The locations of the six remeasured plots are as follows: Schofields Road (Australian Map Grid reference 5752 52447), Wyefield Rivulet (5729 53468), MS Road spur 10-2-2 (5714 53572), Tom's Gully (5900 54218), Apsley Myrtle Forest Reserve (5938 53724) and Mt St John (5936 53734).

Numbers of seedlings were log transformed before analysis. Analysis of variance was used to compare the influence of fencing and time on the numbers of sassafras seedlings. Least significance differences were used to test for differences between fenced and unfenced plots at each time.

RESULTS

The mean trend in numbers of seedlings in fenced and unfenced plots over time is shown in Fig. 1. Numbers of seedlings were significantly influenced by fencing ($F_{(1,5)}=17.5$, $p<0.01$) and the trend over time differed in fenced and unfenced plots ($F_{(4,20)}=7.3$, $p<0.01$). Numbers of seedlings in fenced and unfenced plots did not differ at establishment but were significantly different at all other times (all $p<0.001$).

The patterns observed in the unfenced plots on all of the sites was similar. For those unfenced sites where cotyledons were abundant at establishment only small seedlings (up to four leaf pairs) were subsequently observed with no established seedlings being encountered and numbers of seedlings declining rapidly over time. Established seedlings greater than 10 cm high were only observed in the fenced plots. For fenced plots four patterns were recognisable (Fig. 2). At the majority of sites (Apsley Myrtle Forest Reserve, Wyefield Rivulet and Mt St John) the numbers of seedlings increased dramatically after fencing but declined to low levels after nine years. The trend at MS Road was similar but the extent of the decline was much reduced. At Schofields Road there was a small number of seedlings present originally that stayed relatively constant and ended up at a similar level of density to the majority of sites after nine years. At Tom's Gully the numbers of seedlings in fenced plots declined and ultimately no seedlings survived.

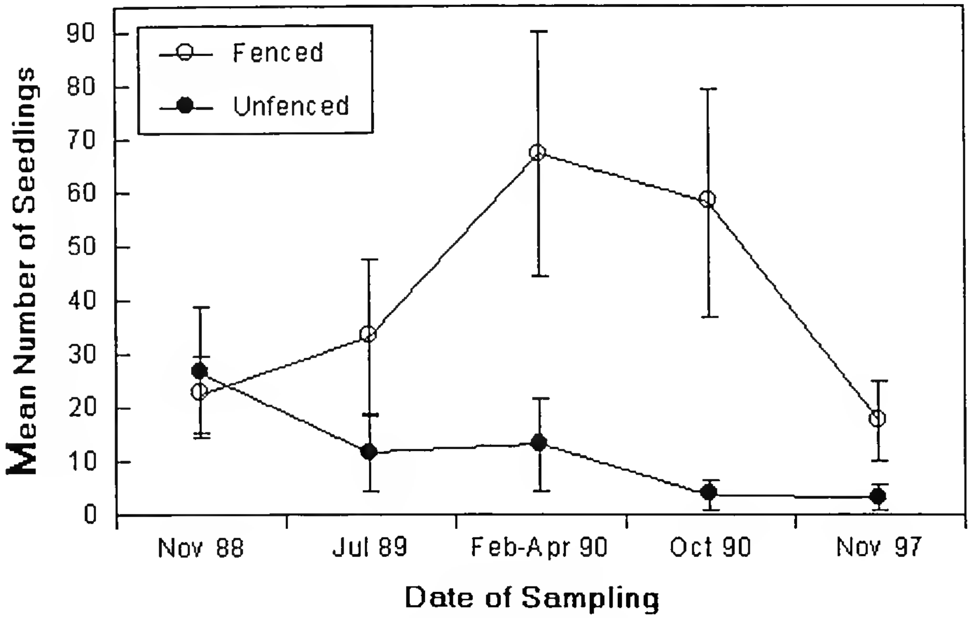

Fig. 1. Mean and standard error of the numbers of sassafras seedlings in fenced and unfenced plots at six sites over time.

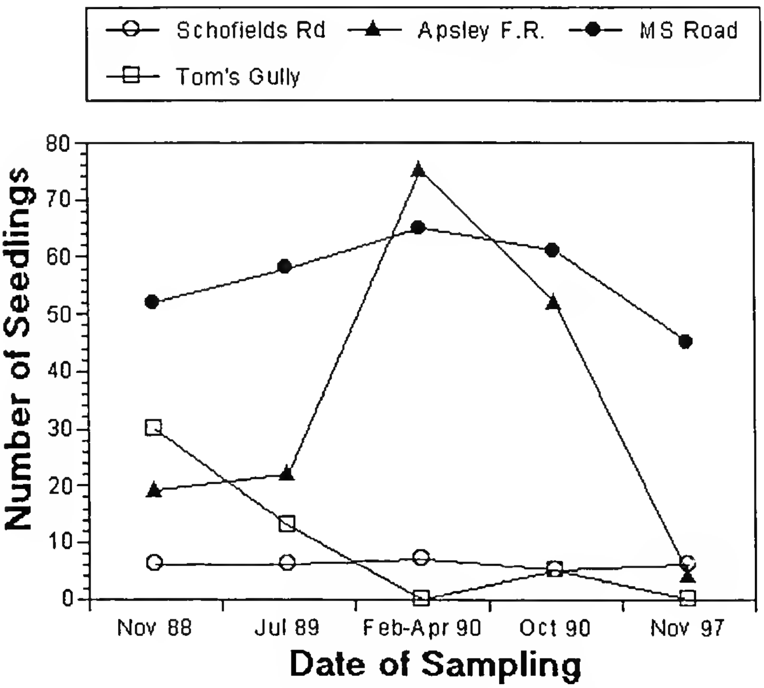

Fig. 2. Patterns of the numbers of sassafras seedlings present over time in fenced plots at different sites.

Table 1. Browsing susceptibility index for rainforest tree species (after Hickey 1982).

Species	Susceptibility Index
Myrtle	1.0
Celery-top pine	1.1
Leatherwood	1.7
Blackwood	4.9
Sassafras	55.0

DISCUSSION

The results clearly show that protection from browsing has a major impact on seedling establishment by sassafrass. Hickey (1982) developed a browsing susceptibility index for rainforest tree species by comparing the survival of seedlings in fenced versus unfenced plots in selectively logged rainforest south of Smithton. Sassafras was found to be the most susceptible species (Table 1). Sassafras seedlings are obviously very palatable to browsing mammals. In unfenced areas established seedlings appear to be restricted to microsites such as logs and amongst fallen debris or dense patches of undergrowth where some protection from browsing is obtained.

The differences between fenced and unfenced plots were much less apparent after nine years compared with that after two years of protection. This is probably related to a self thinning effect mediated through competition between seedlings. However, in most of the fenced plots there were some seedlings which had reached a size large enough (e.g. two metres at Wyefield Rivulet) to probably ensure their survival to adulthood. If the large numbers of seedlings originally present all survived, the undergrowth would become thick and impenetrable.

The main resource limiting survival of seedlings in fenced plots may well be water. Differences between sites (Fig. 2) are explainable by differing moisture availability. MS Road occurred at the highest altitude and had the highest and least variable rainfall. This site showed the least decline in seedlings present and probably most closely represents the actual effects of mammal browsing when other mortality factors are not significant. Most sites showed an initial high rate of recruitment with subsequent high rates of mortality. There were a series of years of below average rainfall between the last two measurements (Neyland 1996) which would probably have induced moisture stress in the seedlings and contributed to the high mortality. The site at Schofields Road was on a steep bank and appeared to be the driest site and hence probably the most drought prone. At this site there was no recruitment after the seedlings were caged but a high survival rate with numbers of seedlings equal to or below most other sites. Recruitment here seemed to be associated with good rains after the 87/88 drought with the low numbers of seedlings present not leading to intraspecific competition. The very high rate of scedling mortality in the fenced plot at Tom's Gully may be a result of the flood proneness of this site. This site was loeatcd in a gully and on several oecasions flood debris was found over the eage.

Two of the exelosurcs were located in the western extremity of what is now the Douglas Apsley National Park, on the margins of eallidendrous rainforest dominated by myrtle and sassafras. Thesc sites were quite different from the other sites which were sassafras dominated (and usually laeking myrtle altogether). They were notable in that in both eages there was an abundanee of seedlings of a range of species (sassafras, myrtle, silver wattle, musk and other speeies) and outside the eages the ground was very heavily disturbed and no established seedlings were observed. It is likely that the ground disturbanee was the result of digging by potoroos *Potorous tridactylus*. In sueh forests the likelihood of suecessful seedling establishment on the ground must be very low indeed.

This study has demonstrated the important role that mammal browsing and disturbanee (such as through digging) plays in influencing the numbers of cstablished scedlings. However, thc long term data prcsentcd hcre has modified earlier eonclusions with other factors, particularly drought, influeneing the results and highlighting the importanee of long term monitoring in ecology.

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THE SIGNIFICANCE AND CONSERVATION OF THE INVERTEBRATE FAUNA OF LAMBERT GULLY, MOUNT NELSON, TASMANIA

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Abstract. The catchment area of Lambert Gully on Mount Nelson in Hobart was found to be endowed with a rich and interesting invertebrate fauna which considerably enhanced the environmental and conservation value of this important urban reserve and its surrounding bushland environs. Several endemic insect species were found that are restricted to the general area and there was strong representation of species that are endemic to Tasmania. Half the Tasmanian butterfly fauna was present and over 600 species of native moths probably occur in the study area. Significant populations of beetles, flies, native bees, wasps, spiders and other groups were also present. Management issues relating to invertebrates include fire management, clearance and fragmentation of bushland, impacts from garden effluent and other runoff, and the increasing invasion of exotic plant and animal species.

INTRODUCTION

This paper examines the diversity of the native invertebrates, the presence of significant species and some of their environmental and management requirements in the bushland area surrounding Lambert Gully on the north-east facing slopes of Mount Nelson. Maintenance of the natural values of the Mount Nelson environment is a high priority for local residents. Invertebrates such as insects and spiders are a major contributor to biodiversity and play a crucial role in maintaining the integrity of natural environments. For this reason their interactions, needs and responses must be considered in any proposed land management regimes.

STUDY AREA

Lambert Gully is a major drainage line for the catchment on the east-facing slopes of Mount Nelson, three kilometres south west of the Hobart city centre. Up until recently it has remained in a reasonably natural state due to its steepness and lack of development pressure. The gully contains a significant tract of wet sclerophyll forest, virtually unique in the metropolitan area. However, the upper part of the catchment, bounded by Nelson Road and Rialannah Road, is less steep and zoned within the council planning scheme for future residential development. The vegetation here is dominated by grassy eucalypt woodland and mixed *Allocasuarina* forest; vegetation types which are not well preserved within Tasmania generally. This area was therefore of particular interest to this study.

METHODS

The invertebrate fauna was studied over an eight week period from mid March to mid May 1994. Casual observations were also made over a period of three years prior to the intensive study. Systematic sampling was targeted at specific groups of invertebrates using the following methods:

Light trapping. Ultra-violet light traps were operated on warm nights at several sites between Nelson Road and Lambert Gully in order to obtain a profile of the nocturnal species present and their relative abundances. Specimens which entered the traps were anaesthetised with the vapours of tetrachlorethane.

Pitfall Trapping. This method was used for surveying litter invertebrates. Plastic cups 10 cm in diameter were sunk flush with the soil surface and one-third filled with ethylene glycol as a preservative. They were arranged in groups of three along traplines 100 metres in length with a cluster every 10 metres. Three traplines were set out, the first in shrubby open wet sclerophyll forest off the end of bend 6 of Nelson Road, the second off the southern end of Invercargill Road in grassy woodland (*Eucalyptus pulchella* and *E. ovata* with an understorey of *Poa labillardieri* and *Themeda*) and the third ran parrallel to a tributory of Lambert Rivulet in *E. globulus/ E. ovata* wet sclerophyll forest with an understory of *Pomaderris apetala*. Traps were set for three periods of 20 days.

