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Wild Places of Greater Melbourne

by Robin Taylor

Publisher: *CSIRO Publishing and Museum Victoria. ISBN 0 9577471 0 1. 224 pp. More than 220 coloured photos, maps and plates. RRP $24.95. ($21.00 from the FNCV Bookshop)*

Consider the following scenarios. The weather has been lousy for three-quarters of the weekend – but at lunch time on Sunday, the sun comes out and it's a perfect afternoon to head for the bush. But where can you go in half a day? The phone rings and it's those people you exchanged phone numbers with on your last holiday. 'We're only in Melbourne for one day. Can you show us some koalas and kangaroos? We would love to see that famous Aussie bush you told us about.' Wild Places of Greater Melbourne can solve your dilemma.

Wild Places of Greater Melbourne is a guide to 31 of Melbourne's wild places, selected from national parks, state forests and conservation reserves. The sites described in this book have been chosen for their habitat values and range of natural features, and all can be reached and explored comfortably in a day trip from Melbourne. In fact, all are within an hour-and-a-half drive from the centre of Melbourne. Several, such as Organ Pipes National Park, Royal Botanic Gardens Cranbourne and Serendip Sanctuary are perfect destinations for those times when you only have a few hours to spare.

The book is cleverly set out so that all the Wild Places are grouped according to location – North East, South East and West of Melbourne. Each section includes a locality guide, details of interesting features and a discussion of vegetation and fauna. With a little planning, several places can be visited in one day, and you could impress your visitors by taking them on a trip which includes a diversity of environments. For example, head up the Calder Highway to Organ Pipes National Park, just opposite the Calder Park Raceway. Organ Pipes was named for the spectacular 20 metre high basalt columns formed two to three million years ago from deep lava flows.

After visiting Organ Pipes, cut across to Melton and head up the Western Freeway to Long Forest Flora Reserve, the only naturally occurring patch of mallee south of the Great Dividing Range. I lived out this way twenty-five years ago, and still remember the fight to save this remnant from subdivision for a housing development. This gem is a reminder of how vigilant we all must be about protecting our urban bushland. From here, head to O'Briens Crossing in the Wombat State Forest. If you visit in Spring, you'll be treated to a wonderful display of wildflowers, but this is a beautiful picnic spot at any time of year.

Visitors to Melbourne from the country often like to head for the beach, and marine environments are not neglected in Wild Places. Point Cooke Coastal Park is only 20 km from Melbourne. Drop in here and marvel at the thousands of migratory and local birds that flock between September and March. Then continue on to the Harold Holt Marine Reserves and explore the rocky shores and rock platforms of Point Nepean and Point Lonsdale. These are just a few examples of the wonderful selection of Wild Places near Melbourne. The book also includes a fascinating discussion of Melbourne's geological past, and informative descriptions of its terrestrial and marine environments. Whether you live in Melbourne, or you are just visiting for a short time, you will find a wealth of places to visit even on the most limited time-budget.

Although beautifully illustrated, the book is not a field guide in itself. The photos will enable you to identify some of the more common plants and animals, but to get the most out of your trip to one of Melbourne's Wild Places, don't forget your specialist field guides and binoculars.

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Cover: The Bottlenose Dolphin *Tursiops truncatus* photographed near the southern end of Port Phillip Bay, Victoria. Photo by Troy Muir. See Research Report on p. 4.

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The Bottlenose Dolphin *Tursiops truncatus* in the Southern End of Port Phillip Bay: Behavioural Characteristics in Spring and Summer

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Abstract

This study reports on the behavioural characteristics of Bottlenose Dolphins *Tursiops truncatus* in the southern end of Port Phillip Bay during Spring and Summer of 1995/1996. A total of 35 hours of direct observations (contact time = 14%) of the dolphins were made using a focal group sampling method. The probability of sighting dolphins in the study area was greatest in January and February and least in October. The most frequently observed group size was 2-5 and within 500 m of the shore. The most commonly recorded behaviour was travel (51%) followed by social (31%) and feeding behaviour (17%). Mixed groups of adults and neonatal-calves were observed during Spring (50%) and Summer (62%). (*The Victorian Naturalist* **117** (1), 2000, 4-9.)

Introduction

The Bottlenose Dolphin (Fig. 1) *Tursiops truncatus* (Cetacea: Delphinidae) is the most extensively studied of all cetaceans (review in Würsig 1989) distributed worldwide, inhabiting temperate and tropical waters (Jefferson *et al.* 1993). *Tursiops truncatus* occupies a wider habitat range than other cetacean genera (Wiley *et al.* 1994). Two distinct forms of this species have been defined: 'inshore' and 'offshore' types (Ridgway 1990). The taxonomy of this species is still fluid but there appears to be two forms in Australian waters (*Tursiops truncatus* in the south and *Tursiops aduncus* in the north). The form in Port Phillip Bay is believed to be the short-nosed inshore type *Tursiops truncatus*.

Warneke (1995) reports the presence of Bottlenose Dolphins along the Victorian Coastline and Bass Strait and refers to a small and apparently resident population of these dolphins in Port Phillip Bay. However, Warneke (1995) provides no indication of number of dolphins in Victorian waters. Reports of geographically distinct populations of Bottlenose Dolphins have indicated that differences in intraspecific behavioural characteristics are evident, which probably result from specific adaptations needed to survive local ecological conditions (Würsig 1978; Würsig and Würsig 1979; Ballance 1992; Shane 1990; Defran and Weller 1999).

Habitat varies throught the range. Therefore, if behaviour of Bottlenose Dolphins is influenced by habitat (Defran and Weller 1999) behavioural characteristics may differ for each population. This study reports on the behavioural characteristics of Bottlenose Dolphins in the southern end of Port Phillip Bay during Spring and Summer.

Methods

The study was conducted at the southern end of Port Phillip Bay (38°05' S, 144°50' E) Victoria, Australia (Fig. 2). The study site covered an area of 2.5 km × 10.5 km and extended from Rosebud to Port Phillip Heads ('Rip') and included Mud Island.

Data was collected between September 1995 and February 1996. Due to research time restraints the authors were unable to complete a full year of observations. Field time was a total of 248 hr, of which 35 hr was spent in direct observation of dolphins (14% contact rate). Observations and recordings were conducted from a 4.5 m aluminum dinghy equipped with an 8 hp outboard motor. A maximum distance of 5 km was travelled from the shore. All searches were opportunistically conducted.

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Fig. 1. A group of Bottlenose Dolphins *Tursiops truncatus* photographed during field work in Port Phillip Bay. Photo kindly provided by Troy Muir.

Once dolphins were observed an instantaneous sampling technique (Shane 1990) was used to document focal groups (Altmann 1974). Focal group activity was documented at five minute intervals and data was transcribed onto prepared data sheets. A focal group was used because it was not possible to identify individual dolphins accurately. A group of dolphins was defined as a number of dolphins greater than one swimming in a coordinated manner within 100 m of each other and displaying similar behaviour. Observations were recorded 10 minutes after the dolphins were first observed, in case the arrival of the observer affected their behaviour. The following temporal and environmental conditions were recorded: date, time, location, water depth, water temperature, height of tide and offshore distance.

Three categories of dolphin behaviour, namely travelling, feeding and social behaviour were identified, as proposed by Shane (1990). Travel behaviour was defined as a steady movement of dolphins in one direction, with no indication of feeding behaviour. Feeding behaviour was composed of erratic swimming, multi-directional diving and feeding circles. Dolphins were also occasionally seen chasing fish at the surface of the water. Social behaviour consisted of aerial activity, touching, rubbing, biting, splashing and mating. During all observation sessions only one observer was responsible for recording behavioural categories. This eliminated bias that may have arisen due to differences in individual observer interpretation during each session.

Group size was a visual estimate of the number of dolphins in a group. The number of dolphins observed were grouped into categories rather than exact individual numbers due to difficulties faced when trying to determine exact numbers especially with groups exceeding 10 dolphins. Number of individuals were divided into the following 6 categories; Category 1: 2-5 dolphins; Category 2: 6-10 dolphins; Category 3: 11-15 dolphins; Category 4: 16-20 dolphins; Category 5: 21-25

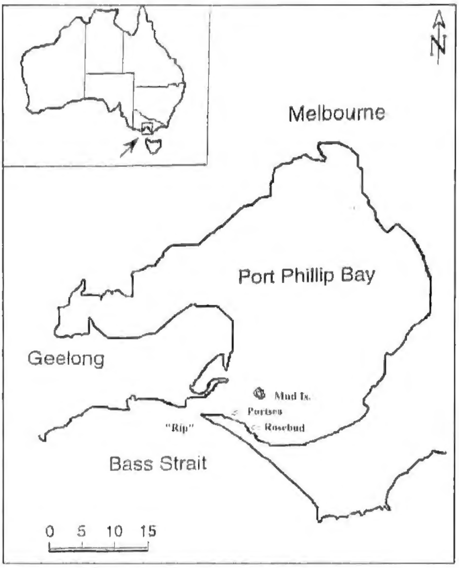

Fig. 2. Port Phillip Bay, Victoria. The study took place at the southern end of the Bay and waters around Mud Island.

dolphins; Category 6: >25 dolphins.

In this study 'calves' refers to neonatal calves. Neonatal was defined as i) an individual less than 120 cm long (Urian *et al.* 1996); ii) closely associated to an adult member at least twice its size; iii) presence of fetal folds and, iv) awkward and immature swimming (Defran *et al.* 1999).

All observations were conducted according to the Wildlife Whale Watching Regulations (1990).

Terminology

Probability of Sighting Dolphins = the number of days dolphins were sighted divided by the number of field days in any one month.

Mean length of time dolphins stayed at different shore distances in the study area = the total time dolphins were observed at a particular shore distance per sighting divided by the number of sightings at that shore distance.

Group sizes (%) = the total time dolphins were observed in different group sizes divided by the total time dolphins were observed expressed as a percentage.

Analysis of data

To determine if the probability of sighting dolphins was influenced by season in the study area a Z test (Albright *et al.* 1999) was applied. Data collected on the ecology and behaviour of the dolphins were analyzed using the non-parametric Kruskal-Wallis test. The distribution free Kruskall-Wallis test was used because the data was not found to be normally distributed. The statistical programs used were SPSS (8.0) and Mini-Tab (11.2) on an IBM computer.

Results

The results presented here are limited, as we were unable to sample continuously throughout the year. However, they provide information on the behavioural characteristics of these dolphins during Spring and Summer in the southern end of Port Phillip Bay not previously reported in the scientific literature.

The probability of sighting dolphins in the study area was significantly influenced by season. The number of sightings was highest during January and February (Fig. 3). The probability of sighting dolphins was significantly greater in February than in November ($p < 0.01$) and December ($p < 0.01$) and the probability in January was significantly different from that in November ($p < 0.01$). There were no other months in which sightings were found to be significantly different from each other.

The length of time dolphins were observed at different shore distances (Table 1) was significantly different (Kruskal-Wallis test: $\chi^2 = 8.916$, df = 3, 43, $p = 0.030$). Dolphins were observed more often at a shore distance of 1-100 m (Mean time = 48.2 min, S.D. = 33.6) and least often at a shore distance of >500-1000 m (Mean time = 17.2 min, S.D. = 10.3).

The most common group size observed was 2-5 dolphins (28%) and the least common group size observed was 11-15 (7%) (Table 2). Results indicate that the amount of time spent by different group sizes of Bottlenose Dolphins in the study area was not significantly different between each behaviour (Kruskal-Wallis test: $\chi^2 = 5.573$; df = 5, 37; $p = 0.350$).

Dolphins spent most of their time travelling (51%) followed by social behaviour (31%) and feeding (17%). However, the mean length of time dolphins engaged in each type of behaviour on any observed

Table 1. The mean length of time dolphins were observed at different distances from the shore.

Shore Distance (m)	1-100	>100-500	>500-1000	>1000
Mean time (min)	48.2	46.5	17.2	40
Standard Deviation	33.6	32.2	10.3	40.3

Table 2. Group size of Bottlenose Dolphins observed in the southern end of Port Phillip Bay expressed as a percentage.

Group Size	2–5	6–10	11–15	16–20	21–25	>25
Time Sighted (%)	27.9	19.2	7	8.7	13.6	23.6
Time Range (min)	10-120	15-90	20-45	40-120	25-135	10-120

occasion was not significantly different between each other (Kruskal-Wallis test: $\chi^2 = 3.301$; df = 2, 48; p = 0.192).

Calves were observed both in Spring (September-November) and Summer (December-February). The majority of adult-calf groups were observed in Summer. Adult-calf groups accounted for 62% of the groups observed in Summer and 50% of the groups observed in Spring. There was no significant difference (p = 0.534) between the number of adult-calf groups observed in the two seasons.

Discussion

Our results indicate that Bottlenose Dolphins are present in the southern end of Port Phillip Bay during both Spring and Summer with the exception of October. However, the probability of sighting dolphins is greatest during January and February. A study conducted by Lear and Bryden (1980) in Moreton Bay, Queensland found a smaller number of Bottlenose Dolphin sightings in Summer than Winter. Several studies have shown that Bottlenose Dolphins have a home range which may be utilized more extensively during particular times of the year (Würsig 1978; Shane 1990; Grigg and Markowitz 1997). There are several possibilities that could explain our findings: i) seasonal change of home-range; ii) the presence of transient dolphins which have migrated temporarily into Port Phillip Bay for feeding and breeding; and iii) the movement of prey species into and out of the study area. The high probability of sighting dolphins during Summer suggests that this part of Port Phillip Bay is an important area to the dolphins and may, indeed, suggest that the southern end of Port Phillip Bay constitutes their Summer home range. Transient Common Dolphins *Delphinus delphis* have been reported in the study area (Scarpaci *et al.* 1999) and there are records of Southern Right Whales *Eubalaena australis* in adjacent waters. The low numbers of Bottlenose Dolphins seen during Spring may be a result of a decrease in prey abundance due to low water temperatures in the preceding Winter months, as observed by Wells *et al.* (1990) along the California Coast. The dolphins may be moving directly in response to their prey species. For example, Southern Squid *Sepioteuthis australis*, a common prey species of Bottlenose Dolphins (Cockcroft and Sauer 1990) are known to spawn in the Port Phillip Heads region during the warmer months of the year (CSIRO 1995).

Our results also suggest that the dolphins of Port Phillip Bay spend most of their time within 500 m of the shore, similar to dolphins in San Diego County, California, which spend 90% of their time within 250 m of the shore (Hanson and Defran 1993). The most common group size observed was 2 to 5 dolphins. A number of researchers (Wursig and Wursig 1979; Silber *et al.* 1994; Wiley *et al.* 1994) suggest that populations of dolphins that have a relatively small group size and whose activities occur close to shore represent an inshore form and it is therefore possible that the dolphins in Port Phillip Bay are of this type. Further research on the behaviour, morphology and genetic composition of these dolphins will provide conclusive evidence as to whether they are an 'inshore' or an 'offshore' ecotype.

In southern Port Phillip Bay dolphins spend most of their time travelling, and less time in social and feeding behaviour

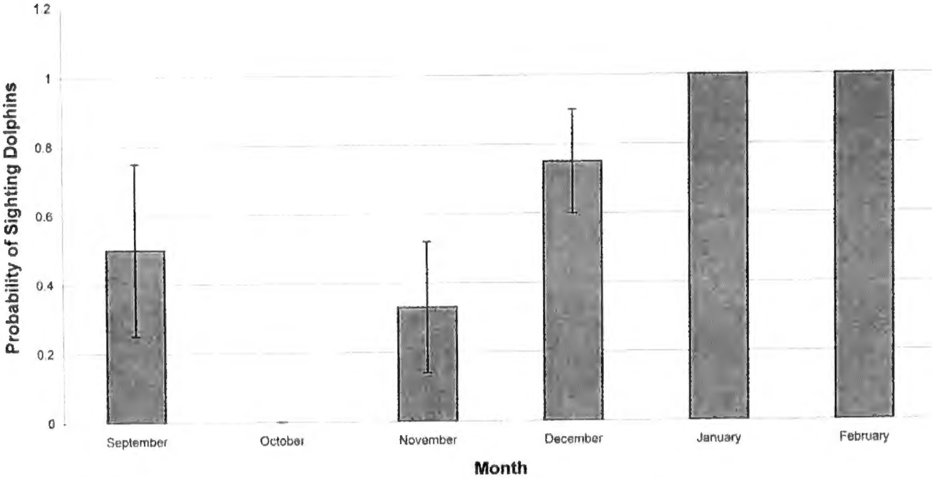

Fig. 3. The probability of sighting Bottlenose Dolphins in the study area from September to February. Error bars represent standard deviation.

during Spring and Summer. We do not know how they partition their time during Autumn and Winter. A study conducted by Ballance (1992) during Spring, Summer and Autumn reported that Bottlenose Dolphins in the Gulf of California, Mexico spent 61% of their time feeding in areas within 5.5 km of an estuary mouth and 22% of their time travelling. In a review by Shane *et al.* (1986), a study conducted in southern Texas is quoted in which travel behaviour was significantly greater than all other observed behaviours in Winter to mid-spring and the first month of Summer. In addition published reports on the behavioural characteristics of Bottlenose Dolphins (Shane 1990; Ballance 1992; Jacob *et al.* 1993; Hanson and Defran 1993) illustrate differences amongst different populations. This emphasizes the importance of accurately studying the behavioural characteristics of the dolphins in Port Phillip Bay in all seasons in order to better understand their population dynamics which may help conserve this population of dolphins. These dolphins have been exposed to the eco-tourism industry (currently four commercial 'swim-with the dolphins' charters operate in the southern end of Port Phillip Bay) before their behaviour and ecology has been evaluated.

Adult-calf groups are present in both Spring and Summer. Bottlenose Dolphins are known to be flexible in their time of reproduction however they often show a distinct pattern of seasonality and reproduction (Urian *et al.* 1996). It is therefore not surprising that adult-calf groups were observed during the study period. Further seasonal studies currently being conducted will determine the main calving season of this population of dolphins.

Conclusion

This paper is the first record of behavioural characteristics of Bottlenose Dolphins in the southern end of Port Phillip Bay. The observations reported here form a baseline for future research and will also aid in determining the conservation requirements for the species in Port Phillip Bay.

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Mr. and Mrs. MacKinnon of Moonraker Dolphin-Seal Charters for the essential provision of a marine vessel and fuel during the study period. Dr. Peter Corkeron from James Cook University, Townsville for his critical advice in improving the manuscript. Kaye E. Marion from the Department of Statistics and Operations Research at RMIT University for her statistical help. We are grateful to two anonymous referees and the editor for their critical input and amendments in improving the manuscript.

References

Albright, S.C., Winston, W.L. and Zappe, C. (1999). Data Analysis and Decision Making with Microsoft Excel. (Duxbury Press: New York).

Altmann, J. (1974). Observational study of behaviour: sampling methods. *Behaviour* **49**, 227-267.

Ballance, L.T. (1992). Habitat use patterns and ranges of the Bottlenose Dolphins in the Gulf of California, Mexico. *Marine Mammal Science* **8** (3), 262-274.

Cockcroft, V.G. and Sauer, W. (1990). Observed and inferred epimeletic (nurturant) behaviour in Bottlenose Dolphins. *Aquatic Mammals* **16**, 31-32.

CSIRO (1995). The present state of knowledge on fish stocks and commercial and recreational fisheries in Port Phillip Bay, Victoria, and their interactions with nutrients and toxicants. CSIRO Technical Report Number 7.

Defran, R.H. and Weller, D.W. (1999). Occurrence, Distribution, Site Fidelity, and School Size of Bottlenose Dolphins (*Tursiops truncatus*) off San Diego, California. *Marine Mammal Science* **15** (2), 367-380.

Defran, R.H., Weller, D.W., Kelly, D.L. and Espinosa, M.A. (1999). Range characteristics of Pacific Coast Bottlenose Dolphins (*Tursiops truncatus*) in the Southern California Bight. *Marine Mammal Science* **15** (2), 381-393.

Grigg, E. and Markowitz, H. (1997). Habitat use by Bottlenose Dolphins (*Tursiops truncatus*) at Turneffe Atoll, Belize. *Aquatic Mammals* **23** (3), 163-170.

Hanson, M.T. and Defran, R.H. (1993). The behaviour and feeding ecology of the Pacific coast Bottlenose Dolphin, *Tursiops truncatus*. *Aquatic Mammals* **19** (3), 127-142.

Jacobs, M., Nowacek, D.J., Cannon, G., Nowicki, S. and Forward, Jr., R.B. (1993). Seasonal changes in vocalizations during behaviour of the Atlantic Bottlenose Dolphin. *Estuaries* **16** (2), 241-245.

Jefferson, T.A., Leatherwood, S. and Webber, M.A. (1993). 'FAO species identification guide. Marine Mammals of the World' (FAO: Rome.)

Lear, R.J. and Bryden, M.M. (1980). A study of the Bottlenose Dolphins *Tursiops truncatus* in eastern Australian waters. Australian National Parks and Wildlife Service Occasional Paper No. 4, 1-125.

Ridgway, S. (1990). The central nervous system of the Bottlenose Dolphin. *In* 'The Bottlenose Dolphin', pp. 69-101. Ed. S. Leatherwood and R.R. Reeves. (Academic Press: London.)

Scarpaci, C., Bigger, S.W., Saville, T.A. and Nugegoda, D. (1999). A Rare Sighting of the Common Dolphin *Delphinus delphis* in Port Phillip Bay, Victoria. *The Victorian Naturalist* **166** (2), 65-67.

Shane, H. (1990). Behavior and Ecology of the Bottlenose Dolphin in Sanibel Island, Florida. *In* 'The Bottlenose Dolphin', pp. 245-266. Eds S. Leatherwood and R.R. Reeves. (Academic Press: London.)

Shane, H., Wells, R.S. and Würsig, B. (1986). Ecology, behaviour and social organization of the Bottlenose Dolphin: a review. *Marine Mammal Science* **2**, 34-63.

Silber, G.K., Newcomer, M.W., Silber, P., Pérez-Cortés, H. and Ellis, G.M. (1994). Cetaceans of the Northern Gulf of California: Distribution, Occurrence and Relative Abundance. *Marine Mammal Science* **10** (3), 283-298.

Urian, K.W., Duffield, D.A., Read, A.J., Wells, R.S. and Shell, E.D. (1996). Seasonality of reproduction in Bottlenose Dolphins, *Tursiops truncatus*. *Journal of Mammalogy* **77**, 394-402.

Warneke, R.M. (1995). Bottlenose Dolphin. *In* 'Mammals of Victoria: Distribution, Abundance, Ecology and Conservation', pp. 290-291. Ed. P.W. Menkhorst. (Oxford University Press: Australia.)

Wells, R.S., Hanson, L.J., Baldridge, A., Dohl, T.P., Kelly, D.L. and Defran, R.H. (1990). Northward extension of the range of Bottlenose Dolphins along the California Coast. *In* 'The Bottlenose Dolphin', pp. 421-431. Eds S. Leatherwood and R. Reeves. (Academic Press: London.)

Wildlife Whale Watching Regulations (1990). Statutory Rules (SR) Number 102. (VGPO: Melbourne.)

Wiley, D.N., Wenzel, F.W. and Young, S.B. (1994). Extralimital residency of Bottlenose Dolphins in the Western North Atlantic. *Marine Mammal Science* **10**, 223-226.

Würsig, B. (1978). Occurrence and group organization of Atlantic Bottlenose Porpoises (*Tursiops truncatus*) in an Argentine Bay. *Biological Bulletin* **154**, 348-359.

Würsig, B. (1989). Cetaceans. *Science* **244**, 1550-1557.

Würsig, B. and Würsig, M. (1979). Behaviour and ecology of the Bottlenose Dolphin, *Tursiops truncatus*, in the South Atlantic. *Fishery Bulletin (U.S.)* **77**, 399-412.

Southern Hemisphere Ornithological Congress

27 June - 2 July, Griffith University, Brisbane, Australia

Birds Australia is presenting the 2nd Southern Hemisphere Ornithological Congress (SHOC) in Brisbane this year. This Congress aims to bring together Southern Hemisphere ornithologists from around the globe to discuss research and conservation of birds in a distinctly southern fashion. With plenary speakers and symposium organisers confirmed from Southern Africa, South America and Australia, SHOC will be a truly international event. This major Congress will be held in Brisbane and hosted by the Queensland Ornithological Society.

Registration brochures and all other information on the Congress can be found at the SHOC 2000 website (http://www.birdsaustralia.com.au/shoc), or obtained from the SHOC 2000 Congress Secretariat: Conventions Queensland, PO Box 4044, St Lucia, South Queensland 4067.

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Moss Collections from Lord Howe Island in the National Herbarium of Victoria (MEL)

Arthur W. Thies[1]

Abstract
Bryum pachytheca, Fabronia australis, Fissidens asplenioides, F. oblongifolius, Leptobryum pyriforme, Schizymenium bryoides and *Sematophyllum homomallum* are added to the recorded moss flora of Lord Howe Island. Other recent published additions *Calomnion milleri, Himantocladium cyclophyllum, Schlotheimia brownii* and *Thuidium sparsum* are mentioned, and *Echinodium hispidum* is restored. Isotypes of *Rhodobryum leucocanthum* are reported. Several *nomina nuda* are synonymised with legitimate taxa. (*The Victorian Naturalist* **117** (1), 2000, 10-13.)

Introduction

As the recording of all mosses (Musci) in the National Herbarium of Victoria (MEL) on a computer data base neared completion, a set of some 80 unnamed specimens from Lord Howe Island (LHI) had to be identified. They were collected by A. C. Beauglehole in November 1962 and September 1963. This task occasioned a review of all LHI moss collections in MEL, including those of Beauglehole's collections which he had already named himself.

Ramsay (1984) gave a comprehensive account of the moss flora of LHI as known then. She reported 105 species, of which 21 were considered to be endemic. Later, in their catalogue of all Australian mosses, Streimann and Curnow (1989) included several additions and corrections published in the meantime. The work described here resulted in further such updating. Changes to nomenclature are also recorded.

Methods

Any mixtures in the unnamed collections were separated out, and about 20 hepatics split off for another day. Some species were well enough known to require no further checks. Most others, notably those not found in Victoria, could be keyed out with the key constructed by Buck and Vitt (no date) for the *Flora of Australia*.

A search for relevant literature was based on the annual publication lists of the *Australasian Bryological Newsletter* and on 'TROPICOS', the Internet-accessible data base at the University of Missouri, USA (http://mobot.mobot.org/Pick/Search/most.html).

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New Records

New published records for LHI since Streimann and Curnow's (1989) Catalogue are listed in Table 1.

Among Beauglehole's collections were new records for LHI which are listed in Table 2. Beauglehole's collections at MEL also include *Himantocladium cyclophyllum* and *Calomnion milleri*. The *Calomnion milleri* collection (MEL 1041444) predates Vitt's type collection of that species.

Records deleted

Euptychium setigerum (Sull.) Broth., listed from LHI by Ramsay (1984), was not listed for LHI in the exhaustive revision of the genus by During (1977), as noted by Streimann and Curnow (1989: p. 150). An 1871 collection in the National Herbarium of Victoria (MEL 1001416) was labelled as *Esenbeckia cuspidata* (a synonym of *E. setigerum)*. This collection is actually the LHI endemic *E. mucronatum*. It may have been the source of the erroneous inclusion.

Thuidium furfurosum (Hook.f. & Wilson) Reichardt was listed from LHI by Ramsay (1984) but was excluded from LHI by Touw and Falter-van den Haak (1989).

Echinodium hispidum (Hook.f. & Wilson) Reichardt was removed from the LHI flora by Churchill (1986). It must however be re-instated, as Beauglehole's MEL 1041526 is a good specimen of it with ripe fruit, his MEL 1063387 is a further, sterile example, and it is reported as an admixture of the type of *Fissidens longiligulatus* (Ramsay *et al.* 1990).

Changes to names

There have been a number of changes to the names of LHI mosses since the compilation of Ramsay (1984). These are compiled

Table 1. New published records for Lord Howe Island (LHI) since Streimann and Curnow's (1989) Catalogue.

Species	Reference
Calomnion milleri Vitt	Vitt (1991)
Fissidens asplenioides Hedw.	Stone (1990b)
Fissidens oblongifolius Hook.f. & Wilson	Bruggeman-Nannenga *et al.* (1994)
Himantocladium cyclophyllum. (Müll. Hal.) M.Fleisch.	Enroth (1992), quoting an 1882 collection in the herbarium of the New York Botanical Garden (NY)
Schlotheimia brownii Schwaegr.	Vitt (1989)
Thuidium sparsum (Hook.f. & Wilson) A.Jaeger	Touw and Falter-van den Haak (1989)

Table 2. New records of Lord Howe Island bryophytes from Beauglehole's collections.

Bryum pachytheca Müll. Hal.
Fabronia ?australis Hook. (The specific identity is doubtful. The genus *Fabronia* has not previously been recorded from LHI.)
Leptobryum pyriforme (Hedw.) Wilson
Schizymenium bryoides Harvey
Sematophyllum homomallum (Hampe) Broth.

in Table 3, where the current name is given with the source of the synonymy.

Nomina nuda

There are two published *nomina nuda* based on LHI collections which are represented at MEL: *Plagiothecium howeanum* Müll. Hal. and *Amblystegium orbiculare* A.Jaeger.

Plagiothecium howeanum seems to be a good species awaiting legitimisation. An old label in this package reads '*Cyrto-Hypnum howeanum* C. M.' in E. Hampe's hand.

Amblystegium orbiculare A.Jaeger is a sterile specimen of *Camptochaete excavata*. The name is typed on the envelope; inside is also an old herbarium label *Porotrichium* (sic) *orbiculare* Mitt. and a further label *Hypnum orbiculare* Hmp. All three names are listed in the *Index Muscorum* (Wijk *et al.* 1959-1969) as synonymous *nomina nuda*.

Odds and Ends

Isotypes

J.R. Spence and H.P. Ramsay, when revising the Bryaceae for the *Flora of Australia*, found that MEL 30848 and MEL 30849 are isotypes of *Rhodobryum leucocanthum* Hampe.

Macromitrium on LHI

Vitt and Ramsay (1985) noted that *M. brachypodium* 'has not been collected on higher elevations ... (e.g.) Mt Gower'. There is now such a collection in MEL. They also noted that *M. leratii* was known 'from one collection from LHI'. Two more are now in MEL.

Endemic species

Ramsay (1984) recognised 21 substantiated endemic species on LHI. Many have since been synonymised with taxa found also elsewhere, and only 12 remain. By its protologue, **Ectropothecium howeanum* is so close to *E. leucochloron*, that a revision of the genus is not likely to retain it as a separate species.

The MEL collection

There are 248 specimens of mosses from LHI in the National Herbarium of Victoria. Among these are represented 68 of the 108 species reported for LHI. Specimens collected by Beauglehole in 1962/3 represent 59 species.

Acknowledgements

The late Dr. George A.M. Scott not only introduced me to bryology, but then also had unlimited time and patience to help me with my bryological problems. Dr. J. Milne and Mr. D.A. Meagher helped me with several determinations. Dr J.E. Beever offered valuable comments and Dr. T. May suggested substantial improvements to the format.

References

Bruggeman-Nannenga., M.A., Pursell, R.A. and Iwatsuki, Z. (1994). A re-evaluation of *Fissidens* subgenus *Serridium* section *Amblyothallia*. *Journal of the Hattori Botanical Laboratory* **77**, 255-272.

Buck, W.R. (1990). A monograph of *Entodon* (Entodontaceae) in Australia, eastern Melanesia and southern Oceania. *Australian Systematic Botany* **3**, 701-709.

Buck, W.R and Vitt, D.H. (no date). 'Key to the genera of Australian Mosses' - This key has been made widely available by ABRS. (Australian Biological Resources Study.)

Churchill, S.P. (1986). A revision of *Echinodium*. *Journal of Bryology* **14**, 117-133.

Table 3. Current name for mosses from LHI whose names have altered since Ramsay (1984). * denotes endemic.

Current name	Name in Ramsay (1984)	Source of synonymy
Barbella trichophora (Mont.) M.Fleisch.	*Barbella enervis* (Thwait. & Mitt.) M.Fleisch.	Streimann (1993)
Camptochaete excavata (Taylor) A.Jaeger	*C. vaga* (Müll. Hal.) Broth.	Tangney (1997)
	Hypnum orbiculare Hampe	syn. nov., this paper
	Porotrichum orbiculare Mitt.	syn. nov., this paper
	Amblystegium orbiculare A.Jaeger	syn. nov., this paper
Campylium polygamum Bruch & Schimper	**Rhynchostegiella campyloides* Broth. & Watts	Hedenaes (1996)
Echinodium umbrosum (Mitt.) A.Jaeger	**E. parvulum* Broth. and Watts	Churchill 1986
**Entodon plicatus* Müll. Hal.	*E. pancherianus* (Besch.) A.Jaeger	Buck (1990)
Eurhynchium laevisetum Geh.	**Oxyrrhynchium howeanum* Broth. & Watts	Hedenaes (1996)
Fissidens aeruginosus Hook.f. & Wilson	**F. arcuatulus* Broth. & Watts	Stone (1990a)
Fissidens hyophilus Mitt.	*F. arboreus* Broth.	Stone (1990b)
Fissidens leptocladus Müll. Hal.	**F. amblyothallioides* Broth. and Watts	Stone (1990c)
Fissidens oblongifolius Hook.f. & Wilson	**F. longiligulatus* Broth. & Watts	Bruggeman-Nannenga *et al.* (1994)
Fissidens pallidus Hook.f. & Wilson	**F. howeanus* Broth.	Stone (1990b)
Fissidens tenellus Hook.f. & Wilson	**F. subtenellus* Broth. & Watts	Stone (1994)
	**F. tenelliformis* Broth. & Watts	Stone (1994)
Hypopterygium muelleri Hampe	*H. rotulatum* (Hedw.) Brid.	Fide all MEL specimens revised by J.D. Kruijer, apparently not yet published
Philonotis hastata (Duby) Wijk & Margadant	*P. jardinii* (Besch.) Paris	Whittier (1976)
Rhodobryum aubertii (Schwaegr.) Ther.	**Bryum leucocanthum* (Hampe) Mitt.	Streimann & Curnow (1989)
Rosulabryum billardierei (Schwaegr.) Spence	*Bryum billardierei* Schwaegr.	Spence (1996)
Rosulabryum campylothecium (Taylor) Spence	*Bryum campylothecium* Taylor	Spence (1996)
Rosulabryum capillare (Hedw.) Spence	*Bryum capillare* Hedw.	Spence (1996)
Syrrhopodon novaevalesiae Müll. Hal.	*S. platycerii* Mitt.	Reese *et al.* (1986)
**Taxitheleum muscicola* (Broth.) Tan, Ramsay & Schofield	**Trichosteleum muscicola* Broth.	Tan *et al.* (1996)
Thuidium bonianum Besch.	**T. trachypodioides* Broth. & Watts	Touw and Falter-van den Haak (1989)
Thuidium cymbifolium (Dozy & Molk.) Müll. Hal.	*T. protensulum* Müll. Hal.	Touw and Falter-van den Haak (1989)
**Trichosteleum subfalcatulum* (Broth. & Watts) Tan, Ramsay & Schofield	**Rhaphidorrhynchium subfalcatulum* Broth. & Watts	Tan *et al.* (1996)

During, H.J.(1977). 'A taxonomical revision of the Garovaglioideae'. (J. Cramer: Vaduz.)

Enroth, J. (1992). Notes on the Neckeraceae (Musci). 13. Taxonomy of the genus *Himantocladium*. *Annales Botanici Fennici* **29**, 79-88.

Hedenaes, L. (1996). Taxonomic and nomenclatural notes on Australian Brachytheciaceae. *Nova Hedwigia* **62**, 531-465.

Ramsay, H.P. (1984). The mosses of Lord Howe Island. *Telopea* **2**, 549-558.

Ramsay, H.P., Seur, J., Wilson, P.G. and Goodwin, T. (1990). Register of type specimens of mosses in Australian herbaria I. *Telopea* **3**, 571-592.

Reese, W.D., Koponen, T. and Norris, D.H. (1986). Bryophyte flora of the Huon Peninsula, Papua New Guinea. XIX. *Calymperes*, *Syrrhopodon* & *Mitthyridium* (Calymperaceae, Musci). *Acta Botanica Fennici* **133**, 151-202.

Spence, J.R. (1996). *Rosulabryum* genus novum. *Bryologist* **99**, 221-225.

Stone, I.G.(1990a). *Fissidens aeruginosus* Hook.f. & Wils. and its synonyms. *Journal of Bryology* **16**, 231-244.

Stone, I.G.(1990b). *Fissidens*, sections *Crispidium*, *Amblyothallia* and *Serridium* and subgenus *Pachyfissidens* in Australasia: some taxonomic changes and a key to species. *Journal of Bryology* **16**, 245-260.

Stone, I.G.(1990c). Nomenclatural changes and new moss records in Australia: including a description of the protonema of *Calomnion*. *Journal of Bryology* **16**, 261-273.

Stone, I.G. (1994). *Fissidens* section *Crenularia* C. Muell. in Australia. *Journal of Bryology* **18**, 169-180.

Streimann, H. (1993). *Barbella trichophora*, an older name for *B. cubensis*. *Bryologist* **96**, 223-225.

Streimann, H. and Curnow, J. (1989). 'Catalogue of mosses of Australia and its external territories'. (Australian Biological Resources Study: Canberra.)

Tangney, R.S. (1997). A taxonomic revision of the genus *Camptochaete* Reichdt., Lembophyllaceae (Musci). *Journal of the Hattori Botanical Laboratory* **81**, 53-121.

Tan, B.C., Ramsay, H.P. and Schofield, W.B. (1996). A contribution to Australian Sematophyllaceae (Bryopsida). *Australian Systematic Botany* **9**, 319-327.

Touw, A. and Falter-van den Haak, L. (1989). A revision of the Australasian Thuidiaceae. *Journal of the Hattori Botanical Laboratory* **67**, 1-57.

Vitt, D.H. (1989). The genus *Schlotheimia* (Orthotrichaceae: Bryopsida) in Australia and New Zealand. *Bryologist* **92**, 282-298.

Vitt, D.H. (1991). A new species of *Calomnion* from Lord Howe Island. *Novon* **1**, 53-55.

Vitt, D.H. and Ramsay, H.P. (1985). The *Macromitrium* complex in Australasia. *Journal of the Hattori Botanical Laboratory* **59**, 325-451.

Whittier, H.O. (1976). 'The mosses of the Society Islands'. (University Presses of Florida: Gainsville.)

Wijk, R. van der, Margadant, W.D. and Florschütz, P.A. (1959-1969). 'Index Muscorum'. (International Bureau for Plant Taxonomy and Nomenclature: Utrecht.)

Fifty Years Ago

AUSTRALIAN POSSUM PEST IN NEW ZEALAND

It was rather surprising to read in Mr. W.R. Stevens' article in the November *Naturalist*, P. 133, that possums were linked with goats and deer as a major cause of destruction in New Zealand. But, if confirmation of his statement were needed, we have it in an authoritative paper by L.T. Pracy and R.I. Kean (Biological officers of the Wild Life Branch, N.Z. Department of Internal Affairs) published in the April number of the *New Zealand Journal of Agriculture* (Vol. LXXVIII, pp. 353-358) – "Control of Opossums an Urgent Problem." It appears that the Australian and Tasmanian *Trichosurus vulpecula* has bred so alarmingly as to become an important economic factor in two main respects: damage to crops, and destruction of trees and cuttings required for soil conservation purposes. In fact, the Poverty Bay Catchment Board describes it as "Pest No. 1 in this district."

Interesting details are given of the marsupial's life history and graphic photographs of defoliation caused in forests all over the Dominion. There are certain food preferences, *Fuchsia excorticata* (Konini) *Metrosideros robusta* (Rata) and *Elaeocarpus dentatus* (Hinau) being high on the preferential list – leaves, fruits, bark, and sometimes flowers, are commonly eaten. Dr. R.A. Falla, Director of the Dominion Museum, says *inter alia:*

> "In general it represents a serious dislocation of bird economy and must impose critical restrictions on their normal food and cover requirements. From the information supplied, the following birds are certain to be affected: pigeons, tuis, bellbird, kakas."

All Australian naturalists should endeavour to read this excellent and thought-provoking survey of the pest proportions assumed by one of our native animals when introduced elsewhere and apparently free from natural controls.

– J.H.W.

From *The Victorian Naturalist* **66**, February 1950.

Shell Studies at Edward Point, St Leonards, South Bellarine Peninsula by the Ringwood Field Naturalists Club

Noel Schleiger[1] and Dorothy Mahler[1]

Abstract
Nine sites, 100 m apart, were sampled on the north shore of the Edward Point peninsula on Port Phillip Bay. At each site, a collection of at least 100 complete, dead mollusc shells was made. By carefully analysing the habitat of each species and water depth at which live specimens are found, inferences were made about the sedimentary conditions offshore as well as the plant and animal life growing there. The species diversity increases when two habitats join and decreases when conditions approach uniformity or are harsh. (*The Victorian Naturalist* **117** (1), 2000, 14-30.)

Introduction

This study was devised to show field naturalists what information can be derived from a collection of shells and what it can tell us about the environment offshore. For example, what sediments are there, the environment in which the shells live and the depths at which they are found.

Methods

Collectors sampled nine sites (A-I inclusive, ranging from north to south) set at equal intervals of 100 metres along the beach beginning at point A, 50 m south of Beach Road along the Edward Point peninsula of Port Phillip Bay. Beach Road terminates at Port Phillip Bay at 38°11.69'S, 144°42.59'E. Point I is located at 38°12.11'S, 144°42.51'E; see Melway 241 J10 to J11. Each pair of collectors drew a straight line from the back of the beach perpendicular to the water's edge. They then collected a maximum of 100 complete dead shells which lay closest to the line on either side.

Following the classification of the molluscs used by Macpherson and Gabriel (1962), the shells were sorted into univalves and bivalves. Identifications were made from reference collections and text books which are listed in the references (see Plates 1-5 inclusive).

Univalves (Gastropods)

Macpherson and Gabriel (1962) classified gastropods according to geological age i.e. when they first appeared in the fossil record:

Archaeogastropods, first appear in the Palaeozoic, and some extend into the base of the Cambrian period (500+ mybp; million years before the present). They are largely herbivores feeding on algae on the rocks (see Plate 1).

Mesogastropods first appeared in the Mesozoic era (150 mypb). They are part herbivorous and part carnivorous and generally feed in shallow water, some liking a sandy substrate (e.g. *Polinices*) others a muddy one (e.g. *Zeacumantus, Batillaria*) (see Plate 5).

Neogastropods first appear at the base of the Tertiary period (65 mypb) and are very ornate and sculptured shells. Most live in shallow water and are mainly carnivorous.

All three groups (orders) are found together but occupy different microhabitats.

Bivalves (Pelecypods or Lamellibranchs)

Macpherson and Gabriel (1962) classified pelecypods by the nature of the teeth at the hinge line. Just as there are three orders of gastropods, there are three orders of pelecypods. These are:

Taxodonta, which have many equal teeth along the hinge line.

Adonta, that do not have teeth, with just a notch with a ligament to hold the two valves together. They include clam *Chlamys* or scallop *Pecten* shells, oyster *Ostrea, Monia* shells, and Mussel *Mytilus, Electroma* shells.

Heterodonta, that have just a few, unequal teeth holding the two valves together. Most of the heterodonts are silt to sand dwellers (see Plate 4).

Name changes of taxa (synonomy)

Since the publication of Macpherson and Gabriel (1962), the names of several taxa (Tables 4, 5 and 6, Appendices 1 and 2)

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Table 1. Total number of species of Univalves (U) and Bivalves (B) found at the nine sites (localities A-I).

Locality	A	B	C	D	E	F	G	H	I	Total
No. of Univalve species (U)	13	2	8	17	17	26	11	11	4	40
No. of Bivalve species (B)	7	10	10	11	10	14	12	9	9	19
Total	**20**	**12**	**18**	**28**	**27**	**40**	**23**	**20**	**13**	**59**
Ratio (U/B)	1.86	0.2	0.8	1.55	1.70	1.86	0.92	1.22	0.44	2.11

Table 2. Abundance of Univalves (U) and Bivalves (B) and the univalve/bivalve (U/B) ratio found at localities A-I.

Locality	A	B	C	D	E	F	G	H	I	Total
Number of Univalves (U)	56	2	10	38	38	147	14	16	7	328
Number of Bivalves (B)	51	86	92	65	64	155	90	69	102	772
Ratio U/B	1.10	0.02	0.11	0.58	0.59	0.95	0.16	0.23	0.07	0.41

Table 3. Classification and relative frequency of Univalve orders found at localities A-I.

Locality	A	B	C	D	E	F	G	H	I	Total	%
Archaeo-gastropods	23	1	3	6	9	80	8	5	5	140	42.7
Meso-gastropods	29	1	6	14	16	39	3	2	1	111	33.8
Neo-gastropods	4	-	1	18	13	28	3	9	1	77	23.5
Total Univalves	**56**	**2**	**10**	**38**	**38**	**147**	**14**	**16**	**7**	**328**	**100**

have changed due to further advances in taxonomy and further studies on the ranges of certain species.

Univalves

The Archaeogastropod known as the Golden Star which was *Micrastrea aurea* is now *Astralium aureum*.

Of the Mesogastropods there are four changes: *Hypotrochus monachus*, the Monk Shell, is now *Plesiotrochus monachus*; *Hipponix conicus* is now *H. australis* since *H. conicus* has been shown to be a tropical species and recently has been known as *Sabia australis*; *Sigapatella calyptraeformis* has recently been referred to as *Calyptraea calyptraeformis*; the Granulated Wentletrap *Granuliscala* sp. has synonyms *Opalia (Granuliscala) granosa* and *Epitomium granosum*.

Two Neogastropods need mentioning: *Niotha pyrrhus* is now *Nassarius pyrrhus*, whilst Excavated Cancellaria *Nevia spirata* is now *Cancellaria spirata*.

Bivalves

Adonta: the Doughboy Scallop/Fan Shell *Chlamys asperrimus* has been reclassified as *Mimechlamys asperrimus*; the King Scallop *Notovola alba* has been referred to as *Pecten albus*, and today is *Pecten fumatus*.

Heterodonta: the Pipi often used as bait by fishermen was *Plebidonax deltoides*, is today *Donax (Plebidonax) deltoides*; the Angel's Wing borer *Pholas* is now *Barnea*. Two species occur on the Edward Point peninsula, *B. australasiae* (which is the more common), and *B. obturamentum*, which has a kinked anterior margin.

Results and Discussion

A complete list of species found at each sampling site, and the species abundance, is set out in Appendix 1. The results of the shell collections are summarised in Tables 1 and 2. Table 1 shows that overall univalves have a greater diversity of species than the bivalves. However, when actual numbers of shells are considered, Table 2 shows that bivalves are more abundant

Table 4. Summary of habitats of univalves found at beach sites A to I, Edward Point, 17 April 1998.

Taxa	Sediment sources					Food sources/indicators												Lowest depth (m)
	Rocks	Rock pools	Sand	Silt	Mud	Calc. algae	Green algae	Brown algae	Red algae	Sea-grass	Ane-mone	Coral	Asci-dians	Bi-valves	Tube worms	Barna-cles	Gastro-pods	
Archaeogastropoda																		
Notoacmea	✓																	3
Phasianotrochus							✓			✓								2
Austrocochlea odontis	✓	✓																3
A. constricta	✓	✓																3
A. concamerata	✓																	3
A. adelaideae	✓	✓																3
Turbo undulata	✓	✓																5
Phasianella spp.							✓	✓										5
Astralium aureum	✓	✓																5
Mesogastropoda																		
Bembicium nanum	✓																	2
Batillaria australis					✓													5
Serpilorbis sipho			✓															30
Hipponix conicus										✓				✓				12
Antisabia foliacea	✓																	12
Polinices spp.			✓	✓										✓				5
Diala monile								✓	✓									30
Hypotrochus monadius				✓			✓	✓		✓								5-20
Zeacumantrus diamenensis					✓													0-5
Granuliscala											✓	✓						
Opalia australis											✓	✓						
Calyptraea calyptraeformis														✓				
Sassia sp.						✓												15
Neogastropoda																		
Alocospira marginata			✓							✓				✓				60
Bedeva paivae			✓	✓	✓									✓				
Cabestana spengleri	✓	✓											✓					20
Lepsiella spp.															✓	✓		10
Pterynotus triformis														✓				20
Thais orbita	✓													✓			✓	10
Bulla quoyi				✓	✓		✓			✓								10
Cominella eburnea	✓		✓															10
C. lineolata		✓	✓	✓						✓								5
Conus anemone	✓														✓			15
Mitrella (Dentimitrella) spp.	✓						✓											10
Nevia spirata			✓														✓	
Nassarius (Niotha) pyrrhus			✓				✓											20
Pleuroploca australasia			✓							✓					✓			100
Siphonaria zelandica	✓																	0

Table 5 Summary of habitats of bivalves found at beach Sites A to I, Edward Point, 17 April 1998.

Taxa	Sediment sources				Food sources/indicators				Lowest depth (m)
	Rocks	Sand	Silt	Mud	Brown algae	Seagrass	Bivalves	Sponges	
Taxodonta									
Anadara trapezia		✓	✓	✓					*
Barbatia pistachia	✓								30 **
Adonta									
Mimachlamys asperrima	✓							✓	100
Electroma georgiana					✓				5 ***
Amonia ione	✓						✓		100
Mytilus (Edulis) planulatus	✓								15
Ostrea angasi	✓			✓					20
Pecten fumatus		✓							30
Heterodonta									
Barnea australasia				✓					5
Barnea obturamentum				✓					8
Donacilla nitida		✓							25
Fulvia tenuicostata		✓	✓	✓					30
Katelysia peronii			✓						3
K. rhytiphora		✓							3
K. scalarina		✓	✓						4
Notocallista kingii		✓							40
Plebidonax deltoides		✓							****
Pseudarcopagia victoriae		✓	✓						20
Soletellina biradiata		✓	✓	✓					3
Spisula (syn. *Noto-*) *trigonella*			✓	✓					1
Tawera gallinula		✓							36
Tellina (Macomona) deltoidalis			✓	✓		✓			15
T. margaritina (mariae)			✓	✓		✓			15
Venerupis galactites		✓	✓			✓			15

* Fossil shell bed. Reef old sea level.
** Bryozoa.
*** Seagrass and seaweed
**** Ocean species. Probably indicates fishermen with bait offshore.

Table 6. Univalve and Bivalve sand dwellers from the Edward Point shell collection.

Taxa	A	B	C	D	E	F	G	H	I	All
Univalve										
Serpulorbis sipho	-	-	2	2	1	4	-	-	-	9
Polinices spp.	7	1	3	-	1	3	1	1	1	18
Alocospira marginata	-	-	-	-	1	1	-	2	-	4
Bedeva paviae	-	-	-	2	1	-	-	-	-	3
Cominella eburnea	1	-	-	1	4	3	-	1	-	10
C. lineolata	1	-	-	3	6	1	-	2	-	13
Nevia spirata	-	-	-	-	-	1	-	-	-	1
Niotha pyrrhus	1	-	-	5	3	1	1	-	-	11
Pleuroploca australis		-	-	-	-	1	-	-	-	1
Bivalve										
Anadara trapezia	1	5	4	6	-	4	3	2	3	28
Pecten fumatus	-	2	2	-	5	2	1	-	-	12
Fulvia tenuicostata	1	4	1	22	6	12	7	9	10	72
Katelysia rhytiphora	33	40	55	9	3	41	46	27	52	306
K. scalarina	1	-	2	1	4	2	1	1	2	14
Pseudarcopagia victoriae	-	15	11	2	8	8	8	-	5	57
Venerupis galactites	6	12	10	10	29	13	11	19	18	128
Soletellina biradiata	-	-	-	-	3	3	-	-	-	6
Notocallista kingi	-	-	-	-	-	-	-	1	-	1
Total sand dwellers	**52**	**79**	**90**	**63**	**75**	**100**	**79**	**65**	**91**	**694**
Total all shells	**99**	**88**	**102**	**97**	**107**	**181**	**103**	**84**	**100**	**961**
Percentage sand dwellers	**53**	**90**	**88**	**65**	**70**	**55**	**77**	**77**	**91**	**72**

Table 7. Relative percentages for silt and rock dwellers.

Locality	A	B	C	D	E	F	G	H	I	All
Mud	28	16	9	42	25	26	15	21	19	23
Rocks	24	8	9	14	20	19	14	19	10	16

Table 8. Rough percentages of sediment habitat (from Tables 6 and 7).

Sediment/Locality	A	B	C	D	E	F	G	H	I	All
Sand	53	90	88	65	70	55	77	77	91	72
Mud	28	16	9	42	25	26	15	21	19	23
Rocks	24	8	9	14	20	19	14	19	10	16
Total	**105**	**114**	**106**	**121**	**115**	**100**	**106**	**117**	**120**	**111**

Table 9. Percentages of sediment habitat (adjusted to account for habitat overlap).

Sediment/Locality	A	B	C	D	E	F	G	H	I	All
Sand	50	79	83	54	61	55	73	66	76	65
Mud	27	14	8.5	35	22	26	14	18	16	21
Rocks	23	7	8.5	11	17	19	13	16	8	14

than univalves.

Localities A and F in Tables 1 and 2 show higher diversity (number of species) and abundance (number of individuals) of univalves. This suggests a merging of two or more habitats offshore, e.g. rocks, seagrass and sand. In contrast, localities B, G and I have high bivalve populations which indicates a predominently sand substrate with a minimum of rocks and seagrass. Shells which occur at all nine localities are *Astralium aureum* (syn. *Micrastrea aurea*), *Ostrea angasi*, *Fulvia tenuicostata*, *Katelysia rhytyphora* and *Venerupis galactites*. Common names for shells are listed in Appendix 2.

Univalves

The classification and relative frequency of each of the univalve orders, i.e. archaeogastropods, mesogastropods and neogastropods in the shell collection, is set out in Table 3.

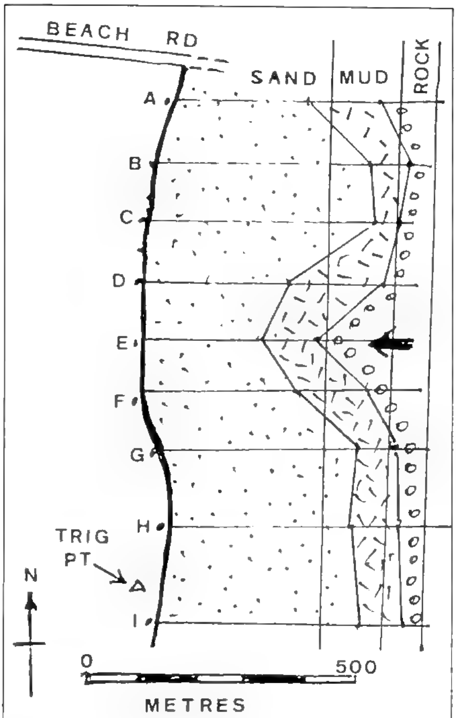

Fig. 1. The distribution of sand, mud and rock as inferred from mollusc collections at nine sites on the northern Port Phillip beach of Edward Point peninsula. Collections at D, E and F suggest sand, mud and rock distribution is in closer proximity to the coast (from Schleiger, 1980).

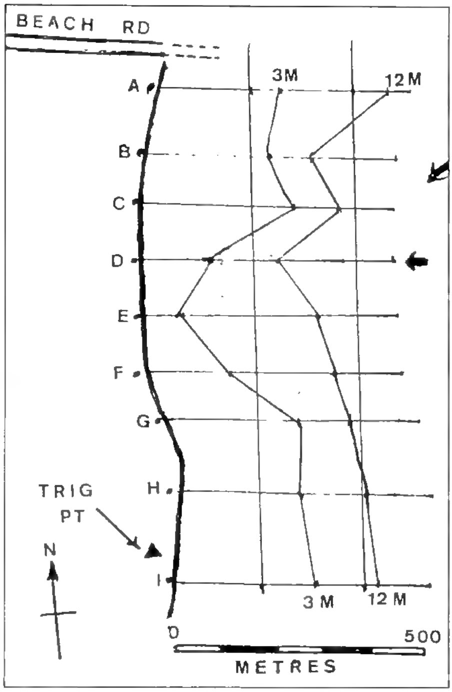

Fig. 2. Depth zones as indicated by the 3 m and 12 m contours suggest that deeper water mollusc distributions approach the coastline between sites C and G. The configuration of the inferred contours suggest scouring from the NE and E. (from Schleiger, 1980).

Rock can exist as discrete boulders, cobbles, pebbles or granules or as a massive reef below the surface forming the sea bed. Cobbles, pebbles and granules of lateritic sandstone occur along the beach of St Leonards eroded off those from reefs of Baxter Sandstone. Baxter Sandstone occurs on both sides of Port Phillip Bay. This formation is of Late Miocene to Pliocene age and indicates a fluviatile shallow water marine habitat when the sea retreated southerly from a more extensive inundated Southern Victoria in earlier Tertiary time. *Cobbles* are usually greater than 64 mm in length. *Pebbles* are usually greater than 4 mm in length. *Granules* range from 2 to 4 mm. If the pebbles and cobbles rest in shallow water less than 1 mm depth it is likely that limpets, siphons and trochids would graze on algae encrusting them.
Sand is composed of rock and mineral particles ranging in size from 2 to 1/16 mm. Some molluscs feed on the plankton and algae living in the pore spaces between the sand grains.
Silt is regarded as fine sand and ranges in size from 1/256 mm to 1/16 mm.
Clay (mud) is the finest sedimentary material, smaller than 1/256 mm. It is the finest mechanical decomposition product of rocks. When mixed with water, clay becomes mud. It is likely that it is mud which cements the silt, sand and rock particles to form siltstone, sandstone and conglomerate respectively. When rock granules comprise the sediment, it can form granule conglomerate on sedimentation; if pebbles, pebble conglomerate, cobbles, cobble conglomerate, and boulders, boulder conglomerate. At St Leonards, the Baxter Formation is largely granule and pebble conglomerate cemented with iron oxide (limonite). In turn this has been eroded and scattered along the shore as many types of coarser conglomerate.

Table 10. Depth zone indicator species for 0-3 m.

Taxa (0-3 m)	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**All**
Gastropoda										
Notoacmea sp.	-	-	-	1	-	-	1	-	-	2
Phasianotrochus sp.	7	-	-	-	-	-	-	-	-	7
Austrocochlea - 4 spp	7	-	2	2	6	6	1	4	-	28
Bembicium nanum	-	-	-	-	1	-	1	1	-	3
Pelecypoda										
Katelysia rhytiphora and *K. peroni*	33	40	57	9	3	44	48	29	55	318
Soletellina biradiata	-	-	-	-	3	3	-	-	-	6
Notospisula trigonella	-	-	-	1	-	-	-	-	-	1
Total 0-3 m Indicators	**47**	**40**	**59**	**13**	**13**	**53**	**51**	**34**	**55**	**365**
Total Shells Collected	**107**	**88**	**102**	**97**	**104**	**251**	**102**	**117**	**109**	**1077**
Percentage	**44**	**45**	**58**	**13**	**13**	**21**	**50**	**44**	**50**	**34**

Table 11. Depth zone indicator species for three depth zones.

Indicator	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**All**
0-3 m	44	45	58	13	13	21	50	44	50	34
3-12 m	37	15	17	31	54	22	19	23	22	38
>12 m	8	31	19	37	34	14	25	24	18	21
Total	**89**	**91**	**94**	**81**	**101**	**57**	**94**	**91**	**90**	**93**

Table 12. Adjusted depth percentages.

Indicator Species	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**All**
0-3 m	49	49	62	16	13	37	53	48	56	37
3-12 m	42	17	18	38	53	39	20	25	24	41
>12 m	9	34	20	46	34	24	27	27	20	22
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Bivalves

Taxodonts

There are only two Taxodonts in the Edward Point collection (Appendix 1), *Anadara* and *Barbatia*. Large *Anadara trapezia* shells showed much erosion and wear and are likely to have come from the scouring of a fossil Pleistocene shell bed offshore (Bird 1993). This would have been beach deposit formed at a time when the sea level was many metres lower than at present. *Anadara* is found today off Portarlington, but the shells are much smaller than those found as fossils of specimens which lived in the warmer temperatures of the last Pleistocene interglacial. *Barbatia* is a sign of rock fragments and rocks and feeds on bryozoa.

Adonts

By far the most abundant are *Ostrea angasi*, the Mud Oyster. *Electroma* is commonly found growing on brown kelp and seaweed. Scallops tend to be commercially fished and depending on the localities where fishermen reject the valves they can be rare or abundant.

Heterodonts

There were twelve species of Heterodonts in the collection (see Appendix 1).

Determining habitat

Tables 4 and 5 show the habitats of univalves and bivalves respectively and their depth limits as well as their food sources. From these tables we can now interpret:

1. the relative percentages of sand, silt and rock offshore (see separate box p.19 for a description of the composition of sand, mud and rocks),
2. the relative lower limit of the sea depth where each species lives.

Tables 4 and 5 are compiled from various sources (Edgar 1997; Macpherson and Gabriel 1962; Phillips *et al.* 1983; Bennett

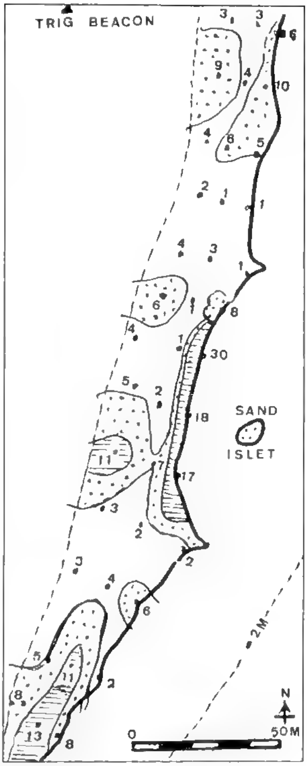

Fig. 3. Distribution of *Katelysia rhytiphora* valves over 270 m strip of beach south of the trig beacon on Edward Point beach approx. 2.5 km south of St Leonards pier. Grid points show the number of valves per square metre. Contouring at five and ten shells per sample suggests a source from swell immediately east on sandbanks from 0 to 2 m. (From Schleiger 1980.)

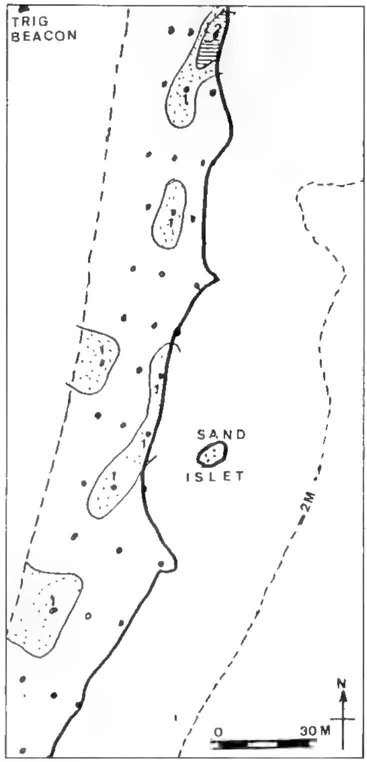

Fig. 4. Distribution of valves of *Electromactra antecedens* shells from the same strip of beach as Fig. 3. Contouring at 0.5 and 1.5 levels suggests a NW-SE trend at the lower beach level – an indication of N to S longshore drift. (From Schleiger 1980.)

1987; Shepherd and Thomas 1989) which describe mollusc habitat. They indicate the sediment type that species live in, as well as the animals and plants they eat, and the lowest depth at which they have been recorded. It is thus possible to look at a shell collection and list, for example, all of the sand dwellers (as shown in Table 6). These can then be calculated as a percentage of the whole shell collection which can then be interpreted as the proportion of that habitat represented by the collection.

In a similar manner, from the data listed in Table 4 and 5, the relative percentages of mud and rock dwellers are listed in Table 7.

However, when the percentages for sand, mud and rock dwellers are summed (data from Tables 6 and 7), the totals exceed 100 (Table 8). This is because there is often an overlap of some species into two or more types of sedimentary habitat. When the percentages are adjusted to take this overlap into account, all localities (A-I) can then be validly compared with each other (Table 9).

Determining depth

The same procedure used to determine the percentages of sand, mud and rocks offshore can be used to gain an indication of the depth offshore of each sampling locality. The 0–3 m depth indicator distribution at the nine sites is set out in Table 10. By also determining the percentage of 3–12 m and >12 m indicator species, the depth variation offshore can be summised (Table 11).

Again, the percentages generally fall short

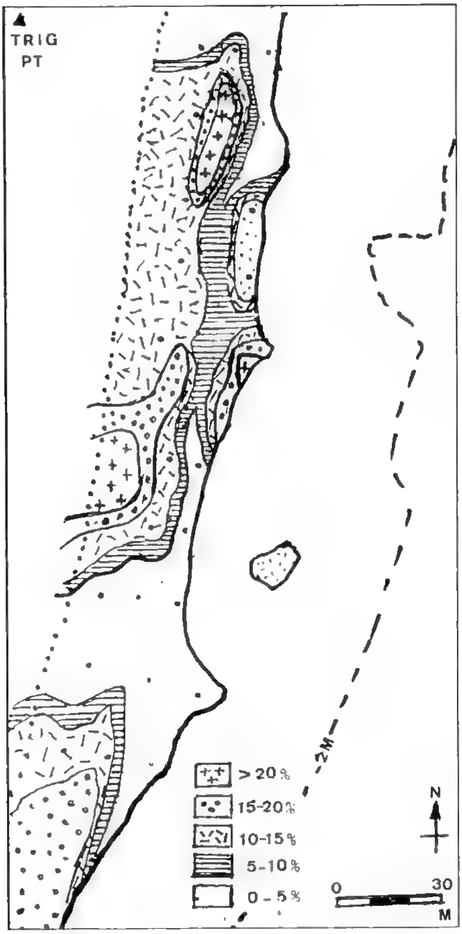

Fig. 5. Distribution of triaxial (bladed) pebbles on the same stretch of beach as Figs 3 and 4. Only slight longshore drift from NNE to SSW is detected in the trends, the main trends being longshore NNW to SSE. (From Schleiger 1980.)

of totalling 100, because some species were not considered as their depth habitat was uncertain. Therefore the percentages were adjusted to total 100 in each case (Table 12) so a valid comparison can be made between sampling localities.

The habitat results are shown on a locality map (Fig. 1) as a series of horizontal bars in the order sand, mud and rocks. When the corresponding points of the bar graphs are joined from locality to locality, an offshore profile of the sediment distribution is formed which indicates where sand, mud and rock is situated.

Fig. 1 shows that the sand is least extensive at sites A, D, E and F, and that the rocks are closest to shore at site E. Mud consisting of red sand and clay beds has accumulated from the erosion of the Moorabool Viaduct Formation which outcrops under water offshore (Bird 1993).

When the depth contours are joined in Fig. 2 the maximum depth can be determined. Table 10 shows the 0-3 m depth indicator species distribution at the nine sites.

Determining the 3-12 m and >12 m indicator species (Table 11) indicates the depth variation offshore.

These adjusted percentages can be plotted as a compound bar graph perpendicular to each sampling site to gain an idea of how the depth varies off the coast. When the corresponding levels on the bars are joined we obtain a rough contour map of the littoral zone (see Fig. 2).

Figs 1 and 2 map the sediment and depth respectively. At locality E both the depth and sediment show the closest proximity. However, the depth map (Fig. 2) suggests scouring from the north-east, whilst the sediment map suggests easterly currents.

The Edward Point peninsula was being built up by westerly wind-blown sand in the Pleistocene in the last glacial period 20 to 30 000 years ago when Port Phillip Bay was dry (Bird 1993). It is assumed that in some places the sand would protrude further easterly into the bay over Pliocene red sandstone than elsewhere, so that the steeper eastern front of the dune would be steeper on the advancing fronts than others. Thus, when the sea level rose from 20 to 10 000 years ago with the inundation of Port Phillip Bay, scouring would be more pronounced at Locality E by easterly wave action – the only direction possible by marine action.

Limitations of project

The limiting factors which need to be addressed with the type of shell sampling described above are as follows: long-shore drift influences; data on habitat information; faithful representation of habitats, and shell preservation with respect to proximity of habitat.

Long-shore drift

This sampling was restricted to whole shells being collected. This eliminated those fauna which had been transported long distances by long-shore drift. Even with complete shells, long-shore drift could be playing a part in what arrives on shore as reworking and transport is important with shells on the lower levels close to water. Shells thrown up by storm waves at the back of the beach obviously have reached their final resting place post mortem. It is likely therefore that we are measuring conditions to the north-east at each locality. Bird (1993:137) showed north to south long-shore drift along the Edward Point peninsula and indeed explained the formation of the peninsula by this process.

Schleiger (1980) demonstrated NE to SW trends along the beach with valves of *Katelysia rhytiphora, Electromactra antecedens* and triaxial (bladed) laterite pebbles of the Moorabool Viaduct Formation which outcrops at the Red Bluff to the north and no doubt offshore. The sample area for the 1980 study was to the south of this study starting at Locality 1. These are reproduced as Figs 3, 4 and 5. The *Katelysia rhytiphora* valves show a more orthogonal distribution as their source habitat is immediately on sand banks offshore as conjoined valves of this species are common. The arrows on Figs 1 and 2 to explain the changing depth zones and distribution of sand, mud and rocks suggest north-east to south-west currents. These currents have a north to south long shore drift component.

Habitat information

The data for Tables 4 and 5 came from a variety of sources, (Macpherson and Gabriel 1962; Marine Research Group (now of FNCV) 1984; Shepherd and Thomas 1989; Bennett 1987; Edgar 1997). Whether this data exactly agrees with conditions in this part of Port Phillip was not questioned, but used in defining the various habitat elements in this study. Time was not available to test this data here but the results suggest these principles are reasonable.

Faithful representation of habitats

It is assumed that the specimens present in Appendix 1 live in the habitats tabulated in Tables 4 and 5. If the appropriate specimens in a particular habitat are not present then that habitat is not represented. If the habitat is present, then we must assume that the appropriate shells living in it have been eroded or destroyed by the time it reached the locality of the sample. Such can only be proved by diving and studying the habitats *in situ*, which was not the aim of this study.

Shell Preservation

Shell preservation is thus important in recording such habitats. Distant habitats, e.g. deep water forms will not be represented unless there are storm surges or unless sampling is extended to shell fragments as well as whole shells.

Conclusion

From a collection of approximately 100 complete shells from a nine-line sample, it was possible to make inferences about the sediment and depth of the littoral zone offshore. In this case, it seems we have the front of a N-S Pleistocene dune advancing over laterised red Pliocene clayey sandstone. Erosion of this combination has resulted in scouring of the central part of the study area by NE tides bringing shells and cobbles on shore from depths down to 20 metres in this N part of the Edward Point peninsula.

Acknowledgements

Geoff and Ruth Christiansen assisted with identification. We are indebted to the participants of the Ringwood Field Naturalists Club for their help with the sampling at Edward Point. The text and interpretation has been improved by discussions with Ken Bell, Robert Burn, Clarrie Handreck and Michael Lyons of the Marine Research Group of FNCV.

References

Bennett, I. (1987). 'W.J. Dakin's Australian Seashores'. (Angus and Robertson Publishers: North Ryde NSW.)

Bird, E.C.F. (1993). 'The Coast of Victoria - The shaping of scenery'. (Melbourne University Press: Melbourne.)

Edgar, G.J. (1997). 'Australian Marine Life'. (Reed Books: Kew.)

Macpherson, J.H. and Gabriel, C.J. (1962). 'Marine Molluscs of Victoria'. (Melbourne University Press and National Museum of Victoria: Melbourne.)

Phillips, D.A.B., Handreck, C.P., Bock, P.E., Burn, R., Smith, B.J. and Staples, D.A. (1984). 'Coastal Invertebrates of Victoria: An Atlas of Selected Species'. (Marine Research Group of Victoria and Museum of Victoria.)

Shepherd, S.A. and Thomas, I.M. (1989). 'Marine Invertebrates of Southern Australia', Part II.

Schleiger, N.W. (1980). Shoreline Statistics. In 'Learn to Love Mathematics' (Ed. N.P. Williamson.) Handbook 17th Annual Conference Dec. 1980. (Mathematical Association of Victoria: Brunswick, Victoria.)

Appendix 1. Abundance of molluscs (gastropods and pelecypods) at Localities A - I inclusive, South of Beach Road., Edward Point Reserve, St Leonards, 17 April 1998.

Taxa	A	B	C	D	E	F	G	H	I	Total
Gastropoda										
Archeogastropoda (9 spp)										
Astralium (syn. Micrastraea) aureum	8	1	1	2	2	10	5	1	4	34
Austrocochlea odontis	1	-	1	1	4	1	-	3	-	11
A. concamerata	1	-	-	-	-	1	-	-	-	2
A. constricta	4	-	-	-	1	1	-	1	-	7
A. adelaideae	1	-	1	1	1	3	1	-	-	8
A. porcata (syn. constricta zebra)	1	-	-	1	-	3	1	-	-	6
Notoacmea sp.	-	-	-	1	-	-	1	-	-	2
Phasianella australis	-	-	-	-	-	3	-	-	-	3
Turbo undulatus	-	-	-	-	1	1	-	-	-	2
Total	**16**	**1**	**3**	**6**	**9**	**23**	**8**	**5**	**4**	**75**
Mesogastropoda (14 spp)										
Alaba (syn.Diala) monile	-	-	-	1	-	-	-	-	-	1
Batillaria australis	2	-	-	-	2	-	-	-	-	4
Batillaria (syn. Zeacumantus) diemenensis	20	-	1	8	10	26	1	-	-	66
Bembicium nanum	-	-	-	-	1	-	1	1	-	3
Granuliscala granosa	-	-	-	1	-	-	-	-	-	1
Hipponyx conicus	-	-	-	4	-	4	-	-	-	8
Pleisiotrochus (Hypotrochus) monachus	-	-	-	-	-	1	-	-	-	1
Polinices conicus	7	1	1	-	1	1	1	1	1	14
P. didymus	-	-	2	-	-	2	-	-	-	4
P.sordidus	-	-	-	-	-	-	1	1	-	2
Serpulorbis sipho	-	-	2	2	1	4	-	-	-	9
Sigaretotrema umbilicata	-	-	-	-	-	1	-	-	-	1
Sigapatella calyptraeformis	-	-	-	-	-	1	-	-	-	1
Total	**29**	**1**	**6**	**16**	**16**	**40**	**4**	**3**	**1**	**106**
Neogastropoda (17 spp)										
Alocospira marginata	-	-	-	-	1	1	-	2	-	4
Bedeva paivae	-	-	-	2	1	-	-	-	-	3
Cabestana spengleri	-	-	-	-	-	1	-	-	-	1
Bulla quoyi	-	-	-	-	-	-	-	-	1	1
Cominella eburnea	1	-	-	1	4	3	-	1	-	10
C. lineolata	1	-	-	3	6	1	-	2	-	13
Conus anemone	1	-	-	2	-	2	1	2	-	8
C. rutilus	-	-	-	-	-	-	-	1	-	1
Dentimitrella pulla	-	-	-	-	-	-	-	-	1	1
Lepsiella sp.	-	-	-	2	-	-	-	-	-	2
Nevia spirata	-	-	-	-	-	1	-	-	-	1
Niotha pyrrhus	1	-	-	5	3	1	1	-	-	11
Pleuroploca australis	-	-	-	-	-	1	-	-	-	1
Pterynotus triformis	-	-	-	-	-	-	1	-	-	1
Sassia eburnea	-	-	-	-	-	1	-	-	-	1
Siphonaria zelandica	-	-	-	-	-	1	-	-	-	1
Thais orbita	-	-	1	1	1	-	-	-	-	3
Total	**4**	**-**	**1**	**16**	**16**	**13**	**3**	**8**	**2**	**63**
Pelecypoda										
Taxodonta (2 spp)										
Anadara trapezia	1	5	4	6	-	4	3	2	3	28
Barbatia pistachia	-	1	-	1	-	-	-	1	-	3
Total	**1**	**6**	**4**	**7**	**0**	**4**	**3**	**3**	**3**	**31**
Adonta (5 spp)										
Chlamys asperrimus	-	-	-	-	-	2	-	-	-	2
Mytilus planulatus	1	-	2	1	1	2	-	-	-	7
Ostrea angasi	4	5	3	2	5	4	4	6	5	38
Pecten fumatus (syn. alba)	-	2	2	-	5	2	1	-	-	12
Electroma georgiana	3	-	-	4	-	5	1	-	4	17
Total	**8**	**7**	**7**	**7**	**11**	**15**	**6**	**6**	**9**	**76**

Appendix 1 continued.

Taxa	A	B	C	D	E	F	G	H	I	Total
Heterodonta (12 spp)										
Barnea australasiae	-	-	-	-	-	-	1	-	-	1
Fulvia tenuicostata	1	4	1	22	6	12	7	9	10	72
Katelysia peroni	-	-	2	-	-	3	2	2	3	12
K. rhytiphora	33	40	55	9	3	41	46	27	52	306
K. scalarina	1	-	2	1	4	2	1	1	2	14
Notocallista kingii	-	-	-	-	-	-	-	1	-	1
Spisula (syn. Notospisula) trigonella	-	-	-	1	-	-	-	-	-	1
Plebidonax deltoides	-	1	-	-	-	2	-	-	-	3
Pseudarcopagia victoriae	-	15	11	2	8	8	8	-	5	57
Soletellina biradiata	-	-	-	-	3	3	-	-	-	6
Tawera gallinula	-	1	-	-	2	2	3	-	-	8
Venerupis galactites	6	12	10	10	29	13	11	19	18	128
Totals	**41**	**73**	**81**	**45**	**55**	**86**	**79**	**59**	**90**	**609**

Appendix 2. Common names of shells of Edward Point.

Gastropoda

Archaeogastropoda (10 species)

Astralium aureum	Golden Star
Austrocochlea adelaideae	Coarse Checkered Top Shell
A. concamerata	Wavy Top Shell
A. constricta	Ribbed Top Shell
Austrocochlea odontis	Fine Checkered Top Shell
A. porcata (syn. *constricta zebra*)	Ridged Top Shell
Notoacmea sp.	Small Limpet
Phasianella australis	Painted Lady
Phasianotrochus sp.	Kelp Shell
Turbo undulatus	Green Wavy Turbo

Mesogastropoda (13 species)

Alaba monile	Spotted Diala
Batillaria australis	Southern Mud Whelk
Bembicum nanum	Striped Mouth Conniwick
Batillaria diemenensis	Common Mud Whelk
Granliscala granosa	Granulated Wentletrap
Hipponyx australis	Conical Horse-hoof Limpet
Plesiotrochus monachus	Monk Shell
Polinices conicus	Conical Sand Snail
P. didymus	Common Sand Snail
Polinices sordidus	Sordid Sand Snail
Serpulorbis sipho	New Holland Worm Shell
Sigapatella calyptraeformis	Shelf Limpet
Sigaretotrema umbilicata	Umbilicated Sand Snail

Neogastropoda (17 species)

Alocospira marginata	Margined Ancilla
Bedeva paivae	Mussel Drill
Bulla quoyi	Botany Bay Bubble
Cabestana spengleri	Spengler's Rock Whelk
Cominella eburnea	Lineolated Cominella
C. lineolata	Ribbed Cominella
Conus anemone	Anemone Con Shell
C. rutilus	Red Cone Shell
Dentrimella sp.	Dove Shell
Lepsiella sp.	Lepsiella
Nevia spirata	Excavated Cancellaria
Niotha pyrrhus	Banded Nassarius

Neogastropoda (cont'd)

Pleuroploca australis	Short Spindle Shell
Pterynotus triformis	Tree Form Murex
Sassia eburnea	Sand Whelk
Siphonaria zelandica	Siphon Shell
Thais orbita	Dog Winkle or Cart Rut Shell

Pelecypoda (Bivalvia)

Taxodonta (2 species)

Anadara trapezia	Mud Ark/Sydney Harbour Cockle
Barbatia pistachia	Hairy Ark

Adonta (5 species)

Chlamys asperrimus	Doughboy Scallop/Fan Shell
Electroma georgiana	Butterfly/Wing Shell/Little Fan
Mytilus planulatus	Port Melbourne Mussel
Ostrea angasi	Common Mud Oyster
Pecten fumatus	Scallop

Heterodonta (12 species)

Barnea australasiae	Australian Borer or Angel's Wing
Fulvia tenuicostata	Heart Cockle
Katelysia peroni	Peron,s Venerid
K. rhytiphora	Oval Sand Cockle
K. scalarina	Stepped/Ridged Venerid
Notocallista kingii	King's Notocallista
Plebidonax deltoides	Pipi
Pseudacopagia victoriae	Round Tellin
Soletellina biradiata	Double-rayed Razor Shell
Spisula trigonella	Little Triangle
Tawera gallinula	Feathered Venerid
Venerupis galactites	Milk Stone

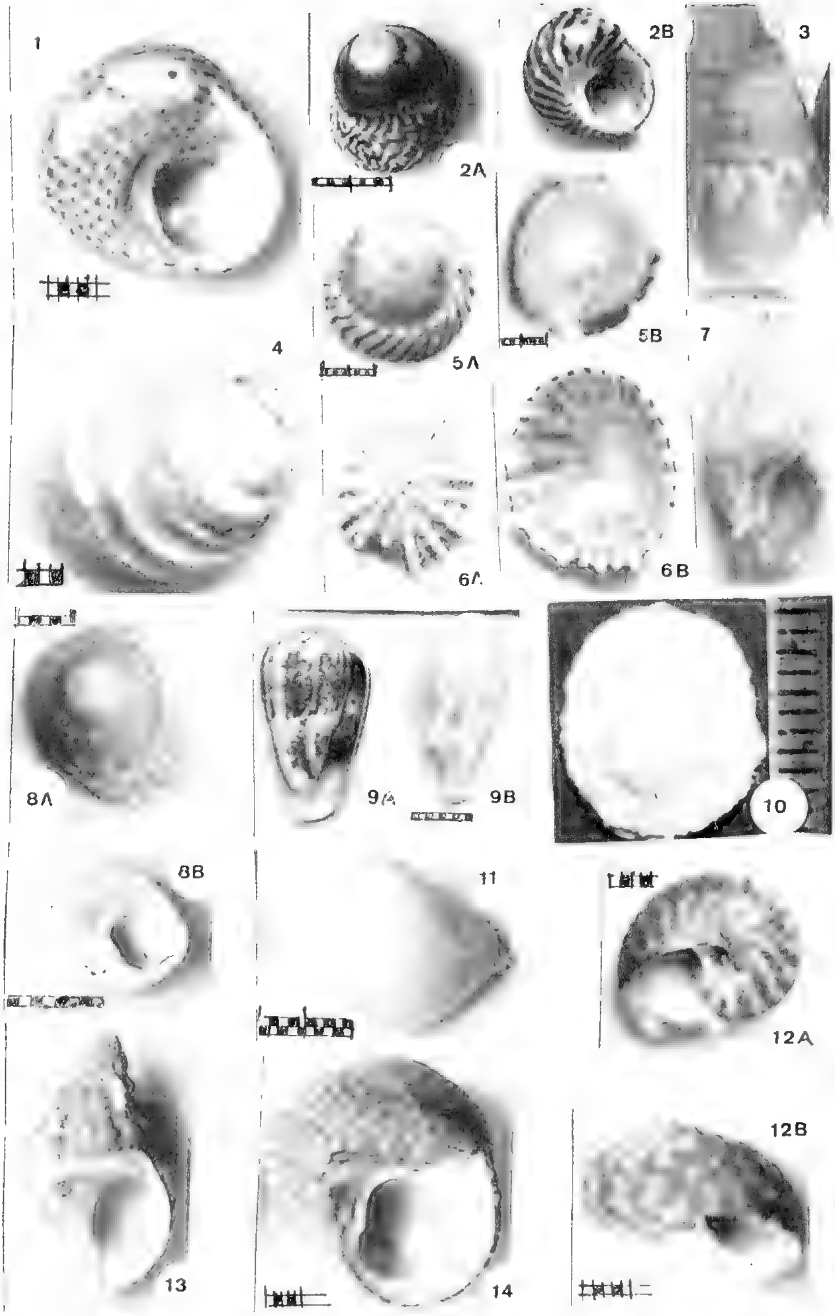

Plate 1. Gastropod rock indicators. (Scale: 2 mm squares.) 1. *Austrocochlea adelaidei* (not coarse checkers); 2. *A. porcata* (a) apical view, (b) apertural view; 3. *Dentimitrella semiconvexa*; 4. *Austrocochlea constricta*; 5. *Bembicium nanum* (a) apical view (b) apertural view; 6. *Siphonaria diemenensis* (a) apical view (b) apertural view; 7. *Cominella eburnea*; 8. *Astralium aureum* (a) apical view (b) apertural view; 9. *Conus anemone* (a) apertural view (b) obverse view; 10. *Notoacmea* sp. (1 mm scale); 11. *Thais orbita* (obverse view); 12. *Turbo undulata* (a) apertural view (b) lateral profile; 13. *Cabestana spengleri*; 14. *Austrocochlea odontis* (fine checkers).

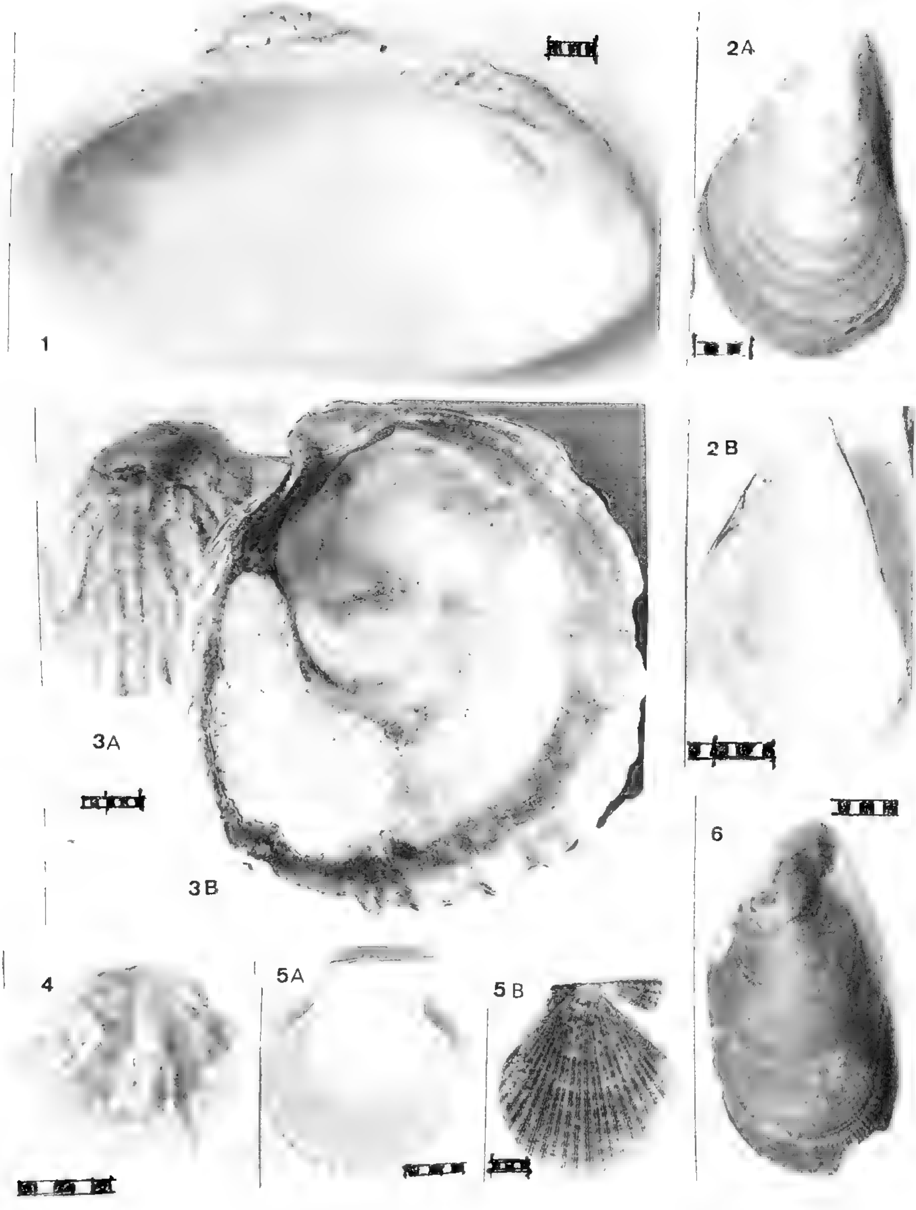

Plate 2. Pelecypod rock indicators. (Scale: 2 mm squares.) 1. *Barbatia pistachia* (ventral view - note taxodont teeth); 2. *Mytilus planulatus* (a) dorsal view (b) ventral view; 3. *Ostrea angasi* (a) dorsal view (b) ventral view (note adductor scar); 4. *Monia ione*; 5. *Chlamys asperrimus* (a) ventral view with adductor scar (b) dorsal view; 6. *Brachidontes rostratus*.

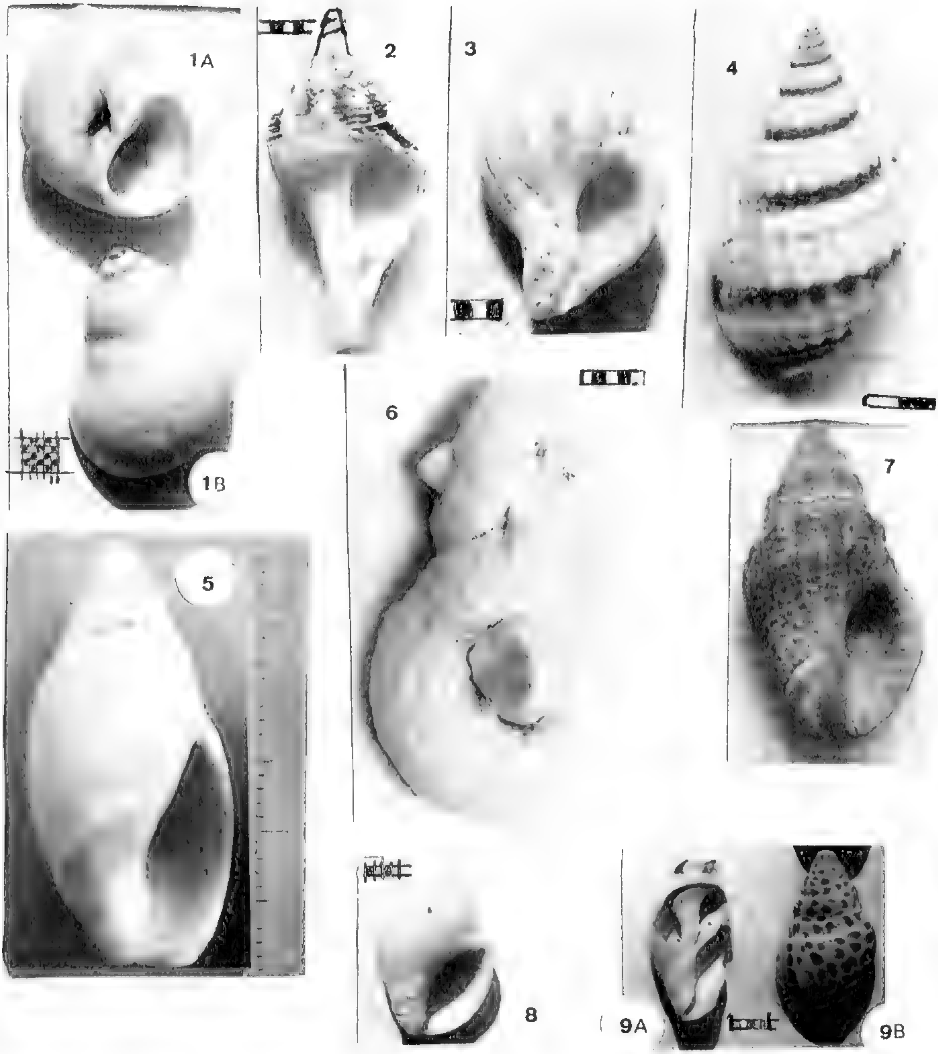

Plate 3. Gastropod sand dwellers. (Scale: 2 mm squares.) 1. *Polinices conicus* (a) apertural view (b) obverse views; 2. *Pleuroploca australasiae*; 3. *Bedeva paviae*; 4. *Parcanassa (Niotha) pyrrhus*; 5. *Alocospira marginata*; 6. *Serpulorbis sipho*; 7. *Cominella eburna*; 8. *Nevia spirata*; 9. *Cominella lineolata* (a) worn specimen showing whorls and columella in section (b) obverse view of fresh specimen.

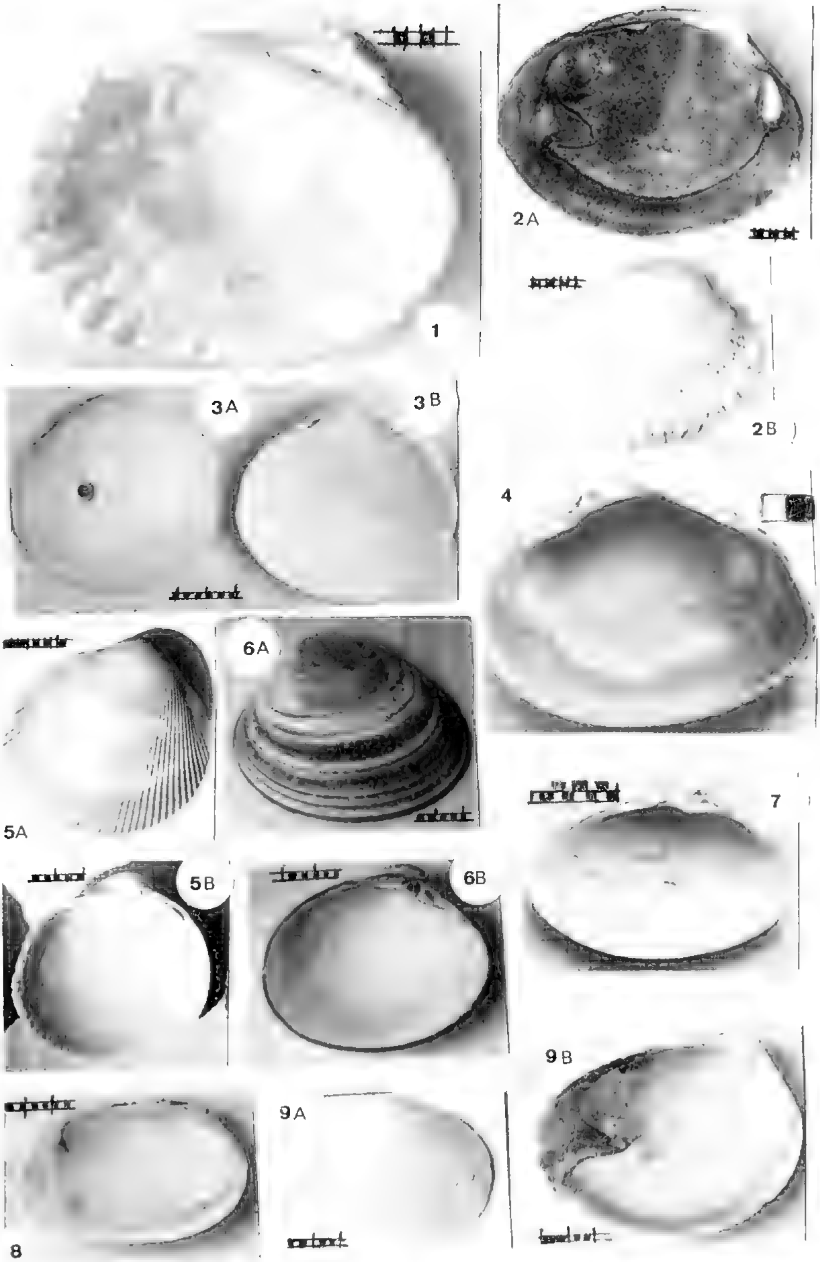

Plate 4. Pelecypod sand dwellers. 1. *Anadara trapezia* (ventral view - note taxodont teeth on hinge); 2. *Katelysia rhytiphora* (a) internal view (b) external view; 3. *Pseudarcopagia victoriae* (a) external view showing Polinicid drill hole (b) internal view; 4. *Tawera gallinula* (internal view - note pallial line and sinus); 5. *Fulvia tenuicostata* (a) external view (b) internal view; 6. *Notocallista kingii* (a) external view showing growth lines (b) internal view to show Venerid tooth pattern; 7. *Electromactra antecedens* (internal view to show Mactrid hinge pattern); 8. *Venerupis galactites* (internal view to show Venerid hinge); 9. *Katelysia scaralina* (a) external left valve showing equal ridging (b) internal view to show straight posterior margin cf 2 (a), (b).

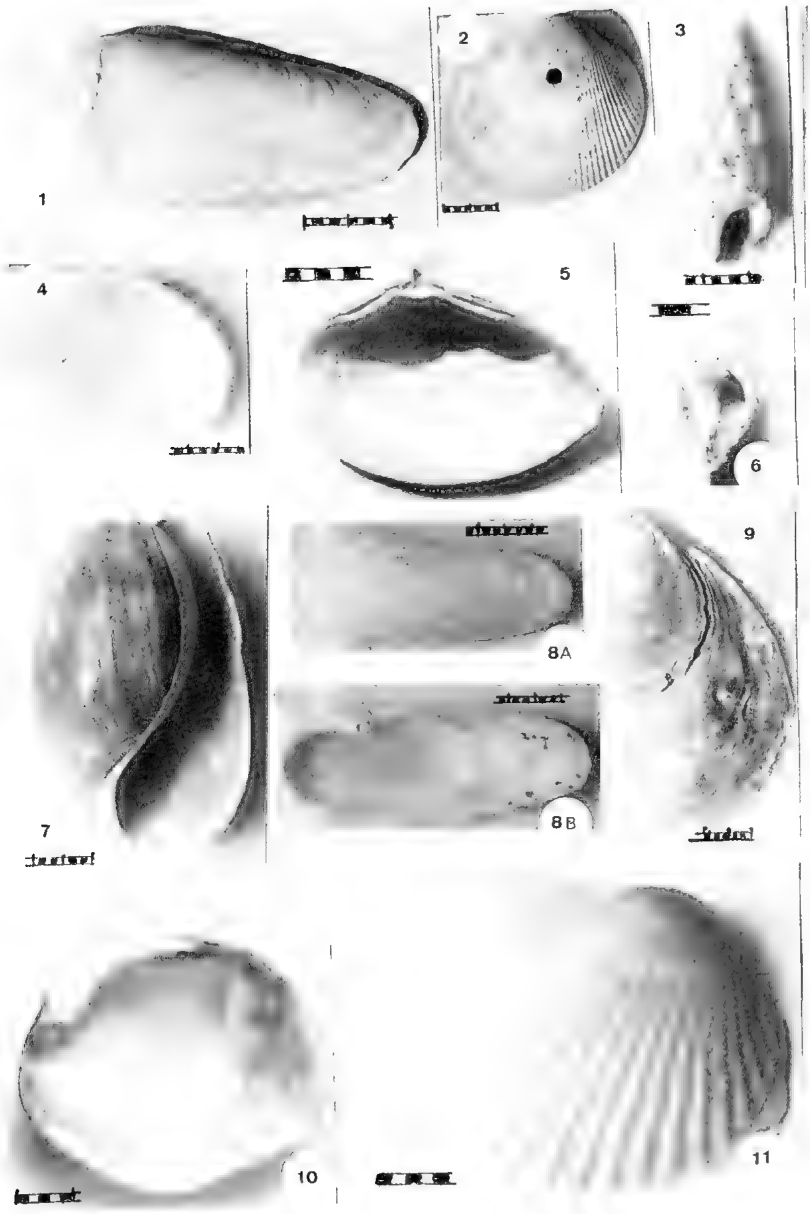

Plate 5. Silt and mud dwellers. (Scale: 2 mm squares.) 1. *Barnea obturamentum* (external view - note kink in anterior margin); 2. *Fulvia tenuicostata* (external view - note Polinicid drill); 3. *Batillaria diemenensis* (apertural view); 4. *Tellina deltoidalis* (interior view); 5. *Notospisula trigonella* (interior view to show Mactrid hinge); 6. *Bedeva paivae*; 7. *Bulla quoyi* (apertural view); 8. *Barnea australiasiae* (a) external view (b) internal view to show tooth pattern; 9. *Ostrea angasi* (anterior view of exterior of Common Mud Oyster); 10. *Katelysia peroni* (showing rounded morphology and 3 cardinal teeth. This species indicates silt and mud); 11. *Anadara trapezia* (showing radial ribbing on exterior).

The Biology, Ecology and Horticultural Potential of *Banksia* L.f.: a Bibliography of Recent Literature

A.K. Cavanagh[1]

This is the fourth bibliography of *Banksia* that I have prepared since 1989 (Cavanagh 1989, 1994, 1997) and brings the number of references on this important topic to more than 430. The bibliography mainly lists papers published in journals between 1996 and 1998, although both books and special reports are included. The large number of papers included in the **Systematics and Paleobotany** section mainly result from the *International Symposium on the Biology of Proteaceae* which was held at the University of Melbourne, September 29 to October 2, 1996 as one of the 1996 Commemorative Conferences to celebrate the centenary of the death of Ferdinand von Mueller, first Victorian Government Botanist. One outcome of the work reported at the conference was that the taxonomy of *Banksia* has been closely scrutinised and there remain disagreements between 'classical' taxonomists and those using the modern approaches of cladistics and molecular phylogeny. One example of such disagreement is the horticulturally important *Banksia coccinea* which has traditionally been placed in Section *Banksia* but is now considered by some to deserve a new section. Thiele and Ladiges (1996) dispensed with sections altogether and instead used series and subseries. The listing of species in Appendix 1 follows the work of George (1996a and 1996b) and Thiele and Ladiges (1996) but it is recognised that other interpretations are possible.

There is still strong interest in pollination biology, particularly of horticulturally important species, and the role of animal pollinators. A number of studies have also considered the feeding and foraging behaviour of birds and animals. Ecological studies remain one of the major areas of interest with the role of fire and the continuing devastating effect of *Phytophthora cinnamomi* (dieback) and *Cryptodiaporthe* canker being the subject of continuing research. Some work continues on the rare and endangered species of Western Australia but this still tends to focus on the better-known species *B. brownii*, *B. cuneata*, and *B. goodii*, while other species such as *B. oligantha*, *B. sphaerocarpa* var. *dolichostyla* and *B. verticillata* have been little studied. There were relatively few papers on applied horticulture, despite the ongoing interest in banksias as cut flowers, but much of the fundamental work on pollination biology has direct relevance to horticulture.

The bibliography is arranged alphabetically by author under the following categories:-

Books on Banksia, Systematics and Paleobotany, Reproductive Biology: *Pollination – General, Pollination – Birds and Mammals, Floral Damage and Flower Consumption, Seed Development and Canopy Storage, Seed Germination.* **Ecology:** *General Studies, Role of Fire, Role of* Phytophthora *and other Plant Pathogens, Rare and Endangered.* **Horticulture:** *General Studies, Propagation, Cultivation and Chemical Studies.*

Numbering begins at 336 and follows on from the 1997 survey (Cavanagh 1997). As noted above, the species listed in Appendix 1 are based on the latest research, although there is disagreement on the status of some taxa. Each taxon is indexed to relevant papers in the bibliography.

References

Cavanagh, A.K. (1989). The biology and ecology of *Banksia* L.f.: a bibliography of recent literature. *The Victorian Naturalist* **106**, 140-147.

Cavanagh, A.K. (1994). The biology, ecology and horticultural potential of *Banksia* L.f.: a bibliography of recent literature. *The Victorian Naturalist* **111**, 25-30.

Cavanagh, A.K. (1997). The biology, ecology and horticultural potential of *Banksia* L.F.: a bibliography of recent literature. *The Victorian Naturalist* **114**, 77-82.

George, A.S. (1996a). Notes on *Banksia* L.f. (Proteaceae). *Nuytsia* **11**, 21-24.

George, A.S. (1996b). 'The Banksia Book', 3rd ed. (Kangaroo Press in association with the Society for Growing Australian Plants: Sydney.)

Thiele, K. and Ladiges, P.Y. (1996). A cladistic analysis of *Banksia* (Proteaceae). *Australian Systematic Botany* **9**, 661-733.

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Bibliography

Books on Banksia

336 George, A.S. (1996b). 'The Banksia Book', 3rd ed. (Kangaroo Press in association with The Society for Growing Australian Plants: Sydney.)

337 Holliday I. and Watton, G. (1996). 'A Field Guide to Banksias', 2nd rev. ed. (Landsdowne: Sydney.)

Systematics and Paleobotany

338 Dettmann, M.E. and Jarzen, D.M. (1998). The early history of the Proteaceae in Australia: the pollen record. *Australian Systematic Botany* **11**, 401-438.

339 George, A.S. (1996b). Notes on Banksia L.f. (Proteaceae). *Nuytsia* **11**, 21-24.

340 George, A.S. (1998). *Proteus* in Australia. An overview of the current state of taxonomy of the Australian Proteaceae. *Australian Systematic Botany* **11**, 257-266.

341 Hoot, S.B. and Douglas, A.W. (1998). Phylogeny of the Proteaceae based on *atpB* and *atpB-rbcL* intergenic spacer region sequences. *Australian Systematic Botany* **11**, 301-320.

342 Johnson, L.A.S. (1998). Proteaceae – where are we? *Australian Systematic Botany* **11**, 251-255.

343 Jordan, G.J., Carpenter, R.J. and Hill, R.S. (1998). The macrofossil record of Proteaceae in Tasmania: a review with new species. *Australian Systematic Botany* **11**, 465-501.

344 Maguire, T.L., Sedgley, M. and Conran, J.G. (1996). *Banksia* sect. *Coccinea* (Proteaceae), a new section. *Australian Systematic Botany* **9**, 887-891.

345 Maguire T.L., Conran, J.G., Collins, G.G., Sedgley, M. (1997). Molecular analysis of interspecific and intergeneric relationships of *Banksia* using RAPDS and non-coding chloroplast DNA sequences. *Theoretical and Applied Genetics* **95**, 253-260.

346 Maguire, T.L. and Sedgley, M. (1997a). Genetic diversity of *Banksia* and *Dryandra* (Proteaceae) with emphasis on *Banksia cuneata*, a rare and endangered species. *Heredity* **79**, 394-401.

347 Mast, A.R. (1998). Molecular systematics of subtribe Banksiinae (*Banksia* and *Dryandra*: Proteaceae) based on *cpDNA* and *nrDNA* sequence data: implications for taxonomy and biogeography. *Australian Systematic Botany* **11**, 321-342.

348 Nicolson, S.W. and Van Wyk, B.-E. (1998). Nectar sugars in Proteaceae: patterns and processes. *Australian Journal of Botany* **46**, 489-504.

349 Stace, H.M., Douglas, A.W. and Sampson, J.F. (1998). Did 'paleo-polyploidy' really occur in Proteaceae? *Australian Systematic Botany* **11**, 613-629.

350 Thiele, K. and Ladiges, P.Y. (1996). A cladistic analysis of *Banksia* (Proteaceae). *Australian Systematic Botany* **9**, 661-733.

351 Vadala, A.J. and Drinnan, A.N. (1998). Elaborating the fossil history of Banksiinae: a new species of *Banksieaephyllum* (Proteaceae) from the late Paleocene of New South Wales. *Australian Systematic Botany* **11**, 439-463.

Reproductive Biology

Pollination – General

352 Carthew, S.M., Whelan, R.J. and Ayre, D.J. (1996). Experimental confirmation of preferential outcrossing in *Banksia*. *International Journal of Plant Sciences* **157**, 615-620.

353 Goldingay, R.L. and Carthew, S.M. (1998). Breeding and mating systems of Australian Proteaceae. *Australian Journal of Botany* **46**, 421-437.

354 Hermanutz, L., Innes, D., Denham, A. and Whelan, R. (1998). Very low fruit-flower ratios in *Grevillea* (Proteaceae) are independent of breeding system. *Australian Journal of Botany* **46**, 465-478.

355 Ladd, P.G., Alkema, A.J. and Thomson, G.J. (1996). Pollen presenter morphology and anatomy in *Banksia* and *Dryandra*. *Australian Journal of Botany* **44**, 447-471.

356 Maguire, T.L. and Sedgley, M. (1998). Interspecific and intergeneric pistil-pollen compatibility of *Banksia coccinea* (Proteaceae). *Australian Journal of Botany* **46**, 453-463.

357 Paton, D.C. (1997). Honey bees *Apis mellifera* and the disruption of plant-pollinator systems in Australia. *The Victorian Naturalist* **114**, 23-29.

358 Sedgley, M., Wirthensohn, M.G. and Delaporte, K.L. (1996). Interspecific hybridization between *Banksia hookeriana* Meisn. and *Banksia prionotes* Lindl. (Proteaceae). *International Journal of Plant Sciences* **157**, 638-643.

359 Vaughton, G. and Ramsey, M. (1997). Seed mass variation in the shrub *Banksia spinulosa* (Proteaceae) – resource constraints and pollen source effects. *International Journal of Plant Sciences* **158**, 424-431.

Pollination – Birds and Mammals

360 Carthew, S.M. and Goldingay, R.L. (1997). Non-flying mammals as pollinators (review).*Trends in Ecology & Evolution* **12**, 104-108.

361 Egan, K.H. (1997). Seasonal changes in the pollen sampled from nectarivorous birds visiting an open forest at Menai, New South Wales. *Corella* **21**, 83-87.

362 Sampson, J.F., Coates, D.J. and Van Leeuwen, S.J. (1996). Mating system variation in animal-pollinated rare and endangered plant populations in Western Australia. *In* 'Gondwanan heritage past, present and future of the Western Australian biota', pp. 187-195. Eds S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George. (Surrey Beatty in association with Australian Systematic Botany Society and Kings Park and Botanic Garden, Western Australia: Sydney.)

363 Van Tets, I.G. and Whelan, R.J. (1997). *Banksia* pollen in the diet of Australian mammals. *Ecography* **20**, 499-505.

364 Woodside, D.P. and Pyke, G.H. (1995). A comparison of bats and birds as pollinators of *Banksia integrifolia* in northern New South Wales, Australia. *Australian Mammalogy* **18**, 9-18.

Floral Damage and Flower Consumption

365 Law, B.S. (1996). Residency and site fidelity of marked populations of the common blossom bat *Syconycteris australis* in relation to the availability of *Banksia* inflorescences in New South Wales, Australia. *Oikos* **77**, 447-458.

366 Mcfarland, D.C. (1996). Aggression and nectar use in territorial non-breeding New Holland honeyeaters *Phylidonyris novaehollandiae* in eastern Australia. *Emu* **96**, 181-188.

367 Quin, D., Goldingay, R., Churchill, S. and Engel, D. (1996). Feeding behaviour and food availability of the yellow-bellied glider in North Queensland. *Wildlife Research* **23**, 637-646.

368 Scarff, F.R., Rhind, S.G. and Bradley, J.S. (1998). Diet and foraging behaviour of brush-tailed phascogales (*Phascogale tapoatafa*) in the jarrah forest of south-western Australia. *Wildlife Research* **25**, 511-526.

369 Sharp, D.J. and Goldingay, R.L. (1998). Feeding behaviour of the squirrel glider at Bungawalbin Reserve, north-eastern New South Wales. *Wildlife Research* **25**, 243-254.

370 Van Leeuwen, S.J. and Lamont, B.B. (1996). Floral damage by animals and its impact on reproductive success in *Banksia tricuspis* Meisner (Proteaceae). *In* 'Gondwanan heritage: past, present and future of the western Australian biota', pp.196-202. Eds S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George. (Surrey Beatty in association with Australian Systematic Botany Society and Kings Park and Botanic Garden, Western Austialia: Sydney.)

Seed Development and Canopy Storage

371 Cheal, D. (1997). Survival of desert banksia *Banksia ornata* seed in detached cones. *The Victorian Naturalist* **114**, 190-191.

372 Egerton Warburton L.M., West, M. and Lott, J.N.A. (1997). Conservative allocation of globoid-held mineral nutrients in *Banksia grandis* (Proteaceae) seeds. *Canadian Journal of Botany* **75**, 1951-1956.

373 Vaughton, G. and Ramsey, M. (1997). Seed mass variation in the shrub *Banksia spinulosa* (Proteaceae): resource constraints and pollen source effects. *International Journal of Plant Sciences* **158**, 424-431.

374 Vaughton, G. and Ramsey, M. (1998). Sources and consequences of seed mass variation in *Banksia marginata* (Proteaceae). *Journal of Ecology* **86**, 563-573.

375 Whelan, R.J., Dejong, N.H. and Vonderburg, S. (1998). Variation in bradyspory and seedling recruitment without fire among populations of *Banksia serrata* (Proteaceae). *Australian Journal of Ecology* **23**, 121-128.

376 Witkowski, E.T.F. and Lamont, B.B. (1996). Disproportionate allocation of mineral nutrients and carbon between vegetative and reproductive structures in *Banksia hookeriana*. *Oecologia* **105**, 38-42.

Seed Germination

377 Lamont, B.B. and Milberg, P. (1997). Removal of the testa during germination or establishment increases germinant mortality, decay and water loss. *Seed Science Research* **7**, 245-252.

Ecology

General Studies

378 Bennett, L.T. and Attiwill, P.M. (1997). The nutritional status of healthy and declining stands of *Banksia integrifolia* on the Yanakie isthmus, Victoria. *Australian Journal of Botany* **45**, 15-30.

379 Blake, J. and Hill, R.S. (1996). An examination of the drought and frost tolerance of *Banksia marginata* (Proteaceae) as an explanation of its current widespread occurrence in Tasmania. *Australian Journal of Botany* **44**, 265-281

380 Brown, S., Mo, J., Mcpherson, J.K. and Bell, D.T. (1996). Decomposition of woody debris in Western Australian forests. *Canadian Journal of Forest Research* **26**, 954-966.

381 Burbidge, A.H., Boscacci, L.J., Alford, J.J. and Keighery, G.J. (1996). A biological survey of Boonanarring nature reserve. *Calmscience* **2**, 153-187.

382 Cowling, R.M. and Lamont, B.B. (1998). On the nature of Gondwanan species flocks: diversity of Proteaceae in mediterranean south-western Australia and South Africa. *Australian Journal of Botany* **46**, 335-355.

383 Dawson, T.E. and Pate, J.S. (1998). Seasonal water uptake and movement in root systems of Australian phraeatophytic plants of dimorphic root morphology: a stable isotope investigation. *Oecologia* **107**, 13-20.

384 Higgins, S.I. and Richardson, D.M. (1998). Pine invasions in the southern hemisphere - modelling interactions between organism, environment and disturbance. *Plant Ecology* **135**, 79-93.

385 Hill, R.S. (1998). Fossil evidence for the onset of xeromorphy and scleromorphy in Australian Proteaceae. *Australian Systematic Botany* **11**, 391-400.

386 Hingston, A.B. and McQuillan, P.B. (1998). Does the recently introduced bumblebee *Bombus terrestris* (Apidae) threaten Australian ecosystems? *Australian Journal of Ecology* **23**, 539-549.

387 Lamont, B.B. (1995). Testing the effect of ecosystem composition structure on its functioning. *Oikos* **74**, 283-295.

388 Lamont, B.B. (1996). Conservation biology of Banksias in southwestern Australia. *In* 'Gondwanan heritage: past, present and future of the western Australian biota', pp.292-298. Eds S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George. (Surrey Beatty in association with Australian Systematic Botany Society and Kings Park and Botanic Garden, Western Australia: Sydney.)

389 Lamont, B.B. and Connell, S.W. (1996). Biogeography of *Banksia* in southwestern Australia. *Journal of Biogeography* **23**, 295-309.

390 Lamont, B.B. and Groom, P.K. (1998). Seed and seedling biology of woody-fruited Proteaceae. *Australian Journal of Botany* **46**, 387-406.

391 Lunt, I.D. (1998). Two hundred years of land use and vegetation change in a remnant coastal woodland in southern Australia. *Australian Journal of Botany* **46**, 629-647.

392 Middleton, N.D., Ladiges, P.Y. and Enright, N.J. (1996). Population ecology of *Banksia saxicola* (Proteaceae). *Royal Society of Victoria Proceedings* **108**, 43-56.

393 Milberg, P., Perezfernandez, M.A. and Lamont, B.B. (1998). Seedling growth response to added nutrients depends on seed size in three woody genera. *Journal of Ecology* **86**, 624-632.

394 Pate, J.S., Jeschke, W.D., Dawson, T.E., Raphael, C., Hartung, W. and Bowen, B.J. (1998). Growth and seasonal utilisation of water and nutrients by *Banksia prionotes*. *Australian Journal of Botany* **46**, 511-532.

395 Witkowski, E.T.F. and Lamont, B.B. (1996). Nutrient losses from commercial picking and cockatoo removal of *Banksia hookeriana* blooms at the organ, plant and site levels. *Journal of Applied Ecology* **33**, 131-140.

Role of Fire

396 Bradstock, R.A., Bedward, M., Scott, J. and Keith, D.A. (1996). Simulation of the effect of spatial and temporal variation in fire regimes on the population viability of a *Banksia* species. *Conservation Biology* **10**, 776-784.

397 Bradstock, R.A., Tozer, M.G. and Keith, D.A. (1997). Effects of high frequency fire on floristic composition and abundance in a fire-prone heathland near Sydney. *Australian Journal of Botany* **45**, 641-655.

398 Enright, N.J., Lamont, B.B. and Marsula, R. (1996). Canopy seed bank dynamics and optimum fire regime for the highly serotinous shrub, *Banksia hookeriana*. *Journal of Ecology* **84**, 9-17.

399 Enright, N.J., Marsula, R., Lamont, B.B. and Wissel, C. (1998a). The ecological significance of canopy seed storage in fire-prone environments: a model for non-sprouting shrubs. *Journal of Ecology* **86**, 946-959.

400 Enright, N.J., Marsula, R., Lamont, B.B. and Wissel, C. (1998b). The ecological significance of canopy seed storage in fire-prone environments: a model for resprouting shrubs. *Journal of Ecology* **86**, 960-973.

401 Gill, A.M. and McCarthy, M.A. (1998). Intervals between prescribed fires in Australia - what intrinsic variation should apply. *Biological Conservation* **85**, 161-169.

402 Gould, S.F. (1998). Proteoid root mats stabilise Hawkesbury sandstone biomantles following fire. *Australian Journal of Soil Research* **36**, 1033-1043.

403 Hammill, K.A., Bradstock, R.A. and Allaway, W.G. (1998). Post-fire seed dispersal and species re-establishment in proteaceous heath. *Australian Journal of Botany*, **46**, 407-419.

404 McLoughlin, L.C. (1998). Season of burning in the Sydney region - the historical records compared with recent prescribed burning. *Australian Journal of Ecology* **23**, 393-404.

405 Richards, M.B. and Lamont, B.B. (1996). Post-fire mortality and water relations of three congeneric shrub species under extreme water stress - a trade-off with fecundity. *Oecologia* **107**, 53-60.

406 Williams, P.R. and Clarke, P.J. (1997). Habitat segregation by serotinous shrubs in heaths: post-fire emergence and seedling survival. *Australian Journal of Botany* **45**, 31-39.

Role of Phytophthora and other Plant Pathogens

407 Austin, A.D. and Dangerfield, P.C. (1998). Biology of *Mesostoa kerri* (Insecta, Hymenoptera, Braconidae, Mesostoinae), an endemic Australian wasp that causes stem galls on *Banksia marginata*. *Australian Journal of Botany* **46**, 559-569.

408 Bathgate, J.A., Barr, M.E. and Shearer, B.L. (1996). *Cryptodiaporthe melanocraspeda* sp. nov., the cause of *Banksia coccinea* canker in south-western Australia. *Mycological Research* **100**, 159-164.

409 El-Tarabily, K.A., Sykes, M.L., Kurtboke, I.D., Hardy, G.E.S.J., Barbosa, A.M. and Dekker, R.F.H. (1996). Synergistic effects of a cellulase-producing *Micromonospora carbonacea* and an antibiotic producing *Streptomyces violascens* on the suppression of *Phytophthora cinnamomi* root rot of *Banksia grandis*. *Canadian Journal of Botany* **74**, 618-624.

410 Gullan, P.J. and Brookes, H.M. (1998). Giant females and bird-of-paradise flies - notes on the biology of *Callipappus* Guerin-Meneville (Hemiptera, Margarodidae). *Australian Journal of Entomology* **37**, 2-7.

411 Murray, D. (ed.) (1997). 'Control of *Phytophthora* and *Diplodina canker* in Western Australia - Final Report to the Threatened Species and Communities Unit, Biodiversity Group, Environment Australia'. (W.A. Department of Conservation and Land Management, and Environment Australia: Perth.)

412 Podger, F.D., James, S.H. and Mulcahy, M.J. (1996). 'Review of Dieback in Western Australia' (Western Australian Dieback Review Panel, Perth).

413 Shearer, B.L. and Dillon, M. (1996a). Impact and disease centre characteristics of *Phytophthora cinnamomi* infestations of *Banksia* woodlands on the Swan coastal plain. *Australian Journal of Botany* **44**, 79-90.

414 Shearer, B.L. and Dillon, M. (1996b). Susceptibility of plant species in *Banksia* woodlands on the Swan coastal plain, Western Australia, to infestation by *Phytophthora cinnamomi*. *Australian Journal of Botany* **44**, 433-445.

415 Shearer, B.L., Crane, C.E., Fairman, R.G. and Grant, M.J. (1997). Occurrence of *Armillaria luteobubalina* and pathogen-mediated changes in coastal dune vegetation of south western Australia. *Australian Journal of Botany* **45**, 905-917.

416 Smith, B.J., Shearer, B.L. and Sivasithamparam, K. (1997). Compartmentalization of *Phytophthora cinnamomi* in stems of highly susceptible *Banksia brownii* treated with phosphonate. *Mycological Research* **101**, 1101-1107.

417 Tynan, K.M., Scott, E.S. and Sedgley, M. (1998a). Evaluation of *Banksia* species for response to *Phytophthora* infection. *Plant Pathology* **47**, 446-445.

418 Tynan, K.M., Scott, E.S. and Sedgley, M. (1998b). Development of excised shoot and root assays for in-vitro evaluation of *Banksia* species for response to *Phytophthora* species. *Plant Pathology* **47**, 456-462.

Rare and Endangered

419 Brown, A., Thomson-Dans, C. and Marchant, N. (eds) (1998). 'Western Australia's threatened flora' (W.A. Department of Conservation and Land Management: Como, Perth). The following rare and endangered *Banksia* are covered:
B. oligantha - p. 70; *B. sphaerocarpa* var. *dolichostyla* - p. 71; *B. goodii* - P. 113; *B. verticillata* - P. 156; *B. brownii* - p.189

420 Cochrane, A., Kelly, A. and Coates, D. (1996). Banking for the future. *Landscope*, **11(4)**, 49-52.

421 Collins, B.G., McDavitt, S. and Sampson, J.F. (1996). Flowering phenology and fecundity of *Banksia brownii* Baxter ex R. Br. (Proteaceae). *In* 'Gondwanan heritage: past, present and future of the western Australian biota', pp. 231-238. Eds S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George. (Surrey Beatty in association with Australian Systematic Botany Society and Kings Park and Botanic Garden, Western Australia: Sydney.)

422 Day, D.A., Collins, B.G. and Rees, R.G. (1997). Reproductive biology of the rare and endangered *Banksia brownii* Baxter ex R. Br. *Australian Journal of Ecology* **22**, 307-315.

423 Durell, G. (1997). 'Matchstick banksia recovery team, annual report, 1996'. (W.A. Department of Conservation and Land Management: Como, Perth.)

424 McNee, S.A. (1997). 'Pollination biology of *Banksia cuneata* at three populations during the 1996 flowering season'. (W.A. Department of Conservation and Land Management: Como, Perth.)

425 Williams, J. (1997) '*Banksia cuneata* 1996 census and population conditions' (unpublished report). (W.A. Department of Conservation and Land Management: Como, Perth.)

426 Witkowski, E.T.F. and Lamont, B.B. (1997). Does the rare *Banksia goodii* have inferior vegetative, reproductive or ecological attributes compared with its widespread co-occurring relative *B. gardneri*? *Journal of Biogeography* **24**, 469-482.

Horticulture

General Studies

427 Maguire, T.L. and Sedgley, M. (1997b). Storage temperature affects viability of *Banksia menziesii* pollen. *HortScience* **32**, 916-917. (Also of relevance although not dealing specifically with *Banksia*, is Vanderwalt, I.D. and Littlejohn, G.M. (1996). Storage and viability testing of protea pollen. *Journal of the American Society for Horticultural Science* **121**, 804-809.)

428 Rieger, M.A. and Sedgley, M. (1996). Effect of daylength and temperature on flowering of the cut flower species *Banksia coccinea* and *Banksia hookeriana*. *Australian Journal of Experimental Agriculture* **36**, 747-753.

429 Rieger, M.A. and Sedgley, M. (1998). Preliminary investigation of genetic variation within and between cultivated and natural populations of *Banksia coccinea* and *Banksia menziesii*. *Australian Journal of Botany* **46**, 547-558.

430 Sedgley, M. (1998). Banksia: new proteaceous cut flower crop. *Horticultural Reviews* **22**, 1-26.

431 Smith, R.S. (1996). 'Conservation and management of privately owned remnant vegetation used for commercial flora harvesting, a report to the Australian Nature Conservation Agency, W.A. Department of Conservation and Land Management, Water and Rivers Commission, Agriculture W.A.' (The author: Perth.)

Propagation, Cultivation and Chemical Studies

432 Barlow, S. and Haigh, A.M. (1997). 'A guide to the nutritional needs of some Proteaceae: a report for the Rural Industries Research and Development Corporation'. (Rural Industries Research and Development Corporation: Barton, ACT).

433 Hasegawa, A., Matsuzaka, M., Fukai, S., Miki, M. and Nakatsu, T. (1997). (Effect of smoking treatment on the seed germination of wildflowers) (in Japanese). *Kagawa Daigaku Nogakubu Gakujutsu Hokoku* **49**, 199-205.

Appendix

Listing of all *Banksia* species (after George 1996a, b and Thiele and Ladiges 1996). Species are indexed to relevant papers. The letters **G** and **T** against a taxon indicate respective treatments by either George or Thiele and Ladiges.

Banksia aculeata A.S. George
Banksia aemula R. Br.
Banksia aquilonia (A.S. George) A.S. George **G** 336, 339
Banksia ashbyi E.G. Baker
Banksia attenuata R. Br. 400
Banksia audax C. Gardner
Banksia baueri R. Br.
Banksia baxteri R. Br.
Banksia benthamiana C. Gardner
Banksia blechnifolia F. Muell.
Banksia brevidentata (A.S. George) K. Thiele **T** 350
Banksia brownii Baxter ex R. Br. 362, 412, 416, 419, 421, 422
Banksia burdettii E.G. Baker
Banksia caleyi R.Br.
Banksia candolleana Meissner
Banksia caneii J.H. Willis
Banksia chamaephyton A.S. George
Banksia coccinea R. Br. 344, 356, 408, 428, 429
Banksia conferta A.S. George subsp. *conferta* **G** 336, 339
Banksia conferta A.S. George subsp. *penicillata* A.S. George **G** 336, 339
Banksia conferta A.S. George var. *conferta* **T** 350
Banksia cuneata A.S. George 346, 362, 387, 423, 424, 425
Banksia dentata L.f. 270
Banksia dolichostyla (A.S. George) K.Thiele **T** 350
Banksia dryandroides Baxter ex Sweet
Banksia elderiana F. Muell. & Tate
Banksia elegans Meissner
Banksia epica A.S. George
Banksia ericifolia L.f. subsp. *ericifolia* **G** 336, 339
Banksia ericifolia L.f. subsp. *macrantha* A.S. George **G** 336, 339
Banksia ericifolia L.f. var. *ericifolia* **T** 350
Banksia ericifolia L.f. var. *macrantha* A.S. George **T** 350
Banksia gardneri A.S. George var. *brevidentata* A.S. George **G**
Banksia gardneri A.S. George var. *gardneri*
Banksia gardneri A.S. George var. *hiemalis* A.S. George **G**
Banksia goodii R.Br. 419, 426
Banksia grandis Willd.372, 380, 409
Banksia grossa A.S. George
Banksia hiemalis (A.S. George) K. Thiele **T** 350
Banksia hookeriana Meissner 358, 376, 377, 395, 398, 399, 428
Banksia ilicifolia R. Br.
Banksia incana A.S. George
Banksia integrifolia L.f. subsp. *aquilonia* A.S. George **T** 350
Banksia integrifolia L.f. subsp. *compar* (R. Br.) Bailey
Banksia integrifolia L.f. subsp. *integrifolia* 364, 365, 369, 378
Banksia integrifolia L.f. subsp. *monticola* Thiele
Banksia laevigata Meissner subsp. *fuscolutea* A.S. George
Banksia laevigata Meissner subsp. *laevigata*
Banksia lanata A.S. George
Banksia laricina C. Gardner
Banksia lemanniana Meissner
Banksia leptophylla A.S. George var. *leptophylla*
Banksia leptophylla A.S. George var. *melletica* A.S. George
Banksia lindleyana Meissner
Banksia littoralis R. Br.
Banksia lullfitzii C. Gardner
Banksia marginata Cav. 374, 379, 391, 403, 406, 407
Banksia media R. Br.
Banksia meisneri Lehm. subsp. *ascendens* A.S. George **G** 336, 339
Banksia meisneri Lehm. subsp. *meisneri* **G** 336, 339
Banksia meisneri Lehm. var. *ascendens* A.S. George **T** 350
Banksia meisneri Lehm. var. *meisneri* **T** 350
Banksia menziesii R.Br. 427, 429
Banksia micrantha A.S. George
Banksia nutans R.Br var. *cernuella* A.S. George
Banksia nutans R.Br. var. *nutans*
Banksia oblongifolia Cav.
Banksia occidentalis R.Br.
Banksia oligantha A.S. George 419
Banksia oreophila A.S. George
Banksia ornata F. Muell. ex Meissner 357, 371
Banksia paludosa R.Br. subsp. *paludosa*
Banksia paludosa R.Br. subsp. *astrolux* A.S. George **G** 336, 339
Banksia penicillata (A.S. George) K. Thiele **T**
Banksia petiolaris F. Muell
Banksia pilostylis C. Gardner
Banksia plagiocarpa A.S. George
Banksia praemorsa Andrews
Banksia prionotes Lindley 358, 383, 394, 433
Banksia pulchella R.Br.
Banksia quercifolia R.Br.
Banksia repens Labill.
Banksia robur Cav.
Banksia saxicola A.S. George 392
Banksia scabrella A.S. George
Banksia sceptrum Meissner
Banksia seminuda (A.S. George) B. Rye
Banksia serrata L.f. 375, 402, 403
Banksia solandri R.Br.
Banksia speciosa R.Br.
Banksia sphaerocarpa R.Br. var. *caesia* A.S. George
Banksia sphaerocarpa R.Br. var. *dolichostyla* A.S. George **G** 419
Banksia sphaerocarpa R.Br. var. *sphaerocarpa*
Banksia spinulosa Smith var. *collina* (R.Br.) A.S. George
Banksia spinulosa Smith var. *cunninghamii* (Sieber ex Reichenbach) A.S. George
Banksia spinulosa Smith var. *neoanglica* A.S. George 354
Banksia spinulosa Smith var. *spinulosa* 352 359, 373, 386
Banksia telmatiaea A.S. George
Banksia tricuspis Meissner 362, 370
Banksia verticillata R.Br. 419
Banksia victoriae Meissner
Banksia violaceae C. Gardner

Companions for the Lone Pine of Jacksons Creek

The discovery of a new population of a species anywhere is always exciting, but especially so when it is in the heart of Melbourne! In early 1998 the former CSIRO land in Maribyrnong was inspected by DNRE officers who located a small number of White Cypress Pine (*Callitris glaucophylla* syn. *Callitris columellaris*). This population in Maribyrnong has not previously been recorded, probably because access to the area was highly restricted. At the request of DNRE and the City of Maribyrnong I was asked to confirm the species, and comment on the significance of the population. At this time, the subdivision of the site for a housing estate was well underway.

In all, 11 trees were located, of which four are on adjacent Commonwealth Department of Defence Explosives Factory land, but quite close to the boundary fence between Commonwealth land and the former CSIRO land (Fig. 1). The trees are located on the slopes above the Maribyrnong River, in a situation very similar to the other relict poulations nearby (Adams 1985). The nearest known population of White Cypress Pine is near the Organ Pipes National Park on Jacksons Creek. Nicholls (1942) described this tiny population of two trees as the Lone Pines of Jacksons Creek. It has declined to only one original tree, and perhaps the presence of the new companions in the Maribyrnong population, only 14 km away to the south east, will at least provide a viable seed source for restoration work such as that carried out at the Organ Pipes National Park (Kemp and Irvine 1993).

All except one of the Maribyrnong trees are quite old, with girths ranging between 125 cm and 250 cm, and heights between 8 m and 14 m. One tree had been cut down during the development, and ring counts from a section of trunk 125 cm in girth indicated an age of about 130 years. The ages of the other nine trees have been estimated by comparing their girths with data provided by David Parker and Ian Lunt (Charles Sturt University), and ages range between 130 to 220 years. This would indicate that the population, if not all the individuals, pre-dates European settlement. Given their age, and the fact that individuals of this species often tend to look 'scruffy' as they age, most are quite healthy and still reproductive. The young tree, on the adjacent Commonwealth land, is 3 m tall and at the time of inspection had a heavy crop of cones. There was some erosion occurring around the roots of a couple of trees, but they also appear quite healthy and stable.

White Cypress Pine is found in all Australian States except Tasmania. Its distribution in Victoria in restricted to the low rainfall areas along the Murray River, and in east Gippsland along the Snowy and Deddick Rivers. Isolated populations occur at Mt. Arapiles near Horsham, in the Warby Ranges near Wangaratta, and at the Terrick Terrick National Park north of Bendigo. The species has also been record-

Fig. 1. *Callitris glaucophylla* on the former CSIRO land, Maribyrnong. There are a further four trees in the background, on Commonwealth Department of Defence land.

ed from a few isolated, relict populations to the west and south-west of Melbourne. These are at Batesford, Maude, Bamganie, Bacchus Marsh, Werribee Gorge, Jacksons Creek, and now at Maribyrnong. All the populations other than that at Werribee Gorge are on private land, and their long term conservation is highly uncertain at this time. Partly as a consequence of their unprotected status, the species has become locally extinct at Batesford, only a single tree remains at Jacksons Creek, and the remaining populations, other than Bamganie, are in poor condition. The trees are generally old, and natural regeneration is low, if it is occurring at all, due to poor site quality and continual grazing of young seedlings by rabbits and stock.

The overall variability in tree and cone morphology of the Maribyrnong population is consistent with the other relict populations near Melbourne, and I think that this population is most likely to be a naturally occurring remnant rather than an horticultural planting. As such, the population is of Regional Significance. The Maribyrnong population is an important part of both Greater Melbourne's and the City of Maribyrnong's natural heritage as it provides an important insight into the pre-European composition of the regional vegetation, and may contribute to vegetation restoration activities by providing a local seed source for revegetation. The conservation of the genetic resources of this population increases the likelihood of regional survival of the species, and contributes to the conservation of plant biodiversity in the Greater Melbourne area. As such, the Maribyrnong population is worthy of formal protection and conservation measures to ensure its long-term survival in its native location. Unfortunately, in spite of the best efforts of the City of Maribyrnong, and the co-operation of the site developer, a number of these trees are already lost.

Acknowledgements

Thanks to Alan Webster, DNRE and the City of Maribyrnong for alerting me to the site, and for their work to preserve this population.

References

Adams, R. (1985). Distribution of *Callitris* in Victoria and some relic populations close to Melbourne. *The Victorian Naturalist* **102**, 48-51.

Kemp, B. and Irvine, R. (1993). Design and use of planting zones at the Organ Pipes National Park. *The Victorian Naturalist* **110**, 113-124.

Nicholls, W.H. (1942). The Lone Pines of Jackson's Creek. *The Victorian Naturalist* **58**, 139-40.

Parker, D.G. (1999). Structural patterns and changes in *Callitris-Eucalyptus* woodlands at Terrick Terrick State Park, Victoria. B.Sc.(Hons) thesis. (School of Environmental and Information Sciences, Charles Sturt University: Albury, N.S.W.)

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We regret to announce the death of Dr Elizabeth Turner on 26 December 1999. Elizabeth had a long association with the club and an obituary will appear at a later date.

We were also saddened to hear of the untimely death of Ken Hamer. Ken was responsible for designing the native garden at the FNCV hall. An obituary will appear in a later issue.

Grassland Plants of South-eastern Australia

by Neil and Jane Marriott

Publisher: *Bloomings Books, 1998. 183 pp.RRP $26.95.*

Grassland Flora: a Field Guide for the Southern Tablelands (NSW & ACT)

by David Eddy, Dave Mallinson, Rainer Rehwinkel and Sarah Sharp

Publishers: *World Wildlife Fund; Australian National Botanic Gardens; NSW National Parks and Wildlife Service; Environment ACT, 1998. 156 pp. Available from Environment ACT, PO Box 144, Lyneham ACT 2602. RRP $15.00 + postage.*

Plains Wandering: Exploring the Grassy Plains of South-eastern Australia

by Ian Lunt, Tim Barlow and James Ross

Publisher: *Victorian National Parks Association and the Trust for Nature, 1998. 152 pp. RRP $24.95.*

These three guides were all published during 1998, no doubt in response to the great demand generated by interest in grasslands, which has continued to grow in recent times. They are testimony to the fact that grasslands are finally being more broadly recognised as an ecosystem worth preserving. Although grasslands and grassy woodlands have been appreciated since settlement as superb grazing country, these ecosystems have now been exploited almost to the point of no return. Less than 1% remains of what was once a vast ecosystem. Remnants are found in isolated paddocks, along roadsides and occasionally in old cemeteries and other reserves. These areas are at risk of being lost to poor management, over-grazing or cultivation for crops. The good news is that the past few years have seen some significant purchases by Government and Community conservation agencies, which will result in long term protection of some of these areas.

One of the characteristic charms of grassland vegetation is the diversity of the flora, particularly amongst the diminutive annuals, which create the colourful spring-time displays. Another characteristic is the transient nature of much of this beauty – the main flowering pulse may only last a month or two, and the variety changes every season. All of the new field guides have captured this beauty with clear colour photographs of many of the plants one can expect to see in grassy ecosystems. The Field Guides have different approaches and slightly different target audiences.

Neil and Jane Marriott's *Grassland Plants of South-eastern Australia* describes and illustrates 170 species, and includes a general introduction with descriptions of the historical and current situations for grassy ecosystems. This guide covers common plants which occur in both grasslands and grassy woodlands, with a specific focus on the herbs and wildflowers. Only native species have been photographed and described, although some exotic species are mentioned in a 'similar species' section, which describes a further 100 plants.

Plants have been described, one per page, alphabetically by scientific name. Each description includes the plant's distribution, status and any species which are similar. The arrangement of species by their Latin name means that while families are split up, genera are together. For those familiar with scientific names, plants are easy to locate, and for those not so keen on Latin names, a common name index has been included. A glossary includes useful descriptions of many technical terms.

Many of the photographs and descriptions of diminutive annuals are particularly good. The guide also includes a reasonable range of Chenopods (salt-tolerant plants, usually with fleshy leaves). A handy feature is the similar species section: when photographs are not able to be used to distinguish between related members of the same genus, the detailed textual description can be used. The guide is glove box-sized, and can be used beyond the boundaries of Victoria as it includes species ranging from New South Wales to Tasmania.

Grassland Flora: a Field Guide for the Southern Tablelands (NSW & ACT)*, by Eddy *et al., is a field guide co-written by representatives from four major conservation organisations. Although it has been designed specifically to cover lowland grassy ecosystems in the ACT and NSW, many of the species described are also found elsewhere. The introductory section includes references to fauna and basic vegetation management. As the book has been produced for the lay person, scientific terminology has been deliberately avoided. Further, plants have been arranged throughout by life form. Forbs have been grouped according to their similarities in foliage, flowers and habit. This format is ideal for beginners but can be a little confusing for the more botanically inclined, as related species are not grouped together.

This guide describes over 120 species in detail, and includes lots of extra information for related species. One to several species have been dealt with on each page. Each species is photographed or illustrated, and usually photographs of 'similar species' have also been included, bringing the total number of species identifiable with this guide to well over 250. Each species has detailed text to accompany the photograph: a description, status and distribution, as well as other notes. Symbols have been used to indicate if a plant is annual, threatened, exotic or noxious.

The detailed grasses section is of particular interest. Those grasses which are difficult to identify have been grouped into genera, so that similar features are obvious. Easy-to-identify grasses are dealt with individually, and a great feature for individual species is a section relating to management. For example, the romantically named 'Love-grasses' are able to survive light grazing, whereas the Plume grasses have been described as persisting poorly under heavy grazing. This sort of information would be very useful for those managing for both conservation and some levels of productivity.

The grouping of the forbs by colour and shape works well for most plants. Weed species have been interspersed with natives, and their differences carefully described. The guide uses clear symbols and includes a good explanation of terms used. For those confident of identifying plants accurately, a photocopiable field sheet has been included. Overall, I believe the book to be a very good introduction, not only to the colourful variety within grassy ecosystems, but to the identification of plants in general.

And finally, possibly the most complete introduction to grassy ecosystems: ***Plains Wandering: Exploring the Grassy Plains of South-eastern Australia*, by Lunt *et al*.** This work would be very useful and informative for both the beginner and the experienced naturalist. It includes a great introductory section with separate headings covering ecology, conservation management, wildlife and human history on the Plains. Eight regional areas within south-eastern Australia are described. The vegetation, geomorphology, history and types of remnants are briefly dealt with for each region.

Over 280 plants are described, and these have been grouped by family and then alphabetically by scientific name. Photographs are clear and occasionally include close-ups. Some of the useful features are the identification of many Koorie food plants, symbols indicating region and habitat, and rare or threatened status where appropriate. Members of the daisy and pea families have been covered particularly well, with a good variety of species and high quality photographs. Grassy woodland and grassy wetland plants are also included.

Grasses are dealt with separately and line drawings have generally been used to more clearly indicate differences between species and genera. Exotic species have been dealt with in a separate section at the end of the book. The book includes a glossary and a comprehensive reference section. In summary, it's an excellent field guide, covering a broad range of species, and serves as a companion to the 'Forgotten Forests' publication covering the Box-Ironbark ecosystem.

So there they are: three new guides to Grassy Ecosystems. Now all you have to decide is which one will most suit your needs. But whatever you do, ensure you get out there next spring, and take in the glories of a grassland or two. You may even meet one of the knowledgeable writers of these guides at a field day where you will hear more about these precious, fragmented ecosystems.

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The Field Naturalists Club of Victoria Inc.

Reg No A0033611X

Established 1880

In which is incorporated the Microscopical Society of Victoria

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The Victorian Naturalist

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From the Editors

This issue of *The Victorian Naturalist* is mainly about weeds and introduced species. We didn't plan this 'theme' issue, it just happened – much like some of the species introductions you will read about in the following pages!

Also included in this issue is Sara Maroske's review of *Feral Future*, Tim Low's book in which he has ably catalogued a depressing litany of introductions.

We hope you enjoy this collection of papers, especially Ian Faithfull's entertaining story of the involvement of the Hawthorn Junior Field Naturalists in the evolution of the Easter Bilby, that admirable replacement for one of Australia's most virulent pests, the Rabbit.

Merilyn Grey and Alistair Evans

Tribute

Ken Hamer

The Club was deeply shocked and saddened to lose an active Committee member and committed naturalist in a tragic road accident on 2 January 2000. Ken had recently completed his studies in Environmental Management at Deakin University and was about to embark on a new career when his untimely death occurred. At university Ken was always challenging us (both staff and peers) about our commitment to environmental conservation. His philosophy was deeply pragmatic, but also one of concern and caring, and he brought to his classes a wonderful breadth of experience which enriched the learning environment. Ken's love of nature and his expertise in indigenous flora meant he was an obvious choice as another person from Deakin University who was recommended for the FNCV Council by President Wallis! Indeed, it was Ken who organised the removal of the trees and exotic vegetation around the Club's premises at 1 Gardenia Street. Council had already decided to replace the plants with a landscape of native species, but action was urgently needed when we received advice that the elder trees on the south wall were starting to cause structural damage to the building. It was Ken who organised his band of helpers and today we all appreciate the planning and very hard work he put into the new garden.

Ken did other things for the Club in his typically modest way. For instance, I recall that Council received correspondence from a local primary school seeking advice about their own landscaping and our possible involvement in their environmental studies programs. Ken agreed to be our liaison person and his efforts there were greatly appreciated.

To Ken's partner Tania Enright and their son Liam we extend our deepest sympathy. Ken will be sorely missed by us all. However, each time I enter the clubrooms and appreciate the *Correas* at the entrance I will be remember Ken's efforts, his humanity and his love of nature.

Rob Wallis
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The
Victorian Naturalist

F.N.C.V.

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Index to Volume 116, 1999 is in the centre of this issue

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Cover: The Bilby *Macrotis lagotis*, Australia's replacement for the Easter bunny. See story on page 68. Photo by Helen McCracken.

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Allelopathic Effects of Sweet Pittosporum *Pittosporum undulatum* Vent. on the Germination of Selected Native Plant Species

Amanda Tunbridge[1], Dianne Simmons[1] and Robyn Adams[1,2]

Abstract
The successful invasion of *Pittosporum undulatum* and displacement of native understorey plant species has been partially attributed to allelopathic effects. This study examined the effects of *Pittosporum* leaf-extract on the germination of *Acacia* spp., *Eucalyptus viminalis* subsp. *pryoriana*, *Leptospermum continentale*, *Kunzea ericoides*, *Poa morrisii*, *Triticum* sp., *Ozothamnus ferrugineus*, and *Pittosporum undulatum*. No germination was recorded for the latter two species for either treated or untreated seeds. Only *Poa morrisii* showed suppression of germination, while treatment with leaf-extract increased germination in *Eucalyptus*. The allelopathic effects recorded for the other species examined are insufficient to explain the decline in native species cover and diversity under *Pittosporum* canopies. The most likely explanation for the successful invasion of *Pittosporum* is the species' competitive ability rather than any allelopathic effect. (*The Victorian Naturalist* **117** (2), 2000, 44-50.)

Introduction

Allelopathy refers to any direct or indirect, harmful or beneficial, effect by one plant on another through the production of chemical compounds that are released into the environment (Rizvi and Rizvi 1992). Allelopathic effects are distinct from competition effects, but it is often difficult to distinguish between them (Weidenhamer 1996). Competition is considered to be the removal or reduction of some factor shared by other organisms (Rice 1974). Plant components known to produce inhibitors of seed germination include stems, leaves, roots, flowers, fruits and seeds (Rice 1974). The processes that allow inhibitors to be released into the environment include volatilization, leaching of water soluble chemicals through rainfall or dew, exudation from roots, and the decay of plant material (Rice 1974). In higher plants, these allelochemicals include water soluble organic acids, phenols, terpenes, glucosides, amino acids, tannins and sugars (Rizvi and Rizvi 1992; Noor *et al.* 1995).

Decomposing plant residues contribute most of the effective allelopathic substances in the environment (Gonzalez *et al.* 1995), and microorganisms are the principle agents which both liberate and inactivate phytotoxins during this decay process (Gonzalez *et al.* 1995). Rabotnov (1974 in Gonzalez *et al.* 1995) suggests that allelopathy is an effect which is mainly observed between species from different areas, or under conditions in which the soil microorganisms are not capable of destroying the metabolic toxins. This suggests that the soil biota is unable to detoxify allelochemicals which are new to their environment. New allelochemicals may be introduced to soils when a species invades an area, and consequently allelopathy has been examined as a possible explanation for the decline in native species diversity in areas being invaded by environmental weeds (Archibold *et al.* 1997; Dietz *et al.* 1996; Gentle and Duggin 1997; McCarthy and Hanson 1998).

Sweet Pittosporum *Pittosporum undulatum* Vent. has a natural range that extends seawards of the Great Dividing Range from Brisbane to Western Port Bay, Victoria, reaching altitudes of approximately 400 m (Gleadow and Ashton 1981). It is common in a variety of habitat types such as wet and dry forests, riparian, and coastal communities (Mullett and Simmons 1995). *Pittosporum undulatum* has now invaded areas outside this natural range and has become widespread throughout Victoria, in other States, and in many countries overseas (Cronk and Fuller 1995), where it invades indigenous vegetation (Mullett and Simmons 1995) and acts as a serious environmental weed (Mullett 1996).

The invasion of *P. undulatum* into native remnants has had detrimental ecological impacts associated with the floristic composition of communities (Mullett 1993). A

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Table 1. Species and lifeforms of species displaced by high *Pittosporum undulatum* cover and abundance. Life-forms follow Society for Growing Australian Plants Maroondah (1993).

Family	Species	Common name	Life-form
Myrtaceae	*Eucalyptus viminalis* subsp. *pryoriana* (L.A.S.Johnson) Brooker & Slee	Coastal Manna Gum	Tree (med - tall)
	Kunzea ericoides . (A.Rich.) Joy Thomps.	Burgan	Shrub (large)
	Leptospermum continentale Joy Thomps.	Prickly Tea-tree	Shrub (large)
Mimosaceae	*Acacia implexa* Benth.	Lightwood	Tree (small - med)
	Acacia melanoxylon R.Br	Blackwood	Tree (med - tall)
	Acacia mearnsii De Wild.	Black Wattle	Tree (small - tall)
	Acacia paradoxa DC.	Hedge Wattle	Shrub (large)
Asteraceae	*Ozothamnus ferrugineus* (Labill.) Sweet	Tree everlasting	Shrub (med - tall)
Poaceae	*Poa morrisii* Vickery	Velvet Tussock Grass	Grass (tussock)
	Triticum sp. L.	Wheat	Grass
Pittosporaceae	*Pittosporum undulatum* Vent	Sweet Pittosporum	Tree (small - med)

reduction in the floristic and structural diversity of indigenous vegetation at invaded sites (Mullett 1996), as well as a significant reduction in cover and abundance, are immediately evident impacts associated with *P. undulatum* invasions (Mullett 1993). The shade cast by the canopy of *P. undulatum* in invaded areas suppresses the light-demanding native understorey species (Gleadow and Ashton 1981), as cover, abundance and diversity of indigenous species declines in response to increasing cover of *P. undulatum* (Mullett and Simmons 1995; Rose and Fairweather 1997; Mullett 1996).

Allelopathic effects have also been suggested as an explanation for this reduction in the cover and diversity of native vegetation. Gleadow and Ashton (1981) tested the litter and leachates from the foliage of *P. undulatum,* and reported that leaf litter significantly inhibited the germination of several eucalypt species.

Although no other investigations have been carried out to determine any allelopathic effects of *P. undulatum*, allelopathy has continued to be used to explain the decline in diversity of indigenous species in sites invaded by *Pittosporum* (Mullett and Simmons 1995; Mullett 1996; Rose and Fairweather 1997). Most 'evidence' is circumstantial. For example, Richardson and Brink (1985) observed that no seedlings of *P. undulatum,* or any other species, are found beneath mature *P. undulatum* trees, and suggested this was due to the high resin, oil and saponin content of the foliage which inhibits the germination and growth of other plants in close proximity. Dean *et al.* (1986) also observed that *P. undulatum* seedlings do not germinate under their own canopy, and suggested this was the result of chemical inhibition rather then light requirements, as *P. undulatum* is able to germinate under the canopy of other trees. Macdonald and Richardson (1986) observed that allelopathy has become evident where *P. undulatum* has invaded scrub and forest patches in parts of the fynbos biome in southern Africa. They suggest allelopathy because *P. undulatum* is capable of invading apparently undisturbed forest patches, and the presence of *P. undulatum* appears to retard the germination and establishment of indigenous species.

Clearly, there is a need to determine if the impact of *P. undulatum* on native species is due to allelopathic effects, to competition effects, a combination of allelopathy and competition, or other effects of *Pittosporum* invasion on essential ecosystem processes. This paper outlines some preliminary findings concerning the allelopathic effects of *Pittosporum* leaf leachates on the germination of selected native species.

Methods

The allelopathic effects of *P. undulatum* were assessed using standard bioassay techniques. Indigenous species known to occur in areas affected by *P. undulatum*

Table 2. Final percentage germination of untreated *Acacia* seeds and *Acacia* seeds treated with *Pittosporum* leaf-extract. Comparisons are significantly different at p<0.05.

Species	Final % Germination	
	Treated	Untreated
Acacia melanoxylon	91	77
Acacia implexa	82	72
Acacia mearnsii	59	41
Acacia paradoxa	57	49

infestations were chosen from surveys conducted at Woods Reserve on the Mornington Peninsula, Victoria (Mullett 1993) and Heany Park in the Dandenong Ranges, Victoria (Mullett and Simmons 1995). The floristic data presented (Mullett 1993; Mullett and Simmons 1995) were used to determine native species that are present with low *P. undulatum* infestations, but are displaced by higher *P. undulatum* cover and abundance. Species chosen also depended on commercial availability of seed and short germination times. Nine native species from four different families and three different 'life-forms' were used (Table 1), as well as *Triticum* sp., a species commonly used in allelopathic assays. *Pittosporum undulatum* seeds were also used to examine any allelopathic effects on the germination of *P. undulatum* itself. Common names of all species are given in Table 1.

Fresh, mature *P. undulatum* leaves were collected, roughly chopped and left in distilled water for 24 hours at the rate of 200 g/litre (Kil and Yun 1992). The extract was filtered, and the leaf material discarded. The filtered solution and a distilled water control were stored in plastic bottles at 2°C before assaying (Chaturvedi and Jha 1992).

For each species, 20 seeds were placed in 10 petri dishes on Whatman No. 2 filter paper. Five petri dishes were treated with the *Pittosporum* leaf-extract ('treated'), and five with distilled water ('untreated'). All seeds were treated with an antifungal solution at the rate of 1:20 distilled water at the beginning of the experiment (Noor *et al.* 1995). At day five, seeds of *Eucalyptus viminalis* subsp. *pryoriana* (L.A.S. Johnson) Brooker & Slee, *Ozothamnus ferrugineus* Vickery and *Pittosporum undulatum* were again treated with the antifungal solution. *Acacia* seeds were heat treated with boiling water 24 hours before germination tests began.

The covered petri dishes were placed in a growth cabinet for 27 days at 20°C. Seeds were checked every 2-3 days and watered as needed. Seeds were considered to be germinated when the radicle just protruded beyond the seed coat, and were discarded once counted (Warrag 1994). Germination percentages were arc-sine transformed and compared using a t-test.

Results

Pittosporaceae and Asteraceae

At the termination of the tests, *Ozothamnus ferrugineus* had just begun to germinate, with treated seeds recording 2% germination, but no germination in untreated seeds. Although optimum germination temperatures for *Pittosporum undulatum* are between 18-21°C (Gleadow 1982), no germination of either treated or untreated seed of *Pittosporum undulatum* was recorded by 27 days. The lack of *Pittosporum undulatum* germination for either treatment is probably due to the short time-frame of the trial, as Mullett (unpublished) subsequently found germination time to be population dependent and to vary between 23 days to 34 days. The results for seeds of *Ozothamnus ferrugineus* may also be due to insufficient time for germination.

Mimosaceae

The exposure of *Acacia* seeds to *Pittosporum* leaf-extract did not delay the onset of germination (Fig. 1a-d). For each of the four species, the final percentage germination achieved was significantly higher (p<0.05) in treated seeds compared to the untreated seeds (Table 2). For *Acacia implexa* Benth. only, the time taken to achieve final percentage germination was also decreased from 16 days in the untreated seeds to 9 days in the treated seeds.

Poaceae

Exposure of *Triticum* seeds to *Pittosporum* leaf-extract did not alter the time to onset of germination and had no significant effect (p>0.05) on the final percentage germination achieved (Fig. 2a). However treated seeds reached maximum germination five days earlier than untreated seeds.

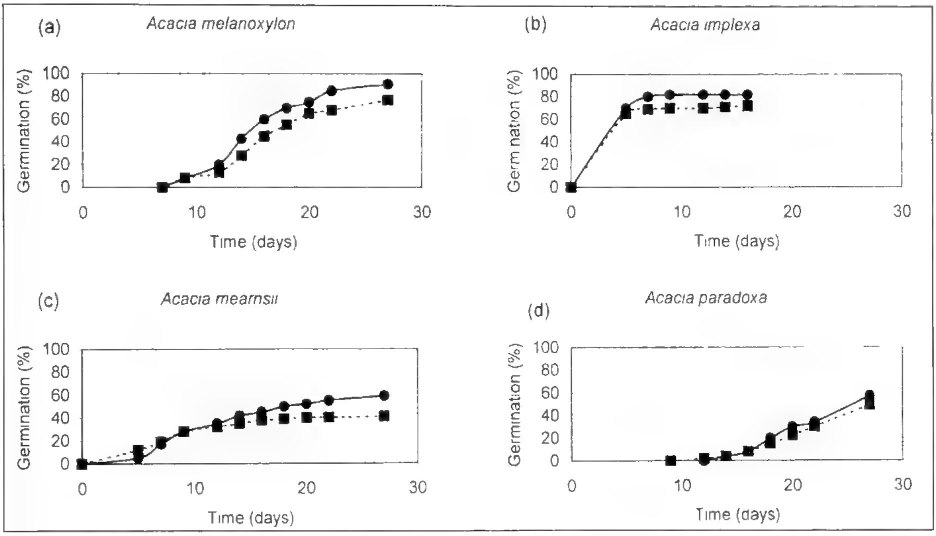

Fig. 1. Germination of untreated (■) seeds of (a) *Acacia melanoxylon*, (b) *Acacia implexa*, (c) *Acacia mearnsii* and (d) *Acacia paradoxa*, and *Acacia* seeds treated (●) with *Pittosporum* leaf-extract.

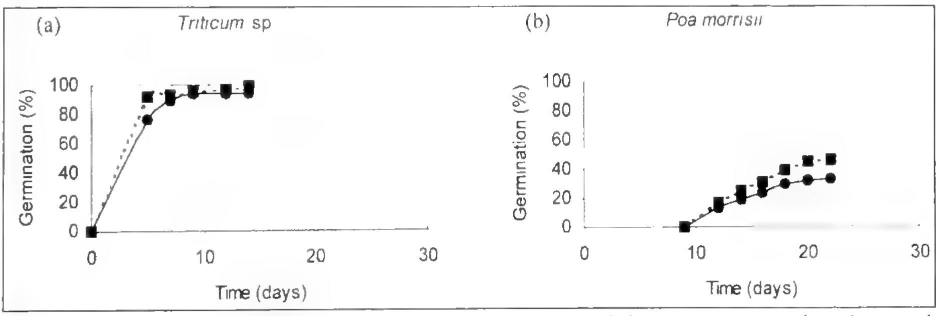

Fig. 2. Germination of untreated (■) seeds of (a) *Triticum* sp. and (b) *Poa morrisii* and seeds treated (●) with *Pittosporum* leaf-extract.

For *Poa morrisii*, the time taken to the onset of germination and the rate of germination were not different between treated and untreated seeds (Fig. 2b). However, the final percentage germination was significantly less ($p<0.05$) for the treated seeds (33%) compared to the untreated seeds (46%).

Myrtaceae

Exposure of seeds of *Leptospermum continentale* Joy Thomps. and *Kunzea ericoides* (A.Rich.) Joy Thomps. to *Pittosporum* leaf-extract had no significant effect ($p>0.05$) on the final germination percentage achieved, although germination of the treated seeds was delayed by 4 to 6 days (Fig. 3a, b).

Exposure of seeds of *Eucalyptus viminalis* subsp. *pryoriana* to *Pittosporum* leaf-extract appeared to stimulate seed germination (Fig. 3c). Treated seeds began germination at day five, and had achieved 50% germination by day 10. Untreated seeds did not begin germination until day 12 and 50% germination had not been achieved by the termination of the trial at day 27. The maximum percentage germination was significantly higher ($p<0.05$) for treated seeds (70%) compared to untreated seeds (33%).

Discussion

The rapid expansion and dominance of environmental weeds into native communities is often difficult to explain, and competition and allelopathic interference are both mechanisms which could be responsible

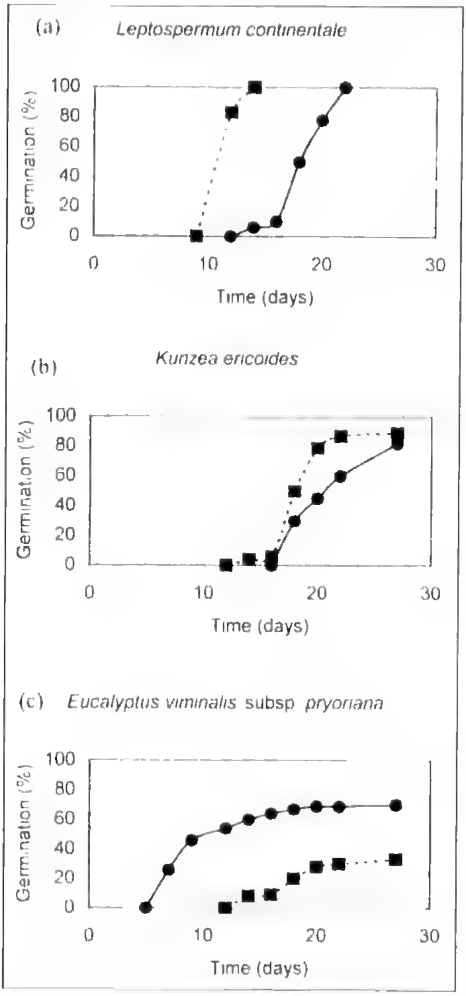

Fig. 3. Germination of untreated (■) seeds (a) *Leptospermum continentale*, (b) *Kunzea ericoides* and (c) *Eucalyptus viminalis* subsp. *pryoriana* and seeds treated (●) with *Pittosporum* leaf-extract.

(Weidenhamer 1996). Many different species show clear phytotoxic effects on their neighbours (Gonzalez *et al.* 1995; Al-Humaid and Warrag 1998; Chick and Kielbaso 1998), and allelopathic effects of *Pittosporum* have been suggested to explain the low native species diversity (Gleadow and Ashton 1981; Mullett and Simmons 1995; Rose and Fairweather 1997) and lack of *Pittosporum* seedlings, under mature *Pittosporum* canopy (Dean *et al.* 1986; Richardson and Brink 1985). However, the phytotoxic effects of *Pittosporum undulatum* leaf-extract on germination of selected native species in this experiment varied considerably. *Poa morrisii* was the only species to show a significantly reduced final percentage germination of seeds treated with *Pittosporum* leaf-extract.

For the species tested in the Mimosaceae and Poaceae, the time to the onset of germination was not altered by treatment with *Pittosporum* leaf-extract, and the final maximum germination percentage achieved was either comparable, or higher, in treated seeds than in untreated seeds. For *Triticum* sp. treated seeds completed germination about five days earlier than untreated seeds, but final percentage germination was not significantly different. In the Myrtaceae, treated seeds of *Leptospermum continentale* and *Kunzea ericoides* tended to germinate about 5 days later than untreated seeds.

The germination response of *Eucalyptus viminalis* subsp. *pryoriana* was quite different compared to the other species tested, and different to the response of the three *Eucalyptus* species examined by Gleadow and Ashton (1981). Treated seeds germinated up to seven days earlier than untreated seeds and maximum percentage germination was significantly higher (70%). This is unexpected, as Gleadow and Ashton (1981) reported that *Pittosporum* leaves suppressed germination in *Eucalyptus obliqua* (47.1%), *Eucalyptus melliodora* (8.1%) and *Eucalyptus goniocalyx* (48.3%). However, Gleadow and Ashton (1981) also note that 'no demonstrable inhibitory effects, other than that expected from deep shade, have been shown under [*Pittosporum*] canopies in the field'.

From these results there is little evidence of a phytotoxic effect sufficient to explain the decline in species cover and diversity under mature *Pittosporum*. Other environmental weeds which have been investigated for allelopathy, including *Bunias orientalis* (Dietz *et al.* 1996), *Alliaria petiolata* (McCarthy and Hanson 1998) and *Rhamnus carthartica* (Archibold *et al.* 1997), have shown few effects sufficient for allelopathy to be accepted as a primary interference mechanism (McCarthy and Hanson 1998). It is more likely that the success of many environmental weeds is due to their strong competitive capacity (Al-Naib and Rice 1971; Dietz *et al.* 1996;

McCarthy and Hanson 1998), high reproductive rates and efficient dispersal (Archibold *et al.* 1997).

The competitive ability of *Pittosporum* is also likely to be more significant in determining this species' invasive success. Like *R. carthatica* (Archibold *et al.* 1997), *Pittosporum* has a high reproductive rate and is efficiently dispersed by birds. Low light penetration under *P. undulatum* canopies is positively correlated with a reduction in indigenous species cover and diversity (Mullett and Simmons 1995), suggesting that competition for light may be a primary interference factor. Other competition factors such as water, temperature or nutrients may also be important. Gleadow and Ashton (1981) suggested that the higher litter return and nutrient status of soils under *Pittosporum* may not favour sclerophyll shrubs adapted to poorer soils. This alteration in soil fertility has also been recorded for soils invaded by *Bunias* (Dietz *et al.* 1996), where test species achieved higher than predicted growth due to higher levels of nutrients and organic matter.

The results of this study indicate that *Pittosporum* leaf-extracts suppress germination in few species. Only *P. morrisii* showed a significant reduction in germination, while *E. viminalis* subsp. *pryoriana* and the *Acacia* species showed increased germination. There were some effects on the times elapsed to reach final germination, but the ecological significance of this, if any, is uncertain. Thus, although laboratory bioassays can indicate potential allelopathic effects, these need to be extrapolated to the field with great caution (Hershey 1996). The presence of allelopathic effects does not prove that allelopathy occurs under natural conditions (Inderjit and Dakshini 1995; Noor *et al.* 1995). For example, leaf extracts of *B. orientalis* had strong inhibitory effects on laboratory germination of seeds, but field testing showed few significant phytotoxic effects (Dietz *et al.* 1996). The most likely explanation for the success of *P. undulatum* invasion into native plant communities is its competitive ability rather than allelopathic interference.

References

Al-Humaid, A.I. and Warrag, M.O.A. (1998) Allelopathic effects of mesquite (*Prosopis juliflora*) foliage on seed germination and seedling growth of bermudagrass (*Cynodon dactylon*). *Journal of Arid Environments* **38**, 237-243.

Al-Naib, F.A. and Rice, E.L. (1971). Allelopathic effects of *Platanus occidentalis*. *Bulletin of the Torrey Botanical Club* **98**, 75-82.

Archibold, O.W., Brooks, D. and Delanoy, L. (1997). An investigation of the invasive shrub European Buckthorn, *Rhamnus carthartica* L., near Saskatoon, Saskatchewan. *Canadian Field Naturalist* **111**, 617-621

Chaturvedi, O.P. and Jha, A.N. (1992). Studies on allelopathic potential of an important agroforestry species. *Forest Ecology and Management* **53**, 91-98.

Chick, T.A. and Kielbaso, J.J. (1998). Allelopathy as an inhibition factor in ornamental tree growth: implications from the literature. *Journal of Arboriculture* **24**, 274-279.

Cronk, Q.C.B. and Fuller, J.L. (1995). 'Plant Invaders: the Threat to Natural Ecosystems'. (Chapman & Hall: London.)

Dean, S.J., Holmes, P.M. and Weiss, P.W. (1986). Seed biology of invasive alien plants in South Africa Namibia. *In* 'The Ecology and Management of Biological Invasions in South Africa', pp. 157-171. Eds I.A.W. MacDonald, F.J. Kruger and A.A. Ferrar. (Oxford University Press: Cape Town.)

Dietz, H., Steinlein, T., Winterhalter, P. and Ullmann, I. (1996). Role of allelopathy as a possible factor associated with the rising dominance of *Bunias orientalis* L. (Brassicaceae) in some native plant assemblages. *Journal of Chemical Ecology* **22**, 1797-1811.

Gentle, C.B. and Duggin, J.A. (1997). Allelopathy as a competitive strategy in persistent thickets of *Lantana camara* L. in three Australian forest communities. *Plant Ecology* **132**, 85-95

Gleadow, R.M. (1982). Invasion by *Pittosporum undulatum* of the forests of Central Victoria. II Dispersal, germination and establishment. *Australian Journal of Botany* **30**, 185-198.

Gleadow, R.M. and Ashton, D.H. (1981). Invasion by *Pittosporum undulatum* of the forests of Central Victoria. I. Invasion patterns and plant morphology. *Australian Journal of Botany* **29**, 705-20.

Gonzalez, L., Souto, X.C. and Reigosa, M.J. (1995) Allelopathic effects of *Acacia melanoxylon* R.Br phyllodes during their decomposition. *Forest Ecology and Management* **77**, 53-63.

Hershey, D.R. (1996). Allelopathy experiment pitfalls. *Journal of Biological Education* **30**, 13-14.

Inderjit and Dakshini, K.M.M. (1995). On laboratory bioassays in allelopathy. *The Botanical Review* **61**, 28-44.

Kil, B. and Yun, KW. (1992). Allelopathic effects of water extracts of *Artemisia princess* var. *orientalis* on selected plant species. *Journal of Chemical Ecology* **18**, 39-51.

McCarthy, B.C. and Hanson, S.L. (1998). An assessment of the allelopathic potential of the invasive weed *Alliaria petiolata* (Brassicaceae). *Castanea* **63**, 68-73.

Macdonald, I.A.W. and Richardson, D.M. (1986). Alien species in terrestrial ecosystems of the fynbos biome. *In* 'The Ecology and Management of Biological Invasions in South Africa', pp. 77-93. Eds I.A.W. MacDonald, F.J. Kruger and A.A. Ferrar. (Oxford University Press: Cape Town.)

Mullett, T.L. (1993). 'The impacts of *Pittosporum undulatum* Vent. (Sweet *Pittosporum*) invasion on selected native vegetation communities'. B.Sc.(Hons) thesis. (School of Ecology and Environment, Deakin University: Victoria.)

Mullett, T.L. (1996). Ecological aspects of Sweet Pittosporum (*Pittosporum undulatum* Vent.): Implications for control and management. Proceedings of the 11th Australian Weeds Conference, Melbourne. pp 489-492.

Mullett, T. and Simmons, D. (1995). Ecological impacts of the environmental weed Sweet Pittosporum (*Pittosporum undulatum* Vent.) in dry sclerophyll forest communities, Victoria. *Plant Protection Quarterly* **10**,131-138.

Noor, M., Salam, U. and Khan, M.A. (1995). Allelopathic effects of *Prosopis juliflora* Swartz. *Journal of Arid Environments* **31**, 83-90.

Rabotnov, T.A. (1974). On the allelopathy in the phytocenoses. *Izv. Ikad. Nauk SSSR Ser. Biol.* **6**, 811-820. (In Polish with English abstract.)

Rice, E.L. (1974). 'Allelopathy'. (Academic Press: New York.)

Richardson, D.M. and Brink, M.P. (1985). Notes on *Pittosporum undulatum* in the south western Cape. *Veld and Flora* **71**, 75-7.

Rizvi, S.J.H. and Rizvi, V. (1992). 'Allelopathy'. (Chapman and Hall: London).

Rose, S. and Fairweather, P.G. (1997). Changes in floristic composition of urban bushland invaded by *Pittosporum undulatum* in northern Sydney, Australia. *Australian Journal Botany* **45**, 123-149.

Society for Growing Australian Plants Maroondah (1993). 'Flora of Melbourne'. (Hyland House: South Melbourne.)

Warrag, M.O.A. (1994). Autotoxicity of mesquite (*Prosopis juliflora*) pericarps on seed germination and seedling growth. *Journal of Arid Environments* **27**, 79-84.

Weidenhamer, J.D. (1996). Distinguishing resource competition and chemical interference: overcoming the methodological impasse. *Agronomy Journal* **88**, 886-875.

Orange Hawkweed *Hieracium aurantiacum* L.: a New Naturalised Species in Alpine Australia

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Abstract

Orange Hawkweed *Hieracium aurantiacum* L. is a new species for mainland Australia. It has been planted at Falls Creek and potentially threatens subalpine communitites. Efforts are underway to control the species. (*The Victorian Naturalist* **117** (2), 2000, 50-51.)

Orange Hawkweed *Hieracium aurantiacum* L.: Perennial stoloniferous herb, leaves to 15 cm, basal, oblanceolate and hairy, flowering stems erect (15-40 cm), inflorescence cymose, capitula 2-12(-25), ligules orange-brown to purple, pappus of achenes with stiff, white bristles to 6 mm long (see Webb *et al.* 1988). *North and central Europe, mainly in the mountains; widely naturalised on roadsides and railway banks throughout the British Isles* (Clement and Foster 1994).

Alpine areas are amongst Australia's least weed invaded areas (Humphries *et al.* 1991; Carr 1993), despite more than 100 years of summer grazing and 40 years of hydroelectricity generation, skiing and tourism. The cold and extreme environment is likely to have prevented many exotic species from invading alpine ecosystems. In many alpine resorts in Victoria, however, deliberate plantings of exotic species occur around ski lodges to 'beautify' the surroundings. These amenity plantings have already introduced new (and potentially well-adapted) species that may invade alpine vegetation, and continued plantings will create more opportunities for this to occur. Recently, a **new naturalised genus for mainland Australia** has been observed growing at Falls Creek, and its original source of introduction is that of a 'cottage' garden planting. The consequences for nature conservation could be dire.

Hieracium aurantiacum (Asteraceae; Fig. 1), a species native to the mountains of northern and central Europe and widely naturalised in New Zealand and elsewhere, has been observed growing in disturbed roadside and skifield vegetation and Snowgum *Eucalyptus pauciflora* heathy woodland at 1600 m asl in the Falls Creek ski village. At least 10 discrete populations (>500 individuals) are known, with some more than 1 km from the presumed source (N. Williams *pers. comm.*). Attempts are being made to eradicate the species using a combination of herbicides and hand-pulling.

The genus is classed as prohibited by the Australian Quarantine and Inspection Service (AQIS 1996), meaning that all species of *Hieracium* are, where possible, prevented from entering the country. Until now, no naturalised *Hieracium* species were known to occur in mainland Australia, although it occurs in Tasmania (Groves 1999). Undoubtedly the population at Falls Creek has been derived from a cultivated garden specimen; a quick glance at mail order catalogues in some interna-

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Fig. 1. Orange Hawkweed *Hieracium aurantiacum* growing at Falls Creek, December 1999. This is the first record of a naturalised population of the genus on mainland Australia.

tional gardening magazines and World Wide Web pages suggests that Hawkweeds are readily available to Australian gardeners. Indeed, one West Australian nursery has been selling the species despite its status (see www.agric.wa.gov.au/progserv/plants/weeds/hawkweed.htm)!

Hieracium aurantiacum appears to be a good candidate for becoming more widely spread in alpine plant communities. It has a strongly stoloniferous growth habit and small, wind-dispersed seeds that appear readily germinable in the subalpine environment, albeit in (mostly) disturbed sites at present. The plant is perennial and appears to be capable of occupying a large proportion of the groundlayer due to clonal growth.

That we should be concerned about the potential impact of *H. aurantiacum* can be demonstrated by considering the impact in New Zealand by other species in the genus. *Hieracium pilosella* and *H. lepidulum* are serious weeds of montane and subalpine areas in the South Island where they carpet the intertussock spaces of native *Festuca* grassland communities and displace the intertussock vegetation (Rose *et al.* 1995; AQIS 1996; J. Morgan *pers. observ.*).

Whilst *H. aurantiacum* may ultimately never threaten alpine vegetation in Victoria, there is an important point to be made: the dispersal barrier for this species into the alps (and more generally, Australia) has now been broken and it is now much more likely to be an invasive threat than if it had never been planted in the resort in the first instance. If we are to be serious about preventing the establishment of environmental weeds into the Victorian alps, then we should minimise the chances of their introduction by preventing their deliberate planting in resort gardens. This means developing and implementing a comprehensive policy on exotic plant introductions for all Victorian ski resorts. Quickly!

Acknowledgements

Richard Groves made me aware of the invasion by *H. aurantiacum* at Falls Creek, first discovered by Nicole Middleton and School of Botany students from University of Melbourne. Nick Williams has recorded new populations of the species and been active in the dissemination of information about the species. Bob Parsons and Warwick Papst helped improve the manuscript. The Falls Creek Management Board is thanked for its quick response to the news that the resort harbours the Victorian type specimen for the species.

References

Australian Quarantine and Inspection Service (1996). Plant quarantine leaflet No. 60. Hawkweeds (*Hieracium* spp.). (Australian Government Publishing Service, Canberra.)

Carr, G.W. (1993). Exotic flora of Victoria and its impact on indigenous biota. *In* 'Flora of Victoria. Volume 1. Introduction', pp. 256-297. Eds D.B. Foreman and N.G. Walsh. (Inkata Press: Melbourne.)

Clement, E.J. and Foster, M.C. (1994). 'Alien Plants of the British Isles'. (Botanical Society of the British Isles: London.)

Groves, R. (1999). Sleeper weeds. *In* '12th Australian Weeds Conference Papers and Proceedings', pp. 632-636. Eds A.C. Bishop, M. Boersma and C.D. Barnes. (Tasmanian Weed Society: Devonport.)

Humphries, S.E., Groves, R.H., Mitchell, D.S., Hallegraeff, G.M. and Clark, J. (1991). 'Plant Invasions'. (CSIRO: Canberra.)

Rose, A.B., Platt, K.H. and Frampton, C.M. (1995). Vegetation change over 25 years in a New Zealand short-tussock grassland: effects of sheep grazing and exotic invasions. *New Zealand Journal of Ecology* **19**, 163-174

Webb, C.J., Sykes, W.R. and Garnock-Jones, P.J. (1988). 'Flora of New Zealand. Volume IV. Naturalised Pteridophytes, Gymnosperms, Dicotyledons'. (Department of Scientific and Industrial Research: Christchurch.)

Plant Invasions in the High Mountains of North-Eastern Victoria

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Abstract

In surveys of Victorian ski resorts since 1980, 113 weed species have been recorded. Less than half of these species have been recorded in the natural vegetation of the surrounding treeless plains. The number of species that have been consciously introduced is greater at Falls Creek and Mt Buffalo than at other ski resorts. This can probably be attributed to the greater summer use at Falls Creek and Mt Buffalo and particularly to the exotic gardens there, which contain species selected for their cold-hardiness. We suggest that the intentional introduction of exotic plants to ski resorts, which are surrounded by National Park, may threaten the natural values of the Victorian high country. It may not be possible to recommend any non-invasive exotic plants for amenity plantings in ski resorts because of the long time taken for plants to reproduce in some cases and the lack of data on invasive potential in most cases. (*The Victorian Naturalist* **117** (2), 2000, 52-59.)

Introduction

In reviewing environmental weeds in Australia, Humphries *et al.* (1991) rated alpine ecosystems, amongst others, as being least at risk of invasion. Whilst this assessment may be true, it is important that it is not misinterpreted. Low risk of plant invasion does not mean no risk of invasion. Several exotic species already occur commonly in a wide range of alpine plant communities, and one, English Broom *Cytisus scoparius*, has recently made major incursions into sub-alpine woodland (Fallavollita and Norris 1992). With the proximity of ski resorts to natural alpine and sub-alpine vegetation, and the increased use of high mountains for summer recreation, the likelihood of further invasions may be increasing.

The potential losses in biodiversity values are monumental if significant invasions were to occur. More than 10% of Victoria's flora has been recorded in treeless high mountain plains and almost 60% of these (i.e. 250 species) are restricted to high country vegetation (McDougall 1997).

In this paper we present the results of field surveys of weeds in alpine and sub-alpine ski-field areas in Victoria to emphasise that, even if the risk of invasion in alpine ecosystems is less than in some other ecosystems, it is still significant and probably growing.

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The Data Used

Lists of weeds were made during summer visits to Victoria's ski resorts between 1980 and 1998. The sampling was biased. Many visits were made to Falls Creek, Dinner Plain and Hotham Heights in the course of other activities. A half day was spent at each of the other resorts (Mount Buffalo (Chalet area), Baw Baw ski village and Mount Buller) in February 1992. All of the ski resorts have boundaries with natural vegetation in National Parks. All are situated in sub-alpine woodland, although parts of Falls Creek, Hotham Heights and Mt Buller are adjacent to alpine plant communities.

In this paper, a weed is a plant that is not likely to occur naturally in Victorian alpine and sub-alpine vegetation and which was found growing in a place where it had not been planted. Although unequivocal for non-Australian plants, the status of native Australian species, which are common in natural vegetation at lower altitudes but not known in alpine plant communities, may be unclear. Plants in maintained ski resort gardens were not included in the survey, although some species are considered to be potential weeds.

Weeds occurring in natural alpine vegetation were compiled from the surveys of McDougall (1982) and Walsh *et al.* (1984) and personal observations over the past 20 years. On the margins of ski resorts, it was sometimes difficult to determine what was natural vegetation, as run-off from roads and developments can significantly alter soil nutrient characteristics and contribute to localised infestations in otherwise natural vegetation. Excluded from our list of weeds in native vegetation were species growing in apparently natural vegetation less than about 100 m from ski resort developments.

The two floristic surveys used to compile the list of weeds in native vegetation (McDougall 1982, Walsh *et al.* 1984) treated alpine vegetation as that occurring in treeless areas at high altitude, even if it was surrounded by trees and effectively in the sub-alpine zone. This treatment of alpine vegetation is also adopted in the current paper.

Species nomenclature follows Ross (1996) for species native to or naturalised in Victoria, and Huxley (1992) for horticultural species not naturalised in Victoria.

Results and Discussion

Fifty weed species have been recorded in high mountain treeless vegetation in Victoria. One hundred and thirteen weed species were recorded in Victorian ski resorts (Appendix 1).

Falls Creek and Mount Buffalo (Chalet area) were found to have by far the most weed species (Table 1). Since Mount Buffalo was one of the resorts with the least intensive sampling and Hotham Heights and Dinner Plain were two of the resorts with the most, the difference in species numbers is not solely attributable to sampling bias. The number of weed species of ski resorts that have also been recorded in alpine native vegetation beyond resort boundaries by McDougall (1982) and Walsh *et al.* (1984) was similar for all resorts. Of the weeds that have not yet been found in native vegetation, Falls Creek and Mount Buffalo had more than twice the number of any other resort (Table 1). Many of these species are likely to have been consciously brought to the two resorts. This may include species planted in gardens, species used in revegetation of ski slopes, and food plants eaten and discarded by humans.

Falls Creek and Mount Buffalo Chalet are the only resorts with extensive maintained gardens and considerable summer use. There is strong evidence to suggest that some of the weeds originated from horticultural plantings in resort gardens. The following weeds of Falls Creek and Mount Buffalo Chalet area were also seen in maintained gardens: Columbine *Aquilegia vulgaris*, Feverfew *Chrysanthemum parthenium*, Montbretia *Crocosmia* X *crocosmiiflora*, Sweet William *Dianthus barbatus*, Tall Bearded Iris *Iris* X *germanica*, Yellow Archangel *Lamium galeobdolen*, Shasta Daisy *Leucanthemum maximum*, Lupin *Lupinus* X Russell Hybrid, Spearmint *Mentha spicata*, and Periwinkle *Vinca minor*. Of these, *A. vulgaris*, *C. parthenium*, *D. barbatus*, *Lupinus* X Russell Hybrid and *M. spicata* had invaded native vegetation adjacent to Falls Creek village, although only *A. vulgaris* and *M. spicata* have so far been found in montane or subalpine areas some distance away.

Whilst many of the plants in ski village gardens are likely to have originated from commercial nurseries, some may not have. In one instance, a weed of roadsides in the montane zone (Coreopsis *Coreopsis lanceolata*) was observed being relocated to a ski-resort garden. This species has not yet

Table 1. Number of weed species found in each ski resort, the number also recorded in native vegetation, and the number of introductions that are incidental or non-incidental (excluding those species also found in natural vegetation). The incidental category includes species commonly found on waste ground and species of uncertain origin. The non-incidental category includes species that are likely to have been consciously brought to the mountains for amenity planting, soil conservation work or as food.

Resort	Total weed species	Also in native vegetation	Incidental introductions	Non-incidental introductions
Baw Baw	32	22	9	1
Dinner Plain	31	23	8	0
Falls Creek	59	29	15	15
Hotham Heights	36	26	8	2
Mt Buffalo	55	22	21	12
Mt Buller	35	21	9	5

been recorded as a weed of ski villages.

Most weeds in ski resorts do not extend far into native vegetation. Very sharp boundaries exist between exotic vegetation and the drier alpine communities such as snow gum woodland and alpine grassland. Drainage features seem to be far more susceptible to invasion. Musk Monkey-flower *Mimulus moschatus*, for instance, extends well downstream from Falls Creek village into more or less undisturbed sections of the East Kiewa River in the montane (Alpine Ash) zone.

The overall weed flora of Australia's high mountain vegetation is small compared with other ecosystems of comparable disturbance (Carr 1993). There are only four weeds that occur in a variety of plant communities in the highest parts of the Victorian Alps: Brown-top Bent *Agrostis capillaris*, Cat's Ear *Hypochoeris radicata*, Dandelion *Taraxacum officinale* and White Clover *Trifolium repens*. These species may have naturalised soon after the summer use of mountains for pasture commenced, in the late part of last century, and they are widespread in a variety of Victorian ecosystems.

The range of species capable of invading alpine plant communities is likely to be limited by the climatic conditions of high mountains. Mallen-Cooper (1990) found that the diversity of weeds on roadsides in Kosciuszko National Park decreased with altitude and that some of the species common at lower altitudes in the Park were incapable of persisting within the alpine zone. The cold climate of Victoria's high country will similarly make it naturally impervious to the invasion of many frost-intolerant species.

Introductions of weed propagules into the alpine environment are made continually, however. Mallen-Cooper (1990) found that, of the species that germinated in soil from a ski resort car park in Kosciuszko National Park, 27 species could not be found as plants in the surrounding area. Twenty of these species had not previously been recorded in the subalpine or alpine area. The seed had probably arrived in mud attached to cars. Whilst none of these species may become established in the alpine area, even if conditions were favourable for germination of their seeds, it demonstrates that visitation to the Alps increases the risk of plant invasion.

Potential invaders may also arrive in the faeces of cattle, which graze much of the high country of Victoria in summer. Van Rees (1984) found that a sample of cattle faeces at the commencement of the grazing season contained the seed of eight species not recorded in alpine vegetation on the Bogong High Plains.