Hand Collection. Day-flying species such as butterflies were collected with a net on an opportunistic basis. Searching under stones and logs yielded sedentary species such as trapdoor spiders, beetles, centipedes and millipedes. Identifications were carried out with the aid of the insect collection at the New Town Laboratories of the Tasmanian Department of Primary Industry and Fisheries where voucher specimens have been deposited.

THE INVERTEBRATE FAUNA

Individuals of approximately 380 species were collected during this survey but this probably represents less than a third of the species actually present. A more comprehensive survey covering every month of the year would be necessary to yield a more complete picture of the biodiversity of the area. The invertebrate fauna is discussed below by taxonomic grouping with emphasis given to significant species and a discussion of the environmental requirements of each group.

Butterflies

Twenty species of butterflies occur in the survey area, including five locally rare species (Table 1). This is about half the species of butterflies recorded from Tasmania (McQuillan and Virtue 1994) and at least fourteen of these are likely to breed in the Mount Nelson area. Further investigation could well reveal the presence of several other eastern Tasmanian species not yet recorded locally.

The presence of the appropriate foodplants for both the larvae and adult are important determinants of habitat suitability. Important larval foodplants in the area include annual herbaceous plants (e.g. *Plantago, Urtica, Helichrysum, Brassica*), species in the families Fabaceae and Epacridaceae, *Cassytha* and various grasses and sedges. Supplies of nectar-bearing flowering plants, such as *Pimelea, Helichrysum, Senecio* and dandelions, are important for adults. Adults of some species feed on flowers. A vagrant specimen of Macleays swallowtail *Graphium macleayanum* was observed feeding at the flowers of *Pimelea nivea* but its larval foodplant sassafrass, *Atherosperma moschatum*, does not occur closer to Mount Nelson than Fern Tree. This powerful flying insect probably forages over several square kilometres. Local highpoints in the landscape are important for "hilltopping" i.e. the tendency of species that breed at low densities over extensive areas to aggregate on local hill tops for mating.

Many butterfly species exist in local colonies which have occupied sites for decades but could be easily exterminated if subject to inappropriate disturbances. This is especially true of sedentary species such as the Tasmanian Hairstreak *Pseudalmenus chlorinda* and the Ptunarra Brown *Oreixenica ptunarra*. Recent research on the latter butterfly has demonstrated that extensive areas of apparently suitable habitat containing the correct larval foodplants can still be devoid of individuals (Neyland 1993). In settled areas it is especially important that the remaining breeding sites of uncommon butterflies are identified and protected. Land clearing for housing south of Hobart in the last few decades has eradicated local colonies of the Tasmanian Hairstreak and some rare Skippers such as the Chaostola Skipper *Antipodia chaostola* and the Chrysotricha Skipper *Hesperilla chrysotricha*. Overall, habitat loss is probably the biggest threat to the survival of species, especially in northern and eastern Tasmania where the majority of species occur.

Moths

Tasmania is home to approximately 1750 species of native moths and, based on extensive knowledge of the moth fauna of the nearby Wellington Range, about 600 species are likely to occur on Mount Nelson. They are a very significant part of the biodiversity of the Hobart area but their largely nocturnal activity means that they are not commonly seen by the casual observer. The rare and endemic species are of particular conservation value (Table 1). Mount Nelson remains the only Tasmanian locality for several rare moth species. These include a new species of *Pectinivalva*, the larva of which is a leaf miner on *Eucalyptus*, and an undescribed species of *Scythris*, associated with *Helichrysum* daisies.

The conservation of this high diversity is strongly dependent on the maintenance of the native vegetation which is fed upon by the larval stage of moths. Most species in the caterpillar stage feed on only a single species of plant and are not able to adapt to introduced weeds. The adult moths of many species visit native flowers at night to obtain nectar and probably play an important role in the pollination of the flora. Unusual foodplants are important for much of the fauna. At least 100 species in the families Oecophoridae, Tortricidae and Pyralidae are specialised to feed on dead *Eucalyptus* leaf litter. Another dozen or so species in the families Psychidae and Arctiidae feed on lichens and algae growing on rocks, logs and tree stems. The delicate lichen flora on undisturbed dolerite outcrops is a key resource for this segment of the moth fauna.

Table 1. List of some of the butterflies and moths recorded in the vicinity of Lambert Gully, Mount Nelson.

r = rare; u= uncommon; E = endemic

BUTTERFLIES

Family Hesperiidae
- *Anisynta dominula* r
- *Argyninna hobartia*
- *Geitoneura klugii*
- *Hesperilla donnysa* u
- *Heteronympha merope*
- *Heteronympha penelope*
- *Junonia villida*
- *Ocybadistes walkeri*
- *Oreixenica lathoniella*
- *Taractrocera papyria*
- *Trapezites luteus* r
- *Vanessa itea*
- *Vanessa kershawi*

Family Lycaenidae
- *Candalides acastus* r
- *Lampides boeticus* r
- *Neolucia agricola*
- *Paralucia aurifera*
- *Zizina labradus*

Family Papilionidae
- *Graphium macleayanum* r

Family Pieridae
- *Pieris rapae*

MOTHS

- *Aenetus ligniveren*
- *Abantiades latipennis* E
- *Fraus nana* r
- *Opodiphthera helena*
- *Chlorodes boisduvalaria*
- *Niceteria macrocosma* r
- *Furcatrox* sp. E, r
- *Paralaea tasmanica* E, r
- *Thalaina selenaea*
- *Thalaina inscripta*
- *Hecatesia fenestrata*
- *Hemibela heliotricha* E, r
- *Liocnema crypsirrhoda* E, r
- *Sphacrelictis* sp. r
- *Phaos acmena* E, r

Beetles

Several hundred species of beetle are likely to occur in the vicinity of Mount Nelson. Collectively, they are ecologically important as predators, grazers on foliage and as decomposers of dead wood and other organic matter. Dead wood, native fungi and leaf litter feature strongly as breeding sites for many species.

Significant species include the Mount Nelson Stag Beetle *Lissotes basilaris* which has only been recorded from Mount Nelson and The Domain in Hobart. The Christmas beetle *Lamprima aurata*, being a colourful and day-active beetle, is a familiar species to many residents. Both species arc reliant on dead wood in contact with the soil as breeding sitcs. Scarab beetles (Family Scarabaeidae) are represented by numerous species. Endcmic species include members of the genera *Heteronyx* and *Aphodius*. Their larvae are familiar to gardeners as cockchafer grubs, being subterranean root-feeders. Recently dead trees are attacked by wood-boring beetles such as longicorns (family Cerambycidae) the larvae of which exploit the carbohydrate resource in the dead tissue. The new generation of beetles emerge from the timber leaving conspicuous elliptical holes. These galleries are in turn exploited as nesting sites for various species of solitary native bees.

Grasshoppers and Crickets

These insects are quite apparent to the casual observer by virtue of their high populations and vocalisations. Most feed on herbaceous plants such as daisies and goodenias. However, a number of grasshopper species have adapted to feed on introduced weeds such as plantains. Despite their name, most Australian grasshoppers do not prefer to feed on grasses. Whereas all the local grasshoppers are active by day, most of the crickets are nocturnal.

About 15 species of native grasshoppers and crickets survive on Mount Nelson. Most commonly seen is the small grasshopper *Phaulacridium vittatum* which occurs widely throughout drier habitats in Tasmania and mainland Australia. Of aesthetic value to residents are thc yellow-winged locust *Gastrimargus musicus* and the dead-leaf mimicking grasshopper *Goniaea australasiae*. Several Tasmanian endemics occur on Mount Nelson. The wingless grasshopper *Tasmaniacris tasmaniensis* is present on the more open shrublands. Small endemic crickets of the genus *Bobilla* are locally common in damp areas, including lawns. A rare flightless cave cricket *Parvotettix domesticus* is restricted to the vicinity of Hobart and occurs under logs and occasionally under floor cavities in houses adjaccnt to bushland. The acoustic ambience of the suburb on warm evenings is enhanced by the presence of a number of vocal species including the mole cricket *Gryllotalpa australis* and the autumn katydid *Caedicia simplex*. The mole cricket lives in shallow tunnels feeding on grass roots whereas the katydid sometimes eats the leaves of roses in gardens.

Many of the grasshoppers' preferred foodplants are low-growing or prostrate species, and the population sizes of these insects are related to the extent of their food resource. Judicious use of fire may be needed to suppress grasses and erect woody species which tend to overgrow the foodplants. Crickets, especially the flightless species, need retreats such as large logs on the ground in which to hide during the day from predators such as birds.

Bees and Wasps

At least twelve species of native bees occur on Mount Nelson where they are important pollinators of the local flora. The number of wasp species probably exceeds one hundred and fifty, many of which are parasites of other insects.

Bees of the genus *Leioproctis* pollinate the trigger plant *Stylidium graminifolium*. The early spring-flowering native peas such as *Dillwynia* and *Pultenaea* are served by small reddish bees of the genus *Exoneura*. Conspicuous wasps in the area include Pompilidae, which hunt spiders as a food resource for their larvae, and Sphecidae, which hunt caterpillars. Wasps of the family Thynnidae parasitise the root-feeding subterranean larvae of scarab beetles. The female thynnid is flightless and reliant on the male for transport to feeding and breeding sites. Males are attracted to the volatile scent of calling females. This interaction has been exploited by orchids of the genus *Caladenia* which emit a mimicking scent and elicit copulatory behaviour from the male wasps which results in pollen being transferred. Grassy woodlands tend to be favoured habitats for wasps, scarab beetles and the *Caladenia* orchids.

Native bees are susceptible to shortages of pollen and nectar, to inadequate nesting sites, and to competition from introduced honey bees. Nesting sites are either holes in the ground or holes in dead, usually standing, trees (stags). It is important therefore that dead trees are not removed unnecessarily from the environment.

Flies

Flies are among the most important pollinators of the Tasmanian native flora and are more prominent in this role than native bees. Their habits in the larval or maggot stage are very diverse. Some smaller species are internal feeders in fungal or plant tissues, sometimes causing galls to form, as on *Olearia ramulosa*. Others are decomposers of organic matter including carrion, some are predatory while others are parasites on other insects or snails. It is estimated that at least 300 species occur on Mount Nelson and almost 100 were collected in this brief survey.

Many fly species have a strong reliance on organic substrates, such as humus-rich damp soils, which are prone to drying out if the shading vegetation is removed. Such species could be at risk if the wetter vegetation types were subjected to an intense burn.

Caddisflies

The caddisflies (Trichoptera) are a small order of insects related to moths (Lepidoptera) but are considered to be more primitive. Their larvae are always aquatic. A few species live under stones but the majority live in cases which they construct by secreting silk and using it to tie small stones or bits of plant debris into elongate cylindrical or coiled tubes. Only the head and legs of the larva stick out of the case so that they are difficult to see on the bottom of streams. The adults look like dull-coloured moths with narrow wings and long antennae and, like moths, they frequently come to light at night.

Only two common species, from the families Leptoceridae and Hydroptilidae, were recorded in the survey but more are likely to be present. Tasmania has about 200 species in total, most of which are endemic to the island.

Caddisflies are very susceptible to pollution, sedimentation and changes in the flow rates of streams. For this reason they are widely used as biological indicators of water quality. Riparian vegetation must be kept intact to buffer the stream against these impacts.