Not all of the potential invaders arrive inadvertently. Exotic species have been used for soil stabilisation at all ski resorts and in other places where soil has been disturbed (e.g. roadsides and hydroelectricity scheme site works such as dams and aqueducts). Three of the four species commonly used in stabilising soils (*Agrostis capillaris*, Red Fescue *Festuca rubra* and *Trifolium repens*) are commonly found in natural high mountain vegetation. *Agrostis capillaris* is abundant in some damp areas in the alpine zone and sporadically in some subalpine grassy plains. *Trifolium repens* is common in the drip zone of snow gums where cattle have traditionally congregated, and in the higher country with basaltic soil. *Festuca rubra* is rare in the alpine zone but is the dominant of at least one montane grassy plain. It is not known if these species have spread from alpine soil conservation works or have been introduced in soil or hay from lower altitudes. The fourth species (Perennial Rye-grass *Lolium perenne*) does not appear to persist at high altitudes and was not recorded in alpine communities by McDougall (1982) despite its use for several decades. Following successful trials with native alpine species (Papst *et al.* 1999), exotic species are less frequently used in soil stabilisation works.

Other exotic species have also been brought deliberately to some ski resorts. Falls Creek and Mount Buffalo have sought to attract visitors to the mountains throughout the year. The beautification of commercial lodges in these resorts has often involved the creation of exotic gardens. Many species appear to have escaped from these gardens, although few species have entered native vegetation within the resorts. A large number of naturalised garden species was similarly recorded at Thredbo ski village in New South Wales by Carr (1993). Thredbo is the principal summer-operating mountain village in the Kosciuszko area. Although exotic species were once commonly planted in ski lodge gardens at Thredbo, they are no longer permitted (Andrew Thornhill, NSW National Parks and Wildlife Service, *pers. comm.*).

The probability of species from ski resort gardens establishing in natural vegetation is likely to be much greater than that of seed attached to cars because many of the garden species will have been chosen for their cold-hardiness. The species arriving on cars have been selected at random and will include a large number of frost-intolerant species and ruderals (species commonly found in highly disturbed areas).

The potential for degradation from gardens surrounding conservation reserves has been documented elsewhere in Victoria. Sherbrooke Forest, part of the Dandenong Ranges National Park on the outskirts of Melbourne, demonstrates the invasive capacity of several species from long-established gardens surrounding the Park. Garden species such as Ivy *Hedera helix*, Holly *Ilex aquifolium*, Cherry Laurel *Prunus laurocerasus* and Sycamore Maple *Acer pseudoplatanus* have severely degraded the natural values of that Park and are now the subject of costly programs of eradication (Freshwater 1989). Like several of the species naturalising in alpine areas, most of the problem garden escapes in Sherbrooke have been selected for their suitability to the particular climatic conditions of that area (i.e. high rainfall, cool climate, dense shade).

The use of potentially invasive plants in Victorian ski resort gardens warrants attention. Russell and Teller (1994), in a review of the Alpine Resorts Commission of Victoria, recommended that

> *"All exotic garden species should initially be banned for planting in Alpine Resort gardens and existing problem species should be eradicated. A list of acceptable non-escaping garden species should be drawn up and circulated to site-holders. Exotic trees should only be planted after consultation with the local CNR officer. An action program on environmental weeds should be conducted jointly with CNR."*

The adoption of such a recommendation is likely to considerably reduce the possibility of serious plant invasions in high mountain plant communities.

The range of potential invaders planted in ski resort gardens has not been exhausted, however. Many plants from high mountain regions around the world can be purchased in local nurseries. For example, 81 largely European species featured in a handbook of alpine flowers of the world (Moggi 1985) are listed by Hibbert (1997) as available in a range of nurseries in south-eastern Australia. Few of these species appear to have been grown yet in ski resort gardens in Victoria.

Serious plant invasions are possible at high altitude. The multiple infestations of *Cytisus scoparius*, which were found recently in sub-alpine woodland east of Falls Creek (Fallavollita and Norris 1992), are a timely reminder of the speed with which significant infestations can occur, the destructive impact of such infestations on natural plant communities and the cost of repair. Two other weed species appear to have become more widespread in the natural vegetation of the Bogong High Plains in the last 20 years: Musk Monkey-flower *Mimulus moschatus* has been found recently in a number of *Sphagnum* bogs near the treeline, and Soft Rush *Juncus effusus* is now widespread on subalpine grassy plains. Neither species was noted to be a significant weed by McDougall (1982).

Although the recommendation of Russell and Teller (1994) would significantly reduce the probability of invasions from resort gardens, it may be difficult to evaluate the invasive potential of some species, particularly if they are long-lived and take many years to become reproductive. Trial conifer plantations on the Bogong High Plains were long thought to be incapable of reproduction in the alpine environment and hence to have no invasive potential. Recently however, seedlings of one of the *Pinus* species have been observed outside the original plantations. Young pines are also occasionally seen on roadsides and waste ground in Falls Creek village, although their origins are unclear. Similarly, in Kosciuszko National Park, seedlings of Lodgepole Pine *Pinus contor-*

ta, a species introduced in the 1960s for soil stabilization trials, have recently been removed from native vegetation at Charlotte's Pass.

Of the species grown in ski resort gardens that now grow beyond, it is difficult to foresee the threat that they pose for native high mountain vegetation. Without controls on introduction, however, the threat from these species can only be adequately assessed in hindsight. It may be argued that some of the garden species (Yarrow *Achillea millefolium*, Shasta Daisy *Leucanthemum maximum* and *Lupinus* X Russell Hybrid) are not a threat because they have been present for many decades in ski resorts and have not apparently spread very far beyond or appear to be restricted to roadsides and other areas of great disturbance. However, *A. millefolium* has invaded the subalpine treeless plains near Kiandra in New South Wales. The conditions required for its invasion of native vegetation may occur rarely. Some species appear to be recent escapes and are found in small populations in one or two resorts (i.e. Alstroemeria *Alstroemeria aurea*, Cotoneaster *Cotoneaster microphyllus*, Montbretia *Crocosmia X crocosmiiflora*, Ivy *Hedera helix*, Bluebells *Hyacinthoides hispanica*, Holly *Ilex aquifolium*, Yellow Archangel *Lamium galeobdolen*, Grape Hyacinth *Muscari armeniacum*, Penstemon *Penstemon* sp., Spiraea *Spiraea alba*). The threat from these is unknown but they are in low enough numbers that control may be effective if it is done soon. One garden species (*Aquilegia vulgaris*) appears to have spread considerably over the past decade. It now occurs in semi-natural vegetation in the Falls Creek resort and in montane forest some distance from the resort. It has also been found recently near the summit of Mt Kosciuszko (Genevieve Wright, NSW National Parks and Wildlife Service, *pers. comm.*). The origin of this population is unknown. *Aquilegia vulgaris* is clearly a species that should not be grown in high altitude resort gardens.

Weeds need not be non-Australian. Common Sneezeweed *Centipeda cunninghamii* is listed in Appendix 1 as a weed at Baw Baw village. It was found growing in a gravel stockpile but was not seen in adjoining native vegetation. This common lowland native species had probably been imported with the gravel and may not survive.

Future weeds of alpine ecosystems may also come from within Australasian alpine ecosystems. Many species growing on Australasian high mountains have very narrow geographic ranges. It is conceivable that, with time and the frequent movement of large numbers of people through the mountains, there will be a mixing of Victorian and nearby alpine floras. There is already some doubt in Kosciuszko National Park about the origin of Hook-sedge *Uncinia sinclairii* and Feldmark Grass *Erythranthera pumila*, both of which are more common in New Zealand. They were discovered in Australia within the last 50 years and are extremely limited in their Australian distribution. The interest in the propagation and growing of native plants may also lead to the mixing of alpine floras, if inappropriate native species are used in ski resort amenity planting. For instance, 16 Tasmanian endemic species, which have been recorded for the Tasmanian high country by Kirkpatrick (1997), are listed by Hibbert (1997) as available in Victorian nurseries.

Almost 60% of the plants growing in treeless vegetation on the Bogong High Plains are restricted to alpine and sub-alpine country (McDougall 1997). This extraordinary level of endemism is associated with less than 1% of Australia's land surface. Until there is certainty that the pool of exotic species capable of growing, establishing and reproducing in Australia's high mountains is negligible, the risk to the natural flora and vegetation from weed invasion is clearly great. There is much to lose. Whilst there may always be incidental plant introductions to the Alps from bird droppings and mud on cars, there is a great opportunity to significantly reduce the risk of plant invasions in the high country by prohibiting the majority of intentional plant introductions, particularly cold-hardened plants destined for ski resort gardens.

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References

Carr, G.W. (1993). Exotic flora of Victoria and its impact on indigenous biota. *In* 'Flora of Victoria. Volume 1. Introduction', pp. 256-297. Eds D.B. Foreman and N.G. Walsh. (Inkata Press: Melbourne.)

Fallavollita, E. and Norris, K. (1992). The occurrence of Broom, *Cytisus scoparius*, in the Australian Alps National Parks. Unpublished report to Australian Alps National Parks.

Freshwater, V. (1989). Control of environmental weeds in Sherbrooke Forest. *In* 'Control of Environmental Weeds. A Workshop presented by the Weed Science Society of Victoria Inc. and the Department of Conservation, Forests and Lands', pp 3-4. Eds R. Adair and R. Shepherd. (Weed Science Society of Victoria Inc.)

Hibbert, M. (1997). 'The Aussie Plant Finder 1997 8: South-Eastern Australia'. (Florilegium: Sydney.)

Humphries, S.E., Groves, R.H. and Mitchell, D.S. (1991) Plant invasions of Australian ecosystems. A status review and management directions. *In* 'Plant Invasions. The Incidence of Environmental Weeds in Australia' *Kowari* **2**, 1-134. (Australian National Parks and Wildlife Service: Canberra.)

Huxley, A. (Ed.) (1992). 'The New Royal Horticultural Society Dictionary of Gardening'. (MacMillan Press Pty Ltd: London.)

Kirkpatrick, J.B. (1997). 'Alpine Tasmania. An Illustrated Guide to the Flora and Vegetation'. (Oxford University Press: Melbourne.)

Mallen-Cooper, P.J. (1990). Introduced Plants in the High Altitude Environment of Kosciusko National Park. (Unpublished Ph.D. Thesis, The Australian National University, Canberra.)

McDougall, K.L. (1982). 'The Alpine Vegetation of the Bogong High Plains'. Environmental Studies Publication No. 357. (Ministry for Conservation: Victoria.)

McDougall, K.L. (1997). The alpine flora of Victoria. *In* 'Abstracts from the Alpine Ecology Symposium (Ecological Sustainable Use of the Alps), held at the University of Melbourne, 15 November 1997'. (Royal Society of Victoria: Melbourne.)

Moggi, G. (1985). 'The Macdonald Encyclopedia of Alpine Flowers'. (Macdonald & Co.: London.)

Papst, W.A., Morgan, J., Wharen, H. and Wilson, D. (1999). Alpine rehabilitation and vegetation management. *In* 'Alpine Ecology Course (Bogong High Plains) Course Notes'. (Department of Natural Resources and Environment: Victoria.)

Ross, J.H. (1996). 'A Census of the Vascular Plants of Victoria, 5th edition'. (Royal Botanic Gardens: Melbourne.)

Russell, W. and Teller, L. (1994). 'Alpine Resorts Commission Review Panel'. A report to the Minister for Natural Resources. (Price Waterhouse: Melbourne.)

van Rees, H. (1984). 'Behaviour and Diet of Free Ranging Cattle on the Bogong High Plains, Victoria' Environmental Studies Publication No 409. (Department of Conservation, Forests and Lands: Victoria.)

Walsh, N.G., Barley, R.H. and Gullan, P.K. (1984). 'The Alpine Vegetation of Victoria (Excluding the Bogong High Plains), Volume 1'. Environmental Studies Publication No. 376. (Department of Conservation, Forests and Lands: Victoria.)

Appendix 1. Weeds found in alpine ski villages (this study) and in natural alpine vegetation (McDougall (1982), Walsh *et al.* (1984) and personal observations) between 1980 and 1997. 1 Falls Creek, 2 = Mt Buffalo (Chalet area), 3 = Dinner Plain, 4 = Hotham Heights, 5 Mt Buller, 6 Baw Baw, N = native vegetation beyond ski resorts.

APIACEAE								
Pastinaca sativa	Parsnip	1						
APOCYNACEAE								
Vinca minor	Periwinkle	1						
AQUIFOLIACEAE								
Ilex aquifolium	Holly					5		
ARALIACEAE								
Hedera helix	Ivy		2					
ASTERACEAE								
Achillea millefolium	Yarrow	1	2		4	5		N
Bellis perennis	Common Daisy						6	
Centipeda cunninghamii	Common Sneezeweed						6	
Chrysanthemum parthenium	Feverfew	1	2					
Cirsium vulgare	Spear Thistle	1	2	3	4	5	6	N
Conyza bonariensis	Tall Fleabane		2					
Crepis capillaris	Smooth Hawksbeard					5		
Crepis setosa	Bristly Hawksbeard		2					
Gamochaeta purpurea	Purple Cudweed							N
Hypochoeris radicata	Cat's-ear	1	2	3	4	5	6	N
Leucanthemum maximum	Shasta Daisy	1				5		
Leucanthemum vulgare	Ox-eye Daisy						6	N
Sonchus asper	Prickly Sow Thistle	1				5		
Sonchus oleraceus	Sow Thistle		2					
Taraxacum Sect. Vulgaria	Dandelion	1	2	3	4	5	6	N
BORAGINACEAE								
Echium plantagineum	Paterson's Curse		2		4			
Myosotis discolor	Forget-me-not		2					N
BRASSICACEAE								
Capsella bursa-pastoris	Shepherd's Purse	1	2		4			
Lepidium campestre	Field Cress		2					

Appendix 1. Continued.

Raphanus raphanistrum	Wild Radish	1						
Sisymbrium officinale	Hedge Mustard		2					
CALLITRICHACEAE								
Callitriche stagnalis	Water Starwort							N
CARYOPHYLLACEAE								
Cerastium fontanum	Mouse-ear Chickweed	1	2	3	4	5	6	N
Cerastium glomeratum	Mouse-ear Chickweed	1	2	3				N
Dianthus barbatus	Sweet William	1						
Moenchia erecta	Erect Chickweed							N
Spergularia rubra	Red Sand-spurrey		2	3	4		6	
CHENOPODIACEAE								
Chenopodium album	Fat Hen	1				5		
CLUSIACEAE								
Hypericum perforatum	St. John's Wort	1	2	3		5		
EUPHORBIACEAE								
Euphorbia peplus	Petty Spurge						6	
FABACEAE								
Cytisus scoparius	English Broom	1		3	4			N
Lotus corniculatus	Bird's-foot Trefoil	1		3	4		6	N
Lupinus Russell Hybrid	Russell Lupin	1	2					
Trifolium dubium	Suckling Clover							N
Trifolium glomeratum	Cluster Clover							N
Trifolium pratense	Red Clover	1		3	4	5		
Trifolium repens	White Clover	1	2	3	4	5	6	N
Vicia sativa ssp. *nigra*	Vetch		2					
FUMARIACEAE								
Fumaria sp.	Fumitory		2					
IRIDACEAE								
Crocosmia X crocosmiiflora	Montbretia	1						
Iris X germanica	Tall Bearded Iris	1	2					
JUNCACEAE								
Juncus acutiflorus	Sharp-flower Rush							N
Juncus articulatus	Jointed Rush	1		3	4	5	6	N
Juncus bufonius	Toad Rush	1		3				N
Juncus effusus	Soft Rush	1		3				N
Juncus tenuis	Slender Rush	1						
LAMIACEAE								
Clinopodium vulgare	Wild Basil					5		
Lamium galeobdolen	Yellow Archangel	1				5		
Mentha spicata	Spearmint	1			4	5		N
Prunella vulgaris	Self Heal	1				5	6	
LILIACEAE								
Allium sphaerocephalon	Round-headed Leek	1			4			
Alstroemeria aurea	Alstroemeria	1	2					
Hyacinthoides hispanica	Bluebells		2					
Muscari armeniacum	Grape Hyacinth		2					
MALVACEAE								
Malva neglecta	Dwarf Mallow		2					
ONAGRACEAE								
Epilobium ciliatum	Glandular Willow-herb	1	2	3		5	6	N
PINACEAE								
Pinus spp.	Pine	1						
PLANTAGINACEAE								
Plantago lanceolata	Ribwort	1	2	3	4	5	6	
Plantago major	Greater Plantain			3			6	
POACEAE								
Agrostis capillaris	Brown-top Bent	1	2	3	4	5	6	N
Agrostis stolonifera	Creeping Bent	1				5		N
Aira caryophyllea	Silvery Hair-grass		2					N
Aira praecox	Early Hair-grass							N
Anthoxanthum odoratum	Sweet Vernal-grass	1		3	4		6	N
Arrhenatherum elatius	False Oat-grass	1						
Avena sativa	Oat		2					
Bromus cartharticus	Prairie Grass		2					
Bromus diandrus	Great Brome		2					
Bromus hordeaceus	Soft Brome	1	2	3				
Bromus sterilis	Barren Brome						6	

Appendix 1. Continued.

Bromus tectorum	Drooping Brome				4			
Dactylis glomerata	Cocksfoot	1	2		4	5	6	N
Festuca arundinacea	Tall Fescue				4			N
Festuca rubra	Red Fescue	1		3	4	5	6	N
Holcus lanatus	Yorkshire Fog	1	2	3	4	5	6	N
Lolium perenne	Perennial Rye-grass	1	2	3	4	5	6	N
Phleum pratense	Timothy Grass	1		3	4	5	6	N
Poa annua	Annual Meadow-grass	1	2					N
Poa pratensis	English Meadow-grass			3	4			N
Vulpia bromoides	Squirrel-tail Fescue		2					N
Vulpia myuros	Rat's-tail Fescue		2					
POLYGONACEAE								
Acetosella vulgaris	Sheep Sorrel	1	2	3	4	5	6	N
Polygonum aviculare	Prostrate Knotweed	1	2	3		5	6	
Rumex conglomeratus	Clustered Dock				4			
Rumex crispus	Curled Dock	1	2	3	4	5	6	N
PRIMULACEAE								
Anagallis arvensis	Pimpernel	1	2					
RANUNCULACAEAE								
Aquilegia vulgaris	Columbine	1	2					
Ranunculus muricatus	Sharp Buttercup							N
Ranunculus repens	Creeping Buttercup						6	N
RESEDACEAE								
Reseda luteola	Weld			3				
ROSACEAE								
Aphanes arvensis	Parsley Piert							N
Cotoneaster microphyllus	Cotoneaster		2					
Cotoneaster sp.	Cotoneaster		2					
Malus X domestica	Apple	1			4	5		N
Potentilla recta	Sulphur Cinquefoil							N
Prunus cerasifera	Cherry-plum	1			4			
Rosa rubiginosa	Briar Rose		2					N
Rubus fruticosus spp. agg.	Blackberry	1				5		
Rubus idaeus	Raspberry	1				5		
Spiraea alba	Spiraea		2					
SALICACEAE								
Salix caprea	Goat Willow	1	2		4		6	N
SCROPHULARIACEAE								
Mimulus moschatus	Musk Monkey-flower	1			4	5	6	N
Penstemon sp.	Penstemon						6	
Verbascum virgatum	Twiggy Mullein	1	2	3	4	5		N
Veronica arvensis	Wall Speedwell		2					N
Veronica peregrina	Wandering Speedwell						6	N
Veronica persica	Persian Speedwell		2		4			
SOLANACEAE								
Solanum tuberosum	Potato		2					
VIOLACEAE								
Viola tricolor	Heart's Ease	1		3	4			N

The Eastern Dwarf Tree Frog *Litoria fallax* (Peters) (Anura: Hylidae): a Recent Introduction to Victoria?

Graeme R. Gillespie[1] and Nick Clemann[1]

Abstract
The Eastern Dwarf Tree Frog *Litoria fallax* (Peters) is an inhabitant of wetlands and swamps along the east coast of Australia, from Jervis Bay south of Sydney, to the Atherton Tablelands in northern Queensland. We report the discovery of the species inhabiting a small wetland in the south-eastern suburbs of Melbourne. This is likely to be a recent introduction rather than a natural range extension. The Eastern Dwarf Tree Frog is one of several species frequently inadvertently transported to Victoria amongst fresh fruit and horticultural products. This discovery highlights the possibility that some of these species could become established outside their natural ranges, which has potentially serious repercussions for local amphibian biodiversity. (*The Victorian Naturalist* **117** (2), 2000, 60-62.)

Introduction

The Eastern Dwarf Tree Frog *Litoria fallax* (Peters) is known from the east coast of Australia: from Jervis Bay south of Sydney, to the Atherton Tablelands in northern Queensland (Cogger 1996). The species breeds in lentic habitats, usually permanent wetlands and swamps (Barker *et al.* 1995). It is a common species which frequently occurs in urban areas of cities, such as Sydney and Brisbane (G. Gillespie *pers. obs.*). Here we report our discovery of this species in the wild for the first time in Victoria, and discuss the significance and possible explanations for this recent occurrence.

Observations

We conducted a survey for frogs at several wetland sites in Moorabbin on 6th October 1999. The specific aim of this survey was to assess the distribution of the Warty Bellfrog (also known as the Growling Grass Frog and Southern Bell Frog) *Litoria raniformis* in the area. The focus of our survey was a series of wetlands in an old sand-mining quarry on Carroll Road (Australian Map Grid Ref. 7922: 322995, altitude: 40 m above sea level) owned by Pioneer International Pty. Ltd. and the City of Kingston, in which *L. raniformis* had been reported previously (G. Marantelli *pers. comm.*). This site contains several large quarry pits, most of which are permanently filled with water. These waterbodies vary in depth and age, and have different levels of emergent vegetation and macrophytes.

We investigated the frog species present at each waterbody during the day and at night, with the aid of head torches and call identification. Movable debris near the waterbodies, such as timber, rocks and scrap metal, was lifted to detect sheltering frogs.

At one waterbody, a single male specimen of *L. fallax* was heard calling repeatedly over a period of 15 minutes. This individual was located perched on a frond of Water Ribbon *Triglochin procerum* at the water surface. The specimen (Fig. 1) was collected, identified (see below) and lodged with Museum Victoria (record no. D70647). The waterbody at which *L. fallax* was recorded was approximately 1 ha in area, with a relatively uniform depth of 0.7 m. Most of the waterbody was colonised by *T. procerum*, which had a fairly uniform coverage of 70% of the water surface. The waterbody was surrounded by steep sand cliffs, 3-5 m high. Much of the cliffs and surrounding banks were covered in thick Kikuyu *Perrisetum clandestinum*, with scattered shrubs (Swamp Paperbark *Melaleuca ericifolia*) and trees (Messmate Stringybark *Eucalyptus obliqua* and Black Wattle *Acacia mearnsii*). Five other species of frog were detected at the site: Southern Brown Tree Frog *Litoria ewingii*; *L. raniformis*; Common Froglet *Crinia signifera*; Banjo Frog *Limnodynastes dumerilii*; and Striped Marsh Frog *L. peronii*. These species also occurred at several other waterbodies at the site.

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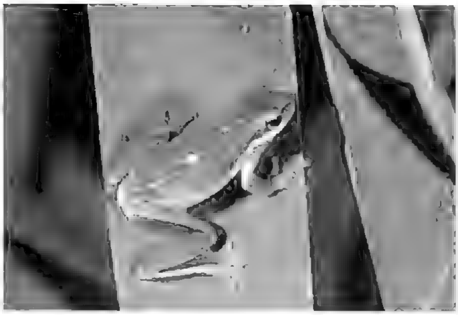

Fig. 1. The Eastern Dwarf Tree Frog *Litoria fallax*, found in a wetland at Moorabbin. Photograph by Nick Clemann.

Identification

Litoria fallax is a small tree frog (25 mm) which should be readily distinguishable from other species in Victoria (Fig. 1), but may be confused with the Northern Dwarf Tree Frog *Litoria bicolor*, which occurs continuously from northern Western Australia to northern Queensland. These species may be differentiated on the basis of body length to head width ratio (>3.5 for *L. bicolor*; <3.5 for *L. fallax*), and the presence on *L. bicolor* of a thin bronze stripe from the tip of the snout, through the nostril and eye, to the groin (Barker *et al.* 1995). *Litoria fallax* lacks this stripe. *Litoria fallax* has a smooth, uniform green or fawn dorsum, sometimes with scattered dark flecks. The groin and thighs are bright orange, and the ventral surface is cream. A distinctive narrow white stripe occurs along the edge of the upper lip to the corner of the mouth, where it widens and continues below the tympanum to the base of the arm. Adult males have a bright orange vocal sac during the spring-summer breeding season (Barker *et al.* 1995; Cogger 1996). The call is insect-like, and Moore (1961) described it as a high-pitched squeaky 'wr-e-e-ek, wr-e-e-ek, wr-e-e-ek', continued many times.

Discussion

This record is the first documented occurrence of *L. fallax* in the wild in Victoria. In addition, the record is approximately 600 km south of the known range of *L. fallax*. The frog fauna of the greater Melbourne area has been studied extensively, and is well documented (Martin 1965; Martin *et al.* 1966; Littlejohn and Harrison 1987; Hero *et al.* 1991). *Litoria fallax* is a distinctive species with a loud and recognisable call (Barker *et al.* 1995; Stewart 1998). It is unlikely that the species historically occurred in the area and has remained undetected. We believe that this record constitutes a recent introduction to the area.

Litoria fallax is one of several species of frog which are frequently inadvertently transported to Victoria and other States amongst fresh food and horticultural produce, primarily from the east coast of New South Wales and Queensland (Victorian Frog Group unpublished data). These frogs have been colloquially termed 'banana-box frogs', after their apparent main form of transport. The Victorian Frog Group (VFG) estimates that several thousand frogs arrive in Melbourne in this way each year. The VFG has established a network to collect many of these frogs, but the fate of most individuals not reported is unknown. Many are probably released or discarded (VFG unpubl. data). There have been other reports of 'escaped' frogs in Victoria. A Green Tree Frog *Litoria caerulea* was found hopping across Bell Street, Preston (G. Marantelli pers. comm.). There have been several confirmed reports of Cane Toads *Bufo marinus* in Victoria in recent years (G. Gillespie *pers. obs.*; G. Hollis, Dept. Natural Resources and Environment, Warragul, *pers. comm.*). These individuals may have arrived inadvertently amongst interstate freight, or been intentionally brought to Victoria as pets and escaped. *Litoria caerulea* is one of several exotic frog species from inter-state commonly sold in pet shops in Victoria.

These observations demonstrate that frogs are easily transported considerable distances across the country, raising the possibility that some species could colonise environments outside their natural range. While species from subtropical regions may have difficulty establishing themselves in Victoria, other species from more temperate regions of Australia, such as *L. fallax*, could potentially colonise some environments. This has already occurred with several other Australian frog species. The Green and Golden Bellfrog *Litoria aurea*, *L. raniformis*, and *L. ewingii* have been established in New Zealand. *Litoria aurea* has been introduced onto a number of other South Pacific islands (A. White, Australian Museum, *pers. comm.*), and *L. tasmaniensis* has been introduced to Western Australia (Martin and Tyler 1978).

Introductions of alien species of frog have a number of significant conservation implications for the local frog fauna. If such species successfully establish themselves they may compete with, or prey upon, local frog species at the larval or adult stage. Such competition has occurred with the introduction of the American Bullfrog *Rana catesbeiana* into the western United States (Kupferberg 1997; Lawler *et al.* 1999). Introduction of species closely related to local species may result in genetic introgression, compromising local gene pools. Some species may not successfully establish themselves, but may provide vectors for disease. Disease has been implicated in the decline of many frog species around the world (Berger *et al.* 1998; Johnson *et al.* 1999). Human activities, such as transporting frogs or aiding natural dispersal of frogs through habitat modification, may have augmented the dispersal of harmful frog pathogens, which may have otherwise been restricted to fewer species in a limited geographic area.

The male *L. fallax* we found was calling, suggesting that the local environmental conditions were suitable at the least for male reproductive activity. The presence of this individual may be an isolated case; however, we only visited a few waterbodies on one night. In view of the number of frogs which are transported to Melbourne, a more extensive survey may detect many more individuals. This observation provides strong evidence that frogs transported to Victoria may find their way to potential breeding habitats and become established. In view of the threats such introductions may impose on our local amphibian fauna, greater diligence is required to minimise the risk of inadvertent translocation of wildlife. 'Banana-box frogs', or any frog species found which are not from the local region, should be reported to the Victorian Frog Group (Ph: 03 93544718), or the Department of Natural Resources and Environment.

Acknowledgements

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References

Barker, J., Grigg, G. and Tyler, M.J. (1995). 'A Field Guide to Australian Frogs', 2nd Ed. (Surrey Beatty: Chipping Norton, NSW.)

Berger, L., Speare, R., Daszak, P., Green, D.E., Cunningham, A.A., Goggin, C.L., Slocombe, R., Ragan, M.A., Hyatt, A.D., McDonald, K.R., Hines, H.B., Lips, K.R., Marantelli, G. and Parkes, H. (1998). Chytridimycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Science U.S.A.* **95**, 9031-9036.

Cogger, H.G. (1996). 'Amphibians and Reptiles of Australia', 6th Ed. (Reed Books: Hong Kong).

Hero, J.-M., Littlejohn, M.J. and Marantelli, G. (1991). 'Frogwatch Field Guide to Victorian Frogs'. (Victorian Department of Conservation and Environment: Melbourne).

Johnson, P.T.J., Lunde, K.B., Ritchie, E.G. and Launer, A.E. (1999). The effect of trematode infection on amphibian limb development and survivorship. *Science* **284**, 802-809.

Kupferberg, S.J. (1997). Bullfrog (*Rana catesbeiana*) invasion of a California river: The role of larval competition. *Ecology* **78**, 1736-1751.

Lawler, S.P., Dritz, D., Strange, T. and Holyoak, M. (1999). Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. *Conservation Biology* **13**, 613-622.

Littlejohn, M.J. and Harrison, P.A. (1987). *Litoria peronii* (Anura: Hylidae): An addition to the amphibian fauna of the Melbourne area. *Victorian Naturalist* **104**, 137-140.

Martin, A.A., (1965). Tadpoles of the Melbourne area. *Victorian Naturalist* **82**, 139-149.

Martin, A.A., Littlejohn, M.J. and Rawlinson, P.A. (1966). A key to the anuran eggs of the Melbourne area, and an addition to the Anuran fauna. *Victorian Naturalist* **83**. 312-315.

Martin, A.A. and Tyler, M.J. (1978). The introduction into Western Australia of the frog *Limnodynastes tasmaniensis* Gunther. *Australian Zoologist* **19 (3)**, 321-325.

Moore, J.A. (1961). The frogs of eastern New South Wales. *Bulletin American Museum of Natural History*. **121**, 149-386.

Stewart, D. (1998). 'Australian Frog Calls – Subtropical East (NASO-02)' compact disk. (Nature Sound: Mullumbimby, NSW).

Birds and Boxthorn

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Abstract
Boxthorn *Lycium ferocissimum* is a noxious weed introduced from South Africa in the 19th century, and is now well established in many parts of Victoria. During weekly ornithological surveys in an area infested with the weed during autumn winter 1999, all species of birds that were observed using clumps of Boxthorn, both as a food-source and for shelter, were recorded. Particular attention was paid to the behaviour of birds feeding in Boxthorn. These observations were compared with published records of feeding behaviour of birds in Boxthorn observed elsewhere. (*The Victorian Naturalist* **117** (2), 2000, 63-66.)

Introduction

Boxthorn *Lycium ferocissimum* is a densely-growing shrub armed with fierce spines. It is endemic to the Cape Province of South Africa, and was first introduced into Australia as a hedge plant in the 19th century. It has been widely planted in hedges throughout the south-eastern states, particularly around homesteads and in rural landscapes, and is quite widespread throughout many districts of Victoria (Cunningham *et al.* 1981; Parsons 1981; Lamp and Collet 1983). It was first declared a noxious weed in 1904 (Parsons 1981). Boxthorn is widespread partly because of the extensive planting which took place in the past, but also because it is readily dispersed by birds (Sargent 1928; Cunningham *et al.* 1981; Parsons 1981; Anon. 1998). Boxthorn shrubs produce many succulent red berries, each up to about 10 mm in diameter, and which may contain between 30 and 70 seeds embedded within the flesh. When eaten by a bird, the seeds pass through the bird's gut, and, remaining viable, are subsequently excreted. This is evident as Boxthorn frequently grows beneath sites, such as trees, poles, fences and overhead wires, where birds often perch (Cleland 1952; Parsons 1981). However, although birds appear to be major vectors in the spread of Boxthorn, there are few published records in the mainstream literature of them feeding on the fruits or seeds of this weed. Barker and Vestjens (1989, 1990) provided a comprehensive summary of the food eaten by Australian birds; however, only 14 species were listed as feeding on Boxthorn berries or seeds.

Between early April and late June 1999, I conducted regular ornithological surveys in a remnant patch of Grey Box *Eucalyptus microcarpa* woodland near Woodlands Historic Park, north of Melbourne (37°39'S, 144°49'E). Within this woodland there is virtually no natural understorey, apart from a few patches of Golden Wattle *Acacia pycnantha*; for the most part, the only understorey is comprised of dense thickets of Boxthorn, up to about 3 metres tall. During these surveys, I recorded all observations of birds using these clumps of Boxthorn, both as a food-source and for shelter or refuge. Although Boxthorn is said to bear fruit mainly during the summer (Parsons 1981; Anon. 1998), berries were present on shrubs throughout this survey, though by June the number of shrubs with berries had declined markedly, and those plants still with berries had far fewer than at the beginning of observations. The prolonged period of fruiting may have been influenced by unseasonal conditions.

Birds

Food

Crimson Rosella *Platycercus elegans*

Crimson Rosellas were commonly seen feeding in Boxthorn, either singly or in small groups of up to four. While most feeding records were of adults, some were also of birds in juvenile plumage. Berries were plucked from the plant with the bill; the fruit was then manipulated by both the mandibles and the tongue, in order to separate the skin from the flesh and seeds. When the skin had been removed, the contents were swallowed, and the skin discarded. One Crimson Rosella was seen to eat five berries in this manner within a minute. Elsewhere, I have observed Crimson Rosellas feeding on berries of other shrubs, such as *Cotoneaster*, making

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much use of their feet to assist with feeding; however, at no stage were the feet seen to be used when eating Boxthorn berries. Crimson Rosellas have previously been recorded feeding on Boxthorn berries (Hewish 1997; Lepschi 1997). The number of Rosellas feeding in Boxthorn in the study area decreased suddenly in early June. This coincided with a decline in the availability of Boxthorn berries, as well as the formation of seeds on Grey Box trees and flower-buds on Golden Wattles, providing alternative sources of food.

House Sparrow *Passer domesticus*

Flocks of House Sparrows were frequently seen feeding in thickets of Boxthorn at the margins of the woodland. They fed by crushing the berries between the mandibles, then swallowing the flesh and seeds, and discarding the skin. This feeding behaviour has previously been recorded (Watson 1955).

European Greenfinch *Carduelis chloris*

This species was recorded in the study area only twice. On both occasions, they were seen feeding in clumps of Boxthorn in the company of House Sparrows. Greenfinches have been observed feeding on Boxthorn berries previously (Ashton 1985).

Mistletoebird *Dicaeum hirundinaceum*

This species specialises in feeding on the fruits of various species of mistletoes, but occasionally eats other types of fruits (Liddy 1982). Once, a male Mistletoebird was seen perched quite low in a Boxthorn shrub, feeding on a large berry by repeatedly pecking at it in a slow and deliberate manner, until the flesh was exposed. It flew away after eating a small portion of the flesh. Mistletoebirds have previously been seen feeding on Boxthorn berries (Watson 1955; Ashton 1985), but used a different foraging method, by first plucking the berry, then squeezing the seeds and flesh into its gape, and discarding the skin, in the manner of a House Sparrow (see above). One bird was seen to do this three times (Watson 1955).

Silvereye *Zosterops lateralis*

Flocks of up to 15 birds, all of the Tasmanian subspecies overwintering on the mainland, were often seen feeding together in Boxthorn shrubs. Though a few birds were seen gleaning food from the stems and foliage of the plants, most fed on ripe berries. Two different feeding strategies were observed. The most common method was to perch in the shrub and repeatedly and rapidly peck at a berry. The second method was to pluck the berry and fly down to the ground with it. When on the ground, the berry was rubbed up and down on a fallen branch. After the skin of the berry had been ruptured, the succulent flesh, along with the seeds, which had been exposed, were consumed. On another occasion, a Silvereye was seen flying away with a Boxthorn berry in its beak, but was not seen consuming it. There are numerous published records of Silvereyes feeding on Boxthorn berries (e.g. Sargent 1928; Ashton 1985; Lepschi 1993).

Common Blackbird *Turdus merula*

Blackbirds were commonly seen feeding in clumps of Boxthorn. Berries were plucked with the bill and swallowed whole, with almost no manipulation by the mandibles.

Other birds recorded in the study area which are known to feed on the fruit or seeds of Boxthorn, but were not recorded doing so during this study are: Purple-crowned Lorikeet *Glossopsitta porphyrocephala*; Eastern Rosella *Platycercus eximius*; Red-rumped Parrot *Psephotus haematonotus*; Red Wattlebird *Anthochaera carunculata*; Black-faced Cuckoo Shrike *Coracina novaehollandiae*; Common Starling *Sturnus vulgaris*; and ravens *Corvus* spp. (Wheeler 1948; Cleland 1952; Watson 1955; Ashton 1985; Forde 1986; Barker and Vestjens 1990; Ashton 1996).

Shelter or refuge

Superb Fairy-wren *Malurus cyaneus*

Although this species was usually seen foraging on open ground, individuals occasionally gleaned invertebrates from stems and foliage of Boxthorn shrubs. However, thickets of Boxthorn were most often used as a refuge: when birds were disturbed in the open, they almost invariably retreated directly into clumps of Boxthorn, where they remained among the inner branches until the threat had passed. In most areas, there was no other understorey to inhabit. In addition, old Fairy-wren nests were often found located in the upper stems of dense Boxthorn shrubs. Presumably the sharp thorns would be a deterrent to any potential predators.

Yellow-rumped Thornbill *Acanthiza chrysorrhoa*

Several old, disused nests of this species, each with its characteristic false nest-cup and hooded entrance, were located in the outer stems of Boxthorn shrubs. Incidentally, the nests were constructed from stems of Serrated Tussock *Nasella trichotoma*, another noxious weed infesting the area. The species has been recorded nesting in Boxthorn elsewhere (Watson 1955; Ashton 1985).

Red-browed Finch *Neochmia temporalis*

When foraging, Finches were occasionally flushed from open areas. They usually sought refuge among nearby clumps of Boxthorn. The species has been recorded nesting in Boxthorn (Hewish *et al.* 1986).

Introduced Mammals

European Rabbit *Oryctolagus cuniculus*

Rabbits are extremely common in the study area; their overgrazing has caused a lack of groundcover and a generally depauperate overall state of the vegetation there. Most Rabbit burrows in the area are located beneath thickets of Boxthorn, and Rabbits were often flushed from the shelter of these thickets. Providing cover for rabbits is considered a major deleterious property of Boxthorn (Parsons 1981; Auld and Medd 1987). Rabbits, in addition to sheltering beneath Boxthorn, also readily feed on its foliage. Virtually every clump of Boxthorn had been defoliated up to a height of approximately 50 cm, about as high as a Rabbit can reach; this was evident as a distinct grazing-line on each of the shrubs, below which, the stems were bare, but above which, foliage grew.

Red Fox *Vulpes vulpes*

Although Foxes were infrequently observed, the number of scats seen indicated that they were probably not uncommon. Almost all of the scats observed were riddled with Boxthorn seeds, and often contained entire, undigested berries, indicating that Boxthorn berries comprised at least a portion of the diet of the Foxes present. Foxes have previously been implicated in the spread of Boxthorn (Parsons 1981; Anon. 1998).

In areas that are infested with Boxthorn, it poses a significant ecological problem, both in environmental and agricultural terms. Not only do thickets of Boxthorn eliminate indigenous vegetation and pasture, their densely-growing habits readily harbour rabbits and possibly other vermin. In addition, they impede movement of people and other animals (Cleland 1952; Cunningham *et al.* 1981; Parsons 1981). However, on the other hand, because Boxthorn can (at least during certain favourable conditions) bear berries during autumn and early winter, a period when other sources of food are often either scarce or absent, it may prove to be seasonally important to several species of birds, at least in the study area and places like it. Further, because thickets of Boxthorn provide the only form of understorey in the study area, Boxthorn thus provides suitable habitat for some avian species which rely on the presence of dense undergrowth, and would not otherwise be present if there was no undergrowth at all. Therefore, although landowners should be encouraged to control noxious weeds, such as Boxthorn, it is important that before there is any attempt to do so (particularly in areas such as this, where several species of birds may have become reliant on Boxthorn for food and shelter), an alternative understorey of indigenous plants should first be established to minimise the adverse effects on dependent fauna.

References

Anon. (1998). 'Environmental Weeds. Invaders of Our Surf Coast'. (Surf Coast Shire: Torquay, Vic.).

Ashton, C.B. (1985). The birds of the Aldinga-Sellicks Beach Scrub. *South Australian Ornithologist* **29**, 159-179

Ashton, C.B. (1996). Changes in the avifauna using Aldinga Scrub Conservation Park. *South Australian Ornithologist* **32**, 93-98.

Auld, B.A. and Medd, R.W. (1987). 'An Illustrated Botanical Guide to the Weeds of Australia'. (Inkata Press: Melbourne)

Barker, R.D. and Vestjens, W.J.M. (1989). 'The Food of Australian Birds. 1. Non-Passerines'. (CSIRO: Melbourne).

Barker, R.D. and Vestjens, W.J.M. (1990). 'The Food of Australian Birds. 2. Passerines'. (CSIRO: Melbourne)

Cleland, J.B. (1952). The dispersal of plants by birds.

South Australian Ornithologist **20**, 72-77.
Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981). 'Plants of Western New South Wales'. (NSW Gov't Printing Office: Sydney).
Forde, N. (1986) Relationships between birds and fruits in temperate Australia. *In* 'The Dynamic Partnership. Birds and Plants in Southern Australia', pp. 42-58. Eds H.A. Ford and D.C. Paton. (D.J. Woolman, Gov't Printer: Adelaide).
Hewish, M. (1997). Geelong Bird Report 1996. *Geelong Bird Report* **1996**, 3-29.
Hewish, M., Baker, R., Baker, M. and Munday, D. (1986). Birds of the Long Forest: Part 2; annotated list. *Geelong Naturalist* **23**, 50-78.
Lamp, C. and Collet, F. (1983). 'A Field Guide to Weeds in Australia'. (Inkata Press: Melbourne).
Lepschi, B.J. (1993). Food of some birds in eastern New South Wales: additions to Barker & Vestjens. *Emu* **93**, 195-199.
Lepschi, B.J. (1997). Food of some birds in southern Australia: additions to Barker & Vestjens, part 2. *Emu* **97**, 84-87.
Liddy, J. (1982). Food of the Mistletoebird near Pumicestone Passage, south-eastern Queensland. *Corella* **6**, 11-15.
Parsons, W.T. (1981). 'Noxious Weeds of Victoria'. (Inkata Press: Melbourne).
Sargent, O.H. (1928). Reactions between birds and plants. *Emu* **27**, 185-192.
Watson, I.M. (1955). Some species seen at the Laverton Saltworks, Victoria, 1950-1953, with notes on seasonal changes. *Emu* **55**, 224-248.
Wheeler, R. (1948). Ravens feeding on Boxthorn berries. *Emu* **48**, 94.

Utricularia gibba L.: a New Bladderwort Record for Victoria

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Abstract
This article records *Utricularia gibba* from two sites in the Frankston area, discusses the status of the plant in Victoria and suggests that it has the potential to become an environmental weed. (*The Victorian Naturalist* **117** (2), 2000, 66-67.)

Utricularia gibba is a free-floating aquatic plant that traps small animals, such as mosquito larvae, in bladders that are scattered on its leaves. The plant can form large mats of slender stems and has small, mostly paired cylindrical leaves and emergent yellow flowers with some red markings (Fig. 1).

In Australia, the natural range of *Utricularia gibba* is the Northern Territory, Queensland and coastal New South Wales, as far south as Sydney (Rowe and Brown 1992).

On 19 May, 1996 a flowering specimen was collected from the reservoir in the Langwarrin Flora and Fauna Reserve (Melway map 103 E9). Subsequently, vegetative fragments were located nearby in the Ballam Swamp. Specimens from both localities have been lodged at the National Herbarium of Victoria (MEL numbers 2031780, 2031781 and 2033167).

Initially these were thought to be natural occurrences. However, efforts to locate the species in similar habitat elsewhere in the region, at Tyabb and Cranbourne, were unsuccessful. It is now considered that the plant is an introduction that has become naturalised. This view tends to be supported by the following:

- the lack of other Victorian records, particularly from East Gippsland, where climatic conditions are closer to those of its known range;
- reports of *Utricularia gibba* being a common weed of aquaria and botanic gardens throughout the world (Taylor 1989), and
- the presence of aquarium fish and another introduced aquatic plant, Dense Waterweed *Egeria densa* Planch., in the reservoir.

It is unclear how or when *Utricularia gibba* was introduced at Langwarrin, however given the extent and size of plants, it is assumed that it has been present for many years. Plants may have been deliberately or inadvertently introduced or they may have dispersed naturally.

Calder (1987) records that there was a hospital at the Langwarrin Reserve between 1916 and 1920 and plans of the complex show both a fish pond and ornamental pond. The reservoir, which was a source of fresh water for the complex, now contains Goldfish, Redfin, Dense Waterweed and the *Utricularia*. It is possible that the fish and water plants were moved from the ponds to the safety of the larger reservoir, either when the hospital

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was closed in 1920 or when firebreaks were constructed (and presumably the fish pond was destroyed) in 1968.

Another Bladderwort, *Utricularia australis* R.Br., which is a superficially similar free-floating indigenous species, is also present in the reservoir and Ballam Swamp. It is interesting to note that plants of that species were breaking up and approaching dormancy in autumn when *Utricularia gibba* was actively flowering. *Utricularia australis* survives winter as small vegetative buds whereas plants the size of *Utricularia gibba* do not seem to vary between seasons. *Utricularia gibba* has been observed in flower at Langwarrin during February, March and May while Aston (1977) gives the flowering time of *Utricularia australis* as November to February.

Utricularia gibba has formed extensive mats at Langwarrin and appears to have the potential to become an environmental weed that could have a significant impact on wetland ecology, for example, by reducing the area of free water, shading lower vegetation and crowding out other aquatic plants. It can grow from small vegetative fragments that are difficult to see and care will be needed to prevent its spread to other wetlands.

Records of *Utricularia gibba* from elsewhere in Victoria would be of interest and specimens, with locality and habitat details, should be sent to the National Herbarium of Victoria.

Acknowledgements

Thanks to Jeff Jeanes for confirming the identity of specimens and accompanying me on a search at Langwarrin and Ballam Swamp. Thanks also to Helen Aston for confirming the identity of specimens, identifying other aquatic plants at the reservoir and discussing the status of *Utricularia gibba* in Victoria.

Fig. 1. Flower of *Utricularia gibba* at Langwarrin.

References

Aston, H.I. (1977). 'Aquatic Plants of Australia'. (Melbourne University Press: Melbourne.)

Calder, W.B. (1987). 'Australian Aldershot Langwarrin Military Reserve Victoria 1886-1980'. (Jimaringle Publications:Canterbury.)

Melway Greater Melbourne, Edition 25. (1998). (Melway Publishing Pty Ltd: Glen Iris, Victoria.)

Rowe, R.R. and Brown, E.A. (1992). Lentibulariaceae. *In* 'Flora of New South Wales, Volume 3'. Ed. G.J. Harden. (New South Wales University Press: Kensington.)

Sainty, G.R. and Jacobs, S.W.L. (1981). 'Waterplants of New South Wales'. (Water Resources Commission: New South Wales.)

Taylor, P. (1989). 'The Genus *Utricularia* a taxonomic monograph'. Kew Bulletin Additional Series 14. (Royal Botanic Gardens: Kew.)

Congratulations

Ernest Perkins, OAM

The council and members of the Field Naturalists Club of Victoria extend their congratulations to Ernest Perkins of Castlemaine, who was awarded an Order of Australia Medal on Australia Day 2000.

He was awarded the Medal for service to conservation and the environment, particularly through the Castlemaine Field Naturalists Club, and to the community of Castlemaine. Ern was a foundation member of the Castlemaine FNC and is currently the club's Vice President. He has also been a member of the FNCV since 1965, as well as a member of some Mt Alexander Shire Council committees, including roadside conservation, heritage, walks and trails, and street trees.

Ern's major natural history interest is the botany of the Castlemaine area, and he is currently secretary of the Bendigo Native Plant Group.

On the Origin, History and Significance of the Easter Bilby

Ian Faithfull[1]

Abstract
Evidence is presented that the concept of the Easter Bilby was invented between 1976 and 1983 by Malcolm Turner of the Hawthorn Junior Field Naturalists Club as a replacement for the Easter bunny at the Club's traditional Easter bush camps. Officials of the Club acted as the Easter Bilby and delivered chocolate eggs to camp participants on Easter morning. The idea was adopted because it replaced a culturally inherited reverence for an introduced pest, the Rabbit *Cuniculus vulgaris* with a conservation-oriented, educative function involving an endangered native mammal (the Bilby, *Macrotis lagotis*), and is believed to have spread slowly in the naturalist subculture and perhaps in professional wildlife conservation circles. The concept also appears to have been invented independently by Tony Robinson of the South Australian National Parks Service about 1980. The idea was developed further in Adelaide by Nicholas Newland of the South Australian Department of Environment who in 1991 conceived the idea of the 'Easter Bilby' as a marketing tool for the Rabbit Fund, a predecessor of the Anti-Rabbit Research Foundation of Australia (ARRFA), to raise funds for research and education on rabbit control. ARFFA registered the name as a trademark and initiated steps to produce the first chocolate confectionary bearing the name. The increased popularity of the 'Easter Bilby' and similar products since the first production in 1993 is described. The enculturation of *M. lagotis* through the Easter Bilby concept and product is interpreted as an object lesson in, and paradigmatic example of the methodology that may be employed in the construction of a more deeply rooted, culturally anchored, conservation ethos. (*The Victorian Naturalist*, **117** (2), 2000, 68-74.)

Introduction

In recent years a new mythological creature has joined the Australian child's pantheon. This beast is the Easter Bilby. Unlike the Easter Rabbit, which the Easter Bilby is gradually displacing, its origins are not obscured by the passage of eons. But the origin of the Easter Bilby is uncertain and its history is controversial. Who invented the Easter Bilby? How has this new tradition been propagated? And what lessons does this development hold for Australian culture, public perceptions of pest animals and conservation of native species? This is the story of the Easter Bilby, as far as I have been able to ascertain.

My interest in these questions was aroused as a student of marsupial biology at La Trobe University, Melbourne, in 1994. Our studies of conservation included the reasons extinctions and declines of Australian marsupials should be of concern. Inevitably the sad position of the Bilby or Rabbit-eared Bandicoot *Macrotis lagotis* had to be considered.

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Bilbies

There are two species in the monogeneric family Thylacomyidae: the Bilby *M. lagotis*, and the Lesser Bilby *M. leucura*. In contrast to the better known peramelid bandicoots, thylacomyids have long, furred tails, large rabbit-like ears and dig burrows for shelter during the day.

The last record of the Lesser Bilby was a skull of unknown age found in the nest of a Wedge-tailed Eagle *Aquila audax* in the Simpson Desert in 1967 (Johnson 1989). Although Aborigines maintained that it still existed in the Gibson and Great Sandy Deserts after that time, the depressing prognosis in the early 1980s was 'extremely rare or extinct' (Johnson 1983a). No evidence has subsequently come to light that would cause us to be more optimistic.

Macrotis lagotis, an endangered species, is somewhat better off, comparitively. It once occupied much of the arid and semi-arid inland of Australia, about 70% of the continent, but declined dramatically after European settlement, disappearing from Victoria in the 19th century and from New South Wales by 1915. It is now found only in the Tanami Desert of the Northern Territory, the Gibson and Great Sandy Deserts of Western Australia and a small area in south-west Queensland. Sadly, its populations continue to decline (Johnson 1983b 1989, Bellchambers 1993, Christensen 1997). The causes of these dramatic range contractions are controversial. Competition from rabbits and livestock, predation by foxes and feral cats, land clearing and altered fire regimes have all been implicated, but the degradation of Bilby habitat caused by rabbits and livestock, in combination with drought, may be the most crucial factors (Bellchambers 1993).

Cultural Development and Conservation

In general, people are only interested in preserving and protecting those things which they value. If an animal never finds a secure place in the culture of the people that inhabit its land, it can, with much greater ease, cease to exist at all. Until the 1990s, few had ever heard of the Bilby, or appreciated its plight. Being almost unknown and of little economic use is not an advantage for a species approaching extinction.

But the value of marsupials also involves their totemic, symbolic and iconic significance. If the Bilby could enter into modern Australian folklore and be given some symbolic value, the desire to conserve it could perhaps be increased, and its future might be more secure. Kangaroos, for example, have acquired an iconic status as a feature of the Commonwealth of Australia coat of arms and the 50 cent coin. The kangaroo is one symbol of Australia, and people the world over are concerned for its welfare. The Thylacine has acquired cultural significance for a very different set of reasons and the symbolism of the thylacine now has deep connotations in the Australian psyche.

The Easter Bilby idea, coming to the aid of a declining species, at first appears to be a strange and fortuitous development. Here is a unique example of symbolism used to good effect and of modern day myth-making. But the history of this idea and the seeming lack of record of its origin was a puzzle for the zoologists-in-training in the class of 1994. A review of recent scientific works on the species drew a blank, despite the evident utility of the new icon to conservation science. Who originated this brilliant idea and how did it come to him/her?

In Search of the Originator of the Idea

Dr Chris Dickman, a marsupial biologist at Sydney University, thought that Dr Richard Southgate, who worked with bilbies for the Conservation Commission of the Northern Territory, might have 'dreamed up the idea a few years ago' (Dickman, *pers. comm.* 1994). However I had memories, vaguely placed in the early 1980s, of the Easter Bilby delivering Easter eggs to children's tents during the traditional Easter camps of the Hawthorn Junior Field Naturalists (now the Melbourne Juniors), a natural history club based in the eastern suburbs of Melbourne.

In my childhood during the 1950s and 1960s, Easter morning had traditionally involved a hunt for chocolate Easter eggs, wrapped in coloured aluminium foil, and concealed in the garden overnight by the Easter bunny or Easter Rabbit. Usurpation of the bunny by the Bilby on Easter morning in the Victorian bush initially appeared to be an embarrassingly stupid thing; I was resistant. Yet the Easter Bilby turned out to be no passing fad. Rabbits might still ravage the bush, but at least Easter morning in the wilds with the 'junior nats' brought no extra evidence of their insidious activity.

However, Southgate (*in litt.* 1994) did not claim responsibility. He thought the origin might have been in South Australia about 1990 and suggested that John Hunwick of the South Australian Bilby Action Group (SABAG) and Ed MacAlister of the Anti-Rabbit Research Foundation of Australia (ARRFA), which had registered the name 'Easter Bilby' as a trade mark in 1993 (Morrison 1998), might know more about it.

Hunwick (*pers. comm.* 1994) first heard the idea from Dr A.C. (Tony) Robinson of the South Australian National Parks Service between 1986 and 1988. Robinson himself (*pers. comm.* 1995) remembers it as his own original 'throw-away line' at the first or second meeting of the South Australian Threatened Species Network about 1980. He and the group were interested in getting rid of the myths and affection that surround the Rabbit. The Burrowing Bettong or Boodie *Bettongia lesueur*, a small potoroid which makes extensive communal burrows, just like a rabbit, and carries nesting material with its prehensile tail, was initially favoured as an alternative Easter symbol. Once very widely distributed in Australia, this species survives only on three offshore islands in Western Australia. The burrow systems it once occupied on the mainland are now inhabited by rabbits, which along with sheep, introduced predators and intensified agriculture, appear to be responsible for its decline (Short 1994).

The Anti-Rabbit Research Foundation of Australia (now the Foundation for Rabbit-free Australia), based at Adelaide Zoo, used a stylised picture of the Bilby as its logo, accompanied by the statement: 'The Bilby, one of many native animals pushed to the edge of extinction by the effects of rabbits on the Australian natural environment'. Ed McAlister (*in litt.* 1994), then chairperson of ARRFA, and then and now Director of the Adelaide Zoo, first heard the idea in 1991 when Nicholas Newland of the South Australian Department of Environment and Planning raised it in the press. The first press report appeared on the front page of the *Adelaide Advertiser* on 27 November 1991.

Easter Bilby Chocolates

This first report in the *Adelaide Advertiser* of the Easter Bilby as a potential chocolate product credits Nicholas Newland as the creator (Morrison *pers. comm.* 2000). Newland conceived of the Easter Bilby idea as a fund-raising tool for the anti-rabbit campaign, discussed it with conservationist and academic David Moyle and the South Australian Environment Minister Susan Lenahan in July 1991, and passed the concept of saleable Easter Bilby products over to the Australian Rabbit Fund (ARF, a predecessor of ARRFA) where Ed McAlister played a leading role in finding chocolate manufacturers (Morrison *pers. comm.* 2000). By the time of the press coverage, plans for the first production of Easter Bilbies by Haigh's Chocolates for the ARF were well advanced (Morrison 1998 and *pers. comm.* 2000). Newland pushed the idea heavily in the media (Morgan *pers. comm.* 1994). He and Robinson were colleagues in the South Australian public service and the original concept of the Easter Bilby as a substitute for the Easter Rabbit may have been taken up as a result of their discourse (Morrison *pers. comm.*).

'Easter Bilby' was registered as a business name for the ARF in December 1991 and ARRFA's first meeting took place in April 1992. In July 1993 ARFFA applied for the 'Easter Bilby' trademark and they obtained the rights later that year (Morrison 1998, 1999 and *pers. comm.* 2000).

The first Easter with Bilby chocolates was 1993. The earliest of the new delicacies, produced at the Port Adelaide Community Centre under licence to ARRFA (Morrison *pers. comm.* 2000) and in association with the South Australian Bilby Action Group and the Threatened Species Network (Hunwick *pers. comm.* 1994), were mostly flat 'Freddo Frog' type chocolates, although a few three-dimensional ones were made (Hunwick *pers. comm.*). Another small Adelaide confectioner, Melbas Chocolates, had adopted the idea in 1992 and were close to giving up, until a petition from a local school changed their attitude (Hunwick *pers. comm.* 1994).

Around 30,000 Bilby chocolates were manufactured for Easter 1993, the largest number being made by the Port Adelaide group (Hunwick *pers. comm.* 1994). In the weeks before Easter the demand was so great it could not be met: Bilby chocolates 'took off'. All three manufacturers contributed money to conservation efforts associated with the Bilby, but in 1994 these arrangements started to break down (Hunwick *pers. comm.* 1994). Melbas have contributed proceeds to wildlife conservation 'ever since' and now make a whole range of wildlife chocolates with royalties going to South Australian National Parks and Wildlife and the Threatened Species Foundation of Australia (Hunwick 1999). Haigh's have remained committed to fund-raising for the wildlife cause and have continued their original relationship with ARRFA to the present day (Morrison *pers. comm.* 2000).

At least three other small groups started making Easter Bilby chocolates in 1994 and about 100,000 were manufactured (Hunwick *pers. comm.* 1994). Hunwick's prediction (*pers. comm.* 1994) that by 1996 the Easter Bilby would definitely overshadow the Easter bunny, did not come to fruition, at least in Melbourne, although the Bilby has taken over a large slice of the market (see for example Oldfield 1996). Some 'Chocolate Bilbies', made by Pink Lady Chocolates of Brunswick, Victoria, were marketed by the Victorian National Parks Association for Easter 1996, and profits from the sales were retained by the Association for campaign work (Pink Lady Chocolates 1996, Griffiths 1996). Haigh's and Melbas are still making 'Easter Bilbies' (Morrison 1998, *pers. comm.* 2000).

Unfortunately some large manufacturers wanted to use the concept and pay nothing for it. Under the aegis of the Confectionary Manufacturers' Association of Australia they contested ARRFA's trademark in court proceedings. After a long battle, ARRFA's rights were recognised in 1997, and from Easter 1998 all 'Easter Bilbies' had to be licensed by ARRFA (Morrison 1998). But even if ARRFA enforces its trademark rights through the courts, there are 'smart' confectioners who make chocolate Easter Bilbies but call them something else and make only token commitments to conservation or none at all.

ARRFA deserves much of the credit for development of the Easter Bilby concept. In late 1994, with support from the Australian Nature Conservation Agency, they published *Easter Bilby*, a marvellous children's book, illustrated with beautiful detail, which describes how the Easter Bilby takes over from the Easter bunny (Garnett and Kessing 1994). In 1995 ARRFA produced the *Easter Bilby Action Pack* (Garnett and Kessing 1995), an activities book for children, and a kit which includes both the Garnett and Kessing books, along with a few extras (ARFFA 1995). The later book includes Bilby songs, pictures to colour and instructions for making Bilby masks, costumes and footprints. Proceeds from sales of these items and of the licensed confectionary have been used to support ARRFA's efforts to raise awareness of the impact of rabbits on the Australian environment, reduce rabbit impact and assist the recovery of endangered native species through education, research and conservation projects (Morrison 1998).

A Youthful Beginning for the Easter Bilby

But wait on! If Dr Robinson thought of the Easter Bilby around 1980 perhaps it was because that animal had already been doing its Easter duties at junior naturalist camps in the Australian bush for quite some time. It was not hard to discover that the Easter Bilby had started egg deliveries so long ago that the people involved had difficulty remembering precise dates and places. Former junior naturalists pointed to Malcolm Turner, an ex-President of the Hawthorn Junior Field Naturalists (HJFNC), as the originator.

Malcolm is a creative and effervescent person with an intimate involvement in environmental issues. He is just the personality type you could believe might originate such an outlandish concept. It was, he says, 'my idea at the time, but that doesn't mean someone else couldn't have thought of it independently' (Turner *pers. comm.* 1994).

The germ of the idea seems to have been in his 'pathological hatred' of rabbits, the association of the Rabbit-eared Bandicoot ('similar size, similar ears') and the necessary duties of a club President at Easter in a bush camp full of children. According to Malcolm, the initial exposure of the Bilby on Easter morning 'started a bit of a tradition'. He thought there were probably written records of this in reports of the Easter camps, and that the Easter Bilby first appeared in 1976 in the Little Desert (Turner *pers. comm.* 1994).

Unfortunately the reports published in the Club's magazine fail to provide confirmation of these recollections. Unusual events at the fifth Easter camp in 1975 possibly proved to be an ill omen for the bunny and perhaps presaged the arrival of the Easter Bilby. That Sunday morning had a 'bad start ... caused by the Easter Bunny sleeping in, however there were few objections raised once she delivered the goods' (Sandell 1975).

If the Easter Bilby took over the following year in the Little Desert, at Nowa Nowa and Lake Tyers in 1977, or on the Lower Glenelg in 1978, no published record appears to have been made. Yet in the following years there are no further references to Easter bunnies. It is not until

1984 that the first published mention of the Easter Bilby appears: 'The Easter Bilby knew where to find us again this year and left a bundle of easter eggs in the morning' (Kelleher 1984). So, from at least as early as 1983 the visit of the Easter Bilby became an important tradition among this young band of dedicated nature lovers and conservationists. One former HJFNC President, Jonathon Stevenson (*pers. comm.* 1994), recalls first being exposed to the idea at the 1983 camp, when Geraldine Richards was the Bilby. He thought it had begun in 1980 (Strathbogie Ranges) or 1981. Richards herself (*pers. comm.* 1994) thought it might have started in 1977, 1979 (Lake Meran and Leaghur) or 1980 and recalls Malcolm himself delivering the eggs on Easter morning.

The tradition did not fade away. In 1985 'Again the Easter Bilby paid a visit ... to our delight' (Anonymous 1985) and in 1987 the planned activities included 'the traditional visit by the Easter Bilby on Sunday morning' (Stevenson 1987a). On Easter eve junior naturalists 'once more fell asleep under the stars, anticipating with excitement the arrival of the Great Easter Bilby the next morning' (Stevenson 1987b). Malcolm Turner made, and used, a set of cardboard Easter Bilby ears (Richards *pers. comm.*). Members of the HJFNC Council took turns in distributing the eggs and being the Easter Bilby (Clark *pers. comm.* 1994). Ros St. Clair, now an aquatic biologist, was 'probably involved very early' (McInnes *pers. comm.* 1995).

Although published records appear to be lacking, the first appearance of the Easter Bilby at the sixth Easter camp held near Kiata in the Little Desert in 1976 cannot be discounted. Easter Sunday that year was 18 April.

Jonathon Stevenson himself took the idea from Melbourne to Adelaide in 1990 but found it already current in South Australia. He inculcated the Adelaide Junior Field Naturalists into the tradition, but South Australian farmers and farming groups, with big rabbit problems, were already promoting the Easter Bilby and the idea was becoming popular (Stevenson *pers. comm.* 1994). Both Stevenson, and Gerard Marantelli (another, but younger, former HJFNC President) think there was probably an independent origin in South Australia, and this seems to have been the flash of brilliance from Dr Tony Robinson.

The Animal Origins of Easter

An understanding of the history of Easter will remove any embarrassment about the idea of the Easter Bilby. Easter has its roots thousands of years ago as a northern hemisphere pagan celebration associated with the coming of Spring. The Bilby joins a minor pantheon of other creatures which are, or have been, important characters in the festivities.

For Christians, Easter is a celebration of the death and resurrection of Jesus Christ and was probably first commemorated in conjunction with the Jewish Passover (Wilson 1963, Baldovin 1987). The word Easter is derived from the Norse *Eostre*, meaning the festival of (northern hemisphere) spring, at the vernal equinox on March 21, when nature reawakens after winter. Thus, in this pagan tradition, it is associated with the rabbit and the egg, both symbols of fecundity and fertility (Wilson 1963). Death and rebirth were symbolised by the Hare in Mesopotamia and Syria around the second millennium before Christ, and this mythology was apparently accepted in altered form by early Christians, who featured the Rabbit on gravestones (Waida 1987).

The Rabbit is one of several animals associated with the Christian Easter. In parts of Germany it is the Easter Hare which leaves eggs and a life-size chocolate version of himself on Easter Morning. Children may make nests of grass or straw for him to leave his eggs in. The Cockerel brings the eggs in Upper Batavia, while in Franconia it is the Fox, in Hanover the Cuckoo and in Hess the Crane (MacDonald 1992). It is curious that metatherian mammals (in contrast to monotremes) and male creatures (e.g. the Cockerel), which are biologically incapable of egg production, should be egg-bearers.

How can Folklore and Religion aid Conservation

Australia has the worst record of any country in the world for the conservation of mammals over the last 200 years, with many extinctions of medium-sized, ground-dwelling species, particularly in the dry inland. There is also an inadequate understanding of the reasons for these losses and the techniques needed to stop them (Short and Smith 1994). The country is overrun with feral animals and livestock, the public is largely ignorant of the existence of threatened species and threatening processes, and governments are too uncaring and 'tight-fisted' to fund adequate scientific studies. The Easter Bilby came along at a critical time and provided a little push in a novel way.

It is difficult to gauge the effects of its arrival. Some funds at least have flowed to conservation. The public is more aware of one of the beguiling and mysterious endangered mammals, which most of them will never get to see. And the displacement of the pest Rabbit as an Easter icon by the Bilby is a nice, if only symbolic, reversal, which helps us to focus on one of the major Australian conservation problems. Bilbies 'bred in the wild for first time in about 100 years' in South Australia in 1998 at the Yookamurra Sanctuary, run by John Walmseley and Earth Sanctuaries (Anonymous 1998). Richard Southgate and colleagues have continued their work on Bilby management, including unsuccessful introductions of captive-bred animals in central Australia. Various land management programs and techniques to control the predators and competitors of bilbies and enhance their habitat have been put into operation (Christensen 1997). But the contribution of the Easter Bilby to these projects appears to be indirect at best.

Nevertheless, the invention of the Easter Bilby as a substitute for the Easter bunny has certainly achieved something. Now many more people know about the Bilby and the problems of conserving it (Christensen 1997). We can, perhaps, be more optimistic about its future as a wild animal. The Rabbit, our worst pest, has been partially knocked from a position on a religious pedestal that might have been thought unassailable. The iconoclasts of ARRFA and other groups in South Australia deserve our praise. Little ideas can grow into big things. Australian folklore has been enriched, and is now being elaborated, in collaboration with ARFFA, by such people as Ali Garnett and Kaye Kessing, and by the children's author Irena Sibley in her 1994 book *The Bilbies' First Easter*. Easter Bilby chocolates have a big future, but if manufacturers want to use the idea, they have at least a moral obligation to contribute a part of their profits to the conservation of *Macrotis lagotis*, and we must demand that they do.

A better understanding of the origin and development of this new icon may assist in the development of a systematic approach to the enculturalisation of other threatened creatures. Is it forlorn to hope, in the current environment of globalisation, that a methodology can be devised which will enable other little-known animals to be adopted into and to enrich popular Australian culture?

Conclusion

Finally, a disclaimer is necessary. This is a very partial and incomplete portrait of the origins, development and significance of the Easter Bilby, based largely on hearsay. Much remains to be documented about the use of chocolate Bilby royalties, the consequences of the Easter Bilby for *M. lagotis*, the precise beginnings of the idea and the ways in which it propagated. There are many leads to pursue. People other than those consulted for this paper may have better or contrary evidence and recollections. The early history of the chocolate Bilby is a much more complicated story than I have been able to portray. Dr Rob Morrison of Flinders University has investigated the South Australian aspects in detail, and his research on the importance of the 'Easter Bilby' product in the origins of ARFFA, the disputes about ownership of the concept, and subsequent developments may one day be published (Morrison *pers. comm.* 2000). A fuller investigation is definitely called for - a job for a careful historian! The Easter Bilby is part of 'white man's culture': the folklore, explanations and traditions of the Aboriginal peoples have received no mention in relation to it here.

I would be pleased to obtain any information which readers might have about the origin and propagation of this marvellous new tradition. Did it spread in the naturalist subculture and thence into popular culture? Are there any others who claim to have originated the idea? Victorian naturalists might like to review their diary entries at Easter in the late 1970s and check their photograph collections for shots of an Easter Bilby quietly performing early morning duties.

Down with the Easter bunny! Long live the Easter Bilby!

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References

Adelaide Advertiser. 27 November 1991, p.1.

Anonymous (1985). Easter camp 1985 - Stanley. *Junior Naturalist* **21** (4), 4-5.

Anonymous (1998). Bilbies born in wild a first. *Herald Sun* (Melbourne) 13 June, p.16.

Anti-Rabbit Research Foundation of Australia (1995). 'Easter Bilby Action Pack'. (ARFFA, Adelaide)

Baldovin, J.F. (1987). Easter, pp. 557-558 in M. Eliade (Ed.), 'The Encyclopaedia of Religion'. (MacMillan: New York).

Bellchambers, K. (1993). The bilby. *Australian Natural History* **24** (5), 16-17.

Christensen, L. (1997) The ears have it for the easter bilby. *Geo Australasia* **19** (2), 18-29.

Garnett, A. and Kessing, K. (1994). 'Easter Bilby'. (Anti-Rabbit Research Foundation of Australia and Australian Nature Conservation Agency: Adelaide.)

Garnett, A. and Kessing, K. (1995). 'Easter Bilby Action Pack'. (Anti-Rabbit Research Foundation of Australia and Australian Nature Conservation Agency: Adelaide.)

Griffiths, L. (1996). Easter Bilbies. (Victorian National Parks Association: Melbourne) [single page order form].

Hunwick, D.J. (1999). Chocolate bilbies. *Nature Australia* **26** (5), 4.

Johnson, K.A. (1983a). Lesser bilby, p. 109 in R.Strahan (Ed.), 'The Australian Museum Complete Book of Australian Mammals'. (Angus and Robertson: Sydney.)

Johnson, K.A. (1983b). Bilby. *In* 'The Australian Museum Complete Book of Australian Mammals', pp. 107-108. Ed. R. Strahan. (Angus and Robertson: Sydney.)

Johnson, K.A. (1989). Thylacomyidae. Ch. 25, pp. 625-635 in D.W. Walton and B.J. Richardson (Eds.), 'Fauna of Australia Vol. 1B. Mammalia'. (Australian Government Publishing Service: Canberra).

Kelleher, N. (1984). Easter camp report 1984. *Junior Naturalist* **20** (5), 5.

MacDonald, M.R. (Ed.) (1992). 'The Folklore of World Holidays'. (Gale Research Inc.: Detroit.)

Morrison, R.G.B. (1998). Will the real Easter Bilby please stand up? *Nature Australia* **26** (2), 5.

Morrison, R.G.B. (1999). Easter Bilby origins. *Nature Australia* **26** (7), 6.

Oldfield, S. (1996). Shoppers hit by early bilby plague. *The Age* 29 February p. A7.

Pink Lady Chocolates (1996). 'Chocolate bilbies'. February. [Advertising pamphlet]

Sandell, R. (1975). Report on the Easter camp Part 1. General. *Junior Naturalist* **11** (9), 4-7.

Short, J. (1994). Burrowing bettong. *Australian Natural History* **24** (9), 22-23.

Short, J. and Smith, A. (1994). Mammal decline and recovery in Australia. *Journal of Mammalogy* **75**, 288-297.

Sibley, I. (1994). 'The Bilbies' First Easter'. (Aird Books: Flemington, and Silver Gum Press.)

Stevenson, J. (1987a). Easter camp Wyperfeld National Park. *Junior Naturalist* **23** (3), 4-5.

Stevenson, J. (1987b). Easter camp report part 1 - Wyperfeld National Park 1987. *Junior Naturalist* **23** (6), 4-7.

Waida, M. (1987). Rabbits. *In* 'The Encyclopaedia of Religion', pp. 192-193. Ed. M.Eliade. (MacMillan: New York.)

Wilson, P.W. (1963). Easter. *In* 'The Encyclopaedia Americana', pp. 506-508. (American Corporation: New York.)

Additional Bibliography

Alexander, J. (1995). Bilby suits as Easter symbol. *Weekly Times* 15 March, p. 26.

Alexander, J. (1995). Easter bunny, it's time to move over. *Weekly Times* 15 March p. 29.

Anonymous (1995). Bilby prizes. *Weekly Times* 12 April, p. 93.

Anonymous (1999). Bilbys to the rescue. *Australian Landcare*, June, p.66

Dusting, R. (1997). 'Billy the Aussie Easter Bilby'. (Anti Rabbit Research Foundation of Australia: Adelaide).

Faithfull, I. (1994). When did the Easter bilby first visit the HJFNC? *Junior Naturalist* **30** (8), 9-10.

Flannery, T. (1998). The triumph of the Easter bilby. *Nature Australia* **25** (12), 80.

Green, L. (1994). Bilbo bilby. *Australian Natural History* **24** (8), 7.

'Griffo'. (1995). Easter won't be the same. *Weekly Times* 28 November p. 3.

Nias, R. (1990). The return of the bilby. *Wildlife In Australia* **27(3)**, 22-23.

Parker, B., Lam, E. and Clarke, I. (1989). The Easter bilby. *The Junior Naturalist* **25(5)**, 7. [Poem]

Strong, G. (1995). They survive on greens but live on borrowed time. *The Sunday Age* 22 January, p. 2.

Personal Communications

Letter from Richard Southgate, Conservation Commission of the Northern Territory, to Ian Faithfull, 13 September 1994.

Letter from E.J. McAlister, Anti-Rabbit Research Foundation of Australia, to Ian Faithfull, 12 October 1994.

Excluding the Common Myna *Acridotheres tristis* from Artifical Nest Boxes Using a Baffle

In June 1996, sixteen artificial nest boxes were erected in Eltham Lower Park, Victoria, as part of a general fauna survey (*The Victorian Naturalist* Vol. **116** (1), February 1999). When these boxes were checked in the Spring of 1996 and 1998, many were found to contain nests of the Common Myna or the Common Starling *Sturnus vulgaris*, both introduced bird species that roost colonially.

Following discussions with Ian Temby, Flora and Fauna Branch, Department of Natural Resources and Environment, several boxes were modified in February, 1999, in an attempt to exclude the Common Myna, in particular, but still allow access to native birds and mammals.

Five boxes, that had been used by the Common Myna in one section of the park during the 1998 breeding season, were chosen. All had 70 mm entrance holes and each box was approximately four metres from the ground. Two of the boxes were left unmodified and the other three were modified by attaching a board or baffle of 19 mm exterior grade ply, using two strips of tin, to the overhanging roof of each box, so that the board hung down in front of the box, thus obscuring the entrance hole (see diagram). The gap between the baffle and the front of each box was 100 mm and the distance from the side of each box to the entrance hole was 104 mm. To stop the baffle from swinging in the wind, a piece of heavy gauge wire was attached from the bottom of the baffle to the side of the box (Fig. 1).

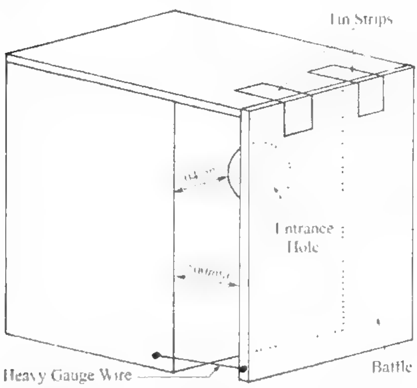

Fig. 1. Diagram of modifications made to artificial nest boxes in order to exclude the Common Myna.

This 'anti-myna baffle' has also been suggested by Birds Australia and features in a handout from that organisation (Birds Australia Information Sheet No. 5, 16 September 1999).

When the boxes were checked on 6 October 1999, the three modified boxes were found to have been used by native species. The first box contained the nest of a Rainbow Lorikeet *Trichoglossus haematodus* (one juvenile), the second contained an empty Sugar Glider's *Petaurus breviceps* nest and the third contained an adult Common Ringtail Possum *Pseudocheirus peregrinus* with two juveniles. The two unmodified boxes, as in previous years, were both found to contain nests of the Common Myna.

Whilst this record only involves a small sample and covers only one breeding season, nonetheless, it provides further evidence that the Common Myna can be excluded from artificial nest boxes using a baffle. This note may be useful to other workers, who may be considering the use of artificial nest boxes as a survey or management tool in areas where introduced pest species exist.

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Those Hitler Birds!

On returning home to check the mail box for recent mail deliveries, I was greeted with an avalanche of grass, leaves and paper at least equal to the volume of mail beneath. Examination of the top letters showed they were spotted with bird droppings. I began to wonder if I had a problem.

Later in the day I met a neighbour in the street, who said she agreed with me. A bird had almost knocked her over when it suddenly flew in her face as she drew level with my letter box. (Recently I had the box and slot enlarged to cope with the increased mail; often junk these days). So, now I knew the problem was real. Local Common Mynas *Acridotheres tristis* (previously called Indian Mynas) were using my letter box as a nesting box.

By pinning a heavy, bright plastic bag above the slot so that the free end covered it, it was possible for the postman to drop the bundle of letters in. On the other hand, the Common Myna did not like the flapping plastic impeding its flight through the slot, so was deterred from entering my box.

After a couple of days, I thought the birds had found an alternative so I removed the plastic. But they were soon up to their old tricks, cluttering the letter box, showing their persistence and lack of success in finding a new nesting spot.

This is the third year I have been pestered by these 'hell-bent' nesting Common Mynas. Last year I found myself clearing the front terrace of grass, leaves and paper every half hour because a pair of Common Mynas decided they should build a nest on a ledge above the windows and under the eaves. Again, I found they were deterred by hanging plastic bags, which flapped in the breeze, across where the birds were trying to nest.

The previous year we had an air conditioner installed on the back terrace through a corner window. Common Mynas were dumping leaves, grass and paper on the top of the air conditioner, under the ceiling. This time we hung cloth around the perimeter of the top of the air conditioner, curtaining it off. After the target was hidden the birds still came in with nesting material and littered the area around the conditioner. They finally gave up after a day, but the litter had to be cleared regularly because of the prevailing windy conditions. During this nesting-urge period Common Mynas are very persistent.

Greg Binns, from Ballarat FNC, aptly described these birds as 'Hitler' birds. They goose step around as if they 'own the joint'. As they strut they synchronise their head movements with the goose step. (If Nazi storm troopers did that they'd be court-martialled for clowning and disrespect.) Their cheeky screech of 'Sieg heil, sieg heil, seig!' during the month of November has sharpened up our 'vigilance' skills.

N. Schleiger
1 Astley Street,
Montmorency, Victoria 3094.

For assistance with the preparation of this issue, thanks to Anne Morton for desktop publishing; Tim Grey for scanning nest box on p. 75; Dorothy Mahler for administrative assistance and John Seebeck for sourcing photographs. Thanks also to Felicity Garde (label printing) and Michael McBain (web page).

Elizabeth Kathleen Turner
19 August 1914 – 26 December 1999
A Tribute

Elizabeth Turner AO, MD, FRACP, LLD (Hon) was the eldest of three daughters born to Harry and Irene Turner. Their home was in Croydon, Victoria. Elizabeth maintained a close relationship with her two sisters – Caroline Nancy Cats (deceased 1997) and Dame Phyllis Frost. Several family camp-outs took them to East Gippsland – Mallacoota was a favourite site. In those early days of settlement, Croydon was surrounded by bush with indigenous flora and fauna: relatives of the Turners also had a farm at Scoresby. All of the fore-mentioned places influenced Elizabeth's innate field naturalist interests. It has been my privilege to have known the Turner family for over 60 years.

The girls' primary education was at a small school in Croydon, their secondary education was at St. Duthus, Canterbury, and from here the sisters were enrolled at Presbyterian Ladies College, East Melbourne. At PLC, Outdoor, Camera and Garden Clubs were extra-curricular activities and membership was voluntary. Excursions to Heathmont, Blackburn bushlands and Beaumaris were held. The Fitzroy Gardens situated opposite the School were used for Biology classes in school time. Miss Laura White was the teacher of Botany and Animal Biology subjects and organiser of the Outdoor Club. She inspired students to further in-depth studies of these subjects, and over a long time was a loved friend, and member of the FNCV. There was also Uncle Tom, T.S. Hart, an Honorary member of the FNCV, and botany was his particular interest. Elizabeth and her friends benefitted from Uncle Tom Hart's knowledge of natural history, both in the field and from his library of references.

After graduating in Medicine at the University of Melbourne in 1948, Elizabeth started a practice in Spring Street, Melbourne. Later she led a very busy life as a consultant paediatrician at the Royal Childrens Hospital as well as roles in clinical educational, academic and administrative duties at this hospital.

The FNCV has benefitted greatly from Elizabeth's interest in its affairs. Her membership extended over 30 years, and she was a member of Council from June 1981 to October 1982. During the 1980s she was secretary of the Victorian Field Naturalists Clubs Association, attended conferences and encouraged continuation of this worthwhile organisation. Elizabeth also contributed to *The Victorian Naturalist*, notable amongst her articles were 'Preventive Marsupalian Paediatrics' (Vol 94, 129-131, 1977) and 'Botany in the Service of Medicine' (Vol 106, 252-258, 1989). Elizabeth was an active supporter of the Botany Group of the FNCV and her reports from 1969-1993 of both short excursions and excursions over longer periods were well documented.

From an early age Elizabeth was an accomplished musician, playing the piano and later concertina, guitar and a Conch Shell! The Congregational Church, Croydon, appreciated her playing the organ for two services each Sunday for many years. Interstate Student Christian Movement conferences and University of Melbourne SCM gatherings also claimed her gift for music. Elizabeth had lessons in painting, and she loved the subjects she painted.

In the 1930s Elizabeth purchased a house on a cliff-top property above Point Leo beach, Westernport Bay. Typical of her generosity, it became a holiday home for members of her family and for friends. Can you imagine the excitement when we discovered Argonauts stranded on the shore platforms between Shoreham and Merricks! Most of the Argonaut specimens have been given to the National Museum of Victoria (1989). Day excursions via ferry to French Island were special events. Over a period of time Elizabeth checked the health of one of her patients from the Royal Childrens Hospital who was an islander, after which we toured the Island for rewarding observations of flora and fauna.

Another highlight was spent with Junior FNC members. At the invitation of Dan McInnes, Elizabeth and I attended the Easter Camp (27 April 1979), at Leaghur Forest Park. The Juniors 'show and tell' session around a log fire in the evening was a memorable experience. When Elizabeth was an excursion participant, Marie Allender, a former FNCV Excursion Secretary would breathe a sigh of relief to have a medico on board!

Elizabeth was an avid traveller, and her scientific curiosity about all her experiences is well documented in her diaries and on film. After travelling to Hawaii and the Galapagos Islands, Elizabeth gave two fascinating lecturettes at General Meetings of the Club. The Latrobe Valley FNC invited her to repeat the Galapagos Islands talk at their monthly meeting. She gave freely of her time and energy towards conservation projects, one being membership of the Native Fauna Conservation Society of Victoria.

The following words were among those given at the Celebration of a Thanksgiving Service for the life of our dear friend, Dr. Elizabeth Turner: 'a life of skill, courage, dedication, altruism and love filled with the joy of living' - Vale Elizabeth.

Mary K. Doery
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Mont Albert, Victoria 3127.

Acknowledgements
Dame Phyllis Frost, Dr. Nate Meyers for an obituary printed in *The Age*, Mrs. Sheila Houghton, FNCV Librarian, Mrs. Elizabeth McRae for the photo with my thanks.

Photo. Elizabeth Kathleen Turner, photographed on 10 June 1997 by Mrs Elizabeth McRae.

Feral Future

by Tim Low

Publisher: *Viking, Penguin Books Australia Ltd, Ringwood, Victoria,1999.*
Paperback, xix + 380 pp. (including 8 pp. colour photographs).
ISBN 0670 88465 0. RRP $24.95.

One of Tim Low's most frightening images in *Feral Future* is of the Cane Toad hopping, inexorably, towards Kakadu National Park. It encapsulates the urgent message of his book. On arriving in Kakadu, the Cane Toad will change the ecology of that place forever, displacing or devouring numerous native species. The Cane Toad was deliberately introduced into Australia in 1935 (to control the Greyback Beetle). We seem to be powerless to stop its advance, and reluctant to face up to its probable consequences. 'How will the traditional owners of Kakadu judge us?' asks Low. How should we judge ourselves?

In Australia, 'exotics' are usually understood to be any organisms that have arrived from overseas since the first contact by Europeans over 200 years ago. Aborigines and people in neighbouring countries have also introduced some species to Australia (such as the Dingo), but not on the same scale as Europeans. They have introduced thousands of organisms, and the rate of introduction is increasing. Feral species are the ones that have successfully gone wild, and become naturalized in disturbed areas like roadsides and agricultural land, but also in the relatively pristine Australian bush.

Low subtitles his book, 'The untold story of Australia's exotic invaders', but that claim is not quite true – as his excellent bibliography attests. The invasive qualities of various organisms have been recorded by writers from a range of disciplines such as agriculture, horticulture, and medicine. What Low has contributed to the record, however, is a synthesis of the whole story. No group of organisms is omitted from his account. Well-known plants and animals are joined in it by seaweeds and fishes, and there are representatives of the fungal, bacterial and protist kingdoms as well.

Low divides Australia's exotics in two categories. In the first are the species that were deliberately introduced, including pasture grasses and garden plants. These imports have been motivated in part by an ignorance of or disdain for native resources and a nostalgia for the plants and animals of 'Home'. In his second category are the species that have invaded by stealth — uninvited guests in contaminated seed and soil, ballast and packing materials to name but a few of the myriad of ways they have entered the country. Both kinds of introductions have been responsible for equally noxious pests.

In the deliberate category, Low singles out the acclimatization societies of the nineteenth century for special ridicule. One of his main targets is the first patron of the Field Naturalist's Club, Ferdinand von Mueller. There is no doubt that Mueller contributed to the introduction of species that we now regard as pests, but does that mean he was stupid? Low omits to mention that the science of ecology was not developed until the very end of the century. Thus, Mueller did not have the concepts that might have helped him to predict the disaster that was to come, and also he did not quite live to see it.

Surely most contempt should go to the people who continue to import plants and animals in the face of incontrovertible evidence of the dangers involved. Low cites the aquarium and horticultural industries as spectacular examples of this practice.There are apparently also agriculturists who still cannot grasp the fact that the new vigorous and hardy plants they want to import for pastures are also the ones most likely to become weeds elsewhere. Another powerful image in Low's book is of happy gardeners blissfully or wilfully ignorant of the havoc caused by escapes from their backyards.

Although Mueller was an acclimatiser, he was also a strong opponent of the introduction of known pests into Australia (including the rabbit). He had in mind, however, only their effect on rural industry, not on the bush. The concept of an environmental weed has only emerged in recent decades. Mueller also spoke out about the destruction of native plants. He laid this at the door of Europeans (the most destructive of all exotic species) whose reckless clearing and burning was motivated by greedy short-term goals and a disregard for the future.

Mueller is a reminder of the difficulties of assigning blame without due regard to historical context (the issues in the past were just as complicated as they are today). He is also a reminder that the history of opposition to the destruction of the Australian landscape is as long as the history of its destruction. Understandably, Low concentrates on the importers in *Feral Future*, but adding a few nineteenth-century heroes to the scientists, environmentalists, and quarantine officers in the front-line in the twentieth century would not have undermined his central thesis.

Australia has already been forever changed by exotic organisms, but Low tells us that there is much worse to come. The feral future he predicts will consist of an international ecology, with far fewer species than in the present. We are, he argues, entering an era of mass extinctions. In this McDonaldized world some Australian natives will hold their own, while others will find homes overseas and become part of the exotic menace in other countries (Low has a whole section on Australians as pests), but that is cold comfort when the overall picture is so bleak.

Most depressing of all is our failure to face up to this future. In are port in 1895 Inspector General Ribbentrop noted that Victoria's forests were poorly managed because of the tendency of governments to put the financial interests of some individuals ahead of the good of the whole community. A recent example of this tendency was the decision of the Tasmanian Government to oppose the release of Blackberry Rust because it would threaten a local honey and berry industry worth about $300,000 a year. Problems caused by blackberries themselves cost Australia $42 million a year.

Low concludes his book with the familiar activist's plea to think globally and act locally. His advice to concerned citizens includes not providing homes for noxious weeds in our gardens, not changing the fertility of bush soils by using them as toilets, and joining a local bushcare group. To this list I would add buying *Feral Future* for yourself, but also for your friends (especially keen gardeners). You may not like what you learn from it, but you will find Low's passion and information so compelling that you will not be able to stop turning the pages.

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The Koala: Natural History, Conservation and Management

by Roger Martin and Kathrine Handasyde

Publisher: *University of New South Wales Press Ltd, 1999. Paperback. Coloured plates, 132 pp. RRP $29.95*

This wonderfully narrated and typographically immaculate book summarises 20 years of research into Koala biology, much of it carried out by the authors themselves. In the ten years since this book was published, new information on the biology of the Koala has accrued rapidly. Consequently, the first edition, as authoritative as it was, no longer provides an adequate summary of current knowledge. The second edition successfully redresses this information 'lag', while retaining the readability of the original book. The authors acknowledge that few Australian animals are as steeped in misconception and misunderstanding as our beloved Koala and state that 'one of the problems of dealing with an animal...icon is that we tend to lose track of the basic facts of its biology.' Perhaps more than anything else, the second edition's purpose is to dispel these misconceptions. It brims with previously unpublished information that is both accurate and thoroughly fascinating.

In addition to providing an up-to-date account of topics such as distribution, abundance, evolution, diet, reproduction and behaviour, the book has been further improved through the inclusion of two new detailed chapters that deal with the complex and interrelated subjects of predators, parasites and pathogens (particularly *Chlamydia*) and Koala population biology. These two chapters alone make the book a worthwhile read, as the dynamics of Koala populations, and the manner in which *Chlamydia* acts upon them, is poorly understood. Yet it has far-reaching implications for the management of the species. The authors use a series of case histories to highlight the apparent paradox of Koala populations, which in some areas seem to be declining, while in others are multiplying so rapidly that they are depleting their food resources. The authors discuss in detail how the chlamydial infection status of a Koala population can, in many cases, be used to explain the differences in fecundity and abundance between populations, and what this means for the species' management.

I believe the most important chapter is the last one, which deals with conservation and management. Here, the reader is forced to confront the reality of Koala population management, which is both complex and problematic. A range of management options is presented for those areas experiencing a Koala overpopulation problem, and the merits and limitations of each are thoughtfully discussed. After reading this chapter, it soon becomes apparent that the management of Koala populations is highly political, and that a fundamental change in community attitudes is needed before that distasteful, yet ecologically sound management option, culling, can be implemented. Until that time, it seems that inappropriate and often expensive management strategies will prevail, which appear to achieve little else than to take limited conservation dollars from more worthy causes.

The information on which this book is based has been largely derived from research carried out in southern Victoria, and I feel that the book would have benefited by incorporating more studies from the northern part of the Koala's range, where its ecology may be quite different. However, the authors are quick to point out that such studies are in short supply. This aside, the book is full of high quality illustrations and colour plates that complement the text well. This work is without doubt the most comprehensive summary of what is known about this unique Australian. I thoroughly recommend this book to all koalaphiles, especially those with an interest in the conservation and management of the species.

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The

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Cover: Angair members Gwen Hall and Ted Faggetter with Alice Talbot and Elspeth Ferguson monitoring vegetation regeneration in heath woodland near Anglesea Victoria, two years after the 1983 Ash Wednesday wildfire. Photo by Margaret Wark. See story on p. 96.

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Mountain Swamp Gum *Eucalyptus camphora* at Yellingbo State Nature Reserve: Habitat Use by the Endangered Helmeted Honeyeater *Lichenostomus melanops cassidix* and Implications for Management

Jennie Pearce[1]

Abstract

Within the Yellingbo State Nature Reserve, breeding neighbourhoods of the endangered Helmeted Honeyeater *Lichenostomus melanops cassidix* are found within patches of Mountain Swamp Gum *Eucalyptus camphora* vegetation characterised by trees of small girth spaced closely together, within standing water. These patches are scattered throughout a more open *E. camphora* matrix. Little is known regarding the regeneration ecology of *E. camphora*, or how stand structure is affected by site conditions such as waterlogging. This study used dendrochronology techniques to assess the hypothesis that Helmeted Honeyeaters occupy younger patches of vegetation within an older matrix. It was found that trees within both Helmeted Honeyeater habitat and the surrounding matrix were approximately the same age. Stand structure therefore apears to be related to prevailing site conditions, with Helmeted Honeyeaters occupying stands that are growing within the more waterlogged sites. These results are discussed in relation to the known features of *E. camphora* regeneration ecology to determine management strategies that will encourage the expansion of suitable Helemeted Honeyeater habitat within the Reserve. (*The Victorian Naturalist*, **117** (3), 2000, 84-92.)

Introduction

The Helmeted Honeyeater *Lichenostomus melanops cassidix* is an endangered subspecies of the Yellow-tufted Honeyeater restricted to the Yellingbo State Nature Reserve and immediate environs in the mid-Yarra Valley (Menkhorst and Middleton 1991). Helmeted Honeyeaters are strongly associated with dense stands of Mountain Swamp Gum *Eucalyptus camphora* forest (Pearce *et al.* 1994). Indeed the current distribution of Helmeted Honeyeater neighbourhoods within the Yellingbo State Nature Reserve can be explained by the distribution of these dense stands (Pearce 1997). These patches of dense forest within a more open matrix of *E. camphora* suggest that the *E. camphora* vegetation across the Reserve may not be even-aged. Past disturbance events, such as clearing, fire, flood or severe windstorm may have resulted in patches of younger forest becoming established. Forest structure may also be influenced by heterogeneous site conditions.

Knowledge of the disturbance history of the Reserve, and the reasons behind the variation in vegetation structure observed within the *E. camphora* vegetation are important for the development of appropriate vegetation management strategies for the maintenance, enhancement and creation of Helmeted Honeyeater habitat. Reconstruction of the disturbance history within the Reserve will provide information on the regeneration biology of *E. camphora*, the expected structural changes of *E. camphora* woodland over time, and information regarding the future availability of habitat suitable for the Helmeted Honeyeater.

This paper seeks to review information regarding the regeneration biology of *E. camphora* and its response to disturbance, collate the known historical disturbance information for the Yellingbo State Nature Reserve, and report a pilot study to determine whether it is possible to utilise dendrochronology techniques with *E. camphora* to determine the age of stands and the events that have led to their establishment. The implications for vegetation management within the Reserve will also be discussed.

Eucalyptus camphora Biology

Eucalyptus camphora was formerly thought to be restricted to high elevation subalpine swamps from New South Wales to Eastern Victoria. Simmons and Brown (1986) extended this range to the Yarra

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Valley in Eastern Victoria, where populations had previously been confused with Swamp Gum *E. ovata*. The *E. camphora* stands within Yellingbo are therefore at the southern limit of the species' range.

The most comprehensive study of *E. camphora* is that of Boden (1962) in the more typical high elevation environment. He studied the waterlogging tolerance of *E. camphora*, along with several other *Eucalyptus* species in Wee Jasper National Park in New South Wales. He found that *E. camphora* was typically found in winter rainfall areas, where waterlogging occurred in winter when little growth was taking place. It commenced growth soon after winter when waterlogging was still present. Flowering occurred from March to April (cf. February to April at Yellingbo; McMahon and Franklin 1993). Pure stands of *E. camphora* occurred in the coldest sites with the least soil aeration, and did not grow in running water but were common on flats which were almost continually waterlogged. Regeneration was sparse on swampy sites, and because of dense grass and reed growth, seedlings were extremely difficult to locate until they appeared above this layer. Seedling numbers were greater on swamp margins compared to within the swamp, with *E. camphora* seedlings well represented in the regeneration layer 40-60 m away from the swamp, but not well represented in the tree layer at these sites.

Eucalyptus camphora has a number of morphological features that are considered to be adaptive to the waterlogged environment. They include the development of aerenchyma tissue which allows for effective gas exchange between roots and shoots, a specialised root system formed largely at or near the soil surface and the ability to form cladogenous roots under conditions of submergence and reduced aeration around the primary root system (Boden 1962).

Boden (1962) studied seed germination and seedling growth both in the field and the greenhouse. He found *E. camphora* seed did not appear to have a dormancy period, as many other cold climate species do, and that *E. camphora* seed germinated and grew vigorously in pot trials under dry and waterlogged conditions. This vigorous growth was due mainly to the development of spongy aerenchyma tissue on the stem at or below the water level. Boden (1962) also broadcast seed and laid capsule-bearing branches in the field across a moisture gradient from wet to dry sites. Seed germinated at all sites, but germination was better on wet sites. Only those seedlings on the swamp margin remained after 1 year.

Surface drying may result in the death of seedlings on dry sites. Boden (1962) found seedlings grown in pot experiments contained a high number of lateral roots in the first 2-5 cm of root development. This may be an advantage with respect to swamp living, but not to living on drier soils in greater competition with other species. Seedling growth was rapid, possibly another adaptation to swamp living where there is a need to compete with a dense grass and sedge layer.

Regeneration in plants may be initiated by several processes, such as fire or wind disturbance (Hibbs 1982). Recruitment may also be gradual, as internal changes in the forest environment promote a steady recruitment of new trees (Oliver and Stevens 1977). Fire is unlikely to occur in very wet sites such as areas occupied by *E. camphora*, except in times of drought when it would be expected to kill most of the overstorey. However, overturning due to wind is quite common within *E. camphora* woodlands in waterlogged soils. When trees are overturned on swampy sites most survive as the roots are not broken and remain alive due to the soft nature of the soil and the wet conditions. The normal inhibition of epicormic buds is removed and numerous shoots develop from the stem (Boden 1962). Overturned living trees are present at Yellingbo, and support Helmeted Honeyeaters. Steady recruitment of *E. camphora* is unlikely, as Boden (1962) found that *E. camphora* seedlings did not establish naturally under a mature *E. camphora* canopy.

It is therefore expected that *Eucalyptus camphora* would be slow to establish in very swampy areas, and there would be a high rate of mortality among seedlings. Boden (1962) found establishment was better in moist but not inundated sites, suggesting that regeneration may be restricted to times of near drought when areas would have substantially dried out. At this time, soil desiccation around windthrown stands, along with fire, may result in the death of large patches of vegetation, allowing *E. camphora* regeneration. It is expected that this type of regeneration would result in even-aged patches of *E. camphora* woodland.

Disturbance History of Yellingbo State Nature Reserve

The history of the Yellingbo State Nature Reserve has been compiled by both Curtis and Smales (1982) and Miller and Buckland (1987). These reports provide a summary of information regarding the disturbance history of the Yellingbo State Nature Reserve. Extensive consultation with older residents of the Yellingbo area and detailed examination of historical aerial photographs is required to obtain more information regarding the exact dates, geographical limits and severity of particular disturbance events within the Reserve. This is currently being undertaken (S. Kassell *pers. comm.*). The disturbance events listed in Curtis and Smales (1982) and Miller and Buckland (1987) are summarised in Table 1.

Dendrochronology as a Source of Information

Dendrochronology is the study of tree rings where the annual growth layers have been assigned to or are assumed to relate to specific calendar years. Growth layers in a tree are sheaths of cells that appear as concentric rings in a cross section of the stem. Each ring is usually the result of a single yearly flush of growth so that one layer is produced each year. A sharp boundary occurs between rings because cells along the inner boundaries are larger and have thinner walls than those in the outer edge. However, not all rings are distinct annual increments of growth. Sometimes, growth cannot begin and no ring is formed. At other times, a stress period occurring in the middle of the growing season may cause two or more rings to form within a particular year. Therefore, a simple count from the outside to the inside of the stem cannot always be used to determine the year each ring formed, so cross-dating with other specimens is necessary (Fritts 1976).

Dendrochronology of eucalypts is difficult. Most display growth rings, but these do not always relate to specific years, are not always distinct, and often vary on different sides of the tree (Mazanec 1968; Readshaw and Mazanec 1969; Mucha 1979; Dunwiddie and La Marche 1980).

No published studies were located that have examined the dendrochronological potential of the tree species occurring within the Yellingbo State Nature Reserve, including Manna Gum *E. viminalis*, *E. ovata* and *E. camphora*. As historical information is scarce, dendrochronology combined with stand structural information is the only technique available to reconstruct the disturbance history of the Yellingbo State Nature Reserve.

Method

***Survey of* Eucalyptus ovata**

Within the Yellingbo State Nature Reserve there are several revegetation sites containing trees of known age. Examination of the pattern of growth within these trees may allow a relationship between the number of growth rings and tree age to be established. These revegetation sites are predominantly on the terraces or low-lying areas of the Reserve that are seasonally and temporally inundated with flood water. Trees are typically spaced two meters apart. No planted *E. camphora* were identified at the revegetation sites. *Eucalyptus ovata* and *E. viminalis* are the dominant species.

To determine the relationship between age, tree diameter and the number of tree growth rings for trees from the revegetation sites, nine *Eucalyptus ovata* trees were randomly chosen from a revegetation site on Sheepstation Creek primarily composed of *E. ovata*. The stand was planted in June 1981 and sampled in early 1994. Trees were cored with a 5 mm increment corer, 1.3 m above the point of establishment (breast height). Tree diameter was measured to 0.5 cm accuracy. Cores were only extracted from the eastern side of the tree, which was usually facing the centre of the plantation. Cores were then air dried and mounted and the surface layer of the core removed with a razor blade to expose the growth zones. The growth zone information contained in the core was reproduced onto graph paper to facilitate interpretation. The number of growth zones was

Table 1. Historical disturbance records, adapted from Curtis and Smales (1982) and Miller and Buckland (1987).

Date	Disturbance	Location
1803	Flood	Melbourne
16 December 1863	Flood	Yarra delta
1895-1902	Drought	Port Phillip region
1898	Fire	Gippsland possibly to Yellingbo region
5 July 1909	Flood	
1913-1914	Drought	Port Phillip region
1925-1927	Drought	Port Phillip region
1926	Fire	Yellingbo region
1929	Flood	Emerald Lake
19 November 1929	Drought	
12 March 1934	Flood	Woori Yallock area
4 September 1934	Flood	
2 January 1935	Flood	
6 September 1935	Flood	
16 November 1936	Flood	
24 November 1936	Drought	
19 January 1937	Flood	
5 October 1937	Flood	
6 February 1937	Drought	
6 December 1938	Drought	
13 January 1939	Fire	Healesville to Woods Point. Yellingbo affected mainly by spot fires from falling ash. Parslow's bridge burnt.
10 March 1939	Drought	
12 July 1939	Flood	
1939-1940	Drought	Port Phillip region
1939-1945	Fire	Cockatoo swamp regularly burnt, possibly to improve summer grazing.
1943-1945	Drought	Port Phillip region
1958	Flood	Parslow's bridge
1960s	Reclamation	Swamp reclamation on Cockatoo Creek where levy bank constructed
1961-1963	Cleared	Approximately 1.2km of the Cockatoo Creek frontage drained, bulldozed and burnt.
1962	Dam	Upper Yarra dam constructed, stopping major floods.
29 January 1963	Flood	
January 1967-1968	Drought	Port Phillip region
1972-February 1973	Drought	Port Phillip region
June 1967	Flood	Sheepstation creek
28-30 June 1980	Flood	
1983	Fire	Many forested areas east of Melbourne, excluding Yellingbo State Nature Reserve.

counted, and averaged across trees to obtain a median stand age. Spearman rank correlation analysis was used to examine the relationship between the number of growth zones and tree diameter.

Survey of* Eucalyptus camphora *woodland

The absence of *E. camphora* from the revegetation sites meant that no relationship between the number of growth zones and age could be established for this species. While the two species are morphologically similar, extrapolation of the *E. ovata* results directly to *E. camphora* at Yellingbo may not be legitimate, as site conditions differ. The majority of revegetation sites are located in areas that are only temporarily inundated by flood water. In contrast, many of the *E. camphora* sites inhabited by Helmeted Honeyeaters are nearly permanently inundated with water, with peak flooding occurring during winter. Climate may be limiting to *E. camphora* (as it is on the edge of its range), and ring width variation should be approximately the same among trees and on both sides of the same tree, in contrast to the patterns of width variation expected due to site conditions. However, site conditions may influence ring width variation within *E. ovata*. Ring width variation in both *E. ovata* and *E. camphora* on opposite sides of the same tree and between trees therefore needs to be examined.

To determine whether easily distinguishable growth zones can be identified, and whether a relationship between stem diameter and number of growth rings exists in *E. camphora*, sites were chosen randomly within the Cockatoo Swamp so that four trees from each diameter class, two within Helmeted Honeyeater occupied and unoccupied forest respectively, were obtained. Diameter classes were 5-10 cm, 11-20 cm, 21-30 cm, 31-40 cm, and 41+ cm. Trees were cored with a 5 mm increment corer at breast height, and the diameter measured to within 0.5 cm accuracy. A complete core from one side of the tree to the other was taken from trees less than 25 cm in diameter, and a radial core was taken for trees with larger bole diameters. Cores were extracted from the longest radius to minimise error due to missing rings. Cores were then prepared as described above for *E. ovata*. Spearman rank correlation analysis was used to relate bole diameter to the average number of growth rings for each tree. The median number of growth rings for trees from sites occupied by the Helmeted Honeyeater, and those from trees in unoccupied sites were compared using the Mann-Whitney U-test.

Results

Dendrochronology of *E. ovata* and *E. camphora* relied primarily on variation in colour between early wood and late wood, combined with cell density information. However, not all trees displayed marked variation in colour or cell density along the length of the core. This was particularly prevalent within *E. camphora* suggesting that the growth of many trees was slow and relatively continuous, with no periods of enhanced growth.

Survey of Eucalyptus ovata

Nine *Eucalyptus ovata* trees at Sheepstation Creek were cored on the eastern side of the tree. These trees were almost 13 years old. All cores passed through the centre of the tree except two, which missed the tree centre by approximately 0.5 cm. These two cores were assumed to pass through the centre of the tree, and thus contain all growth ring information, for analysis. The results are shown in Table 2.

Table 2. Dendrochronological results for approximately 13 year-old *Eucalyptus ovata* from Sheepstation Creek.

Tree number	Tree diameter (cm)	Core length (cm)	Number of growth zones
1	28.3	9.5	12
2	30.3	11.5	11
3	32.0	11.4 (incompl.)	9 (incompl.)
4	30.1	9.5	11
5	27.3	8.75	12
6	17.4	7.6	10
7	9.2	4.3	9
8	12.3	6.1	9
9	21.9	9.4 (incompl.)	8 (incompl.)

The median number of growth zones was 10, with all observed values being less than the expected number of 13. Therefore, counts of the number of growth zones usually underestimated true tree age by one to four years. A positive relationship between the number of growth zones and tree diameter was recorded (Spearman rank correlation = 0.359), although the relationship was weak. As all trees are expected to be 13 years old, this result suggests that the determination of growth rings may be easier in larger trees.

Survey of Eucalyptus camphora

Seven trees were cored within Helmeted Honeyeater occupied habitat and ten outside. Of these, one of the first group (the largest diameter recorded) and four of the second group, were uninterpretable as there was little differentiation in colour or cell density along the core length. Results are shown in Table 3.

The growth zones of all trees within Helmeted Honeyeater habitat except one were very narrow (relative to the *E. ovata* samples) with greater than 10 growth zones recorded, and a median of 21.5. Assuming this stand was relatively even-aged (as suggested by the regeneration ecology of *E. camphora*) and a single growth zone was laid down each year, this would suggest the stand was established prior to 1973. If the median value was calculated using only the larger number of

Table 3. Dendrochronological results for *Eucalyptus camphora* from Helmeted Honeyeater occupied and unoccupied habitat within the Cockatoo Swamp. [1] Including 8 rings from a section of the core that was not interpretable. This number was determined from an equivalent length of core adjacent to the uninterpretable section.

Tree No.	Site No.	Tree diameter (cm)	Core length (cm)		Number of growth zones	
			1	2	1	2
Helmeted Honeyeater occupied sites						
5	162	18.8	8	5.5	23	15
6	162	22.2	8.8	7.5	10	10
7	162	18.8	8.6	5.8	21	24
8	160	30.5	16		Uninterpretable	
12	243	9.5	4.2	3.2	29	23
13	243	9.6	4.0	3.3	22	14
14	238	22.8	9.1		41	
Helmeted Honeyeater unoccupied sites						
1	153	7.5	3.5	2.7	21	18
2	153	14.5	5.3	5.8	10	9
3	153	8.2	2.8	3.8	Uninterpretable	
4	153	13.5	?	?	Uninterpretable	
9	256	41.0	18.5		39	
10	217	20.2	9.5	5.2	23	21
11	256	24.4	8.7	7.5	24	26
15	283	43.0	?		Uninterpretable	
16	119	30.5	13.3		25	
17	119	37.4	?		Uninterpretable	

growth zones from each tree, the stand may have been initiated prior to 1969. However, these establishment dates are likely to be conservative estimates, as distinct growth zones were often difficult to separate due to the narrowness of each zone in the profile. Several growth zones may have been missed, and given the harshness of the swamp environment and the narrowness of the growth zones in most years, growth zones may not have been laid down every year. The prevalence of false rings in this species is not known. There was no positive relationship between the average number of growth zones per tree or the maximum number of growth zones per tree and tree diameter (Spearman rank correlation = 0.058).

Trees in habitat not occupied by Helmeted Honeyeaters had wider growth zones than trees within Helmeted Honeyeater occupied habitat. The median number of growth rings across all trees was 22, or 24 if only the larger number of growth zones per tree was considered. This is equivalent to the median number of growth zones recorded for Helmeted Honeyeater habitat (Mann Whitney U-test$_{10,10}$ = 43.5). There was a positive relationship between the largest number of growth zones per tree and tree diameter (Spearman rank correlation = 0.886, p-value = 0.06) and the average number of growth zones per tree and tree diameter (Spearman rank correlation = 0.928, p-value = 0.04).

Discussion

Dendrochronology of E. ovata *and* E. camphora *at Yellingbo*

The low levels of variation in colour between early wood and late wood, or in cell density within particularly the *E. camphora* cores suggests that site conditions, particularly the degree of waterlogging, may have a large influence on tree growth. It will be necessary to identify known age *E. camphora* within a similar environment to determine whether this species develops annual growth zones within the waterlogged environment. The estimated age of trees cored in this study suggests that clear growth rings do develop, but diameter increment is slow, with growth zones possibly not being laid each year. The median number of growth zones in both Helmeted Honeyeater occupied and unoccupied habitat suggested the *E. camphora* stands sampled are at least 20-25 years old. This places their establishment around the time of the designation of the Reserve in the mid 1960s.

Curtis and Smales (1982) recorded that the area from Parslow's bridge through the Cockatoo Swamp was burnt in the 1939 fires, and that the swamp was regularly burnt up until World War II. Examination of historical aerial photographs from the early 1950s by S. Kassell (*pers. comm.*) has shown that the Cockatoo Swamp was bare of trees at this time. The *E. camphora* stands within the Cockatoo Swamp are therefore estimated to have been initiated sometime between the mid 1950s and the late 1960s. However, if opening of the canopy (through for example clearing) followed by a period of soil dryness (through for example drought or drainage) is required for tree regeneration (as suggested by the regeneration ecology of *E. camphora*), it is noteworthy that Curtis and Smales (1982) record severe droughts during this period in 1967-1968, which corresponds closely to the number of growth zones recorded in sampled trees. Grazing of the Reserve prior to this time may have also reduced the density and extent of Common Reed *Phragmites australis*, allowing eucalypt seedling establishment.

There does not appear to be a strong relationship between tree diameter and tree age for *E. ovata* or for *E. camphora* within the Helmeted Honeyeater occupied sites. However there was a relationship within Helmeted Honeyeater unoccupied habitat. This relationship is possibly due to a difference between waterlogged and other sites in terms of tree diameter (Mann-Whitney U $test_{3,3} = 0$) and the median number of growth zones (Mann Whitney U $test_{3,3} = 0$). Growth rings appeared to be nearly annual in plantation grown *E. ovata*.

There is a need for further study into the disturbance history of the Yellingbo State Nature Reserve, and the *E. camphora* vegetation in particular. Extensive consultation with older Yellingbo residents, former reserve managers and members of ornithological groups may provide more information on the timing, extent and severity of past fires, floods, droughts and management regimes. In addition, a larger, population-based dendrochronological study may provide more information on stand characteristics. Such a study would involve coring a large number of trees within homogenous patches in the *E. camphora* community and comparing the 'within patch' and 'between patch' variation in growth zone number and width. It would also require stratification based on the degree of waterlogging at a site, as this site factor is expected to have the greatest influence on tree growth. This information combined with the geographical structural information base developed during this study may provide more insights on stand dynamics.

Implications for vegetation management within Yellingbo State Nature Reserve.

The slow rate of growth within the *E. camphora* vegetation suggests that existing habitat may be suitable for the Helmeted Honeyeater for some time before natural thinning of the stands occurs. However, this habitat is expected to become unsuitable once the stands begin to mature. As little evidence of natural *E. camphora* regeneration within the Reserve was observed during this study, the development of replacement stands is therefore of paramount importance.

Boden (1962) found that *E. camphora* required canopy gaps for natural establishment, with seedling survival greatest in moist but not inundated areas. Large areas of the Yellingbo State Nature Reserve, particularly within the Cockatoo Swamp, meet these requirements: *E. camphora* canopy cover is sparse or absent, and the accumulation of silt and organic matter has raised the soil level above or near the water level. However, natural *E. camphora* regeneration within these areas is unlikely, due to the density of *Phragmites australis* growth. Eucalypt and sedge species would not be able to establish within these areas, or would be rapidly outcompeted by the vigorous reed growth. Removal or thinning of *P. australis* may therefore be required.

***Control of* Phragmites australis**

Phragmites australis is a pandemic reed species, adapted to waterlogged environments in temperate areas. It tolerates permanent flooding and is able to grow in over 2 m of water due to the abundance of aerenchymous tissue in the stems allowing it to live under poorly aerated conditions.

Phragmites australis predominantly regenerates and spreads vegetatively by means of underground rhizomes.

Clucas (1980) reviewed the known biology of *P. australis* and provides insight into methods and timing of potential control mechanisms. Burning breaks the internal dormancy of the rhizome, with all formed or forming buds emerging about a month post-fire. Winter fires give *P. australis* a competitive advantage, as emergence is very rapid early in spring due to the increased availability of light. Spring or summer fires initiate a replacement crop which may be denser than the original. In all cases fire must be severe enough to break the stems.

Cutting the rhizomes through ploughing also releases internal dormancy, so a crop of dense but short reeds will grow. These reeds are of reduced competitive power as they are too short to form a thick litter mat or to shade invading species. Cutting the aerial shoots decreases reed growth, the extent of damage depending on the season of cutting. If the reeds are cut early in the emergence period, complete replacement will occur due to the use of accumulated carbohydrates within the rhizome. Cutting later in the emergence period will reduce the size of the replacement crop. Cutting carried out in mid-summer will result in few, if any, replacements; the second half of the growing season, when rhizomes are acquiring the carbohydrate store and new rhizomes are made, is thus lost. Cutting later in the season has no effect. Grazing is equivalent to persistent but incomplete cutting, with stands often becoming shorter as shoot height and diameter are affected. If cut stands are flooded, then aeration is impeded and the reed stand may not recover (as long as dead standing material is not present to provide aeration).

Cutting the aerial shoots during mid-summer appears to be the safest and most effective means of controlling *Phragmites australis*. Mid-summer cutting should kill the stand, or at least reduce its density to a level at which *E. camphora* seedlings and sedge species are able to compete. The swamp should also be at its driest during this time, allowing easier access to the stand for cutting.

Manual cutting is extremely labour intensive, particularly within dense stands where dead stems may remain standing for up to two years before falling over and beginning to rot. Even stands in which decomposition is more rapid may contain a mat of rotting material at the soil surface, obstructing access to the base of the living plants. Less labour intensive control may be obtained by chemical means, using compounds such as 'Roundup' or 'Touchdown' that contain glyphosate (Parsons and Richardson 1995). However, neither of these products is specific to *P. australis* or safe to use around waterways, and so is not recommended.

Habitat creation and enhancement

The density of a *P. australis* stand may indicate the suitability of the site for successful establishment of *E. camphora* seedlings. Like *E. camphora*, *P. australis* prefers an open habitat, often forming sparse and short stands under trees, with few if any flowering shoots. Wetter *P. australis* stands also tend to be sparser, as growth at these sites is not affected by frosts. Therefore, dense *P. australis* stands may indicate those areas where revegetation efforts will be most successful.

Natural regeneration of *E. camphora* in these areas may be encouraged by laying capsule-bearing branches on the ground, or by broadcasting seed. Both these techniques resulted in seedling establishment in trials conducted by Boden (1962). Natural establishment may also be encouraged by removal of dense *P. australis* undergrowth from around widely spaced, mature *E. camphora* trees. Natural seedfall may provide sufficient regeneration to fill the gaps between the mature trees.

Alternatively, cleared areas may be revegetated with nursery grown *E. camphora* seedlings. Seedlings would need to be gradually conditioned to waterlogging prior to planting out. Seedlings should also be planted densely. The densest site currently occupied by Helmeted Honeyeaters has a density of 440 stems per hectare (*unpub. data*), which may provide a guide to the required planting density. To achieve this level of density, seedlings would need to be planted approximately 50 cm apart.

Further research

Field trials need to be initiated within the Reserve to determine the optimum strategy for *Phragmites australis* control, and for *Eucalyptus camphora* establishment. This involves investigating ways to minimise the intensity of labour required to remove *P. australis*, and the sowing or planting time required to obtain maximum *E. camphora* seedling survival. Given that it may take an *E. camphora* stand approximately 20 years to become suitable for habitation by the Helmeted Honeyeater, it is imperative that these trials be initiated immediately so that actions can be taken as soon as possible to address the predicted future shortage of habitat that will occur as stands mature.

Acknowledgements

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References

Boden, R.W. (1962). 'Adaptation in eucalypts to the waterlogged environment.' (MSc. thesis, University of Sydney, Sydney.)

Clucas, R.D. (1980). 'Aspects of the biology and salt tolerance of *Phragmites australis* (Cav.) Trin. Ex. Steud'. (MSc. Thesis, University of Melbourne.)

Curtis, C., and Smales, I. (1982). 'A history of Yellingbo'. (Unpublished report to the Ministry for Conservation, Victoria.)

Dunwiddie, P.W., and LaMarche, V.C., Jr. (1980). Dendrochronology characteristics of some native Australian trees. *Australian Forestry* **43**, 124-135.

Fritts, H.C. (1976). 'Tree rings and climate' (Academic Press: London.)

Hibbs, D.E. (1982). White pine in the transition hard wood forest. *Canadian Journal of Botany* **60**, 2046-2053.

Mazanec, Z. (1968). Influence of defoliation by the phasmatid *Didymuria violescens* on seasonal diameter growth and the pattern of growth rings in Alpine Ash. *Australian Forestry* **32**, 3-14.

McMahon, A.R.G., and Franklin, D.C. (1993). The occurrence of *Eucalyptus camphora* (Mountain Swamp Gum) in the Yarra valley and its significance for the Helmeted Honeyeater. *Victorian Naturalist* **110**, 230-237.

Menkhorst, P., and Middleton, D. (1991). 'Helmeted Honeyeater recovery plan'. (Department of Conservation and Environment, Victoria.)

Miller, J., and Buckland, I. (1987). 'Just for today - An historical manuscript of Yellingbo and district'. (Jan Miller and Isobell Buckland: Yellingbo, Victoria.)

Mucha, S.B. (1979). Estimation of the tree ages from growth rings of Eucalypts in northern Australia *Australian Forestry* **42**, 13-16.

Oliver, C.D., and Stevens, E.P. (1977). Reconstruction of a mixed species forest in central New England. *Ecology* **58**, 562-572.

Parsons, J.M., and Richardson, R.G. (1995). 'Australian weed control handbook', tenth edition. (Inkata Press: Melbourne.)

Pearce, J.L. (1997). 'The delineation and prediction of habitat, with particular reference to the endangered Helmeted Honeyeater'. (Ph.D. thesis, University of Melbourne, Melbourne.)

Pearce, J.L., Burgman, M.A., and Franklin, D.C. (1994). Habitat selection by Helmeted Honeyeaters. *Wildlife Research* **21**, 53-63.

Readshaw, J.L., and Mazanec, Z. (1969). Use of growth rings to determine past phasmatid defoliation of Alpine Ash forests. *Australian Forestry* **33**, 29-36.

Simmons, D., and Brown, G. (1986). The distribution of some *Eucalyptus* species (the Swamp Gums) in the Yarra Valley, Victoria. *Victorian Naturalist* **103**, 19-25.

Identification of Cypress-pines (*Callitris* Species) at Terrick Terrick National Park, Victoria

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Abstract

Some confusion surrounds the identity of *Callitris* species in Terrick Terrick National Park, due to the presence of trees with glaucous or green foliage. Some studies have reported just one species, *C. glaucophylla*, whilst others have recorded two common species, *C. glaucophylla* and *C. gracilis*. We investigated the identity of *Callitris* species in the reserve, and compared ecological differences in habitats and growth-rates between the two colour forms. All collected cones were identified as *C. glaucophylla*, thereby indicating the presence of one species only. There was no evidence of ecological differentiation between the two forms, and both occurred in mixed stands across a similar range of soils. The mean girth of trees of both colour forms was virtually identical, indicating that both have grown at the same rate since regenerating last century. We conclude that the two forms represent different forms of *C. glaucophylla*, rather than two different species. *Callitris gracilis* should be omitted from reserve species lists unless particular trees are unambiguously identified by cone characteristics. (*The Victorian Naturalist* 117 (3), 2000, 93-95.)

Introduction

Terrick Terrick National Park, 45 km west of Echuca, contains the largest woodland in Victoria dominated by White Cypress-pine. Most recent reports record the dominant *Callitris* species in the park as White Cypress-pine *Callitris glaucophylla* J. Thompson and L.A.S. Johnson (e.g. Morcom 1990a,b; Parks Victoria 1997). However, some naturalists and earlier reports have stated that two species are abundant in the reserve, White Cypress-pine *C. glaucophylla* and Slender Cypress-pine *C. gracilis* R. Baker. For instance, Wright (1970) recorded that 'about 80% of the crop' were White Cypress-pine with glaucous, 'greyish green foliage' whereas 'about 20%' were Slender Cypress-pine with 'dark-green foliage'. Wright (1970) used the older taxonomic name, *C. preissii* subsp. *murrayensis* instead of *C. gracilis*. Trees with bright green and glaucous foliage are common in the park, and both forms are easily distinguished.

In this article, we investigate the identity of *Callitris* species in Terrick Terrick National Park, and compare ecological differences in habitats and growth-rates between the two colour forms.

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Methods

The recently proclaimed Terrick Terrick National Park contains an older State Park (of 2493 ha) which is dominated by *Callitris-Eucalyptus* woodland, and a newly acquired grassland area (1277 ha). This study refers only to the older State Park area.

To properly document species identity within the reserve, sample cones were collected (by DP) from ten trees with bright green foliage and ten with glaucous foliage. These cones were separated from all foliage and were sent in unmarked envelopes to be identified by Robyn Adams, based on her experience in *Callitris* systematics throughout Victoria (Adams 1982, 1985; Adams and Simmons 1987).

In addition to this formal taxonomic test, tree distributions and girths were assessed to see whether the two colour forms had different habitats or growth rates. As part of a broader study (Parker 1999), trees (> 25 cm girth) were sampled in 179 plots, each 20 × 20 m in size, arranged along a series of transect lines running east-west across the park. Transects were approximately 400 m apart and 3.5 km in length and plots were located at 400 m intervals along each transect. The foliage colour of all *Callitris* trees in each plot was recorded as glaucous or bright green, and the girth of each tree was also recorded.

Two major vegetation zones occur in the reserve: an open eucalypt woodland (dominated by Yellow Box *Eucalyptus melliodo-*

ra and Grey Box *E. microcarpa*) and a belt of dense *Callitris* forest with relatively few eucalypts. To see whether the two colour forms had different environmental preferences, each plot was allocated to one of the two structural zones based on a 1990 aerial photograph.

Additional environmental differences between the colour forms were investigated in the following ways. Slope was recorded at each plot using a clinometer and elevation was estimated from topographic maps. Surface and subsoil (50 cm deep) soil samples were also collected at each plot. Soil pH was measured using a Hanna Soil pH Meter, texture was assessed by Northcote's (1979) hand texture method, and soil colour was compared against a Munsell Soil Colour Chart using moist samples under natural light. Differences between the two colour forms were investigated statistically using Chi-square tests and the non-parametric Kruskal-Wallis One-way ANOVA (Norusis 1993).

Results and Discussion

All cones were identified as *C. glaucophylla*, with no differences between the two colour forms, thereby indicating the presence of one species only. All cones possessed the smooth surface characteristic of *C. glaucophylla* (see Costermans 1983), and none possessed the larger, warty appearance of *C. gracilis* (see Costermans 1983, p. 142, under the name *C. preissii*).

The two colour forms were easy to distinguish in the field, with no evidence of intermediates between the two forms. Furthermore, there was no evidence of ecological differentiation between the two colour forms. The mean girth of both colour forms was virtually identical (126 cm vs 127 cm, Chi-square test, $p = 0.8545$, N.S.). Most trees in the reserve regenerated in a major recruitment pulse in the late 1800s (Parks Victoria 1997; Parker 1999), so the similarity in tree girths indicates that both colour forms have grown at the same growth rate throughout this century.

The two colour forms occurred in mixed stands, and 85% of plots with bright green trees contained glaucous trees as well. The two forms occupied the same habitat range, and the proportion of each colour form did not differ significantly between the dense *Callitris* zone and the open woodland zone ($p = 0.72$). Similarly, the two forms occurred on similar topsoil textures ($p = 0.67$), subsoil textures ($p = 0.75$), topsoil pH ($p = 0.54$) and subsoil pH ($p = 0.31$).

In total, 77% of 766 sampled trees had glaucous foliage and 23% had bright green foliage. These proportions accord well with Wright's (1970) record of 'about 80% of the crop' as White Cypress-pine with glaucous, 'greyish green foliage' and 'about 20%' as Slender Cypress-pine with 'dark-green foliage'. Whilst Wright (1970) believed that 'there are no apparent differences in the timber of the two species', Allan Marlow (the retired local forester and park ranger) believes that heartwood colour differs between the two colour forms; trees with glaucous foliage have light-coloured heartwood whilst bright green trees have a redder heartwood (A. Marlow, *pers. comm.* 1998). Thus, further examination of possible genetic differences between the two forms could prove illuminating.

Callitris glaucophylla is known to vary in foliage colour (Boland *et al.* 1984), although the proportion of bright green trees at Terrick Terrick would appear to be greater than that in many other *Callitris* forests further north in NSW (Lacey 1973). *Callitris glaucophylla* is not the only native cypress-pine that displays colour polymorphism. Scrub Cypress-pine *Callitris verrucosa* also has two colour forms, with trees with glaucous and green foliage (R. Adams, *pers. observ.*). Seeds collected from individual trees of *C. verrucosa* were germinated and produced both glaucous and green seedlings (R. Adams, *unpubl. data*). *Callitris glaucophylla* may also be able to produce both colour forms from seed of a single individual.

These results strongly suggest that the two colour forms of *Callitris* in Terrick Terrick National Park represent different forms of the one species, *C. glaucophylla*, rather than two different species. *Callitris gracilis* was not recorded in this study, and the only basis for its record at Terrick Terrick would appear to be from mis-identified, bright green trees of *C. glaucophylla*. Consequently, it should be omitted from future species lists for the reserve unless particular trees are unambiguously identified by cone characteristics.

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References

Adams, R.B. (1982). 'Aspects of the Distribution and Ecology of Two Species of *Callitris* Vent. in Victoria'. (PhD thesis, School of Botany, LaTrobe University: Melbourne.)

Adams, R. (1985). Distribution of *Callitris* in Victoria and some relic populations close to Melbourne. *The Victorian Naturalist* **102**, 48-51.

Adams, R. and Simmons, D. (1987). A chemosystematic study of *Callitris* (Cupressaceae) in south-eastern Australia using volatile oils. *Australian Forest Research* **17**, 113-125.

Boland, D.J., Brooker, M.I.H., Chippendale, G.M., Hall, N., Hyland, B.P.M., Johnston, R.D., Kleinig, D.A., and Turner, J.D. (1984). 'Forest Trees of Australia'. (Nelson Wadsworth: Melbourne.)

Lacey, C.J. (1973). 'Silvicultural Characteristics of White Cypress Pine'. Research Note No. 26. (Forestry Commission of NSW, Australia.)

Costermans, L. (1983). 'Native Trees and Shrubs of South-eastern Australia'. Revised Edn. (Lansdowne: Sydney.)

Morcom, L. (1990a). 'Terrick Terrick State Park Draft Resources Inventory and Draft Interim Management Guidelines'. (Unpublished report, Department of Conservation, Forests and Lands: Bendigo.)

Morcom, L. (1990b). 'The Effects of Grazing by Introduced Stock on the Vegetation of Terrick Terrick State Park'. (Unpublished report, Department of Conservation, Forests and Lands: Bendigo.)

Northcote, K.H. (1979). 'A Factual Key for the Recognition of Australian Soils'. (Rellim Technical Publications: Adelaide.)

Norusis, M.J. (1993). 'SPSS for Windows Base System User's Guide Release 6.0'. (SPSS Inc.: Chicago.)

Parker, D.G. (1999). 'Structural Patterns and Changes in *Callitris - Eucalyptus* Woodlands at Terrick Terrick State Park, Victoria'. B.Sc.(Hons) thesis. (School of Environmental and Information Sciences, Charles Sturt University: Albury NSW.)

Parks Victoria (1997). 'Terrick Terrick State Park Management Plan.' (Parks Victoria: Melbourne.)

Wright, J.P. (1970). 'Report of 1968 Re-measurement and 1964-1968 Growth Trends'. (Unpublished Report, Forestry Commission of Victoria, Melbourne.)

Flora and Fauna Guarantee Act 1988

The following Flora and Fauna Guarantee Action Statements have been received.

New Action Statements

No. 85 Jumping-jack Wattle *Acacia enterocarpa*
No. 86 Weeping Myall *Acacia pendula*
No. 87 Major Mitchell's Cockatoo *Cacatua leadbeateri*
No. 88 Curly Sedge *Carex tasmanica*
No. 89 Eastern Bristlebird *Dasyornis brachypterus*
No. 90 Shiny Nematolepis *Nematolepis wilsonii*
No. 91 Warragul Burrowing Crayfish *Engaeus sternalis*
No. 92 Powerful Owl *Ninox strenua*
No. 93 Silurian Limestone *Pomaderris* Shrubland and Marble Daisy-bush *Olearia astroloba*
No. 94 Southern Right Whale *Eubalaena australis*
No. 95 Bead Glasswort *Halosarcia flabelliformis*
No. 96 Small Milkwort *Comesperma polygaloides*
No. 97 Southern Pipewort *Eriocaulon australasicum*
No. 98 Wrinkled Buttons *Leptorhynchos gatesii*
No. 99 Gully Grevillea *Grevillea barklyana*
No. 100 Introduction of exotic organisms into Victorian marine waters

Other Documents

An updated index of Action Statements published by Common Name (Nos 1-100).
An updated index of Action Statements published by Scientific Name (Nos 1-100).
An updated index of Action Statements in numerical order (Nos 1-100).

Copies of all FFG documents are held in the FNCV library.

Note that Action Statement 100 will be the last one printed as a hard copy. All future Action Statements will be issued via the NRE website:
http://www.nre.vic.gov.au/plntanml/native/actstats/actstats.htm

After the 1983 Wildfire: the Anglesea Vegetation Regeneration Project – How it Grew

Margaret C. Wark[1]

Angair Inc. (Anglesea and Aireys Inlet Society for the Protection of Flora and Fauna)

Abstract

This paper describes how a long-term, low-cost study of the regeneration of vegetation in the Anglesea Aireys Inlet region of the Eastern Otway Ranges, Victoria, following the devastating wildfire of February 1983 (Ash Wednesday) was organised and sustained over 10 years. The project was carried out entirely by volunteers and the results have now been published in the scientific literature. The study increased knowledge of the flora of the region and how it responds to wildfire. It also provided data to support submissions to protect, and preserve for the public, significant areas of indigenous local vegetation, as well as information to assist in the future planning of conservation management. (*The Victorian Naturalist* **117** (3), 2000, 96-106.)

Introduction

One February afternoon in 1983, shortly after the wildfires of Ash Wednesday (Rawson *et al.* 1983), three members of the Anglesea and Aireys Inlet Society for the Protection of Flora and Fauna Inc. (Angair) drove out into the hills north of Anglesea, Victoria. A blackened, silent landscape stretched as far as one could see in every direction. Stumps of Grass Trees *Xanthorrhoea* and charred trunks of eucalypts were all that remained of the heath woodland where Angair members had held a pre-Christmas picnic two months earlier. 'Well, things can only get better', said Carleen. 'Let's hope it rains soon', commented Mary. 'Why don't we document how it recovers', I suggested. Rain came three weeks later and everything sprang to life.

So began a scientific project carried out by amateurs. Its aims were to document the post-fire recovery of the main vegetation communities of the district, and obtain information for use in the planning of conservation management.

The project had several unique features: it was a natural experiment, as no attempt was made to modify the environment; it was long term, with the field work taking 10 years, and writing up a further five; all field work was carried out by volunteers; it was a low cost project, expenses averaging about $1,000 per annum; and results were published as four papers in the scientific literature (Wark *et al.* 1987, Wark 1996, 1997, 1999).

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Over the 15 years, data generated by the project was used by Angair to support its various campaigns to conserve and protect the local environment. The papers published gave the Society credibility and scientific authority when presenting its conservation strategies.

The project grew in size and scope with time, as did the number of people involved. Starting with an Angair group of four, who knew the local plants, it expanded to include a pool of over 150 volunteers of all ages. The project remained viable because it had both educational and social aspects; these were major strengths and helped keep the group of field workers together. Most of the participants knew Angair members and helping with the surveys became synonymous with a pleasant day or weekend at Anglesea/Aireys Inlet. The project was promoted as a fun learning experience, and a lot of effort put into sharing knowledge, providing volunteers with information about the local plants and the Anglesea area, and giving regular updates and feedback of results. The project created considerable interest within the local community and it also expanded the knowledge base within Angair, as more and more members became familiar with the local plants, and increasingly aware of environmental issues.

The project also remained viable because it was underpinned by Angair members with local botanical knowledge, training and time to organise the project and, when field work was finished, to complete the documentation and publication. It also remained viable because there was adequate funding and support from professional scientists.

Initiation of the study

Before Ash Wednesday, Angair had never carried out a research project and its Committee voiced several concerns before final approval to proceed was given. Questions raised included: Did the Society have the expertise and the labour force to carry out a long term project? Who would plan the project? What would the project cost, and where would the money come from? Who would organise and control the project and do the final documentation? How could Angair ensure that the project produced useful published information?

Appointment of Project Consultant and Project Leader

The question of expertise was the first to be addressed. Were there sufficient skills within the Angair membership to carry out the project? The group was enthusiastic, but did the Society have sufficient knowledge of the local flora, training in scientific method and practical field experience to undertake the project?

There were at that time two Angair members with different skills which could be useful in the project. The Secretary, the late Mary White OAM, was a retired teacher who lived at Anglesea. Mary was an expert and respected field naturalist, skilled in plant identification and she knew the local indigenous flora well (White 1982), but she had little training in scientific method. I had scientific training, a background in botany and organisational skills, but no experience in field ecology. It was therefore obvious that professional guidance was needed and I suggested to Angair that the Society appoint a project consultant to review Angair expertise, oversee preparation of a project plan, guide the project initiation phase and later review progress. It was crucial that the project be correctly planned from the start, otherwise Angair would not obtain useful publishable information. Dr David Ashton (Ecologist and Reader in Botany, University of Melbourne) was contacted and agreed to act as project consultant on an honorary basis. I was appointed Project Leader, reporting to the Angair Committee.

The Project Plan

A formal project plan was developed between February and April 1983. It gave the Angair Committee a clearer idea of what might be involved, and helped me prioritise tasks. The plan gave historical background, defined aims and methods, and proposed a tentative budget for the 10 years.

It was decided that canopy and understorey recovery would be studied using permanent quadrats. Surveys would be carried out in spring and autumn for each of the first three years after fire and then in spring in later years. At this early stage it was not clear when, or if, other time points would be needed. Soil studies were considered desirable both to help evaluate community diversity and assess fire effects on the regeneration process. It was planned to collect soils at each site at two months, one year and two years, dry them out, and hold them for possible testing in later years. Computer analysis of vegetation data was planned, but at what stage this would be done would depend on how quickly the vegetation appeared to regenerate. Vegetation profiles would be drawn at several stages during the project, and a photographic record kept of changes at each site, and all quadrats in each site.

In preparing the project plan, Mary White's pre-fire species lists of vascular plants at various locations in the district were used to evaluate possible plant diversity. From these lists and others, it appeared that heath, dry sclerophyll woodland (heath woodland) and dry sclerophyll open-forest were the three most widespread plant communities of the district. It was decided therefore to put the greatest effort into monitoring these communities. There also appeared to be considerable species diversity in heath and heath woodland communities in different parts of the district, so it was decided to monitor these communities in several locations. For completeness, three other plant communities were included because they were restricted in distribution, vulnerable to disturbance and floristically interesting. These were the closed scrub of the non-saline swamps in the river valleys, the gully communities within open-forest, and the open scrub and heath of the coastal dunes.

The study sites selected were located in the Angahook-Lorne State Park, the Coastal Reserve, the Alcoa leasehold, and the Ironbark Basin Reserve near Point Addis. Though there were some differences in fire history between sites, essentially all of the areas selected had not been burnt for 10 years prior to the wildfire, and were severely burnt on Ash Wednesday.

The criteria used in selecting the study sites were:

1. they should be on public land
2. pre-fire species lists should be available
3. they should be in areas of native vegetation
4. they should, if possible, be on soils of different geological origin
5. they should have good accessibility by road at all times of year.

It was possible to meet most criteria, though access proved a problem. The fern gully site could only be reached on foot, a 45-minute hike along a walking track, and teams would have to be organised to carry in star pickets and equipment and carry out soil samples. We found later that sites on the Alcoa leasehold were often inaccessible in winter, when the unsealed tracks became impassible and volunteers had to walk 30-40 minutes to sites.

At this early stage the project plan could only be a guide, for it was highly likely that it would need to be modified in time. For example, if it was found that the six plant communities selected were more diverse than anticipated, sampling would need to be increased. This proved to be the case. Initially 60 permanent quadrats were installed at six locations; by the end of the project 120 permanent quadrats were required to sample the plant communities adequately.

Project Funding

Completion of the project plan in May 1983 indicated that the budget estimate for the project over 10 years would be between $15,000 and $20,000. The expensive items were soil analyses, computer analyses and assistance with word processing in preparing papers for publication. The Angair Committee was alarmed by this estimate, because the Society's funding was then quite limited and largely committed to land purchase. The Society was reluctant to embark on financing a long-term project when other conservation priorities might arise.

I suggested Angair apply for external research grants to make the project self-funding, since the Ash Wednesday wildfire had aroused wide interest among environmentalists and grants were available to community groups. The Committee asked me to prepare grant submissions and agreed to fund the project until grants were obtained on the understanding that high cost items (such as soil analyses) were put on hold.

The grant applications were prepared and included expanded project aims which emphasised the positive aspects of a community-based project. The first of these aims was to create local awareness of the unique flora of the Anglesea/Aireys Inlet district by training people to identify local plants. It was also hoped that the project would document the regeneration of the local plant communities following fire, and record the effect of fire on rare plants in the district. The results would then be published in scientific journals so they would be accessible to anyone interested in the flora of the area and provide information to assist in managing the plant communities of this fire-prone area.

The submissions also stressed the competence of the group, in that the project was already underway and had produced results. It also had the input of professional scientists. In addition, the Society kept audited accounts and the project was 'good value for money' in that the amounts sought were small in comparison with the cost of a fully salaried project.

In 1984, grant applications were lodged with the Department of Conservation Forests and Lands (now Department of Natural Resources and Environment) under its 'Grants for Conservation Groups, Special Projects' funding and also with the Myer Fund, The Potter Foundation, and the Native Plants Preservation Society. Each of these four applications were successful, and small grants totalling $9,525 were obtained. The following year further applications were lodged and additional funds of $5,000 were obtained. Later a further $4,000 was donated to the project by the Native Plants Preservation Society. With the funding already received from Angair ($925), the project income stood at $19,550.

This income allowed the project to run for 17 years (from 1983 to 2000). Though annual expenditure varied, it averaged out at about $1,000 per annum. One policy established from the start was that no salaries or travel expenses would be paid to the volunteers.

Project Organisation

The project was run by a Subcommittee whose function was to control expenditure and see that regular reporting occurred. The Subcommittee had its own project account and audited financial statements were produced annually. Reports on project progress were made monthly to Angair, and regularly to all granting bodies.

As Project Leader, my responsibilities were to plan the project, liaise with consultants, organise the surveys, evaluate and publish the results, prepare reports and grant submissions, oversee training of volunteers and provide feedback. As Deputy Project Leader, Flora Anderson assisted with survey organisation and volunteer training and oversaw publicity. The late Phillip Marriot was responsible for installing, maintaining and locating the permanent and extended plots. He also assisted in survey organisation, volunteer training and analysis of canopy data. Phillip was helped by Ted Faggetter who acted as project Treasurer, site photographer, and carried out the soil fertility bioassays. Jack Hurst, with his wife Ruth, measured and drew the vegetation profiles. Mary White checked plant identifications, liaised with the National Herbarium, Melbourne, and assisted in training volunteers.

Most members of the Subcommittee were retired and lived at Anglesea or Aireys Inlet. They were both willing and able to devote time to the project during the week. This proved invaluable, especially at survey times when much preparation and follow-up was required. The Subcommittee dealt with a wide range of important and trivial issues. These ranged from how could volunteers (especially those over the age of 70 years) be insured, to who would bake the carrot cakes for morning tea at surveys!

The first year - getting underway

The first year was a steep learning curve for everyone and the major challenges were learning to identify the local plants, getting the sampling correct and developing reliable survey techniques.

Plant identification problems

Four Angair members carried out the survey at two months. Learning how to identify the tiny regenerating plants on foliage characteristics alone took many hours of careful observation and comparison. Sending samples to the Herbarium in Melbourne proved not to be useful, because we could not provide the flowering material, seed and adult foliage they required. It was up to us to gradually work it out ourselves.

With her excellent skills as a field naturalist, Mary White proved invaluable. She tenaciously combed the district comparing specimens until she was absolutely confident of every identification. As we became familiar with the look of the young regenerating plants, with practice, we could eventually identify most species on vegetative characteristics alone. Our recording system was organised so that suspect identifications could be confirmed later when the plants flowered and seeded. Monocotyledons like grasses and sedges were among the most difficult. Over time, we began to compile post-fire species lists for each area.

Sampling difficulties

Most sites were sloping and the quadrats had been laid out along topographic gradients. Even at this early stage, it appeared that there was community variability across most sites. Comparison of site and quadrat species data would confirm later if extra quadrats were needed to improve sampling.

Development of methodology

Gradually the group refined its survey methods. They had to be simple, and the interpretation unambiguous. Questions constantly arose. When was a plant 'in' a quadrat? If a plant sprawled, what was its height? Where did one measure trunk girth in low, multistemmed wind-pruned eucalypts? How could cover-density estimations be made less subjective? It became obvious that illustrated instruction sheets were needed. Interpretation problems were discussed with David Ashton and instruction sheets prepared.

The two-month survey was in fact little different to all subsequent ones in that questions constantly arose and problems had to be solved. Questions changed as the vegetation grew and thickened up, and as the knowledge and ability of the volunteers increased. In later years queries included - what do we do if the cover density adds up to more than 100% or, how can we measure the canopy height when we can't get a line of sight anywhere along a contour?

First project review and modification of project plan

The project was first reviewed by David Ashton six months after the fire. He spent two days in the field with Angair members and visited the sites for the first time. The data, which had been collected in the first six months, was reviewed and it was confirmed that extra quadrats must be installed before the spring (eight month survey). It was also decided that extra plots would be required at a later stage if data analysis at 12 months indicated that sampling was still light.

Need to expand the group

By six months, we could see that there was going to be an amazing floral display during the spring months. Dozens of species of lilies, irises, orchids, herbs and grasses had appeared and were in bud.

Interest in the project increased and, by the eight month survey, a total of 15 Angair members was involved. Most were unfamiliar with the plants. Quadrat work was carried out in groups each with a leader responsible for plant identification. The survey went well, but revealed two potential problems: a lack of people skilled in plant identification and a labour force probably too small to cope with the future work load.

Though the Angair group was very keen, few people could still confidently identify the local plants, or had experience with field work. Questions were innumerable, and the experienced members were constantly being called away from the quadrats they were working on to answer queries. In future, at least one experienced person would need to circulate during the survey, to answer questions and help solve problems. There were just not enough experts to go round.

It was also apparent that the vegetation was regenerating very rapidly and dozens of 'new' species appearing each month. By the next survey, one year post-fire, a larger and more expert group of volunteers would be required to handle the work load. It was also clear that more training of Angair volunteers was required and that the Society must recruit skills from outside its membership.

Strategies for recruitment

It was decided to try and recruit more volunteers from Melbourne and Geelong by approaching friends in the Australian Plants Society and the Field Naturalists Club of Victoria. It seemed that the most likely way to build a skilled enthusiastic team would be to go to special interest groups like these, rather than advertise more generally. The project was also publicised among staff and students at the Botany School at the University of Melbourne.

To maintain interest, and help induct and train new volunteers, it was also decided that, in the future, a training day ('Plant Identification Day') would be held out of doors one month before each survey at which anyone interested in the project could participate. Some survey sites would be visited, and there would be an opportunity to picnic in the bush and learn from experts how to identify local native plants. It would provide an opportunity for everyone to 'get their eye in' before surveys, familiarise themselves with the survey methods, and hear about project progress. The training days and survey details would be publicised together, and the first training day was scheduled for a month before the one year survey.

Later years – expanding the group

Training

The first training day attracted 20 people, many coming from Melbourne. Everyone who came was given a set of reference material to keep. This included the total vascular plant list for the district, sets of all work sheets, and instruction sheets explaining survey methods. (There were eight different sets of work sheets each for a plant community. Each set listed all the plants and had columns for data recording.) The group visited the sites (or areas similar to them), progress was reported,

Fig. 1. Angair members Frank Feltham and Therése Turner monitoring vegetation regeneration in coastal sand dunes near Anglesea, Victoria, two years after the 1983 Ash Wednesday wildfires. Photo by Margaret Wark.

survey techniques explained, and volunteers were shown (by Mary White and the Project Leader) how to identify local plants using field characteristics. There was an informal lunch time speaker who talked about the local plants, birds, animals, geology, or a related topic.

To reinforce the training, sets of illustrated information sheets describing the native plants of the district were prepared over the years. Two new sets were distributed each training day. Each set featured a different plant family, explained its characteristics, described the local genera and species in the family and the plant communities in which they occurred. These information sets were initially prepared by the Project Leader, and later on members and friends from the Australian Plant Society groups helped. By the end of the project, sets had been prepared on all vascular plant families except Orchidaceae, which was undergoing taxonomic review.

Recruitment, maintaining motivation and momentum

The first training day went smoothly, and the one year survey saw expansion of the group beyond Angair. The strategy of promoting the surveys to people with botanical or field naturalist interests worked well, and in later years the project was never short of field workers as the word spread. Many of these new recruits added skills and expertise and many brought their friends. As many of the volunteers knew Angair members, this added a pleasant social element to the study.

Some 25 volunteers participated in the one year survey. In this, as in later years, about 20% of the workforce were local residents and the other 80% of the volunteers came down from Melbourne for the day or weekend – a 240 km round trip. About 25% of all volunteers were members of Angair.

New volunteers were attracted to the study because it was promoted as an enjoyable outdoor activity, and presented an opportunity to learn about the plants of the district (see Front Cover and Fig. 1). For local residents and Angair members with homes or holiday homes in the area, it was also the opportunity to participate in a community project where outcomes appeared both positive and constructive, after the appalling destruction of Ash Wednesday. Angair members with homes in the district provided accommodation for field workers from Melbourne, and often socialised on the Saturday evening at one of the local restaurants.

Momentum was maintained by continuous feedback to the volunteers, all of whom received a handwritten thank you letter after each survey together with a photo of themselves in action. They also received copies of all interim reports and final papers.

As another way of sustaining interest, experts were invited to Anglesea for a weekend between surveys to give an evening talk to Angair about Australian vegetation and to visit the study sites. Experts included David Ashton, the late Dr Jim Willis, the late 'Budge' Bleakley, and Leon Costermans. Their visits always included one or two field days in which Angair members and their friends could participate.

The surveys and training days were always advertised well in advance, and a mailing list and phone booking system was instituted. By the end of the project it was found, to the Subcommittee's amazement, that over 150 people had participated in the field work or contributed to the project in some way during the first 10 years. Ages of volunteers ranged from 14-80, excluding babies and toddlers in back packs. There was a core group of volunteers who remained throughout the life of the project. This group was very highly motivated and, as their expertise increased, they put more and more into the project, often making extra observations and comments or suggestions which helped our understanding or resulted in improved accuracy or efficiency. In later years, groups of up to 40 volunteers worked on each day of a survey. The logistics of handling larger numbers was quite difficult.

Surveys were never cancelled because of bad weather, and often field workers worked in difficult and wet conditions, umbrellas covering their work sheets. Long sleeves and eye protection were needed in later years when pushing through dense stands of Prickly Moses Wattle *Acacia verticillata* in the forest communities. Similar difficulties were encountered in the swamps where the dense stands of Scented Paperbark *Melaleuca squarrosa* bound together by climbing rushes and ferns became almost impenetrable.

Survey organisation

Volunteers were insured either through the Department of Natural Resources and Environment or the Australian Conservation Trust for Volunteers. Care was taken to see that there was someone with medical or nursing qualifications present at each survey. Only two incidents occurred in the 10 years of field work. They were grazing of a shin on a short star picket marking one of the extended plots, and an allergic reaction to a jumper-ant bite. First aid kits were always on hand.

The Project Leader and her Deputy decided work allocation. Care was taken to combine in work groups people with complementary skills and compatible personalities. Everyone was part of a group, and each person within that group had a specific task suited to their ability. Each group had its own set of equipment, as well as a site plan, work sheets, instruction sheets and plant lists. Stools and kneeling mats were provided for quadrat workers as was morning tea. Groups were encouraged to take an hour for lunch and to socialise. As on the training days, there was often an informal lunch time talk on a topic linked to the survey. Subjects included local animals, insects, birds, geology and soils, cinnamon fungus infestation, rare plants of the district, and mosses, lichens and liverworts.

Canopy measurements were carried out by a group of four 'tree people' led by Phillip Marriot. Understorey recovery was monitored by several groups of 'quadrat people'. Each group consisted of a 'plant identifier', a 'recorder', and one or two helpers who assisted in counting and measuring. All unknown species were collected for identification later. The Project Leader circulated between groups answering questions and checking identifications. At each survey Mary White independently compiled a total site list of plants and also assisted with plant identification. Quadrat groups were encouraged to take their time, and ask questions, and were never allocated more than three or four plots per day.

About 400 species of local native vascular plants were monitored during the 10 year study. (This was about 60% of the total indigenous vascular flora of the district.) As 90-100% of all species appeared in the first two years, volunteers had to learn many species quickly. In early years, up to 50 different species could be present in a 1 × 2 m quadrat. Very careful observation was required, for some plants, such as Pygmy Sundew, were less than 1 cm tall when mature, and could easily be missed.

When groups finished their allocated quadrats, they often participated in other tasks such as canopy mapping. At one survey, two Venturer Scouts (working toward their environment badge) obtained in a couple of hours quantitative data on the percentage of *Xanthorrhoea australis* which resprouted following the fire and subsequently died due to Cinnamon Fungus *Phytophthora cinnamomi* infection.

Data was collated immediately after each survey and checked for errors or inconsistencies. The plots were revisited within one week to collect any missing data or check misidentifications. Estimation of percentage cover (cover-density) often proved difficult and it was sometimes necessary to repeat all cover density estimations so as to eliminate major inconsistencies in interpretation.

When it was confirmed that all species present before the fire had reappeared by year three, it was decided that further monitoring would only be carried out in spring at seven and 10 years post-fire.

During the interim years, project documentation began, and one progress paper was written and published (Wark *et al.* 1987). Some informal monitoring was done, and one reunion training day was held at year five to thank the group and distribute copies of Angair's first paper from the study.

Regular site surveillance was needed between years three and 10 and this was carried out by Phillip Marriot and Ted Faggetter, who checked and replaced quadrat posts and tree tags, and located and marked all plots before the seven and 10 year surveys.

Other technical and professional support

Huge carpets of mosses and liverworts appeared at the forest sites at six months and it seemed desirable to monitor these also. Angair had no lists of, or skills at identifying non-vascular plants and Arthur Theis suggested we contact the late Dr George Scott (Reader in Botany, Department of Botany, Monash University) who agreed to be the project's Honorary Consultant on mosses, liverworts and lichens, and to identify all species collected. About 70 species of mosses, liverworts and lichens were collected and identified over 10 years. One moss was a species new to science.

During the second year, signs of Cinnamon Fungus infestation were observed and Dr Gretna Weste (Reader in Plant Pathology, Botany School, University of Melbourne) was contacted for advice. She showed Angair how to collect soil and plant samples and arrange for these to be tested for the presence of the pathogen by Dr G.F. Marks (Department of Forests, Conservation and Lands, Kew, Victoria). He confirmed that Cinnamon Fungus was present. Dr Weste advised how we could minimise pathogen spread, and became actively involved in the fieldwork for the remainder of the study.

By the third year (when all pre-fire species had reappeared) we could see that there appeared to be several distinct plant communities at each site. One of David Ashton's PhD students (Dr David Robertson, Deptartment of Applied Science, Charles Sturt University, Wagga), was approached to carry out computer analyses of year one and three floristic data. He agreed and showed that there were indeed many floristically distinct plant subcommunities at each survey site, and that these plant communities were both species-rich and diverse.

By the third year, when funds were available, chemical analyses of soils collected earlier were carried out by Austin Brown at the State Chemistry Laboratory, Melbourne. These analyses confirmed the wide diversity of soil types in the district.

Data analyses and writing up

All data collection and sorting was done manually; in retrospect this was extremely cumbersome, and if the project was to be repeated today computer techniques would be used. Manual collection made it easy to go back and recheck records, but did generate a huge amount of paper. By the time the project fieldwork was finished (year 10), project records filled a small room.

Data sorting, data analysis and writing up was my responsibility and took a further five years, due both to limited time and, in part, to long delays (two years or more) in the review and publication process. Draft manuscripts were read by David Ashton and Gretna Weste and their guidance and knowledge of the scientific literature was extremely helpful.

Findings

Though this paper is the story of 'how we did it', it seems desirable to briefly summarise some of the key results which were published as four papers between 1987 and 1999.

The project confirmed for Angair that the vegetation of the local area was both extremely diverse (species rich) and resilient to a single summer surface wildfire, and our key findings were:

1. The first signs of vegetation recovery were seen three weeks after the fire.
2. Most plants regenerated by regrowth, some regenerated only from seed, and others by both regrowth and seed.
3. With two exceptions, all species of vascular plants reappeared in the first three years.
4. Most species of non-vascular plants appeared in later years.
5. The species richness of vascular plants decreased with time.
6. Several rare species, as well as a moss new to science (*Campylopus* sp. *nova*) were found.
7. There was spectacular flowering of herbs in the first year.
8. Structural recovery occurred within 7-10 years.
9. Exotic and indigenous species of 'environmental weeds' proliferated and spread following the fire.
10. The soil pathogen *Phytophthora cinnamomi* appeared to survive the wildfire, and infect regenerating plants causing dieback and death.

In two communities (fern gully and swamp thicket), localised peat fires were ignited by the surface wildfire, killing all above-ground and in-ground vegetation. Key findings for these communities were that the previous plant communities never recovered; that there were major changes in vegetation floristics and structure; and that regeneration from seed or spores was the main regeneration strategy.

Conservation implications

All papers published stressed the conservation implications of the results. Copies of all papers and recommendations were sent not only to the granting bodies but to all organisations associated with land management in the Anglesea/Aireys Inlet region, including the Department of Natural Resources and Environment.

Among the conservation implications were that the species richness of vascular plants in heaths and heath woodlands decreases with time post-fire, and to retain species diversity, heath and heath woodland and other dry sclerophyll communities need to be burnt from time to time. Some plant species (which reproduce only from seed shed following fire) may be eliminated from a plant community if a second fire occurs before young plants set seed and re-establish.

Secondly, fire may stimulate the proliferation and spread of 'environmental weeds' which then compete with regenerating native vegetation. Exotic species such as Boneseed *Chrysanthemoides monilifera* subsp. *monilifera*, seed prolifically, and their seed is spread by native birds. Fire may disturb the ecological balance of plant communities, and native shrubs such as Coast Wattle *Acacia longifolia* var. *sophorae* may become invasive and 'weedy'. There is need to implement environmentally appropriate control programmes to reduce the spread of exotic and indigenous species of weeds in the Anglesea/Aireys Inlet region and protect the local flora.

Phytophthora cinnamomi dieback may modify the floristics and structure of plant communities causing reduction in species richness and simplification of vegetation structure. In the Anglesea area there is a need for mapping of *Phytophthora* distribution and investigation of the susceptibility of species which only reproduce vegetatively such as the endemic Anglesea Grevillea, *Grevillea infecunda* which could be eliminated by this pathogen.

Finally, peat fires may cause major

changes in floristics and structure of plant communities threatening the habitat of rare local species such as the Lizard Orchid *Burnettia cuneata*.

Concluding remarks

For groups planning to embark on a long-term project, our experience has shown that certain elements are crucial if a community project is to succeed and produce results. For Angair, the requirements were:

- the idea, and recognising the potential value of the work;
- an expert local naturalist;
- a scientist who could organise the project and document and publish the results;
- expert guidance by professionals;
- an enthusiastic pool of volunteers; and
- stable funding.

Locally, the Angair project served as a positive social and community activity following, as it did, the trauma of the Ash Wednesday wildfire in 1983. It showed how teams of enthusiastic volunteers could be organised and sustained to contribute to a scientific study that continued for ten years. Such long term studies are rare and the scientific data collected has enhanced the credibility of Angair and given it a more effective voice in local conservation issues.

Data collected during the project has been used in Angair submissions to protect the Alcoa leasehold, which was classified as part of the National Estate in 1987, and to protect and acquire for the public significant coastal heath and heath woodland areas between Anglesea and Aireys Inlet. Reservation of these areas was achieved in 1997.

Information collected during the study has increased our knowledge not only of the flora of the Anglesea/Aireys Inlet region but also how it responds to wildfire, and recommendations which could be of use in planning of conservation management have been sent to DNRE. It is hoped that these recommendations will be implemented when the management plans for the coastal heathlands incorporated into the Angahook-Lorne State Park are drawn up, and when a management plan for the Alcoa leasehold is put in place.

Postscript – Parallel studies on fauna

'Regeneration' was the theme of the Angair 1983 Spring Nature Show (six months after the fire), and a series of coloured posters were produced explaining the project aims and illustrating how the plant communities were regenerating. After the Nature Show, Dr Barbara Wilson (Senior Lecturer, Department of Biology, Deakin University) approached Angair and suggested her research group collaborate with the vegetation regeneration project. Her special interest was small mammals and she had been working in the district for some years. She offered to monitor small mammal recolonisation of the Angair sites post-fire, and asked if Angair could supply her group with vegetation data and train them in vegetation survey methods.

So began, in late September 1983, the first of three parallel, collaborative studies on the Angair vegetation study sites, which investigated recolonisation of these burnt areas by native fauna. The small mammal studies (which were organised and funded completely separately from the vegetation project) ran for three years and resulted in two papers (Wilson and Moloney 1985a, 1985b) and the Deakin group has continued to work in many other areas of the district during the last 15 years.

Following commencement of the small mammal project, it was suggested that a study of recolonization of the sites by birds be initiated. Angair had a local member, Pauline Reilly, who was an expert and respected ornithologist and who had been involved in production of the 1982 Australian Bird Atlas. She was already studying local bird populations (Reilly 1991a) and agreed to lead a project monitoring bird recolonisation of the Angair sites if she could hand-pick her field workers, and if Angair would pay all project costs. This was agreed and the bird studies commenced in March 1984 and ran for three years, resulting in two papers (Reilly 1985, 1991b).

At the time these faunal studies commenced, David Ashton had a PhD student (Dr Alan Andersen, CSIRO Division of Rangeland and Wildlife Ecology) who was studying ant populations in heathland communities. The vegetation project provided an ideal opportunity to study insect recolonisation of all the sites, and it was suggested that invertebrate sampling be done over a one-year period. Species identification could wait till funding was available. Dr Alan Yen (Museum of Victoria) and Alan Anderson agreed to collaborate and setting of pitfall traps and sampling of insects in the air, in litter and on vegetation, was carried out in October 1984. I prepared a grant submission for Angair which was submitted to the Commonwealth Government Department of Arts, Heritage and the Environment, and in October 1986 a grant of about $8,500 was obtained to fund the identification work. Alan Andersen was employed for six months to carry out the project under the supervision of Alan Yen, Joan Forster and Mary White. One publication resulted (Andersen 1987).

Acknowledgements

This project would not have been possible without the help of the estimated 150 volunteers (members and friends of Angair Inc.) who carried out the field work. The financial assistance of the Government of Victoria (Department of Conservation, Forest and Lands), the Potter Foundation, Sidney Myer Fund and Native Plants Preservation Society is acknowledged.

References

Andersen, A. (1987). A survey of the invertebrates of the Anglesea region following wildfire. Report to Angair Inc. 28 pp. (Unpublished.)

Rawson, R.P., Billing, P.R. and Duncan, S.F. (1983). The 1982-83 forest fires in Victoria. *Australian Forestry* **46**, 163-72.

Reilly, P. (1985). Victorian Group - regeneration survey. *Royal Australian Ornithologists Union Newsletter* No. 64, p. 8.

Reilly, P. (1991a). Effect of wildfire on bird populations in a Victorian coastal habitat. *Emu* **91**, 100-106.

Reilly, P. (1991b). The effect of wildfire on bush bird populations in six Victorian coastal habitats. *Corella* **15**, 134-42.

Wark, M.C. (1996). Regeneration of heath and heath woodland in the north-eastern Otway Ranges three to ten years after the wildfire of February 1983. *Proceedings of the Royal Society of Victoria* **108**, 121-42.

Wark, M.C. (1997). Regeneration of some forest and gully communities in the Angahook-Lorne State Park (north-eastern Otway Ranges) 1-10 years after the wildfire of February 1983. *Proceedings of the Royal Society of Victoria* **109**, 7-36.

Wark, M.C. (1999). Regeneration of *Melaleuca lanceolata* Otto. and *Melaleuca squarrosa* Donn ex Sm. communities of the coast and river valleys in the north-eastern Otway Ranges 1-10 years after the wildfire of February 1983. *Proceedings of the Royal Society of Victoria* **111** (in press).

Wark, M.C., White, M.D., Robertson, D.J. and Marriot, P.F. (1987). Regeneration of heath and heath woodland in the north-eastern Otway Ranges following the wildfire of February 1983. *Proceedings of the Royal Society of Victoria* **99**, 51-88.

White, M.D. (1982). Anglesea-Aireys Inlet native plant list. In 'Anglesea - A Natural History Study', 5th edition, Angair Inc., Anglesea, Victoria, 38 p. (Unpublished.)

Wilson, B.A., and Moloney, D.J. (1985a). Small mammals in the Anglesea-Aireys Inlet area of southern Victoria - a post fire study. *Victorian Naturalist* **102**, 65-70.

Wilson, B.A. and Moloney, D.J. (1985b). An investigation of small mammal recolonization and vegetation regeneration in fire affected areas of the Anglesea-Aireys Inlet region. 40 pp. (Unpublished Report to the Ministry of Conservation, Forestry and Lands, Melbourne, Victoria.)

One Hundred Years Ago

A TRIP TO ANGLESEA RIVER

by H.T. Tisdall

(*Read before the Field Naturalists' Club of Victoria, 10th April,* 1900.)

"As the road nears Anglesea it dips down several hundred feet through well-timbered country. We found the Anglesea River to be a pretty sheet of water, from fifty to sixty yards broad, but barely two miles long. Rowing up the river we soon came to a full stop where the estuary commences in a number of small freshwater streams. The ground between the streams is very soft, being composed of a rich dark soil, thoroughly soaked with moisture, but the growth of the plants in this soil is perfectly marvellous. I measured specimens of the common Coral Fern, *Gleichenia circinata*, nearly twenty feet high. The principal shrubs were Cassinia and other species of Compositæ, the Hazel, *Pomaderris apetala*, with *Pultenæa daphnoides*. The greater mass of Tea-tree was *Leptospermum scoparium*, which was in full bloom. Anything like the mosquitos I had never seen; they were simply in clouds, and of the largest size – in fact, we had finally to decamp from the land into the boat. I was surprised to find bushes of that prickly Proteacean, *Persoonia juniperina*, so near the coast, as I had hitherto thought that it was confined to the Gippsland hills. Huge clumps of reeds, *Lepidosperma gladiatum*, are to be seen on both sides of the river."

From *The Victorian Naturalist* **XVII**, June 1900.

The Six 'Lone Pines' of Jackson's Creek and Their Many Descendants

Robert Bender[1,2] and David Akers[1,3]

In 1942 *The Victorian Naturalist* featured an article by W.H. Nicholls titled 'The Lone Pines of Jackson's Creek' (Nicholls 1942). He gave an account of a small colony of three mature White Cypress Pine *Callitris glaucophylla* syn. *Callitris columellaris* in a gully on the brow of the escarpment, which overlooked the creek about 100 metres below in what is now Sydenham Park. Subsequent discoveries show that he missed three more mature trees at the bottom of the slope, closer to the creek. A recent edition of this journal reported on an exciting find of a colony of remnant *C. glaucophylla* at the CSIRO Maribyrnong site (Adams 2000). In that article she reported that the Jackson's Creek colony 'has declined to only one original tree', adding to the earlier depressing conclusion of Willis' 1970 assessment that this population was 'now almost extinct' (Willis 1970). Happily, this is not the case.

Of the six remnant trees present in 1942 only one has died - the photo that accompanied Nicholls article shows it with two tiny crowns of foliage, and it is now a whitened skeleton (Fig. 1). But the other five are alive and well, and still producing cones (Figs 2 and 3). Nicholls' original 'lone pines' have also had their future chance of survival enhanced. The remaining five old trees in Sydenham Park were surrounded with wire netting, rabbit-proof fencing by staff of the National Park about 1990, with permission from the then Keilor Council. They were fenced into three enclosures. One, near the escarpment, about 100 metres east of the boundary of Organ Pipes National Park, contains two living trees and the dead one; another down by the creek contains another two trees, and a third, about 110 metres further east close to the creek, has one tree. The Friends group has undertaken considerable work at these three sites, to remove Boxthorn, Prickly Pear, Artichoke Thistle, Nightshade and other weed invasions in the decade since the enclosures were fenced.

L.A. Pederick, of the Department of Conservation Forests and Lands, took a core sample from two of the trees in 1985 in order to count the tree rings. His account does not indicate which two of the trees were selected. He experienced problems in obtaining an accurate estimate of age and was unable to sample right to the central pith 'because of the high density and hardness of the wood, eccentricity of cross-sec-

Fig. 1. 'The Sentinel Pine of Jackson's Creek.' This tree is now dead. Photograph by W.H. Nicholls in 1942.

Fig. 2. 'Murray Pines (*Callitris glauca*) at Jackson's Creek.' Photograph by W.H. Nicholls in 1942.

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Table 1. Girth and estimated height of the six *C. glaucophylla* at the Sydenham site, March 2000. Key: GGrd, girth at ground level (mm); G1.5, girth at 1.5 m (mm); Ht, estimated height (m). * Height of side branch, as main trunk snapped off at about 7 m.

Tree	GGrd	G1.5	Ht
Upper: skeleton	1190	910	6
Upper: east	1340	1250	9
Upper: west	1415	1130	12
Lower: east	2010	1530	11*
Lower: west	2550	2180	15
Solitary	1650	1540	9

tion of the trunks, and decay in one of them. Furthermore, interpretation of age was difficult due to the slow growth, frequent indefinite ring formation, and apparent formation of some false rings.' However he managed to count 77 rings in one, omitting 8 cm of rotten wood near the core, and 105 rings in the other, which did not penetrate to the pith. He estimated their age as a minimum 120 years, and concluded, 'on the basis of the number of rings sampled in the trunks of two of the trees, and the difficult terrain on which they are growing, I am of the opinion that the four trees are native to the site' (Pederick 1985).

The girth and height of each of these six old trees, measured in March 2000 (Table 1), indicate considerable age, especially the two in the lower enclosure. Estimates of age obtained by Adams for the Maribyrnong population in which the trees have similar girths (Adams *pers. comm.*) postulate an age of about 220 years for one tree, which has a girth of 2.5 m at 1.5 m from ground .

When the Organ Pipes National Park was established 2 km upstream in 1972, the founders of the Friends group knew of this nearby population of White Cypress Pine. They assumed the trees had little hope of survival outside a protected area. With this in mind, the group used seed from the Sydenham Park remnants to establish a new population of *C. glaucophylla* on suitable soils within the newly established National Park. A recent survey by one of us (DA) discovered 71 trees scattered over the park, at various stages of maturity (Akers 1999) (Fig. 4).

The population of planted *C. glaucophylla* in the National Park is in good condition

Fig. 3. Two of the old *Callitris* in Sydenham Park on the floor of the valley near Jackson's Creek. Photo R. Bender (March 2000).

and has in fact undergone a degree of natural regeneration. In several areas of the park, staff have undertaken a program of rabbit-proof fencing of small areas, and subsequent eradication of rabbits; one of these rabbit-free areas is on the main spur just below the park Visitor Centre. In 1995, Friends of Organ Pipes members Carl Rayner and Ian Taylor surveyed this spur, which has nine mature seed-producing *C. glaucophylla* (Fig. 5), and they discovered a considerable number of new seedlings (Bender 1996).

Shortly after, one of us (RB) commenced a regular monitoring program of the growth and survival of these seedlings. Over 40 of these seedlings had wire netting tree guards placed around them in the hope of protecting them from the Eastern Grey Kangaroos and Black-tailed Swamp Wallabies that have taken up residence within the National Park since 1989. Around 35 seedlings still survive, the tallest now being about 80 cm.

There are now three generations of White Cypress Pine along the creek – the old

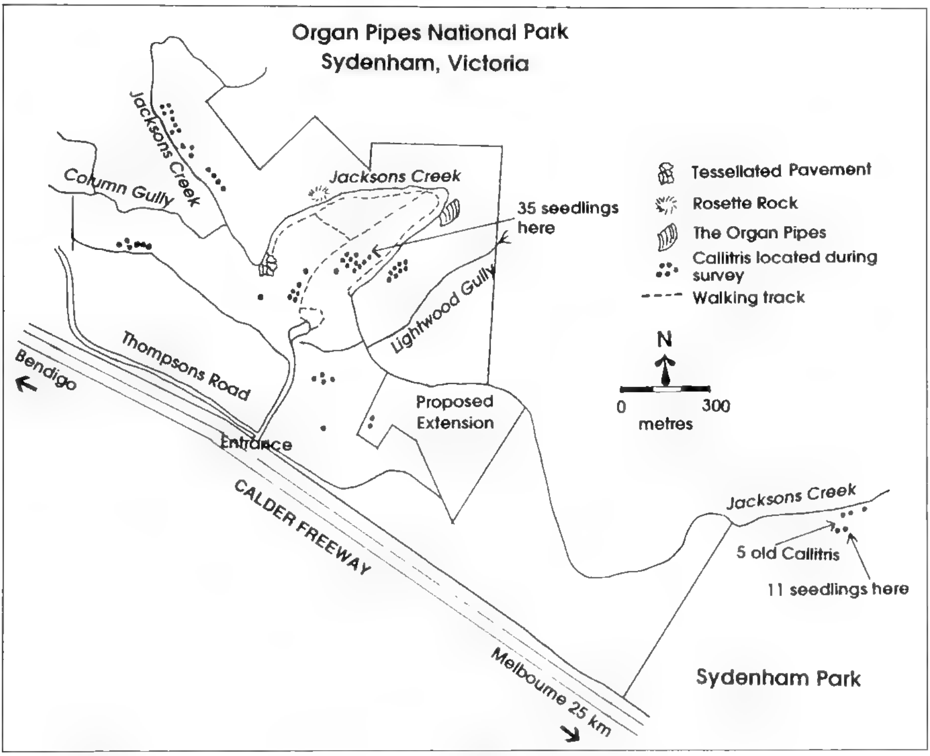

Fig. 4. Map of Organ Pipes National Park showing survey results and location of the old *Callitris* trees.

Fig. 5. Regenerating *Callitris glaucophylla* in a rabbit-proof enclosure on the main spur near the Visitor Centre, Organ Pipes National Park. Photo R. Bender (1997).

specimens in Sydenham Park, the propagated trees planted in the 1970s around the National Park, and a new generation of self-generated seedlings within a rabbit-proof fenced enclosure on one spur. No seedlings are evident around the other 62 trees, though quite a few are producing seed-cones. A project to install exclusion fencing around these other trees is to start soon, once grant funding is obtained for materials.

In 1998, at a working bee in the upper enclosure at Sydenham Park (containing the trees reported by Nicholls), one member, Claude Odorisio, mapped 11 seedlings that had established in the newly cleared scree slope of the gully (Bender 1999a). These are all uphill of the two mature trees, suggesting that the main wind direction in the area at time of seed dispersal is up the slope.

The 'Lone Pine of Jackson's Creek' is fortunately an underestimate. The five old trees still surviving have been supplemented by another 71 planted in the nearby National Park, and a further 35 naturally regenerated seedlings (Bender 1999b). This population is now probably quite secure, with good prospects for the future, with more planting of the species in the Organ Pipes National Park planned for the near future.

In recent years, visits to other local remnant sites at Bacchus Marsh and Werribee Gorge show these much larger naturally-occurring populations of White Cypress Pine to be in a much less secure state, with eroding valley slopes, dense rabbit populations, and old trees not balanced by young seedlings.

References

Adams, R. (2000). 'Companions for the Lone Pine of Jacksons Creek' *The Victorian Naturalist* **117**, 36-7.

Akers, D. (1999). *Callitris glaucophylla* at Organ Pipes National Park July 1999. *Friends of Organ Pipes newsletter* **85**, August.

Bender, R. (1996). *Friends of Organ Pipes newsletter* **64**, April.

Bender, R. (1999a). *Friends of Organ Pipes newsletter* **84**, June.

Bender, R. (1999b). White Cypress Pine in Sydenham and Organ Pipes National Park. *Indigenotes* **12**, August.

Nicholls, W.H. (1942). 'The Lone Pines of Jackson's Creek'. *The Victorian Naturalist* **58**, 139-140.

Pederick, L.A. Letter to D. Saunders, Director National Parks Service, 24 June 1985.

Willis, J.H. (1970). 'A Handbook to the Plants in Victoria', 2nd edition, volume 1, p. 57. (Melbourne University Press: Melbourne.)

White Cypress Pine – the New Generation

There are few occasions when it is nice to be proved wrong, but the note by Bender and Akers (2000) describing five surviving 'lone pines' of Jacksons Creek, rather than the single tree I referred to (Adams 2000), is one such occasion. The tree girths and age estimates they report for the Jacksons Creek trees, and those of the Maribyrnong population, fit well with those for the trees at Bacchus Marsh, and the population overlooking the Werribee Gorge. Some individuals at Werribee Gorge have girths in excess of 300 cm GBH (girth at breast height) and ages probably in excess of 300 years. As more of the scattered data on the White Cypress Pine populations around Melbourne come to light, a much clearer picture of the species' pre-European distribution and importance in the regional flora is emerging.

The expansion of the White Cypress Pine population from a state of 'almost extinction' to one of active regeneration and security, should serve as an encouraging example of the contribution to long-term species conservation which can be achieved by dedicated community groups. It will be a great day for local conservation, and restoration of the regional flora, when all of the White Cypress Pine populations have a new generation of trees and the same healthy future as the 'Lone Pines of Jacksons Creek'.

References

Adams, R. (2000). Companions for the Lone Pine of Jacksons Creek. *The Victorian Naturalist* **117**, 36-37.

Bender, R. and Akers, D. (2000). The six 'Lone Pines' of Jackson's Creek and their many descendents. *The Victorian Naturalist* **117**, 107-110.

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Significant Species at Lake Mountain, Victoria: an Addendum on Coleoptera (Lucanidae and Melolonthinae)

The ecological significance of Lake Mountain, Victoria (Jelinek *et al.* 1997) is reinforced by the presence of a number of rarely collected Coleoptera. Specimens were taken in the vicinity of the carpark at Gerraty's on Lake Mountain on 28 February 1988 during a field excursion of the Entomological Society of Victoria. Two species were flightless stag beetles (Lucanidae) with a restricted range in subalpine or alpine areas of Victoria. There appear to be no published records of the third species, a cockchafer (Scarabaeidae: Melolonthinae), in Victoria.

Lissapterus howittanus (Westwood), Lucanidae. According to Moore and Cassis (1992) this species is known from Gippsland (the type specimen), Baw Baw and Mt Donna Buang. The larva was described by Alderson (1975). One adult female was taken under a log, 0.5 km S of Gerraty's.

Lissotes darlingtoni Benesh, Lucanidae. According to Moore and Cassis (1992) this beetle is known from Marysville, Mt Baw Baw and Mt Donna Buang. One adult was found under a log, 0.5 km S of Gerraty's.

Heteronyx crinitus Blackburn, Scarabaeidae. According to Houston and Weir (1992) this species is known only from Tasmania, the type locality being Mt Wellington. However I have collected it from Starlings Gap, near Powelltown, Victoria. The Lake Mountain specimen was collected 0.5 km N of Gerraty's as it ate a juvenile leaf of *Eucalyptus pauciflora* during the daytime. The genus *Heteronyx* contains several hundred species of mostly undistinguished, brown, nocturnal, *Eucalyptus*-feeding beetles. *Heteronyx crinitus* is one of the most distinctive because it bears a dense vestiture of long, orangey-brown setae.

The lucanids are 'largely dependent on fallen timber', in or beneath which the larvae feed, 'mostly within very soft, fungus-infested wood', although *Lissotes* may be found in "humus beneath fallen timber in a less advanced state of decay" (Moore and Cassis 1992 pp. 4-5). Removal of timber from ski runs effectively sterilises such areas for these rare beetles.

Acknowledgement

I thank Dr E.B.Britton for identification of the *Heteronyx*.

References

Alderson, J. (1975). Descriptions of the larvae of four species of Lucanidae (stag beetles). *The Victorian Naturalist* **92**, 71-79 (errata 92, 95).

Houston, W.W.K. and Weir, T.A. (1992). Melolonthinae. *In* 'Zoological Catalogue of Australia Volume 9. Coleoptera: Scarabaeoidea', pp. 174-358. Ed. W.W.K. Houston. (AGPS: Canberra)

Jelinek, A., Cameron, D., Belcher, C. and Turner, L. (1997). New perspectives on the ecology of Lake Mountain (ii): significant ecological communities and species. *The Victorian Naturalist* **114**, 30-39.

Moore, B.P. and Cassis, G. (1992). Lucanidae. *In* 'Zoological Catalogue of Australia Volume 9. Coleoptera: Scarabaeoidea', pp. 4-19. Ed. W.W.K Houston. (AGPS: Canberra)

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We regret to announce the death of Ellen Lyndon, OAM on 15 April 2000 at Leongatha. Ellen had a long association with the club and had been an honourary member of the FNCV since 1983. An obituary will appear in a later issue.

Flora of Australia
Volume 1: Introduction. 2nd Edition

Publisher: *ABRS/CSIRO, 1999. 694 pp. 54 colour photos, several colour maps, numerous black & white maps and illustrations. Hardback RRP $79.95.*

When I received this book, I had finished biographical entries for various botanists for *The Oxford Companion to Australian Gardens*. This is a pity because the revised *Introduction to Flora of Australia* includes an impressive historical chapter by Dr Tony Orchard with potted biographies for over 200 collectors and taxonomists, many of whom will appear in *The Oxford Companion*.

Now I am preparing a *Companion* entry on Australian field naturalists' societies. While the activities of the FNCV are recorded in *The Victorian Naturalist*, other clubs do not have such an enduring record and I am searching for threads of evidence for the existence of other field naturalists' clubs and societies, all of which are younger than the FNCV. Some have died. Some were born in the twentieth century. And here my thick green and gold (don't mention the olympics) volume produced historical gold. I knew from CSIRO's directory of Australian scientific societies that the North Queensland Naturalists' Club was formed in Cairns in 1932. From Orchard's chapter I learned that Hugo Flecker, a medical doctor and FNCV member, founded the Club and for 25 years contributed to and curated its herbarium, which was incorporated into CSIRO's new herbarium in Atherton in 1971. The author index of *The Victorian Naturalist* reveals that Flecker did not forget the FNCV in 1932.

Flora of Australia provides, for the first time in over a century, a uniform account of Australian plants, with keys for their identification and information on their distribution and ecology. Fifty-nine volumes are proposed, the first of which is the *Introduction*. It is an enormous project involving botanists from across Australia - in federal and state herbaria, universities and CSIRO - and writers and editors in the Australian Biological Resources Study (ABRS). Its intended readership includes field naturalists as well as land managers, biologists and students.

Any significant piece of writing deserves at least two introductions. The first, written at the begining of a project, can consider foundational sources and anticipate the shape of the article, book or series that will grow out of that material. During the weeks or years of writing, sources appear and data is generated, and the author's ideas and interpretations change. The introduction should now be rewritten. Fortunately the Flora of Australia project has done this. The first published volume of *Flora of Australia* was the *Introduction* in 1981. Since then much taxonomic work has been stimulated by the Flora project and historical work has been facilitated by the Mueller Correspondence Project. The centenary of Mueller's death in 1996 spawned historical conferences and publications, including Mueller commemorative issues of *The Victorian Naturalist* and *Historical Records of Australian Science*.

In the century following the publication of Bentham's *Flora Australiensis* (1863-78) and Mueller's *Systematic Census of Australian Plants* (1882 and 1889) the number of Australian plant taxa more than doubled to about 18 000 species in 1981. But even then few parts of Australia had been fully explored botanically. Largely via taxonomic work supported by ABRS grants, the Flora project has had a synergic effect on Australian plant taxonomy. Research has crossed state boundaries and its results have shaped taxonomic descriptions, relationships and distributions in *Flora of Australia*. New species and even genera continue to be described. A 40 m tree was unknown to botanists until its 'discovery' in 1994 in a Wollemi National Park gorge, only 150 km from Sydney. In 1995 the Woollemi Pine was described and named *Wollemia nobilis*, thereby establishing a new genus!

The 1981 edition of the *Flora*'s *Introduction* was so popular that its 1993 reprint sold out in 1995. By then 16 volumes of the *Flora* had been published and the growing body of taxonomic and historical understanding of the Australian flora justified a completely revised *Introduction*. Twenty authors, six illustrators and eighteen photographers (and numerous slides from the Australian National Botanic Gardens) more than tripled its size. Chapters in the 1981 edition, on the evolution and classification of the Australian flora and the development of the Flora of Australia project, were updated and expanded, as was the glossary of botanical terms, which is continually updated on the ABRS website. Now I can find the meaning of 'elaiosome' and 'eucamptodromous'. There is still a key to Australian flowering plant families, but CSIRO has also provided something outside the *Introduction*. It has published a collateral CD - *The Families of Flowering Plants (of Australia) CD-ROM: An Interactive Identification Guide* by Kevin Thiele and L.G. Adams. Available from CSIRO Publishing for $69.95, it allows the family of any native or naturalised Australian flowering plant to be determined.

The revised *Introduction* includes new chapters. As well as Orchard's splendid history of systematic botany in Australia, there are chapters on the evolution and influence of Australian environments, the aquatic flora and the biogeography of the terrestrial flora. Helen Hewson, author of the recently published *Australia: 300 Years of Botanical Illustration*, writes on images of Australian plants. Their utilisation and conservation is also discussed, with legislation for flora protection listed for each state. Tony Orchard and Alex George have prepared a valuable resource - an annotated bibliography, in chronological order, of the most significant Australian floristic publications. The 54 colour photographs of various types of vegetation are generally stunning. Only one is Victorian - 'Wet sclerophyll forest (open-forest) Kallista-Belgrave Road, Dandenong Ranges'. Since vegetation changes with time, I would appreciate dates on the photographs, and links with Richard Groves' table on the 'floristic divisions, character genera, structure and distribution of the Australian flora' would be useful. The families included in the various volumes of *Flora of Australia* are listed inside the front and back covers. As should all authoritative texts, this volume has a substantial index.