Spiders

The native spider fauna of Mount Nelson probably exceeds one hundred species of which twenty were sampled in this study. Spiders are essential predators.

Mount Nelson preserves a small population of the endemic Tasmanian funnel web spider *Hadronyche venenatus*. This interesting spider is long lived, especially the females, and is sensitive to urbanisation pressures including persecution by people. The most common orb web builders are members of the genus *Araneus* which typically build their large circular webs at dusk and remove them at dawn. A specialised fauna which includes many tiny endemic species occurs in the damp litter in the gully forest. Most readily observed of the ground dwelling spiders are the fast moving wolf spiders of the genus *Lycosa*. These are the only spiders which carry their egg sacs about on their spinnerets and their newly hatched young on the abdomen. At least three species occur, including the endemic *Lycosa tasmanica* which survives in urban gardens on a diet which includes introduced slaters. Small colourful spiders of the genus *Diaea* occur on flowers in summer where they ambush visiting insects, especially flies. The well known *Dinopus* spider is present in the area. This large stick-mimicking spider envelops crawling prey in an elastic net thrown over its victim. Spiders of the family Amaurobiidae are found throughout the area especially in association with woody forest debris amongst which they may build untidy webs. This family has a high level of endemism in Tasmania. The sombrero spider *Stiphidium* is familiar to local residents by virtue of its characteristic horizontal sheet web with a conical retreat which is commonly constructed under houses.

Spiders need a mixed environment to maintain a high species diversity. The physical architecture of the environment is significant for web builders and this is increasingly simplified by frequent fires which consume twigs and litter. As predators, spiders are indirectly sensitive to events which cause a decline in their potential prey species.

Scorpions

Scorpions are generalised predators which are active at night. By day, individuals retreat under stones, logs or bark on trees. A single species of scorpion, *Cercophonius squama*, occurs in the Mount Nelson area. It is a widespread and abundant animal which can survive in native-type gardens, especially if bark chips are used as ground cover.

Earthworms

A large native earthworm of the family Megascolidae, not yet formally named, is restricted to the Mount Nelson area. The characteristic clay soils derived from dolerite are not conducive to a diverse earthworm fauna. Introduced species of European origin, such as *Allolobophora caliginosa*, are present in adjacent gardens but seem not to invade natural areas.

Ants

Ants are key dispersers of the seeds of many native plants, including many *Acacia*, Fabaceae, *Eucalyptus* and numerous herbs (e.g. *Viola*). Orchids from the genus *Microtus* are thought to rely on ants for pollination.

Ants help to maintain the population stability of sap-sucking insects on gum trees, such as psyllids and lerps, by keeping them free of parasites and insect predators. At least one species of native butterfly present in the area, *Paralucia aurifera*, relies on ants to attend its larvae and pupation occurs in the protection of the ants nest itself.

The bulldog ants of the genus *Myrmecia* are amongst the largest and most primitive ants in the world and are an Australian wildlife icon. The population of the jackjumper ant (*Myrmecis pilosula*) which lives on Mount Nelson is unique among the world's multicellular animals in having a single chromosome in the nucleus of its reproductive cells. The more aggressive species such as bulldog and jackjumper ants rarely survive urbanisation even at low density. Some people are hypersensitive to stings and therefore usually destroy nests as they find them. Such action is understandable but highlights the potential for conflict with some elements of the biota.

The viability of permanent nesting sites for ants needs to be assured. Important resources for ants are large stones and rocks on the soil surface which are important for regulating the temperature in the nests below. Sloping, well-drained nest sites are also sought by ants as they do not tolerate flooding in low-lying flat sites. Certain rarer ant species nest in rotten wood. Collection of bushrock and firewood can destroy existing ant colonies and represents a loss of future potential nesting sites.

Introduced Insects

A number of foreign insect species have invaded the Mount Nelson area and represent varying degrees of threat to the native fauna. They impact detrimentally by usurping the resources or functions of the native insects or by directly predating on them.

Bee keeping should be discouraged in the area because European honeybees *Apis mellifera* can act as nectar robbers which do not efficiently pollinate the native flora and compete with native animals for nectar resources. The winter-flowering native heath is an important plant commonly robbed of its nectar by bees to the detriment of local honeyeaters. Swarms of European honeybees often bud off from kept hives during summer and establish feral hives in the forested areas. Hollows in tall trees are often occupied which renders them useless as nesting sites for native birds and mammals. European honeybees are also responsible for more deaths to people each year in Australia than all other animals combined (c.g. sharks, spiders and snakes). Therefore locally high populations represent a health hazard to sensitive individuals. Against these problems must be weighed their utility in pollinating backyard fruit trees.

The introduced Argentine ant *Iridomyrmex humilis* is now widespread in the closely settled parts of Hobart and is slowly spreading its range. Possessed of a generalised ecology, it is able to out-compete most native ant species as it monopolises energy-rich food sources and nesting sites and establishes very large colonies. Indeed, the disappearance of native ants is a hallmark symptom of invasion by this pest. There is little that can be done to halt its spread but a degraded natural environment gives this pest an advantage.

The recent (1992) establishment of the European bumblebee, *Bombus terrestris*, in the Hobart area is a matter for regret due to their interference in the pollination dynamics of the local flora (Hingston 1997). These bees are social animals and build annual hives which typically contain up to one hundred individuals. Nests are usually in the ground or in abandoned animal burrows. Bumblebees are likely to become much more widespread in the future and there is little that can be done to stop their spread.

Similarly the European wasp *Vespula germanica* attacks the native insect fauna as a food supply and nests of this pest should be eradicated whenever possible. Predation pressure on the native insect fauna is especially high in spring and summer when colonies are rearing broods of new wasps and have a high demand for protein. A large and active nest harbouring thousands of workers could account for several kilograms of native insects per day. Poor standards in developing new urban areas can benefit European wasps. For example, the Invercargill Road development resulted in a large scree of boulders and rubble pushed into Lambert Gully where it not only destroyed a significant amount of native flora but has been colonised by wasps and is a major breeding site for them.

MANAGEMENT CONSIDERATIONS

Like all bushland close to residential areas, the Lambert Gully area has been burned regularly by wildfire and especially by deliberate burning-off. This policy has yielded ambivalent outcomes. One detrimental effect has been reinforcement of the flammability of the vegetation by selection for fire-tolerant native plants and a possible increase in aggressive fire-tolerant weeds such as *Erica*. Fire consumes the dead wood resource to the detriment of the numerous animal species that are dependent upon it. The deep leaf litter and humus present in the damper parts of the gully is an important habitat for many invertebrates and essential in the nutrient cycles which maintain the forest. Too frequent a fire regime could lead to the wetter vegetation in the gully gradually being replaced as successive fires eat away at the edge of the moist gully habitat.

Weeds represent a significant and increasing threat to the biodiversity of the Mount Nelson area. Grassy weeds displace native species and are generally unsuitable as foodplants for insects such as butterflies. Cotoneaster is invasive in Lambert Gully and forms thickets which shade the ground and eliminate native species. *Erica lusitanica* has become noticeably worse in recent years and is especially prevalent after fires.

Misguided though well meaning attempts at "tidying up" the bush by removing leaf litter, sticks, twigs and dead wood does serious harm to the invertebrate fauna which progressively becomes simplified as a result. The tidy parkland environs around Mount Nelson oval illustrates the problem: nice to look at, but with its biodiversity severely depleted. Collection of firewood and rocks for gardens by local residents needs to be actively discouraged.

Impacts of land use in the contiguous urban areas also needs to be minimised. Runoff bearing fertilizers from gardens can lead to detrimental eutrophic conditions as observed in the lower reaches of Lambert Gully. These fertilizers and other water-borne effluents can prove detrimental to aquatic fauna in the streams and to the litter invertebrates in the damp drainage lines in the upper parts of the catchment. Use of the natural areas at the back of houses as a dump site for garden waste is also detrimental for many invertebrates.

Lambert Gully is a valuable educational resource where natural phenomena and values can be demonstrated to students. It is also an increasingly important site for ecological research due to its proximity to the University of Tasmania. The results of such research can be valuable for guiding site management.

The remaining bushland on Mount Nelson forms an integral part of the forest continuum with the Wellington Range. The collective altitudinal range this represents is significant. Further fragmentation of this bushland may threaten its future viability. There are relatively few areas of native forest left in inner cities in Australia and the Mount Nelson bushland is valuable as both a biological benchmark and a barometer of human impact in a suburban context. It must be understood that the bushland character of Mount Nelson is reliant on more than the simple presence of trees alone. A complex web of biological interactions mediated through the activities of hundreds of invertebrate species supports the treescape as a functioning, renewable entity. If this support system is dismantled or fragmented, we risk a scenario similar to that now prevailing in the rural Midlands where tree death is the final chapter after decades of degradation of the native grassy woodlands.

Management of invertebrates can be difficult because there is a lack of knowledge of the needs of many species and their interactions with the environment more generally. However, some invertebrate groups have been successfully used elsewhere as biological indicators of environmental health. Biological monitoring stations should be strategically located in the Lambert Gully catchment in order to gain early warning of undesirable impacts on the invertebrates. The invertebrates on Mount Nelson of particular conservation interest (e.g. *Lissotes basilaris, Parvotettix domesticus, Scythris*) should have management plans prepared for them to guarantee their ongoing survival and should be monitored at appropriate intervals.

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DISTRIBUTION AND CONSERVATION OF THE BURNIE BURROWING CRAYFISH *ENGAEUS YABBIMUNNA*

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Abstract. *Engaeus yabbimunna*, a small burrowing crayfish, appears to be restricted to an area of less than 9 km^2 within the catchments of Shorewell, Romaine and Cooee creeks in the township of Burnie in north-west Tasmania. It has been confirmed at ten sites with four of these containing only small populations and the two largest populations occurring in Burnie City Council reserves. The species is largely restricted to isolated pockets of remnant native vegetation along creeks and seepages within the Burnie urban environment. Removal of remnant riparian vegetation within the species' range is continuing. The *E. yabbimunna* population is further threatened by pollution from council refuse sites as well as poaching and removal of individuals by children. Due to its exceptionally restricted distribution, its likely past decline and continuing threatening processes acting on the species, *E. yabbimunna* warrants classification as endangered. Management requirements for the species, including the need for community participation, are discussed.

INTRODUCTION

Engaeus is a genera of freshwater burrowing crayfish with a body length of under 10 cm. Several species of *Engaeus* are very restricted in their distribution (Horwitz 1994). One of these species, *Engaeus yabbimunna*, was only discovered in 1992 and work by Horwitz (1994) suggested it was confined to the environs of the town of Burnie in north-west Tasmania. The species is currently listed as vulnerable under the Tasmanian *Threatened Species Protection Act (1995)*. The present study was undertaken to further document the distribution of *E. yabbimunna* and to provide management recommendations for this species.

METHODS

A survey of the distribution of *E. yabbimunna* was undertaken in an area of 30 km^2 surrounding the town of Burnie on the north-west coast of Tasmania. The survey covered creeks and surrounding catchments from which *E. yabbimunna* was previously recorded in order to examine the distribution of the species in greater detail. A total of eight catchments, which included both suburban and rural sites, were encompassed by the main study area. Approximately 80% of the native riparian vegetation had been removed from these catchments. The few sites within urban Burnie which contain remnant native vegetation are restricted to public reserves. Most riparian vegetation has been replaced with exotics, including willows and blackberries while at some sites no vegetation is present. Many of these locations are at the headwaters of the catchments where creeks flow through paddocks and stock access is permitted, causing bank erosion and siltation. Further less intensive investigations outside of the main study area were undertaken at roadside access points on the lower catchments of Ellis Creek and Penguin Creek.