Orchard manages to squeeze into his mammoth (would *regnans* be a more appropriate descriptor?) chapter three lots of important information. He summarizes the development of herbaria in each Australian state and territory, provides concise biographies for over 200 'botanists, collectors, early voyagers and other describers of Australian plants', each with selected references, and presents a substantial list of about 400 references. The latter includes papers in the 1996 Mueller commemorative issue (and other issues) of *The Victorian Naturalist*, but not the 1997 Muellerian issue of *Historical Records of Australian Science*. The biographies include the famous and the lesser-known. One of the largest entries is for Ferdinand von Mueller, about whom we all know something. It is followed by a small entry for Luis Nees, whose specimens, collected at Port Jackson during a Spanish expedition in 1793, were used to establish the genera *Angophora* and *Bursaria*. Well, Nees is new to me. Orchard discusses early nineteenth century, predominantly coastal, Victorian plant collections which enriched European herbaria, Mueller's development of a significant Australian herbarium (now MEL) from his own collections and those of his vast network of collectors, and younger university herbaria. Orchard mentions Victorian government botanists, published *Floras*, recent major taxonomic contributors and the National Herbarium's own journal *Muelleria*, which was launched in 1955. Since *The Victorian Naturalist* provided an important vehicle for descriptions of new taxa from specimens in MEL, before and after 1955, perhaps it deserves acknowledgement. But it is easy to point out omissions in an already full-to-bursting summary.

The revised *Introduction* is a veritable goldmine of botanical information. It is scholarly and authoritative, and written sufficiently clearly and directly to engage any interested English-literate reader.

Certainly it provides a comprehensive introduction to the multivolume *Flora of Australia*. But it also provides a comprehensive context for the study of any aspect of Australian botany - taxonomic, biological, ecological or historical. There is even economic information about our flora. You can find out where the two species of *Macadamia* are grown commercially for their nuts, and where two Victorian species of *Solanum* have been cultivated for the extraction of a steroid for the contraceptive pill.

I am indeed glad that, as Orchard points out, systematic botany is such an historical science. Despite his modest acknowledgement of his 'somewhat idiosyncratic' selection of historical material, his comprehensive historical chapter in such a botanically comprehensive volume provides an historical high note for Australian botany at the turn of the century.

And it is printed in Australia.

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Flora of Australia Volume 17B
Proteaceae 3, *Hakea* to *Dryandra*

Publisher: *Australian Biological Resources Study (ABRS), Canberra/ CSIRO, Melbourne. Published May 1999.*
416 pages, colour illustrations, black and white drawings, maps.
RRP hardback $89.95, paperback $69.95.
Available from: *CSIRO Publishing, PO Box 1139, Collingwood, Victoria 3066.*

This long-awaited volume of the *Flora of Australia* will be welcomed by everyone, scientists, amateur naturalists and growers of Australian plants alike, who has an interest in plants of the Proteaceae family. It is the second published volume covering this important family. Volume 16 containing introductory chapters describing important features of the Proteaceae in Australia, including relationships, morphology, palaeobotany, pollination biology and uses, was published in 1995 while volume 17A, covering the large genus *Grevillea* and remaining members of the Proteaceae, is due in April 2000.

The *Flora of Australia* is an ambitious project begun in 1980 to describe 'all flowering and non-flowering plants known to be indigenous or naturalised in Australia' but excluding bacteria – possibly as many as 27000 species. The complete work will occupy 59 volumes, a far cry from the last attempt to document the Australian flora, George Bentham's *Flora Australiensis* (1863-1878) which included just 8125 vascular plants in seven volumes.

Members of the Proteaceae family are conspicuous and important components of the forests, heathlands, and woodlands and shrublands of Australia. The main genera are large and recognisable, *Banksia, Hakea, Grevillea* and *Dryandra,* and are important in horticulture and floriculture, being widely grown both in Australia and overseas. This volume comprises *Hakea* (150 species), *Banksia* (76 species), *Dryandra* (93 species) and two small rainforest genera from northern Queensland, *Musgravea* (2 species) and *Austromuellera* (2 species). Each genus was revised by specialist authors - W.R. and R.M. Barker and L. Haegi of the State Herbarium of South Australia for *Hakea,* Alex George, formerly of the Western Australian Herbarium, covered *Banksia* and

Dryandra and B.P.M. Hyland of the Tropical Forest Research Centre, Atherton, dealt with *Musgravea* and *Austromuellera.* The only group that has been previously revised is *Banksia* so this book is important for its up-to-date treatment of these other genera, the first revision in more than 130 years. Especially with *Hakea* and *Dryandra,* this has resulted in a large number of new species so that with *Dryandra* for example, the 93 species and 34 infraspecific taxa (sub-species and varieties) compare with 59 species previously known. Despite long interest in Australian plants, surprisingly little scientific research has been carried out on the biology of most genera and families. W.R. Barker, R.M. Barker and L. Haegi include a valuable 'Introduction to Hakea' to provide background information on taxonomy, biology and biogeography of hakeas.

The intention of the editors of the *Flora* has always been that descriptions and discussions will be concise and emphasise taxonomic aspects although information on habitat, distribution, synonomy and illustrations is included. A key is also provided for each genus as well as a Supplementary Glossary and a list of Abbreviations and Contractions used. To meet the formal publication requirements of the *International Code of Botanical Nomenclature,* new taxa not previously described are included in an Appendix. Hence this book is a valuable reference work for the most recent understanding of the Australian flora but is in no way a 'popular' treatment. It is intended for use by 'professional botanists, knowledgeable amateurs and students requiring botanical information'. The value for the non-professional user I think lies in the many black and white line drawings that supplement the scientific text and the 16 pages of quality colour plates illustrating 32 species of *Hakea,* 14 *Banksia,* 16 *Dryandra* and one each of *Musgravea* and *Austromullera.* Many of the colour pictures, especially of *Hakea* and *Dryandra,* have not been published previously. Eleven professional botanical artists prepared the 58 plates of line drawings that provide excellent visual identification aids. Thus in *Hakea,* the fruits are often characteristic, for example, Figures 4, 5, 6 while in *Banksia* and *Dryandra,* leaf outlines can be useful in showing differences, for example Figures 27-31, 37, 43-45. No information is provided about cultivation although some indication of garden requirements could be inferred from habitat information for species. Finally, small-scale maps showing distribution in Australia are arranged in the same sequence as the species and are grouped together at the end of the text. These provide a general guide only to locations but the individual descriptions can be consulted for more specific details.

The volume continues the high quality of publishing of earlier volumes and CSIRO Publishing are to be congratulated on the clarity of the text lay-out and the many fine black and white line drawings and colour illustrations which enhance it. I found little to criticise although details of the references in the introduction (page ix) could perhaps have been listed at the end of this section and not buried on page 176. For anyone with an interest in this important Australian plant family, the book is a 'must', although at $89.95 for the handback and $69.95 for the paperback, it is not cheap. The *Flora of Australia* project is so important for improving our understanding of the flora and documenting the many new species still being discovered. I look forward to the publication of Volume 17A later this year.

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For assistance with the preparation of this issue, thanks to Anne Morton for desktop publishing. Thanks also to Maria Belvedere (label printing), Michael McBain (web page) and Dorothy Mahler (administrative assistance).

Flora of the Nathalia District and Barmah Forest

by Nathalia Wildflower Group

Publisher: *Nathalia Wildflower Group,*
produced with funding assistance from Parks Victoria, 1999.
Paperback, VIII + 96 pp. (88 colour photographs, black and white sketches.)
ISBN 0646383485. RRP $20.00 plus $3.00 for postage.
Available from Joan Harding, Box 3, P.O. Nathalia, Victoria 3638.

This compact Pocket Guide describes the most common plants of an area of north-central Victoria which covers approximately 900 square kilometres. More than 600 plant species have been recorded here, of which 400 are native. The 'Flora of the Nathalia District and Barmah Forest' contains colour photos of 82 of the most commonly seen native plants, and six introduced species (or weeds). There is a huge contrast between the two main regions covered by this guide. The Barmah Forest is a relatively large, intact, Red Gum forest along Murray River. At 28,900 ha, it forms the largest Red Gum forest in the world. In contrast, the Nathalia district, encompassing an area of 123,897 ha, has been heavily cleared for agriculture, and native vegetation can only be found in isolated pockets and small scattered remnants and corridors of Red Gum along the water courses. This mainly Grey Box grassy woodland on the riverine plains is one of the most threatened environments in Australia.

Plant descriptions are written in plain English and each is accompanied by a colour photograph of the species, sometimes with an inset photo which shows a feature of the plant, such as the flowers, in more detail. A small black and white sketch on every page supplements each photo and illustrates features which may not be immediately evident. A whole page is devoted to each of the 88 species featured in the book.

Each plant description has a section headed 'can be found' which provides the reader with useful tips on where to look for the plant. In an area that is highly disturbed and fragmented, such as around Nathalia, this information is often known only to those with 'local knowledge'. Beginner botanists and tourists unfamiliar with the area will certainly appreciate this feature.

The overall arrangement of the book is generally according to height and grasses and waterplants are also included. A handy ruler inside the back cover will help judge the size of small plants. Approximate measurements of features of the plants are given in the descriptions however.

Overall, the book is concisely written and the photographs are clear and informative. My only criticism is that an inset photograph of additional plant details is not provided with every description. This would have been very useful for many of the plants, such as the Sprawling Bluebell on p. 60, where the general photo showing the life-form of the plant does not show the flower in detail. Most of the photographs are of good quality, although there are a few over-exposed or unclear pictures.

'Flora of the Nathalia District and Barmah Forest' is a small, light-weight book. The spiral binding enables you to fold the cover back on itself, a very useful feature for comparisons in the field when you may want to lay your field guide flat. This is an ideal guide for the amateur naturalist visiting the area. Buy a copy and pop it into your jacket pocket next time you plan a trip to northern Victoria and you can benefit first-hand from the vast local knowledge of the Nathalia Wildflower Group.

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The Bat: Wings in the Night Sky

by M. Brock Fenton

Publisher: *Key Porter Books Limited, Toronto, Canada, 1998*
144 pp, 60 colour photos, hardback. Distributed by UniREPS, University of New South Wales, Sydney NSW 2052. RRP $35.00

Bats are a fascinating group of our fauna that unfortunately suffer from bad press, therefore any book that portrays the positive side of bats is good publicity. Brock Fenton is a bat researcher based in Canada who has studied bats for over 35 years in many countries of the world, and is well qualified to produce a book on bats.

The book is written for people with an interest, but limited knowledge, of bats. It covers aspects of their biology, such as anatomy, echolocation, diet, and roosting habitats. It is printed in large font with generous line spacings, which enables easy reading. With over 80 colour photos, there is at least one large photo per double page spread.

On first picking up this book and flicking through the pages, one is drawn to the high quality photos, and could be enticed to buy the book. Unfortunately, however, on closer scrutiny, the text is not up to the standard of the photos. To me, it reads like a draft hastily written, which was not thoroughly revised or peer reviewed (although the acknowledgements would indicate the contrary). An example of this lack of editing is repetition between chapters and within chapters. In places, the text is confusing and the writing style does not flow easily. A considerable amount of interesting information is provided, but it comes across as an assortment of facts, rather than a coherent story with a central theme. It would have been useful to provide a broad introduction into the types of bats (for example, what proportion of the worlds species are microchiropterans vs megachiropterans, what proportion eat insects vs fruit etc) to set the scene, enabling subsequent information to be put in context.

The use of examples from throughout the world provides interesting comparisons; however, at times it leaves the text disjointed. In places, the author develops an argument and then cuts it off abruptly without further explanation, leaving the reader to wonder why it was included. For example, the final paragraph of Chapter Five reads 'The appearance and behaviour of bats may allow us to predict a great deal about their lifestyles and ecology. It is the exceptions that make the story interesting. Spotted bats or big-eared brown bats are excellent examples.' Although there is mention of these two species ten pages earlier, a sentence indicating why these species were good examples would have helped here. However, on re-reading the earlier section it appears that these species **are** behaving as predicted by their echolocation calls and so are **not** exceptions!

Contrary to the claims of the advertising material for this book, there is little tangible information provided on making neighbourhoods or homes more bat friendly. The only suggestions are on the use of bat boxes, and here Fenton is equivocal as to their value. This leaves the reader unsure whether it is worth trying to provide artificial homes for bats.

While most of the photos are of high quality, a few are below standard, and several have been rotated 90°, including the photo on the title page! One major problem with the book is that there was little attempt to position the photos adjacent to the relevant sections of the text. I found this very disrupting to the flow of reading, having to continually flick forward or back up to six pages to find the photo that corresponded to the text. For example, the section which talks about ears and echolocation includes two photos of human hands showing bat bite marks. It is not until several pages later that there is a discussion on blood-feeding bats, which contrasts the teeth and hence the type of bite produced by a vampire bat with that of another species. Here the photos would have been in context and relevant. In their present position, they leave the reader scratching her head wondering why the photos have been included. Unfortunately this is not an isolated example, as a large proportion of the photos are out of context.

Although many of the photo captions provide extensive information, such as the species name, its weight and distribution, they often fail to provide the critical information that links the pictures to the text, thus reducing their relevance.

At the end of the book there are lists of other published information on bats. The book list is a comprehensive guide to other (better!) books that are available. The list of 'Further reading: some technical references' is selective, including only the author's publications – there are many other authors that it would have been useful to include in order to provide a general overview of scientific research on bats.

Having been very disappointed in this book, I wondered if it was just that I expected too much from a book of this type. To try and simulate the audience the book was targeting, I asked a friend who has a general interest in bats to read and comment on it. Her reaction was the same as mine – one of dissatisfaction and disappointment. Asked if she would consider buying it, her answer was a definite 'No'.

Brock Fenton has produced many good publications during his 35-year study of bats. Unfortunately this is not one of them. Although containing interesting factual information and abundant glossy photographs, the manuscript required further editing to turn it into a coherent book. In my opinion there are other general books on bats which are much better.

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Field Guide to the Birds of Australia

Sixth Edition

by Ken Simpson, Nicholas Day and Peter Trusler

Publisher: *Penguin Books Australia Ltd, 1999. 440 pp, RRP $35.00*
colour and black and white illustrations and distribution maps

Around 760 bird species have been recorded within Australia. For one to identify a bird that's just appeared in the back yard for the first time, or unfamiliar birds encountered during wider travels, a field guide becomes an essential reference. The '*Simpson & Day Field Guide to the Birds of Australia*' is one of three popular guides that should be considered when shopping for an Australian bird field guide. As with the others (Slater *et al* 1995, Pizzey and Knight 1996), the guide follows a tried and tested format aligning textual information and maps with the corresponding illustrations on the facing page. Birds are treated in taxonomic order typically dealing with four to seven species per page. Textual information includes a summary of key characters for each species, brief plumage descriptions for females and young where they differ from adult males, an indication of size, a description of common or diagnostic calls and a list of the habitats in which the species usually occurs. Simple codes and symbols provide additional concise information on abundance, movements and endemism. A map of the species' distribution and black and white line drawings illustrating features not shown on the plates complete the species panels.

Approximately a third of the book is devoted to a handbook section that deals with varied topics including hints for birdwatchers, vegetation and habitats, prehistoric birds, bird life cycles and a new section on bird evolution in Australia. More detailed accounts of behaviour, breeding activity and taxonomy can be found in the bird families section. The handbook section is well referenced. Readers are directed to more comprehensive works at the end of each family account, whilst a suggested core library for readers that wish to develop their interest further is also presented. The handbook is a departure from the traditional minimalist approach of field guides and contains information typically only seen in larger (and more expensive) reference texts. Its inclusion in a field guide (often a reader's first introduction to birds and bird watching) is of considerable value as it has the potential to facilitate a wider appreciation and understanding of this fascinating group.

The sixth edition of a *Field Guide to the Birds of Australia* has in line with previous editions undergone a number of significant changes. Since the last edition 15 colour plates have been replaced with new ones that typically depict more races where they differ noticeably from one another. The addition of more illustrations of younger birds is also welcome as this age group has been previously underrepresented in Australian field guides, often leaving birdwatchers bewildered as to a juvenile bird's identity. A further three plates have been modified to improve colour tones and finer detail and approximately 300 black and white drawings have been added to assist the user by depicting typical postures or key characters not shown in the plates. Of greatest significance is the redrawing of all the distribution maps. These maps depict the breeding and non-breeding range for each species with arrows indicating the directions migrants move during summer and winter dispersal. The passerine maps (Red-bellied Pitta to Common Myna) are exceptional and now include the distribution of all races recognised by Schodde and Mason (1999). This will assist the observant bird watcher to further appreciate and understand the reasons for variation in appearance and song across a species' range.

Shortcomings with this guide are minor. While I found Day's plates to be of a high standard, the numerous colourful backgrounds may not appeal to all users. Personally, I find them distracting but am aware others find this style attractive. For the species shown predominately in flight (for example many of the seabirds and birds of prey) better use of available space could have been made by increasing the size of individuals depicted. This would have also facilitated more accurate depiction of key characters, which are sometimes lacking, particularly in the older seabird plates (pp 29, 31 and 41). Beginners may also find it annoying that species illustrations are not always aligned with species accounts on the facing page resulting in the plates being searched at random for the relevant illustration(s). Certain colours in several plates of the review copy also appeared unnaturally bright (e.g. yellows for the gerygone, and shrike-tit plates), although this may have been a problem that arose in final production.

Despite these minor problems this remains an easy field guide to use. Readers who already possess one of the earlier editions of the guide will find new information in the more detailed treatment of races (principally in the range maps) and in the handbook section which provides additional information and suggestions for further reading. However whether these features alone warrant its purchase will depend on the individual's needs. Overall I rate this field guide highly and would recommend it as a worthy addition to a field naturalist's library.

References

Pizzey, G. and Knight, F. (1996) 'Field Guide to the birds of Australia'. (Angus and Robertson: Sydney.)

Schodde R. and Mason, I. J. (1999) 'The Directory of Australian Birds. Passerines'. (CSIRO: Canberra).

Slater, P., Slater, P. and Slater, R. (1995) 'The Slater Field Guide to Australian Birds' Revised Edition. (Lansdowne: Sydney).

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The Orchids of Tasmania

by David Jones, Hans Wapstra, Peter Tonelli, Stephen Harris

Publisher: *The Miegunyah Press, an imprint of Melbourne University Press. Hard cover, 408 pp, 195 coloured plates and maps. RRP $79.95 (incl. GST)*

With the continuing and exciting taxonomic research into Australian native orchids by research botanists, assisted by keen orchid specialists, it is often difficult for the enthusiastic amateur to keep abreast of the many new species recognised.

The book under review is a timely production as it lists all of the 195 recorded species for Tasmania, one species per page. Identification is assisted by a colour photograph, paragraphs on taxonomic description, recognition, confusing species, habitat and flowering period, which should clear up any difficulties with identification previously experienced. Distribution maps for each species indicate the areas in which they may be found.

There is interest, not only for students of Tasmanian orchids, but also for enthusiasts from other areas in Australia, as many of the species described are shared with south eastern areas of the mainland. Some of these, such as Striped Sun Orchid *Thelymitra erosa* and Lobed Sun Orchid *Thelymitra longiloba*, have only recently been described (*Australian Orchid Research*, Volume 3, D.L. Jones 1998).

The introductory chapters of this type of publication are often skimmed through by the reader with most emphasis being given to the details of individual species. This should not be the case with this book as these chapters are most important, especially those on Tasmanian habitats and conservation.

The first of these chapters describes, through the geology of the region, how the various landscapes were formed, their differing climatic conditions which may assist in predicting where orchid species may be found, the vegetation with its influence on orchid habitats and the several types of habitat with the genera which may be found in each of these.

A complete lack of conservation programmes has been a problem throughout Australia, resulting in many species becoming extinct since European settlement. We have gradually encroached on natural bushland areas as our cities and suburbs grow, more and more land is cleared for food production to cope with increases in population and vast areas of habitat have been destroyed by forestry and mining.

This is also true for Tasmania and a most compelling chapter is the one on orchid conservation in that State. Of the 64 species and subspecies of endemic orchids, 24 are listed as Critically Endangered, 6 as Endangered and many of the non-endemic orchids are also threatened. This chapter lists many threats to the native orchids, such as difficulty in identification of species, destruction of habitat through fire or clearing, urban sprawl, mining, fertilisers and weeds. An eight point strategy is proposed for the conservation of orchids and other flora, which if acted upon, would help save further species from extinction.

Three innovative sections enhance the value of the book. A 'Key to Orchid Leaves' assists in the identification of Tasmanian orchids when they are not in flower, with all genera being keyed.

An accurate line drawing, which explains the floral structure, is included in the introduction to each genus. This will assist in identifying a genus when the floral segments are hidden or not apparent.

The column (the structure formed by the union of stamens, style and stigma) in the various species of *Thelymitra* is the main feature for identification of the members in this genus. The two pages of photographs of *Thelymitra* columns will be of great value to amateur orchidists.

A comprehensive glossary and index, together with the features already mentioned, make this a book for all orchid specialists, enthusiastic amateurs and novice observers. The excellent illustrations and presentation make it more of a reference book than a field guide, with the photographs and descriptions ensuring that the identification of orchids seen on bush excursions can be made with a high degree of confidence.

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The Victorian Naturalist

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Assistant Editor: Alistair Evans

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Cover: The Yellow-bellied Glider *Petaurus australis*. See the story of its discovery in South Gippsland on p. 150. Photo by John Seebeck.

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Changes in Ant and Termite Activity and Community Structure as Indicators of Ground Layer Disturbance in Box-Ironbark Forest

John Gibbens[1]

Abstract
Victorian Box-Ironbark forest remnants are subject to a range of human disturbances, including grazing by stock. Grazed forest is characterised by a sparse or non-existent understorey and reduced levels of wood and leaf litter. Ant and termite activity is influenced by ground layer characteristics and these taxa were used as indicators of disturbance. Ant and termite communities were surveyed at four grazed and four ungrazed Box-Ironbark forest sites using pitfall traps and wooden baits, respectively. High proportions of 'opportunist' ant taxa occurred at all sites, indicating the effects of disturbance are not limited to grazed areas. This is reasonable given the extent of forest fragmentation and other disturbances experienced by ungrazed forest remnants. Ant analysis was unable to discriminate between different types of disturbance effects on grazed and ungrazed areas. Termite activity, however, was greatly reduced in grazed areas and was probably related to the lack of understorey cover, reduced litter layer and soil compaction. *Nasutitermes* sp., a common termite which forages in large groups, was particularly less active in grazed areas, possibly due to the lack of appropriate food items. (*The Victorian Naturalist*, **117** (4), 2000, 124-130.)

Introduction

Extensive areas of Box-Ironbark forest occur on land subject to grazing. In addition to direct grazing effects, ungulate stock such as cattle and sheep alter ground layer structure by trampling, browsing and dung deposition. Trampling effects include compaction of soils, reduced water infiltration and retarded new growth (Wilson 1990). Trampling also affects the ground layer which becomes more uniform through litter breakdown and flattening of the soil surface, leading to an altered soil fauna composition (Yen and Butcher 1997). Browsing reduces the understorey and retards new growth. Litter input is accordingly reduced, altering litter layer composition (Wilson 1990). Effects of ungulate dung deposition include raised soil nutrient levels, which may encourage weeds (Yen and Butcher 1997). In summary, the ground layer of a forest is greatly affected by grazing. The altered ground layer characteristics of grazed forests should be reflected in an altered community of ground-dwelling animals.

Two animal groups were chosen to study ground layer disturbance caused by grazing. Ants have been suggested as ideal indicators of habitat change (Andersen 1990), being primarily ground dwelling and involved with many aspects of ecosystem functioning. Termites are cryptic (soil and wood-dwelling) animals sensitive to changes in soil characteristics (Abensperg-Traun 1992) and therefore provide an indication of ground layer disturbance.

Ant species richness has been used as an indicator of disturbance (Majer 1983, 1997; Greenslade and Greenslade 1977), following the theory that a disturbed ecosystem contains fewer microhabitats. Grazed Box-Ironbark forests appear to have reduced structural complexity due to the lack of an understorey, so lower ant species richness would be expected than in ungrazed forest.

Grazing may have beneficial effects on termites: dung may be an extra food source and trampling may break up plant litter for easier consumption (Abensperg-Traun 1992). Alternatively, soil microclimates may be adversely affected by reduced canopy and litter cover and soil compaction (Wilson 1990). In a study of grazed Western Australian woodland, termites showed no significant difference in abundance or diversity compared with ungrazed woodland (Abensperg-Traun 1992).

This study compared ant and termite communities in grazed and ungrazed areas of Box-Ironbark forest. It is expected that ant communities will be less diverse in grazed forest due to reduced structural complexity. Termites are expected to be less abundant principally due to the reduced litter layer found in grazed Box-Ironbark forest.

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Study Methods

Study Area

The study area was located in central Victoria, approximately 150 km due north of Melbourne and 52 km east of Bendigo (36°45' S, 144°17' E). Annual rainfall for Bendigo is 550 mm, with greater rainfall in winter months. Box-Ironbark forest in the region is highly fragmented and interspersed with cleared agricultural land (Calder 1994). State Forests and Flora Reserves protect some areas of forest, while some remnants exist on private land.

Study Site Descriptions

Four paired sites were used, each with one plot in grazed forest and one in ungrazed forest. Grazed forest occurred on private land adjoining cleared areas grazed by cattle or sheep, and stock were free to move through the forest at will. Ungrazed forest plots were in State forest, a flora reserve and on private land that was protected from grazing.

Grazed and ungrazed plot pairs were surveyed for vegetation characteristics and matched on the basis of having significantly similar numbers and types of trees but significantly different understorey and ground layer characteristics (Geoff Brown *unpubl. data*; Gibbens 1997). Plot pairs were separated by a road and located approximately 100 m apart. Grazed areas were separated from the road by a fence. All sites were located within a four-kilometre radius. Two pairs of sites were dominated by Red Ironbark *Eucalyptus tricarpa* and were termed 'Dry Forest' (after Calder 1994). The other two pairs were dominated by Bull Mallee *E. behriana* and Grey Box *E. microcarpa* and were termed 'Mallee'.

Ant Sampling

Twenty five pitfall traps were set in a 20 × 20 m grid formation at each plot. Traps were plastic vials of 44 mm internal diameter, one-third filled with equal parts 70% ethanol and ethylene glycol, a solution which is not attractive to ants (Greenslade and Greenslade 1971). Four 14-day sampling periods were conducted, during March, April, May and September 1997. Traps remained in the ground between sampling periods to minimise digging-in effects (Greenslade 1973).

Ants were identified to genus using the keys of Andersen (1991) and Greenslade (1979). As the Australian ant fauna is poorly known at the species level (Andersen 1990), distinct species were identified as morphospecies. Voucher specimens and samples were lodged with the Museum of Victoria.

Termite Sampling

Termites were surveyed at the same plots as ants. Twenty-five wooden baits, each a 300 × 100 × 10 mm piece of weathered *Eucalyptus* fence paling, were arranged in between the pitfall traps. Baits were placed flat on the soil surface (beneath the litter layer) and covered with a 350 × 300 mm piece of clear plastic sheeting. The sheeting was intended to increase the attractiveness of the baits by allowing absorption of soil moisture and reducing dessication.

Baits were inspected monthly and the number and genus of termites at the bait recorded. Inspection of each bait took no more than 15 seconds, after which it was carefully replaced to minimise any disturbance to the termite gallery system.

At the conclusion of the project, all baits were collected and the amount of wood consumed by the termites was visually assessed. A subjective rating scale was used (**0** – none eaten, **1** – <50% of bait surface consumed, **2** – 50-100% of surface, **3** >100% surface but <50% volume of bait, **4** = 50-100% volume consumed). Note: termites ate the weathered surface of baits to a depth of approximately 1 mm before eating deeper into the bait.

Baiting does not give comprehensive quantitative data on termite abundance and is used in this instance to estimate relative activity of termites in different areas. The number of termites present indicates numbers of foraging individuals, but means may be easily biased by the presence of a large number at a single bait. Therefore, the number of baits at which termites were present was also recorded. Finally, the amount of bait consumed over the duration of the study was estimated in order to indicate overall foraging success in different areas. Used together, these three measures should give a reasonable qualitative indication of local termite abundance and foraging activity.

Student's t-tests were used for significance tests of means.

Results

Ants

Over 11,500 ants from 30 genera were collected, comprising 67 morphospecies (Table 1). More ants were trapped in ungrazed areas than grazed, although the difference was not statistically significant ($t_3 = 0.28$, $p = 0.80$).

By far the most abundant species was the opportunist *Rhyditoponera metallica*, which comprised 21% of the total catch. *Rhyditoponera metallica* was abundant at all sites, although almost twice as many were trapped at ungrazed areas. *Iridomyrmex itinerans* and *I. purpureus* (meat ant) were the next most abundant, being 12% and 10% of the total respectively. These two species were widespread at all sites although *I. itinerans* was almost four times as abundant at grazed compared with ungrazed plots. In contrast, *I. purpureus* was observed almost twice as frequently at ungrazed compared with grazed plots. Other notable species included *Iridomyrmex* sp. 6 and *Notoncus enormis*. *Iridomyrmex* sp. 6 was found only in grazed areas, although 155 of the 163 individuals were collected from a single trapping event. *Notoncus enormis* was the most abundant climate specialist, comprising 4% of the total catch; three times as many were found at ungrazed sites.

Ungrazed areas had a slightly higher species richness (59 species compared with 52 at grazed sites), but this was statistically insignificant ($t_3 = 1.13$, $p = 0.33$). More opportunist species were found at grazed sites (seven compared with four) although very low numbers were recorded for the three exclusive species. The most diverse ant genus was *Camponotus*, consisting of 12 species.

A multivariate analysis was performed on data for each species at every plot. To test for similarities between any of the eight

Table 1. Total ants captured in pitfall traps at ungrazed and grazed sites.

Morphospecies	Ungrazed	Grazed	Total	Morphospecies	Ungrazed	Grazed	Total
Acropyga sp. 1	1	-	1	*Monomorium* sp. 1	318	281	599
Amblyopone sp.	4	3	7	*Monomorium* sp. 2	353	330	683
Camponotus sp. 1	50	72	122	*Monomorium* sp. 3	1	10	11
Camponotus sp. 2	12	-	12	*Monomorium* sp. 4	72	54	126
Camponotus sp. 3	33	44	77	*Myrmecia forficata*	17	20	37
Camponotus sp. 4	59	59	118	*Myrmecia tepperi*	7	-	7
Camponotus sp. 5	430	340	770	*Myrmecia* sp. 3	1	-	1
Camponotus sp. 6	16	5	21	*Notoncus ectatommoides*	109	113	222
Camponotus sp. 7	1	8	9	*Notoncus enormis*	337	101	438
Camponotus sp. 8	6	-	6	*Notoncus* sp. 3	1	-	1
Camponotus sp. 9	9	-	9	*Paratrechina* sp. 1	117	98	215
Camponotus sp. 10	10	3	13	*Paratrechina* sp. 2	16	8	24
Camponotus sp. 11	1	2	3	*Pheidole* sp. 1	442	313	755
Camponotus sp. 12	1	3	4	*Pheidole* sp. 2	151	225	376
Cerapachys sp.	-	2	2	*Podomyrma* sp. 1	1	2	3
Colobostruma sp.	-	10	10	*Podomyrma* sp. 2	3	2	5
Crematogaster sp.	71	104	175	*Polyrhachis* sp. 1	13	2	15
Discothyrea sp.	1	-	1	*Polyrhachis* sp. 2	10	7	17
Doliromyrma sp.	-	8	8	*Polyrhachis* sp. 3	1	-	1
Dolochoderus sp.	50	5	55	*Prolasius* sp.	36	57	93
Epopostruma sp.	14	10	24	*Quadristruma* sp.		2	2
Heteroponera sp.	30	56	86	*Rhytidoponera metallica*	1590	883	2473
Hypoponera sp.	4	2	6	*Rhytidoponera* sp. 2	-	13	13
Iridomyrmex glaber	69	16	85	*Selenopsis* sp.	13	10	23
Iridomyrmex itinerans	291	1128	1419	*Stigmacros* sp. 1	26	33	59
Iridomyrmex purpureus	755	408	1163	*Stigmacros* sp. 2	66	13	79
Iridomyrmex sp. 2	37	-	37	*Stigmacros* sp. 3	1	-	1
Iridomyrmex sp. 3	82	126	208	*Stigmacros (Hagiostigmacros)* sp. 4	1	-	1
Iridomyrmex sp. 6	-	163	163				
Iridomyrmex sp. 7	6	-	6	*Tapinoma* sp.	204	367	571
Iridomyrmex sp. 8	4	2	6	*Tetramorium* sp. 1	17	36	53
Maryella sp.	-	7	7	*Tetramorium* sp. 2	-	2	2
Melophorus sp. 1	1	3	4				
Melophorus sp. 2	7	-	7	**Total Ants**	**6000**	**5582**	**11582**
Melophorus sp. 3	1	-	1	**Total Species**	**59**	**52**	**67**
Meranoplus sp. 1	10	11	21				

plots, Bray-Curtis similarity indices (Clark and Warwick 1994) were calculated with group average clustering on log(x-1) transformed species abundances. One would expect grazed plots to be grouped together and likewise for ungrazed plots, but this was not the case (Fig. 1). The analysis did not reveal any significant similarities in species composition between any plots (R= -0.042, p= 0.6).

Termites

There was a large difference in termite activity between Mallee and Dry Forest sites (Fig. 2). In Mallee, very few termites were observed at baits, with insignificant differences between grazed and ungrazed plots. In contrast, Dry Forest sites revealed high numbers in ungrazed plots with significantly fewer in grazed plots (Fig. 2a). Similarly, numbers of baits attacked were few at Mallee sites, with no significant difference between grazed and ungrazed plots, while Dry Forest sites had high numbers of baits attacked at ungrazed plots and significantly fewer at grazed plots (Fig. 2b). Amounts of bait consumed also followed the same pattern. Consumption was significantly higher at Dry Forest ungrazed plots than grazed plots. Low amounts of bait were consumed at all Mallee plots, with no significant difference between grazed and ungrazed plots (Fig. 2c).

Composition of genera

In ungrazed areas, over 20 times as many *Nasutitermes* individuals were recorded as *Heterotermes* or *Amitermes*, yet similar numbers of all three genera were recorded in grazed areas (Fig. 3a). This result was reflected in the numbers of baits attacked, with *Nasutitermes* attacking more baits in ungrazed areas (Fig. 3b). Grazed areas showed much less activity by *Nasutitermes*, while *Heterotermes* was

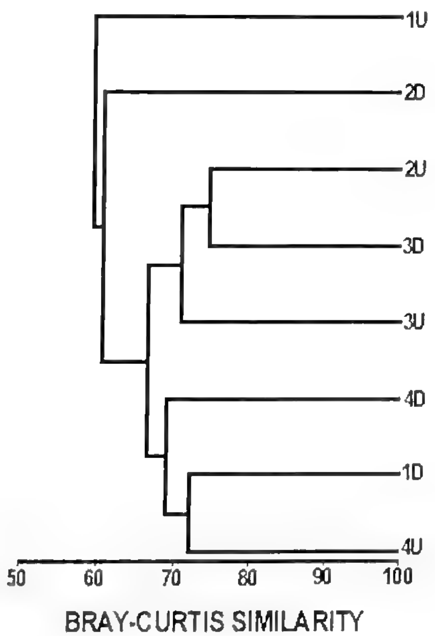

Fig. 1. Dendrogram of Bray-Curtis similarities for species composition of ants at each site. (U = ungrazed; D = grazed.)

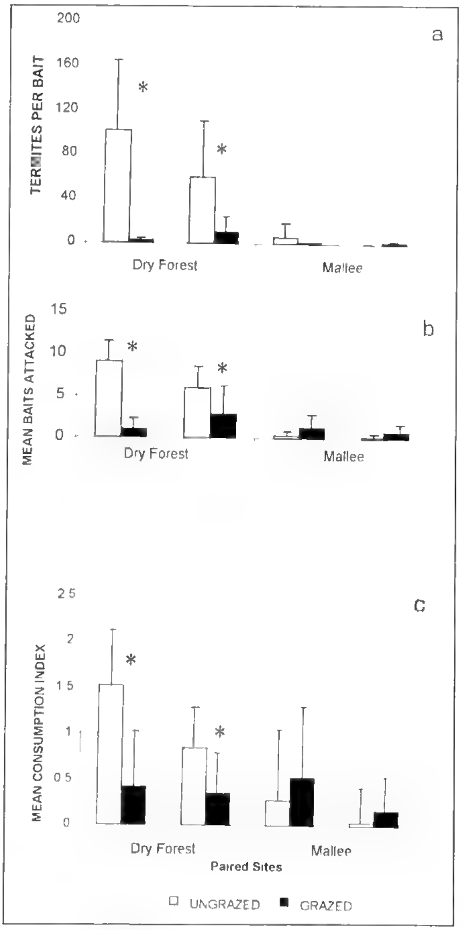

Fig. 2. Termite activity at grazed and ungrazed plots pairs. Estimated by a) number of termites per bait, b) number of baits attacked and c) amount of bait consumed. Values are means with standard errors (note: *represents p<0.05).

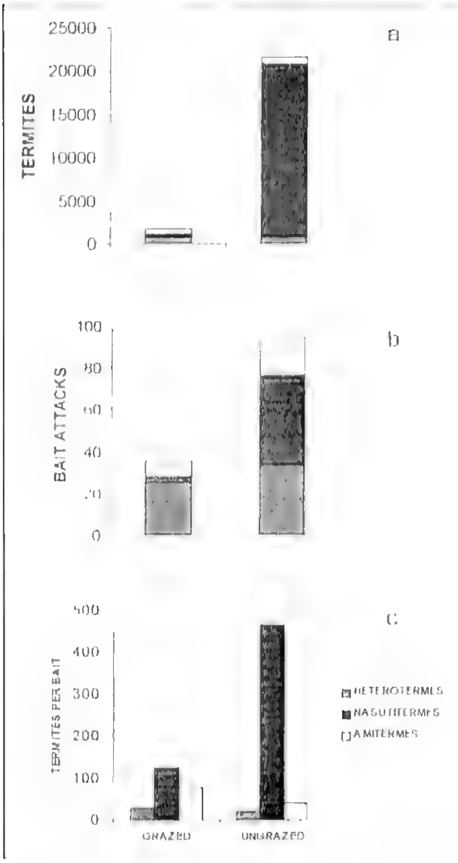

Fig. 3. Termite genera composition. a) Total number of each genus at baits; b) Number of bait attacks by each genus; c) Mean size of foraging group for each genus.

most active. Numbers of *Amitermes* at baits were not significantly different in grazed and ungrazed areas. *Amitermes* also attacked similar numbers of baits. *Heterotermes* was slightly more active overall than *Amitermes*, but did not have significantly different numbers in grazed and ungrazed areas, nor did it attack more baits in an area. The difference in termite activity between the two areas was mainly due to *Nasutitermes*, which had far more individuals foraging in ungrazed areas at significantly more baits. *Nasutitermes* tended to forage in larger groups than the other genera (Fig. 3c).

Discussion

The differences in ant and termite communities in grazed and ungrazed forest were not as great as expected. Ant species richness was not significantly less in grazed forest although it was reduced. Termite activity was reduced in grazed forest, as expected, but only at Dry Forest sites.

Ant Species Richness

Species richness is usually correlated with the structural complexity of an environment (Majer 1997) and this has been demonstrated with ants (Andersen 1986a, b; Majer 1983). Ant species richness has been shown to correlate with general invertebrate species richness (Majer 1983) and is therefore a valuable indicator. Although a greater richness was recorded in ungrazed Dry Forest in this study, the difference was not statistically significant. A more extensive sampling regime might reveal greater differences in richness of arboreal and cryptic species, which would be particularly influenced by trampling effects and the lack of understorey but are undersampled by pitfall trapping (Majer 1997).

Ant Community Structure

Rhytidoponera is a common opportunist genus and was prevalent at all sites. While observed as a significant proportion of ant communities in cooler southeastern Victoria (Andersen 1986a, b), it is observed in low proportions of the community in drier areas (Andersen 1984; Andersen *et al.* 1991). *Rhytidoponera* is able to adapt to a variable environment, such as one subject to disturbance (Andersen 1990) and has been suggested as an indicator of disturbance, being found to be more abundant in areas disturbed by grazing (Andersen and McKaige 1987), recreation (Yeatman and Greenslade 1980), mining (Majer 1983) and fire (Andersen and McKaige 1987; Andersen 1988). As this study took place in a drier environment, the high proportion of *Rhytidoponera* at all sites was unexpected and may suggest that the ungrazed Dry Forest sites were subject to significant disturbance prior to this study.

The entire Box-Ironbark region has suffered major disturbance since European settlement (Calder 1994). While some regions may appear untouched, it is possible they have been subjected to disturbances such as grazing in the past. Current sources of disturbance to the region include amateur prospecting and firewood collection, habitat fragmentation and edge effects. The ungrazed plots' close proximity to a road could expose them to these disturbances.

Termites

Termite baits presented a food source that was probably more desirable than naturally occurring litter, being flat against the soil surface and kept moist by plastic sheeting. As not all of the baits were attacked at any of the sites, it can be assumed that food sources were not the limiting factor of termite abundance in the study areas.

Numbers of termites at baits, baits attacked and amounts of bait consumed all revealed similar results for each plot, providing a reasonable measure of relative activity. As expected, relative activity was higher in ungrazed plots of Dry Forest compared with grazed plots. Plots in Mallee showed very low activity under both conditions, indicating that Mallee is an unfavourable environment for termites in this study area. Mallee occurs in drier soils that are often stony and compacted (Calder 1994), while termites prefer moist, loose soils (Abensperg-Traun 1992). Grazed soils may be similarly dry and compacted due to trampling, a reduced litter layer and less shade resulting from the lack of an understorey. A reduction in soil moisture of only 3% or 4% is enough to adversely affect termites (Abensperg-Traun 1992). Arid soils reduce the ability of bacteria to decompose wood, which increases its palatability to termites.

The difference in termite activity was largely due to the presence of *Nasutitermes* in ungrazed areas. Whereas *Heterotermes* and *Amitermes* colonies exist in small, diffuse underground chambers (Noirot 1970), *Nasutitermes* forms small mounds of 1-2 million individuals. Foraging in larger groups, *Nasutitermes* seeks larger food items (Hadlington 1996) and may be limited by the smaller amount of coarse litter in grazed forest.

Conclusions

While the analysis of ant species richness and proportion of opportunists have been used as indicators of disturbance, their use in this project did not reveal any difference between grazed and ungrazed forest. The possibility that the ungrazed forest had been subjected to previous disturbance meant that grazed land may not have been compared with a pristine environment.

Termites appeared to be a better indicator of grazing disturbance, being much less common in grazed plots. This would indicate grazing has a negative effect on termites, possibly through trampling and an increase in soil aridity. However, termite activity was low at all Mallee sites. This may suggest that termites are not ideal indicators in all environments, or that the baiting technique was less than ideal.

Further study on Box-Ironbark disturbance could measure factors such as soil aridity and disturbances of 'protected' forest.

Acknowledgements

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References

Abensperg-Traun, M. (1992). The effects of sheep grazing on the subterranean termite fauna (Isoptera) of the Western Australian wheatbelt. *Australian Journal of Ecology* **17**, 425-432.

Andersen, A.N. (1984). Community organization of ants in the Victorian mallee. *The Victorian Naturalist* **101**, 248-251.

Andersen, A.N. (1986a). Diversity, seasonality and community organization of ants at adjacent heath and woodland sites in south-eastern Australia. *Australian Journal of Zoology* **34**, 53-64.

Andersen, A.N. (1986b). Patterns of ant community organization in mesic south-eastern Australia. *Australian Journal of Ecology* **11**, 87-97.

Andersen, A.N. (1988). Immediate and longer term effects of fire on seed predation by ants in sclerophyllous vegetation in south-eastern Australia. *Australian Journal of Ecology* **13**, 285-293.

Andersen, A.N. (1990). The use of ant communities to evaluate change in Australian terrestrial ecosystems: a review and a recipe. *Proceedings of the Ecological Society of Australia* **16**, 347-357.

Andersen, A.N. (1991). 'The Ants of South Australia'. (CSIRO Australia.)

Andersen, A.N. and McKaige, M.E. (1987). Ant communities at Rotamah Island, Victoria, with particular reference to disturbance and *Rhytidoponera tasmaniensis*. *Proceedings of the Royal Society of Victoria* **99**, 141-146.

Andersen, A.N., Myers, B.A. and Buckingham, K.M. (1991). The ant fauna of a mallee outlier near Melton, Victoria. *Proceedings of the Royal Society of Victoria* **103** (1), 1-6.

Calder, D.M. (1994). 'The Forgotten Forests: A field guide to Victoria's Box and Ironbark Country'. (Victorian National Parks Association: Melbourne.)

Clark, K.R. and Warwick, R.M. (1994). 'Change in Marine Communities: an approach to statistical analysis and interpretation.' (NERC, U.K.)

Gibbens, J.R. (1997). 'Ants and termites as indicators of habitat disturbance in Box-Ironbark forest'. (Unpublished B.Sc. (Hons) thesis, Department of Zoology, University of Melbourne.)

Greenslade, P. and Greenslade, P.J.M. (1971). The use of baits and preservatives in pitfall traps. *Journal of the Australian Entomological Society* **10**, 253-260.

Greenslade, P.J.M. (1973). Sampling ants with pitfall traps:

digging in effects. *Insectes Sociaux* **20**, 345-353.
Greenslade, P.J.M. (1979). 'A Guide to Ants of South Australia'. (South Australian Museum: Adelaide.)
Greenslade, P.J.M. and Greenslade, P. (1977). Some effects of vegetation cover and disturbance on a tropical ant fauna. *Insectes Sociaux* **24**, 163-82.
Hadlington, P. (1996). 'Australian Termites and other common timber pests'. (New South Wales University Press: Sydney.)
Majer, J.D. (1983). Ants: Bio-indicators of Minesite Rehabilitation, Land-Use, and Land Conservation *Environmental Management* **7**, 375-383.
Majer, J.D. (1997). The use of pitfall traps for sampling ants – a critique. *Memoirs of the Museum of Victoria* **56** (2), 323-329.
Noirot, C. (1970). The nests of termites. *In* 'Biology of Termites', pp. 73-120. Eds K. Krishna and F.M. Weesner. (Academic Press: London.)
Wilson, A.D. (1990). The effect of grazing on Australian ecosystems. *Proceedings of the Ecological Society of Australia* **16**, 235-44.
Yeatman, E.M. and Greenslade P.J.M. (1980). Ants as indicators of habitat in three conservation parks in South Australia. *South Australian Naturalist* **55** (2), 20-30.
Yen, A.L. and Butcher, R.J. (1997). 'An Overview of the Conservation of Non-Marine Vertebrates in Australia'. Report to the Biodiversity Unit, Environment Australia.

Do We Know What We Are Eating?

In these days of genetically-modified food, it is interesting to find that the question of what we ate was one which concerned a microscopist in the 1880s.

In 1882 the Rev. J.J. Halley, later to be President of the Field Naturalists Club of Victoria, was called upon to give the annual address to the Microscopical Society of Victoria, as Vice-President, in the absence of their President, Dr Ralph. Describing it as an 'unusual honour', he remarked that he ventured 'to perform the duty with a diffidence which, I confess, is not generally mine in speaking in public', attributing this to the fact that in the microscopical world he thought that he had 'achieved nothing' in the past year, 'matters of higher importance' having 'absorbed every moment' of his time.

Faced with the paucity of major scientific discoveries, he proceeded to give a humorous talk, creating the 'great genus' of *Microscopista*, 'whose habitat is the civilized world'. The species of this genus comprised *M. delectata*, the playing microscopist; *M. evocationes*, the collecting microscopist; *M. tabernarius*, the tradesman microscopist, with the sub-species, *M. detergitata*, the detective microscopist, in which he included himself; *M. medicus*, the medical microscopist, sadly lacking from the gatherings of the Microscopical Society (perhaps a sly dig at their President who was a medical doctor); and finally, *M. germanus*, a true genuine microscopist, who adds to the 'sum of the world's knowledge, and so to the sum of its happiness.'

Microscopista detergitata he described as a 'class directly useful to mankind'. 'By the aid of the microscope we discover largely what it is that we eat and drink, how - sometimes very widely - the real differs from the apparent, and how true it is that 'things are not what they seem', - a wide field that has hitherto not been taken up to any extent by our Society.' Though he had not achieved as much as he had hoped during the previous year, he laid before his audience the results of his investigations. Arrowroot was adulterated with sago; and arrowroot, tapioca and sago all showed more or less of the well-known form of potato starch. Cocoa had contained potato starch, sago starch, the 'beautiful grain of tous-les-mois'*, as well as sugar crystals and inorganic matter 'that may be colouring or may be dirt', and in one case he suspected, plaster of Paris. Mustard was also adulterated with pea-flour, potato starch and wheat flour, and again probably plaster of Paris. Oatmeal revealed wheat flour, and maizena, potato starch.

It was not the Society's province to deal with legislative action, but he did think that people had a right to know what they were eating and drinking. While many of the adulterations were not injurious to public health, they were to public morals. *M. detergitata* was much needed in the ranks of their Society, and he hoped that their energetic Secretary would secure numerous specimens of them.

Mr Halley would no doubt welcome the legislation which has improved the 'purity' of our food, and the mandatory listing of ingredients, but the genetic modification of food might well make him ponder the work of scientists and reassert that we had a right to know what we eat and drink.

* starch obtained from the root-stock of species of *Canna* especially *Canna edulis*.

For the full text of the Rev. Halley's speech see *Southern Science Record*, **2**, 285-289, 1882.

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A Survey of the Butterfly Fauna at The Paps Scenic Reserve, Mansfield, Victoria

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Abstract

A survey of butterflies was undertaken at The Paps Scenic Reserve, Mansfield, during the 1995-1996 summer flight season. The locality was targeted because of previous records of at least two species of conservation significance at The Paps, the importance of The Paps as a 'hill-topping' area by butterflies, and the suggestion that the butterfly community at The Paps is similar in composition to the protected butterfly community at Mt Piper. Twenty-one species of butterflies were recorded during the 1995-1996 survey. Of these, 19 were recorded hill-topping at the summit of the higher peak. The total number of butterfly species recorded from The Paps is now 27. Two species of conservation significance have been recorded from The Paps, the Bronze Ant-blue *Acrodipsas brisbanensis cyrilus* and the Southern Purple Azure *Ogyris genoveva araxes*, although only the latter was recorded in this study. The Paps has a rich and diverse butterfly community, and is an important landmark for hill-topping butterflies. However, the butterfly community at The Paps cannot, on the basis of currently available knowledge, be considered the same as that at Mt Piper. (*The Victorian Naturalist* **117** (4), 2000, 131-140.)

Introduction

A survey of the butterflies (Lepidoptera) at The Paps Scenic Reserve, Mansfield, was undertaken during the summer period of 1995-1996 as part of an environmental impact study on the effects of building an Optus Communications mobile digital telephone base station near the summit.

Butterflies were chosen in this study for three reasons: (1) the previous records of at least one threatened and protected species at The Paps, the Bronze Ant-blue *Acrodipsas brisbanensis*; (2) the importance of The Paps as a 'hill-topping' area for the local butterfly community; and (3) the suggestion that the butterfly community at The Paps is similar to the protected butterfly community at Mt Piper.

The *Flora and Fauna Guarantee Act 1988* automatically confers protection to listed invertebrates (either as taxa or a community) under the *Wildlife Act 1975*. In relation to The Paps, there are two issues relevant to threatened invertebrates. First, there is a record of a *Flora and Fauna Guarantee* listed species of butterfly, the Bronze Ant-blue Butterfly *Acrodipsas brisbanensis* from the summit at The Paps (Britton and New 1992, 1993). Second, there is the question as to how similar the butterfly community found at The Paps is to that found at Mt Piper (near Broadford). The butterfly community found at Mt Piper (Butterfly Community No. 1) has been listed as threatened under the *Flora and Fauna Guarantee Act*. If the butterfly community at The Paps was considered the same as that at Mt Piper, then under the *Flora and Fauna Guarantee Act*, the butterfly community at The Paps would automatically be protected as part of Butterfly Community No. 1.

There is an extensive literature on the use of butterflies as environmental indicators, both at the species level (Brown 1991) and at the community level (Kremen 1992). The main characteristics of butterflies that make them amenable as environmental indicators are that they are relatively taxonomically diversified with many, but not too many, species in each locale; they are taxonomically well known and relatively easy to identify; and they associate closely with other species (Brown 1991). Many butterfly species rely on plants as food for their larval stages, and they often have a close association with particular species of ants that protect the larvae in return for nutritious secretions from the butterfly larvae. The Ant-blue Butterflies are also closely associated with an ant, but instead of providing the ants with food, they apparently feed upon the ant larvae and pupae.

Many species of butterflies are attracted to isolated hilltops. This is called 'hill-topping' and it is hypothesised as an effective means of mate location. It is an important

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part of the life cycle of many species of butterflies. Males may establish territories, which they defend from other males and wait for unmated females for mating.

Methods

The Paps can be likened to an island of native vegetation surrounded by cleared agricultural land. The area has a history of disturbance, with quarrying and a rubbish tip. The area has been subjected to some tree clearing or thinning for the track to the summit, the electricity power lines, and erection of a trigonometric point and various telecommunication towers.

The Paps is actually a pair of wooded peaks 9 km west of Mansfield (37°02'40"S, 45°59'03"E). The summit of Peak 1, the higher of the two peaks (704 m) has been cleared and has several telecommunication installations and a graded road to the summit. The summit area consists of a ridge running east-west approximately 50 × 10 m. The summit of Peak 2 has also been cleared and has a fire tower.

There has been no published vegetation survey of The Paps. The vegetation is a mosaic of open eucalypt forest and woodland, dominated by Red Box *Eucalyptus polyanthemos*, White Box *E. albens* and Candlebark *E. rubida* at the lower slopes and surrounding plain, and Red Stringybark *E. macrorhyncha*, *E. polyanthemos* and Long-leaved Box *E.goniocalyx* on the higher altitudes. Surrounding the summit ridge, trees of significance to hill-topping butterflies are Black Wattle *Acacia mearnsii* and Silver Wattle *A. dealbata* from 5 to 8 m in height. Other trees near the summit include Golden Wattle *A. pycnantha* and Cherry Ballart *Exocarpos cupressiformis*. Understorey shrubs consist of occasional Common Cassinia *Cassinia aculeata* and Shiny Cassinia *C. longifolia*. Ground layer plants are chiefly herbaceous annual weeds dominated by Large Quaking-grass *Briza maxima* and St. John's Wort *Hypericum perforatum*. According to Britton (1995), some of the important plants for butterflies are the mistletoes (*Amyema miquelli* and *Muellerina eucalyptoides*) on eucalypts on the adjacent farmland and mistletoes (*A. miquelli*, *A. pendulum* and *M. eucalyptoides*) in the gully between Peaks 1 and 2.

Previous work on the butterflies at The Paps includes observations by various amateur lepidopterists (Ross Field, *pers. comm.* 1995). Some observations were undertaken at The Paps as part of the Mt Piper butterfly survey from 1991 until early 1995 (Britton 1995).

Fieldwork for this project was conducted from mid-November 1995 until mid-March 1996 (the summer flight season). Work was concentrated near the site of the proposed Optus Communication base station (Peak 1) and the adjacent area beneath it. However, some surveys of the adjacent peak (Peak 2) were undertaken, as well as the area around the base of the peaks. A total of 17 days was used for observation and collection of butterflies; extra days were taken to search for ants.

Adult butterflies and moths active in daylight were observed hill-topping on the summit of Peak 1 of The Paps. On each occasion, for each taxon identified, abundance was either recorded as infrequent (single individual or low numbers only), occasional (up to 10 separate sightings on a given day), common (between 10-50 sightings on a given day) or abundant (over 50 sightings on a given day). A butterfly net (circumference 44 cm) with a 4.8 m extension handle, and 10×24 binoculars were used to observe adult Lepidoptera. Netted specimens were identified and released if they had been previously recorded on the summit. Voucher specimens for a reference collection were taken of each sex of each species recorded. All identifications of adult butterflies were made from Common and Waterhouse (1981), and of adult moths from Common (1990). Common names used in this paper are those suggested by Braby *et al.* (1997). Set specimens are deposited in the Museum of Victoria.

A search was also made for the Coconut Ant *Papyrius nitidus*, a species associated with Ant-blue Butterflies. The areas selected for searching for Coconut Ants were based on information about the habitat requirements of this species (Beardsell 1994), and most areas were a fair distance away from the peaks because it is known that some butterflies hill-top from some distance. Britton (1995) did not find *P. nitidus* at The Paps during his surveys.

Table 1. Species of butterflies recorded at The Paps during the summer flight period, 1995/1996 (day/month).
Key: 1–infrequent, single individual or small numbers only; 2–occasional, up to 10 separate sightings on a given day; 3– common, between 10 and 50 sightings on a given day; 4=abundant, over 50 sightings on a given day.

Species	23/11	1/12	5/12	9/12	15/12	22/12	29/12	30/12	6/1	7/1	13/1	14/1	22/1	23/1	4/2	5/2	13/3
Anaphaeis java teutonia		1	1	1	1												
Delias aganippe				1	2	2	1	1		1	1	1	2	1	2	2	2
Delias harpalyce	2	2				1											
Dispar compacta																1	1
Geitoneura acantha ocrea								1									
Geitoneura klugii klugii				1	1	3	4	4	4	4	4	4	4	4	4	4	3
Heteronympha merope merope		2	1	3	4	4	4	4	4	4	4	4	4	4	3	4	3
Hypochrysops delicia delos				2	2	2	3	3	3	3	3	2	3	2	3	2	
Jalmenus evagoras evagoras													1				
Junonia villida calybe	1																
Lampides boeticus															1		
Nacaduba biocellata biocellata		1			1				1				1			1	3
Ogyris genoveva araxes							2	1	2	2	2	1	2	2	2	2	
Ogyris olane ocela		1		3	3	2	3	3	3	3	3	3	2	2	2	2	3
Papilio anactus				1	1						1	1					
Papilio demoleus sthenelus		1															
Pieris rapae rapae		1			2	1		1		1	1	1				1	1
Trapezites phigalioides	2	2		2	2	2	1	1									
Vanessa itea	1	2		2	1	2	1	1	3	2	1	2	1		2		
Vanessa kershawi	3	4	3	4	3	3	2	2	3	3					2	2	
Zizina labradus labradus	3	3	1	3	4	3	3	4	3	3	4	3	3	3	3	2	2
Day-flying moths																	
Comocrus behri						1		1	1								
Phalaenoides glycinae					1	1	1			1	1			1			

Ants were sampled by pitfall trapping with a line of 10 plastic cups (depth 8 cm, top diameter 6.5 cm) placed 5 m apart, at 9 sites. Cups were 1/3 filled with ethylene glycol and ethanol as preservative. The traps were installed on 21 January 1996 and collected two weeks later (4 February 1996). A direct search was made for colonies of the Coconut Ant on 13 March 1996.

Results

The butterfly fauna

A total of 21 species of butterflies was recorded at The Paps during the 1995-1996 survey. Table 1 lists the butterfly species, along with their abundance, observed on the summit of Peak 1 of The Paps on 17 days over the 1995-1996 butterfly flight season according to the date of observation. Fewer species and individuals of butterflies were seen on Peak 2 compared to Peak 1, and all the species recorded on Peak 2 were found on Peak 1.

The total number of butterfly species recorded at The Paps is now 27 when the data summarised by Britton (1995) and New *et al.* (1994) are included. Six species listed by those authors were not found during the 1995-1996 survey: the Bronze Ant-blue *Acrodipsas brisbanensis*, Lesser Wanderer *Danaus chrysippus petilia*, Grassland Copper *Lucia limbaria*, Dark-purple Azure *Ogyris abrota*, Tailed Emperor *Polyura sempronius*, and the Salt-bush Blue *Theclinesthes serpentata serpentata*.

With regard to the threatened species, no specimens of the Bronze Ant-blue *Acrodipsas brisbanensis* or the Small Ant-blue *Acrodipsas myrmecophila* were found during the summer of 1995-1996. However, up to six individuals of the Southern Purple Azure *Ogyris genoveva araxes* were observed at any one time during the survey.

The following is a brief resume of the butterfly species collected at The Paps during this 1995-1996 survey:

Family Hesperiidae

Dispar compacta Butler (Barred Skipper). Resident. Not seen until late in season when observed occasionally flying around and landing on foliage of *Acacia* species on the summit.

Trapezites phigalioides Waterhouse (Montane Ochre). Resident. Common on the summit early in November. Seen most frequently on the summit at ground level on rocky exposed areas, landing on small stones or low herbs. Males defend territories against conspecifics and other small butterflies. Conspecifics take part in fast flying aerial dog fights.

Family Papilionidae

Papilio anactus Macleay (Dingy Swallowtail). Vagrant. Occasional individuals seen flying low, over and amongst *Acacia* species on summit.

Papilio demoleus sthenelus Macleay (Chequered Swallowtail). Vagrant. Only one individual seen (1 December 1995) flying close to *Acacia* species on the summit.

Family Pieridae

Belenois java teutonia (Fabricius) (Caper White). Vagrant. Single individuals seen flying low across summit, apparently not staying to defend territories. Not a hill-topping species.

Delias aganippe Donovan (Red-spotted Jezebel). Resident. Common throughout season, flying around and landing on *Acacia* species. Male and female seen mating on the wing (29 December 1995 and 22 January 1996).

Delias harpalyce (Donovan) (Imperial Jezebel). Resident. Infrequently seen and only in low numbers flying around *Acacia* species on the summit.

Pieris rapae rapae (Linnaeus) (Cabbage White). Introduced species. Vagrant. Single individuals passing quickly across summit. Not a hill-topping species.

Family Nymphalidae

Geitoneura acantha ocrea (Guest). (Ringed Xenica). Resident. Not seen at the summit of peak during the 1995-1996 survey.

Geitoneura klugii klugii (Guérin-Méneville) (Marbled Xenica). Resident. Not seen until 9 December 1995 but from then on abundant. Generally landing on ground vegetation to dart up to attack conspecifics or other butterflies such as *Heteronympha merope*. Two individuals mating on the wing were recorded on 29 December 1995. Not a hill-topping species.

Heteronympha merope merope (Fabricius) (Common Brown). Resident. Uncommon in early summer after which abundant. Prefers flying under the canopy amongst the foliage of *Acacia* species on the summit. Not a hill-topping species.

Junonia villida calybe (Godart) (Meadow Argus). Resident. Only one individual seen, 23 November 1995. Not a hill-topping species.

Vanessa itea (Fabricius) (Yellow Admiral). Resident. Occasional single individuals seen flying around and within the canopies of *Acacia* species on the summit. More common amongst *Acacia* species 20-30 m down hill off the summit. Not a hill-topping species.

Vanessa kershawi (McCoy) (Australian Painted Lady). Resident. Often landing on low weeds such as dandelion and thistles. Not a hill-topping species.

Family Lycaenidae

Hypochrysops delicia delos (Waterhouse & Lyell) (Moonlight Jewel). Resident. Not seen until mid December after which it was common. Generally first seen after 4 pm Eastern Summer Time. By 5 pm very active and common flying around and landing on *Acacia* species on the summit. It exposes its bright upper wing surface sometimes when landed. Frequently dogfights with conspecifics, *Ogygis olane ocela* or *Ogyris genoveva araxes*.

Jalmenus evagoras evagoras (Donovan) (Imperial Hairstreak). Resident. Although this species was not collected at the summit during 1995-1996, larvae and pupae were found on *Acacia mearnsii*, a host species recorded in Common and Waterhouse (1981), at the north-east base of Peak 1 on 22 January 1996.

Lampides boeticus (Linnaeus) (Long-tailed Pea-blue). Vagrant. Seen only once (4 February 1996) flying around and landing on *Acacia* near the summit and darting up to dogfight with passing *Ogyris olane*.

Nacaduba biocellata biocellata (Semper) (Two-spotted Line-blue). Resident. Occasionally seen close to ground or on *Cassinia longifolia* flowers. On 6 January 1996 one individual seen flying rapidly around crowns of *Acacia dealbata*, occasionally landing on a branch in an exposed situation, darting up for aerial dogfights with passing *Ogyris olane*. The species was common late in the season.

Ogyris genoveva araxes Waterhouse and Lyell (Southern Purple Azure). Resident. First seen in late December. One female seen, 29 December 1995. Males fly fast around the summit often persued by conspecifics, *Ogyris olane* or *Hypochrysops delicia*. Generally first seen after 4 pm after which up to six males seen at any one time. Sometimes lands on wooden power poles and *Acacia* species on the summit.

Ogyris olane ocela Waterhouse (Dull-purple Azure). Resident. Very common throughout season, flying fast around the summit from one *Acacia* to another, frequently dog fighting with conspecifics, other butterflies and large insects such as dragonflies, flies and even Christmas beetles (*Anoplognathus*).

Zizina labradus labradus (Godart) (Common Grass-blue). Resident. Abundant throughout season, flying near ground and landing on weeds and *Cassinia* flowers. Not a hill-topping species.

Day-flying moths

Some moth species fly during the day. At least 10 species have been recorded at Mt Piper, including the *Flora and Fauna Guarantee* listed *Synemon plana* (Golden Sun Moth). Records were consequently made at The Paps for day-flying moths, and two species were recorded from the family Noctuidae:

Comocrus behri (Angas). Resident. Single individuals occasionally seen flying fast around summit from one *Acacia* to another. Sometimes seen flying around electric power insulators or high up telecommunications tower.

Phalaenoides glycinae Lew (Vine Moth). Vagrant. Flies fast around *Acacias* on summit, occasionally seen interacting with *Delias aganippe*, *Hypochrysops delicia* and *Geitoneura klugii*.

Butterfly hill-topping behaviour

There is little doubt that Peak 1 of The Paps is an important hill-topping site for several species of butterflies. Most butterflies, irrespective of the species (19 of the 21 species recorded during this survey), prefer the southern aspect of the peak, and congregate around a few of the *Acacia dealbata* or *Acacia mearnsii* that are at the edge of the cleared area at the summit. In particular, there is a marked preference for two prominent *Acacia* trees, one of which is an *A.dealbata* and the other is an *A.mearnsii*, by many of the butterflies.

During the summer flight survey in 1995-1996, most butterflies hill-topped from the south, although much lower numbers did come up from the north, east and west. The direction appeared to depend upon a variety of factors, including source of origin of the butterflies and wind direction. Most of the remaining native vegetation at The Paps is located to the south of Peak 1 (between Peak 1 and Peak 2), and the Fraser National Park is also due south. It is likely that many of the butterflies hill-topping at The Paps will originate from the south. Although cleared farmlands occur to the north and east, some butterflies could still originate from the mistletoes on the remnant eucalypt trees on these farmlands.

The Coconut Ant

The Coconut Ant *Papyrius nitidus* may represent a species complex. It is a species that builds nests in old rotting wood (such as tree stumps or dead wood on the ground), or in the base of several species of wattles, under rocks or in the ground. The nests of the Coconut Ant are found in sunny and well-drained ridges that have an overstorey of trees with less than 25% foliage cover, and where the slope of the ground does not exceed 20° (Beardsell 1994). It is known to be associated with the Small Ant-blue Butterfly, and is also associated with the Bronze Ant-blue Butterfly and the Fiery Jewel *Hypochrysops ignitus*. It is characterised by a strong and persistent smell of coconuts (other species of ants also have such a smell, but only when their bodies are crushed, and the smell is not as strong). Colonies of the ant have been found in several locations in Victoria, and initial experiments indicate that they will readily colonise suitable habitat (such as rotting wood) (Beardsell 1994). Their presence does not necessarily indicate the presence of Ant-blue Butterflies, but it is likely that the Small Ant-blue does require the presence of *P. nitidus*. No specimens of *P. nitidus* were found in either the pitfall traps or during the direct searching. However, the pitfall trapping resulted in a total of 55 morphospecies of ants, a high number of species considering the short period of trapping.

Discussion

The butterfly fauna at The Paps

Twenty-one species of butterflies were recorded at The Paps during the 1995-1996 summer flight season survey. Of the 21 species, 19 were recorded hill-topping on Peak 1. Two species, the Ringed Xenica *Geitoneura acantha ocrea* and the Imperial Hairstreak *Jalmenus evagoras evagoras*, were recorded at lower elevations.

Six species that had been previously recorded at The Paps by Britton (1995) were not recorded during the summer flight season of 1995-1996. This is not surprising given the vagaries of butterfly occurrences in response to variation in weather. Only one species not previously recorded at The Paps was found during 1995-1996. This was the Chequered Swallowtail *Papilio demoleus sthenelus* which is a rare vagrant species in Victoria (Common and Waterhouse 1981).

A total of 27 species of butterflies has now been recorded at The Paps. Although 41 species have been recorded at Mt Piper, this does not lessen the importance of The Paps as a hill-topping site. The less intensive searching undertaken at The Paps to date compared to Mt Piper may contribute to the smaller tally at The Paps. By 1993, Britton (1995) had recorded 37 species of butterflies from 51 visits to Mt Piper and 26 species from 6 visits to The Paps.

It is evident that there is a rich butterfly community at The Paps. This indicates that there is a diverse array of complex biological relationships between the plants, the butterflies and their attendant ants. The rich community can be taken as an 'indicator' of the ecological integrity of The Paps as well as highlighting its importance as a hill-topping site. With the experience of

Table 2. Butterflies recorded at The Paps and at Mt Piper. [1]Based on Britton & New (1992, 1993), Britton (1995). [2]Based on 1995-1996 summer flight season survey (this study).

Species	Mt Piper[1]	The Paps[1]	The Paps[2]
Acraea andromacha andromacha	+		
Acrodipsas brisbanensis cyrilus	+	+	
Acrodipsas myrmecophila	+		
Anapheis java teutonia	+	+	+
Appias paulina ega	+		
Candalides hyacinthinus hyacinthinus	+		
Candalides hyacinthinus simplex	+		
Danaus chrysippus petilia	+	+	
Delias aganippe	+	+	+
Delias harpalyce	+	+	+
Dispar compacta	+	+	+
Eurema smilax	+		
Geitoneura acantha ocrea		+	+
Geitoneura klugii klugii	+	+	+
Hesperilla donnysa	+		
Heteronympha merope merope	+	+	+
Heteronympha penelope	+		
Hypochrysops delicia delos	+	+	+
Jalmenus evagoras evagoras	+	+	+
Jalmenus icilius	+		
Junonia villida calybe	+	+	+
Lampides boeticus	+	+	+
Lucia limbaria	+	+	
Nacaduba biocellata biocellata	+	+	+
Neolucia agricola agricola	+		
Ocybadistes walkeri sothis	+		
Ogyris abrota	+	+	
Ogyris genoveva araxes	+	+	+
Ogyris olane ocela	+	+	+
Papilio anactus		+	+
Papilio demoleus sthenelus	+		+
Pieris rapae	+	+	+
Polyura sempronius	+	+	
Signeta flammeata	+		
Taratrocera papyria papyria	+		
Theclinesthes miskini miskini	+		
Theclinesthes serpentata serpentata	+	+	
Trapezites luteus luteus	+		
Trapezites phigalia phigalia	+		
Trapezites phigaliodes	+	+	+
Vanessa itea	+	+	+
Vanessa kershawi	+	+	+
Zizina labradus labradus	+	+	+
Total number of species	41	26	21

the Mt Piper butterfly project, it is highly probable that further short term (the next 1-3 years) monitoring of The Paps will increase the number of butterfly species observed there. Longer-term monitoring of the butterflies can give an indication of any decline in the ecological integrity of The Paps if there is a continuous decline in the number of butterflies recorded.

The interest in The Paps arose from the co-occurrence of the Bronze Ant-blue and the Small Ant-blue Butterflies at Mt Piper and the possibility of these two species co-occuring at The Paps. The Bronze Ant-blue was found in 1991-1992 and in 1992-1993 (Britton and New 1992, 1993), but not during this survey. The Bronze Ant-blue is a rare butterfly species in Victoria, but possibly future monitoring will find it again at The Paps.

The interest in the Coconut Ant *Papyrius nitidus* stems from the fact that if it is found at The Paps, then the likelihood of the Small Ant-blue occurring there increases. More importantly, if the Coconut Ant does occur at The Paps, then there is the potential to use The Paps as a site for translocation of the Small Ant-blue. Research by Beardsell (1994) and Britton (1995) using artificial nest boxes indicated that the Small Ant-blue has potential for translocation to other areas with suitable habitat.

The butterflies of conservation interest recorded at The Paps are the Bronze Ant-blue *Acrodipsas brisbanensis*, listed as a threatened taxon on Schedule 2 of the *Flora and Fauna Guarantee Act*, and the Southern Purple Azure *Ogyris genoveva araxes*, listed on the Threatened Fauna List in Victoria (CNR 1995). The Paps is an important location for the Southern Purple Azure because of its recent absence from Mt Piper. There were no sightings of the Southern Purple Azure at Mt Piper in 1992-1995 (Britton 1995; New *et al.* 1994). New *et al.* (1994) observed newly emerged adult Southern Purple Azures hill-topping at The Paps, although they did not find any immature stages. Suitable host plants (the mistletoe *Amyema miquelli*) are located in farmland to the northeast of The Paps.

Another species that is of interest is the Tailed Emperor *Polyura sempronius*. This species occurs sporadically in Victoria and is not common in southern Australia. It has been recorded breeding in Victoria, and one of the plants that the larvae feed on is *Acacia dealbata* (Common and Waterhouse 1981). This butterfly was not recorded during the 1995-1996 summer flight season, but was recorded at The Paps by Britton (1995).

Comparison with Mt Piper

The emphasis in this report of comparing The Paps with Mt Piper results from observations of hill-topping butterflies at The Paps over the previous four flight seasons. It was suggested that the fauna may be similar to that of Mt Piper (Britton and New 1992, 1993), an area whose day-flying Lepidoptera have warranted listing as a Threatened Community on Schedule 2 of the *Flora and Fauna Guarantee Act* as Butterfly Community No. 1 (Jelinek 1991).

In terms of composition of the invertebrate fauna, three elements are relevant: butterflies, day-flying moths, and ants. With regard to the butterflies, Mt Piper has 41 recorded species of butterflies of which 16 are not found at The Paps. The Paps has 27 recorded species of butterflies of which only two species have not been found at Mt Piper. There were 25 species common to both Mt Piper and The Paps (Table 2). Ten species of day-flying moths have been found at Mt Piper, including the *Flora and Fauna Guarantee* listed *Synemon plana* Walker (Britton *et al.* 1995); only two species of day-flying moths were recorded at The Paps in 1995-1996 (Table 1) and these did not include *S. plana*. A total of almost 140 morphospecies of ants was trapped at Mt Piper (New *et al.* 1994) compared to the 55 morphospecies at The Paps, although with much more limited sampling. The number of ant species common to both areas has not been determined. The Coconut Ant, which is an integral component of Butterfly Community No. 1 at Mt Piper, was not found at The Paps.

When Butterfly Community No. 1 was listed under the *Flora and Fauna Guarantee Act* as a threatened community, the community was characterised by the presence of at least 20 species of butterflies that included a number of significant, rare and extremely rare butterflies. The latter involved the unique co-occurrence of the two species of Ant-blue and three other rare species: the Small Ant-blue *Acrodipsas myrmecophila*, the Bronze Ant-blue *Acrodipsas brisbanensis*, the Southern Purple Azure *Ogyris genoveva araxes*, the Varied Dusky-blue *Candalides hyacinthina simplex* and Wattle Blue *Theclinesthes miskini miskini*, as well as the Coconut Ant *Papyrius nitidus* (SAC 1991).

As more data were gathered at Mt Piper, the composition of the rare butterflies changed slightly. In the Action Statement for Butterfly Community No. 1, the Yellow Albatross *Appias paulina ega* and the Moonlight Jewel *Hypochrysops delicia delos* were added to the list of rare butterflies while the Wattle Blue was removed (Jelinek 1991). The discovery of the day-flying Golden Sun moth *Synemon plana* has added another *Flora and Fauna Guarantee* listed species to the list. Although the Golden Sun moth is not a butterfly, its presence has broadened the emphasis at Mt Piper from just butterflies to include day-flying Lepidoptera (both butterflies and moths).

In terms of community definition at The Paps, the data gathered so far indicate that the community cannot be considered the same as Butterfly Community No. 1 at Mt Piper. Although the butterfly community at The Paps has over 20 species, and has two of the rare species found at Mt Piper (the Bronze Ant-blue and Southern Purple Azure), both the Small and Bronze Ant-blue Butterflies, and the Coconut Ant, have not yet been found together there, and therefore it cannot be considered equivalent to the community at Mt Piper. If future work at The Paps does turn up the Small Ant-blue and the Coconut Ant, a reappraisal of the definition of the butterfly community will be required.

The limitations of the summer flight survey for 1995-1996 need to be considered because future observations can alter matters considerably. The monitoring of any group of insects is very much dependent on the weather, both in the longer term and on a daily basis. Flight activity is influenced by variation in annual weather patterns. For example, the butterfly records at Mt Piper indicated high numbers of butterflies in the 1991-1992 and the 1992-1993 seasons, but lower numbers in the 1993-1994 season, due to the disruption of the normal patterns of butterfly phenology by unusual weather patterns (New *et al.* 1994). Hence monitoring during one season does not necessarily provide an accurate record of the fauna.

Also, the length of a study influences the results. The fieldwork at Mt Piper began in 1991 and continued every summer until 1995. The ants at Mt Piper were sampled over a full year. The numbers of butterfly and ant species at Mt Piper may be indicative of a greater number of species than occur at The Paps; then again, it may only reflect more intensive collecting. An accurate answer will only be obtained if both sites have comparable sampling efforts.

Finally, the absence of some of the target species (such as the Small Ant-blue Butterfly and the Coconut Ant) does not mean that they definitely do not occur at The Paps. Their absence may be due to seasonal factors determining their activity, inadequate search effort, or the fact that more appropriate collecting techniques were not employed. For example, the Coconut Ant was considered very rare at Mt Piper when using pitfall traps and direct searching, but the numbers found increased dramatically when trap nests were employed (Britton 1995).

A total of 27 species of butterflies has been recorded at The Paps including two species of conservation significance. It is likely that more species will be recorded if more summer surveys are conducted. It is possible that more species of conservation significance may be found at The Paps with further searching. The Paps is an important hill-topping site for butterflies because it is both a prominent landscape feature and an island of green surrounded by agricultural land.

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References

Beardsell, C. (1994). Report on field surveys from 22 October 1993 to 23 January 1994 for the Small and Large Ant-blue butterflies and their attendant ant species. (Unpublished report to the Department of Conservation and Natural Resources: Melbourne.)

Braby, M.F., Atkins, A.F., Dunn, K.L., Woodger, T.A. and Quick, N.B. (1997). A provisional list of common names for Australian butterflies. *Australian Journal of Entomology* **36**, 197-212.

Britton, D.R. (1995). Research on the ecology of the Coconut ant and breeding biology of the Small and Large Ant-blue and other target butterflies at Mt Piper, Broadford, 1994/1995. (Unpublished report to the Department of Conservation and Natural Resources: Melbourne.)

Britton, D.R. and New, T.R. (1992). Ecology of the butterfly and ant community at Mt Piper, Victoria. (Unpublished report to the Department of Conservation and Environment as part of the National Estate Grants Program Project No. 836: Canberra.)

Britton, D.R. and New, T.R. (1993). Communities of diurnal Lepidoptera in central Victoria, with emphasis on the Mt Piper region, Broadford. (Unpublished report to the Department of Conservation and Natural Resources: Melbourne.)

Britton, D.R., New, T.R. and Jelinek, A. (1995). Rare Lepidoptera at Mount Piper, Victoria - the role of a threatened butterfly community in advancing understanding of insect conservation. *Journal of the Lepidopterists' Society* **49**, 97-113.

Brown Jr., K.S. (1991). Conservation of Neotropical environments: Insects as indicators. *In* 'The Conservation of Insects and their Habitats', pp. 349-404. Eds N.M. Collins and J.A. Thomas. (Academic Press: London.)

Common, I.F.B. (1990). 'Moths of Australia'. (Melbourne University Press: Carlton.)

Common, I.F.B. and Waterhouse, D.F. (1981). 'Butterflies of Australia'. (Angus and Robertson: Sydney.)

CNR (1995). 'Threatened Fauna in Victoria - 1995'. (Department of Conservation and Natural Resources, Victoria: Melbourne.)

Jelinek, A. (1991). Butterfly Community No. 1. Flora and Fauna Guarantee Action Statement No. 6. (Department of Conservation and Natural Resources, Victoria: Melbourne).

Kremen, C. (1992). Assessing the indicator properties of species assemblages for natural areas monitoring. *Ecological Applications* **2**, 203-217.

New, T.R., Britton, D.R. and Hinkley, S. (1994). Recovery plan, research phase, for a rare and threatened butterfly community. (Unpublished report to the Department of Conservation and Natural Resources: Meboume).

SAC (1991). Flora and Fauna Guarantee - Scientific Advisory Committee. Final Recommendation on a Nomination for Listing. Butterfly Community No. 1. No. 89/2909. (Department of Conservation and Environment Victoria: Melbourne).

Death of a Kangaroo

Since it is relatively rare for causes of mortality in wild vertebrates to be identifiable, we report this observation of the death of a sub-adult female Eastern Grey Kangaroo *Macropus giganteus*. On finding the animal dead, we arranged for a post-mortem examination which strongly suggested heart failure as the cause of death. The animal (ID No. 69) was a member of the population at the Yan Yean Reservoir catchment (approximately 35 km north of Melbourne) and was trapped on 29 May 1998, ear-tagged and fitted with a radio-collar. She weighed 10.5 kg and crus, pes and arm measurements indicated an age between 12 and 15 months. The draw-string trapping method that we employed is highly selective as non-target animals can move through the trap freely; this method is not biased towards slow individuals (Coulson 1996).

Female 69 was radio-tracked from this time until she was found dead on 27 August 1998. Fixes in this period indicated that she was ranging over an area of 48 ha in the farmland adjacent to the Yan Yean Reservoir catchment. The post-mortem examination was conducted on 28 August 1998 and identified significant stenosis in the aorta, hypertrophy of the left ventricle, pulmonary oedema and fluid in the thorax and abdominal cavity. A complete lack of fat tissue indicated that she was in poor condition. In addition, haemorrhages on the heart surface suggested that death occurred following a period of violent exertion.

Two observations are consistent with this finding. Firstly, Female 69 was found dead at the peak of a hill, outside her usual home range. Secondly, on 17 July 1998, she was observed foraging in a group of 34 individuals for approximately half an hour. When disturbed, the remainder of this group hopped over a fence and moved away uphill. At this time, Female 69 was the only kangaroo in the group not to cross the fence and move up the hill. She was observed for a further 15 minutes and remained alone, moving along the fence-line but never crossing it. These observations are consistent with the hypothesis that she was in a weakened condition, limited in her activity by heart disease. Death occurred following extreme exertion, possibly being chased up the hill by a dog; we have frequently observed harassment of kangaroos by dogs at this site.

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References

Coulson, G. (1996). A safe and selective draw-string trap to capture kangaroos moving under fences. *Wildlife Research* **23**, 621-7.

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Longitudinal Distribution of Macroinvertebrates on Erosional Substrates in the Mainstream Yarra River

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Abstract
Macroinvertebrates of erosional substrates were sampled at nine sites along the mainstream Yarra River in August, December and February of 1994/95. Classification (flexible UPGMA) and ordination (SSH, semi-strong hybrid multidimensional scaling) analyses were performed to assess the relationships between samples. The results highlight the disparity between the three urban sites and upstream rural and forested sites. Information on distribution of individual taxa is presented, and communities are assessed in terms of the objectives set down in the State Environment Protection Policy for Waters of the Yarra River Catchment. (*The Victorian Naturalist* **117** (4), 2000, 141-149.)

Introduction

The value of macroinvertebrates for the monitoring and assessment of river health, and hence the protection of aquatic systems, is widely accepted (Plafkin *et al.* 1989; Rosenberg and Resh 1993; Chessman 1995). In recognition of this, ecological indicators and objectives have been incorporated into the State Environment Protection Policy (SEPP) for the Waters of the Yarra River Catchment in Victoria (Government of Victoria 1999). Specified objectives for invertebrate communities are based on the biotic index SIGNAL (Chessman 1995), and a requirement that a minimum number of invertebrate families and a suite of key invertebrate families be present.

The results of a survey of macroinvertebrates of erosional substrates in the mainstream Yarra River are reported below, and biological communities are compared with the ecological objectives set down in the SEPP for Waters of the Yarra Catchment.

Methods

Nine sampling sites between Upper Yarra Dam and urban Melbourne (Fig. 1) were selected on the basis of accessibility and the availability of erosional substrates. Urban sites at Banksia Street and Fitzsimmons Lane featured substrates of gravel and the occasional boulder, while at Warrandyte the substrate was predominantly bedrock, with a few boulders and some gravel. Cobble was absent at all three sites. By contrast, all rural sites featured more heterogeneous substrates, with cobble well represented and usually dominant. All sites were sampled on three occasions, in August, December and February of 1994/95. At each site erosional substrates from a range of current speeds were sampled using a kick sampling technique (EPA 1998). The total area of stream bed sampled was about 3 m^2, and within this constraint sampling was continued until a 2 litre sample container was filled with substrate material. Samples were preserved and returned to the laboratory for sorting in their entirety using a stereomicroscope. Identifications were to species level using available published keys (Hawking 2000) or by comparison with material held in a voucher collection maintained by the Environment Protection Authority. Exceptions were the taxa Nematoda, Oligochaeta and Acariformes, which were not identified further, while chironomids were identified to genus using the keys in Cranston (1997). Voucher species designations follow Glaister (1992) [Elmidae], Dean (1999a) and Suter (1997, 1999) [Ephemeroptera], Cartwright (1997, 1998), Dean (1999b) and Jackson (1998) [Trichoptera], or unpublished EPA designations. Adult and larval Elmidae were treated as separate taxa in the analyses.

Analyses of the data were performed using clustering and ordination programs in the numerical analysis package PATN (Belbin 1993). Similarity of sites was assessed using the Bray-Curtis dissimilarity measure and clustered using unweighted pair-group arithmetic averaging (UPGMA). Resultant groups were confirmed by examining their positions in

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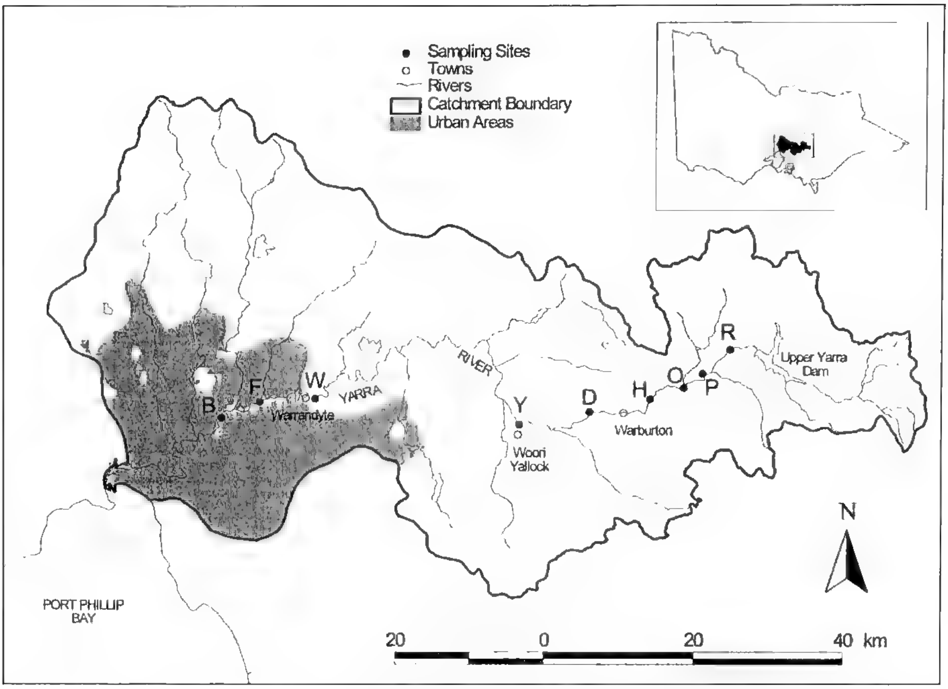

Fig. 1. Map of study area, showing sampling locations. Site codes are listed in the caption of Table 1.

ordination space using semi-strong hybrid multidimensional scaling (SSH). Analyses were performed with rare taxa included in the data set. Data were transformed to $\log_{10}(x+1)$ before analysis. The original data set was also used to generate presence-absence data and data based on family level identifications, and the above analyses repeated.

Results

A summary of results is presented in Table 1. Numbers of taxa were relatively low at the three downstream sites (65 to 73), increased at Woori Yallock (99), and were highest at Dee Road (123) and the four sites upstream from Warburton (128 to 154). This trend was also observed in the Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies) (see Table 1). Taxa lists for each of the sites are presented in the appendix.

The UPGMA classification enabled recognition of six site groups (Fig. 2). Groups a and b included all 9 samples from the three downstream locations, strongly differentiating between urban and rural sites. Groups a and b appeared to reflect seasonal differences. Group b included the February samples from all three urban sites and the December sample from Warrandyte, while the remaining two December samples and the August samples from the three sites were placed in group a. Further upstream, the August sample from Woori Yallock was the sole member of group f, while the remaining five samples from Woori Yallock and Dee Road were placed in group c. Samples from the four sites upstream of Warburton were classified into two groups, with the three samples from Reefton Road forming group e and all nine samples from Hazlewood, O'Shannassy, and Peninsula Roads included in group d. These groupings were confirmed by the SSH ordination (Fig. 3).

Analyses using presence-absence data and family level identifications yielded similar overall patterns in classification and ordination to the original analyses, with a strong distinction between urban sites and rural-forest sites.

Discussion

The present study has identified strong and consistent differences between

Table 1. Biological statistics for individual samples and sampling sites. Abbreviations for SEPP Yarra River Segments: Urb – urban; REW – rural eastern waterways; P&F – parks and forests. Site codes: B=Banksia Street, F=Fitzsimmons Lane, W=Warrandyte, Y=Woori Yallock, D=Dee Road, H=Hazlewood Road, O=O'Shannassy Road, P=Peninsula Road, R=Reefton Road.

Site codes	B	F	W	Y	D	H	O	P	R
No. individuals									
Aug 94	1349	1534	1167	1702	1478	2456	1467	1483	2128
Dec 94	1058	701	2356	1919	1634	1476	1556	1327	1221
Feb 95	820	1232	1299	2673	3240	2268	1467	1738	2894
No. species									
Aug 94	34	53	34	47	80	96	82	97	90
Dec 94	40	44	48	56	74	88	87	83	79
Feb 95	41	37	46	68	89	102	91	97	91
Total	65	73	66	99	123	154	137	140	128
No. species									
Ephemeroptera	3	4	5	9	13	16	15	18	12
Plecoptera	8	7	5	9	10	13	10	10	9
Trichoptera	10	12	10	16	21	32	32	28	30
No. of Families	22	24	22	28	36	45	39	42	42
No. of Key Families	11	13	11	18	21	22	19	20	19
Signal Score	5.4	5.5	5.7	6.4	6.6	6.6	6.7	6.6	6.5
SEPP Objectives									
Segment	Urb	Urb	Urb	REW	REW	REW	P&F	P&F	P&F
No. of Families	26	26	26	27	27	27	30	30	30
No. of Key Families	16	16	16	17	17	17	17	17	17
Signal Score	6.0	6.0	6.0	6.5	6.5	6.5	7.0	7.0	7.0

macroinvertebrate communities at the three urban sites and communities at rural and forested sites further upstream. The urban sites were clearly separated from rural sites using classification and ordination techniques, and were characterised by reduced taxa richness, a feature previously reported by Campbell *et al.* (1982) and Pettigrove (1989). In a review of the ecology of the Yarra River, Davis *et al.* (1998) also drew attention to a discontinuity in biological and water quality features at the boundary between rural and urban reaches.

Whilst the studies cited above have noted that downstream biological changes are accompanied by deterioration in water quality parameters, there has been little consideration of the influence of substrate type on biological communities in the lower Yarra River. Erosional substrates sampled in the present study were quite different at urban and rural sites, with cobble absent from urban sites and usually dominant at rural sites. Remedial works aimed at improving the health of the river should not only address the issue of water quality, but should also give consideration to the availability of suitable habitat.