Field work was conducted over three weeks in July 1996. At each site an intensive search was conducted for crayfish burrows with soil, vegetation and stream characteristics recorded. Burrows were excavated and any crayfish found were identified and released.

RESULTS

Of the forty stream-side sites surveyed only ten contained specimens of *E. yabbimunna* (Fig.1). Three of these were previously identified by Horwitz (1994). All ten sites were located in the catchments of Shorewell, Romaine and Cooee Creeks, as previously determined by Horwitz, and were contained within the boundaries of urban Burnie.

The majority of *E. yabbimunna* specimens were collected from areas of remnant riparian vegetation within seepages or tributaries of the creeks. Four of these sites were dominated by tree ferns with a ground cover of ferns and shrubs while stands of tea-trees provided the canopy cover at a further two locations. Two specimens were collected from recently or previously cleared sites where willows and other introduced vegetation provided the only canopy cover. However, *E. yabbimunna* occurred in low numbers at such sites. With the exception of Burnie Park, the substrate at all *E. yabbimunna* locations included a high level of clay and organic matter overlaying Tertiary basalt. At Burnie Park, where quartzite, slate, sand and gravel dominated, *E. yabbimunna* was restricted to areas where remnant vegetation has provided rich organic soils overlaying the rocky substrate.

Of the ten sites at which *E yabbimunna* occurred six contained the largest subpopulations. Two of these sites (upstream of Romaine reservoir and within Burnie Park) represent the major portion of the total *E. yabbimunna* population. The six sites are, in decreasing order of abundance and habitat availability, Romaine Creek reserve (upstream of the reservoir), Shorewell Creek (Burnie Park, western bank), Shorewell Creek (Eastwood reserve), Cooee Creek (TAFE agricultural farm site), Romaine Creek (downstream of Mount Road), and Cooee Creek (West Mooreville Road crossing, eastern branch).

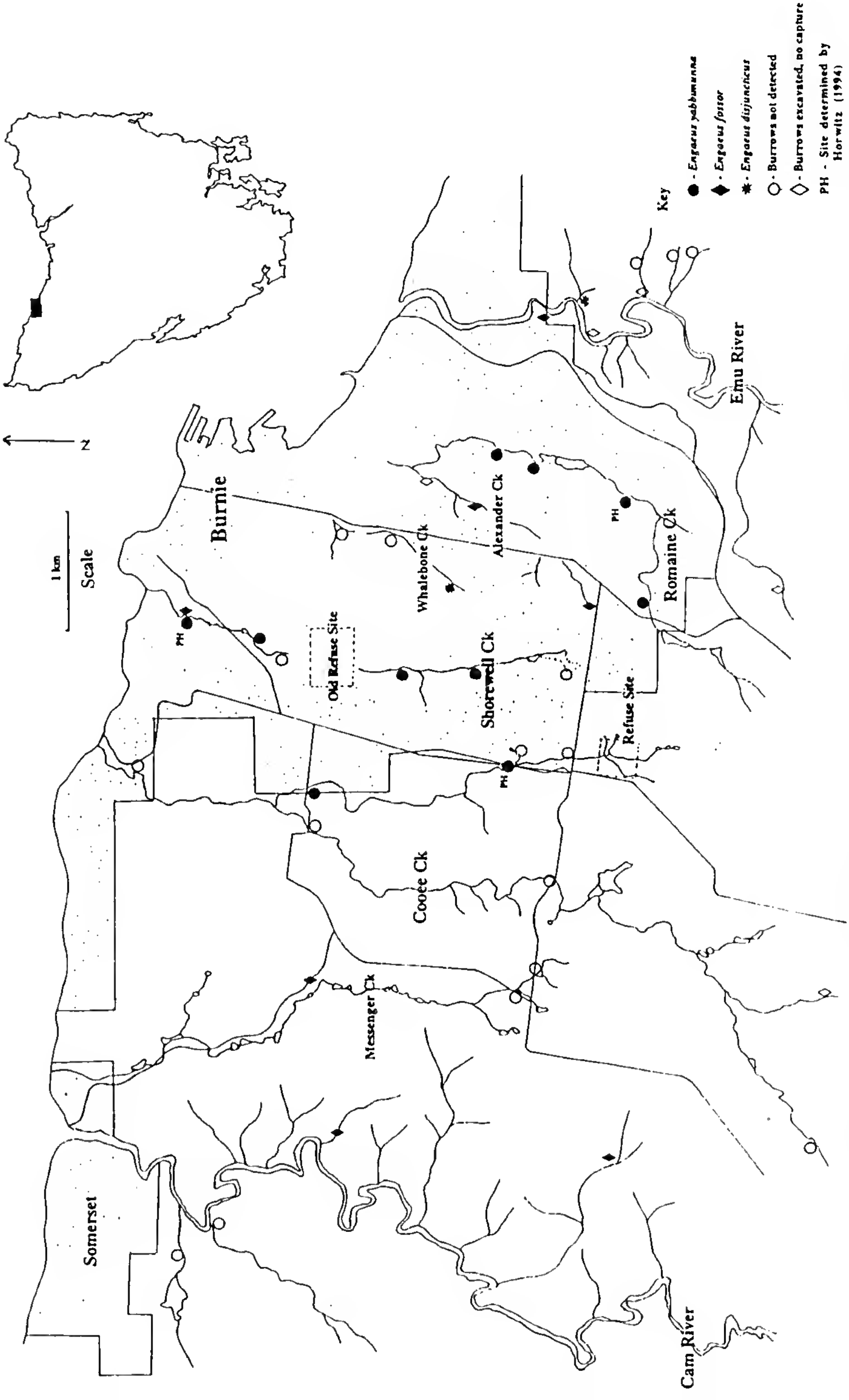

Fig. 1. Distribution of *E. yabbimunna* and the occurrence of other species of *Engaeus* within its range.

Two other species of *Engaeus* were collected during the survey. *E. fossor* and *E. disjuncticus* both occurred in tributaries of the Emu River, while *E. fossor* was found in two tributaries of the Cam River (Fig 1). *E. disjuncticus* also occurs in Whalebone Creek, a site in the middle of the *E. yabbimunna* distribution and *E. fossor* occurred sympatrically with *E. yabbimunna* within Burnie Park.

A further eighteen sites showed no evidence of crayfish burrows. These sites ranged in levels of disturbance (rural to forested) and altitude (sea level to 140m), and included eight catchments. Of the three locations investigated outside of the 30 km^2 study area only one, south of Burnie, provided evidence of crayfish burrows. However, exhaustive searching failed to reveal any specimens.

DISCUSSION

E. yabbimunna appears to be restricted to the catchments of Shorewell, Romaine and Cooee creeks within the township of Burnie. This limited distribution may be related to geology. Upper Burnie has a uniform substrate of Tertiary basalt, while the Burnie shoreline is of a different origin. The Cam and Emu rivers, east and west of the study area respectively, flow through a coarse substrate originating from quartzite and slate material. The soil structure in these areas is poor, with little organic material. Shallow burrowing behaviour (type 1 burrow, Horwitz and Richardson 1986) was observed in the *E. fossor* collected in a tributary of the Cam River (Doran and Richards 1996). Horwitz (1994) was unable to determine any different niche requirements for *E. yabbimunna* and *E. fossor* where they live sympatrically within Burnie Park. However, at sites where *E. fossor* was collected during this study the species showed a tendency to occur in areas where some form of environmental disturbance had recently occurred.

E. yabbimunna was found to inhabit moist remnant riparian zones. It was previously thought that the species may be confined to remnant native vegetation (Horwitz 1994). However, while the species is found in its highest numbers at such sites, specimens were collected from sites where little remnant vegetation cover existed. At these sites willows and blackberries formed the dominant canopy, although a few ferns remained. One site had recently been cleared. In Burnie it appears that neither *E. yabbimunna* nor *E. fossor* are showing any tendency to colonise areas which have previously been cleared of native vegetation such as along parts of Shorewell Creek. It is unlikely that the small subpopulations of *E. yabbimunna* detected on the upper Shorewell Creek represent an expansion of the population limits. It is more likely that they are either remnant subpopulations or that local residents have captured the individuals elsewhere and released them at these sites. Based on comments from students of the Acton Primary School, excavation of crayfish burrows by local children appears to be a common practice.

The total *E. yabbimunna* population exists within an expanding urban setting and appears to have declined due to a combination of habitat loss (through clearing of native vegetation and/or destruction of the stream channel using a mixture of cement and rocks making direct access to the water almost impossible) and pollution (in the form of increased heavy metals and toxins leaching from refuse sites). The species has the majority of its numbers in two subpopulations, with both of these sites presently within the Burnie parks system under the control of the Burnie City Council. Of concern, however, are the sites on Cooee Creek. Threatening processes at these sites include the presence of the active Burnie Municipality refuse site, continued removal of remnant vegetation and declining water quality. Leachates were observed seeping from the previous Municipality refuse site on Shorewell Creek. Downstream of this no burrows were observed directly adjacent to the creek, only congregated along seepages and tributaries entering the creek.

Conservation status

Since the classification of *E. yabbimunna* as vulnerable by the Invertebrate Advisory Committee (1994) the IUCN has released quantitative criteria to be used to determine the conservation status of species. The Scientific Advisory Committee responsible for listing and delisting of species under the Tasmanian *Threatened Species Protection Act (1995)* has also released its own criteria, based on the IUCN system. Under these criteria *E. yabbimunna* qualifies as endangered due to its limited extent of occurrence (area of occupancy is less than 500 km^2) and the severely fragmented nature of the populations. The actual known extent of occurrence of *E. yabbimunna* is less than 9 km^2, and its area of occupancy may be as low as 0.22 km^2. The populations are considered highly fragmented as only those on Romaine Creek are interconnected, and its ten recorded sites can be classified as only four true locations on three small water-courses: lower Shorewell Creek, Romaine Creek, Cooee Creek, and a relatively poor subpopulation in the upper reaches of Shorewell Creek. The considerable morphological variation shown between specimens in the different creek lines (Horwitz 1994, pers. obs.) is evidence for the relative isolation of the populations. The species has likely been and is potentially subject to a decline in area of occupancy and extent of occurrence. It is alsosubject to a decline in habitat quality due to the effects of pollutants, particularly in Cooee Creek.

Management Recommendations

The Burnie City Council should manage Burnie Park and Romaine Creek Reserve so as to ensure protection of all remaining native vegetation and all seepage zones within these areas.

Revegetation should be carried out along sections of creek banks where native vegetation has been removed. Revegetated sites should be monitored to determine the response of crayfish populations.

Methods of weed control, clearing of introduced plants and revegetation works at sites currently inhabited by *E. yabbimunna* need to be modified to ensure minimal disturbance to the substrate.

The Burnie City Council should review its continued use of the refuse site in the Cooee Creek catchment. *E. yabbimunna* is absent immediately downstream of the disused refuse site on Shorewell Creek where the water is orange, acidic and odorous and shows no evidence of aquatic macroinvertebrate activity. Similar pollution could occur downstream of the Cooee Creek refuse site over time.

An education program should be conducted among the residents of Burnie to inform them of the presence of the species. Particular attention should be given to school children so as to reduce the collection of crayfish, and to residents bordering creeklines, so that these areas are not subjected to damaging activities. Some community involvement in the management of the specie has already occurred since field work for the project was undertaken. This needs to be encouraged further.

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ADDENDUM

E. yabbimunna has recently been discovered at further sites along Seabrook Creek 10 km west of the Cooee Creek population. The species was first located here by members of the Deloraine Field Naturalist Club on a small crown land block which is well wooded but contains blackberries and willows. Other sites were subsequently located by Nial Doran and Mark Wapstra from the Forest Practices Board on private property in situations varying from an open, grazed pasture to a heavily wooded wet gully with ferns. These new locations only minutely increase the distribution of the crayfish and do not change its classification as endangered.

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THE SHORT-TERM EFFECTS OF FIRE AND ITS INTENSITY ON AVIAN ABUNDANCE IN *EUCALYPTUS PULCHELLA* WOODLAND

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Abstract. Nine areas, of two hectares each, were surveyed for birds using the Area Search Method during August and September 1995 in urban bushland on Mt Nelson, near Hobart in southern Tasmania. These were divided equally between unburnt areas, those subjected to a low-intensity fire, and those subjected to a high-intensity fire. No significant differences in either the numbers of bird species, or total numbers of individuals, were observed between the three areas. However, there were marked differences in the responses of individual species and feeding guilds. Undergrowth-inhabiting and bark-probing insectivores, along with the Green Rosella, were adversely affected by fire. In contrast, ground-feeders preferred the area subjected to the high-intensity fire. Species which capture insects from canopy foliage favoured the area subjected to the low-intensity fire, probably because of increased food availability. Raptors were also most abundant on this area, although the reason is unclear. It is recommended that fuel reduction burns in this vegetation be conducted in a patchy manner and at varying intensities, to maintain a mosaic of habitats which can support a wide variety of avifauna.

INTRODUCTION

Fire management is of great concern where housing occurs in bush settings. Areas of native vegetation are perceived by some home owners as a fire threat to their property. Consequently there is a push to increase the number of fire tracks and fuel reduction burns in the outer Hobart suburb of Mt Nelson (Waterhouse 1995). Controversy and concern over the planned use of fire results from the limited knowledge of its impact on natural ecosystems and the inability of management agencies to define long term objectives (Good 1981).

It is obvious that fire will continue to be a management tool in Mt Nelson. To determine the appropriate fire regime, research is required to determine the impacts of fire on the area's fauna. Previous studies in this area have found declines in bird species diversity immediately after fire, and that recolonisation was delayed following a high intensity fire compared with a low intensity fire (Ratkowsky 1978, 1979). Recent fires of differing intensities at Mt Nelson provided an opportunity for further study into the short term effects of fire on the area's avifauna.

METHODS

Study sites

The three areas surveyed were in *Eucalyptus pulchella* Desf. woodland at Mt Nelson on similar dolerite slopes and aspects, ranging from northeast to northwest, and had similar understoreys of grass and low shrubs before the fires. However, one area of approximately 50 ha (HB) experienced a high-intensity fire in February 1995, which scorched the canopy, and another area of similar size (LB) was subjected to a low intensity fire in June 1995, which removed the understorey without scorching the canopy. Node counts on *Banksia marginata* Cav. indicated that the last fire on the unburnt area (UB) was almost twenty years ago. The HB area was 2 km northwest of the UB area, while the LB area was 200 m northeast of the centre of the UB area.

Survey method

Three 200 m x 100 m sites were marked out within each area, and their vegetation sampled with ten 10 m x 10 m quadrats. These were positioned using randomised systematic sampling to ensure that the full length of each site was sampled. Within each quadrat, the percentage canopy cover of the overstorey prior to fire was estimated. The total basal areas of the dominant tree species were also measured within each quadrat, and all major species were identified, to ascertain whether there were any differences in their pre-fire vegetation.

All sites were surveyed for birds using the Area Search Method (Hewish and Loyn 1989) on 15 occasions during August and September of 1995. Each survey was conducted over 20 minutes, within a four hour period during the morning. The order of sampling was varied between occasions as much as possible to minimise any confounding effects of diurnal variation. Birds were identified by both visual and aural means. The Area Search Method was favoured because it is effective in detecting inconspicuous species, robust against weather and diurnal variation, and the researcher can stay within relatively uniform habitat while having the flexibility to investigate unfamiliar calls and determine the numbers of each species present (Hewish and Loyn 1989).

Bird species were categorised into feeding guilds in the hope of revealing community responses to fire which would otherwise be obscured by the mass of species-specific data (Wiens 1989a). It must be remembered that these guilds merely represent the particular species' main mode of feeding, and that there may be some overlap of species between guilds.

It was assumed that there were no differences in the numbers of each bird species between the areas before fire, and that burning of the vegetation did not alter the detectability of each species, or their responses to the observer.

Data analysis

Despite the assumptions of normality and homoscedasticity not always holding due to outliers, this is unlikely to have a serious impact on the degree of significance determined by ANOVA (Sokal and Rohlf 1987). Hence ANOVA was used to test for differenees in abundances of birds and the dominant plant spceies between areas, in preferenee to the non-parametric Kruskal-Wallis test, for which no correction factor for this amount of tied seores was available. Where a significant difference in abundance was detected across all thrce areas, Tukey's test was used to determine which pairs of areas were significantly different.

RESULTS

Analysis of the vegetation demonstrated that the sites were relatively homogeneous, with no significant differences between areas in original eucalypt canopy cover, basal areas of the most common canopy speeies *Eucalyptus pulchella*, two of the canopy subdominants *E. ovata* Labill. and *E. viminalis* Labill., or the two dominant species in the mid-storey *Allocasuarina verticillata* (Lam.) L. Johnson and *Exocarpos cupressiformis* Labill. However, there was a difference ($p<0.01$) in the subdominant canopy species composition, with *Eucalyptus globulus* Labill. being significantly more common ($p<0.01$) on the HB than the UB.

There were no significant differences in the total numbers of individuals or bird species between areas (Tables 1 and 2). However, there were significant differences in the abundances of some guilds and some speeies between areas (Tables 1 and 2).

Ground-feeding granivores were significantly more abundant on the HB than the UB area. This was demonstrated by its most abundant member, the European Goldfinch *Carduelis carduelis*. Ground-feeding inseetivores were more common on the HB than either of the other areas, which was illustrated by its most abundant member the Flame Robin *Petroica phoenicea*.

Undergrowth-inhabiting and bark-probing insectivores were significantly more abundant on the unburnt than either burnt area. However, there were no significant differences in abundance between the two burnt areas. This was also demonstrated by the most common species from these guilds, the undergrowth-inhabiting Brown Thornbill *Acanthiza pusilla*, and the bark-probing Yellow-throated Honeyeater *Lichenostomus flavicollis* and Grey Shrike-thrush *Colluricincla harmonica*. There was also evidence of a greater number of parrots on the UB than the HB area. However, there was no evidence of fewer parrots on the LB than the UB areas.

The guild eomprising birds which captured insects from foliage was most abundant on the LB area, being significantly less common on both of the other areas.

Table 1. Bird species encountered, their guild allocations, and their abundances in each area.

Guilds and species	No. of individuals UB	LB	HB
Ground-feeding granivores (GG)			
Coturnix australis Brown Quail	0	0	1
Carduelis chloris European Greenfinch*	0	5	19
Carduelis carduelis European Goldfinch*	2	5	16
Total	2	10	36
Ground-feeding insectivores (GI)			
Petroica multicolor Scarlet Robin	7	1	7
Petroica phoenicea Flame Robin	8	0	50
Melanodryas vittata Dusky Robin	0	2	11
Cuculus flabelliformis Fan-tailed Cuckoo	2	1	0
Cuculus pallidus Pallid Cuckoo	0	1	0
Sturnus vulgaris Common Starling*	0	0	2
Turdus merula Blackbird*	2	0	2
Total	19	5	72
Bark-probing insectivores (B)			
Colluricincla harmonica Grey Shrike-thrush	19	0	1
Lichenostomus flavicollis Yellow-throated Honeyeater	38	7	11
Total	57	7	12
Undergrowth-feeding insectivores (U)			
Acanthiza pusilla Brown Thornbill	70	29	10
Malurus cyaneus Superb Fairy-wren	8	1	1
Sericornis frontalis White-browed Scrubwren	2	0	0
Total	80	30	11
Parrots of various feeding modes (P)			
Platycercus caledonicus Green Rosella	15	3	2
Cacatua galerita Sulphur-crested Cockatoo	0	3	0
Total	15	6	2
Foliage-feeding insectivores (F)			
Pardalotus striatus Striated Pardalote	0	22	10
Pardalotus punctatus Spotted Pardalote	3	2	2
Coracina novaehollandiae Black-faced Cuckoo-shrike	8	14	2
Pachycephala pectoralis Golden Whistler	3	0	0
Total	14	38	14

Raptors (R)			
Haliaeetus leucogaster White-bellied Sea-eagle	1	1	0
Aquila audax Wedge-tailed Eagle	0	1	0
Accipiter fasciatus Brown Goshawk	1	2	0
Accipiter novaehollandiae Grey Goshawk	0	1	0
Falco berigora Brown Falcon	0	2	0
Falco peregrinus Peregrine Falcon	0	2	0
Total	2	9	0
Other large predators (OP)			
Corvus tasmanicus Forest Raven	54	72	149
Strepera versicolor Grey Currawong	12	25	2
Dacelo novaeguineae Laughing Kookaburra*	2	5	1
Total	68	102	152
Aerial-feeding insectivores (A)	5	2	19
Rhipidura fuliginosa Grey Fantail	5	1	4
Artamus cyanopterus Dusky Woodswallow	0	1	15
Total	5	2	19
Nectarivores (N)			
Melithreptus affinis Black-headed Honeyeater	3	3	7
Phylidonyris pyrrhoptera Crescent Honeyeater	13	1	0
Acanthorhynchus tenuirostris Eastern Spinebill	1	0	0
Anthochaera paradoxa Yellow Wattlebird	3	1	0
Lathamus discolor Swift Parrot	1	1	2
Zosterops lateralis Silvereye	0	9	9
Total	21	15	18
Total number of individuals	283	224	336
Total number of species	25	30	24

*introduced species; HB = high intensity burn; LB = low intensity burn; UB = unburnt.

This trend appeared to be mostly due to the Striated Pardalote *Pardalotus striatus*, for which there was strong evidence of more individuals on the LB than the UB area. Raptors were also significantly more abundant on the LB than the HB area.

Other large predators showed no significant evidence of differences in abundances across the three areas. This was also apparent in its most frequent member, the Forest Raven *Corvus tasmanicus*. However there was a significant difference in the numbers of the second most abundant member of this guild, the Grey Currawong

Table 2. ANOVA on the abundances of birds in areas subjected to three different fire regimes.

Dependent Variable	Significance of difference	Comparison of areas	p
No. of individual birds	N.S.	-	-
No. of bird species	N.S.	-	-
guild GG	<0.05	HB>UB	<0.05
European Goldfinch	<0.05	HB>UB	<0.05
guild GI	<0.001	HB>LB=UB	<0.001
Flame Robin	<0.001	HB>LB=UB	<0.001
guild B	<0.001	UB>LB=HB	<0.001
Grey Shrike-thrush	<0.001	UB>HB=LB	<0.001
Yellow-throated H.E.	<0.001	UB>HB	<0.01
		UB>LB	<0.001
guild U	<0.001	UB>HB	<0.001
		UB>LB	<0.01
Brown Thornbill	<0.001	UB>HB	<0.001
		UB>LB	<0.05
guild P	<0.05	UB>HB	<0.05
guild F	<0.01	LB>HB=UB	<0.05
Striated Pardalote	<0.001	LB>UB	<0.001
guild R	<0.05	LB>HB	<0.05
guild OP	N.S.	-	-
Forest Raven	N.S.	-	-
Grey Currawong	<0.01	LB>HB	<0.01
guild A	N.S.	-	-
guild N	N.S.	-	-

Strepera versicolor, across the three sites, being more abundant in LB than HB. Both aerial-feeding insectivores and nectarivores exhibited no significant differences in numbers between areas.