The SEPP objectives for both number of families and number of key families were met at all sites in the Rural Eastern Waterways segment and the Parks and Forests segment, but at none of the sites in the Urban Waterways segment. Signal Index Score objectives were met at Dee Road and Hazlewood Road in the Rural Eastern Waterways segment, but failed to be met at all other sites. Comparison of the findings of the present study with biological objectives laid down in the SEPP for Waters of the Yarra River Catchment should, however, be undertaken with caution. The Policy stipulates that assessment of biological indicators should employ an EPA-approved Rapid Bioassessment, which involves collection of samples from two habitats (flowing riffle and stream edge in little or no current) using a hand-held net, and live picking in the field for at least 30 minutes to obtain about 200 individuals (Environment Protection Authority 1998). While a hand-held net was used for sampling in the present study, samples were collected from a single habitat (riffle) on each of three occasions, and the three samples from each site were sorted completely to yield 3000-6000 individuals. To some extent these different approaches

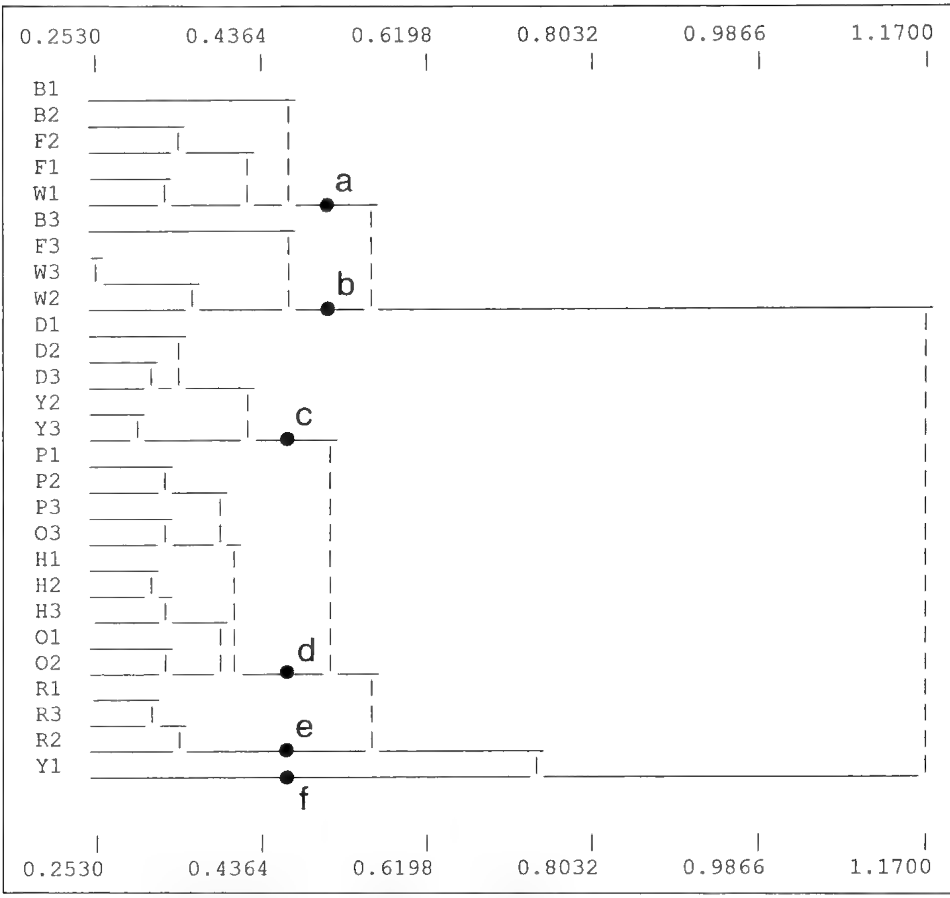

Fig. 2. UPGMA classification of species level data. Samples coded by site (alpha, see Table 1) and sampling event (numeral). Sampling events: 1 - August 1994; 2 - December 1994; 3 - February 1995.

would be expected to cancel out, with the large number of individuals picked yielding additional families and the restriction of samples to one habitat decreasing the number of families recorded. Nevertheless, the implication of variations in sampling and sorting strategies requires investigation.

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References

Belbin, L. (1993). 'PATN - Pattern Analysis Package'. (CSIRO Division of Wildlife and Ecology: Canberra.)

Campbell, I.C., Macmillan, L.A., Smith, A.J. and McKaige, M.E. (1982). 'The benthic macroinvertebrates of the Yarra River and its tributaries'. Environmental Studies Program, Ministry for Conservation, Publication No. 362.

Cartwright, D.I. (1997). 'Preliminary guide to the identification of late instar larvae of Australian Ecnomidae, Philopotamidae and Tasimiidae (Insecta: Trichoptera)'. Identification Guide No. 10. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Cartwright, D.I. (1998). 'Preliminary guide to the identification of late instar larvae of Australian Polycentropodidae, Glossosomatidae, Dipseudopsidae and Psychomyiidae (Insecta: Trichoptera)'. Identification Guide No. 15. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Chessman, B. (1995). Rapid assessment of rivers using macroinvertebrates: a procedure based on habitat specific sampling, family level identification and a biotic index. *Australian Journal of Ecology* **20**, 122-129.

Cranston, P.S. (1997). 'Identification guide to the Chironomidae of New South Wales'. AWT Identification Guide No.1. (Australian Water Technologies Pty Ltd: West Ryde.)

Davis, J.; Breen, P. and Hart, B.T. (1998). 'The ecology of the Yarra River: A discussion paper'. Technical Report. (Cooperative Research Centre for Freshwater

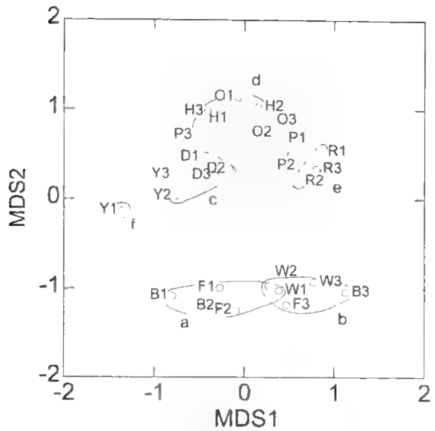

Fig. 3. SSH ordination of species level data. Site groups derived from classification analysis enclosed in envelopes. Samples coded by site (alpha, see Table 1) and sampling event (numeral). Sampling events: 1 - August 1994; 2 - December 1994; 3 - February 1995.

Ecology: Albury.)

Dean, J.C. (1999a). 'Preliminary keys for the identification of Australian mayfly nymphs of the family Leptophlebiidae'. Identification Guide No. 20. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Dean, J.C. (1999b). 'Preliminary keys for the identification of Australian Trichoptera larvae of the family Hydropsychidae'. Identification Guide No.22. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Environment Protection Authority (1998). 'Rapid Bioassessment of Victorian Streams. The approach and methods of the Environment Protection Authority'. Environment Protection Authority, Publication No. 604.

Glaister, A. (1992). 'Illustrated keys to late instar larvae of some Australian Elmidae'. Taxonomy Workshop, Murray-Darling Freshwater Research Centre, 11-12th February, 1992.

Government of Victoria. (1999). 'Variation of the State Environment Protection Policy (Waters of Victoria) Insertion of Schedule F7. Waters of the Yarra Catchment'. *Victorian Government Gazette* No. S89 Tuesday 22 June 1999. (Victorian Government Printer: Melbourne.)

Hawking, J.H. (2000). 'Key to Keys: A guide to keys and zoological information to identify invertebrates from Australian inland waters'. Identification Guide no. 2 (Second Edition). (Cooperative Research Centre for Freshwater Ecology: Albury.)

Jackson, J. (1998). 'Preliminary guide to the identification of late instar larvae of Australian Calocidae, Helicophidae and Conoesucidae (Insecta: Trichoptera)'. Identification Guide No. 16. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Pettigrove, V.J. (1989). 'Biological Monitoring of the Yarra River using Macroinvertebrates'. Environment Protection Authority Scientific Report Series No. 88/014.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K. and Hughes, R.M. (1989). 'Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish'. EPA/440/4-89/001. (Office of Water Regulations and Standards, US Environmental Protection Authority: Washington, DC.)

Rosenberg, D.M. and Resh, V.H. (Eds). (1993). 'Freshwater biomonitoring and benthic macroinvertebrates'. (Chapman and Hall: London).

Suter, P.J. (1997). 'Preliminary guide to the identification of nymphs of Australian baetid mayflies (Insecta: Ephemeroptera) found in flowing waters'. Identification Guide No. 14. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Suter, P.J. (1999). 'Illustrated key to the Australian caenid nymphs (Ephemeroptera: Caenidae)'. Identification Guide No .23. (Cooperative Research Centre for Freshwater Ecology: Albury.)

Appendix. Macroinvertebrate species collected from erosional substrates, mainstream Yarra River, 1994-95. Site codes: B=Banksia Street, F=Fitzsimmons Lane, W=Warrandyte, Y=Woori Yallock, D Dee Road, H Hazlewood Road, O=O'Shannassy Road, P Peninsula Road, R=Reefton Road.

Site		B	F	W	Y	D	H	O	P	R
Cnidaria	*Hydra* sp.								*	*
	Cordylophora sp.			*						
Platyhelminthes	*Temnocephala* sp.						*			
	Cura pinguis	*	*	*	*	*	*	*	*	*
Nemertea	*Prostoma* sp.	*	*	*	*					*
Nematoda	Nematoda (Unident.)	*	*	*	*	*	*	*	*	*
Mollusca	Hydrobiidae (Unident.)	*	*		*	*	*		*	*
	Ferrissia petterdi	*	*	*	*	*	*	*	*	*
	Ferrissia tasmanica	*	*	*	*	*	*	*	*	*
	Physa acuta	*	*							
	Glacidorbis hedleyi					*			*	*
	Corbiculina australis	*								
	Sphaeridae (Unident.)	*		*		*	*		*	*
Annelida	Hirudinea EPA sp.1						*			*
	Oligochaeta (Unident.)	*	*	*	*	*	*	*	*	*
Acariformes	Acariformes (Unident.)		*		*	*	*	*	*	*
Crustacea	*Pseudomoera* sp.					*	*			
	Heterias sp.			*						
	Paratya australiensis		*							
	Parastacidae (Unident.)			*			*	*	*	

Appendix. Continued.

Site		B	F	W	Y	D	H	O	P	R
Coleoptera	*Sternopriscus mundanus*		*							
	Paracymus EPA sp. A1		*							
	Hydraena sp.							*		
	Scirtidae (Unident.)					*	*	*	*	*
	Austrolimnius anytus					*		*		*
	Austrolimnius cheops						*			
	Austrolimnius dayi	*		*	*	*	*	*	*	*
	Austrolimnius diemensis				*	*	*	*	*	*
	Austrolimnius hebrus		*		*	*	*	*	*	*
	Austrolimnius maro				*	*	*	*	*	*
	Austrolimnius metasternalis						*	*	*	
	Austrolimnius mila						*			
	Austrolimnius sulmo						*	*	*	
	Austrolimnius victoriensis					*				
	Austrolimnius waterhousei				*	*	*			
	Austrolimnius EPA sp. *A1*	*	*	*						
	Austrolimnius EPA sp. *A8*				*	*				
	Austrolimnius EPA sp. *A9*			*			*	*		
	Austrolimnius EPA sp. A11						*	*	*	
	Austrolimnius EPA sp. A12				*	*	*	*	*	
	Austrolimnius sp. L25E		*	*	*	*	*	*	*	*
	Austrolimnius sp. L58E	*								
	Austrolimnius sp. L39E						*	*		
	Austrolimnius sp. L32E					*	*	*		
	Austrolimnius sp. L67E						*	*	*	
	Austrolimnius sp. L10E	*	*	*	*	*	*	*	*	*
	Simsonia EPA sp. A2	*	*							
	Simsonia EPA sp. A4	*				*		*	*	*
	Simsonia EPA sp. A7				*					
	Simsonia EPA sp. A8	*								
	Simsonia sp. L2E		*	*			*	*		
	Simsonia wilsoni (Larva)	*	*	*	*	*		*	*	*
	Notriolus maculatus	*	*							
	Notriolus quadriplagiatus	*			*	*	*	*	*	*
	Notriolus victoriae				*	*	*	*		
	Notriolus tasmanica						*			
	Notriolus EPA sp. A3	*	*							
	Kingolus tinctus				*	*	*	*	*	*
	Kingolus EPA sp. A3				*		*	*	*	
	Kingolus sp. L1E						*	*	*	
	Kingolus sp. L45E					*	*			
	Coxelmis novemnotata	*	*	*						
	Coxelmis v-fasciata	*								
	Stetholus sp. L69E			*						
	Sclerocyphon basicollis					*			*	*
	Sclerocyphon striatus	*	*	*	*	*	*	*	*	*
	Sclerocyphon zwicki			*		*				
	Ptilodactylidae (Unident.)				*	*	*	*	*	*
Diptera	Tipulidae EPA sp. 36				*	*	*	*	*	*
	Tipulidae EPA sp. 37	*	*							*
	Tipulidae EPA sp. 39				*	*	*	*		
	Tipulidae EPA sp. 40	*	*	*	*	*		*	*	
	Tipulidae EPA sp. 41						*			
	Tipulidae EPA sp. 42							*		
	Tipulidae EPA sp. 1					*	*			*
	Tipulidae EPA sp. 8	*	*							
	Tipulidae EPA sp. 10				*					
	Edwardsina polymorpha					*			*	
	Paradixa sp.									*
	Ceratopogonidae EPA sp. 3					*	*		*	*

Appendix. Continued.

Site		B	F	W	Y	D	H	O	P	R
Diptera (cont.)	Ceratopogonidae EPA sp. 28			*		*	*	*	*	*
	Ceratopogonidae EPA sp. 15				*		*	*		*
	Ceratopogonidae EPA sp. 46						*			
	Austrosimulium bancroftii	*		*	*					
	Austrosimulium furiosum	*	*	*	*	*	*	*	*	*
	Austrosimulium montanum						*	*	*	*
	Austrosimulium torrentium				*	*				
	Austrosimulium victoriae				*	*	*	*	*	
	Simulium melatum					*				
	Paracnephia sp.						*		*	
	Psychodidae EPA sp. 1						*			*
	Dasyomma sp.				*	*	*	*	*	*
	Stratiomyidae (Unident.)									*
	Empididae EPA sp. 1	*	*	*	*	*	*	*	*	*
	Empididae EPA sp. 6	*	*	*	*	*	*	*	*	*
	Empididae EPA sp. 7						*	*	*	*
	Aphroteniella sp.				*		*	*	*	*
	Paraheptagyia sp.				*				*	
	Podonomopsis sp.					*			*	*
	Apsectrotanypus sp.					*	*	*	*	*
	Djalmabatista sp.	*	*	*						
	Procladius sp.		*						*	
	Ablabesmyia sp.						*			
	Paramerina sp.					*	*		*	*
	Pentaneura sp.				*	*	*	*	*	*
	Nilotanypus sp.				*					
	Pentaneurini genus A					*	*	*	*	*
	Rheocricotopus sp.	*	*	*						
	Parakiefferiella sp.		*	*	*	*	*	*	*	*
	Nanocladius sp.		*	*						
	Stictocladius sp.				*	*	*	*	*	*
	Corynoneura sp.								*	
	Thienemanniella sp.	*	*	*	*	*	*	*	*	*
	Austrobrillia sp.		*	*	*	*	*	*	*	*
	Pirara sp.					*				
	Paralimnophyes sp.									*
	Eukiefferiella sp.		*		*	*	*	*	*	*
	Cardiocladius sp.	*	*	*	*	*		*	*	*
	Cricotopus sp.	*	*	*	*	*	*	*	*	*
	Limnophyes sp.									*
	Botryocladius	*	*	*	*	*	*	*	*	*
	Orthocladiinae SO1				*	*	*	*	*	*
	Orthocladiinae MO5						*			*
	Orthocladiinae SO4				*					
	Riethia sp.		*	*	*	*	*	*	*	*
	Stempellina sp.					*	*	*	*	*
	Cladotanytarsus sp.	*	*	*						
	Tanytarsus sp.		*	*	*	*	*	*	*	*
	Paratanytarsus sp.				*	*	*	*	*	*
	Rheotanytarsus sp.	*	*	*	*	*	*	*	*	*
	Harrisius sp.					*	*		*	*
	Stenochironomus sp.			*						
	Xenochironomus sp.	*								
	Dicrotendipes sp.		*							
	Polypedilum sp.	*	*	*	*	*	*	*	*	*
	Zavreliella sp.							*	*	*
	Demicryptochironomus sp.		*			*	*			*
	Paracladopelma sp.		*		*					
Ephemeroptera	*Edmundsiops* MV sp. 3			*	*	*	*	*	*	*
	Edmundsiops MV sp. 6	*	*	*	*	*		*	*	*

Appendix. Continued.

Site		B	F	W	Y	D	H	O	P	R
Ephemeroptera (cont.)	*Edmundsiops* EPA sp. 9				*	*	*	*	*	*
	Centroptilum sp.						*			
	Tasmanophlebia sp.					*				
	Coloburiscoides sp.				*	*	*	*	*	*
	Atalophlebia sp. AV4						*	*	*	
	Garinjuga sp.						*	*	*	*
	Atalomicria sp.								*	*
	Austrophlebiodes pusillus				*	*	*	*	*	*
	Austrophlebioides marchanti				*	*	*	*	*	*
	Kirrara procera					*	*	*	*	
	Nousia sp. AV1		*	*	*	*	*	*	*	*
	Nousia sp. AV2				*	*	*	*	*	*
	Koorrnonga sp. AV1						*		*	
	Jappa sp. AV3					*	*	*	*	
	Ulmerophlebia sp. AV1					*	*	*	*	*
	Ulmerophlebia sp. AV2								*	
	Neboissophlebia hamulata						*	*	*	
	Tasmanocoenis sp. B	*	*	*						
	Irpacaenis deani	*	*	*						
	Irpacaenis sp. D					*	*	*	*	*
Hemiptera	*Microvelia* sp.					*	*	*	*	*
	Micronecta annae		*							
Mecoptera	*Nannochorista* EPA sp. 1									*
Megaloptera	*Archichauliodes* sp.	*	*	*	*	*	*	*	*	*
Neuroptera	*Austroneurorthus* EPA sp. 1						*	*	*	
Odonata	*Diphlebia* sp.						*		*	
	Austroaeschna inermis						*		*	
	Austroaeschna pulchra			*	*	*	*	*	*	*
	Austroaeschna unicornis unicornis	*								
	Austroaeshna parvistigma / multipunctata			*			*	*	*	*
	Austroaeshna atrata / subapicalis							*		*
	Notoaeschna sagittata	*	*	*						
	Hemigomphus gouldii / heteroclytus				*		*	*	*	
	Eusynthemis brevistyla						*	*		
Plecoptera	*Cosmioperla kuna*						*	*		
	Acruroperla atra				*	*	*			
	Dinotoperla brevipennis	*	*		*	*	*	*	*	*
	Dinotoperla christinae							*		
	Dinotoperla eucumbene				*	*	*	*	*	
	Dinotoperla fontana				*	*			*	*
	Dinotoperla serricauda	*	*		*		*			
	Illiesoperla sp.	*		*	*	*	*	*	*	*
	Leptoperla primitiva	*	*			*	*		*	
	Leptoperla tasmanica	*	*	*						
	Newmanoperla thoreyi	*	*	*		*	*	*	*	*
	Riekoperla rugosa						*	*	*	*
	Riekoperla tuberculata	*	*	*	*	*				
	Riekoperla williamsi						*			
	Trinotoperla montana					*	*	*	*	*
	Trinotoperla nivata	*	*	*	*	*	*	*	*	*
	Austrocercella / Austrocercoides sp.						*		*	*
Trichoptera	*Apsilochorema gisbum*				*			*		*
	Apsilochorema obliquum				*	*	*	*	*	*
	Ethochorema turbidum / brunneum				*	*	*	*	*	*
	Koetonga clivicola									*
	Tanjilana zothecula	*								
	Taschorema evansi			*	*	*	*	*	*	*

Appendix. Continued.

Site		B	F	W	Y	D	H	O	P	R
Trichoptera (cont.)	*Ulmerochorema onychion*			*						
	Ulmerochorema seona					*	*	*	*	*
	Ulmerochorema rubiconum / membrum				*	*		*	*	*
	Agapetus sp.			*	*	*	*	*	*	*
	Hellyethira basilobata							*	*	*
	Hellyethira sp.		*						*	
	Hydroptila sp.	*	*							*
	Maydenoptila cuneola				*		*	*		
	Orthotrichia sp.				*	*	*	*	*	*
	Oxyethira sp.					*		*	*	*
	Chimarra australica							*	*	
	Chimarra monticola						*	*	*	
	Hydrobiosella waddama						*	*		
	Hydrobiosella sp. 1								*	
	Asmicridea sp. AV1	*	*	*	*	*	*	*	*	*
	Asmicridea sp. AV2						*	*	*	
	Cheumatopsyche sp. AV1	*	*	*		*				
	Cheumatopsyche sp. AV2		*							
	Cheumatopsyche sp. AV3					*		*	*	*
	Cheumatopsyche sp. AV4	*	*	*		*				
	Cheumatopsyche sp. AV6		*	*					*	
	Diplectrona sp. AV1						*			
	Smicrophylax sp. AV2						*			*
	Plectrocnemia sp.							*		
	Polycentropodidae Genus I sp. AV1						*	*	*	*
	Ecnomina sp. D1						*		*	
	Ecnomina sp. E1						*			*
	Ecnomina batyle						*	*	*	
	Ecnomus pansus	*	*	*						
	Ecnomus continentalis	*	*	*		*				
	Tasimia sp.									*
	Conoesucus sp. AV5				*	*	*	*	*	*
	Costora delora					*	*	*		
	Costora sp. AV1				*	*	*	*	*	
	Lingora sp. AV1	*	*		*	*	*			*
	Hampa patona						*	*	*	*
	Helicopsyche tillyardi						*	*	*	*
	Tamasia sp.				*	*	*	*	*	*
	Aphilorheithrus sp.						*			
	Austrheithrus sp.						*	*	*	*
	Kosrheithrus sp.				*	*				
	Marilia bola						*	*	*	
	Atriplectides dubius									*
	Anisocentropus sp.					*	*	*	*	*
	Notalina bifaria				*	*	*	*	*	*
	Notalina ordina						*	*		
	Oecetis EPA sp. 1	*	*							
	Oecetis EPA sp. 3						*			*
	Triplectides australicus		*							
	Triplectides similis						*			
	Triplectides sp.				*			*		*

Discovery of the Yellow-bellied Glider *Petaurus australis* in South Gippsland

Ed McNabb[1], Rolf Willig[2] and Jim McNabb[3]

Abstract
The Yellow-bellied Glider *Petaurus australis*, which had not previously been recorded in South Gippsland, was discovered in Mullunding State Forest during surveys for owls. *The Victorian Naturalist* **117** (4), 2000, 150-153).

Introduction

In Victoria, the Yellow-bellied Glider *Petaurus australis* inhabits a range of forest and woodland types across the eastern and southern parts of the state. Its strongholds are in the Central Highlands, central and eastern Gippsland, the Otways and to a lesser extent, the forests of the Great Divide bordering the north-east of the state. An isolated but substantial western population occurs in the south-western forests of the lower Glenelg River (Menkhorst 1995).

The species has not been recorded in South Gippsland (i.e. south of the Latrobe River). This is despite the occurrence of suitable habitat with a large component of mature trees (Craig and Belcher 1980), e.g. damp sclerophyll, herb-rich foothill and riparian forest, in the Strzelecki Ranges and the Gippsland Plains (e.g. Mullundung and Won Wron areas). In west Gippsland, south of the Princes Highway, it has only been recorded at three sites, and all of these were prior to 1910 (Menkhorst 1995; Fig. 1 from Atlas of Victorian Wildlife).

The Fisheries and Wildlife Survey Team conducted mammal surveys in the Strzelecki Ranges and Mullundung/Won Wron State Forests during 1977 (Gilmore 1977, Norris and Menkhorst 1977). Despite a good deal of spotlighting, no Yellow-bellied Gliders were recorded.

The technique of surveying for owls by playback of tape recorded territorial (owl) calls often elicits response by potential prey species. For example, Sugar Gliders *P. breviceps* and Yellow-bellied Gliders often respond vocally with the latter 'homing in' on the perceived predator (McNabb 1994).

Because of such responses, many new records for Yellow-bellied Gliders (and other arboreal mammals) were collected during recent surveys of large forest owls conducted by Arthur Rylah Institute (ARI) teams throughout Victorian public lands. These surveys were conducted as part of forest planning processes and establishment of Regional Forest Agreements (RFA) between the Victorian and Commonwealth Governments, following a national forest policy initiative (Commonwealth of Australia 1992). Fifty-nine of these owl surveys were conducted at sites throughout South Gippsland (excluding Wilsons Promontory) between July 1998 and September 1999. No Yellow-bellied Gliders were detected.

Further surveys for owls were conducted between February and May 2000 at 84 sites across Central and South Gippsland. Thirteen of these sites were in South Gippsland. The Yellow-bellied Glider was discovered at one of these sites.

Methods

At 2240 hr on 22 February 2000 in calm, clear conditions, tape recordings of Powerful Owl *Ninox strenua*, Sooty Owl *Tyto tenebricosa* and Masked Owl *T. novaehollandiae* territorial calls were played through a 10 watt megaphone at approximately 110% of natural volume. Each species' call was played for several minutes interspersed with 2-3 minutes of silence during which the observers listened for responses by owls or other fauna. During the playback, 12v 50 watt spotlights were used when necessary, to locate

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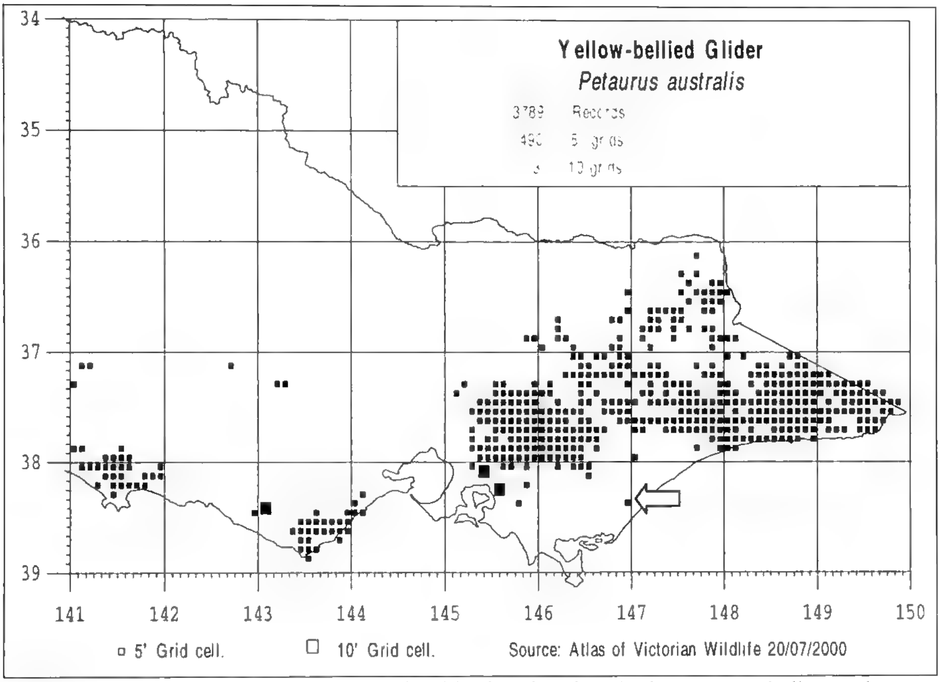

Fig. 1. Distribution of the Yellow-bellied Glider in Victoria. The large arrow indicates the new record described in this report.

and identify species that responded to the tape. Following playback, a 10 minute spotlight walk was conducted to search for owls and mammals that may not have been detected earlier.

Site description

The observations were made in Mullundung State Forest, at the intersection of North South Road and Shield Road (Lat 38° 23'S, Long 146° 55'E) at an altitude of 80 m above sea level, 3 km southeast of the privately owned property known as 'Kangaroo Swamp'.

The dominant trees were Yellow Stringybark *Eucalyptus muellerana*, Manna Gum *E. viminalis*, and Narrow-leaved Peppermint *E. radiata*. A few Apple-box *E. bridgesiana* occurred nearby. The generally sparse middle-storey consisted of mature Saw Banksias *Banksia serrata* with scattered thickets of Burgan *Leptospermum phylicoides*. Small Silver Banksias *B. marginata*, Sand-hill Sword-sedge *Lepidosperma concavum* and Austral Bracken *Pterideum esculentum* dominated the ground cover. Topography was flat to undulating with a slight south-westerly aspect. The southward flowing Four Mile Creek passes along the western perimeter of the site. Many live and a few dead hollow-bearing trees were present with approximately 90% of trees <50 cm diameter at breast height (DBH), 9% 50-100 cm and 1% >100 cm DBH.

Observations

During the playback, three vertebrate species were heard: Australian Owlet-nightjar *Aegotheles cristatus*, White-striped Freetail Bat *Tadarida australis* and Powerful Owl, the latter calling from about 400 m to the west. During the subsequent ten minute spotlighting session seven species of vertebrate were heard: Sugar Glider, Yellow-bellied Glider, White-throated Nightjar *Caprimulgus mystacalis*, Australian Owlet-nightjar, Common Brushtail Possum *Trichosurus vulpecula*, Southern Brown Tree Frog *Litoria ewingii* and an unidentified macropod. A Common Ringtail Possum *Pseudocheirus peregrinus* was seen.

Fig. 2. Two recent and one very old healed over (indicated by finger) Yellow-bellied Glider incisions in feed tree no. 2. The latter incision is 38 cm long. Photo by E.G.McNabb.

Fig. 3. One of the old sap feeding incisions made by Yellow-bellied Gliders in feed tree no. 2. The incision is 31.5 cm long. Photo by E.G.McNabb.

The authors were alerted to the presence of the Yellow-bellied Glider by its characteristic gurgling shriek, grading into lower frequency gurgles (Kavanagh and Rohan-Jones 1982), which was heard 50 m west of the intersection. EM and JM immediately scanned the area where the glider had called from with spotlights. A Yellow-bellied Glider was seen by JM, approximately 3 m above ground, at the flower of a Saw Banksia. EM saw only its eye-shine reflected in the spotlight beam. JM had a clear view for several seconds (with 8 × 40 binoculars) in the spotlight beam, of yellow pollen spots on the glider's face, suggesting that it had been feeding from the banksia flowers, possibly on nectar. The glider was apparently disturbed by the two spotlights and jumped out of the banksia, away from us. It was heard vocalising several minutes later, 200-300 m away to the north.

The site was visited again by EM and JM on 11 May 2000 to search for den trees and feed trees, ie. sap site trees (Henry and Craig 1984). Feed trees, incised by the gliders while feeding on the sub-cambial phloem (sap), can provide clues to the history of Yellow-bellied Gliders at a site.

Two Manna Gums were identified as major sap site trees. Feed tree no. 1 bore several incisions varying in age from old to recently incised. Feed tree no. 2 bore a few recent incisions but was also severely scarred from 1 to 8 m above ground level with scars of very old incisions, apparently made by previous generations of gliders, plus a few recent incisions (Figs 2 and 3). Several transit trees (i.e. trees used to climb and launch in movement through the forest), identified by landing and climbing marks, were located between and near the feed trees.

A dusk watch was conducted to monitor any emergence of gliders from dens or of any feeding at feed trees. At 1750 hr (dusk), a Yellow-bellied Glider called from an estimated 300 m to the north. At 1805 hr another call was made at approximately 200 m NNW, followed by an immediate reply from a second glider a similar distance away, to the NW. Another call was made at 1818 hr approximately

100 m to the NE. No gliders approached the monitored feed trees. We left the area at 1830 hr.

Discussion

The old incisions in feed tree no. 2 indicate that Yellow-bellied Gliders have inhabited this section of Mullundung State Forest for many generations. These gliders may be the only remnants of an originally wider-ranging population in the South Gippsland region. Further investigation is required to determine the status of the population in both local and regional contexts. The results of such an investigation will assist in the development of strategies aimed at ensuring the conservation of this isolated population.

Acknowledgements

Our thanks to John Seebeck and Peter Menkhorst for providing information regarding the 1977 ARI fauna surveys of South Gippsland. Steve Craig, Richard Loyn, Todd Soderquist and Peter Menkhorst made helpful comments on various drafts. The Atlas of Victorian Wildlife provided the distribution map and an anonymous referee commented on the final draft.

References

Commonwealth of Australia. (1992). 'National Forest Policy Statement a new focus for Australia's forests'. (Advance Press: Perth.)

Craig, S.A. and Belcher, C.A. (1980). A technique for live-trapping the Yellow-bellied Glider, *Petaurus australis*; with notes on the biology of the species. *The Victorian Naturalist* **97**, 205-210

Gilmore, A.M. (1977). A survey of vertebrate animals in the Stradbroke area of South Gippsland, Victoria. *The Victorian Naturalist* **94**, 123-128.

Henry, S.R. and Craig, S.A. (1984). Diet, ranging behaviour and social organization of the Yellow-bellied Glider (*Petaurus australis* Shaw) in Victoria. In 'Possums and Gliders'. Eds A.P. Smith and I. Hume. (Surrey Beatty and Sons Pty Ltd.: Chipping Norton).

Kavanagh, R.P. and Rohan-Jones, W.G. (1982). Calling behaviour of the Yellow-bellied Glider *Petaurus australis* Shaw (Marsupiala: Petauridae). *Australian Mammalogy* **5**, 95-111.

McNabb, E.G. (1994). Predator calls and prey response. *The Victorian Naturalist* **111**, 190-195.

Menkhorst, P.W. (Ed.) (1995). 'Mammals of Victoria'. (Oxford University Press: Melbourne).

Norris, K.C. and Menkhorst, P.W. (1977). 'Fauna Survey of South Gippsland journal notes and mammal, reptile and amphibian records'. (Unpubl.). (Fisheries and Wildlife Survey Unit: Victoria.)

One Hundred Years Ago

GENERAL BUSINESS

"Mr F.G.A. Barnard drew attention to the approach of the flowering season of the wattles, and moved that the secretary be directed to write to the daily papers, and also to the Minister of Lands, asking their assistance in preventing the great destruction of the trees which usually takes place. The resolution was seconded by Mr. H.T. Tisdall, and carried unanimously."

NATURAL HISTORY NOTES

"Mr. G.A. Keartland drew attention to his exhibit of a pair of live Collared Plains Wanderers, *Pedionomus torquatus*. The birds were captured recently by a friend when out quail-shooting. His dog "stood" at them as they squatted in short grass, and when approached they made no effort to escape. Though the female had been taken only eight days, she was now so tame as to take worms from the hand. He had on several previous occasions known birds of this species to make no attempt to escape when approached."

From *The Victorian Naturalist* Vol. **XVII**, August, 1900.

Sea Snakes: Australian Natural History Series

by Harold Heatwole

Publisher: *University of New South Wales Press, 1999. 167 pp. 12 pages with colour plates. RRP $32.95 (incl, GST), paper cover.*

Are there such animals as giant 'sea serpents'? How many species of sea snake inhabit the waters of the world? How do sea snakes rid their bodies of salt water? What physiological adaptations do sea snakes possess which allows them to dive to depths of 100 metres, and remain there for up to two hours? Which species have caused human fatalities and why? These are examples of the breadth of questions to which this book will provide answers.

'Sea Snakes' follows an older book of the same name, but this version is so different as to be unrecognisable. It is a handsome publication, amply illustrated with diagrams and photographs. It is not a field guide, but rather a fascinating account of the biology of sea snakes. The author has spent more than thirty years studying sea snakes in the far flung corners of the Pacific and Indian Oceans, and this experience is evident. Not only are the most recent research results incorporated into the text, but those aspects of sea snake biology which are not yet well understood are clearly articulated. This is, therefore, an invaluable resource for anyone contemplating research into any aspect of the biology or ecology of these animals.

Harold Heatwole, who is currently a professor of Zoology at North Carolina State University at Raleigh in the United States, has authored eight books and close to 300 papers in scientific journals. His writing skill is particularly sought after because of his ability to bring together highly technical information in a form that is also attractive and informative to the lay person. This book is a good example of his skill, relating much of the strict biological detail to broader ecological and social contexts. There is no need to worry about local content, as the author spent 25 years working in Australia, and much of the book focuses on Australian examples.

The book begins with a short chapter explaining the meaning of the term sea snake, before moving on to taxonomy and evolution. There are about 70 species of sea snake in the world, which come from four of the fifteen living families of snakes. These species are as varied in their morphology as they are in their life histories. The last part of the chapter delves briefly into the mythical world of 'sea serpents', but the author's analysis of the consistent reports of such huge creatures through the ages, leaves readers to make up their own minds about the serpents' existence.

Chapter two follows with detailed descriptions and maps of the world-wide distributions of sea snake species, and explanations of the sea snake biodiversity of countries within their range. Here we learn that the sea snakes are species of the tropical oceans, and that the waters of the western coast of the Americas are poorly endowed with sea snake fauna (one species), while the Atlantic Ocean is completely devoid of sea snakes. Australia has a rich sea snake fauna, with a total of 38 species. The characteristics of many of the world's sea snakes are also identified in this chapter. Interestingly, however, the basic biology of nearly 25% of species is unknown.

The subsequent four chapters deal with natural history, food and feeding, enemies and population and community ecology. Reproduction for sea snakes presents some interesting problems, with some equally interesting physiological solutions. For example, mating in sea snakes spans more than one breathing cycle, with the female controlling the breathing rhythm. The hapless male, who incidently possesses two functional penises (called *hemipenes*) covered by an array of backward facing spikes and hooks, is unable to disengage and is forced to gulp air when the female surfaces!

Most sea snakes take small fish as the major component of their diet. However, some species are fish egg, eel or crab specialists. It is thought that odour and water vibrations are the primary tools used to search for prey. Despite being extremely venomous animals, sea snakes themselves are preyed upon by a range of predators including sea eagles, sharks (particularly tiger sharks) and crabs. Like all marine creatures, they are also subject to marine fouling (pollution), but shed their skins every two to six weeks which seems to rid the snake of marine organisms growing on the skin.

The factors influencing the population densities of sea snakes are further interesting, but poorly understood, aspects of their ecology. Some patch reefs contain dense populations of sea snakes, while adjacent reefs contain none. Mortality also appears high in most sea snakes, especially among young individuals. Longevity is also largely unknown, but one species on the Great Barrier Reef is known to live up to the age of 15 years.

Chapters seven to nine deal with aspects of the physiology of sea snakes, in particular how their bodies deal with excess salt water, their adaptations for diving, and the production and use of venom. These three chapters are particularly authoritative, reflecting the many years of research by the author and his students, but they still identify important gaps in knowledge, which is useful for prospective students. The chapter on venom carries much general interest, investigating the toxicity of venoms and the coevolution of venom and prey resistance.

The last chapter of the book will be of particular interest to almost anyone who ventures into the sea in areas where sea snakes occur. It first outlines the human uses of sea snakes as a source of high quality leather, as a food source in some Asian countries, and the medicinal and research uses for the venoms. The sustainability of sea snakes for these uses is discussed. Finally, the question 'How dangerous are sea snakes?' is answered. The answer to this question is by necessity equivocal, because many factors influence the danger that these venomous snakes pose. A useful table lists the relevant attributes of the most likely encountered species, and as the author points out, only a few species commonly bite and kill humans. Most fatalities occur in south-east Asian countries, and are linked to the particular fishing methods employed in those areas. However, the incidence of human fatality from sea snake bite appears to be decreasing, probably because of an increasing acceptance of modern medical treatments in these countries.

If you have any interest in herpetology, marine ecology or sea snakes, this book is a must. I found it interesting and educational, and a welcome addition to my library. I do not know the size of the print run, but a number of other titles by the author sold out relatively quickly.

Paul O'Neill
Queensland Parks and Wildlife Service,
PO Box 3130, Rockhampton Shopping Fair,
Queensland 4701

Australian Natural History Medallion Trust Fund

The following donations were gratefully received during 1999-2000.

Mr. Eric Allen	$100
Field Naturalists Club of Ballarat	$20
Victorian Ornithological Research Group	$25
Royal Society of Victoria	$100

The fund relies almost entirely on donations. Anyone wishing to make a donation to this fund should make cheques payable to the Field Naturalists Club of Victoria, and send to the Treasurer, FNCV, Locked Bag 3, Blackburn 3130.

The Australian Natural History Medallion, which was instituted in 1939, is awarded annually to a person who, in the preceding ten years, has made a significant contribution to the understanding of natural history in Australia.

WildGuide: Plants & Animals of the Australian Alps

by Barbara Cameron-Smith

Publisher: *Envirobook, Armadale, NSW, 1999.*
ISBN 0 85881 168 5. 96 pp., paperback. RRP $14.95

This attractive, easy-to-use guide has been produced to help people appreciate and enjoy the natural beauty of the Australian Alps. Packed with interesting information and clear colour photographs and water colour paintings, it contains a surprising amount of detail for its size. It is an ideal starting point for people visiting any part of our 1.6 million hectares of alpine national parks and reserves, especially if they are not familiar with alpine environments or with identifying plants and animals. Suitable for a wide audience, the book is designed particularly for families and visitors with children.

A brief introduction is followed by an explanation of how to use the book. A double page map shows where the alpine area is located, and each of the nine national parks and reserves is described. Alpine climate, geology, habitats, and the 'habitat symbol' (used in the animal and plant sections) are introduced

Five types of habitat are described, namely Alpine (heaths and herbfields), Subalpine (snow gum woodlands), Montane (wet mountain forests), Montane (dry mountain forests), and Wetlands and waterways. A list of species is included for each habitat, and flower colour is indicated on the left of each list of flowering plants.

The bulk of the book comprises pictures and descriptions of animals and plants that are commonly seen or heard in the Australian Alps, as well as some of the threatened species that live nowhere else. A total of 83 animals and 112 plants is included. All introduced species are depicted in water colour, and the problems they cause are clearly stated.

Each illustration of a species is accompanied by a habitat symbol which indicates where that species can be found. It is pleasing to see that both scientific and common names are supplied.

The **animals** are divided into mammals, birds, snakes, lizards, frogs, fish, crayfish, insects and spiders. Symbols indicate whether the animal is active during the day or at night, and the time of year when it is most likely to be seen is also noted. The birds are grouped according to plumage colour. Since many birds have several colours in their plumage this is a challenging method of arrangement, but is quite well handled. In cases where the male is a different colour from the female, the female's plumage is briefly described. The Superb Fairy-wren, Flame Robin and Crimson Rosella are grouped at the end of the section as 'bright birds'.

The **plants** are grouped as trees, flowering shrubs and herbs, moss and sedges, ferns and grasses. The flowering shrubs and herbs are arranged according to flower colour, starting with white (there are plenty of these!) and ending with green. Colour symbols in the top left- and right-hand corners of each page cater well for various shades of yellow, pink, mauve, etc. The season when each plant can be seen in flower is printed under its name.

For those who would like to learn more, a list of publications which provide extra information is included after the index.

Personally I would have preferred the print to be slightly darker, and the photo of the wombat on page 29 rather less orange, but these are minor criticisms.

WildGuide is a suitable size for the glove box or back pack, and will certainly enhance your trip to the Australian Alps. Give it a transparent cover to prevent damage in the field and to preserve the beautiful photo of snow gums opposite the title page.

Virgil Hubregtse
6 Saniky Street,
Notting Hill, Victoria 3168.

Ellen Lyndon OAM

Naturalist, Historian, Conservationist
19 December 1906 – 15 April 2000

Ellen Agnes O'Connor was born on Prospect Station at Seaspray where her father was the manager. When she was six her father bought a farm at The Heart by the Latrobe River. There she grew up with 4 younger brothers and 2 sisters. Throughout her childhood years, living among the swamps and streams where the Latrobe River entered Lake Wellington, Ellen was able to explore the surrounding countryside and enjoy the birds and other native animals as well as the masses of wildflowers which grew in the area.

Ellen moved to Melbourne in the early thirties, and in time joined the Albert Park Ladies Rowing Club which Don Lyndon coached, the Bird Observers' Club, Walking Clubs and the Field Naturalists Club of Victoria. These interests were shared with Don Lyndon whom she married in 1936. After Don returned from overseas service in the 1939-45 war, they made a successful application for a soldier settlement farm near Leongatha.

Since her childhood days, Ellen had always been interested in the world around her and once they were settled on the farm her spare time was spent exploring the bush and roads of South Gippsland and with Jean Galbraith's first book 'Wildflowers of Victoria' was able to increase her knowledge of native plants and encourage others to do likewise. Ellen joined the C.W.A. and Horticultural Society, and both she and Don were active on the committee which raised funds for the building of the Leongatha Swimming Pool. When the South Gippsland Highway was re-aligned at the hospital hill and an area of land left between the old road and the new, they approached the Council to buy this so that it could be planted to show what native trees and shrubs would grow in the Leongatha area. Don ploughed and hoed the land before Ellen started planting. Leongatha Apex Club installed playground equipment on the lower portion and it was the Apex Club who suggested that the Council name this the Ellen Lyndon Park. Both were foundation members of Woorayl Historical Society and after some years Ellen took on the office of Secretary which position she held for 14 years. After Woorayl District Memorial Hospital was opened in 1959 Ellen for many years cared for the memorial garden in the foyer. She was a foundation member of the Hospital Ladies Auxilliary and supported this group for many years.

During their expeditions about the countryside exploring the roads and discovering the plants which grew along those roads Ellen looked at all the Crown Reserves in the Shire of Woorayl and beyond, and it was she who was responsible for Hamman's Bush and King's Park becoming bush reserves. In 1974 she obtained permission from the Shire of Woorayl to plant trees on the bare roadside bank beside the Koonwarra Tip and so transformed that stretch of road. When Coal Creek Historical Park at Korumburra was being developed Ellen assisted with the planting to create an area with vegetation similar to that which originally grew there. Both Ellen and Don were foundation members of the Gippsland Field Naturalists Club (now the Latrobe Valley Field Naturalists Club) when it was formed at Morwell in 1960.

From the time Ellen first heard of and then saw the many native plants, and particularly the Butterfly Orchid which grew in Foster's Gully near Yinnar she was keen to see it reserved to protect those plants. Over many years she wrote submissions and letters and enlisted the help of various groups and associations and persons who might help to have the gully reserved, until in 1965 Morwell Shire used a Government grant for half the purchase price of the land and National Parks Authority supplied the remainder of the price. Lyndon Clearing in the park was named in appreciation of all she had done towards the declaration of Morwell National Park.

Never did she go on an outing without a small plastic bag to collect samples of

Ellen Lyndon with foundation and other members of the LaTrobe Valley Field Naturalists Club at the presentation of a Memorial Garden Seat at 'Dunedin' Tyers, November 1999. 'Dunedin' was where Jean Galbraith built her beautiful 'garden in a valley'.
Standing L to R: Mrs Archbold, Ollie Thompson, Iris Petersen, Peg Wall, Philip Rayment, Eric Lubeke. Seated L to R: Ellen Lyndon, Bon Thompson, Eulalie Brewster. Photo by M. Austin.

plants or fungi which she did not know. These specimens she took home to check against any reference books to verify identification. If unable to do this she sent them to those more knowledgeable. As well as the plastic bag on outings, in earlier days she had a special 'book bag,' which hung about her waist and in it carried Jean Galbraith's first edition of 'Wildflowers of Victoria'.

After each outing she wrote out the plant list for that particular place and day, and so built up a comprehensive list of plants and fungi in South Gippsland and other places visited.

When she first started to learn the names of fungi and had sent away one which she could not identify, Ellen was greatly amused to find it unknown and so given the specific name *lyndoni* 'a wood destroying fungus named for a conservationist!'

Rarely did she ever attend a Field Naturalists meeting, a Conservation or SGAP (Society for Growing Australian Plants) meeting without taking along a selection of named specimens either from her own garden, the Ellen Lyndon Park or friends' native gardens. Whatever the season there were always a few dried fungi on a tray to be enjoyed and shown to those interested.

Bad weather never deterred her when an expedition was planned for she always declared 'Get out and face up to the weather and the day will improve'.

After their retirement from farm life to Leongatha more time was given to interests in natural history. With Don's photographic ability with coloured slides and Ellen's wide knowledge of native plants (flowers, ferns, fungi) and birds they gave talks to many interested groups around Victoria, especially to the Gippsland Field Naturalist Clubs - Sale, Bairnsdale and Latrobe Valley and also Traralgon and Warragul before they disbanded. She also led many excursions on varying subjects, e.g. fungi, ferns, weeds, alpine flowers and many others covering the whole gamut of natural history. She and Don also travelled giving talks in such places as Mildura and Bendigo and many other locations.

Ellen was the first secretary of the Victorian Field Naturalists Clubs Association. She was a life member of the Sale Field Naturalist Club in recognition of her help to that club. She was a foundation member of the Latrobe Valley Field Naturalist Club and was made an Honorary Member of the Field Naturalists Club of Victoria on 8 August 1983.

Ellen joined The Field Naturalists Club of Victoria on 12 July 1943 and contributed regularly to *The Victorian Naturalist* over a period of 50 years, publishing her first paper in December 1950 ('Flowering of Blackwoods', Vol. 67, p. 149) and her last in October 1999 ('Coroboree Frog *Pseudophryne corroboree*', Vol. 116, p. 168).

Ellen was interested and well informed on many spheres of natural history but her main interest was in fungi and ferns. She collected fungi avidly, especially those of Tarra Bulga National Park.

As a leader of an excursion Ellen never tired of explaining what the plants were or how to identify them. Identification often had a humorous twist as Ellen had a wonderful sense of humour.

Campouts in the Alpine country in January were one of Ellen's delights and her sense of humour always added to the enjoyment of the weekends. One year she and Don returned three times during January-March looking for plants that flowered later than the campout weekend.

In 1988 Ellen was awarded the Order of Australia for her voluntary community work and her outstanding contribution to organisations such as the Leongatha Hospital, The Field Naturalists Club of Victoria, the Latrobe Valley Field Naturalists Club, the South Gippsland Conservation Society and the Woorayl Historical Society.

Ellen had an ageless and generous spirit, humour and an instinctive eye for even the smallest jewels and grandest plans of nature.

She was an enthusiastic, energetic, knowledgeable field naturalist who has left a lot of knowledge with many people, and a large number of reserves in South Gippsland that she was responsible for saving for future generations.

We trust that the national parks and nature reserves of Gippsland that Ellen's life has been such a large part of, continue to be appreciated; a legacy of Ellen's fascination for nature, and so many wonderful friendships.

Eulalie Brewster and Bon Thompson
with assistance from Dick Lester
LaTrobe Valley Field Naturalists Club.

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The Field Naturalists Club of Victoria Inc.

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In which is incorporated the Microscopical Society of Victoria

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The Victorian Naturalist

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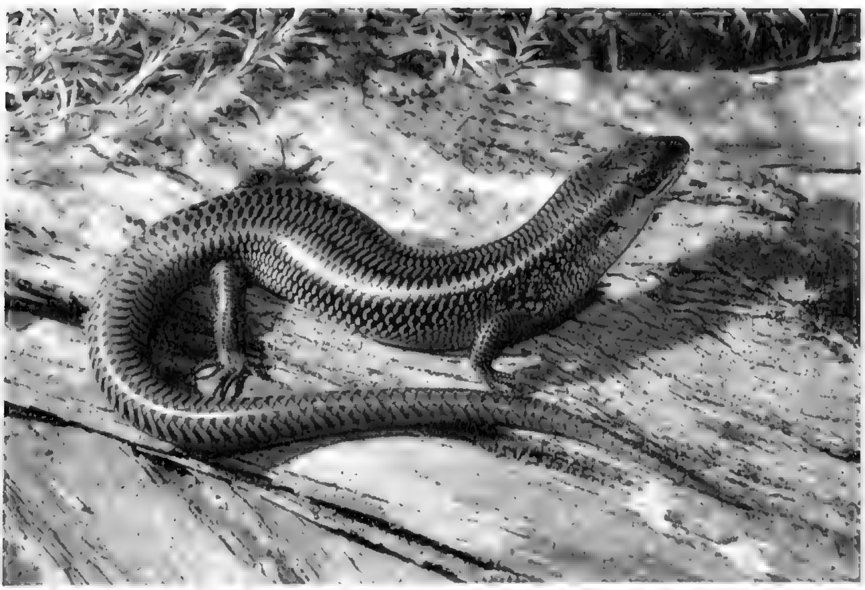

F.N.C.V.

Published by The Field Naturalists Club of Victoria *since 1884*

Australian Rushes: Biology, Identification and Conservation of Restionaceae and Allied Families

Edited by Kathy A. Meney and John S. Pate

Publisher: *University of Western Australia Press, 1999, 496 pp. Numerous line drawings. RRP $95.00*

This handsome volume is the definitive monograph of the Australian Restionaceae and some related (or perhaps just similar-looking) families. The title is ambiguous - in all of the English-speaking world 'rush' means the cosmopolitan *Juncus* and its close relatives, although the word is also a part of some sedge names as well (e.g. leaf-rush). The Restiads are a very different group of southern hemisphere families, most of them found in South Africa and Western Australia, with fewer species in eastern Australia, though these are often ecologically important.

The South African species are mostly known by Afrikaans names, all of which are unfamiliar here. Most Australian species were unfamiliar and poorly documented until publication of this volume, so many have no common name. Even so, quite a few are widely referred to as cord-rushes, rope-rushes or scale-rushes, all of which are good descriptive terms. It is a pity that the editors didn't decide on one of these names to use for the Restiads as a group, rather than 'rush' alone.

Australian Rushes is a great improvement on the largely taxonomic monographs of the not-so-distant past, covering diverse aspects of their biology from fire adaptation, nutrient responses and diseases to reproduction as well as their place in the overall ecology of wetlands and heathlands,. Kathy Meney's expertise in practical aspects of conservation in Western Australian wetland and monocot flora can be seen in concise discussions of their propagation and rehabilitation.

This book unveils some considerable revisions within these families, many based on genetic studies, and some of the name changes will take a little getting used to. *Restio* in particular has now been restricted to African species, and Australian species are now separated into thirteen other genera - for example the familiar Tassel Cord-rush *R. tetraphyllus* is now *Baloskion tetraphyllum*.

The (previously) widespread and often abundant *Leptocarpus* has been considerably reduced to three species, with the closely related genus *Meeboldina* absorbing many of the renamed plants, and others moved to several familiar and several new genera. While such name changes are the bane of the naturalist's life, they are genuine indicators of the natural relationships of this complex group, based on years of study.

The plant descriptions cover around 150 species, with a full page of text and a full page of line drawings for each one. I would have preferred to have had all synonyms included with these descriptions, not just discussed and listed separately in an earlier section of the book. The use of not-yet-officially published names in commas is welcome. Too many revisions use only numbers for undescribed species, a nuisance for readers with a relatively casual interest who just want to know what the plants are called, without having to chase up later literature to find out.

Australian Rushes will remain the definitive work on these families for years or even decades to come. Despite the high price, it is highly recommended for anyone with a serious interest in wetlands or heathlands, in the ecology and evolution of the Australian and Gondwanaland floras, and in practical aspects of propagating and re-establishing indigenous plants with highly specialised needs.

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The Victorian Naturalist

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Assistant Editor: Alistair Evans

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Cover: An adult female Swamp Skink *Egernia coventryi* from Enfield State Forest, south-west of Ballarat. See the report on p. 180 of the rediscovery of this threatened skink in a Melbourne suburb. Photo by Nick Clemann.

See our new web page: http://calcite.apana.org.au/fncv/vicnat.html
email: fncv@vicnet.net.au

Australian Natural History Medal 2000

Malcolm Calder

In a long and distinguished career Dr Malcolm Calder has made a major contribution to disseminating knowledge in his specialist fields of botany, reproductive plant biology, conservation and ecology and to the advancement of understanding in natural history generally.

In his academic career Dr Calder pursued an active research and teaching programme which has left a lasting legacy on a new generation of scientists. In 25 years at the University of Melbourne he achieved the position of Associate Professor and Head of Department in the School of Botany where his major research interests were in plant ecology, population biology and plant reproductive biology. He supervised 27 postgraduate student research projects and published two books, over 70 scientific papers and several book chapters. His former students continue to make contributions to botany, ecology and conservation. Malcolm is currently an Honorary Senior Research Associate at Melbourne University.

Through his membership of several advisory bodies Malcolm has extended his influence to government decision makers and administrators, his input being crucial in ensuring that the voice of conservationists was heard and that the value of nature conservation was considered. Of particular importance was his work on the Land Conservation Council where for 12 years (the last as Deputy Chair) he was active in assessing the conservation values of public land and ensuring that areas of significant value in Victoria were appropriately reserved. For three years he was convenor of the Scientific Advisory Committee set up under the Flora and Fauna Guarantee Act 1988 to evaluate nominations of threatened species and communities for protection under the Act. In this position, his expertise has made a major contribution to the conservation of biodiversity in Victoria. Malcolm has been involved in a number of other advisory bodies.

Perhaps even more important than his professional work has been Malcom's extremely active participation in voluntary community activities, especially so since his retirement from full-time academic work. His contributions to furthering the understanding of natural history and in promoting nature conservation in the wider community are exceptional. Highlights of his voluntary work include presidency of the Victorian National Parks Association (1971 - 1975) and an outstanding contribution to The Field Naturalists Club of Victoria as vice-president (1992), President (1993 - 1995) and member of Council (1996). Malcom's contribution to the FNCV has been inestimable: and under his leadership the Club continued to consolidate its standing in the conservation community. A major achievement during his presidency was the purchase of the clubrooms. These have provided a solid and permanent home which has greatly enhanced the Club's ability to be an active participant in promoting the study and conservation of nature. Malcolm is also an active member of numerous other conservation organisations.

Malcolm's willingness to share his extensive knowledge and his outstanding communications skills has meant that he is greatly in demand as a speaker to community groups, as a leader of excursions and tours and an organiser of workshops. These have all had a conservation or natural history theme and have disseminated awareness of nature to an extremely wide cross section of the community - not only those who are already committed environmentalists, but more importantly those whose interests are in the formative stage. Among many other achievements, Malcolm was instrumental in organising the highly successful Skills Workshop at Anglesea in 1994 in association with the Victorian Field Naturalists Clubs Association, which enhanced the skills of over 85 naturalists from all over Victoria, and the Mistletoe Forum in 1996 which made a significant contribution to knowledge of this plant group. He gives regular Plant Identification courses designed to enhance botanical skills for non-specialists. For some 5 years, Malcolm has been leader of between 2 to 4 week-long tours per year, for The Field Naturalists Club of Victoria, for the Council of Adult Education and Bronz Discovery Tours. He also leads 8 or more excursions per year, which include bush walks in the Victorian National Parks Association 'Walk, Talk and Gawk' program and excursions for local community groups, and gives at least six talks per year.

As a distinguished academic and environmental consultant and through his active participation in community conservation activities Malcolm Calder has made a significant contribution to the understanding and preservation of the natural environment. The Field Naturalists Club of Victoria took great pleasure in nominating him for the award of the Australian Natural History Medallion. The nomination was also supported by the Upper Yarra and Dandenong Environment Council, Group for the Lilydale and District Environment, and the Victorian National Parks Association.

Ian Endersby
56 Looker Road,
Montmorency, Victoria 3094.

Editor's note: The Australian Natural History Medallion will be presented to Dr Malcolm Calder at a meeting of the FNCV on Monday, 20 November 2000 at 8.00 pm. The presentation will take place at the FNCV Hall, 1 Gardenia Street, Blackburn, Victoria. After the presentation Malcolm's talk will be 'On being a Field Naturalist - people, plants and politics'. All welcome.

Malcolm Calder leaning on the flood-level indicator at Gascoyne River Crossing, W.A. Photo by Michael Holt (2000).

Sexuality of *Wijkia extenuata* (Brid.) Crum in Wet Victorian Forests

B. Sinclair[1] and M. Gibson[1,2]

Abstract

The sexual nature of *Wijkia extenuata* (Brid.) Crum was examined at four areas within Victoria: Bellell Creek, Marysville, and Cement Creek both in the Yarra Ranges National Park, Mount Erica in Baw Baw National Park and Masons Falls in Kinglake National Park. *Wijkia extenuata* was found to be dioicous and isomorphic. (*The Victorian Naturalist* **117** (5), 2000, 166-171.)

Introduction

Wijkia extenuata (Brid.) Crum is a pleurocarpous moss. It grows horizontally in a loose, tangled weft. It is common in the wet sclerophyll forests and rainforests of Australia but occurs in greatest abundance in the tropical rainforests of north-eastern Queensland (Tan *et al.* 1996). It also occurs in New Zealand, albeit less commonly (Scott and Stone 1976). It grows on fallen logs, rocks, soil and the trunks and exposed roots of trees. *Wijkia* belongs to the Sematophyllaceae, which is distributed widely throughout the world, including Europe, North America, South America, South-east Asia and Canada (Buck 1986; Chiang 1996). Thirty-six species in 13 genera occur within Australia (Ramsay and Schofield 1987; Tan *et al.* 1996). Two species, *Wijkia crossii* Broth. & Geh. ex. Broth. and *Wijkia rigidifolia* Dix., are endemic to Queensland (Tan *et al.* 1996).

Both sporophytes and gametophytes (Scott and Stone 1976) are known but whether or not gametophytes are unisexual or bisexual is unknown.

The aim of this study, therefore, was to elucidate the sexual nature of *W. extenuata* by determining the presence (or absence) of archegonia (female reproductive structures) and antheridia (male reproductive structures) in representative samples from a number of localities in Victoria.

Method

Five populations of *W. extenuata* from each of the following four areas were examined:

1. Bellell Creek, Marysville, Yarra Ranges National Park.
2. Cement Creek, Yarra Ranges National Park.
3. Mount Erica, Baw Baw National Park.
4. Masons Falls, Kinglake National Park.

The first three sites consisted of cool temperate rainforest pockets, surrounded by wet sclerophyll forest. Within these pockets, isolated trees of Mountain Ash *Eucalyptus regnans* F. Muell. overtopped a dense canopy of Myrtle Beech *Nothofagus cunningamii* (Hook.) Oerst. and scattered Blackwood *Acacia melanoxylon* R. Br.. The understorey was generally sparse and consisted of Hard Water Fern *Blechnum wattsii* M. A. Tindale, Soft Tree Fern *Dicksonia antartica* R. Br., and Rough Tree Fern *Cyathea australis* R. Br..

The site at Masons Falls consisted of wet sclerophyll forest with Shining Gum *Eucalyptus nitens* Maiden dominant, and *B. wattsii* , *D. antarctica* and *C. australis* again forming the understorey. *Wijkia extenuata* was extremely common in all areas, forming dense carpets on fallen logs, extending up the trunks of trees and forming large patches on soil and rock.

Ten plants from each population were collected from the area of healthiest growth. They were placed into plastic bags, labelled appropriately, and transported back to the laboratory in an esky with ice and examined within 24 hours. Sampling occurred from 22 June to the 29 June 1999. The number of perichaetia and perigonia were recorded. These are the specialised leaves that surround the female and male gametangia respectively. These were removed from the stem and dissected to reveal any archegonia and antheridia respectively, which were then counted.

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[2] to whom correspondence should be addressed.

Fig. 1. (a) Stem segment showing location and size of perigonia.

Results

Both perigonia and perichaetia were observed [Fig. 1(a) and 1(b)] and always occurred on separate plants. Perichaetia occurred on the main stem of the female gametophyte and occasionally at the base of primary branches [Fig. 2(a)]. Perigonia occurred in the axils of the branches and leaves of the male gametophyte [Fig. 2(b)]. Other than the presence of perichaetia and perigonia, no distinction could be made between the female and male plants.

Of the 200 plants collected in total, 104 were fertile (Table 1). The females outnumbered the males with 59 female plants occurring and 45 males. The sexuality of *W. extenuata* varied from place to place, both in terms of the number of fertile plants occurring and in the distribution of the two sexes (Table 1). Populations at the Bellell Creek, Cement Creek and Masons Falls sites had moderate to high levels of fertility. The numbers of fertile plants ranged from 26 to 42 out of a total of 50 plants collected at each site, but only few plants (8) were fertile at the Mount Erica site. At each site the sex ratios varied (Table 1). Females predominated at Bellell Creek, Mount Erica and Masons Falls, but at Cement Creek, males were found in higher numbers.

A total of 89 perichaetia and 346 perigonia was dissected, revealing 687 archegonia [Fig. 3(a)] and 2998 antheridia [Fig. 3(b)] respectively (Table 1). The number of archegonia per perichaetium varied [Table 2(a)] ranging from 0-38. Most commonly, however, there were 0-4 archegonia per perichaetium. Archegonia possibly

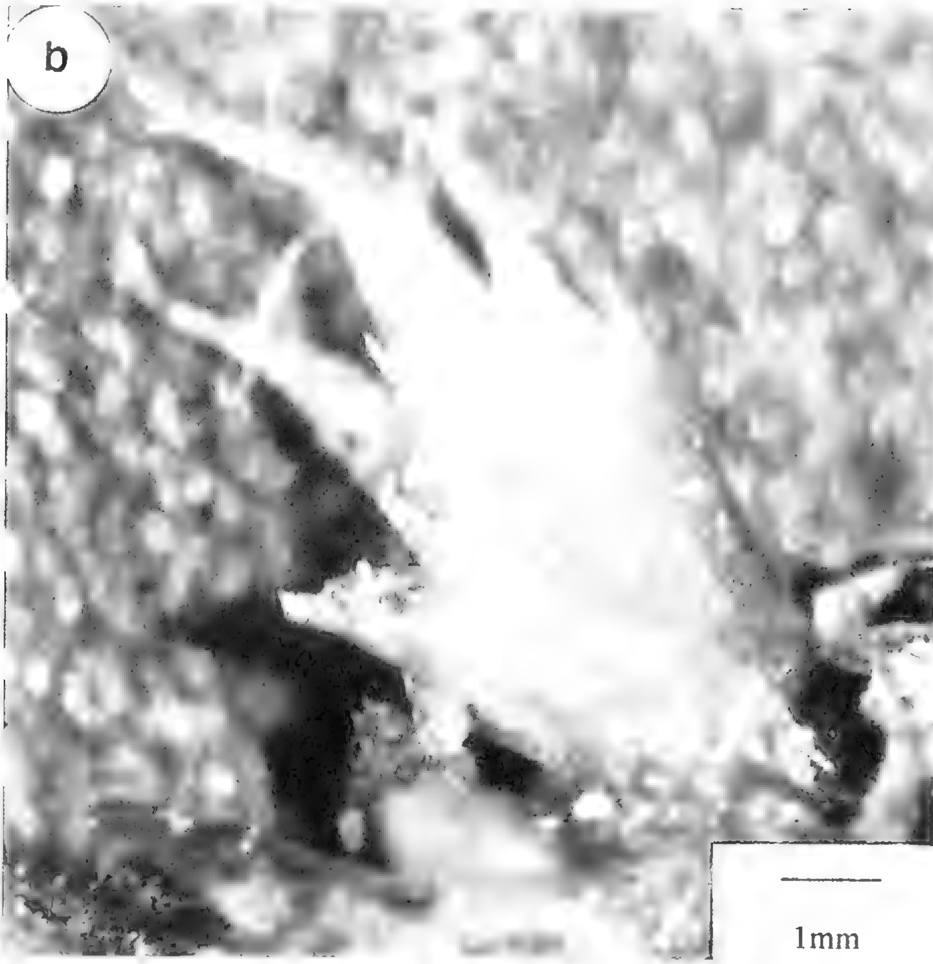

Fig. 1. (b) Single perichaetium on stem segment.

were present in perichaetia when a value of zero was recorded but were too young to be discernible. The number of antheridia per perigonium ranged from 2-24 [Table 2(b)]. Generally, there were more antheridia per perigonium than archegonia per perichaetium. Anything from 2-24 antheridia per perigonia was common.

Table 1. Variability in the sexuality of *Wijkia extenuata* at each study site (n=200 plants).

	Bellell Creek	Cement Creek	Masons Falls	Mount Erica	Total
Non fertile plants	22	18	14	42	96
Fertile plants:	28	26	42	8	104
No. of males	7	17	19	2	45
No. of females	21	10	22	6	59
No. of perigonia	38	126	170	12	346
No. of perichaetia	30	26	22	11	89
No. of antheridia	194	1265	1474	65	2998
No. of archegonia	257	140	145	145	687

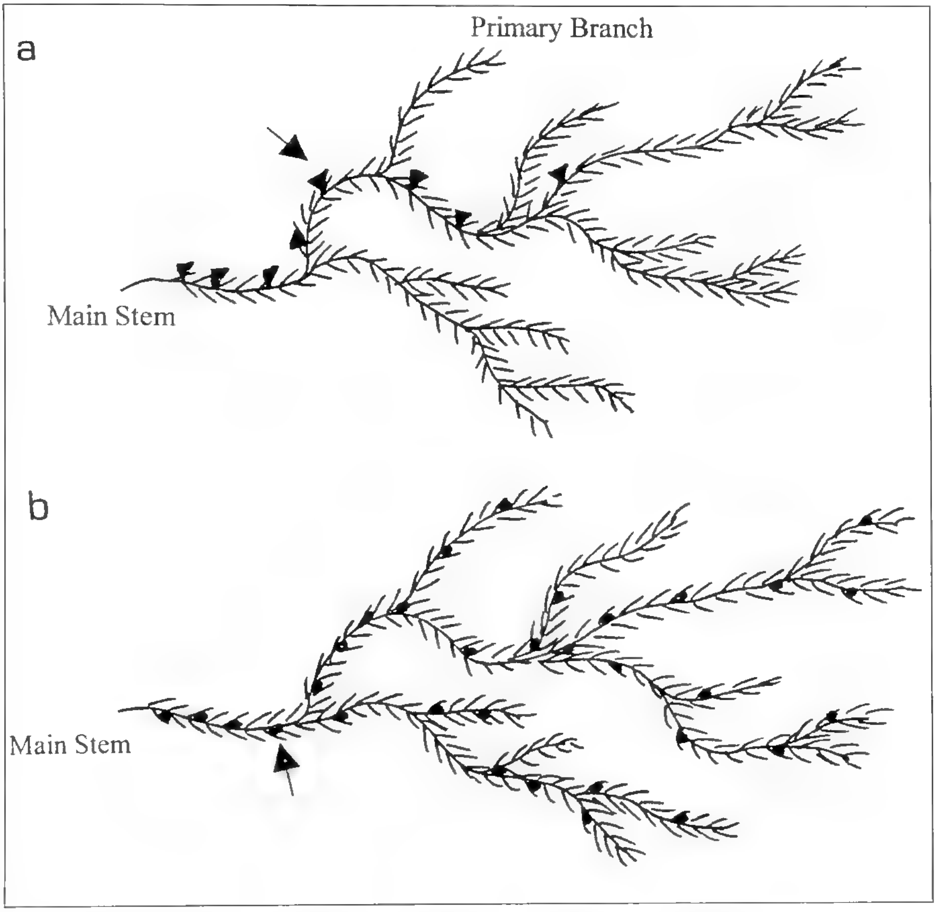

Fig. 2. (a) Diagrammatic representation of perichaetial positioning. **(b)** Diagrammatic representation of perigonial positioning.

Discussion

The sexual nature of a moss, that is, whether it is male, female or bisexual is determined by the presence of archegonia and/or antheridia on the gametophyte (Cousens 1988; Longton 1988; Mishler 1988; Richardson 1981; Wyatt and Anderson 1984). Mosses generally are divided into monoicous or dioicous species but polyoicous species also occur. Monoicous species have both the female and male sexual structures on the one plant. Dioicous species have separate male plants and separate female plants. Polyoicous species have bisexual as well as unisexual individuals where the unisexual individual may be male or female.

Wijkia extenuata was found to be dioicous with antheridia and archegonia occurring on separate gametophytes in each population, at each locality. It is unlikely that it would be polyoicous considering that a total of 200 plants was collected from four different areas. If any bisexual plants had occurred, then some would have been expected to be found in the samples collected. The gametophytes were isomorphic; that is, male plants were morphologically identical to female plants. This was not unusual, in that most (known) dioicous mosses are isomorphic (Mishler 1988; Wyatt and Anderson 1984). Similarly, the dioicous nature of *W. extenuata* is not unusual in that mosses are divided into almost equal proportions of monoicous and dioicous species (Longton and Schuster 1983) with slightly more dioicous species occurring than monoicous

Table 2. Variation in the **(a)** number of archegonia per perichaetium and **(b)** number of antheridia per perigonium for four study sites.

(a)

Number of archegonia per perichaetium	Frequency (number of perichaetia) **0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Mount Erica	0	1	2	1	1	1	1	0	0	0	0	0	1	
Masons Falls	4	2	4	4	0	0	0	0	0	0	0	1	0	
Cement Creek	4	3	4	2	4	3	1	0	0	0	0	0	0	
Bellell Creek	2	3	4	3	3	2	2	0	0	0	0	0	1	
Total no. of perichaetia	**10**	**9**	**14**	**10**	**8**	**6**	**4**	**0**	**0**	**0**	**0**	**1**	**2**	
Number of archegonia per perichaetium	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**26**	**27**	**32**	**38**	**Total**
Mount Erica	0	1	0	0	0	0	0	0	0	1	0	1	1	11
Masons Falls	0	0	0	1	1	1	0	2	1	0	0	0	0	22
Cement Creek	2	1	2	0	0	0	0	0	2	0	0	0	0	26
Bellell Creek	2	1	1	0	1	0	1	1	1	0	1	1	0	30
Total no. of perichaetia	**2**	**3**	**3**	**1**	**2**	**1**	**1**	**3**	**4**	**1**	**1**	**2**	**1**	**89**

(b)

Number of antheridia per perigonium	Frequency (number of perigonia) **2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mount Erica	2	0	3	3	1	0	1	1	0	1	0
Masons Falls	9	8	15	10	11	14	27	9	11	8	16
Cement Creek	9	2	10	12	10	3	12	9	5	1	6
Bellell Creek	1	8	6	10	4	5	2	1	1	0	0
Total no. of perigonia	**21**	**18**	**34**	**35**	**26**	**22**	**42**	**20**	**17**	**10**	**22**
Number of antheridia per perigonium	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**24**	**Total**
Mount Erica	0	0	0	0	0	0	0	0	0	0	12
Masons Falls	12	14	0	1	1	1	0	1		2	170
Cement Creek	10	10	4	7	5	1	3	2	4	1	126
Bellell Creek	0	0	0	0	0	0	0	0	0	0	38
Total no. of perigonia	**22**	**24**	**4**	**8**	**6**	**2**	**3**	**3**	**4**	**3**	**346**

species (Anderson 1980; Cummins and Wyatt 1981; Kimmerer 1994; Wyatt and Anderson 1984). Further, in the Sematophyllaceae, both monoicous and dioicous species are known. For example *Sematophyllum amoenum* (Hedw.) Mitt. is monoicous while *Sematophyllum leucocytus* (C. Muell.) Sainsb. is dioicous (Scott and Stone 1976).

Lower numbers of archegonia were observed than antheridia but the higher number of female plants produced could act to counterbalance the gametangial numbers. The higher occurrence of antheridia per perigonium than archegonia per perichaetium was not unexpected. *Atrichum aristophyllum* (C. Muell.) Par. and *Pogonatum inflexum* (Lindb.) Lac. (Imura 1994), have three times more antheridia per perigonium than archegonia per perichaetium. The larger number of antheridia would result in higher sperm numbers, which would increase the likelihood of sperm reaching the archegonium and fertilising the egg. An investigation of gametangial development, fertilisation and subsequent sporophyte production is underway.

Acknowledgements

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References

Anderson, L.E. (1980). 'Cytology and Reproductive Biology of Mosses.' (Allen Press: San Fransisco.)

Buck, W.R. (1986). *Wijkia* (Sematophyllaceae) in the New World. *Hikobia* **9**, 297-303.

Chiang, T. (1996). *Wijkia tanytricha* (Mont.) Crum (Muscie, Sematophyllaceae), a new record to the moss flora of Taiwan. *Botanic Bulletin of Academia Sinica* **37**, 147-150.

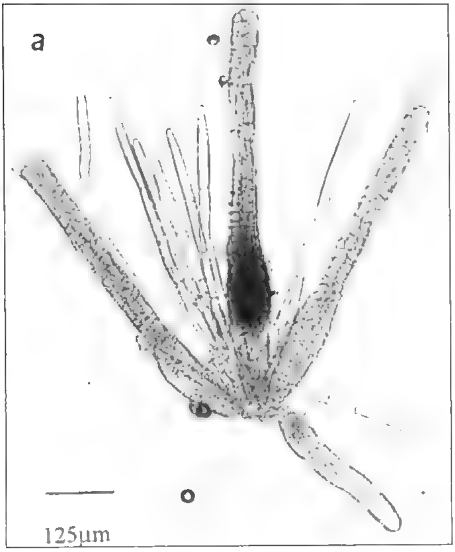

Fig. 3. (a) Archegonia and sterile paraphyses from a dissected perichaetium.

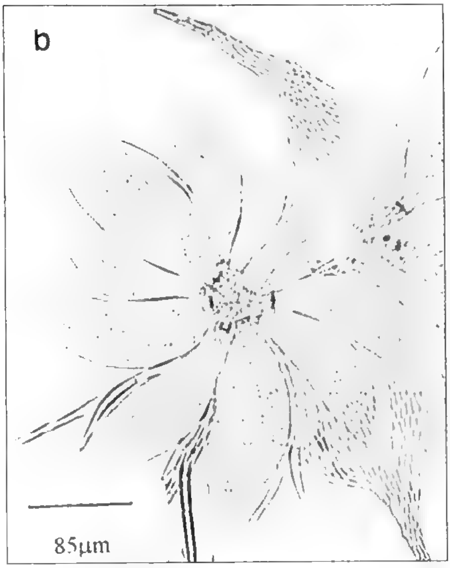

Fig. 3. (b) Antheridia and sterile paraphyses from a dissected perigonium.

Cousens, M.I. (1988). 'Reproductive Ecology of Bryophytes'. (Oxford University Press: New York.)

Cummins, H. and Wyatt, R. (1981). Genetic variability in natural populations of the moss *Atrichum angustatum*. *The Bryologist* **84**, 30-38.

Imura, S. and Iwatsuki, Z. (1994). Phenological study of *Trachycystis microphylla* (Dozy et Molk.) Lindb. (Mniaceae, Musci). *Hikobia* **10**, 303-308.

Kimmerer, R.W. (1994). Ecological consequences of sexual versus asexual reproduction in *Dicranum flagellare* and *Tetraphis pellucida*. *The Bryologist* **97**, 20-25.

Longton, R.E. (1988). 'Biology of Polar Bryophytes and Lichens'. (Cambridge University Press: Melbourne.)

Longton, R.E. and Schuster, R.M. (1983). 'Reproductive Biology'. (The Hattori Botanical Laboratory Japan: Tokyo.)

Mishler, B.D. (1988). 'Reproductive Ecology of Bryophytes'. (Oxford University Press: New York.)

Ramsay, H.P. and Schofield, W.B. (1987). Preliminary studies on the Sematophyllaceae (Bryopsida) North Queensland. *Australian Systematic Botanical Society Newsletter* **50**, 7-12.

Richardson, D.H.S. (1981). 'The Biology of Mosses'. (Blackwell Scientific Publications: Melbourne.)

Scott, G.A.M., and Stone, I.G. (1976). 'The Mosses of Southern Australia'. (Academic Press: London.)

Tan, B.C., Ramsay, H.P. and Schofield, W.B. (1996). A contribution to Australian Sematophyllaceae (Bryopsida). *Australian Systematic Botany* **9**, 319-327.

Wyatt, R. and Anderson, L.E. (1984). Breeding Systems in Bryophytes. *In* 'The Experimental Biolgy of Bryophytes', pp. 39-64. Eds A.F. Dyer and J.G. Duckett. (Academic Press: Sydney.)

GLOSSARY

Archegonia: the female reproductive organs, which are flask-shaped, each consists of an enlarged rounded base which contains the egg

Antheridia: the sac-like male reproductive organs, which contain the spermatozoids within a wall one cell thick.

Dioicous: male and female sexual organs occur on separate plants

Gametangia. reproductive organs containing the gametes ie. antheridia and archegonia

Gametophyte: the haploid generation, consisting of protonema (branched algal-like filaments or plate-like growths arising from the spores) and the stems it gives rise to with their accompanying leaves, rhizoids, sex organs, etc. The gametophyte produces gametes. Fertilisation results in development of a sporophyte

Isomorphic: identical in form

Monoicous: having the male and female organs on the one plant

Perichaetia: specialised leaves that surround the archegonia and later the setae

Perigonia: specialised leaves that surround the antheridia

Pleurocarpous: having the archegonia and later the sporophytes on specialised short side branches, not at the apices of main stems or branches - the resulting moss growth form often becomes horizontal with stems occurring in a loose, tangled weft

Polyoicous: pertaining to a species having male and female organs on the one plant or on separate plants, ie. having dioicous and monoicous individuals

Sporophyte: the diploid generation consisting of capsule, seta (stalk on which capsule is borne) and a foot embedded in the gametophyte. The sporophyte produces spores. Germination of a spore results in development of a gametophyte

Lichens of the Soft Tree-fern *Dicksonia antarctica* Labill. in Victorian Rainforests

Sharon Ford[1] and Maria Gibson[1]

Abstract
The lichens of the Soft Tree-fern *Dicksonia antarctica* Labill. were examined in the rainforests of three regions across Victoria: the Otways, the Baw Baw Range and Errinundra. Twenty-five species from 10 families were noted. Errinundra was the most floristically rich with 21 lichen species recorded on the tree-ferns. Inclination of trunk and age of tree-fern are suggested to be important factors in providing suitable habitat for lichens. (*The Victorian Naturalist*, **117** (5), 2000, 172-179.)

Introduction

Tree-ferns, notably the Soft Tree-fern *Dicksonia antarctica* Labill., are a dominant component of the understorey of cool temperate rainforests (Busby and Brown 1994; Peel 1999) and wet sclerophyll forests (Ough and Murphy 1996) in Victoria, though they may grow tall enough to form a sub-canopy in mature rainforest.

The trunks of tree-ferns have been cited as important substrata for epiphytes (Cameron 1992; Ough and Murphy 1996) such as orchids, ferns and bryophytes. Indeed, some species appear to be obligate epiphytes on tree-ferns, for example the Fork Fern *Tmesipteris* sp. (Ough and Murphy 1996) and the moss *Calomnion complanatum* (Meagher 1999). There are few data available, however, for the lichen flora of these conspicuous components of the Victorian forest flora. This paper presents data on lichen species floristics and general distributional trends of lichens on Soft Tree-ferns across three regions of rainforest in Victoria: the Otways, the Baw Baw Range and Errinundra.

Methods

A total of 98 Soft Tree-ferns (*D. antarctica*) was sampled in three regions across Victoria: 43 Soft Tree-ferns in the Otways, 18 from the Baw Baw region and 37 from the Errinundra Plateau (Fig. 1). Three rainforest types were represented; rainforest dominated by *Nothofagus cunninghamii* (Hook.) Oerst. (Otways), rainforest co-dominated by *N. cunninghamii* and *Atherosperma moschatum* Labill. (Baw Baw Range) and rainforest co-dominated by *A. moschatum* and *Elaeocarpus holopetalus* F. Muell. (Errinundra). Common names for vascular plants are listed in the appendix.

Nothofagus cunninghamii-dominated cool temperate rainforest in the Otways

Cool temperate rainforests dominated by *N. cunninghamii* have been cited as one of the most important vegetation communities in the Otways (D.N.R.E. 1996). They occur mainly along the southern fall of the ranges in steeply dissected gullies and along major river flats between Lavers Hill in the west and the headwaters of the Cumberland River in the east (Peel 1999). These forests represent the western-most biogeographic limit of cool temperate rainforest (Peel 1999). Many Victorian rainforests are co-dominated by *N. cunninghamii* and *A. moschatum*, however, the latter species appears to be absent from the Otways (Busby and Brown 1994; Ladd 1991; Peel 1999), and is apparently replaced there by *Hedycarya angustifolia* A. Cunn. for the most part, but also in part by *Pittosporum bicolor* Hook., *Olearia argophylla* (Labill.) Benth. and *Acacia melanoxylon* R.Br. *Dicksonia antarctica* is always present in the understorey (Fig. 2) along with ground ferns such as *Blechnum wattsii* Tindale and/or *Polystichum proliferum* (R.Br.) Presl. The Otways *N. cunninghamii*-dominated rainforests are classified as 'Otways cool temperate rainforest' after Peel (1999). They are analogous to Tasmanian 'callidendrous rainforest' or 'callidendrous mixed forest' (Jarman *et al.* 1991).

Nothofagus cunninghamii-dominated rainforests of the Baw Baw Range

Rainforests examined in the Baw Baw region are dominated by *N. cunninghamii*

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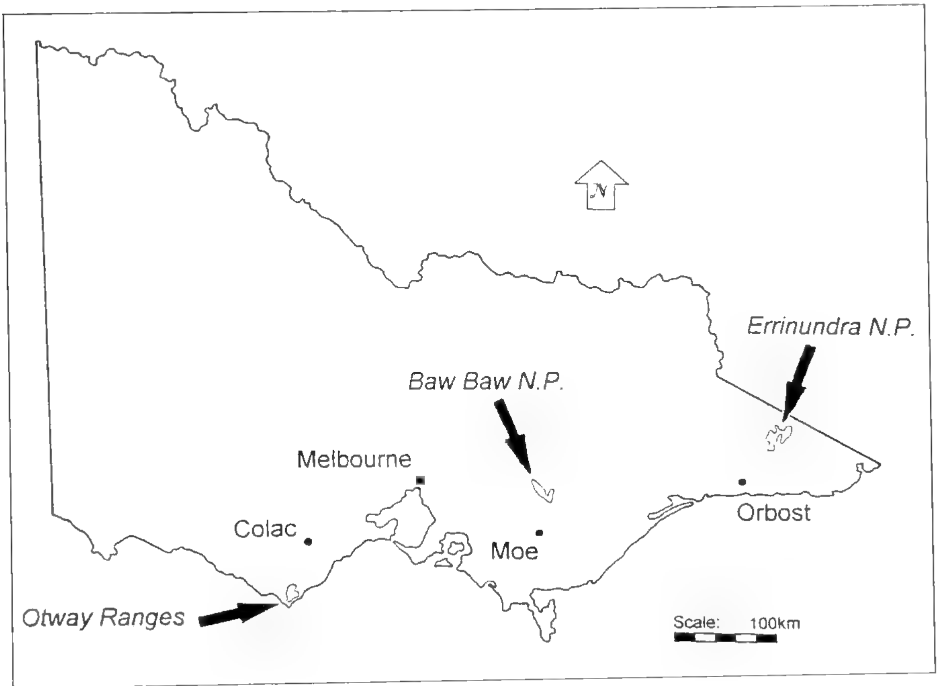

Fig. 1. The three rainforest regions where soft tree-ferns were sampled: the Otway Ranges, the Baw Baw Range and the Errinundra Plateau, Victoria (adapted from Calder 1990).

which may or may not include a sub-dominant component of *A. moschatum*. These small pockets of rainforest are confined to steep, protected gullies, and are found predominantly around Mt Erica Road on the eastern side of the range, and in widely dispersed pockets along the Thompson Valley Road. Species such as *A. melanoxylon*, *O. argophylla*, *Acacia dealbata* Link and *Pomaderris aspera* Sieb. ex DC. are components of the overstorey. *Coprosma quadrifida* (Labill.) Robinson, *P. bicolor* and the ferns *Cyathea australis* (R.Br.) Domin, *D. antarctica*, *B. wattsii* and *P. proliferum* are major understorey species. These cool temperate rainforests are classified as Central Highlands Cool Temperate Rainforest (Peel 1999).

Atherosperma moschatum–Elaeocarpus holopetalus-*dominated rainforests of the Errinundra Plateau*

The rainforests of the Errinundra National Park are co-dominated by *A. moschatum* and *E. holopetalus*. Rainforests are widely distributed in the Errinundra National Park, usually forming narrow, riparian strips along streams and sheltered gullies, but occurring in much larger stands on the Plateau (D.C.F.L. 1989). Indeed, the *Atherosperma-Elaeocarpus* rainforest of Coast Range Road on the Errinundra Plateau is estimated at 150 ha in size and is the largest tract of uninterrupted rainforest in Victoria (D.C.F.L. 1989; Seddon and Cameron 1985). The *Atherosperma-Elaeocarpus* rainforests in eastern Victoria are the southern extremity of the cool temperate rainforests which extend south through the tablelands of New South Wales (Ladd 1991).

Species associated with *Atherosperma-Elaeocarpus* rainforests include *A. melanoxylon*, *P. bicolor*, *O. argophylla*, *Lomatia fraseri* R. Br. and *Telopea oreades* F. Muell. in the overstorey, with *C. quadrifida*, *Tasmannia lanceolata* (Poir) A.C. Smith, *B. wattsii* and *P. proliferum* dominating the understorey. *Dicksonia antarctica* occurs as a component of the sub-canopy, and in the understorey (Fig. 3). Peel (1999) classified the cool temperate rainforests of Errinundra as 'East Gippsland Cool Temperate Rainforest'.

Fig. 2. *Dicksonia antarctica* with *Nothofagus cunninghamii* overstorey, Otway Ranges. Photograph by J.E. Ford, 1999.

Sampling Procedure

Up to five representative Soft Tree-ferns were sampled from twenty-six randomly selected, 20 × 20 m quadrats within rainforest pockets. A computer-generated random number table was used to 'select' quadrats from an extensive list of rainforest pockets located in each region. Sampled ferns always exceeded one metre in height as smaller tree-ferns were rarely observed to support lichens. Lichen species and estimates of cover-abundance were recorded. Where lichen identity was unknown, a sample was taken for further analysis. Representatives of each species recorded were lodged at the Herbarium, Royal Botanic Gardens, Melbourne (MEL).

Results

A total of 25 lichen species was recorded on the tree-ferns sampled (Table 1). Macrolichens (foliose and fruticose growth forms) were the more dominant lichen type in terms of numbers of species, with 18 of the 25 species having this growth form. Microlichens (crustose or leprose/powdery growth forms) numbered seven species. A

Fig. 3. *Dicksonia antarctica* in rainforest dominated by *Atherosperma moschatum* and *Elaeocarpus holopetalus*, Coast Range Road, Errinundra Plateau. Photograph by S. Ford, 1999.

total of ten families was represented with Sphaerophoraceae, Cladoniaceae, Lobariaceae and Trapeliaceae being represented by more than one species (Table 1).

Tree-ferns of Errinundra had the highest species richness with 21 lichen species being recorded (Table 1). Those of the Baw Baw Range had a very low species richness, with a total of only two species.

Twenty-one percent of the total number of tree-ferns examined had no lichens growing on them (Fig. 4). Thirty-four percent of tree ferns sampled supported only one lichen species. In most cases this was *Lepraria* sp.

In the Otways, a large percentage of tree-ferns (42%) supported one lichen species. Tree-ferns supporting two lichen species or no lichens were also commonly observed, with the maximum number of lichen species supported by a single tree-fern being five species (Fig. 5). In the Baw Baw region tree-ferns had either no lichen species growing on them or only one (Fig. 5). In Errinundra, however, tree-ferns supporting two lichen species were in the majority, but a high proportion of tree-ferns supporting one, three or five lichen species was also observed. Few tree-ferns in the Errinundra region did not support lichens, and the maximum number of lichen species supported by single tree-ferns was nine (Fig. 5).

Lichen species cover-abundance was compared between regions. Only lichen species which were abundant in one or more regions were considered. Generally, the tree-ferns of Errinundra supported the highest cover-abundance of lichens (Table 2).

Table 1. The lichens supported by the Soft Tree-fern *Dicksonia antarctica* showing the presence of each lichen species (+) in each of the regions studied.

Species	Otways	Baw Baw Range	Errinundra
Sphaerophoraceae			
Bunodophoron australe			+
Bunodophoron insigne			+
Bunodophoron murrayi	+		
Bunodophoron patagonicum			+
Bunodophoron ramuliferum	+		
Bunodophoron scrobiculatum			+
Lefidium tenerum			+
Cladiaceae			
Cladia aggregata	+		+
Cladoniaceae			
Cladonia ochrochlora			+
Cladonia ramulosa	+		+
Cladonia rigida var. *rigida*	+		+
Cladonia scabriuscula			+
Cladonia subradiata			+
Cladonia ustulata			+
Metus conglomeratus	+	+	+
Gyalectaceae			
Dimerella lutea			+
Micareaceae			
Micarea spp. agg.			+
Peltigeraceae			
Peltigera dolichorhiza	+		
Lobariaceae			
Pseudocyphellaria dissimilis	+		
Pseudocyphellaria glabra			+
Pannariaceae			
Psoroma asperellum			+
Trapeliaceae			
Trapeliopsis congregans			+
Trapeliopsis granulosa			+
Fungi Imperfecti			
Lepraria sp.	+	+	+
Crustose sp. 1			+
Total Species 25	**9**	**2**	**21**

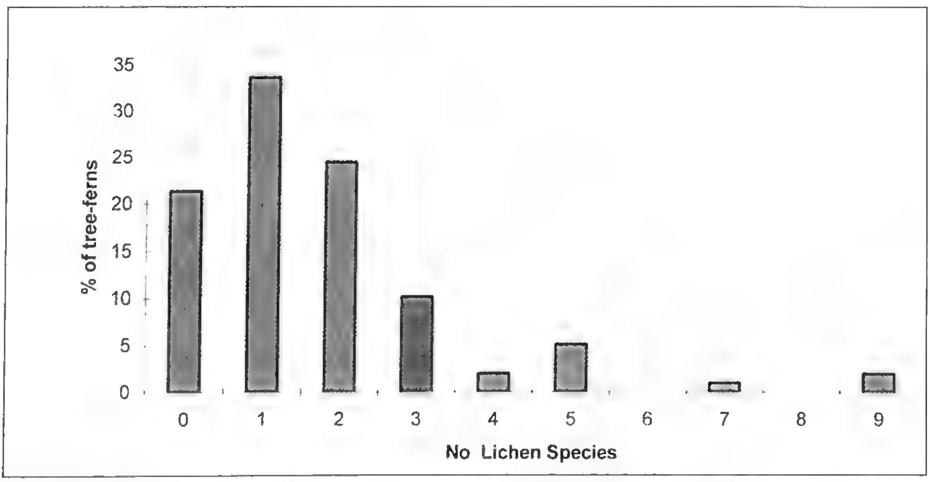

Fig. 4. Number of lichen species per tree-fern for all three rainforest regions, shown as a percentage of the total number of tree-ferns (n = 98).

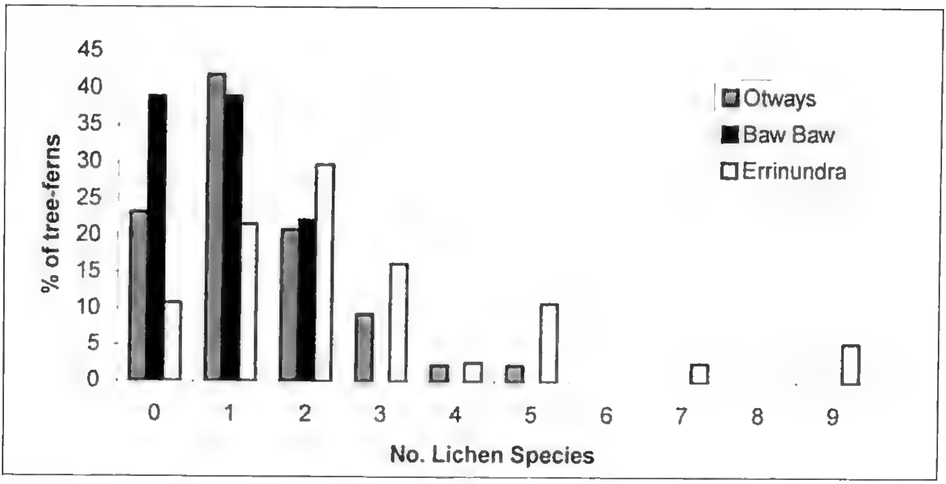

Fig. 5. Number of lichen species per tree-fern in each region, shown as a percentage of the total number of tree ferns, Otways (n = 43), Baw Baw Range (n = 18) and Errinundra (n = 37).

An exception was *Pseudocyphellaria dissimilis* (Nyl.) D.J. Galloway & P. James which was found only on the tree-ferns of the Otways. *Lepraria* sp. and *Metus conglomeratus* were found in all regions. *Lepraria* sp. usually had a cover of less than 5% although it did reach up to 20% and 40% cover at the Otways and Errinundra respectively, but only for a small proportion of tree-ferns. *M. conglomeratus* reached up to 40% cover in both the Otways and the Baw Baw Range but generally occurred on fewer trees than did *Lepraria* sp.

Cladia aggregata (Sw.) Nyl., *Cladonia rigida* var. *rigida* (Hook. f. & Taylor) Hampe and *Dimerella lutea* (Dicks.) Trevis. were all found in higher abundance at Errinundra than elsewhere, as was the case for most species. Only *Bunodophoron murrayi* (Ohlsson) Wedin, *Bunodophoron ramuliferum* (I.M. Lamb) Wedin, *Peltigera dolichorhiza* (Nyl.) Nyl. and *P. dissimilis* were not found at Errinundra (Table 1).

Discussion

The age of a tree-fern may be important in determining the number of lichens that can be supported. Tree-ferns in rainforests of the Otways and Errinundra were much taller, and therefore probably older, than those observed in rainforests in the Baw Baw Range. It is on these older tree-ferns that the highest species richness and highest numbers of lichens supported by each tree-fern were observed. The dead fronds of *D. antarctica* remained attached and formed a 'skirt' around trunks of shorter, younger tree-ferns. This was reported (Page and Brownsey 1986) to inhibit the colonisation and growth of climbers and large epiphytes. Ough and Murphy (1996) also reported that epiphytes were rarely seen on tree-fern trunks of less than 1.5 to 2 m in height, and were most commonly observed on taller tree-ferns, in the wet forests of the Central Highlands. This also was observed in this study for lichens in Victorian rainforests, although the microlichen *Lepraria* was sometimes observed in small amounts on young tree-ferns.

Victorian rainforests frequently display structural and floristic features which are clearly the result of past disturbance (Cameron 1992). Fire is the primary agent of disturbance at these sites, and may result in the development of multi-stemmed trees (Cameron 1992) such as those observed in many pockets of rainforest in the Baw Baw region. The low lichen abundance and species richness found in this study on tree-ferns in this region might be a result of a recent disturbance event such as fire. Widespread wildfire in 1926 burnt the southern slopes of the Baw Baw Range, and another fire in 1932 burnt the northern side of the Range as far as the Mt Erica-Thompson Dam Road intersection (D.C.E. 1991). The 'Black Friday' fires on 13 January 1939, burnt most of the Baw Baw National Park including the Plateau

Table 2. The percentage cover of selected lichen species on tree-ferns in the Otways (n = 43), Baw Baw Range (n = 18) and Errinundra (n = 37), Victoria. Only lichen species which were abundant in one or more regions were considered.

Cover-abundance of Lichen	% of tree-ferns with lichen cover *Otways*	*Baw Baw Range*	*Errinundra*
***Lepraria* sp.**			
0	25	39	22
<5	58	56	38
5	9	0	19
10	2	6	13
20	5	0	5
40	0	0	3
Metus conglomeratus			
0	81	78	78
<5	9	11	11
5	2	6	3
10	2	0	3
20	2	0	5
40	2	6	0
Cladia aggregata			
0	95	100	81
<5	5	0	3
5	0	0	13
70	0	0	3
Dimerella lutea			
0	100	100	73
<5	0	0	16
5	0	0	8
50	0	0	3
Pseudocyphellaria dissimilis			
0	79	100	100
<5	12	0	0
5	5	0	0
40	2	0	0
50	2	0	0
***Cladonia rigida* var. *rigida*.**			
0	98	100	92
<5	2	0	0
5	0	0	5
30	0	0	3

(D.C.E. 1991). It is very likely that the rainforest pockets of the region did not escape fire on all of these occasions, so, for many quadrats, a fire incident within the last 75 years seems likely. Similarly, the Otways forests were burnt in 1919, 1926 and 1939 (Brinkman and Farrell 1990). It appears that much of the rainforest has been free of fire for at least 60 years, although field observation for many rainforest stands examined suggest much longer fire-free periods probably occurred. The Errinundra Plateau does not show any signs of fire history within the last 150-160 years (D.C.F.L. 1989), suggesting fire history may be an important factor in the establishment and growth of lichens on tree-ferns.

Nothofagus cunninghamii is known to support a great diversity of lichen species (Kantvilas 1990). In Tasmania, a single tree may support in the order of 50 lichen species (Kantvilas 1990). However, a study on *N. cunninghamii* forests in the Baw Baw Range, Victoria, recorded a maximum of eight species per tree (Ford 1996). In that study, a total of 75 lichen species was recorded for this host (n=400 trees). Louwhoff (1995) reported 39 lichens for *N. cunninghamii* (n=205 trees) and 14 lichens for *A. moschatum* (n=47 trees) from the rainforests and mixed forests of Mt Donna Buang, Victoria. An old Huon Pine *Lagarostrobos franklinii* in western Tasmanian rainforest was recorded to support 76 lichen species (Jarman and Kantvilas 1995). A much younger Huon Pine from the same study supported 50 lichen species (Jarman and Kantvilas 1995). In the present study *D. antarctica* supported considerably fewer lichens than many other rainforest host species, with 25 lichen species recorded (n =98 tree-ferns), and a maximum number of nine lichens recorded on a single tree-fern.

Tree-ferns with inclined trunks tended to have more lichen species than those growing upright, especially those in the Errinundra region. Tree-ferns bend towards canopy gaps in search of light, so there was no shortage of examples of inclined trunks; however, no quantitative data are available. In the central highlands of Victoria, these ferns grow to about five metres and then fall over (Mueck *et al.* 1996). Where the growing meristem is not damaged, ferns continue their upward climb, providing the kind of habitat apparently needed for lichen growth.

Microlichens may not be as successful as macrolichens on tree-ferns because of the fibrous nature of the trunk. Many may be unable to find a suitable growing substratum under these conditions, although crustose species that are typically found growing over bryophytes tend also to be found on the trunks of tree-ferns, for example *M. conglomeratus* and *D. lutea*. A number of authors (Adams and Risser 1971; Eversman *et al.* 1987; James *et al.* 1977; Kantvilas and Minchin 1989) suggest that microclimatic factors, such as substratum characteristics and the availability of light, are more important than macroclimate in determining the distribution of lichens. Most factors influencing lichen distribution may be interpreted in terms of light and substratum characteristics (Kantvilas *et al.* 1985). For example, temperature is affected by the amount of sunlight, and forest age is related to differing substrata characteristics, i.e. fissured bark in *Nothofagus* spp. (Kantvilas 1990; Kantvilas *et al.* 1985).

Ongoing studies by the authors in the rainforests of Victoria, reveal that species of *Trapeliopsis* Hertel & G. Schneid. were rarely recorded on substrata other than tree-ferns. Similarly, *Peltigera dolichorhiza* (Nyl.) Nyl. was recorded mainly on rotting stumps, mossy rocks and tree-fern bases (tree-ferns being the only plants that the species is commonly recorded on). *Metus conglomeratus* also appears to have a fairly restricted host preference which includes the tree-fern *D. antarctica*, and the bases of large, old *N. cunninghamii*.

Overall, *D. antarctica* tree-ferns may make poor hosts for lichens, especially when the ferns are young, compared to other rainforest host species. However, certain species of lichen appeared to have a 'preference' for tree-ferns over other available rainforest hosts, marking the importance of *D. antarctica* in the forest ecosystem. Also, with age of tree-fern, and maturity of rainforest environment in the absence of fire, an increase occurs in the number of lichens supported by this conspicuous rainforest host species.

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References

Adams, D.B. and Risser, P.G. (1971). Some factors influencing the frequency of bark lichens in North Central Oklahoma. *American Journal of Botany* **58**, 752-757.

Brinkman, R. and Farrell, S. (1990). 'Statement of resources, uses and values for the Otway forest management area'. (Department of Conservation and Environment: Victoria.)

Busby, J.R. and Brown, M.J. (1994). Southern Rainforests. *In* 'Australian Vegetation', pp. 131-156. Ed. R.H. Groves. (Cambridge University Press: Melbourne.)

Calder, J. (1990). 'Parks: Victoria's National and State Parks'. (Victorian National Parks Assiciation, Canterbury Press Pty. Ltd.: Melbourne.)

Cameron, D. (1992). A portrait of Victorian rainforests: distribution, diversity and definition. *In* 'Victoria's rainforests: perspectives on definition, classification and management'. Eds P. Gell and D. Mercer. (Department of Geography and Environmental Science, Monash University: Melbourne.)

D.C.E. (1991). 'Mt Baw Baw National Park Resources and Uses'. (Department of Conservation and Environment: East Melbourne.)

D.C.F.L. (1989). 'Errinundra National Park proposed management plan'. (National Parks and Wildlife Division: Victoria.)

D.N.R.E. (1996). 'Otway National Park management plan'. (Department of Natural Resources and Environment – National Parks Service: Victoria.)

Eversman, S., Johnson, C. and Gustafson, D. (1987). Vertical distribution of epiphytic lichens on three tree species in Yellowstone National Park. *The Bryologist* **90**, 212-216.

Ford, S. (1996). 'Lichen distribution of cool temperate rainforest of the Baw Baw Range, Gippsland, Victoria'. (Unpublished Honours thesis, Department of Biological and Chemical Sciences, Deakin University: Melbourne.)

James, P.W., Hawksworth, D.L. and Rose, F. (1977). Lichen communities in the British Isles – a preliminary conspectus. *In* 'Lichen Ecology', pp 295-414. Ed. M.R.D. Seaward. (Academic Press: London.)

Jarman, S.J. and Kantvilas, G. (1995). Epiphytes on an old Huon Pine tree (*Lagarostrobos franklinii*) in Tasmanian rainforest. *New Zealand Journal of Botany* **33**, 65-78.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1991). 'Floristic and ecological studies in Tasmanian rainforest'. Tasmanian NRCP Technical Report No. 3. (Forestry Commission, Tasmania, and the Department of the Arts, Sport, the Environment, Tourism and Territories: Canberra.)

Kantvilas, G. (1990). Succession in rainforest lichens. *Tasforests* **2**, 167-171.

Kantvilas, G., James, P.W. and Jarman, S.J. (1985). Macrolichens in Tasmanian rainforests. *Lichenologist* **17**, 67-83.

Kantvilas, G. and Minchin, P.R. (1989). An analysis of epiphytic lichen communities in Tasmanian cool temperate rainforest. *Vegetatio* **84**, 99-112.

Ladd, P.G. (1991). Late Quaternary history of rainforest in Victoria. *In* 'The Rainforest Legacy: Australian National Rainforests Study. Volume 3 - Rainforest history, dynamics and management', pp. 55-69. Eds G. Werren and P. Kershaw. (Australian Government Publishing Service: Canberra.)

Louwhoff, S. (1995). 'The Lichen Flora of Mt Donna Buang Scenic Reserve, Victoria'. (Unpublished Master of Applied Science thesis, Biological and Chemical Sciences, Deakin University: Melbourne.)

Meagher, D. (1999). *Calomnion complanatum*: an endangered moss found in Victoria. *The Victorian Naturalist* **116**, 68-69.

Mueck, S.G., Ough, K. and Banks, J.C.G. (1996). How old are wet forest understoreys? *Australian Journal of Ecology* **21**, 345-348.

Ough, K. and Murphy, A. (1996). The effect of clearfell logging on tree-ferns in Victorian Wet Forest. *Australian Forestry* **59**, 178-188.

Page, C.N. and Brownsey, P.J. (1986). Tree fern skirts: a defense against climbers and large epiphytes. *Journal of Ecology* **74**, 787-796.

Peel, B. (1999). 'Rainforests and cool temperate mixed forests of Victoria'. (Department of Natural Resources and Environment: Melbourne.)

Seddon, G. and Cameron, D. (1985). Temperate rainforest. *Landscape Australia* **2**, 141-151.

Appendix. Scientific and common names index for vascular plants.

Scientific Name	Common Name
Acacia dealbata	Silver Wattle
Acacia melanoxylon	Blackwood
Atherosperma moschatum	Southern Sassafras
Blechnum wattsii	Hard Water Fern
Coprosma quadrifida	Prickly Current Bush
Cyathea australis	Rough Tree-fern
Dicksonia antarctica	Soft Tree-fern
Elaeocarpus holopetalus	Black Olive-berry
Hedycarya angustifolia	Austral Mulberry
Lomatia fraseri	Tree Lomatia
Nothofagus cunninghamii	Myrtle Beech
Olearia argophylla	Musk Daisy-bush
Pittosporum bicolor	Banyalla
Polystichum proliferum	Mother Shield Fern
Pomaderris aspera	Hazel Pomaderris
Tasmannia lanceolata	Mountain Pepper
Telopea oreades	Gippsland Waratah

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Survival in the Suburbs! The (re)discovery of the Threatened Swamp Skink *Egernia coventryi* East of Melbourne, with Comments on the Failure of Elliott Traps in a Survey for this Species

Nick Clemann[1]

Abstract
The Swamp Skink *Egernia coventryi*, listed as *Vulnerable* in Victoria, inhabits densely-vegetated wetlands, including both freshwater and saltmarsh habitats. Here I report the discovery and survey of a small, remnant population of Swamp Skinks occurring in a reserve at Boronia, east of Melbourne. Although visual surveys detected several individuals, none were caught in Elliott traps over 1530 trap nights, despite the lizards being observed very close to traps. These results have implications for the methods employed in future surveys for Swamp Skinks, and highlight the ease with which this species may be overlooked during surveys. The significance of this population, and its habitat, is discussed. (*The Victorian Naturalist*, **117** (5), 2000, 180-183.)

Introduction

The Swamp Skink *Egernia coventryi* is a medium-sized skink with a maximum snout-vent length of 130 mm and a maximum total length of 340 mm (Robertson 1980). It occupies a predominantly coastal distribution in south-eastern Australia. Within Victoria, the Swamp Skink occurs across the southern parts of the state, with disjunct coastal populations recorded from East Gippsland to the South Australian border. Relatively few inland populations have been reported, although records exist for localities including the Grampians Ranges National Park, Enfield State Forest, Yellingbo and East Gippsland (Smales 1981, Clemann and Beardsell 1999, Atlas of Victorian Wildlife database). The Swamp Skink is considered *Vulnerable* in Victoria (NRE 1999), and *Rare or Insufficiently Known* nationally (Cogger *et al.* 1993).

The Swamp Skink is an obligate inhabitant of densely-vegetated wetlands, including both freshwater and saltmarsh habitats (Robertson 1980, Smales 1981, Schulz 1985, Clemann 1997). It typically occurs in or adjacent to dense sedge and tussock life-form vegetation. The clearing of this vegetation for agricultural, residential and industrial development has exacerbated the disjunct distribution of populations, and is a major factor in concerns about the conservation of this species.

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Museum Victoria holds an old (1971) specimen of Swamp Skink collected in the Bayswater area. Dorward (1976) stated that the locality from which this specimen was collected is now a housing development. Robertson (1980) believed that populations in this area, if extant, must be fragmented as a result of development. Previous searches in the vicinity of this locality, by the author and others (J. Coventry *pers. comm.*), failed to detect the species. However, in September 1999 the author observed two individuals in a reserve in Boronia, close to the site where the Bayswater specimen was detected. The location of this reserve has been kept confidential because of the vulnerability of this population to collecting or other disturbance. This paper reports a survey undertaken to determine the distribution of the Swamp Skink within the reserve, and presents an evaluation of the significance of this population.

Methods

Trapping and observations

Trapping was conducted between 7 and 16 March 2000, using a total of 170 Elliott traps (1530 trap nights). Traps were used in groups of five to 20 traps (depending on the area of habitat available), and laid in various habitats within the reserve. Traps were positioned at distances ranging from 0.5 and 4m apart. Half of the traps in each group were baited with a mix of peanut butter, rolled oats and honey, and the rest with a piece of pilchard. The former bait has traditionally been used during surveys for Swamp Skinks (Robertson 1980, Schulz 1992), whilst the latter bait has been used in several studies and has proven effective (Clemann 1997, Clemann *et al.* 1998, Clemann and Beardsell 1999, P. Robertson *pers. comm.*). Within each trapping site, traps containing either bait were distributed in a bait-blind fashion, and positioned in microhabitats likely to contain Swamp Skinks. Traps were checked each morning and afternoon for the duration of the study, and fresh bait was added where necessary.

Opportunistic visual censuses were undertaken at all trapping sites and any other potentially suitable habitat throughout the reserve during optimal weather conditions (i.e. fine, sunny conditions with ambient temperatures ranging from 18°C to approximately 30°C). Observations of varying duration (depending on the amount and complexity of habitat) were conducted using 8x30 binoculars. Additionally, rocks and logs were rolled, and litter and grass clippings raked in an effort to detect sheltering Swamp Skinks.

Habitat

The reserve contains two lakes, remnant bush and swampland, and large expanses of open, grassy areas. Trap sites were chosen in the remnant bush and swampland and lakeside vegetation.

Common Reed *Phragmites australis*, Broadleaf Cumbungi *Typha orientalis* and Marsh Club-rush *Bolboschoenus medianus* dominate the lakeside habitat. More localised plants along the lake margins include Tall Sedges *Carex apressa*, Rushes *Juncus* spp. and Toowoomba Grass *Philaris aquatica*. The remnant bush and swampland consists of eucalypt woodland on the western boundary of the reserve, grading into a paperbark swamp in the south-west. The swamp is dominated by Swamp Paperbark *Melaleuca ericifolia* with a varying understorey of weed grasses, Soft Twig-rush *Baumea rubiginosa*, Red-fruit Saw-sedge *Gahnia sieberiana*, Tall Sedges and Blackberries *Rubus fruticosus*. On its western margin, the swamp forms an ecotone with the eucalypt woodland, where the dominant Swamp Paperbarks become interspersed with occasional eucalypts, acacias and Cherry Ballart *Exocarpus cupressiformis*. The understorey in this area contains abundant Austral Bracken *Pteridium esculentum*, weed grasses and occasional Spiny-headed Mat-rush *Lomandra longifolia longifolia*.

Results

The weather during trapping was ideal for surveying Swamp Skinks, with generally sunny conditions and daily maximum temperatures ranging between 21-33°C. Despite the relatively high human use of the reserve, and the prominent positioning of some traps, human disturbance was minimal. One trap was stolen, one was crushed, and several were moved small distances or thrown into the centre of reed beds.

Opportunistic visual censuses yielded six separate observations of adult Swamp Skinks. One individual was observed basking on a fallen paperbark branch amongst beds of Tall Sedge in a drainage line in the paperbark swamp. One small area of lakeside reeds yielded three sightings of Swamp Skinks basking in the reeds, including one sighting of two adults basking close together. This area contained numerous traps, and the lizards were usually basking within several centimetres of a trap. One individual was seen at the base of lakeside reeds a short distance from the previous observation, and another individual in grass on the fringe of the paperbark swamp in the south of the reserve. Previously (September 1999), the author had observed two individuals in weed grass at this latter site, one Swamp Skink in the lakeside reeds mentioned above, and one in weed grass beside a drainage ditch adjacent to these reeds.

No Swamp Skinks were trapped during the study. The traps yielded two species of small exotic rodents, the House Mouse *Mus musculus* (155 captures) and Black Rat *Rattus rattus* (16 captures). Ants invaded many of the traps, and this undoubtedly affected trap success. Ants more frequently invaded traps baited with pilchards than traps baited with peanut butter, rolled oats and honey, and the pilchard baits attracted far more ants to individual traps than did the other bait.

Discussion

The failure of the Elliott traps to capture any Swamp Skinks during this survey, even when the lizards were observed within *c.* 5 cm, was interesting. Previous authors (Robertson 1980, Schulz 1992, Clemann 1997, Clemann *et al.* 1998, Clemann and Beardsell 1999) have reported the success of this technique for surveying Swamp Skinks, and two (Robertson 1980, Schulz 1992) suggested that one can be reasonably certain of procuring specimens if they occur in an area and weather conditions and trap positioning are suitable. Weather conditions during this study were ideal for surveying Swamp Skinks, the baits previously proven, and the choice of trap position was based on the author's previous extensive experience with this species.

There are several factors that may have contributed to the failure of traps to capture Swamp Skinks. The population of Swamp Skinks within the reserve appears to be extremely small (as is the area of potential habitat). Robertson (1980, *pers. comm.*) has suggested that Elliott traps may fail to capture the species if population densities are very low. Different individuals appear to vary in their willingness to enter traps; very few of the animals present in a population enter traps in any one trapping session (P. Robertson *pers. comm.*). Recapture rates for this species are usually low, even in areas where large, dense populations exist, such as Boneo Swamp and the Hastings saltmarsh (Clemann 1997, P. Robertson *pers. comm.*). Swamp Skinks respond to visual cues from potential predators such as humans and birds (N. Clemann *pers. obs.*, Schulz 1985). Clearly, the animals were present in close proximity to the traps, however the constant threat of disturbance from people and dogs may deter the lizards from entering traps. Many of the traps became covered with ants attracted to the bait, and this is likely to discourage lizards from entering the traps.

Swamp Skinks were detected only by sight, and most individuals were seen in dense vegetation on the edges of open parkland where I was able to quietly approach potential basking sites. Only one individual was observed in dense vegetation some distance away from the cleared areas. It is likely that the vegetation in much of the paperbark swamp and small areas of lakeside habitat contain Swamp Skinks in low densities, but the dense vegetation and low number of Swamp Skinks in these sites makes visual detection difficult. Considerable effort (both trapping and visual censusing) was expended to detect the species during this study, and the results suggest that the population in the reserve is very small.

Visual censuses were confounded by interference from people and dogs. However, even when no people or dogs interfered with censuses, and weather conditions were apparently ideal, lizards were not observed at sites where they had been previously observed. This fact, combined with the failure of the traps to capture Swamp Skinks during this study, presents a dilemma. Even under apparently ideal conditions, it appears that it is very easy to overlook this species. Caution must therefore be exercised when assuming that this species does not exist in apparently suitable habitat, even in areas where the habitat is considered marginal or unlikely to support Swamp Skinks. This situation was highlighted by Clemann and Beardsell (1999) who detected the species in habitat that was atypical for Swamp Skinks.

The population of Swamp Skinks at this reserve is significant for a number of reasons. The conservation status of the species is of local, State and National importance, as shown by its State and National threatened species listing(NRE 1999; Cogger *et al.* 1993). Few secure populations of this species exist, and almost all of those occur near the coast in southern Victoria. The population at the reserve in Boronia is one of few inland populations, and the only one known to occur in the suburbs of Melbourne. The nearest Swamp Skink population to Boronia occurs at Yellingbo. The extremely small size of both this Swamp Skink population, and available habitat at the reserve in Boronia, makes it highly susceptible to extirpation with no chance of natural recolonisation. Habitat destruction is one of the major threats to the Swamp Skink, and undoubtedly a major factor contributing to its rarity and disjunct distribution. It is significant that the Swamp Skink has survived for three decades in an urban environment. Nevertheless these small patches of remaining habitat are not adequate for the long-term maintenance and survival of the species in the area. The remnant paperbark swamp at the reserve is the reason for the persistence of the lizard in this area, and is one of the few such habitats remaining in the region. Thus, both the Swamp Skink and the swamp are highly significant in the area, and, according to Reid *et al.* (1997), 'the patch of swamp scrub is undoubtedly one of the richest and most ecologically healthy in the Melbourne region. Such valuable examples are almost entirely confined in the region to the sand belt, where different plant species are present' (p. 91).

Future surveys for this species should consider using a variety of techniques (Elliott traps, rolling of rocks, logs and debris, and careful visual censuses) over a reasonable period of time under appropriate weather conditions.

Acknowledgements

This study was funded by Melbourne Water, and complements other studies on the Swamp Skink funded by this organisation. Angela Nott (Melbourne Water) was an invaluable contact, and facilitated all stages of the project. Willing field assistance was provided by Dr Geoff Brown and John Silins (both from the Arthur Rylah Institute), and Judith Graham. John Silins also provided technical support throughout the project. Peter Robertson (Wildlife Profiles Pty Ltd) provided useful advice and expert comment during the project. John Coventry (Museum Victoria) provided information on earlier surveys for Swamp Skinks. David Cameron (ARI) identified plant specimens. Dr Graeme Newell (ARI) provided useful guidance on computer graphic programs. This paper benefited from critical comments and insightful suggestions from Dr Geoff Brown, Dr Ian Norman and Richard Loyn (all ARI).

References

Clemann, N. (1997). Aspects of the biology and ecology of the Swamp Skink *Egernia coventryi* Storr, 1978 (Sauria: Scincidae). B. Sc. (Hons.) Thesis. Deakin University, Rusden Campus.

Clemann, N., Brown, P. and Brown, G. (1998). A note on bait selection when trapping the Swamp Skink *Egernia coventryi* in Elliott traps. *The Victorian Naturalist* **115:** 81-83.

Clemann, N. and Beardsell, C. (1999). A new inland record of the Swamp Skink *Egernia coventryi* Storr, 1978. *The Victorian Naturalist* **116:** 127-128.

Cogger, H. G., Cameron, E. E., Sadlier, R. A. and Eggler, P. (1993). 'The Action Plan for Australian Reptiles'. (Australian Nature Conservation Agency, Canberra. Endangered Species Program, Project No. 124.)

Dorward, D. F. (1976). 'Sites of special scientific interest in the Victorian coastal region. A report on the zoological aspects'. (Town and Country Planning Board: Melbourne).

Natural Resources and Environment (1999). 'Threatened vertebrate fauna in Victoria – 1999. A systematic list of vertebrate fauna considered extinct, at risk of extinction or in major decline in Victoria' (Department of Natural Resources and Environment: East Melbourne)

Reid, J. C., Moss, H. and Lorimer, G. S. (1997). 'Vegetation survey of linear reserves: a management strategy for riparian and flood plain vegetation'. (Knox City Council: Knoxfield, Victoria).

Robertson, P. (1980). 'ALCOA Portland Aluminium Smelter Environmental Report No. 1: Mourning Skink Investigations'. Report by Peter Robertson and Kinhill Planners Pty Ltd.

Schulz, M. (1985). The occurrence of the Mourning Skink, *Egernia coventryi* Storr, in saltmarsh in Westernport Bay, Victoria. *The Victorian Naturalist* **102 (5):** 148-152.

Schulz, M. (1992). 'The Swamp Skink (*Egernia coventryi* Storr 1978): a review' Report by Martin Schulz, Ecological Horticulture Pty Ltd, to Melbourne Water.

Smales, I. (1981). The herpetofauna of Yellingbo State Faunal Reserve. *The Victorian Naturalist* **98:** 234-246.

One Hundred Years Ago

"The Extinct Australian Emu

The following interesting letter appeared in Nature of 31st May last:-

A third specimen of the extinct *Dromaius ater*, VIEILLOT; FOUND IN THE R. ZOOLOGICAL MUSEUM, FLORENCE. –In January, 1803, a French scientific expedition, under Baudin, visited the coast of South Australia and explored Kangaroo Island, called by them 'Isle Decres'. One of the naturalists attached to the expedition was the well-known F. Péron, who wrote an interesting narrative thereof. He noticed that Decrès Island was uninhabited by man, but, although poor in water, was rich in kangarooos and emus (*Casoars* he calls the latter), which in troops came down to the shore at sunset to drink sea water. *Three* of these emus were caught alive, and safely reached Paris. Péron was unaware that the emu he had found on the Kangaroo Island was peculiar and specifically quite distinct from the New Holland bird; this was found out much later, and *too late*; for after Péron and his colleagues no naturalist evermore set eyes on the pigmy emu of Kangaroo Island in its wild condition! It appears that when South Australia was first colonized, a settler squatted on Kanagaroo Island and systematically exterminated the small emu and kangaroos.

Henry H. Giglioli, R. Zoological Museum, Florence, 15th May."

From *The Victorian Naturalist* Vol XVII, October 1900

Editor's note: The extinct King Island Emu is now known as *Dromaius ater*. The extinct Kangaroo Island Emu is now *Dromaius baudinianus*.

An Account of Ritual Combat in the Highland Copperhead *Austrelaps ramsayi* (Serpentes: Elapidae)

Nick Clemann[1] and Stephen Saddlier[1]

Abstract
Ritual combat has been observed in numerous families and genera of snakes. We report an observation of ritual combat in the Highland Copperhead *Austrelaps ramsayi*. Observations were made in February 1994 near Marysville, north-east of Melbourne in Victoria. Unusually for fighting snakes, the combatants occasionally reversed their postures, changing from being entwined with heads at the same end, to a head-tail posture. The adaptive significance of these observations is discussed. (*The Victorian Naturalist* 117 (5), 2000, 184-186).

Introduction

Ritual combat between male snakes has been observed in numerous genera of Australian elapid snakes, namely *Austrelaps*, *Cryptophis*, *Demansia*, *Drysdalia*, *Hemiaspis*, *Notechis*, *Oxyuranus*, *Pseudechis*, *Pseudonaja*, *Rhinoplocephalus* (Shine 1994) and *Parasuta* (as *Rhinoplocephalus*) (Turner 1992). It has also been documented on other continents, in, for example, Black Mambas *Dendroaspis polylepis* in Africa (Greene 1997). Similarly, ritual combat has been observed in many genera and species of pythons, boas, colubrids and vipers (Covacevich 1975; Shine 1994; Greene 1997). Combat may involve hissing and biting between combatants (Shine and Allen 1980; Turner 1992, Greene 1997), or simply elaborate wrestling matches (Baker 1968; Covacevich 1975; Greene 1997). Snakes rarely injure each other during combat, although Mole Snakes *Pseudaspis cana* may slash opponents whilst biting (Greene 1997).

Combat is more frequently observed in some species than in others. Ritual combat in the Red-bellied Black Snake *Pseudechis porphyriacus*, for example, has been documented on several occasions (Fleay 1937, 1951; Baker 1968; Shine 1977a), whereas few observations of combat exist for the genera *Austrelaps* and *Notechis*. The majority of recorded combat bouts in snakes are believed to occur between conspecific males. Combat is believed to occur during the mating season, often in the proximity of a female (Baker 1968). A strong correlation exists between the occurrence of male combat, and sexual dimorphism in which the male is the larger sex (Shine 1978). Combat does occur between males of species where females are the larger sex, however this is far less common (Shine 1978). The victor of such bouts is thought to secure mating 'rights' with the female (Greene 1997), and is usually the larger of the combatants (Shine 1991). In some species females may even delay mating to encourage combat before copulating with the victorious male (Greene 1997). Combat has been rarely recorded between female snakes, although it is known to occur (Whisenhunt 1949; Firmage and Shine 1996). Firmage and Shine (1996) document two types of combat in captive Island Tigersnakes *Notechis ater*. The first type of combat was between large males in the presence of a female, and was interpreted by the authors to be motivated by sexual competition. The second type of combat involved snakes of both genders and all sizes, including juveniles. This combat was initiated by the introduction of food into the snake's enclosures, and, unlike sexually-motivated combat, involved biting as well as (or instead of) wrestling. The authors suggest that this second type of combat may be a function of the high densities of snakes in the enclosures.

The genus *Austrelaps* consists of three species, all of which are endemic to Australia. The Dwarf Copperhead *A. labialis* occurs on Kangaroo Island and the southern Mount Lofty Ranges in South Australia, the Highland Copperhead *A. ramsayi* occurs in upland areas of eastern Victoria and New South Wales, and the

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Lowland Copperhead *A. superbus* occurs in Tasmania and lowland areas in southern Victoria, extending just into the south-eastern corners of South Australia and New South Wales (Cogger 2000). The distributions of *A. superbus* and *A. ramsayi* 'interdigitate and abut in eastern Victoria, particularly in the area south and west of the Baw Baw Plateau, but the species have not been collected syntopically' (Rawlinson 1991: p.126). Within this genus, ritual combat has been documented for *A. superbus* (Shine and Allen 1980) and *A. ramsayi* (Lintermans 1992). In the present paper, we document an additional account of ritual combat in *A. ramsayi*. Anecdotal reports of combat in this species have also been cited elsewhere (Shine 1987, Shine 1994).

Austrelaps ramsayi is a large, robust elapid that attains a maximum length of about 1.7 m (Green and Osborne 1994). The species exhibits sexual dimorphism; males attain larger sizes than females (Shine 1987). It occurs in montane and alpine environments up to 2000 m above sea level in eastern New South Wales and Victoria, predominantly along and east of the Great Dividing Range. The diet of the species primarily consists of lizards and frogs (Shine 1987, Coventry and Robertson 1991, Green and Osborne 1994). It is viviparous, mating in late spring to early summer, as well as autumn (Shine 1977a) and produces up to 31 young in March (Shine 1977b), although litters half this size are the norm (Shine 1987, 1991). Ovulation in spring and parturition in late summer allow gravid females to maintain high body temperatures for embryonic development, despite the occurrence of the species in high altitude (therefore cool) habitat. Evidence from dissected museum specimens (Shine 1987) suggests that female *A. ramsayi* often skip reproduction every third year or so, probably depending on weather and prey availability.

Observations and discussion

Two presumably male *Austrelaps ramsayi* were already engaged in combat when encountered on Lady Talbot Drive (800 metres above sea level), approximately eight kilometres north-east of Marysville, at around 1510 pm (daylight saving time) on February 9, 1994. This combat behaviour was recorded on video camera, for approximately 22 minutes. One snake was clearly larger than the other, and, although they were not measured, both were estimated to be between 0.6 and 0.8 m long. When initially sighted, the snakes were entwined along their mid-bodies, with tails lying side-by-side and heads apart. The tails of the snakes were repeatedly and vigorously entwined, and then separated, usually writhing the whole time. For most of the 'bout' the mid-bodies of the snakes remained tightly entwined. Although the heads of the snakes were separated and facing opposite directions for almost the entire bout, on two occasions one of the snakes struck savagely at the other, but did not inflict a 'chewing' bite. On these occasions the snakes would release each other before once again becoming entwined along the mid-body. After the second striking incident, the combatants rejoined in a reversed fashion, head to tail. This release and re-joining occurred several times, twice with the snakes' heads at opposing ends of the body, but more frequently with heads at the same end, though always separated. When the snakes released each other, one would attempt to ride along the other's dorsal surface, whilst re-commencing the entwining process. The observations were terminated when one of the observers removed the still-joined pair from the road, and this was the only time the snakes showed any reaction to the approach of the observers.

The position of the snakes' heads, when they were joined head to head, is consistent with sexually-motivated combat postures in other male elapids (i.e. whilst the posterior of the snakes was tightly entwined, the anterior of the combatants was not entwined).

The present observation of ritual combat in this species is consistent with combat in other ophidian taxa where males usually (but not always) attain greater sizes than females. The dimorphism exhibited by *A. ramsayi* (and other members of the genus) is likely to have selectively arisen in response to ritualised combat (Shine 1978). The combat documented in the present paper is broadly consistent with that observed for *A. superbus* (Shine and Allen

1980) and *A. ramsayi* in the Australian Capital Territory (Lintermans 1992). Similarities to the description of combat reported by Shine and Allen (1980) include the strikes delivered by the snakes, not followed by biting, and the oblivion to human observers. However, the behaviour whereby *A. ramsayi* would separate and re-join with heads at opposing ends, has not been reported for other members of the Elapidae.

The seasonal timing of the present observation (February 9) is consistent with that reported by Lintermans (1992), who observed this species fighting in late February. These observations in late summer suggests an extension to the putative breeding season of *A. ramsayi* (assuming that combat is always a prelude to mating activity), of spring to early summer, and autumn. We postulate that female *A. ramsayi* may store sperm over winter in readiness for spring ovulation and fertilisation.

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References

Baker, A. B. (1968). Snakes in combat. *Proceedings of the Royal Zoological Society of New South Wales* **1966-67,** 29-31.

Cogger, H. G. (2000). *Reptiles and Amphibians of Australia*. 6th Edition. (Reed New Holland: Frenchs Forest).

Covacevich, J. (1975). Snakes in combat. *The Victorian Naturalist* **92,** 252-253.

Coventry, A. J. and Robertson, P. (1991). 'The Snakes of Victoria: A Guide to their Identification'. (Department of Conservation and Environment: East Melbourne).

Firmage, M. and Shine, R. (1996). Battles for mates and food: intraspecific combat in island tigersnakes (*Notechis ater*) from southern Australia. *Amphibia Reptilia* **17,** 55-65.

Fleay, D. (1937). Black snakes in combat. *Proceedings of the Royal Zoological Society of New South Wales* **136-37,** 40-42.

Fleay, D. (1951). Savage battles between snakes. *Walkabout* **17,** 10-13.

Green, K. and Osborne, W. (1994). 'Wildlife of the Australian Snow Country' Reed Books: Chatswood).

Greene, H. W. (1997). 'Snakes: the Evolution of Mystery in Nature'. (University of California Press, Berkely and Los Angeles: California).

Lintermans, M. (1992). Ritual combat in the Highland Copperhead *Austrelaps ramsayi* (Serpentes, Elapidae). *Herpetofauna* **22 (2),** 15-17.

Rawlinson, P. A. (1991). Taxonomy and distribution of the Australian tiger snakes (*Notechis*) and copperheads (*Austrelaps*) (Serpentes, Elapidae). *Proceedings of the Royal Society of Victoria* **103 (2),** 125-135.

Shine, R. (1977a). Reproduction in Australian elapid snakes. I. Testicular cycles and mating seasons. *Australian Journal of Zoology* **25,** 647-653.

Shine, R. (1977b). Reproduction in Australian elapid snakes. II. Female reproductive cycles. *Australian Journal of Zoology* **25,** 655-666.

Shine, R. (1978). Sexual size dimorphism and male combat in snakes. *Oecologia* **33,** 269-277.

Shine, R. (1987). Ecological ramifications of prey size: food habits and reproductive biology of Australian Copperhead snakes (*Austrelaps*, Elapidae). *Journal of Herpetology* **21(1),** 21-28.

Shine, R. (1991). 'Australian Snakes: a Natural History'. (Reed Books: New South Wales).

Shine, R. (1994). Sexual size dimorphism in snakes revisited. *Copeia* **1994 (2),** 326-346.

Shine, R. and Allen, S. (1980). Ritual combat in the Australian Copperhead *Austrelaps superbus* (Serpentes, Elapidae). *The Victorian Naturalist* **97,** 188-190.

Turner, G. (1992). Courtship behaviour and male combat in the Little Whip Snake *Rhinoplocephalus flagellum* (Elapidae). *Herpetofauna* **22(1),** 14-21.

Whisenhunt, M. H. Jr. (1949). An account of copulation of the Western Diamond Rattlesnake. *Natural History Miscellany* **49,** 1.

Australian Natural History Medallion

2000 Medallionist: Dr. Malcolm Calder

The Medallion will be presented at a meeting of the Field Naturalists Club of Victoria
1 Gardenia Street, Blackburn (Melway 47 K10)
Monday 20 November at 8 pm

Malcolm Calder will speak on:

On Being a Field Naturalist – People, Plants and Politics

Admission to presentation is free. All welcome.

The meeting will be preceded by a reception with a light buffet at 7 pm. Cost $10 per head.
General enquiries ph. 9877 9860. Bookings for pre-presentation reception ($10)
Maria Belvedere, ph. 9877 9860, fncv@vicnet.net.au

We Paddle with the Platypus

Last March we drove to Forrest to Paddle with the Platypus. Three of us drove down the Great Ocean Road on a glorious Autumn Saturday. The ocean, the surf and the beaches looked magnificent. At Lorne we turned inland and joined the Benwerrin to Mount Sabine Road. This is beautiful wild-flower country, but there were no flowers in March. They are very colourful in November. However, we detoured down Turton's Track to see the huge eucalypts and the big old beeches of the rain forest. We almost missed Forrest, a small timber town by-passed by most roads. We spent the night at a quaint old-fashioned guest house, where we were served a delicious three-course meal at a garden table.

The Platypus man, Mark De-La-Warr, would collect us at 5.20 am on Sunday. This was the end of daylight saving, so clocks had to be adjusted. Predictably, the friend with the alarm clock forgot the time change, so we were showered and dressed at 3.40 am instead of 4.40 am. To fill in the time we lay down for an hour and one of us went to sleep. We all heard her snore! Eventually at 5.20 am, on what should have been the best sleep of the year, we set off in the back of a 4WD for Lake Elizabeth (Fig. 1). This is a most beautiful lake set in rain forest and girded by hillsides covered with tree ferns and eucalypt forest. It formed as a result of a large mud slide, blocking the East Barwon River in 1952, a very wet year. The year was made splendid by the coronation of Queen Elizabeth, so the lake was called Elizabeth.

Fig. 1. Lake Elizabeth, near Forrest, Victoria.

We climbed out of the jeep and our little torchlight procession wound along the forest track for about 20 minutes to the lake. Mark produced mugs of tea and fruit cake and went to fetch his long red Canadian canoe, hidden in the trees. We donned the lifejackets and binoculars provided and climbed in. Mark paddled along the lake in the early dawn mists. We immediately saw several Platypuses. They came up to the surface, swam along, then dived under the water for food. They were silver in the dawn light. We paddled around the lake for an hour or so. Every few minutes came a gently hissed location and direction of another Platypus, '10 o'clock in front of the big tree, 2 pm at 2 metres from the large stump.' About a dozen were feeding, swimming and diving on that small lake.

Mark has helped Melody Serena, of the Australian Platypus Conservancy, with her Platypus study in this area. He records the field observations and is the co-author of a paper (1999). He is a registered nurse at the Colac Hospital and he contributes part of the tour fee to Platypus research; for instance, to research on the ulceration of the Platypus' coat by the fungus *Mucor amphibiorum* which occurs in the Platypus colony on the Tamar River, Tasmania. Mark is also a mountaineer, having climbed in Peru and New Zealand.

We paddled to Mark's 'kitchen', a clearing in the bush, where he brewed espresso coffee on his camp stove and served it with shortbread. For the next hour or two we paddled around the banks to see the Platypus burrows, each with its little exit ramp (Fig. 2). Mark was able to tell us lots about the Platypus families, their lives and

Fig. 2. Platypus burrows and exit ramps, Lake Elizabeth.

their mating habits, which he is one of the very few to observe, and their feeding on shrimps, yabbies and caddis fly larvae, anything that moves slowly through the water. The Platypus embryo is very well formed inside the egg, so does not need continuous warmth. The nest is lined with grass and this composts providing warmth and comfort. When submerged, the Platypus can wedge itself in position, lower its respiration rate and is safe for about 10 minutes.

Mark tells his guests about the ecology of the area, about the trees and shrubs growing along the track that follows the steep, narrow, winding valley of the East Barwon River (Fig. 3).

Eventually, about five hours after our early start, we returned to the Country Guest House for brunch, a wonderful repast of bacon, eggs and tomatoes, served with orange juice, home-made bread and coffee. We drove back to Melbourne on the Otway Road, via Morac. There was not a blade of living grass on those bare, brown paddocks. What a contrast to the green forest with its lush ferns!

Mark reminded us that the first Platypus sent back from the young colony to England was regarded as a hoax. In those days Asians would create such a hoax by sewing together bits of different animals. And the Platypus does have a bird or duck-like bill with a sleek fur covered body and partly webbed and clawed feet!

Fig. 3. White-trunked blackwoods *Acacia melanoxylon*.

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Mark De-La-Warr, Otwild Adventures, Birregurra, Victoria; Adrian and Thea Brown, Forrest Country Guest House, Forrest, Victoria.

Reference

De-La-Warr, M., and Serena, M. (1999). Observations of Platypus *Ornithorhynchus anatinus* mating behaviour. *The Victorian Naturalist* **116**, 172-174.

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Water Rats *Hydromys chrysogaster* Seen in Fitzroy Gardens at Easter-time

At Easter-time, 19 April 2000, I sat down on emerald green grass next to the Dolphin Fountain pond, Fitzroy Gardens. I expected nothing more than the enjoyment of golden sunlight, and the pleasure of watching the head-bobbing displays of Pacific Black Ducks as they cruised the pond between bank and island.

Not more than five minutes had passed when the water's surface parted in a V-shape to reveal a broad bewhiskered face, powered by a ratty body. The creature up-ended in a dramatic vertical dive to the bottom of the pond, displaying the white tip of a heavily furred tail. A Water Rat, or Rakali – or *Hydromys chrysogaster*, which translates as 'golden bellied water mouse'.

What a treat! I watched the Water Rat swim around the man-made pond, collecting petals from the surface of the water. After procuring one petal, the rat would return to the island, climb up the low concrete wall and disappear briefly into some overhanging vegetation. My excitement had hardly died when I realised that the industrious Water Rat I had seen to-ing and fro-ing from the island to the water was in fact **two** Water Rats!

My front-row seat at this city pond enabled me to positively identify the second rat by the white tip of its tail, as it dived and swam less than a metre away.

I watched the Water Rats forage for about an hour, in the manner described above. Although the Water Rats were hidden in the overhanging vegetation, I wondered if they had taken the petals to a 'feeding table'. Water Rats are well known for having feeding platforms, which are generally out in the open, where prey is taken and eaten after hunting. Water Rats are primarily carnivores, therefore it may have been small arthropods feeding on the underside of the petals that were eaten by the rats at their feeding platform on the island.

I filed away the experience in my memory, under 'Enjoyable Urban Wildlife Encounter'. It was not until this July that I mentioned my sighting to George Paras, of the La Trobe University Wildlife Reserve. According to George, the Water Rat has been seen along the Yarra River and along the foreshore of Port Phillip Bay ... but never before in a man-made city park!

John Seebeck, in 'Mammals of Victoria', identifies the Water Rat as being widespread in fresh, brackish and saltwater bodies, including country Victoria and the urban areas of Port Phillip (Seebeck 1995). French Island, Phillip Island and Sunday Island are also home to the Water Rat (Seebeck 1971, 1995; Myroniuk *et al.* 1993). Water Rats are also reasonably common along the banks of the Yarra (Seebeck 1977), although there was some concern expressed about the effects of pollution and re-alignment of the river on these aquatic animals, especially downstream from Heidelberg.

Water Rats living in an artificial pond in the Fitzroy Gardens could signify an extension of their range into an environment entirely constructed by human hands.

While I watched the Water Rats, no less than three groups of people walked by, stood at the edge of the pond, and pointed out the Rats to each other. I believe this kind of chance encounter with native wildlife, whilst still in the city, is very important to ensure that native wildlife is present in the hearts and minds of the general public. Some of the people who visit the Fitzroy Gardens on their office lunch break may never visit more 'natural' environments like the Yarra or the foreshore where Water Rats usually live. Water Rats in Fitzroy Gardens could also represent an example of a wild animal that has managed to adapt (in an incredibly short time!) to our urban environment.

There remains many questions to answer – how long have the Water Rats been in Fitzroy Gardens? Did they come from the Yarra, or from the coast? What drains or other access points did they use? Is it a breeding population? Can Water Rats be found in other city parks with ponds?

Let's keep an eye out for these attractive mammals in our inner city parks, and try to answer some of these questions.

References

Myroniuk, P., Grusovin, J. and Thompson, R. (1993). Mammal survey of Sunday Island, South Gippsland, Victoria. *The Victorian Naturalist* **110**, 165-169.

Seebeck, J.H. (1971) Recommendations for a French Island Wildlife Reserve. Fisheries and Wildlife Department, Victoria, mimeograph.

Seebeck, J.H. (1977). Mammals in the Melbourne metropolitan area. *The Victorian Naturalist* **94**, 165-171.

Seebeck, J.H. (1995). Water Rat *Hydromys chrysogaster*. *In* 'Mammals of Victoria', p. 203. Ed. P.W. Menkhorst. (Oxford University Press: Melbourne.)

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Rock of Ages: Human Use and Natural History of Australian Granites

by Ian Bayly

Publisher: *University of Western Australia Press, 1999. 144 pp., 100 colour photographs. RRP $34.95*

This A4-sized book of 132 pages, excellently illustrated with colour photographs, gives the layman a comprehensive introduction to granite outcrops for Australian flora and fauna. It especially deals with the geomorphology of granite outcrops, which gives the tourist an extra scenic dimension when touring new areas. This is important when one realises that granite accounts for 15% of the area of our continent. Concentrating on photography but supported by excellent line diagrams, one can flick over the pages and appreciate the formation of flared slopes like Wave Rock, East of Hyden in WA (Chapter 1), gnammas (Chapter 4), the influence of jointing on the size and shape of granite tors (Chapter 10), cavernous weathering of tors, including fluting, split boulders, balancing tors, and sculptured boulders: all are dealt with from the aesthetic and recreational aspect.

The contents start with the age and distribution of granites. It is interesting to look at Fig. 1.2, p. 2 showing the distribution of Australian granites and noting the trends of the various sedimentary basins of different ages with which they are associated. Chapter 2 deals with the use of quarrying of granite, stressing its use for monuments, gravestones, building facades, lighthouses, park pavillions, dam walls and water storages. Chapter 4 deals with gnammas (pits and pans) and how they have been used by humans along with the life associated with them.

For the botanist, Chapter 6 deals with lichens, mosses and herbs on granite, especially resurrection plants, geophytes, therophytes, insectivorous plants and orchids. Rock isotomes seem to be specific to granite and no doubt there are others.

Chapter 8 shows how granite jointing assists the growth of eucalypts on granite at all altitudes. The same is true for sheoaks and pines, whilst granites can be the sites for the flowering plants *Calothamnus*, *Kunzea*, *Melaleuca*, *Dodonaea*, Heaths, *Acacia*, *Callistemon* (especially *C. pallidus*), *Correa*, and *Cyathodes*.

Terrestrial animals, especially reptiles and marsupials, frequenting granites are dealt with in Chapter 9.

Chapter 10 features magnificent granite formations in national parks, such as Murphy's Haystacks (Eyre Peninsula, SA), Standing Stones (Glen Innes, NSW), stone arrangements (Carma, WA), pillars (Carma, WA), cavernous boulders (Wedderburn, Victoria), polygonal cracking (Corrobinnie Hill, SA), fluting and sculptured tors (Flinders Chase, Kangaroo Island, SA).

Chapter 11 completes the treatise with conservation of granite areas for the future, especially for nature reserves, aesthetics and geomorphology. Managers need to heed the human impacts on granite landscapes, e.g. trail bikes, horse-riding and weed infestations.

Pages 123-4 contain a useful glossary of terms, a comprehensive bibliography (pp. 125-6) and a general scientific index (pp. 127-132).

Just by selecting this book and turning the pages, the photography and diagrams alone are enough to capture the interest of the reader somewhere through the book. Before you know it, you find yourself delving into the text for more detail. The book would make a wonderful gift for the generalist but for the specialist there is a wealth of detail, especially for those interested in geomorphology and natural history.

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Exploring Central Australia: Society, the Environment and the 1894 Horn Expedition

Edited by S.R. Morton and D.J Mulvaney

Publisher: *Surrey Beatty Pty Ltd, Chipping Norton, N.S.W., 1996.*
389 pp., illustrations, maps.
ISBN: 0949324671. RRP $85.00

The Horn Expedition, the last of the great scientific exploring expeditions of the nineteenth-century, set off in May 1894 to explore Central Australia, following the Finke River system into the Macdonnell Ranges and visiting Palm Valley and Uluru. Fourteen weeks and 2000 miles later the party reached Alice Springs where the Expedition effectively disbanded on 18th July. The inspiration and funding for this ambitious undertaking came from South Australian philanthropist William Horn. His vision for the Expedition was a systematic appraisal of the geology and mineral resources of the region, its fauna and flora, and the manners customs and appearance of the Aboriginal inhabitants. Principal members of the team, who were drawn from several of the Australian colonies, were Baldwin Spencer (zoologist and photographer), Ralph Tate (geologist and botanist), John Watt (who assisted Tate as geologist and mineralogist), Edward Stirling (anthropologist and medical officer) and Charles Winnecke (surveyor and meteorologist). The combined expertise of the expedition members made this possibly the most scientifically accomplished expedition that had ever ventured into the outback.

This volume of papers, *Exploring Central Australia: society, the environment and the 1894 Horn Expedition*, is the outcome of a centenary Symposium organised to mark the 100th anniversary of the Expedition. It is at once a celebration of the Expedition, an assessment of its accomplishments and an appraisal of the research which has been undertaken in the same areas in the 100 years since the Expedition. The Symposium was designed to encompass as wide a variety as possible of aspects of the cultural and natural history of Central Australia, as did the original Expedition. Prehistorians, historians, anthropologists, biologists, ecologists, geologists, Aboriginal people and social commentators were among those at whom the Symposium was aimed. The range of papers presented reflects the success of the organisers in meeting this aim.

The book is arranged broadly into four sections, each comprising papers grouped to illustrate the achievements of the Expedition or the work that has followed. In the first section are five papers which seek to place the Expedition in its cultural and scientific context and to assess its success. In putting the Expedition in context, the papers by P. Jones and T. Griffiths are illuminating. The Expedition was unlike any previous such ventures. It was not exploratory as had been usual. And unlike its immediate predecessors, it was well-organised, scientifically successful and not marred by the deaths of some of the participants. Coming at a time when nationalist sentiment was on the rise it was a co-operative enterprise which drew on expertise from several colonies and was backed by the participation of a number established museums and universities with their networks of connections. The Expedition also came at the point where research was shifting away from descriptive natural history and a concentration on field collecting towards an analysis of organisms in their environment. In addition the Expedition coincided with a prolonged dry period, where overstocking had such pronounced consequences in terms of erosion, stock disease, the destruction of native flora and ultimately the retreat from pastoral expansion.

D.J. Mulvaney, while giving passing reference to the Expedition's scientific and literary achievements, emphasises the impact of the Expedition on the local Aborigines and on Spencer himself. While not the leader of the Expedition, Spencer has attracted the greater share of attention, in part because of his critical role in editing and writing much of the original 5-volume Expedition report. Equally important was that Spencer's exposure to the Central Australian Aboriginal people proved a catalyst for the development of his subsequent career. The aborigines of the Centre became a focus of his attention in a manner that they did not for the Expedition's anthropologist Stirling. In material terms Spencer's major contribution was his collection of sacred objects and the vast number of photographs he took. Indeed many of his photographs are reproduced in the book and provide a fascinating and graphic insight into indigenous life in the outback. Spencer made a number of contacts during the Horn Expedition which helped him in his anthropological studies. The most important of these was Frank Gillen, and the association between these two men was a focus for several papers in this book. The correspondence of Spencer and Gillen during the years after the Expedition was influential in the direction which Australian anthropological studies took thereafter. G. Briscoe in his paper argues that the all-pervading influence of these two men was detrimental in that later government policy, so firmly based on their findings, was the cause of much injustice to Aboriginal people.

The emphasis on the anthropological aspects of the Expedition is continued in the second and third sections. Here are papers on Aboriginal way of life in the period up to 1894 and the impact of ever-encroaching European settlement, on Aboriginal tools, on the role that Aboriginal knowledge of the environment played in the Expedition's progress and conversely the impact of the Expedition on the indigenous people with whom it came in contact. The geological and botanical work of Tate is the subject of two papers. Both the geological report written by Tate in conjunction with Watt and Tate's palaeontological observations, published as an appendix to the geological report, are examined by P.F. Murphy with a view to assessing how far their work elucidated the geology of Central Australia. Tate's botanical collections were of great interest to Australia's leading botanist, Ferdinand von Mueller, himself one of the earliest expeditioners in the Australian outback but not a member of the Horn Expedition. His extensive knowledge of the flora of the desert regions of Australia allowed him to examine these collections as part of a larger flora, and his central role in working with Tate in the determination of his botanical specimens is discussed by L. Gillbank and S. Maroske.

In the final section are eight papers covering topics as diverse as hydrogeology, aquatic ecosystems and biogeographic patterns in inland Australia. A common theme in these papers is environmental change in the period since the Expedition, in particular the effect of climate and isolation on the biota of the region. The value of the observations made by the Expedition members as benchmarks for future management of the resources of the area is highlighted by several of the writers, a demonstration of the current concern with conservation and the dramatic shift in knowledge systems since 1894. There is a wealth of information in this volume, both of a historical nature and in relation to research in more recent times. Contemporary photographs are balanced by modern ones of the country through which the Expedition travelled. Each paper has an extensive list of references and the index is both comprehensive and easy to use.

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Sherbrooke Forest: its Flora and History

by Friends of Sherbrooke Forest Inc.

Publisher: *Friends of Sherbrooke Forest Inc, Belgrave, Victoria, 2000. 92 pp., RRP $18.00*

Sherbrooke Forest, situated in the Dandenong Ranges, has attracted visitors, picnicers, tourists, naturalists and walkers for over 100 years. I remember Sherbrooke from the 1950s when it was the destination for annual Sunday School picnics to the Dandenongs and the Forest, and during the sixties when the family piled into the car for a lazy Sunday afternoon drive through the hills and a stroll amongst the tall timbers of Sherbrooke.

The Friends of Sherbrooke Forest have produced a book designed to encourage all visitors to the Park to not only appreciate and respect the tall forest canopy, but also to see and identify the plants around them.

A short history opens the reader to past land and tree use, with timber harvesting, pine plantations and wildfires shaping the vegetation present today. The survival of the Lyrebird in Sherbrooke Forest provoked public controversy and eventually led to the removal of the pine plantations by clearfelling and their replacement with Mountain Ash, beginning in the 1970s.

But then the weeds took control. English Ivy, the main culprit, covered the planted Mountain Ash and smothered shrubs and understorey plants. The Friends of Sherbrooke was formed in 1980 with their major tasks being the removal of weeds and the conservation of habitat for the Lyrebirds. They aim to maintain Sherbrooke Forest in its natural state and encourage people to respect the integrity of the forest.

Creeks and gullies and the tracks of the forest are discussed and illustrated with black and white photographs, some from early this century, but still quite clear. The information on the tracks is particularly useful and includes details such as the name of the track, interesting facts about the track and its ease of use.

A valuable chapter on environmental weeds follows with a strategy for control. This information can be used in garden or bushland and would be of benefit to many Friends, Parkcare, Landcare and other environmental groups with similar weed problems. A reference list is included and those books recommended for plant study and bush management are asterisked.

The main part of this book is clearly the plants of the forest. The three major forest types – 'wet forest', 'damp forest' and 'cool temperate rainforest' are delineated according to dominant tree species and the guide describes where each is found in Sherbrooke. Plant species are listed under dicotyledons, monocotyledons and ferns, with each section colour-coded for easy reference. Each main section is further divided, the dicotyledons from large (Eucalypt trees) to small (herbs); monocotyledons by family groups (Juncaginaceae to Orchidaceae); and ferns (terrestrial and epiphytic). There is a descriptive page at the beginning of each section with illustrations of leaf and flower parts.

A total of 170 plants of 190 indigenous species found in the forest is presented in this book. Each has common name, scientific name, family and a detailed description of the species, including height, type of bark, leaves, flowers, flowering season and whether it is attractive to butterflies. Also included is information on where the species may be seen in the forest, a useful aid for any naturalist, who may be visiting the forest to find a particular species. The photographs are excellent, some showing close-ups of the flowers only, others leaves and flowers. Sometimes inserts are presented to provide more detail for some species, such as the fruits of eucalypts, leaf detail on Three-veined Cassia, or the fruit of Austral Mulberry.

I was confused at first by the presentation of the map before I realised that the middle section is shown on both pages. On the whole though, all detail is clearly marked including the three major vegetation types, creeks, tracks, roads, picnic grounds and points of interest.

Having read this book, I suddenly had the desire to revisit Sherbrooke Forest, book in hand, to walk the tracks and try to locate many of the species so enticingly illustrated on its pages. By its very nature, this book is not confined to the tall timbers of Sherbrooke, but it can also be used as a guide in other regions such as the mountain ranges of eastern Victoria and in the foothills of the Dandenongs, at parks and natural areas in Knox.

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William Dampier in New Holland – Australia's First Natural Historian

by Alex S. George

Publisher: *Bloomings Books, 37 Burwood Road, Hawthorn, Victoria, 1999.*
171 pp., 64 colour plates, with maps. RRP $43.95

Did you know that the first validated collections of Australian native plants were made by an Englishman on the north-western coast of Western Australia in 1699? This was 69 years before Joseph Banks made collections in Botany Bay; and 54 years before Linnaeus published his system of plant nomenclature which is the basis of modern plant taxonomy. Did you know that these collections were made by a self-trained natural historian who made his living as an explorer and privateer sometimes described as a pirate? Did you know that these specimens included a sample of Sturt Desert Pea, originally named *Donia formosa*, but subsequently changed to *Clianthus formosus*, then *Swainsona formosa* and now must be referred to as *Willdampia formosa*?

These, and many other revelations, dealing with plants and animals, are made in a wonderful book by Dr Alex George which has been published recently in Melbourne by Bloomings Books, entitled 'William Dampier in New Holland'. Dampier sailed in the *Roebuck* on January 24, 1699. He anchored in Shark Bay, landing on Dirk Hartog Island on August 17 of the same year. Later he landed on East Lewis Island, Dampier Archipelago (September 1), and then at Lagrange Bay from September 9-15 before heading to Timor and home via New Guinea and Cape Town.

Alex George is one of Australia's leading botanists and he has produced a book which is scholarly and a delight to read. Anyone who is interested in Australian plants, animals or scientific history should read this book. It is based on years of research and direct field and herbarium experience. George has had the good fortune to study Dampier's 24 plant specimens, deposited now in the Sherardian Herbarium at the University of Oxford. He has visited the sites where Dampier made his landing and he has produced a book which will become a landmark in Australian identification and interpretation of the animals Dampier described or had illustrated. The result is a balanced and authoritative account of these extremely important collections.

I think 'William Dampier in New Holland' will appeal to field naturalists generally, since it provides clear identification of all the plants and animals Dampier described and illustrated in his 1703 account of his expedition – 'A Voyage to New Holland in the Year 1699'. George has gone to great lengths to provide current nomenclature to the plants and animals which Dampier collected or described. He provides current, colour photographs of the sites as well as the organisms involved and compares them with the observations made by Dampier. It is a fascinating study.

Native plant enthusiasts will be particularly interested in the section covering the flowering plants collected by Dampier. These include: *Acacia coriacea* - a specimen with no flowers or fruit and only positively identified by George in 1968 when he studied the actual specimen; *Acacia ligulata*; *Adriana tomentosa*; *Beaufortia sprengelioides*; a Brachycome; *Calandrinia polyandra*; *Conostylis stylidioides*; *Dampiera incana*; *Diplolaena grandiflora*; *Frankenia pauciflora*; *Hannafordia quadravalvis*; *Lotus cruentus*; *Melaleuca cardiophylla*; *Myoporum insulare*; *Olearia 'dampieri'*; *Paractaenum novaehollandiae*; *Pittosporum phylliraeoides*; *Sida calyxhymenia*; *Solanum orbiculatum*; *Thryptomene baeckeacea*; *Trachymene elachocarpa*; *Triodia danthonioides*; *Willdampia formosa*; and the seaweed *Cystoseira trinodis*. For each of these species, none of which were given these names by Dampier, George sets out the history of nomenclature and the complex task of positive identification of specimens over 300 years old.

Dampier also described his observations of Cape Petrel; Caspian Tern; Australian Gannet; Crested Tern; Pied Cormorant; Eastern Reef Heron; Pied Oystercatcher; Australian Pelican; Grey Teal; Black-and-white Fairy-wren; Singing Honeyeater; Richard's Pipit; Little Corella; Boobies; Bridled Tern; Common Noddy; Crows, Hawks, Eagles and Kites. Marine animals include Flathead; Remora; Dolphin; Flying Fish; Spanish Mackerel; Alligator Pike; Humpback Whale and many others. Many of these animals and the plants were illustrated by Dampier or members of the crew and they constitute the very first illustrations of Australian wildlife. Dampier provided comprehensive notes on these and some land animals whose identification is difficult but probably includes Dingo; Banded Hare-wallaby; Quokkas and Bobtail Lizard. We can all take heart from the fact that Dampier and his crew suffered the annoying attention of the Australian Bush Fly. To quote (p. 133):

> 'While we were at work about the Well we were sadly pester'd with the Flies, which were more troublesome to us than the Sun, tho' it shone clear and strong upon us all the while, very hot.'

The Master, Jacob Hughes, wrote:

> 'There is ashoar abundance of small Flyes, which annoyed our people very much in tickling their faces & buzzing about their ears.'

This book is a natural history classic, written by a naturalist about a naturalist who introduced the English-speaking world to the unique flora and fauna of Australia. I strongly recommend it. It is superbly produced with wonderful historic and contemporary illustrations. It is a book I shall treasure and return to from time to time.

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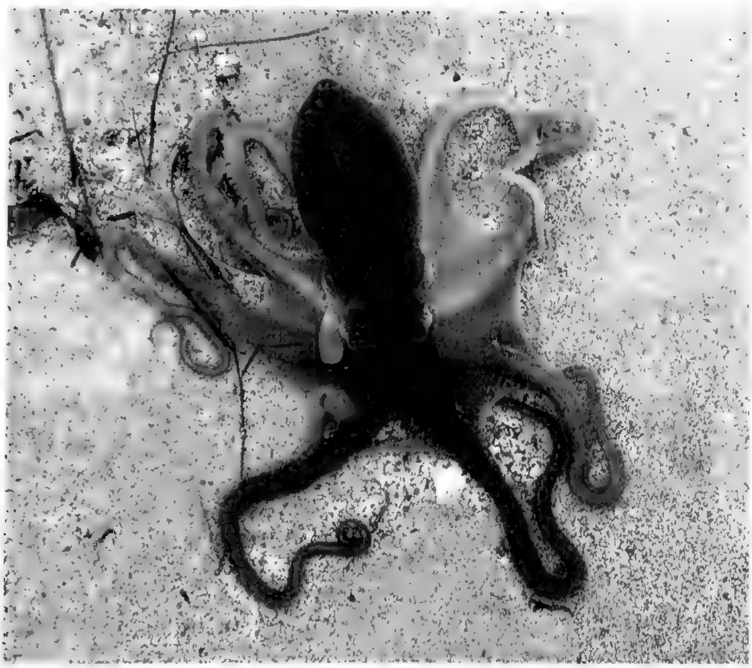

F.N.C.V.

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From the Editors

The Victorian Naturalist would not be successful without the enormous amount of time and effort voluntarily given by a large number of people who work behind the scenes.

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Guidelines for Authors at the end of this issue

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Cover: *Octopus kaurna* discovered at San Remo, Victoria. The octopus was sighted during low tide. See note on p. 228. Photo by Platon Vafiadis.

See our new web page: http://calcite.apana.org.au/fncv/vicnat.html
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Values and Knowledge of Wildlife among Members of the Field Naturalists Club of Victoria

Kelly K. Miller[1,2] and Tara K. McGee[2]

Abstract

This paper presents the findings from one aspect of a larger study (Miller 2000) which was prompted by a limited understanding of people's values and knowledge of wildlife in Victoria. It focuses specifically on the values and knowledge of wildlife held by members of the Field Naturalists Club of Victoria (FNCV), and how wildlife managers and other wildlife management stakeholders perceive FNCV members. In-depth interviews ($n = 15$) were used to explore wildlife managers' perceptions of FNCV members, while postal questionnaires ($n = 145$) were used to explore the values and knowledge of wildlife held by FNCV members. FNCV members expressed a very strong interest in learning about and interacting with wildlife, high levels of knowledge about wildlife and a relatively strong emotional attachment to individual animals. FNCV members displayed a very low interest in controlling wildlife for utilitarian purposes and a relatively low interest in the aesthetic value of wildlife. FNCV members also expressed a low fear of particular types of animals such as snakes and spiders. While the interviewed wildlife managers perceived FNCV members to have a strong interest in learning about wildlife, there was also a general perception that FNCV members would be less knowledgeable and have a weaker scientific perspective than the questionnaire findings suggested. Wildlife managers would benefit from remembering that community groups such as the FNCV often have a wealth of expert knowledge about wildlife and can make a significant contribution to wildlife management programs. (*The Victorian Naturalist* **117** (6), 2000, 200-206.)

Introduction

Human dimensions of wildlife management can be defined as '... the challenge of understanding and clarifying stakeholders' perspectives on wildlife management programs and issues, and systematically incorporating such insight into decision making' (Decker and Enck 1996: 61). Studies have shown that perceptions about the values and knowledge held by particular groups of people are not always consistent with the actual values and knowledge held by those groups. For example, Vining and Ebreo (1991) investigated discrepancies between groups' (resource managers, members of an environmental group, and the public) perceptions of each other's goals, and actual responses in relation to natural resources management. They found, for example, that resource managers perceived environmentalists as being less concerned about economic issues than they actually were.

It has also been shown that inaccurate perceptions among wildlife managers of others' values of wildlife can potentially lead to inappropriate or unsuccessful wildlife management programs. For example, an attempt to reintroduce wolves to Michigan's upper peninsula in the 1970s failed, largely because of human-inflicted mortality. Although biological and regulatory factors had been carefully assessed prior to wolf reintroduction, deeply ingrained anti-predator and anti-government attitudes contributed significantly to the program's failure (Kellert 1991, 1996).

Thus, it is important to conduct human dimensions research to better understand people's values and knowledge relating to wildlife. Such an understanding will enable wildlife management decision makers to either confirm or modify their perceptions to be consistent with reality. This will assist with more effective communication between stakeholders and the public, which is crucial in 'building commitment to a common direction' (Land and Water Resources Research and Development Corporation 1999: 8) among community and professional groups that sometimes have competing agendas (see also Hobbs and Saunders 1995; Harding 1998; Duda *et al.* 1998).

In Australia, a recognition of human dimensions as an important component of wildlife management is relatively recent (Jones *et al.* 1998). A lack of human

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dimensions research in Australia has meant that wildlife managers have had to rely on their perceptions of the values and knowledge of wildlife held by members of the public and wildlife management stakeholder groups when developing management programs. Importantly, research indicates that there can be considerable discrepancies between wildlife managers' beliefs, and the values and knowledge of wildlife held by stakeholder groups and the public that they serve (Miller and McGee, *unpubl. data*). Thus, there is an urgent need for managers to have a better understanding of the values and knowledge of wildlife held by groups with a 'stake' in wildlife management issues. This paper focuses on one such group, the Field Naturalists Club of Victoria (FNCV).

The FNCV was formed in 1880, making it the oldest conservation group in Australia. As of May 1997, the FNCV had just over 900 financial members listed. It is important for wildlife managers to understand the values and knowledge held by members of community groups with a 'stake' in wildlife management issues, as such groups play an important role in wildlife conservation and education. The major aims of the FNCV include:

- Promoting the study of natural history in all its branches.
- Establishing, encouraging, fostering and stimulating interest in natural history and in its advancement and popularisation by all and every means available.
- Taking all such steps as may be considered most effective to preserve, conserve and protect the natural environment of Australia and its environs and in particular the flora and fauna of Victoria.
- Collecting and disseminating information on all matters coming within the scope of the purposes of the Club or of associations and bodies affiliating or cooperating with the Club in its proceedings and activities (Julian 1996: 6).

The motto of the FNCV is 'understanding our natural world' and its vision statement reads: 'The FNCV will be well known, highly regarded and expert in nature education, field research and conservation, with an active and involved membership' (Wallis 1997: 1). Human dimensions research will be an important tool for assessing whether the Club is achieving this vision. Thus, this paper describes the values and knowledge of wildlife held by members of the FNCV, and how wildlife managers and other wildlife management stakeholders perceive FNCV members in terms of their values and knowledge of wildlife.

Methods

In order to explore the way in which wildlife managers perceive members of the FNCV, semi-structured interviews were conducted with professional wildlife/environmental managers from Parks Victoria and local government. Members of non-management stakeholder groups, including FNCV, Australian Conservation Foundation, Royal Society for the Prevention of Cruelty to Animals, Victorian Field and Game Association[1] and Bird Observers Club of Australia, who have an important, though indirect, role to play in wildlife management were also interviewed. In total, 15 interviews were conducted. Interview participants were chosen using 'extreme case' sampling, a technique which involves choosing participants who will 'throw a particularly strong light on the phenomenon of interest' (Robson 1993: 142). In most cases, participants were selected by telephoning each government organisation or stakeholder group and asking to speak with their conservation officer or equivalent. The resulting sample was one that included a range of different types of wildlife managers/environmental managers and members of community groups that have a key role to play in wildlife management or input into decision making.

The interviews were exploratory in nature, and were designed to investigate the way in which the participant perceived the members of the FNCV in terms of their values and knowledge of wildlife. Prior to commencing the interview, participants were given an introductory letter which outlined the purpose of the interview, time required (approximately one hour) and issues of confidentiality. These details were also included in the consent form,

[1] In late 1998, the Victorian Field and Game Association became a national body and is now called Field and Game Australia.

which was completed and signed by participants before the interview commenced.

In order to explore the actual values and knowledge of wildlife held by members of the FNCV, a postal questionnaire was distributed to 200 randomly selected FNCV members. The 12 page questionnaire, based on that used by Kellert (1979, 1980; Kellert and Berry 1981; Kellert *pers. comm.*), was designed to explore public values of wildlife, knowledge of wildlife, behaviours relating to wildlife, and basic demographic characteristics of respondents. Values of wildlife were explored by asking respondents to indicate the extent to which they agree or disagree with a range of attitude statements on a scale of one to five. A values framework was then developed (Table 1) based on Kellert's (1996) Typology of Basic Values and Factor and Reliability Analyses of questionnaire data.

Items on the curiosity/learning/interacting value scale related to learning about the ecology and biology of Australian wildlife species and interacting with nature. While the scale focused mainly on animals (invertebrates and vertebrates), it also included questions relating to plants. Items on the dominionistic/wildlife-consumption value scale related to activities such as recreational hunting, trapping, wildlife harvesting for meat or fur, and the use of animals in circuses and medical research. Items on the utilitarian-habitat value scale related to issues such as timber production, the economic livelihood of people who make a living from primary production, and the use of pesticides in food production. Items on the humanistic value scale related to the emotional bond and 'love' felt for animals. Negativistic value scale items related to interaction with certain types of wildlife such as snakes and spiders; and items on the aesthetic value scale related to the preference of wildlife/nature perceived to be attractive over wildlife/nature perceived to be unattractive, and included wild animals, zoo animals, companion animals and plants (Miller and McGee 2000).

Knowledge of wildlife was explored by asking respondents to select the correct answer to a range of questions. Topics for the knowledge of wildlife scale included insects, fish, amphibians, reptiles, birds, mammals (monotremes, marsupials, and placental mammals), native and introduced species in Australia and wildlife management (Miller and McGee 2000).

Questionnaires were mailed to FNCV members in September 1997, with a covering letter, consent form and a reply-paid envelope. The covering letter outlined the purpose of the study, how participants were selected, the use of the consent form, approximate time required to complete the questionnaire (approximately 15 minutes), issues of confidentiality, and contact details for further information. It also explained that participation was voluntary

Table 1. Values Framework (Miller and McGee 2000).[1]

Value	**Description**
Curiosity learning/interacting	Interest in exploring, experiencing and learning about wildlife and nature.
Dominionistic wildlife-consumption	Interest in controlling aspects of nature through consumptive wildlife activities
Utilitarian-habitat	Interest in the practical value of the land.
Humanistic	Emotional attachment and love for aspects of nature.
Negativistic	Fear and aversion of wildlife.
Aesthetic	Interest in the physical appeal and beauty of wildlife and nature.

[1] Reliability Analyses confirmed the reliability of each value scale, with reliability coefficients (Cronbach's Alpha) ranging from 0.7 to 0.9. Each value scale consisted of between five and 18 questions

This value is a combination of Kellert's original naturalistic value (an interest in the direct experience and exploration of nature), ecologistic value (an interest in the relationships between species and natural habitats) and scientific value (an interest in the physical attributes and biological functioning of animals)

Statistical analysis found this value to be the opposite of Kellert's original moralistic value (a spiritual reverence and ethical concern for nature).

and that they could choose not to answer particular questions if they wished. A total of 145 completed questionnaires were returned from a total of 190 eligible questionnaire recipients (76%) and the demographic profile of the sample is shown in Table 2. More than 70% of the FNCV sample lived in metropolitan Melbourne, almost 60% were male, almost 60% were 50 years of age or more, approximately 50% held a bachelor degree or higher, and over 80% of the sample were born in Australia.

For data obtained through the interviews, open-ended questions were analysed qualitatively for key themes and important comments. These components of the data are illustrated using direct quotes from respondents, labelled with the participant's job description (e.g. Conservation Coordinator, March 1998). To ensure anonymity, exact job titles were not used. Although the interview sample consisted of a broader range of people than just wildlife managers, interview participants are referred to as 'wildlife managers' when discussing responses. For quantitative data obtained through the questionnaires, inferential (One-Way ANOVA and Chi-Square tests) and descriptive statistics were used with comparative data statistically significant at $p \leq 0.05$.

Results and Discussion

The values held by members of the FNCV were perceived in different ways by wildlife managers. While most interview respondents believed that FNCV members would have a strong naturalistic perspective, others felt that their interest would be more scientific or ecologistic (see Table 1 for value descriptions). There was also a clear perception that members of voluntary conservation organisations such as the FNCV would have a strong emotional perspective relating to wildlife (e.g. humanistic and moralistic values), as opposed to a scientific perspective.

Interestingly, one respondent described the material published in *The Victorian Naturalist* as 'semi-scientific'. These perceptions are highlighted by the following responses:

> I don't believe that the field naturalists would be as experienced and as scientific (I could be wrong) as Parks Victoria... They're similar to the Bird Observers Club, would have the best intentions at heart, but I don't know

Table 2. Demographic profile of the Field Naturalists Club of Victoria sample.

Variable	Category	Percentage of sample (n = 145)
Geographic location	Metropolitan Melbourne	72.4
	Regional Victoria	26.9
	Not stated	0.7
Gender	Male	57.9
	Female	42.1
	Not stated	0.0
Age	18-34	7.6
	35-49	31.7
	50-69	37.2
	70+	22.1
	Not stated	1.4
Formal education	Not qualified[1]	21.4
	Vocational qualification/Diploma	20.0
	Bachelor degree/Postgraduate diploma/ Higher degree	49.7
	Inadequately described/Not stated	8.9
Country of birth	Australia	84.1
	UK/Ireland	10.3
	Europe	0.7
	Other	4.1
	Not stated	0.7

[1] The Department of Infrastructure (1998) defines people with no educational qualifications beyond secondary school as having 'no qualifications'.

> whether they would be education-wise... as experienced as Parks Victoria (Environmental Control Officer, May 1998).

> [FNCV has] much more of a naturalistic approach..., and the science, the aesthetics, all the other bits really are add-ons (Environment Coordinator, April 1998).

Thus, some wildlife managers may regard the FNCV and other similar stakeholder groups as unscientific and lacking objectivity. This may affect the interaction between managers and such groups. For example, a manager who perceives the members of the FNCV as having humanistic values rather than scientific or ecologistic values may dismiss the opinions of FNCV members regarding a proposed management plan.

Several interview participants expressed the view that the staff from Parks Victoria would have a stronger scientific perspective than members of voluntary organisations such as the FNCV. Similarly, most interview participants believed that members of the FNCV would have high levels of knowledge about wildlife. For example, one interview respondent said:

> The people that I know [from the FNCV] spend a huge amount of time researching, they read a lot, a lot of them produce papers and study. So yeah, as good as the paid pros who've been through uni in Parks Vic (Land Management Officer, April 1998).

However, several of the interviewed managers expressed the view that FNCV members would have a lower knowledge than the staff of Parks Victoria. For example, one interview respondent said of the FNCV:

> Oh I think they're well meaning people who try to use the scientific knowledge of Parks Victoria to better explain to the community aspects of wildlife in more simplistic and practical terms (President of wildlife management stakeholder group, May 1998).

Many of the perceptions expressed by the interviewed wildlife managers were found to be inaccurate, with FNCV members scoring higher on the curiosity/learning/interacting and knowledge of wildlife scales than the other stakeholder groups included in the study[2], including the staff of Parks Victoria (Fig. 1). FNCV members expressed a very strong curiosity/learning/interacting value, high levels of knowledge about wildlife and a relatively strong humanistic value. They displayed low dominionistic/wildlife-consumption, utilitarian-habitat, negativistic and aesthetic values. Further comparisons between the stakeholder groups sampled will be the subject of a future paper.

The results obtained for the FNCV were not surprising considering the aims and demographic profile of the Club. What was surprising, was that some wildlife managers did not perceive the members of the FNCV to be as knowledgeable or as interested in science and ecology as they actually were. Further, the demographic profile of the FNCV sample (Table 2) shows that members of the FNCV have very high levels of formal education[3], with 49.7% holding bachelor degrees or higher (n = 145). This is considerably higher than Parks Victoria, where 30.3% of staff[4] who completed questionnaires (n = 142) held bachelor degrees or higher (Chi-Square Test: χ^2 = 11.21, df = 1, $p < 0.001$). Thus, the findings of this enquiry suggest that the perception held by some wildlife managers that Parks Victoria staff are more knowledgeable and scientific than FNCV members is not an accurate one.

These findings have some important management implications. Managers should not overlook the importance of working together with community groups such as the FNCV so as to utilise their expertise and commitment to wildlife conservation. As Decker and Chase (1997)

[2] The other stakeholder groups included in the study were Parks Victoria, the Bird Observers Club of Australia, the Victorian Field and Game Association, the Royal Society for the Prevention of Cruelty to Animals and the Australian Conservation Foundation.

[3] Of the 101 FNCV respondents who held formal educational qualifications, 50.5% studied for their qualification in the natural and/or physical sciences.

[4] Staff employed in the 'finance and property' section of Parks Victoria, administration and personnel staff, casual staff, and 'construction and maintenance' staff were omitted from the sampling frame to ensure that the selected sample consisted only of those staff who have a role to play (either direct or indirect) in environmental management (e.g. rangers, conservation officers, environmental planners etc.).

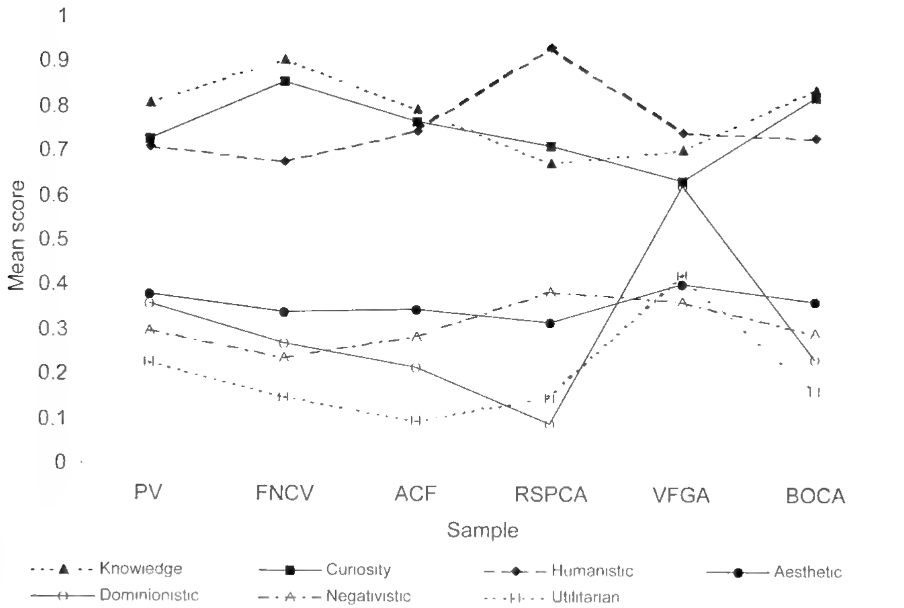

Fig. 1. Mean value and knowledge scores for stakeholder samples. Scores were standardised between 0 and 1. Value scores of less than 0.5 suggest that the respondent does not express the value; a score of 0.5 suggests a neutral perspective; and a score of greater than 0.5 suggests that the respondent does express the value. One-Way ANOVA tests revealed significant differences between the stakeholder groups for each of the value and knowledge scales ($p < 0.05$).
PV = Parks Victoria ($n = 142$), FNCV = Field Naturalists Club of Victoria ($n = 145$), ACF = Australian Conservation Foundation ($n = 144$), RSPCA = Royal Society for the Prevention of Cruelty to Animals ($n = 127$), VFGA = Victorian Field and Game Association ($n = 82$), BOCA = Bird Observers Club of Australia ($n = 152$).

suggest, in their review of the types of approaches to stakeholder input and involvement in wildlife management issues in the United States, future wildlife management may require management agencies to 'share or delegate authority for management to stakeholders' (p.793). Such an approach will require wildlife managers to be aware of knowledge levels and values of wildlife held by stakeholder members. Such an understanding may assist wildlife managers in working together with stakeholder groups to achieve management objectives.

Conclusions

The results of this study support the finding that wildlife managers often have inaccurate perceptions about voluntary community groups such as the FNCV. It is important to understand such perceptions if wildlife managers are to successfully communicate and interact with community groups. It is also important for the FNCV to understand how other stakeholder groups perceive their membership, so that they can develop strategies to achieve their aim to be 'well known, highly regarded and expert in nature education, field research and conservation, with an active and involved membership' (Julian 1996: 6). The results of this study have shown that members of the FNCV have a very high level of knowledge about wildlife and a high level of formal education in the natural and physical sciences. They also hold a very strong curiosity/learning/interacting value. However, the aims for the FNCV to be 'well known' and 'highly regarded' in nature education, field research and conservation need some attention to bring perceptions in line with reality. Once managers recognise and understand the values and knowledge of wildlife held by groups such as the FNCV, there may be more effective communication between groups and better management of Victoria's wildlife.

Acknowledgements

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References

Decker, D.J. and Chase, L.C. (1997). Human dimensions of living with wildlife - a management challenge for the 21st century. *Wildlife Society Bulletin* **25** (4), 788-795.

Decker, D.J. and Enck, J.W. (1996). Human dimensions of wildlife management: knowledge for agency survival in the 21st century. *Human Dimensions of Wildlife* **1** (2), 60-71.

Department of Infrastructure (1998). 'Melbourne in Fact: 1996 Census Statistics in Melbourne's Local Government Areas'. (Government of Victoria: Melbourne.)

Duda, M.D., Bissell, S.J. and Young, K.C. (1998). 'Wildlife and the American Mind: Public Opinion on and Attitudes toward Fish and Wildlife Management'. (Responsive Management: Harrisonburg, Virginia.)

Harding, R. (Ed.) (1998). 'Environmental Decision-Making'. (The Federation Press: Sydney.)

Hobbs, R.J. and Saunders, D.A. (1995). Conversing with aliens: do scientists communicate with each other well enough to solve complex environmental problems? *In* 'Nature Conservation 4: The Role of Networks', pp. 195-198. Eds D.A. Saunders, J.L. Craig and E.M. Mattiske. (Surrey Beatty & Sons: Chipping Norton.)

Jones, D.N., Enck, J.W., Siemer, W.F., Decker, D.J. and Brown, T.L. (1998). An introduction to human dimensions of wildlife management: taking the North American experience to Australia. HDRU Series, 98-7. Human Dimensions Research Unit, Cornell University: Ithaca, New York.

Julian, J. (1996). The way forward: a review of the strategic issues and directions of the Field Naturalists Club of Victoria Inc. Field Naturalists Club of Victoria: Melbourne, Australia.

Kellert, S.R. (1979). 'Public Attitudes Toward Critical Wildlife and Natural Habitat Issues'. (U.S. Government Printing Office and U.S. Fish and Wildlife Service: Washington, D.C.)

Kellert, S.R. (1980). 'Activities of the American Public Relating to Animals'. (U.S. Government Printing Office and U.S. Fish and Wildlife Service: Washington, D.C.)

Kellert, S.R. (1991). Public views of wolf restoration in Michigan. Transactions of the North American Wildlife and Natural Resources Conference **56**, 152-161.

Kellert, S.R. (1996). 'The Value of Life: Biological Diversity and Human Society'. (Island Press: Washington, D.C.)

Kellert, S.R. and Berry, J.K. (1981). 'Knowledge, Affection and Basic Attitudes Toward Animals in American Society'. (U.S. Government Printing Office and U.S. Fish and Wildlife Service: Washington, D.C.)

Land and Water Resources Research and Development Corporation (1999). Social and Institutional Research Program, 1999-2004 Plan. (LWRRDC: Canberra.)

Miller, K.K. (2000). Public and Stakeholder Values and Knowledge of Wildlife in Victoria, Australia. (Unpublished Ph.D. Thesis, Deakin University, Victoria.)

Miller, K.K. and McGee, T.K. (2000). Sex differences in values and knowledge of wildlife in Victoria, Australia. *Human Dimensions of Wildlife* **5** (2), 54-68.

Miller, K.K. and McGee, T.K. (unpublished data). Towards incorporating human dimensions information into wildlife management decision making. Deakin University, Melbourne.

Robson, C. (1993). 'Real World Research: A Resource for Social Scientists and Practitioner-Researchers'. (Blackwell Publishers: Oxford.)

Vining, J. and Ebreo, A. (1991). Are you thinking what I think you are? A study of actual and estimated goal priorities and decision preferences of resource managers, environmentalists, and the public. *Society and Natural Resources* **4**, 177-196.

Wallis, R. (1997). President's Report. *Field Nats News* **57**, 1.

Water Rats in Fitzroy Gardens

Re the article by Tania Loos about Water Rats in the Fitzroy Gardens (*The Victorian Naturalist* 117 (5), 2000). Our company, Eco-Adventure Tours, delivers possum education tours in these gardens for the City of Melbourne over the summer months. A Water Rat was observed in a pond in the Fitzroy Gardens by our guide, Richard Seymour, on 7 April, 1999.

Karen Garth
Eco-Adventure Tours, P.O. Box 542,
Healesville, Victoria 3777.

Stand Structure and Recruitment Patterns in *Callitris-Eucalyptus* Woodlands in Terrick Terrick National Park, Victoria

David Parker[1,2] and Ian D. Lunt[1]

Abstract

Terrick Terrick National Park supports the largest stand of White Cypress-pine *Callitris glaucophylla* in Victoria. This project aimed to assess: (1) changes in *Callitris* distribution in Terrick Terrick National Park over the past 50 years using aerial photographs and girth analyses; (2) the amount of regeneration which has occurred since grazing was removed in the early 1990s, and; (3) the potential for future *Callitris* expansion by comparing soils in areas of dense *Callitris* and open woodland. Aerial photographs showed little change in *Callitris* distribution since the 1940s. Dense regeneration (92,500 saplings / ha) occurred in small plots that were fenced in 1958, indicating that regeneration was inhibited by rabbits and stock. Additional regeneration occurred after heavy rains in the 1970s, and recruitment appears to be ongoing in some areas. Contrary to expectations, stand class analysis showed that *Eucalyptus* species have recruited more abundantly than *Callitris* in recent years. Eucalypts are thought to have recruited after removal of stock grazing and cessation of eucalypt culling since transfer to a State Park in 1988. *Callitris* forest tended to occur on sandier soils than open woodlands, however there was considerable overlap between *Callitris* and non-*Callitris* soils, which suggests that some open areas may be suitable for *Callitris* recruitment in the future. Current levels of eucalypt and *Callitris* recruitment may play a valuable role in enhancing habitat complexity at Terrick Terrick National Park. (*The Victorian Naturalist* **117** (6), 2000, 207-213.)