DISCUSSION

This experiment was not confounded by major differences in the pre-fire vegetation between areas. Hence the pre-fire avian communities on the three areas were probably similar, and differences in their compositions during the survey period can be regarded as the result of their recent fire histories. The greater basal area of *Eucalyptus globulus* on the HB than the LB area is unlikely to have confounded this study, as the birds which were significantly more common in the HB area were ground-feeders (Table 1).

The absence of significant differences in the total numbers of birds between unburnt areas and those subjected to either low or high intensity fires is in accordance with surveys conducted in Western Australian sclerophyll forests (Christensen and Kimber 1975; Wooller and Brooker 1980). However, other surveys (e.g. Catling and Newsome 1981; Christensen *et al.* 1985; Recher *et al.* 1985; Wooller and Calver 1988; Reilly 1991) observed reduced total numbers of birds after intense fires. Nevertheless, the decline detected by Reilly (1991) was short-lived, with a pronounced recolonisation evident in the first spring after fire. As this survey was conducted in early spring when many plants were recovering through vegetative means, it may have been subsequent to the period during which any decline in total numbers occurred.

Burning this forest type also had no significant impact on the avian species richness, in contrast to previous studies in areas nearby (Ratkowsky 1978, 1979). This apparent anomaly can be attributed to differences in the time after burning at which the studies were undertaken. Our study investigated bird communities two months after a low intensity fire and six months after a high intensity fire, whereas Ratkowsky investigated the first three months after two low intensity fires and the first 19 weeks after a high intensity fire. In accordance with our study, Ratkowsky (1978) found that avian species richness in an area subjected to a low intensity fire did not differ from an adjacent unburnt area between 11 and 13 weeks after burning. These findings are consistent with other studies in southeastern (Recher *et al.* 1985; Reilly 1991) and southwestern Australia (Wooller and Calver 1988). In spite of this, individual species exhibited very different responses, as has also been recorded in many other instances (e.g. Christensen and Kimber 1975; Wooller and Brooker 1980; Catling and Newsome 1981; Christensen *et al.* 1985; Recher *et al.* 1985; Mc.Farland 1988; Wooller and Calver 1988; Smith 1989; Woinarski 1990; Brooker and Rowley 1991; Reilly 1991).

Both guilds comprising species which fed primarily on the ground were most abundant on the area subjected to the high intensity fire, in accordance with studies elsewhere (e.g. Catling and Newsome 1981; Marchant 1985; Recher *et al.* 1985; Woinarski 1990; Reilly 1991). The response of ground-feeding granivores was typified by the introduced European Goldfinch. This species was observed feeding on the ground below *Allocasuarina verticillata* in the HB area, which supports the opinion of Recher *et al.* (1985) and Woinarski (1990) that the increase in granivores after fire is due to its stimulation of seed release. However, neither of these guilds exhibited significant differences in their abundances between the UB and LB areas, suggesting that high fire intensities create conditions conducive to ground-feeders, but low-intensity fires do not. Nevertheless, as the high-intensity fire occurred four months prior to the low-intensity fire, the possibility that the preference of ground-feeding insectivores for the former is due to the greater time since fire, and hence longer period for arthropods to recolonise (Reilly 1991), cannot be discounted. Alternatively, the lower numbers from this guild on the LB than the HB area may be due to the greater abundance of raptors on the former (Fretwell 1972 in Wiens 1989b).

In contrast, the undergrowth-inhabiting and bark-probing insectivores, along with parrots, were adversely affected by fire. This response by parrots was entirely due to the Green Rosella, which was also less common in a burnt than an unburnt area studied by Ratkowsky (1979). This species was observed feeding on the seeds of *Epacris impressa* Labill. in the unburnt area. Hence the sensitivity of this species to fire may be attributed, at least partly, to the loss of its food supply. However, the guilds most adversely affected by fire were the insectivores. Smith (1989) recorded a similar occurrence at Bega (NSW) especially for birds associated with a dense shrubby environment, as this is the structural element most affected by fire. The decline in undergrowth-inhabiting insectivores is consistent with other studies (e.g. Catling and Newsome 1981; Christensen *et al.* 1985; Smith 1989; Woinarski 1990), with fewer Brown Thornbills after fire also being recorded by Recher *et al.* (1985) and Smith (1989). However, the decline in bark-probing insectivores is contrary to several other studies (e.g. Ratkowsky 1978; Catling and Newsome 1981; Christensen *et al.* 1985; Woinarski 1990). While intense fires may adversely affect such canopy feeders (Recher *et al.* 1985; Ford 1989), this study suggested that they are also sensitive to the loss of the understorey. As fire adversely affects invertebrates (Springett 1976; Recher *et al.* 1983), this may be due to a decrease in food availability. This is supported by Wooller and Calver (1988) who found that the decline in the abundances of other sedentary bird species, after a low intensity fire in southwestern Australian dry sclerophyll forest, was paralleled by such a decrease in the number of invertebrate taxa. Other factors which may have contributed to the low numbers in these insectivorous guilds after the low intensity fire are the loss of cover in which to shelter from the weather and from predators (Recher *et al.* 1985; Brooker and Rowley 1991; Russell and Rowley 1993), as well as a paucity of nesting materials and sites (Brooker and Rowley 1991; Recher 1991).

The significantly greater numbers of foliage-feeding insectivores on the LB than the HB area can obviously be attributed to the different levels of damage to the canopy foliage (Sherry and Holmes 1985), and therefore food availability (Recher *et al.* 1985). This supports the opinions of Woinarski (1990) that low-intensity fires have little effect on canopy-feeders, and Recher *et al.* (1985) and Ford (1989) that intense fires may adversely affect canopy-feeders. The significantly greater abundance of this guild on the LB than the UB area, appears to be largely due to the Striated Pardalote, apparently in contrast to the situation observed by Christensen *et al.* (1985). However the decline in this species after fire described by Christensen *et al.* (1985) only lasted for one year, with the trend reversed in subsequent years. Recher *et al.* (1985) and Ford (1989) attributed this to the greater abundance of manna, lerps, honeydew and insects, in response to the flush of soft, nutrient-rich new foliage resulting from release of nutrients in soluble form by the fire (Recher and Christensen 1981; Recher *et al.* 1985; Ford 1989; Smith 1989). Hence this guild favoured the LB area because of the retention of *Eucalyptus* foliage which has enhanced nutrient levels, while the unburnt area is less favourable because of the less nutritious foliage, and the HB area is avoided due to the lack of foliage. While enhanced food availability after fire may be negated by increased predation due to the reduction in cover (Recher *et al.* 1985; Russell and Rowley 1993), hollow-nesters such as pardalotes (Schodde and Tidemann 1990) are less vulnerable to this (Wiens 1989b).

Raptors were also significantly more abundant on the LB than the HB area, but were not significantly less common on the UB area. This contrasts with the increase in the abundance of this guild after a high-intensity fire in coastal Victoria observed by Reilly (1991). The result here may be due to the presence of more vertebrate prey on the LB area because of its proximity to unburnt areas (Tolhurst *et al.* 1992), or the position of this area on the crest of a hill overlooking the Derwent River where updraughts occur. This preference was also exhibited by Grey Currawongs, which nested on the LB area. This species was observed feeding on the skink *Niveoscincus metallicus*, which was more visible on this site than on the unburnt site due to the removal of the understorey, but was probably more abundant on the LB than the HB area because of recolonisation from the adjacent unburnt area (Tolhurst *et al.* 1992).

However other large predators as a guild, which contained the Grey Currawong, showed no significant differences in abundance across the three areas largely due to the dominance of Forest Ravens. This highlights the difficulties associated with the allocation of species to guilds which result from niche overlap (Root 1967; Hingston 1994). Although the mean number of Forest Ravens was higher on the HB area (Table 1), this was not statistically significant (Table 2). As the higher mean was due to two outliers resulting from the presence of large flocks, the view of Sokal and Rohlf (1987) that ANOVA is robust against outliers is supported, and therefore the choice of this statistical test vindicated.

The absence of significant differences in the abundances of aerial-feeding insectivores and nectarivores is contrary to previous observations of increases in aerial feeders after fire (Christensen *et al.* 1985; Ford 1989), and decreases in some nectarivores (Ratkowsky 1979; Catling and Newsome 1981; Brooker and Rowley

1991; Reilly 1991). However the sample sizes were very small for both of these guilds, due to most aerial-feeders only migrating to Tasmania at the end of the survey period, and *Epacris impressa* being past its peak in flowering. It must be noted that very high population densities of Eastern Spinebills *Acanthorhynchus tenuirostris* and Crescent Honeyeaters *Philidonyris pyrrhoptera* were observed feeding on *E. impressa* nectar in the unburnt area during June and July 1995 and in April 1996 by one of us (ABH). Similar congregating of fire-sensitive bird species in unburnt patches has been observed elsewhere (e.g. Dwyer 1972; Smith 1989; Woinarski 1990). As all species in both of these guilds are either migratory or nomadic (Dwyer 1972; Schodde and Tidemann 1990; Hingston 1994), their differences in habitat preferences could only be determined with any certainty by conducting a year-long survey.

CONCLUSIONS

The highly varied habitat preferences exhibited by different bird species indicate that a wide variety of avifauna is best maintained by the creation of a mosaic of habitats through conducting fuel reduction burns of varying intensities in a patchy manner. However, introduced species of birds appear to benefit from more intense fires. Small unburnt patches act as important refuges for invertebrates, mammals, reptiles, birds and plants (Tolhurst *et al.* 1992), which aid recolonisation of the burnt areas by those bird species whose abundances increase in parallel with the rate of revegetation and invasion by invertebrates (Reilly 1991).

It must be noted that these results are only applicable to August and September, and a longer term survey may produce different results, particularly for migratory and nomadic species. Neither can these findings be extrapolated to more mesic vegetation types, where the effects of fire may be more deleterious, as birds of drier woodlands are generally more resilient to fire (Ford 1989).

It must be stressed that these results only involve the short-term response to fire, and that bird abundances may be altered by long-term vegetation changes resulting from particular fire regimes (Newman 1987). If fire is too frequent then birds that prefer later successional stages of the vegetation may be eliminated from the site (McFarland 1988).

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The Tasmanian Naturalist (1998) **120:** 45-47.

TASMANIAN ANT SPECIES COLLECTED BY BEDE LOWERY

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The Rev. B.B. (Bede) Lowery SJ (1924 - 1996) passed away on 2 November 1996 in Sydney after battling with cancer for many months. Some naturalists in Tasmania, particularly those in the south, may not have heard of Bede but in the relatively short time he spent in Tasmania he made a huge contribution to our knowledge of one of the invertebrate groups, the ants. He was a true naturalist in the tradition of Victorian England. A parish priest by calling but with a hobby in which he was one of the most knowledgeable people in Australia.

Bede Lowery took up pastoral duties in the Latrobe - Devonport area in 1989. In subsequent years he established himself as the foremost authority on the Tasmanian ant fauna. (Lowery and Taylor 1994). He first became interested in ants after studying Australian orchids with his father. He took the ants he found on the orchids he collected to a fellow Jesuit who encouraged him to pursue his new hobby.

Since the early 1960s he collected widely throughout Australia, Papua New Guinea, Borneo and the Philippines establishing substantial collections which he donated to specialists and institutions around the world. (Taylor and Lowery 1972).

From 1966 he became associated with the Australian National Insect Collection holdings in Canberra where his friend and colleague Dr Bob Taylor was Curator of Formicidae. It was there in 1967 that he published the description of a new ant species. (Lowery 1967). Bede has two species of ants named after him (neither found in Tasmania) *Mesostruma loweryi* Taylor and *Polyrhachis loweryi* Kohout.

Bede was a member of the Tasmanian branch of the Australian Entomological Society and he will be missed by members of that Society. He was always happy to receive specimens for identification and was involved in a wide range of projects. He loved collecting in the field and enjoyed talking about his favourite ant species with visitors at his home in Latrobe. His enthusiasm stimulated several studies of ants in Tasmania while his legacy in defining the Tasmania myrmecolgical fauna will influence entomological research for many years.

While in Tasmania he collected many thousands of specimens encompassing all but two of the known species of the ant fauna. He often collected series of queens, males and immature stages of a species which, along with his succinct notes, provided a wealth of new information. Bob Taylor is working to complete a monograph on the ants of Tasmania, a project in which Bede actively collaborated and will be a joint author (Taylor 1995). In 1995 Taylor and Lowery recognised 125 species in 43 genera (Taylor 1995). In 1996 Bede generously donated complete sets of specimens to several museums and institutions in Tasmania, including Forestry

Tasmania. These specimens include all the described species bar two and additionally all of the groups Bede recognised as being different to presently described species (Appendix 1). Thus the duplicate vials for the undetermined species listed in Appendix 1 will contain one or more presently undescribed species. He also deposited in the Forestry Tasmania Collection a series of 199 taxonomic monographs including many signed by the authors with whom he was corresponding.

ACKNOWLEDGEMENTS
My thanks to Dr Tim Kingston for providing a check list of the Lowery ants held at the Queen Victoria Museum.

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Appendix 1. List of reference specimens in the Bede Lowery ant collection held by Forestry Tasmania.

DILOCHODERINAE

Anonychomymra biconvexa (Santschi,1928)
Anonychomyrma biconvexa ?
Anonychomyrma itinerans (Lowne, 1865)
Anonychomyrma nitidiceps (E.Andre, 1896)
Anonychomyrma triconvexa sp. nov.
Anonychomymra sp. (5 vials)
Bothriomyrmex sp. (2 vials)
Creophilus erythrocephalus Wheeler, 1934
Doleromyrma darwinianum (Forel, 1907)
Dolichoderus australis E. Andre, 1896
Iridomyrmex gracilis (Lowne, 1865)
Iridomyrmex sp.1
Iridomyrmex sp.2
Iridomyrmex sp.3
Linepithema humile
Ochetellus punctatissimus Emery, 1887
Ochetellus glaber (Mayr, 1862)
Ochetellus sp.
Tapinoma minutum Mayr, 1862
Technomyrmex albipes (F.Smith, 1861)

FORMICINAE

Camponotus claripes Mayr, 1876
Camponotus consobrinus (Erichson,1842)
Camponotus hartogi Forel,1902

Camponotus testaeeipes (F.Smith,1858)
Camponotus sp.
Colobopsis fietor Forel, 1902
Colobopsis gasseri (Forel, 1894)
Melophorus sp. (3 vials)
Myrmecorhynchus earteri Clark, 1934
Myrmeeorhynchus emeryi E. Andre, 1896
Myrmecorhynehus sp.
Notoneus eetatommoides (Forel,1892)
Notoncus hickmani Clark, 1930
Notoncus spinisquamis (E.Andre, 1896)
Notonus ectatommoides (Forel, 1892)
Paratrechina braueri (Mayr, 1868)
Plagiolepis exigua Forel, 1894
Plagiolepis sp.
Paratreehina tasmaniensis (Forel, 1913)
Paratrechina sp (4 vials)
Plagiolepis sp. (6 vials)
Polyrhaehis femorata F. Smith, 1858
Polyrhaehis fuseipes Mayr, 1862
Polyrhaehis hexaeantha (Erichson, 1842)
Polyrhaehis leae Forel, 1913
Polyrhachis patiens Santschi, 1920
Polyrhachis semipolita E. Andre, 1896
Polyrhaehis sp. (2 vials)
Prolasius niger Clark, 1934
Prolasius nitidissimus (E.Andre, 1896)
Prolasius sp (29 vials)
Stigmaeros barretti Santschi, 1928
Stigmaeros sp. (11 vials)

MYRMICIINAE

Myrmecia esurens Fabricius, 1804
Myrmeeia forfieata (Fabricius, 1787)
Myrmecia fulvipes Roger, 1861
Myrmeeia pilosula F. Smith, 1858
Myrmecia pyriformis F. Smith, 1858
Myrmecia urens Lowne, 1865

MYRMICINAE

Chelaner flavigaster (Clark, 1938)
Chelaner sp.1
Chelaner sp.2
Chelaner sp. (6 vials)
Colobostruma alinodis (Forel, 1913)
Colobostruma froggatti (Forel, 1913)
Crematogaster sp.
Epopostruma quadrispinosa (Forel, 1895)
Epopostruma sp.
Mayriella abstinens Forel, 1902
Meranoplus sp. (9 vials)
Monomorium flavigaster Clark, 1938
Monomorium sp. (large)
Monomorium leae Forel, 1913
Monomorium nigellum (Emery, 1914)
Monomorium seulpturatum Clark, 1934
Monomorium sp. (19 vials)
Monomorium sp. (dark form)
Oreetognathus clarki Brown, 1953
Pheidole sp. (12 vials)
Pheidole vigilans (F. Smith, 1858)
Pheidole vigilans?
Podomyrma sp.
Solenopsis froggatti Forel, 1913
Solenopsis sp.
Strumigenys perplexa (F.Smith, 1876)
Tetramorium sp.

PONERINAE

Amblyopone australis Erichson, 1842
Amblyopone longidens Forel, 1910
Amblyopone saundersi sp. nov.
Cerapachys larvatus (Wheeler, 1918)
Cryptopone sp.1
Crypopone sp.2
Discothyrea bidens Clark, 1928
Hypoponera sp. (14 vials)
Myopias tasmaniensis Wheeler, 1923
Platythyrea turneri Forel, 1895
Ponera leae Forel, 1913
Rhytidoponera tasmaniensis Emery, 1898
Rhytidoponera victoriae (E.Andre, 1896)
Sphinetomyrmex steinheili Forel, 1900

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OBSERVATIONS ON THE AVOIDANCE OF CULVERTS BY PLATYPUS

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INTRODUCTION

Records of platypus killed on roads above culverts suggest that platypus avoid using these structures (Tyson 1980; Taylor and Mooney 1991; Taylor *et al.* 1991). This paper documents two separate observations of avoidance of culverts by platypus in the Surrey Hills area, north-west Tasmania. The growing number of reports of road kills highlight the need to record creek and culvert design characteristics at each incident. This information is critical in understanding why platypus avoid using the structures and to assist in the design of culverts that will encourage entry and passage by this species.

OBSERVATION NO. 1.

On 2/5/98 a male platypus, aged at approximately 18 months on the basis of spur development (Grant 1995), was found dead with injuries consistent with being run over by a vehicle on a sealed road above a creek culvert consisting of three large (1.1 m diameter), parallel concrete drains. It was not possible to tell whether the animal had been travelling up or down the stream.

At the culvert junction the creek was 5 m wide, 0.5 m deep and flowed at 0.2 m/s. At the upstream end a small concrete section joined the creek bed to the culvert lip. The water flowing through the culvert at this point was 40 cm wide and 4 cm deep. The culvert was approximately 15 m long and contained a few patches of moss and some natural substrate. The downstream end was fixed at water level to a pool 3 m wide. From here the water flowed over one of three 0.3 m high cement walls, into a second pool and continued as a shallow riffle section.

There were no apparent structures or design features which would have physically impeded platypus entry.

OBSERVATION NO. 2.

On 5/11/97 a platypus was observed crossing a gravel road directly above a creek culvert. The platypus travelling upstream would have encountered a culvert measuring 7.5 m in length and 0.5 m in diameter, with water 25 cm wide and 10 cm deep, flowing at 0.25 m/s. The culvert was free of natural debris and substrate. The upstream end of the culvert was set into the earth by at least 15 cm to aid proper drainage and would not have prevented platypus entry.

The downstream end protruded 30 cm out from the road embankment with a 20 cm vertical distance between the culvert lip and the water in the pool below. While captive platypus have been observed climbing short vertical sections in their enclosure at Healesville Sanctuary (H.O. pers. obs.), the distance and lack of surrounding material to assist climbing into this culvert may have prevented entry by the platypus.

Additionally, numerous narrow worn tracks leading from the downstream pool up to the road (similar to those described by Taylor *et al.* 1991), suggest that platypus using this stream regularly travelled overland rather than use the culvert.

DISCUSSION

The two observations highlight the complex nature of avoidance of culverts by platypus. In the case where the platypus successfully crossed the road, culvert design (i.e. prevention of entry from downstream) appeared to be the most significant factor for its not being used. The design of this culvert could easily be improved by extending the road embankment out to the end of the culvert or adding rocks to the pool at the lip of the culvert.

The record of the less successful platypus suggests that even when culvert design does not appear to impede entry, some platypus still do not use them. Taylor *et al.* (1991) suggest that possible problems for platypus may include the length or size of the culvert or speed of water flow. In this case, water flow through the pipe may be improved by using square rather than circular pipes to replicate creek conditions more accurately, since increasing water volume in the pipe alone does not appear to encourage platypus movement (Taylor and Mooney 1991).

It is obvious that both creek characteristics and culvert design influence whether platypus use or avoid these waterways. While bridges are the obvious solution, this is not always economically viable, particularly in Tasmania with the prolific number of small waterways. There is a critical need for research into culvert design and movement not only by platypus but also native fish and the giant freshwater crayfish. If this problem is not addressed local extinctions of these species may occur in aquatic systems with large numbers of culverts and immigration back into areas where populations have been eliminated may not occur (Growns 1995).

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Illlustration by Dominac Fanning from *The Platypus*, UNSW Press.

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GOOSE BARNACLES *LEPUS AUSTRALIS* ON PENGUINS AT MACQUARIE ISLAND

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The foraging ecology of royal *Eudyptes schlegeli* and rockhopper penguins *E. chrysocome* has been examined each year at Macquarie Island since the 1993/4 season. In the course of field work during the 1994/5 season I noticed a number of penguins arriving at the island with barnacles attached to their feathers. Both Royal and Rockhopper Penguins carried the barnacles, but it is unknown if the two other species of penguins on Macquarie Island (gentoo *Pygoscelis papua* and king *Aptenodytes patagonicus*) also carried them, as no work was being conducted on these penguins at the time. Two specimens of barnacles were collected and sent to Dr Diana Jones of the Western Australian Museum, who identified them as a juvenile and young adult goose barnacle *Lepus australis*. The goose barnacle is found in cold, temperate seas (Jones 1990), with the most important habitat being the *Macrocystis* algae-belt in the Southern Ocean (Nilsson-Cantell 1926, 1930).

A systematic survey of barnacles on penguins was not carried out, hence there are no detailed descriptions of the number of penguins carrying barnacles nor the quantity on each bird. However, some penguins appeared to have up to 50 barnacles, attached to the tail, breast and back feathers. The barnacles were only observed when the penguins returned to the island to commence breeding (at the beginning of October and November in royal and rockhopper penguins, respectively), and must have been acquired during the winter non-breeding period at sea. The foraging grounds of royal and rockhopper penguins during the non-breeding season are unknown, although both species remain at sea in the Southern Ocean.

During subsequent field seasons all penguins that have been handled or observed in the course of the foraging ecology work have been examined for barnacles. However, in the three following seasons (1995/6, 1996/7 and 1997/8), none have been observed. Therefore, it appears that the presence of barnacles during the 1994/5 season was an aberration at this site. Whether this aberration is a function of the penguins foraging in different sectors of the ocean such as in the *Macrocystis* algae belt where they may have acquired the barnacles, or whether the barnacles were far more abundant and hence attaching to penguins more readily, cannot be determined.

It is rare for members of the Lepadidae family to attach to other living animals, although there are records of them on turtles, fish, seals and whales (see Jones 1990, Arnbom 1995). Records of barnacles attached to penguins are rare, although Jones

(1990) cites four cases in Snares crested penguins *E. robustus* and one in Fiordland crested penguins *E. pachyrhynchus*. Goose barnacles have been found attached to the pelage of Antarctic fur seals *Arctocephalus gazella* at Macquarie Island (Shaughnessy *et al.* 1988), but they have not been recorded before on penguins at this site.

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BOOK REVIEW

Larger Fungi of South Australia
by C.A. Grgurinovic

Published by The Botanic Gardens of Adelaide and State Herbarium and The Flora and Fauna of South Australia Handbooks Committee, Adelaide, 30th May 1997. RRP A$95

Fungi of Southern Australia
by Neale L. Bougher and Katrina Syme

Published by the University of Western Australia Press, Nedlands, W.A. 1998. RRP A$75

Reviewed by David Ratkowsky

These two important books on Australian fungi help fill the great need for scholarly books on the "larger", or "macro" fungi, that is, species that produce conspicuous fruit bodies. There have been few regional books on Australian fungi, and those that do exist are badly out of date taxonomically, or difficult to obtain (Cleland 1934-35, Willis 1963, Aberdeen 1979).

Cheryl Grgurinovic was awarded a Research Fellowship in Mycology by the Cleland Committee on 4 October 1983 and was given the task of re-examining the Mycological Herbarium of John Burton Cleland, his collections having been made largely between 1910 and 1935. Her goal, which took 14 years to bear fruition, and which was largely unfunded, was to prepare a revision of his pioneering two-part handbook on the higher fungi of the State of South Australia (Cleland 1934-1935). The appearance of *Larger Fungi of South Australia* has to be greeted with enthusiasm by amateurs and professionals alike, not only in South Australia, but in neighbouring States where there is a considerable overlap of the fungal flora.

Grgurinovic's book is confined to 19 orders of Homobasidiomycetes, and excludes all Ascomycetes, the "cup-bearing" fungi. Cleland, on the other hand, considered all the Basidiomycetes, together with a few of the most highly developed cup-fungi. Cleland had personally taken a great interest in other divisions and classes of fungi. He was an all-around naturalist with a life-long interest in ornithology, and also had some knowledge of insects and marine animals, being concerned with the toxic effects of the bites, stings and injuries that they inflict on humankind. He even had a role in the subsequent finding that the suffering of Mertz and Mawson in Antarctica in 1913 was due to hypervitaminosis A from eating carnivore liver.

Among the lasting benefits that accrue from this book include a clarification of the existing nomenclature, some of which was very confusing, and the description of some new taxa (96 new species and 1 new variety) as well as ca. 52 new names or combinations. Some of these name changes were necessitated by Cleland's unfortunate habit of storing more than one collection of what he thought was the same species in a single box or under a single heading. In some of these cases, more than one species was involved, necessitating choosing one of them to be the holotype for a new species. For example, the name *Cortinarius fibrillosus* (p. 190) was proposed by Cleland and supported by two collections rather than one in his protologue (i.e. the first verbal description of a taxon). Regrettably, one of these collections (AD 4169) is an *Inocybe*, while the other (AD 4170) is a species of *Cortinarius*. Since the protologue reproduces the collection notes accompanying the *Inocybe* collection rather than the *Cortinarius* collection, Grgurinovic has proposed the new combination *Inocybe fibrillosa*, designating AD 4169 as the lectotype. That leaves the *Cortinarius* collection AD 4170 without a valid name. Another example is *C. ochraceo-fulvus*, also originally described by Cleland. The protologue of this species records two syntypes, one of which has smaller spore measurements than the other, and whose mean length is outside the range given for that species. Hence, Grgurinovic has made the smaller-spored collection the holotype of a new species, *Cortinarius bambrus*. Other examples can be cited over a range of genera.

The 96 new species described by Grgurinovic make a definitive contribution to the understanding of the Australian fungal flora. Descriptions of species are almost always accompanied by detailed microscopic-based drawings which will greatly aid the professional mycologist in obtaining a better understanding of each of the species, and assisting accurate identification. This book also offers benefits to the amateur naturalist. The centre of the book contains 84 drawings and water-colours by predominantly female illustrators, who painted mushrooms for J.B. Cleland over a period of more than three decades. These will clearly assist the naturalist in coming to a correct identification. There are, in addition, a number of plates of photographs illustrating a further 24 species.

No book is perfect and that of Grgurinovic also has its limitations. Careful editing has kept misprints to a minimum, but there are some, nevertheless. For example, under *Gymnopilus*, the name *G. macrosporus* appears in the Key, whereas it should be *G. megasporus*, as in the text. Three of the species are omitted from the Index on p. 719. Other criticisms of this otherwise scholarly book can be made. Sometimes her descriptions lack important details, and her new species are almost always the result of splitting existing species on the basis of spore differences or of mixed collections by Cleland, discussed above. She offers little new in the way of systematic arrangement, relying heavily on the approaches of other mycologists, ignoring some of the more recent advances. For example, in *Cortinarius*, the systematic arrangement of Singer (1986) has been largely surpassed, with new criteria now being used to group the components of this genus. However, these criticisms do not diminish the admiration that this reviewer has for the enormity of the task that confronted Cheryl Grgurinovic. She was forced to make decisions about more than 475 taxa described in the text, without having the luxury of being able to choose to include only those species that are visually attractive or which would make the book sell well. It is a fine book and is an indispensable reference work for anyone who is serious about identifying Australian mushrooms and toadstools.

Fungi of Southern Australia by Bougher and Syme has a different objective to that of Grgurinovic, namely to combine an in-depth scientific approach to mycology with a beautiful work of art. This objective has been admirably achieved, with 125 species described and illustrated on pp. 92-341 of this 391-page book. A constant format has been followed throughout, with two pages devoted to each species. The left-hand page (and sometimes a part of the right-hand page as well) usually contains an introductory paragraph with useful general information, followed by a detailed scientific description of the fruit body and then a detailed description of the microscopic features. The right-hand page contains the illustration, being an original painting by Katrina Syme. These have been painted from fresh material collected in south-western Australia, almost all of which were taken along a transect ca. 200 km long between Walpole and Albany, centred on Denmark, W.A. The title of this book, in the earlier promotional literature, was to be "Fungi of South-western Australia", but the publishers probably thought that such a title might severely restrict sales, and thereby replaced "South-western" by "Southern". The justification for the name change is that most species included in the book occur throughout the southern regions of Australia with a high winter rainfall.

In addition to the descriptions and illustrations of the fungal species in Chapter 7, there are six introductory chapters, which include information on (1) the Kingdom Fungi and the difference between mushrooms and toadstools; (2) Australian fungi and the south-west region; edible, poisonous and hallucinogenic fungi; (3) the naming of fungi and how they are described in the book; (4) how to find, collect and preserve fungi; (5) describing fungi; (6) the main groups of fungi and how they are classified. At the end of the book, there is a useful glossary of terms used for larger fungi, which will be particularly welcomed by beginners to mycology, the scientific study of fungi. Here, complicated terms such as "mycorrhizal" and "sequestrate" are simply explained.

Clearly this is a very successful book, achieving its objective of marrying science and art in an appealing way. Nevertheless, with only 125 species illustrated, only a small percentage of the Australian higher fungi are dealt with. The number of mushroom-type species in Australia has been variously estimated to range between 5000 to 22,000; whichever estimate is closer to the truth, it is clear that there is a long way to go before a significant number of Australia's macrofungi are identified, described and illustrated. Books such as the two reviewed here are welcome contributions towards that goal.

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Willis, J.H. (1963) *Victorian Toadstools and Mushrooms.* Third Edition. (Field Naturalists Club of Victoria, Melbourne).

ADVICE TO CONTRIBUTORS

The Tasmanian Naturalist publishes articles on all aspects of natural history and the conservation, management and sustainable use of natural resources. These can be either in a formal or informal style. Articles need not be written in a traditional scientific format unless appropriate. A wide range of types of articles is accepted. Examples include observations of interesting or unusual animal behaviour, flora or fauna surveys, aspects of the biology and/or ecology of plants and animals, critical reviews of management plans and overviews on contemporary issues relating to natural history.

Reviews of publications on Australian natural history are included. Unsolicited reviews are welcome as are suggestions for books to be considered for review.

Submission of Manuscripts

Manuscripts should be sent to Dr Robert Taylor, C/- Forestry Tasmania, GPO Box 207B, Hobart, Tasmania 7000.

Formal articles should follow the style of similar articles in recent issues. Informal articles need not fit any particular format. An abstract need only be included with longer articles. References cited in the text should be listed at the end of the paper in the following format:

Ratkowsky, A.V. and Ratkowsky, D.A. (1976) The birds of the Mt. Wellington Range, Tasmania. *Emu* 77: 19-22.

Watts, D. (1993) *Tasmanian Mammals. A Field Guide.* (Peregrine Press, Kettering).

Ponder, W.F. (1993) Endemism in invertebrates in streams and rivers as demonstrated by hydrobiid snails. In *Tasmanian Wilderness: World Heritage Values.* Eds. S. Smith and M. Banks. (Royal Society of Tasmania, Hobart).

Bryant, S.L. (1991) The Ground Parrot *Pezoporous wallicus* in Tasmania: Distribution, Density and Conservation Status. Scientific Report 1/91. Department of Parks, Wildlife and Heritage, Hobart.

A good quality original of graphs, illustrations or maps should be provided. These can also be provided on computer disk in EPS or TIFF format.

Formal articles are normally sent to an independent referee for comment. This is undertaken to try to ensure accuracy of information and to improve the quality of presentation. It should not be seen by prospective authors as a venue for their work to be critised but rather as a service to help them improve their manuscripts. The editor is willing to assist any prospective authors who have little experience in writing articles.

After an article is accepted for publication, authors will be asked to provide a copy on computer disk, if possible.

Tasmanian Field Naturalists Club Inc.

G.P.O. Box 68A, Hobart, Tas. 7001

Founded 1904

OBJECTIVES

The Tasmanian Field Naturalists Club aims to encourage the study of all aspects of natural history and to advocate the conservation of our natural heritage. The club is comprised of both amateur and professionals who share a common interest in the natural world.

ACTIVITIES

Members meet on the first Thursday of each month in the Biological Sciences Building at the University of Tasmania at Sandy Bay. These meetings include a guest speaker who provides an illustrated talk. This is followed by an excursion on the next weekend to a suitable site to allow field observations of the subject of that week's talk. A mammal survey group also undertakes trapping and recording of native mammals in local areas. The Club's committee coordinates input from members of the club into natural area management plans and other issues of interest to members.

THE TASMANIAN NATURALIST

The Club publishes the journal *The Tasmanian Naturalist*. This journal provides a forum for the presentation of observations on natural history and views on the management of natural values in both formal and informal styles.

MEMBERSHIP

Membership of the Tasmanian Field Naturalists Club is open to any person interested in natural history. *The Tasmanian Naturalist* is distributed free to all members, the club's library is available for use and a quarterly bulletin is issued with information covering forthcoming activities. Enquiries regarding membership should be sent to The Secretary at the above address or by phoning Genevieve Gates on (03) 62278638.

Membership	**Rates**
Adults	$20
Families	$25
Concession	$15
Junior	$15

Subscription Rates for *The Tasmanian Naturalist*

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