Introduction

Woodlands dominated by White Cypress-pine *Callitris glaucophylla* J. Thompson and L.A.S. Johnson are widespread across central and southern Australia (Boland *et al.* 1984; Bowman and Harris 1995). Most *C. glaucophylla* woodlands in south-eastern Australia have been substantially altered since European settlement, owing to lengthy periods of fire exclusion, heavy grazing by rabbits and stock, and forestry activities (Lacey 1972, 1973; Forestry Commission of New South Wales 1988; Curby 1997; Noble 1997; Allen 1998).

In northern Victoria, most *C. glaucophylla* woodlands have been cleared for agriculture, and few large tracts remain. Until recently, *C. glaucophylla* was listed as a 'depleted' species in Victoria (Gullan *et al.* 1990), as a result of habitat loss and restricted regeneration. The largest *Callitris glaucophylla* woodland in Victoria is at Terrick Terrick National Park, 45 km west of Echuca, in the Victorian Riverina (Environment Conservation Council 1997; Parker *et al.* 2000). This 2493 ha reserve was managed for timber production until 1988, when the Terrick Terrick State Park was proclaimed (Parks Victoria 1997). In 1999, the State Park was incorporated into a larger Terrick Terrick National Park, with an adjacent native grassland. This paper refers to woodlands in the old State Park only.

The Terrick Terrick woodland has undergone major changes in management. Since European settlement in the mid 1800s, fire has been excluded and the area has been grazed by stock, and throughout the 1900s the reserve has been managed for timber production. Silvicultural activities included thinning of dense recruitment, heavy stock grazing to reduce fuel loads, culling of eucalypts in *Callitris* stands, and felling of larger *Callitris* trees for timber (Parker 1999). The reserve was grazed by sheep until 1974, when they were replaced by cattle, and all stock were removed in the early 1990s (Morcom 1990; Parks Victoria 1997). Forestry management ceased in the late 1980s (Parks Victoria 1997). Like most conservation reserves, the vegetation now receives little active management other than noxious weed control.

These management changes have caused substantial changes in vegetation structure. In 1863 the area was mapped as, 'open forest land lightly timbered with Box (*Eucalyptus* species), Pine (*Callitris*

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glaucophylla), She Oak (*Allocasuarina luehmannii*) and shrubbery, rich grassy rises in Winter and Spring, parched during Summer and Autumn' (Willis 1863). Morcom and Westbrooke (1998) found that the order of species names on old survey maps reflected the relative dominance of older trees in remnants, so it seems likely that box eucalypts (principally Yellow Box *E. melliodora* but also Grey Box *E. microcarpa*) were originally more abundant than *Callitris* at Terrick Terrick. About 50 *Callitris*/ha may have existed in the mid-1800s in the area of the reserve which now supports dense *Callitris* forest (Lunt *et al.*, unpublished data). In the mid to late 1800s a dense belt of *Callitris* regenerated across large parts of the reserve (Morcom 1990). This regeneration was thinned and felled for wood production until proclamation of Terrick Terrick State Park in 1988. Virtually no *Callitris* regenerated for almost 100 years under forestry management, owing to heavy grazing by sheep and rabbits (Morcom 1990; Parks Victoria 1997; Parker 1999).

The removal of grazing stock in the early 1990s provides the potential for widespread recruitment by native trees and shrubs. *Callitris* recruitment may enhance the suitability of the reserve for wildlife which require a shrub layer, especially many bird species (Gilmore 1985; Arnold 1988; Arnold and Weeldenburg 1990; Freudenberger 1999), including the threatened Grey-crowned Babbler which occurs in the reserve. In this study, we aimed to assess: (1) changes in *Callitris* distribution in Terrick Terrick National Park over the past 50 years using aerial photographs and girth analyses; (2) the amount of regeneration which has occurred since grazing was removed in the early 1990s, and; (3) the potential for future *Callitris* expansion by comparing soils in areas of dense *Callitris* and open woodland.

Methods

Air photo analyses

Four sets of aerial photographs were examined, including the earliest set available (1945) and subsequent runs in 1970, 1981 and 1990. Interpretation of the 1981 photo set was assisted by earlier stand mapping of part of the reserve by Ritchie and Duncan (1982). A base-map was prepared from the 1990 photos to show all roads, major vegetation zones and rocky outcrops. Five vegetation zones were identified on this map: (1) open woodland, (2) dense *Callitris* forest, (3) rocky outcrop woodland, (4) small fenced regeneration areas, and (5) plantations. These five zones were mapped on all four photo sets (where appropriate), and the area occupied by each vegetation type at each date was calculated using ArcView Version 3.0 (Environmental Systems Research Institute 1996).

Field sampling

Tree species were sampled in 1998 in 178 plots, each 20 × 20 m in size, arranged along a series of transect lines running east-west across the park. Transects were approximately 400 m apart and 3.5 km in length and plots were located at 400 m intervals along each transect. In each plot, girth over bark at ground level (GAGL) was recorded for all overstorey species that exceeded 25 cm girth at ground level. GAGL was assessed instead of the more usual girth at breast height over bark (GBHOB) to allow accurate comparisons between trees and stumps, as part of a broader study (Parker 1999). Each plot was then allocated to one of the structural zones identified on the 1990 aerial photograph.

Slope was recorded at each plot using a clinometer and elevation was estimated from topographic maps. Surface and subsoil (50 cm deep) soil samples were collected. Soil pH was measured using a Hanna Soil pH Meter, texture was assessed by Northcote's (1979) hand texture method, and soil colour was compared against a Munsell Soil Colour Chart (Anon 1994) using moist samples under natural light. *Callitris* and *Eucalyptus* stumps in each quadrat were counted to test the possibility that open woodlands may have been caused by past timber harvesting.

In 1958, foresters established two small fenced plots in the reserve to assess the influence of grazing on *Callitris* recruitment. To promote recruitment, seed-bearing *Callitris* branches were distributed throughout the plots. Abundant seedling recruitment in the plots clearly demonstrated that sheep and rabbit grazing was preventing regeneration in the reserve (A.

Marlow, *pers. comm.* 1998). These plots was surveyed in 1998 to document sapling growth rates in dense stands, 40 years after their establishment. All *Callitris* saplings were counted and height and girth at ground level were measured in three 4 m² quadrats. No mature *Callitris* or eucalypts occurred in these quadrats.

Statistical analyses

The following environmental variables were compared between quadrats in the open woodland and *Callitris* forest zones: altitude, slope, topsoil and subsoil colour, texture and pH, and number of *Callitris* and *Eucalyptus* stumps. Rocky outcrop woodlands, natural regeneration areas and plantations were excluded from these analyses owing to their small area and limited number of samples. Ordinal variables were tested for normality and homogeneity of variances. Where normality was observed and variances were not significantly different, the untransformed data were analysed using independent samples t-tests. Attributes that could not be transformed to achieve normality or homogeneity of variances were tested using the non-parametric Kruskal-Wallis One-way ANOVA (Norusis 1993). Soil texture and colour were grouped into broader classes to increase sample sizes and the number of sites in each class was compared between the two zones using Chi-square tests.

Results

Aerial photographs

Examination of historical aerial photographs showed that vegetation patterns have remained relatively stable since 1945 (Table 1), with a slight expansion of *Callitris* forest (from 1363 ha to 1542 ha) at the expense of open woodland (Table 1). The area of rocky outcrop woodland increased slightly in 1970 and 1981, then declined by 1990 (Table 1). Regenerating *Callitris* could be seen in the 1970 photographs in small fenced plots that were established by the Forests Commission in 1958. Further regeneration was evident in the 1981 photographs around the Mitiamo cemetery on the southern boundary of the Park, and in an old racetrack and picnic area in the centre of the reserve.

Table 1. Area occupied by five vegetation zones in Terrick Terrick National Park (in hectares), as mapped from aerial photographs flown between 1945 and 1990.

Zones	1945	1970	1981	1990
Callitris Forest	1363	1450	1410	1542
Open Woodland	1073	939	976	981
Rocky Outcrop Woodland	134	177	175	126
Callitris regeneration		3.8	4.4	5.5
Planted *Callitris* stands			1.4	1.4

Stand structural data

On average, there were 156 trees/ha and 104 saplings/ha in the *Callitris* forest zone and 96 trees/ha and 87 saplings/ha in the open woodland zone in 1998. The high density of saplings in both zones indicates abundant recruitment in recent times. Each of the dominant species (*C. glaucophylla, E. microcarpa* and *E. melliodora*) displayed different size class characteristics in the open woodland and *Callitris* forest zones (Fig. 1).

Most *Callitris* trees in the reserve were of a single size class (c. 100 cm girth over bark at ground level; Fig. 1a), and resulted from regeneration in the 1800s. However, a large number of small saplings (< 25 cm girth) also existed, especially in the *Callitris* forest zone (Fig. 1a). *Callitris* saplings occurred throughout the reserve, but were especially abundant in and near the Mitiamo cemetery, south-east of the reserve, and in the north-west of the reserve. The latter saplings were not observed in the aerial photographs.

Populations of *E. microcarpa* and *E. melliodora* in the *Callitris* forest zone had similar size structures, with few mature trees and abundant saplings and small trees less than 50 cm girth (Fig. 1). The two species of eucalypt had different size structures in the open woodland zone however. *Eucalyptus melliodora* trees in the woodland zone were of a wide range of girth classes (Fig. 1b), suggesting a low level of continuous recruitment over the years. By contrast, there were very few large *E. microcarpa* in the woodland zone, but abundant small trees and saplings less than 50 cm girth (Fig. 1c). The latter pattern indicates relatively dense seedling recruitment in recent times, after a protracted period with little recruitment. Contrary to expectations, eucalypt saplings were more

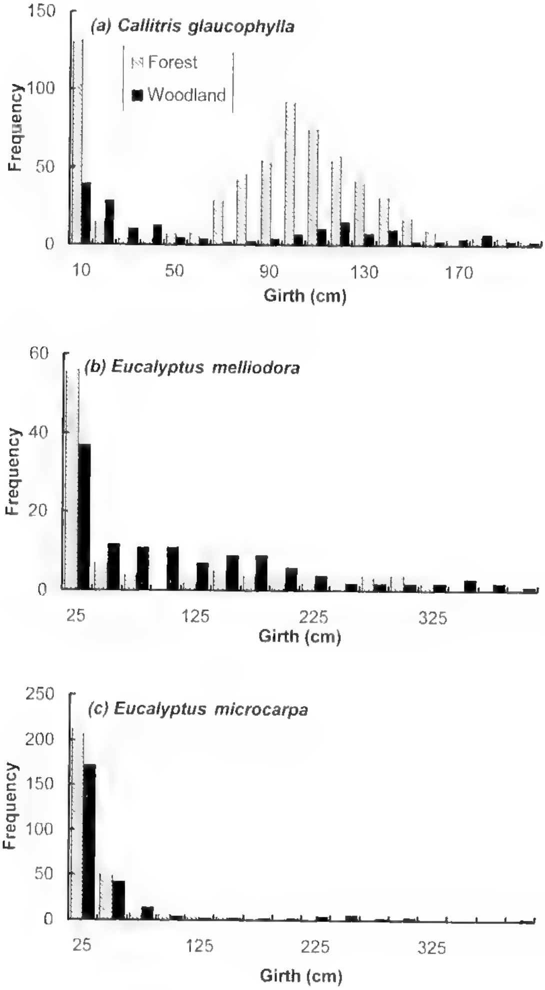

Fig. 1. Size structure of (a) *Callitris glaucophylla*, (b) *Eucalyptus melliodora* and (c) *E. microcarpa* stands in the *Callitris* forest zone and open woodland zones in Terrick Terrick National Park in 1998. Girth was measured as girth over bark at ground level. A small number of larger trees were omitted from each chart for clarity of presentation.

abundant than *Callitris* saplings (466 vs. 222) and occurred in more quadrats than *Callitris* saplings (in 79 c.f. 30 quadrats).

Callitris saplings were extremely dense in the 40-year old, fenced recruitment plot. On average, there were 9.25 *Callitris* saplings/m^2 (i.e. 92,500 saplings/ha) in the fenced plot, which was almost 900 times the density of *Callitris* saplings in unfenced areas of the *Callitris* forest zone, where only 104 saplings/ha grew. Growth rates under these dense conditions were extremely slow, and on average the 40-year old saplings were just 2.1 m tall, with an average girth at ground level of just 10.1 cm (i.e. just 3.2 cm diameter).

Environmental differences between zones

The *Callitris* forest zone and open woodland zone differed significantly in mean altitude, slope, topsoil texture, subsoil texture and subsoil pH (Tables 2 and 3). Topsoil pH was not significantly different at the $p < 0.05$ level, but showed a similar trend to subsoil pH. Most topsoil (76%) and subsoil (92%) samples were dark reddish brown, and there was no significant difference in soil colour between the two zones ($p < 0.05$). The open woodland zone tended to occur at higher elevations, on slightly steeper slopes, and on slightly less acidic soils of greater clay content, compared to the *Callitris* forest zone. However, considerable overlap existed between the two zones for all of these features (Table 3).

There were significantly more *Eucalyptus* and *Callitris* stumps in the *Callitris* forest zone than in the open woodland zone (Table 4). On average there were 47 *Callitris* stumps per hectare in the open woodland zone, but the frequency distribution was strongly skewed and no stumps were recorded in 80% of open woodland plots. The paucity of cut stumps in the open woodland suggests that the open vegetation structure is not due to past clearing.

Discussion

Historical aerial photographs demonstrate that vegetation patterns at Terrick Terrick have remained relatively stable over the past 50 years, with only minor expansion of *Callitris* during this period. However, despite the broad stability of vegetation zones, girth data indicated a

Table 2. Mean altitude, aspect, slope and topsoil and subsoil pH in open woodland and *Callitris* forest zones. P values: * = P < 0.05, ** = P < 0.01, NS = not significant (P > 0.05).

Attribute /zone	Open woodland	*Callitris* forest	P value
Altitude (m ASL)	126.6	121.3	*
Slope (°)	2.6	1.9	*
Topsoil pH	6.1	5.9	NS (0.0514)
Subsoil pH	6.4	6.0	**

Table 3. Number of plots in each vegetation zone possessing each soil characteristic.

Attribute/zone	Open woodland	*Callitris* forest
Topsoil texture		
clay	19	11
sandy clay loam	55	87
Subsoil texture		
clay	37	28
sandy clay	26	58
sandy clay loam	16	12
Topsoil colour		
very dark red brown	10	13
dark reddish brown	48	77
dark brown	8	8
Subsoil colour		
dark reddish brown	61	90
dark brown	5	8

pulse of recent recruitment of eucalypts and *Callitris*.

The pulse of eucalypt recruitment probably reflects two recent changes in management practices: the removal of stock grazing in the early 1990s, and the cessation of eucalypt culling and silvicultural activities in 1988. Under earlier forestry management, eucalypts were routinely culled from the dense *Callitris* zone to minimise competition with harvested *Callitris* (A. Marlow, *pers. comm.* 1998).

Continuing eucalypt recruitment in the *Callitris* forest zone may result in a more even mixture of *Callitris* and *Eucalyptus* species, perhaps resembling the proportions of the two genera last century, when *Callitris* may have been less abundant than eucalypts. However, the density of both species is considerably greater than existed before the pulse of *Callitris* regeneration in the late 1800s (Lunt *et al., unpubl. data*). Despite difficulties in obtaining accurate estimates of past tree densities, it appears that about 50 *Callitris*/ha grew in the dense *Callitris* zone in the mid 1800s (before the dense regeneration pulse), which is about one-third of the current tree density (156 *Callitris*/ha).

Some of the minor changes in structure that were evident on aerial photographs can be related to known management activities in the Park. For instance, the small increase in the area of rocky outcrop woodland between 1945 and 1970 was due to gravel extraction around the rocky outcrops, which occurred from the 1950s to early 1970s (Morcom 1990). The area of rocky outcrop woodland declined after 1981 due to eucalypt regeneration after gravel extraction ceased.

The small increase in the amount of natural regeneration in the 1970 photo occurred in small, fenced plots that were established by the Forests Commission in 1958. The plots provide unequivocal evidence that heavy grazing by stock and rabbits prevented *Callitris* recruitment for most of this century. Additional regeneration that was evident in the 1980s and 1990 aerial photographs resulted from small areas of natural regeneration after a series of wet years in the early 1970s (A. Marlow *pers. comm.*, 1998). However, abundant young *Callitris* were recorded in many quadrats in the north-east of the reserve, even though they were not evident on the aerial photographs. Many of the saplings in this area were less than 1 m tall, suggesting that new saplings are continuing to recruit in this zone. The reasons why this recruitment is not yet more widespread across the reserve are unknown.

The *Callitris* forest zone is dominated by single-aged *Callitris* which regenerated in the late 1800s. Since then there has been only a small amount of natural recruitment, most of which occurred after the 1970s. This situation differs from that which is commonly reported from *Callitris* forests in central NSW, many of which experienced dense recruitment between the late 1860s and early 1880s (as at Terrick Terrick), but also another peak of recruitment in the 1950s after the introduction of myxomatosis (Curby 1997; Allen 1998). *Callitris* recruitment in intervening years was almost entirely prevented by heavy grazing by rabbits and stock.

The absence of 1950s recruitment at Terrick Terrick may be due to heavy grazing by sheep in this period, as the forest

Table 4. Mean number of *Callitris* and *Eucalyptus* stumps per hectare in open woodland and *Callitris* forest zones.

Species/Zone	Open woodland	*Callitris* forest	P value
Callitris stumps	47	237	< 0.001
Eucalyptus stumps	10	22	< 0.001

was continually grazed by stock until the early 1990s (A. Marlow, *pers. comm.*, 1998). It is unlikely to be due to unsuitable climatic conditions, as rainfall records from Pyramid Hill (15 km NW of the reserve) indicate that 50% of annual totals between 1941 and 1971 were above average (Bureau of Meteorology, *unpubl. data*). Furthermore, runs of good seasons occurred on three occasions during this period (1949-1951, 1954-1957 and 1970-1974), and there were seven successive years of above average rainfall between 1958 and 1964. Thus, it seems most likely that grazing by stock and rabbits, rather than climatic conditions, has been influential in preventing *Callitris* recruitment over the past century.

Environmental differences

Whilst a number of environmental features differed significantly between the *Callitris* forest zone and the open woodland zone, most environmental features overlapped considerably between the two zones. *Callitris glaucophylla* occurs in a wide variety of environments across Australia, on a wide range of soil types, but prefers well-drained, sandy soils that do not get waterlogged (Lacey 1973; Forestry Commission NSW 1988).

The soil data collected here indicate that many open woodlands at Terrick Terrick are on heavier clay soils than the *Callitris* forest zone. Further experimental studies would be required to determine whether *Callitris* can successfully regenerate in these open areas. However, from the published information on *Callitris* soil preferences, it seems likely that many open areas may be ecologically unsuitable for *Callitris*, and so may always remain relatively open. However, the presence of similar soils in many open and dense areas suggests that further *Callitris* expansion is likely to occur at some stage. Furthermore, *Callitris* and eucalypts are already regenerating in many open areas. If most recorded saplings survive, densities of mature trees may almost double in the next decade or two, regardless of future recruitment.

Potential for future vegetation change

Current levels of eucalypt and *Callitris* recruitment may play a valuable role in enhancing habitat complexity at Terrick Terrick National Park, given the long period of minimal recruitment throughout this century. However, in the absence of grazing and burning, *C. glaucophylla* is capable of extremely dense seedling regeneration, especially during years of heavy summer rainfall, when little seedling mortality occurs. Data from the small, 40-year old fenced plot illustrate the high densities of *Callitris* recruitment which can be sustained (92,500 saplings/ha after 40 years), and the ability of *Callitris* to survive in slow-growing, 'locked stands' for lengthy periods, with little natural thinning (Lacey 1972; Horne 1990). Dense recruitment in the fenced plot was undoubtedly aided by the introduction of large quantities of seed-bearing boughs in 1958. However the density of regeneration is similar to that which occurs naturally, under suitable weather conditions in ungrazed areas. Lacey (1972) reported that densities of 120,000 saplings/ha commonly regenerate in NSW *Callitris* forests, and over 2.5 million seedlings/ha have been recorded. Ongoing monitoring is required to detect future pulses of dense wheatfield regeneration, since extremely dense, widespread stands could have negative impacts for biodiversity conservation, by eliminating open gaps and ground flora. Further studies are required on the implications and management of *Callitris* stands in conservation reserves.

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References

Allen, M.R. (1998). 'Forest History Projects for State Forests of New South Wales. Case Studies of Three Cypress Pine Forests on the Lachlan and Bogan River Catchments, Forbes Forestry District on Back Yamma, Euglo South and Strahorn State Forests'. (State Forests of New South Wales: Pennant Hills.)

Anon. (1994). 'Munsell Soil Colour Charts'. (Land Evaluation Unit, Macbeth Division of Kollmorgen Instruments Corporation: New York, USA.)

Arnold, G.W. (1988). The effects of habitat structure and floristics on the densities of bird species in Wandoo woodland. *Australian Wildlife Research* **15**, 499-510.

Arnold, G.W. and Weeldenburg, J.R. (1990). Factors determining the number and species of birds in road verges in the wheatbelt of Western Australia. *Biological Conservation* **53**, 295-315.

Boland, D.J., Brooker, M.I.H., Chippendale, G.M., Hall, N., Hyland, B.P.M., Johnston, R.D., Kleinig, D.A., and Turner, J.D. (1984). 'Forest Trees of Australia'. (Nelson Wadsworth: Melbourne.)

Bowman, D.M.J.S. and Harris, S. (1995). Conifers of Australia's dry forests and open woodlands. *In* 'Ecology of the Southern Conifers', pp. 252-270. Eds N.J. Enright and R.S. Hill. (Melbourne University Press: Melbourne.)

Curby, P. (1997). 'Forest History Project for State Forests of New South Wales. Narrandera Study on Buckingbong, Gillenbah and Matong State Forests'. (State Forests of New South Wales: Pennant Hills.)

Environment Conservation Council. (1997). 'Box - Ironbark Forests and Woodlands Investigation Resources and Issues Report'. (Environment Conservation Council: Melbourne.)

Environmental Systems Research Institute (1996). 'Using ArcView GIS, Ver. 3.0 for Windows'. (ESRI: Redlands.)

Forestry Commission of New South Wales. (1988). 'Notes on the Silviculture of Major N.S.W. Forest Types. 10. Cypress Pine Types'. (Forestry Commission of New South Wales: Sydney.)

Freudenberger, D. (1999). 'Guidelines for Enhancing Grassy Woodlands for the Vegetation Investment Project'. Unpublished report to Greening Australia NSW (CSIRO: Canberra.)

Gilmore, A.M. (1985). The influence of vegetation structure on the density of insectivorous birds. *In* 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management', pp. 21-31. Eds A. Keast, H.F. Recher, H. Ford and D. Saunders. (RAOU and Surrey Beatty & Sons: Chipping Norton, NSW.)

Gullan, P.K., Cheal, D.C., and Walsh, N.G. (1990). 'Rare or Threatened Plants in Victoria'. (Department of Conservation and Environment Victoria: Melbourne.)

Horne, R. (1990). Stand height response following variable spacing of wheatfield white cypress pine regeneration in New South Wales. *Australian Forestry* **53**, 47-54.

Lacey, C.J. (1972). 'Factors Influencing Occurrence of Cypress Pine Regeneration in New South Wales'. Technical Report No. 21. (Forestry Commission of NSW: Sydney.)

Lacey, C.J. (1973). 'Silvicultural Characteristics of White Cypress Pine'. Research Note No. 26 (Forestry Commission of NSW: Sydney.)

Morcom, L. (1990). 'Terrick Terrick State Park Draft Resources Inventory and Draft Interim Management Guidelines'. (Unpublished report, Department of Conservation, Forests and Lands: Bendigo.)

Morcom, L.A. and Westbrooke, M.E. (1998). The pre-settlement vegetation of the western and central Wimmera Plains of Victoria, Australia. *Australian Geographical Studies* **36**, 273-288.

Noble, J.C. (1997). 'The Delicate and Noxious Scrub: CSIRO Studies on Native Tree and Shrub Proliferation in the Semi-Arid Woodlands of Eastern Australia'. (CSIRO: Canberra.)

Northcote, K.H. (1979). 'A Factual Key for the Recognition of Australian Soils'. (Rellim Technical Publications: Adelaide.)

Norusis, M.J. (1993). 'SPSS for Windows Base System User's Guide Release 6.0.' (SPSS Inc.: Chicago.)

Parker, D.G. (1999). 'Structural Patterns and Changes in *Callitris-Eucalyptus* Woodlands at Terrick Terrick State Park, Victoria'. B.Sc.(Hons) Thesis. (School of Environmental and Information Sciences, Charles Sturt University, Albury NSW.)

Parker, D., Lunt, I. and Adams, R. (2000). Identification of Cypress-pines (*Callitris* species) at Terrick Terrick National Park, Victoria. *Victorian Naturalist* **117**, 93-95.

Parks Victoria. (1997). 'Terrick Terrick State Park Management Plan'. (Parks Victoria: Melbourne.)

Ritchie, T. and Duncan, M. (1982). Forest Type Mapping, Terrick Terrick State Forest. (Unpubl. map, DNRE: Bendigo).

Willis, G. (1863). 'Survey of the Northern Plains of Victoria.' (Microfiche map). (Central Plans Office: Melbourne.)

One Hundred Years Ago

Note on the Occurrence of the European Crab, *Carcinus Mænas*, Leach in Port Phillip

By Sydney W. Fulton and F.E. Grant

Included in a series of specimens of Crustaceans collected by us in Port Phillip this spring were a number of forms which we were unable to identify with the description of any recorded Australian species. The local museum collection not being then available for comparison, we forwarded some of these to Mr. G.M. Thomson, of Dunedin, a well-known worker in the Crustacea, who had kindly promised to assist us by checking identification. He writes as follows:- "These specimens are most interesting, and want carefully going into. I think it is the common English shore crab, *Carcinus maenas* and if so, how comes it to be on your coast, and where does it occur? ... The existence of an introduced marine animal such as this appears to us to be especially noteworthy, as, although the terrestrial fauna of Australia has been so largely modified by introduced European genera, the list of introduced marine forms is a very small one: and it will be of interest to observe whether *Carcinus maenas* will, in course of time, replace to any extent the common species of Paragrapsus, Cyclograpsus, and others whose habit of life is similar, and whose place it fills in European littoral fauna.

From *The Victorian Naturalist* **XVII**, December 1900 (pp. 147-148).

Small Mammal Activity on the Snow Surface

K. Green[1]

Abstract

Small terrestrial mammals are forced to travel over the snow when the subnivean space is collapsed and the snow too dense for tunnelling. The period spent above the snow is one of high exposure to predators, and small mammals generally keep this time to a minimum. The length of small mammal trails above the snow in subalpine areas is significantly correlated with the mean distance between trees. Small mammal trails are longer in treeless areas (average 73.5 m) than woodland (17.8 m); longer where they cross man-made tracks than in adjacent woodland by a factor of one to three times the width of the track and longer in mid season than early season snow because of the changing availability of routes to the subnivean space. (*The Victorian Naturalist* **117** (6), 2000, 214-218.)

Introduction

The study of small mammals in snow in Australia is relatively recent, with the first continuing studies of winter activity commencing in 1978 (Osborne *et al.* 1978, Osborne 1980, Carron 1985). Osborne (1980) suggested that small mammal tracks on the snow were caused by the Bush Rat *Rattus fuscipes*. Since then, however, Broad-toothed Rat *Mastacomys fuscus*, Dusky Antechinus *Antechinus swainsonii* and Agile Antechinus *A. agilis* have been added to the list of small mammals known to be active on the snow surface (*pers. obs.*). The only mammal restricted to alpine/subalpine regions of mainland Australia, the Mountain Pygmy-possum *Burramys parvus*, hibernates over winter in boulder fields so no over-snow movement has been recorded.

Small mammals remaining active in the space beneath the snow (subnivean space) achieve a high level of protection against supranivean predators such as foxes, hawks and owls (Evernden and Fuller 1972, Pruitt 1984) in contrast to those that come out onto the surface (Formozov 1946). There are few nocturnal birds of prey in areas of Australia with lengthy periods of snow cover (Osborne and Green 1992). Originally, the chief predator of small mammals in these areas was probably the Spotted-tailed Quoll *Dasyurus maculatus* but this species has largely been replaced by the Red Fox *Vulpes vulpes* in the past 100 years (Green and Osborne 1994).

Foxes are common in the Snowy Mountains, where their main winter food is native small mammals (Green and Osborne 1981). The density of foxes in subalpine woodland in the Snowy Mountains is similar to figures for temperate Europe at about 1.8 per km^2 with an even higher figure in the vicinity of ski resorts where foxes congregate in winter (Bubela 1995). For most small mammals, time spent on the surface of the snow is dangerous 'because of low temperatures, danger of predation and the difficulty of getting into and under the snow cover when necessary to hide themselves' (Formozov 1946). Although this statement was made over 50 years ago, there have been few attempts to determine the degree of exposure of small mammals to predation when above the snow. The aim of this study was to examine the supranivean movements of small mammals and how their exposure was determined by limited access to the subnivean space, particularly in relation to tree density.

Methods

The study was conducted in the Snowy Mountains and the Victorian Alps. The dominant vegetation types were heaths, herbfields and woodland dominated by Snowgum *Eucalyptus niphophila* (Costin 1954, 1961). Snow falling on the understorey forms a layer over the vegetation, supported both by adherence to the plants and by the intercrystalline bonds within the snow, enabling it to bridge over open spaces, very much like a blanket. An extensive subnivean space is created so that most mid-winter movement by small mammals is below the snow (Green 1998). The height of subnivean space depends on the height, density and strength of the vegetation (Coulianos and Johnels 1962) and in Australia can be quite considerable

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(Green 1998). Marchand (1996) presents a discussion of the importance of the subnivean space to small mammals.

Trails made by small mammals on the snow in the Snowy Mountains and Victorian Alps were measured opportunistically from the 1970s to 1990s. Only trails where the point of origin and termination could be determined were measured and the general vegetation was recorded (either woodland or areas lacking trees which were recorded as heath but may well have included some grassland). Small mammal trails encountered in woodland during the thaw of 1995 in the Victorian Alps were measured and again in similar woodland one week later to determine the effects of a fresh fall of snow.

In July 1996, transects were skied in the Snowy Mountains along a network of mechanically groomed cross-country ski tracks, and also parallel to the tracks through undisturbed woodland and heath. The total length of all small mammal trails crossing the ski track were measured as were all small mammal trails encountered in the parallel transect but not joining the ski track. In 1999 and 2000, with the first winter snowfalls depositing in excess of 25 cm of snow, small mammal trails were measured in a similar fashion across two tracks and in undisturbed woodland.

To determine snow density and the height of subnivean space on one of the cross-country ski tracks used above, an attempt was made to excavate a hole on the track. The track was machine-groomed daily over a 12-week period and automatic track counters recorded on average 235 skiers per day in the week prior to measurement. The track was sampled once at about the middle of the ski season: excavation of the track proved impossible with snow shovels so, instead, four holes at each of five locations were excavated at the uncompacted edge of the track and cut back to the edge of the hardened track so that the snow could be seen in cross-section, and the subnivean height measured. Five sites adjacent to these locations were chosen for their apparent lack of disturbance. A single hole was excavated and the maximum height of the subnivean space was measured on each of the four faces of the hole. Snow density was measured at five of the ski-track holes and all five off-track holes using a copper pipe 50 cm long of 61 mm internal diameter and sharpened from the outside of the pipe. The pipe was weighed with an electronic balance in the laboratory to the nearest gram and weighed in the field with a snow core using a Pesola 5 kg spring balance accurate to 50 g.

In the winters of 1998 and 1999, transects were skied through a variety of woodland types in the Snowy Mountains. For each small mammal trail encountered, the distances to the nearest five potential access points to the subnivean space (usually trees) were measured from each end of the trail. The trail length was plotted against the average of these ten distances and was examined using simple linear regression.

Results

Effects of tree presence and absence and spacing

In snow-covered heath, the average length of small mammal trails (73.5 ± 90.3 m, $n = 15$) (mean and standard deviation throughout) was significantly greater ($t = 4.565$, $df = 69$, $P < 0.0001$) than lengths of small mammal trails in all types of woodland (17.8 ± 16.4 m, $n = 56$). The longest small mammal trail was 334 m made by *M. fuscus* (identified from characteristic faeces on the trail) in alpine heath. In heath, most recorded access points to the subnivean space (19 of 28) were at protruding rocks, with four at protruding vegetation, one at a bank, one where a ski trail had broken through the snow, and only three where the animal had dug through the snow surface. One mammal (*M. fuscus*) only moved three metres from an excavated hole before being taken by a fox. Overall, of 333 trails between the subnivean and the supranivean spaces, 209 were at trees, 61 at rocks, 46 at shrubs and only five (one fatal) at a hole excavated exclusively by a small mammal.

Small mammal trails in woodland during the thaw with frequent spaces leading to the subnivean space around trees averaged 9.5 ± 13.4 m in length ($n = 13$) and were significantly ($t = 2.719$, $df = 23$, $P < 0.05$) shorter than eight days later (30.7 ± 24.3 m, $n = 12$) after a fall of fresh snow blocked many such holes.

Table 1. Distance covered (m) on the snow surface by small mammals when moving across compressed snow tracks and away from tracks in early-season and mid-season snow. Comparisons were made using two-way ANOVA.

	Early-season	n	Mid-season	n
Average across track	9.7 ± 3.3 m	8	29.3±19.2 m	13
Average away from track	5.0 ± 3.4 m	20	8.6±7.11 m	15
Difference	4.7 m		20.7 m	

Effects of ski trails and compaction

The lengths of trails made by small mammals were significantly longer when crossing a track than in undisturbed woodland ($F = 21.862$, $df = 52$, $P < 0.0001$) (Table 1). The lengths of small mammal trails were shorter early in the season than in mid-season snow both when crossing tracks and in undisturbed woodland ($F = 14.182$, $df = 52$, $P < 0.001$).

There was a significant difference (paired t-test, $t = 6.465$, $df = 4$, $P = 0.003$) between snow density on cross-country ski tracks (0.42 ± 0.06 $g.cm^{-3}$) and off tracks (0.21 ± 0.09 $g.cm^{-3}$). The average height of the subnivean space away from the track was 12.6 ± 11.3 cm ($n = 20$). Of 20 pits excavated on the edge of the ski track, 18 had no subnivean space, one had a 1 cm gap beneath the snow and another had a 2 cm gap.

There was a significant positive relationship between the distance travelled by small mammals above the snow surface and the distance between access points (usually trees) into the subnivean space ($r^2 = 0.608$, $F = 37.217$, $P < 0.001$) (Fig. 1).

Discussion

Green and Osborne (1994) found the highest number of trails of small mammals on snow in June, when the snow cover was about 20 cm deep, with small mammals using access points to the subnivean space at boulders, logs or shrubs. As snow depth increased to 30-40 cm, the number of trails on snow decreased, and holes at higher structures such as trees and boulders were used for access. As the snow deepened further there was little activity on the snow until spring. The cause of the higher frequency of trails early in the season is probably due to the lack of development of the subnivean space and the ease of access onto the snow surface at protrusions through the shallow early season snow (Green and Osborne 1994). A further consequence of this in the present study was that small mammal trails were shorter earlier in the season than later when there were fewer such protrusions because the increasing snow depth or density buried shrubs beneath the snow cover (Table 1).

The lack of access to the subnivean space at shrubs in deeper snow cover is also reflected in a comparison of trail length in heath and woodland. There is a clear difference in the present study between the distances small mammals move above snow in these two habitats. Both Sonerud (1986) and Hansson (1982) found that trails of small mammals were more common in forested than non-forested areas. The importance of trees in providing holes through the snow was illustrated by Sonerud (1986) who found that excavated ventilation holes were significantly more common in clear-cut areas than in forest, where naturally open passages occurring around trees were used. Drickamer and Stuart (1984) have also suggested that small mammals use trees as navigational cues above the snow, because holes around low shrubs may be invisible at snow-level.

The shorter trail length in the Victorian Alps on old snow when there were a number of holes at the base of trees compared with a week later when many such holes were blocked by fresh snow is further indication of the importance of naturally occurring holes relative to ones excavated by the animals themselves. Whilst Pruitt (1984) has suggested that small mammals are reluctant to burrow through dense snow, the drifting snow that blocked access to the subnivean space in the present study would not have been of high density. Although two species in the present study area are adept at digging (*R. fuscipes* and *A. swainsonii*) the number of stand-alone burrows was low, only five of 333. The present study suggests that the local animals are loathe to burrow in snow at all and *R. fuscipes* will dig trenches in

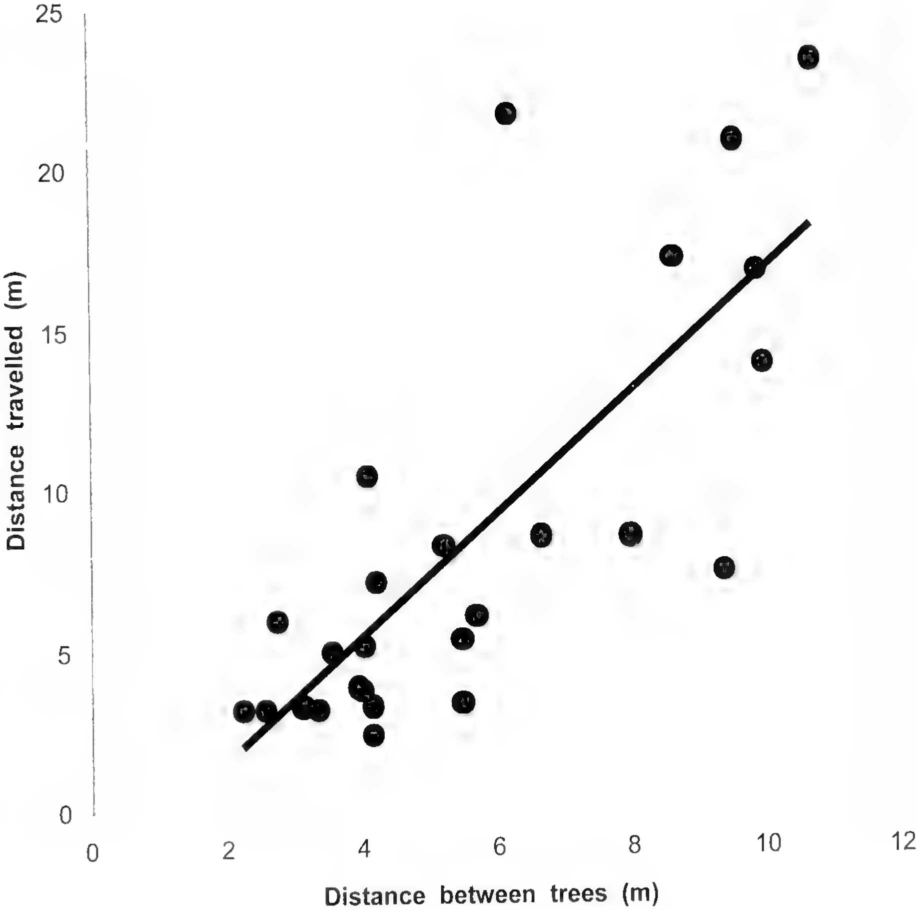

Fig. 1. Relationship between the distance small mammals move over the snow and the distance between surrounding trees.

soil beneath compressed snow to provide passageways rather than tunnel through the snow itself (*pers. obs.*).

This poses a problem where habitat is fragmented by wide compressed snow trails. Long-tailed Voles *Microtus longicaudus* are believed to be deterred from burrowing through snow of density above 0.15 g.cm^{-3} (Spencer 1984) and Schmid (1971) found that voles would come to the snow surface to cross over-snow vehicle tracks rather than burrow through dense snow compacted to 0.4 g.cm^{-3}. This is the same density as was found on the groomed cross-country ski tracks in the present study and, combined with the lack of subnivean space, would be sufficient to force the animals to cross over the snow. The length added to supranivean trails by having to cross such tracks must place the small mammals at greater risk of predation, particularly given that foxes will regularly use compressed snow tracks (Green and Osborne 1994).

The length of small mammal movements above the snow is largely dictated by how soon the mammals can regain access to the subnivean space. Sonerud (1986) suggested three reasons why small mammal tracks are more common in forest than in clear-cut land. Of these the first, habitat-related differences in the formation of the subnivean space are probably minimal in Australia where, because of the more open structure of the snowgum canopy compared to coniferous forests of the northern hemisphere, the shrub layer is more likely to be similar beneath trees and in the open (*pers. obs.*). The second reason, species-specific differences, may be important given that *R. fuscipes* and *A. swainsonii* are more common in woodland and *M. fuscus* in heath (Carron 1985). Distances moved in heath were longer and, although the longest track recorded in the present study was made by *M. fuscus*, this species is generally less active in winter (Bubela *et al.* 1991). The third reason proposed by Sonerud (1986), the 'greater risk of predation during supranivean movements' is most likely to be the reason for a greater number of trails in areas where they can be kept short. Coulianos and Johnels (1962) found that in areas with trees, small mammals on the snow surface can escape quickly to the subnivean space by moving towards the nearest tree or bush 'which is usually surrounded by an open passage'. In the present study, not only were small mammal trails found more commonly in woodland than in heath, but their length, and hence the time the small mammals spent above the snow, was shorter, being determined largely by the distance between access holes, mainly at trees. Although they did not measure stem spacing, Drickamer and Stuart (1984) working with two species of *Peromyscus* found a mean trail length of 2.0 m with at least 87% of trails leading from tree to tree (indicating a high stem density) whereas in 'spruce fir forest' and 'forest meadow' (possibly indicating greater tree spacing), Formozov (1946) found an average length of trails of 9.2 m for shrews and voles. It is likely that the relationship found in the present study between stem spacing and trail length will hold in general in nival areas.

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References

Bubela, T.M. (1995). Social effects of sterilising free-ranging vixens (*Vulpes vulpes* L.) in subalpine Australia. Unpublished PhD thesis, University of Sydney.

Bubela, T.M, Happold, D.C.D. and Broome, L.S. (1991). Home range and activity of the broad-toothed rat, *Mastacomys fuscus*, in subalpine heath. *Wildlife Research* **18**, 39-48.

Carron, P.L. (1985). The ecology of three species of small mammals in subalpine habitat. Unpublished PhD thesis, Australian National University.

Costin, A.B. (1954). 'A Study of the Ecosystems of the Monaro Region of New South Wales'. (Government Printer: Sydney.)

Costin, A.B. (1961). Ecology of the high plains I. *Proceedings of the Royal Society of Victoria* **75**, 327-337.

Coulianos, C.-C. and Johnels, A.G. (1962). Note on the subnivean environment of small mammals. *Arkiv für Zoologi* **15(24)**, 363-370.

Drickamer, L.C. and Stuart, J. (1984). *Peromyscus*: Snow tracking and possible cues used for navigation. *American Midland Naturalist* **111**, 202-204.

Evernden, L.N. and Fuller, W. A. (1972). Light alteration caused by snow and its importance to subnivean rodents. *Canadian Journal of Zoology* **50**, 1023-1032.

Formozov, A.N. (1946). 'Snow Cover as an Integral Factor of the Environment and its Importance in the Ecology of Mammals and Birds'. (Boreal Institute for Northern Studies, University of Alberta: Edmonton.)

Green, K. (1998). A winter niche: the subnivean space. *In* 'Snow: A natural history; an uncertain future', pp. 125-140. Ed. K. Green. (Australian Alps Liaison Committee: Canberra.)

Green, K. and Osborne, W.S. (1981). The diet of foxes, *Vulpes vulpes* (L.) in relation to abundance of prey above the winter snowline in New South Wales. *Australian Wildlife Research* **8**, 349-360

Green, K. and Osborne, W.S. (1994). 'Wildlife of the Australian Snow-Country'. (Reed: Sydney.)

Hansson, L. (1982). Use of forest edges by Swedish mammals. *Fauna och Flora* **77**, 301-308. (in Swedish with summary in English). Cited in Sonerud (1986)

Marchand, P.J. (1996). 'Life in the cold: an introduction to winter ecology Third edition'. (University Press of New England: Hanover, NH.)

Osborne, W.S. (1980). Movement over the snow by the bush rat *Rattus fuscipes*. *The Victorian Naturalist* **97**, 163-164.

Osborne, W.S. and Green, K. (1992). Seasonal changes in composition, abundance and foraging behaviour of birds in the Snowy Mountains. *Emu* **92**, 93-105.

Osborne, W.S., Preece, M., Green, K. and Green, M (1978). Gungartan: A winter fauna survey above 1500 metres. *The Victorian Naturalist* **95**, 226-35.

Pruitt, W.O. (1984). Snow and small mammals. *In* 'Winter Ecology of Small Mammals', pp. 1-8. Ed. J.F. Merritt. (Special Publication No. 10. Carnegie Museum of Natural History: Pittsburgh.)

Schmid, W.D. (1971). Modification of the subnivean microclimate by snowmobiles. *In* 'Proceedings of the 'Snow and Ice in relation to wildlife and recreation' Symposium', pp. 251-257. Ed. A.O. Haugen. (Iowa State University, Ames Iowa.)

Sonerud, G.A. (1986). Effect of snow cover on seasonal changes in diet, habitat, and regional distribution of raptors that prey on small mammals in boreal zones of Fennoscandia. *Holarctic Ecology*. **9**, 33-47.

Spencer, A.W. (1984). Food habits, grazing activities, and reproductive development of Long-tailed Voles, *Microtus longicaudus* (Merriam) in relation to snow cover in the mountains of Colorado. *In* 'Winter Ecology of Small Mammals', pp. 67-90. Ed. J.F. Merritt. (Special Publication No. 10.: Carnegie Museum of Natural History: Pittsburgh.)

The Use of DNA in Natural History Studies

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Abstract

Recent technical advances in molecular biology now make the analysis of DNA a fairly routine procedure. This has led to a significant increase in the use of DNA approaches for comparative evolutionary, ecological and behavioural studies. In this paper we briefly outline the nature of DNA and the techniques used in assessing its variation, such as sequencing and fingerprinting. The uses of DNA in natural history studies, ranging from taxonomy to conservation, are then reviewed focussing on examples dealing with the Australasian biota. (*The Victorian Naturalist* **117** (6), 2000, 219-225.)

Introduction

Studies of genetic variation continue to make enormous contributions to our understanding of the evolution and natural history of organisms. Genetic variation is responsible for much of the physical, structural, biochemical and even behavioural differences we observe among individuals and between populations or species. The source of all this genetic variation is DNA. By studying the levels and patterns of DNA variation within and among populations of a species we can learn about its breeding behaviour and social structure, trace familial relationships, infer patterns of dispersal and unravel the historical processes responsible for population subdivision. By studying DNA differences between species we learn how and when they evolved.

What is DNA?

DeoxyriboNucleic Acid (DNA) is the biological molecule that carries genetic information. It is present in all organisms. DNA comprises two chain-like strands of genetic information. Each strand is composed of a long sequence of four bases or nucleotides. These are adenine, cytosine, guanine, and thymine, symbolised by the letters A, C, G and T. This code is universal - the same four bases encode the information contained within the DNA of all organisms. The universal nature of the genetic code is what makes genetic engineering - the transfer of DNA from one species to another - possible.

Most DNA is contained within the nucleus of a cell. It forms tightly coiled structures known as chromosomes during cell division. The DNA within a human nucleus is approximately 3,000 million bases long. DNA is also present in mitochondria which occur in the cytoplasm of cells and are responsible for energy production. Mitochondrial DNA is usually circular and approximately 17,000 bases long in animals (Brown 1983). The chloroplasts in plant cells also have their own separate DNA molecule (Crawford 1989).

How does genetic variation arise?

Genetic variation results from changes in the order of nucleotides in a DNA molecule. These changes are termed mutations and occur as a result of replication errors (mistakes introduced during the copying of a DNA molecule) or damage caused by external agents such as radiation. Mutations can cause different types of changes within the DNA molecule. The most common are point mutations where one base or nucleotide is replaced by another. For example, the sequence ACT**G**CATT changes to ACT**A**CATT as the result of a point mutation at the fourth base. Mutations may also cause small sections of DNA to be added, removed or duplicated.

In sexually reproducing species, recombination is also an important source of genetic variation. Recombination occurs when the DNA of two individuals (the parents) is mixed to produce a new DNA combination in the offspring. The genetic variation produced by recombination is evident when we look at closely related individuals within a family (parents and children). All will bear a striking resemblance but, with the exception of identical twins, no two individuals are identical. This is because each of the children carries a different combination of the DNA molecules present in their parents.

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The combined effects of mutation and recombination mean that every individual has a unique DNA sequence (at least in sexually reproducing organisms). It also means that the more closely related two individuals are, the more similar their DNA will be. These principles also extend to populations, species and higher order associations (genera, families, orders, etc). Assessing the degree of genetic similarity (or differentiation) among individuals at any level of this hierarchy is the basis of DNA studies.

Studying DNA

Obtaining DNA

Obtaining appropriate biological samples is the first step in a DNA study. The type of sample chosen depends on a number of factors: the method of DNA analysis, the type of DNA to be analysed (nuclear, mitochondrial or chloroplast), the amount of DNA required and the ease of sampling. This sometimes requires the sacrifice of whole organisms in order to obtain sufficient amounts of DNA (as is the case with most invertebrates) or where voucher specimens are required for taxonomic validation. Seeds, leaves and roots of plants are good sources of DNA although leaves are favoured where analysis of chloroplast DNA is undertaken (e.g. Byrne *et al.* 1993). DNA can be obtained from most parts of an animal. Blood (Aretander and Fjeldsa 1994), plucked hair (e.g. Osborne *et al.* 2000; Cardinal and Christidis 2000) and feathers (Ellegren 1992) are commonly used for large scale population studies as these can be obtained by non-destructive sampling methods. For taxonomic and evolutionary studies specific body tissues such as heart or liver are often used as these are rich in mitochondrial DNA (Dowling *et al.* 1990), the preferred type of DNA for these analyses. DNA can also be obtained from some quite unusual sources including faecal samples (Wasser *et al.* 1997), stomach contents (Scribner and Bowman 1998), museum specimens (Thomas *et al.* 1989; Leeton *et al.* 1993) and a limited range of subfossil material (Cooper *et al.* 1992).

Analysing DNA

The past decade has seen a significant change in the type of genetic analyses being used in natural history studies. This change was brought about by the development of the polymerase chain reaction (PCR) (Saiki *et al.* 1988). PCR is a simple procedure which enables us to artificially generate large quantities of the short (300-1,000 nucleotide) DNA segments we wish to study. This amplification process is necessary as individual cells contain minute quantities of DNA that are not detectable by standard analytical methods. Using PCR, approximately one million copies of a targeted DNA segment can be produced from a single DNA molecule.

Another important property of PCR is that it enables us to amplify very specific segments of DNA. Natural history studies of vertebrates, for example, have largely focussed on two segments of mitochondrial DNA - one encoding the gene for cytochrome-*b* (Irwin *et al.* 1991; Graybeal 1993) and the other, a non-coding segment called the control region (Quinn and Wilson 1993). When a particular segment of DNA such as cytochrome-*b* is amplified from different individuals a direct comparison of their DNAs can be made.

A number of different procedures can be used to detect variation between DNA fragments. Among the most common of these are DNA sequencing, DNA fingerprinting and the analysis of randomly amplified polymorphic DNA (RAPDs).

DNA sequencing

DNA sequencing is the most sensitive method for assessing genetic variation. It provides information on the order of the four nucleotides (A, C, T and G) within a DNA fragment and allows the precise nature and location of any mutations to be determined.

Because the DNA of most organisms comprises millions of nucleotides it is not possible to obtain information on the ordering of nucleotides for entire genomes. Instead, only very small regions of the DNA are targeted using PCR. These regions are typically 300 to 1,000 nucleotides in length, and thus constitute a very small proportion of the organism's total DNA. Most natural history and evolutionary studies of animals have focussed on specific regions of the mitochondrial DNA molecule as it accumulates mutations more rapidly than nuclear DNA (Brown *et al.* 1979). This makes mitochondrial DNA a sensitive indicator of the levels and patterns of genetic variation within and among populations and species. In plants, however, chloroplast and mitochondrial DNA are not that variable (Palmer 1987; Crawford 1989) and nuclear DNA markers such as RAPDs (described later) are normally used for population studies (e.g. Waycott 1998; Bussel 1999).

DNA fingerprinting

Another DNA-based technique which is widely used in natural history studies is *DNA fingerprinting* or *DNA profiling*. This procedure targets regions of repetitive DNA (Burke 1989). These regions are highly variable and occur irregularly throughout the genome. Given the highly variable nature of the number and location of repeat sequences within the genome it is possible to generate a unique DNA fingerprint for every individual in a population.

Traditionally, DNA fingerprints were generated by fragmenting the DNA using restriction enzymes - biologically active proteins which cut the DNA at specific sequences. The fragments are then visualised using radioactive minisatellite probes. Although cumbersome, this methodology is still widely used as the same minisatellite probes can be used to generate DNA fingerprints for a wide range of organisms. In fact, the most commonly used minisatellite probes were originally isolated from human DNA (Jeffreys *et al.* 1985) and have been used successfully in genetic studies of Australian birds (Birkhead *et al.* 1990; Dunn *et al.* 1995). A disadvantage of this method is that it requires large amounts of intact DNA which cannot always be obtained by non-destructive sampling methods.

An alternative approach for generating these unique DNA profiles is to use PCR to amplify segments of DNA containing microsatellite repeats (Queller *et al.* 1993). Like minisatellites, these repeat arrays occur throughout the genome and vary in size from individual to individual. When a series of different microsatellites are amplified and information on all the resulting DNA fragments combined a unique DNA profile can be generated for each individual in a population (Queller *et al.* 1993). Unlike minisatellite probes, PCR amplified microsatellites tend to be very species specific. This means that microsatellite screening methods must be developed for every organism studied, a costly and time-consuming procedure. However once developed, microsatellite analysis can be used where the quality and quantity of DNA is limited, making it more applicable for larger scale studies of natural populations.

Recent microsatellite studies on the Australian biota have ranged from examinations of genetic diversity in tea tree *Melaleuca alternifolia* (Rossetto *et al.* 1999) to parentage in the seahorse *Hippocampus angustus* (Jones *et al.* 1998).

RAPD PCR

Unlike the PCR-based methods described above which target specific segments of the DNA molecule, RAPD PCR amplifies random DNA fragments from throughout the genome. Because the same DNA fragments are not amplified in all individuals, variation is assessed solely on the basis of differences in the number and size of the fragments obtained (Williams *et al.* 1990; Hadrys *et al.* 1992). This is a relatively simple method for assessing the degree of genetic differentiation among individuals within a species. It has proven particularly useful in studying the population structure of plants (e.g. Waycott 1998; Bussell 1999; Skotnicki *et al.* 1999) and marine invertebrates such as bryozoans (Okamura *et al.* 1993). RAPD PCR is less suitable for comparative studies of variation between species and for this reason has found limited application in natural history studies of vertebrates, where more sensitive techniques such as DNA sequencing and targeted PCR amplification are preferred.

Natural history studies using DNA

Evolutionary relationships

Evolution proceeds through the accumulation of genetic variation (changes in the DNA), therefore, species which are closely related will have similar DNA sequences and those which are distantly related will have quite different DNA sequences. This simple relationship between DNA divergence and the time since two species shared a common ancestor enables us to reconstruct the pattern of evolutionary relationships among organisms. Since DNA mutations accumulate at a fairly constant rate the number of differences observed between the DNA sequences of two species can also be used to estimate the approximate time since they diverged. For vertebrate mitochondrial DNA it appears that the rate of DNA change is 2% per million years between lineages (Brown *et al.* 1979). Therefore a crude estimate of the time since divergence (in millions of years) between two taxa can be calculated by halving their per cent mitochondrial DNA divergence.

For the Australasian biota, mitochondrial DNA sequences have been used to examine phylogenetic relationships within a range of groups such as carnivorous marsupials (Krajewski *et al.* 1997; Blacket *et al.* 1999), varanid lizards (Fuller *et al.* 1998), birds-of-paradise (Nunn and Cracraft 1996), and onycophorans (Gleeson *et al.* 1998). In many cases these molecular phylogenies have supported traditional morphological studies but have added further resolution on the evolutionary history of the group under study. Analysis of mitochondrial DNA in onycophorans, for example, revealed two assemblages within Australia, a mainland one and one occurring largely in Tasmania. Interestingly, the Tasmanian species were more closely related to those occurring in New Zealand.

Analysis of chloroplast DNA has been used to examine relationships within the tree genera *Nothofagus* (Martin and Dowd 1993) and *Eucalyptus* (Sale *et al.* 1993, 1996). A combination of molecular and morphological data (Ladiges *et al.* 1995) now indicates that the genus *Eucalyptus* actually comprises two lineages- the 'bloodwoods' (including the previously separate genus *Angophora*), and the 'non-bloodwoods'. This separation has also been confirmed from analysis of nuclear DNA sequences (Steane *et al.* 1999).

Molecular phylogenies, in combination with comparative biology, have also been used to trace the evolution of cooperative breeding in Australian thornbills *Acanthiza* (Nicholls *et al.* 2000) and migration in shorebirds *Charadrius* (Joseph *et al.* 1999). By mapping breeding and non-breeding distributions as characters onto their DNA phylogeny, Joseph *et al.* (1999) concluded that shifts in breeding distributions were commonly involved in the evolution of migration in shorebirds. Similarly, by mapping breeding systems onto the DNA phylogeny Nicholls *et al.* (2000) suggested that cooperative breeding was the ancestral behaviour in thornbills. These two studies highlight how DNA based approaches can add to our understanding of the phylogeny of a group of organisms as well as aspects of their biology.

Identifying species and taxonomic diversity

DNA studies have proven particularly informative for determining the taxonomic status of isolated populations and identifying hidden taxonomic diversity (Norman and Christidis 1997). These decisions are based on assessments of the levels of genetic differentiation among the component forms. There is, however, no set level of genetic differentiation that automatically defines a population as being a species or subspecies. These values must be empirically determined for each species group. This involves a determination of the levels of DNA divergence characteristic of individuals within a population, between populations within a species and between species within the genus. Such an approach was used to establish species status for the Christmas Island Hawk-Owl *Ninox natalis* (Norman *et al.* 1998). Although previously recognised as a subspecies of the Moluccan Hawk-Owl *Ninox squamipila*, DNA sequence analysis revealed levels of differentiation comparable to that observed between obvious species of *Ninox* owl such as the Rufous Owl *N. rufa* and the Powerful Owl *N. strenua*. Other examples of additional species diversity being detected using DNA sequence data include the Southern Beaked Whales *Hyperoodon* (Dalebout *et al.* 1998) and the New Zealand Mudfish *Neochanna* (Gleeson *et al.* 1999). DNA data in combination with morphology has also been used to detect additional subspecific diversity among populations of the Large Bentwing Bat *Miniopterus schreibersii* in southern Australia (Cardinal and Christidis 2000).

Molecular ecology

Molecular ecology is the field of research where DNA techniques are used to complement ecological studies of population structure, dispersal and behaviour. The simplest application is in determining if geographically isolated populations are genetically distinct and whether distributional fragmentation is due to recent human activities or natural historical processes. Populations that have been historically isolated with limited migration will be characterised by significant differences in their genetic structures. Conversely, an absence of genetic differentiation could indicate that the populations are either interconnected by moderate to high levels of migration, or that they have only recently been isolated so that genetic differences have not yet accumulated (summarised in Avise *et al.* 1987).

DNA studies of the Koala *Phascolarctos cinereus* (Houlden *et al.* 1999), Greater Bilby *Macrotis lagotis* (Moritz *et al.* 1997) and Numbat *Myrmecobius fasciatus* (Fumagalli *et al.* 1999) have revealed low levels of genetic differentiation. This suggests that geographically separate populations in each of these species have only recently become isolated. In contrast, DNA studies of the alpine restricted Mountain Pygmy-possum *Burramys parvus* have revealed a high level of genetic subdivision among regional populations suggesting a long-term separation of the populations (Osborne *et al.* 2000). This finding is consistent with the limited dispersal capabilities, narrow ecological tolerance and fragmented distribution of the species.

Non-mammalian examples of DNA studies being used to detect population differentiation, gene flow and dispersal patterns in Australasian plants and animals include ants (Tek Tay *et al.* 1997), freshwater fish (Hurwood and Hughes 1998; Jerry and Baverstock 1998), mosses (Skotnicki *et al.* 1999), and seagrasses (Waycott 1998).

Mitochondrial DNA markers can also be used to determine if migratory species such as the Green Turtle *Chelonia mydas*, which can migrate thousands of kilometres between feeding and breeding grounds, are philopatric i.e. do they return to their natal sites to breed? In such species, populations from different regions should show significant differences in their mitochondrial DNA. Using this approach it has been demonstrated that Australian populations of the green turtle are philopatric; both male and female turtles return to their natal sites to breed some 35 to 50 years after hatching (Norman *et al.* 1994; FizSimmons *et al.* 1997).

DNA markers have also proven highly useful in understanding social structure within populations, particularly of birds (Birkhead *et al.* 1990; Dunn *et al.* 1995; Dunn and Cockburn 1998; Conrad *et al.* 1998). One of the major findings from these studies has been the observation that extra-pair fertilisations are common in many apparently monogamous species (Westneat *et al.* 1990). For example, DNA studies have demonstrated that Superb Fairy-wrens *Malurus cyaneus* are highly promiscuous with most broods examined containing some young sired by males from outside the social pair raising them (Dunn and Cockburn 1998). Furthermore, most of the helpers at the nest were shown to be unrelated to the young they attended (Dunn *et al.* 1995). In contrast, it has been shown that Bell Miners *Manorina melanophrys*, which also breed cooperatively, are not promiscuous and most of the helpers at the nest are close relatives of the breeding pair (Conrad *et al.* 1998). Without DNA data such detailed elucidation of the social structure and breeding behaviour of these species would not have been possible.

Conservation

Information from DNA data is also being used to assist in the conservation and management of rare and threatened plants and animals (reviewed with regard to avian examples in Norman and Christidis 1997). Threatened species in Victoria where the management strategy involves some application of DNA-based research include: Mountain Pygmy-possum *Burramys parvus*, Eastern-barred Bandicoot *Perameles gunnii*, Long-footed Potoroo *Potorus longipes*, New Holland Mouse *Pseudomys novaehollandiae*, Helmeted Honeyeater *Lichenostomus melanops cassidix*, Black-eared Miner *Manorina melanotis*, Regent Honeyeater *Xanthomyza phrygia* and Orange-bellied Parrot *Neophema chrysogaster*.

In these examples DNA techniques are being used for taxonomic assessment (higher conservation priorities are normally accorded to species than to subspecies), as a tool for measuring and monitoring changes in genetic diversity, and as a complement to ecological studies of population structure and demography.

References

Arctander, P. and Fjeldså, J. (1994). Avian tissue collections for DNA analysis. *Ibis* **136**,359-360.

Avise, J.C., Arnold, J., Ball, R.M., Bermingham, E., Lamb, T., Neigel, J.E., Reeb, C.A. and Saunders, N.C. (1987). Intraspecific phylogeography: the mitochondrial DNA bridge between population genetics and systematics. *Annual Review of Ecology and Systematics* **18**, 489-522.

Blacket, M.J., Krajewski, C., Labrinidis, A., Cambron, B., Cooper, S. and Westerman, M. (1999). Systematic relationships within the dasyurid marsupial tribe Sminthopsini- A multigene approach. *Molecular Phylogenetics and Evolution* **12**, 140-155.

Birkhead, T.R., Burke, T., Zann, R., Hunter, F.M. and Krupa, A.P. (1990). Extra-pair paternity and intraspecific brood parasitism in wild zebra finches *Taeniopygia guttata*, revealed by DNA fingerprinting. *Behavioral Ecology and Sociobiology* **27**, 315-324.

Brown, W.M. (1983). Evolution of animal mitochondrial DNA. *In* 'Molecular Evolutionary Genetics', pp. 62-8. Eds M. Nei and R.K. Koehn. (Plenum Press: New York.)

Brown, W.M., George, M. and Wilson, A.C. (1979). Rapid evolution of animal mitochondrial DNA. *Proceedings of the National Academy of Sciences USA* **76**, 1967-1971.

Burke, T. (1989). DNA fingerprinting and other methods for the study of mating success. *Trends in Ecology and Evolution* **4**, 139-144.

Bussell, J.D. (1999). The distribution of random amplified polymorphic DNA (RAPD) diversity amongst populations of *Isotoma petraea* (Lobeliaceae). *Molecular Ecology* **8**, 775-789.

Byrne, M., Moran, G.F. and Tibbit, W. (1993). Restriction map and maternal inheritance of chloroplast DNA in *Eucalyptus nitens*. *Journal of Heredity* **84**, 216-220.

Cardinal, B.R. and Christidis, L. (2000). Mitochondrial DNA and morphology reveal three geographically distinct lineages of the large bentwing bat (*Miniopterus schreibersii*) in Australia. *Australian Journal of Zoology* **48**, 1-19.

Conrad, K.F., Clarke, M.F., Robertson, R.J. and Boag, P.T. (1998). Paternity and the relatedness of helpers in the cooperatively breeding bell miner. *Condor* **100**, 343-349.

Cooper, A., Mourer-Chauvire, C., Chambers, G.K., von Haeseler, A., Wilson, A.C. and Pääbo, S. (1992). Independent origins of New Zealand moas and kiwis. *Proceedings of the National Academy of Sciences, USA* **89**, 8741-8744.

Crawford, D.J. (1989). 'Plant Molecular Systematics: Macromolecular Approaches'. (Wiley: New York.)

Dalebout, M.L., Van Helden, A., Van Waerbeek, K. and Baker, C. S. (1998). Molecular genetic identification of southern hemisphere beaked whales (Cetacea: Ziphiidae). *Molecular Ecology* **7**, 687-694.

Dowling, T.E., Moritz, C. and Palmer, J.D. (1990). Nucleic acids II: restriction site analysis. *In* 'Molecular Systematics', pp. 250-317. Eds D.M. Hillis and C. Moritz. (Sinauer Associates: Sunderland).

Dunn, P.O. and Cockburn, A. (1998). Costs and benefits of extra-group mating in superb fairy-wrens. *In* 'Avian Reproductive Tactics: Female and Male Perspectives', pp. 147-162. Eds P. Parker and N. Burley. (Ornithological Monograph no. 49. American Ornithologists' Union: Washington, DC.)

Dunn, P.O., Cockburn, A. and Mulder, R.A. (1995). Fairy-wren helpers often care for young to which they are unrelated. *Proceedings of the Royal Society of London series B* **259**, 339-343.

Ellegren, H. (1992). Polymerase-chain-reaction (PCR) analysis of microsatellites - a new approach to studies of genetic relationships in birds. *Auk* **109**, 886-895.

FitzSimmons, N.N., Limpus, C.J., Norman, J.A., Goldizen, A.R., Miller, J.D. and Moritz, C. (1997). Philopatry of male marine turtles inferred from mitochondrial DNA markers. *Proceedings of the National Academy of Sciences USA* **94**, 8912-8917.

Fuller, S., Baverstock, P. and King, D. (1998). Biogeographic origins of goannas (Varanidae): a molecular approach. *Molecular Phylogenetics and Evolution* **9**, 294-307.

Fumagalli, L., Moritz, C., Taberlet, P. and Friend, J. A. (1999). Mitochondrial DNA sequence variation within the remnant populations of the endangered numbat (Marsupialia: Myrmecobiidae: *Myrmecobius faciatus*). *Molecular Ecology* **8**, 1545-1549.

Gleeson, D.M., Howitt, R.L.J. and Ling, N. (1999). Genetic variation, population structure and cryptic species within the black mudfish, *Neochanna diversus*, an endemic galaxiid from New Zealand. *Molecular Ecology* **8**, 47-57.

Gleeson, D.M., Rowell, D.M., Tait, N.N., Briscoe, D.A. and Higgins, A.V. (1998). Phylogenetic relationships among Onycophora from Australasia inferred from the mitochondrial cytochrome oxidase subunit 1 gene. *Molecular Phylogenetics and Evolution* **10**, 237-248.

Graybeal, A. (1993). The phylogenetic utility of cytochrome b: lessons from bufonid toads. *Molecular Phylogenetics and Evolution* **2**, 256-269.

Hadrys, H., Balick, M. and Schierwater, B. (1992). Applications of random amplified polymorphic DNA (RAPD) in molecular ecology. *Molecular Ecology* **1**, 55-63.

Houlden, B.A., Costello, B.H., Sharkey, D., Fowler, E.V., Melzer, A., Ellis, W., Carrick, F., Baverstock, P.R. and Elphinstone, M.S. (1999). Phylogeographic differentiation in the mitochondrial control region in the koala, *Phascolarctos cinereus* (Goldfuss 1817). *Molecular Ecology* **8**, 999-1011.

Hurwood, D.A. and Hughes, J.M. (1998). Phylogeography of the freshwater fish, *Mogurnda adspersa*, in streams of northeastern Queensland, Australia: evidence for altered drainage patterns. *Molecular Ecology* **7**, 1507-1517.

Irwin, D.M., Kocher, T.D. and Wilson, A.C. (1991). Evolution of the cytochrome b gene in mammals. *Journal of Molecular Evolution* **32**, 128-144.

Jeffreys, A.J., Wilson, V. and Thein, S.L. (1985). Hypervariable 'minisatellite' regions in human mitochondrial DNA. *Nature* **314**, 67-73.

Jerry, D.R. and Baverstock, P.R. (1998). Consequences of a catadromous life-strategy for levels of mitochondrial DNA differentiation among populations of the Australian bass, *Macquaria novemaculenta*. *Molecular Ecology* **7**, 1003-1013.

Jones, A.G., Kvarnemo, C., Moore, G.I., Simmons, L.W. and Avise, J.C. (1998). Microsatellite evidence for monogamy and sex-biased recombination in the Western Australian seahorse *Hippocampus angustus*. *Molecular Ecology* **7**, 1497-1505.

Joseph, L., Lessa, E.P. and Christidis, L. (1999). Phylogeny and biogeography in the evolution of migration: shorebirds of the *Charadrius* complex. *Journal of Biogeography* **26**, 329-342.

Krajewski, C., Blacket, M., Buckley, L. and Westerman, M. (1997). A multigene assessment of phylogenetic relationships within the dasyurid marsupial subfamily Sminthopsinae. *Molecular Phylogenetics and Evolution* **8**, 236-248.

Ladiges, P.Y., Udovicic, F. and Drinnan, A.N. (1995). Eucalypt phylogeny - molecules and morphology. *Australian Systematic Botany* **6**, 483-497.

Leeton, P.R., Christidis, L. and Westerman, M. (1993). Feathers from museum birds skins - a good source of DNA for phylogenetic studies. *Condor* **95**, 465-466.

Martin, P.G. and Dowd, J.M. (1993). Using sequences of *rbc*L to study phylogeny and biogeography of *Nothofagus* species. *Australian Systematic Botany* **3**, 441-447.

Moritz, C., Heideman, A., Geffen, E. and Mcrae, P. (1997). Genetic population structure of the greater bilby *Macrotis lagotis*, a marsupial in decline. *Molecular Ecology* **6**, 925-936.

Nicholls, J.A., Double, M.C., Rowell, D.M. and Magrath, R.D. (2000). The evolution of cooperative and pair breeding in thornbills Acanthiza (Pardalotidae). *Journal of Avian Biology* **31**, 165-176.

Norman, J.A. and Christidis, L. (1997). Genetics and the conservation of Australian birds. *Pacific Conservation Biology* **3**, 306-315.

Norman, J.A., Christidis, L., Westerman, M. and Hill, R.F.A. (1998). Molecular data confirms the species status of the Christmas Island Hawk-Owl *Ninox natalis*. *Emu* **98**, 197-208.

Norman, J.A., Moritz, C. and Limpus, C.J. (1994). Mitochondrial DNA control region polymorphisms: genetic markers for ecological studies of marine turtles. *Molecular Ecology* **3**, 363-373.

Nunn, G.B. and Cracraft, J. (1996). Phylogenetic relationships among the major lineages of the birds-of-paradise (Paradisaeidae) using mitochondrial DNA gene sequences. *Molecular Phylogenetics and Evolution* **5**, 445-459.

Okamura, B., Jones, C.S. and Noble, L.R. (1993). Randomly amplified polymorphic DNA analysis of clonal population structure and geographic variation in a freshwater bryozoan. *Proceedings of the Royal Society of London series B* **253**, 147-154.

Osborne, M.J., Norman, J.A., Christidis, L. and Murray, N.D. (2000). Genetic distinctness of isolated populations of an endangered marsupial, the mountain pygmy-possum, *Burramys parvus*. *Molecular Ecology* **9**, 609-613.

Palmer, J.D. (1987). Chloroplast DNA evolution and biosystematic uses of chloroplast DNA variation. *American Naturalist* **130**, S6-S29.

Queller, D.C., Strassmann, J.E. and Hughes, C.R. (1993). Microsatellites and kinship. *Trends in Ecology and Evolution* **8**, 285-288.

Quinn, T.W. and Wilson, A.C. (1993). Sequence evolution in and around the mitochondrial control region in birds. *Journal of Molecular Evolution* **37**, 417-425.

Rossetto, M., Slade, R.W., Baverstock, P.R., Henry, R.J. and Lee, L.S. (1999). Microsatellite variation and assessment of genetic structure in tea tree (*Melaleuca alternifolia*- Myrtaceae). *Molecular Ecology* **8**, 633-643.

Saiki, R.K., Gelfand, D.H., Stoffel, S., Scharf, S.J., Higuchi, R., Horn, G.T., Mullis, K.B. and Erlich, K. (1988). Primer-directed enzymatic amplification of DNA with a thermostable DNA polymerase. *Science* **239**, 487-491.

Sale, M.M., Potts, B.M., West, A.K. and Reid, J.B. (1993). Relationships in *Eucalyptus* using chloroplast DNA. *Australian Systematic Botany* **6**, 127-138.

Sale, M.M., Potts, B.M., West, A.K. and Reid, J.B. (1996). Relationships within *Eucalyptus* (Myrtaceae) using PCR amplification and southern blotting of chloroplast DNA. *Australian Systematic Botany* **9**, 273-282.

Scribner, K.T. and Bowman, T.D. (1998). Microsatellites identify depredated waterfowl remains from glaucous gull stomachs. *Molecular Ecology* **7**, 1401-1405.

Skotnicki, M.L., Ninham, J.A. and Selkirk, P.M. (1999). Genetic diversity and dispersal of the moss *Sarconeurum glaciale* on Ross Island, East Antarctica. *Molecular Ecology* **8**, 753-762.

Steane, D.A., McKinnon, G.E., Vaillancourt, R.E. and Potts, B.M. (1999). ITS sequence data resolve higher level relationships among eucalypts. *Molecular Phylogenetics and Evolution* **12**, 215-223.

Tek Tay, W., Cook, J.M., Rowe, D.J. and Crozier, R.H. (1997). Migration between nests in the Australian arid-zone ant *Rhytidoponera* sp. 12 revealed by DGGE analyses of mitochondrial DNA. *Molecular Ecology* **6**, 403-411.

Thomas, R.H., Schaffner, W., Wilson, A.C. and Paabo, S. (1989). DNA phylogeny of the extinct marsupial wolf. *Nature* **340**, 465-467.

Wasser, S.K., Houston, C.S., Koehler, G.M., Cadd, G.G. and Fain, S.R. (1997). Techniques for application of faecal DNA methods to field studies of Ursids. *Molecular Ecology* **6**, 1091-1097.

Waycott, M. (1998). Genetic variation, its assessment and implications to the conservation of seagrasses. *Molecular Ecology* **7**, 793-800.

Westneat, D.F., Sherman, P.W. and Morton, D.L. (1990). The ecology and evolution of extra-pair copulations in birds. *Current Ornithology* **7**, 331-369.

Williams, J.G.K., Hanafey, M.K., Rafalski, J.A. and Tingey, S.V. (1990). DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Research* **18**, 6531-6535.

Records of the Giant Banjo Frog *Limnodynastes interioris* from Gunbower Island and the Ovens Floodplain, Victoria

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Abstract

Two new records of the critically endangered Giant Banjo Frog *Limnodynastes interioris*, one from the Lower Ovens Regional Park and one from Gunbower Island State Forest, extend the known range of the frog west by about 100 km. This brings the number of records of the Giant Banjo Frog in Victoria to eight. (*The Victorian Naturalist* **117** (6), 2000, 226-227.)

The Giant Banjo Frog *Limnodynastes interioris* is classified as Critically Endangered in Victoria (NRE 2000), with only six previous records for the state between 1929 and 1993 (Atlas of Victorian Wildlife (AVW) 2000). The species occupies a restricted area of the Murray River floodplain in Victoria, which forms the southern margin of its main range in New South Wales. We present two new records and locations for the species for individuals captured in the Gunbower Island State Forest (35°45'22"S 144°17'54"E) near Cohuna, and Lower Ovens Regional Park (36°03'03"S 146°11'26"E) near Yarrawonga, Victoria. Both individuals were released unharmed.

These specimens were pitfall trapped during a more extensive study of the vertebrate fauna of Gunbower Island, Barmah State Forest and Lower Ovens Regional Park (Mac Nally *et al.* in press). Capture rates of frogs by pitfall trapping were generally associated with rainfall events, but the extensive area of wetlands with permanent water at Lower Ovens led to consistently higher capture rates of frogs than at either Barmah State Forest or Gunbower Island (Table 1).

The Giant Banjo Frog is distributed through Central New South Wales west of the Great Dividing Range and south to the Murray River (Cogger 1992) and marginally on the Victorian section of the Murray River floodplain (Hero *et al.* 1991). It is typically found in a range of dry habitats from woodlands to mallee and semi-arid shrublands (Cogger 1992) and cleared farmland (AVW 2000; G. Brown, *pers. comm.*). It is a burrowing species usually seen on the surface only after substantial rain (Cogger 1992; Hero *et al.* 1991).

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An individual of *L. interioris* was captured in the Lower Ovens Regional Park between 22-28 October 1999, and another in Gunbower Island State Forest on 27 January 2000. The Lower Ovens specimen was identified subsequently by reference to field guides (Cogger 1992; Hero *et al.* 1991), but the Gunbower Island frog was identified in the hand. Notes were taken before release of the second frog: '*orange supra-orbital patches (small), series of orange dots on upper vertebral line ... four broad orange longitudinal bands on dorsum ... pale yellow belly ...*', substantiating the distinctive appearance of this species.

The Lower Ovens capture site was in mature River Red Gum *Eucalyptus camaldulensis* woodland with a Silver Wattle *Acacia dealbata* middle-storey and dense ground sward of Common Tussock-grass *Poa labillardieri*, adjacent to a backwater of the Ovens River. The Gunbower Island capture site was in an area of regrowth, single-age River Red Gum woodland near the Murray River. Both captures were made in pitfall traps during long periods of heavy rain and within 30-50 m of permanent watercourses.

These new records extend the known range west by about 100 km to Cohuna, and confirm its on-going presence in an area where the last records were from 1929 (AVW 2000). The Giant Banjo Frog clearly is rare in Victoria (Brown and Bennett 1995). Although eight records are few data, it seems possible, given the widespread and evenly spaced nature of the Victorian records, that this species may occur along much of the Murray floodplain between Wodonga (36°07'35"S 146°53'00"E) and Cohuna, mirroring its distribution in southern New South Wales.

Table 1. Capture rates of frogs at three sites along the Murray and Ovens Rivers (2100 pitfall nights per site; 1998-2000). *N*† Captures per 100 pitfall nights.

Species	Barmah Forest		Gunbower Island		Ovens Floodplain	
	N	*N*†	*N*	*N*†	*N*	*N*†
Crinia parinsignifera	1	0.05	2	0.10	40	1.90
Crinia signifera	5	0.24	14	0.67	105	5.00
Limnodynastes dumerilii	8	0.38	3	0.14	491	23.38
Limnodynastes interioris	0	0.00	1	0.05	1	0.05
Limnodynastes tasmaniensis	149	7.10	83	3.95	136	6.48
Litoria ewingii	0	0.00	0	0.00	11	0.52
All species	**163**	**7.76**	**103**	**4.90**	**784**	**37.33**

The cryptic habit of the species means that its detection will require very intensive, targeted surveying to elevate records substantially. Nevertheless, it seems possible that the total area occupied by the Giant Banjo Frog in Victoria is potentially large (~15 000 km²).

Acknowledgements
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References

AVW (2000). Atlas of Victorian Wildlife (Department of Natural Resources and Environment: Heidelberg, Victoria.)
Brown, G. and Bennett, A.F. (1995). The distribution, habitat requirements and conservation status of the reptile fauna of the Murray-Darling Basin area in Victoria. Murray-Darling Basin Commission report
Cogger, H.G. (1992) 'Reptiles and Amphibians of Australia'. (Reed Books: Sydney.)
Department of Natural Resources and Environment (2000). Threatened Vertebrate Fauna in Victoria 2000. A systematic list of vertebrate fauna considered extinct, at risk of extinction or in major decline in Victoria (Department of Natural Resources and Environment: Melbourne.)
Hero, J., Littlejohn, M. and Marantelli, G. (1991). 'Frogwatch Guide to Victorian Frogs'. (Department of Conservation and Environment Melbourne.)
IUCN (1994). 'IUCN Red List Categories'. (IUCN: Gland, Switzerland.)
Mac Nally, R., Parkinson, A., Horrocks, G., Conole, L. and Tzaros, C. (*in press*). Relationships between vertebrate diversity, abundance and availability of coarse woody debris on south-eastern Australian floodplains. *Biological Conservation*.

Sharing a Nest Hollow

Observations of animals sharing nest hollows have been described by FNCV members, most recently by Maria Belvedere (*The Victorian Naturalist*, Volume 116 (6), December 1999). Maria observed a Common Brushtail Possum, a colony of Sugar Gliders and feral European Honeybees occupying separate hollows in the one tree at Wattle Glen. Over three consecutive years, during nesting time, the Common Brushtail Possum was evicted from its hollow by a family of Laughing Kookaburras.

At Silvan Reservoir Park, Silvan, I have observed this same scenario for the past two years. A Common Brushtail Possum occupies a hollow in a dead eucalypt in the middle of the main picnic area most of the year. In August/September, a family of Laughing Kookaburras takes possession of the hollow for nesting and the possum relocates to another (unknown) site. However, I cannot determine if the same individual moves back into the hollow after the kookaburra breeding season as the possum has no identifying marks.

In this area of the park, nest hollows of this size are not easy to find due to the relatively young age of the current eucalypts. Although Common Brushtail Possums are over-abundant in some areas of suburban Melbourne, on a regular night walk in and around this park, I would encounter many Eastern Ringtail Possums but rarely a Common Brushtail.

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Octopus kaurna at San Remo, Victoria

On the afternoon of Thursday 25 February 1999, at San Remo, Victoria, a solitary *Octopus kaurna* Stranks, 1990 was sighted during low tide. It was in the lowermost littoral zone, buried in sand. Only the white posterior mantle and the ends of several arms were visible (Fig. 1). The day was warm and overcast.

The octopus was delicately exposed by placing a hand vertically into the wet sand next to it; both the octopus and the surrounding sand were then gently levered to the surface. It assumed a brick-red colour and made its way to the water's edge, about 15 centimetres away. For the next ten minutes it remained there in shallow water, relatively motionless (see photo on front cover). Observations were not continued as the tide had started to rise.

The mantle length was approximately 50 to 60 mm and the arms looked relatively long (estimated at 110-130 mm) and tapered to fine tips, with biserial suckers. The absence of a hectocotylus on the third right arm suggested a female specimen. Stranks (1990) notes that this species can attain a mantle length of 85 mm and a total length of 420 mm.

Octopus kaurna is known to inhabit sandy habitats from the intertidal zone to depths of 49 metres (Stranks 1990). It remains buried during the day and emerges at night to feed (Norman and Reid 2000; Edgar 1997), mainly on crustaceans (Norman and Reid 2000). Beesley, Ross and Wells (1998) shows photographs of burying behaviour in this species (Plate 20, Figures 5 and 6 in that work).

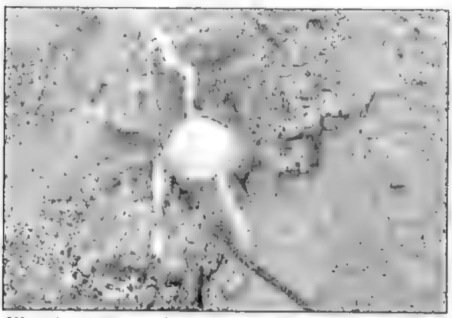

Fig. 1. *Octopus kaurna* as initially found. The octopus is almost completely buried in sand.

Octopus kaurna is found from the central Great Australian Bight to southern New South Wales, including northern Tasmania and Bass Strait (Stranks 1996). Its eggs are relatively large (9-11 mm diameter), suggesting that hatchlings are benthic (Stranks 1996). Details of egg attachment to the substrate, number of eggs laid or hatchling size and behaviour are unknown (Stranks 1996; Norman and Reid 2000).

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References

Beesley, P.L., Ross, G.J.B. and Wells, A. (eds) (1998). 'Mollusca: The Southern Synthesis. Fauna of Australia. Vol. 5, Part A'. (CSIRO Publishing: Melbourne.)

Edgar, G.J. (1997). 'Australian Marine Life. The Plants and Animals of Temperate Waters'. (Reed Books: Australia.)

Norman, M. and Reid, A. (2000). 'A Guide to Squid, Cuttlefish and Octopuses of Australasia'. (The Gould League of Australia, and CSIRO Publishing: Collingwood.)

Stranks, T.N. (1990). Three new species of *Octopus* (Mollusca: Cephalopoda) from South-Eastern Australia. *Memoirs of the Museum of Victoria* **50** (2), 457-465.

Stranks, T.N. (1996). Biogeography of *Octopus* species (Cephalopoda: Octopodidae) from south-eastern Australia. *American Malacological Bulletin* **12** (1/2), 145-151.

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Wandering With Water Rats or, Rambling With Rakali

Most of us are automatically turned off by the word RAT. Rats have a bad public image, due to their generally perceived undesirable effects on humans and their surroundings. Rats carry disease – the most famous (or, rather, infamous) being the bubonic plague, which decimated the population of Europe in the 14th century (in that case it was fleas travelling with the rats that transmitted the disease, but the rats still copped the blame); rats eat or damage stored foodstuffs – and in modern times, electrical wiring; rats will attack humans – especially babies – and eat their fingers or toes or ears; rats attack or infect livestock – the list goes on. In most people's eyes, rats are bad news, and we use all manner of methods to rid ourselves and our property from rats. Ancient Egyptians, and later the Romans, used cats as rodent controllers. The Pied Piper of Hamelin was, of course, originally employed to rid that medieval city of rats, not children. Dogs were used as rat-catchers until very recently – and may even still be used in some places. The English Royal Ratcatcher's office lasted until the 1940s or even later. Poisons are now the most commonly used controlling method, and every supermarket carries its chosen brands of nasties.

So why, you may ask, am I writing all this bad stuff about rats? I want to set the scene for a different view. Not all rats are bad company. In fact, most rats (and mice) – and there have been about 2000 species described, so far – are OK. Australia is home to nearly 70 different kinds of native rats and mice, most of which are inoffensive and indeed have little contact with humans – except for those fortunate few who set out to study them. Australian rodents range in size from the Giant White-tailed Rat and the Water Rat (of which, much more very soon) both weighing over half a kilogram, to the tiny Delicate Mouse, the Pebble-mound Mice or the Pilliga Mouse, all of which are only around 10-15 grams. Some species of native rodents are extinct – about 12% of all those known to be present when Europeans settled here; others are considered to be threatened with extinction; and only about 50% of species are reckoned to be secure.

Rodents are believed to have come to Australia from Asia, on at least two occasions in the distant past, the first some 4.5 million years ago, and the second more recently, perhaps within the last million years or so. Water Rats, the main subject of this essay, are part of the older group, the so-called 'old endemics'. Most native rodents belong to this group, which is also widespread in New Guinea and other islands to our north.

About 20 species of rodent have been recorded from Victoria. Three are introduced (Brown Rat, Black Rat and House Mouse), at least six (and probably more) are extinct and nine remain extant. Of these, the most widespread is the Water Rat, *Hydromys chrysogaster*. The scientific name means 'water mouse with a golden belly', and describes the animal very well indeed; typical specimens are a rich dark brown on the back and head and have gloriously golden-toned belly fur. Not all Water Rats are this colour, and that has led to several different species being described in the past. But they are all one species, found from Tasmania to Cape York, as far west as the Kimberleys and south-western WA, in addition to New Guinea and some nearby islands. There are about 16 or 17 species of related rodents in New Guinea, some of which are 'water rats', others are more properly described as 'moss rats' – some examples include the Earless Water Rat, Ernst Mayer's Leptomys and the Waterside Rat. We really know very little about most of these fascinating species.

The Water Rat was first described in 1804, from a specimen collected on Bruny Island, Tasmania, by a French expedition. But they must have been familiar to the first settlers at Sydney Cove, and later when other colonies were established. The wonder is that they are still found in all those places, having managed to survive in their aquatic environment in spite of all the changes that we have made. The earliest illustration that I could find was that published by Cuvier in 1837, which is a pretty good representation of the animal. Only the webbed hind feet are not clearly shown. John Gould subsequently described and illustrated three species (1853, 1863), and in 1950 George Browning's drawing for the National Museum of Victoria handbook neatly represented this fine animal.

Rodents around the globe have taken to the water as a way of life. In Europe and North America, Beavers, Water Voles and Muskrats occupy this niche. In South America, the niche is taken by the only aquatic marsupial, the Yapock; and in Australia, the Water Rat. And there are other groups of small mammals that have adopted water as part of their environment; otters, of course, and our own Platypus. All have specialised features that enable them to exploit a watery world. These include, for the Water Rat, webbed hind feet, a thick tail that can be used as a rudder, an elongate, flattened head with lots of whiskers, small ears and eyes and a soft, water-repellent coat. Actually, Water Rats are really terrestrial rats that have secondarily taken to the water, and they are not as well-adapted to water as some other small aquatic mammals. Nevertheless, they ARE very successful in exploiting the rivers, swamps and seashores that they inhabit.

Water Rats are probably one of the native mammals more likely to be seen by people, due to their being not totally nocturnal, as most other small mammals are. Particularly in the early morning and the evening they can be seen swimming, with just the head showing ahead of a distinctive bow-wave. Diving to search for prey they may reappear some distance away. They are territorial, and males in particular often have damaged tails, the result of fights. Their tracks may be seen in the mud or wet sand at the water's edge, and clear evidence of their presence is found in the so-called 'feeding tables', where the inedible remains of their meals may be seen. They are almost entirely carnivorous, and eat yabbies, crabs, fish, mussels, frogs, snails, bird's eggs and even fully-grown waterbirds, bats and in fact anything that they can catch. We are not certain that food is deliberately taken to special feeding places, but the rats do make use of flat, accessible spots - rocks, banks, logs - and even the decks of moored boats.

Water Rats live in burrows that are excavated along the banks of the water, although hollow logs may be used if they are available. Burrows are above water level, and lead to a nest chamber lined with vegetation. Water Rats are not very easy to keep in captivity, and early attempts often resulted in decline and death of the animal. David Fleay, at Healesville Sanctuary, was probably the first to understand the captive needs of Water Rats, and developed his own *hydromusary*, in which he was able to breed the rats. The present Water Rat display at Healesville is a very good example of how to maintain such animals in a modern zoo.

Breeding can occur throughout the year but most breeding takes place in spring and summer. Females may breed as early as four months old but the norm is about twice that. The gestation period is 34 days, followed by about four weeks suckling and four weeks close to mum before the young rats move off to seek their fortune. There are four teats and litters are generally 3-4; up to five litters may be born in a year, but 1-2 is more common. In most situations, Water Rat density is low, but when conditions are good, numbers in a given area can increase markedly.

Predators themselves, Water Rats are prey to large fish, snakes, birds of prey such as kites, and feral Cats. The other major predator is man. The dense, soft fur was a highly sought-after pelt and so Water Rats were trapped in large numbers to make coats and rugs and the like. Tens, if not hundreds, of thousands were trapped, using rabbit traps, nets and even tin cans with the lid so cut that a rat got its head caught and it was drowned, and others were poisoned.

This unregulated trapping had a serious effect on numbers of Water Rats in Victoria, and in 1931 the Chief Inspector of Fisheries and Game, Fred Lewis, began to seek information about numbers taken and by mid-1935 he was considering legislative controls. In 1938 a Closed Season from 1 August to 30 April was proclaimed - 'to protect them during the breeding season'. Further legislative devices were applied in 1940, mainly relating to marketing, and the use of poison was prohibited in 1942.

Water Rats have been accused of damaging irrigation channels and structures, through burrowing which creates holes leading to water loss. The then State Rivers and Water Supply Commission was concerned at the perceived damage issue in the 1950s – it cost them £14 000 for repairs in 1953, for example – and political pressure was brought to bear. The Australian Primary Producers Union called for them to be classified as vermin and the Country Party lobbied for an open season. During the 1950s John McNally, the Fisheries and Game Department's biologist, carried out a study of Water Rats, in order to gain an understanding of how this damage might be addressed. He studied the rats in the field and laboratory, keeping live animals at Melbourne Zoo. Finally, the Department agreed to a licensed season. The first of these was held in 1958, followed by others in 1959, 1960 and 1962-63. Some 55 000 skins were sold as a result, with a 5-10% royalty being paid to the Government. The average price per skin ranged between 4 and 9 shillings - 40-90 cents. One more season was held, in 1967, but returns were poor and no further requests were made for a repeat. Full protection was confirmed by the new **Wildlife Act** in 1975 and there have been few complaints about damage by Water Rats in the last 30 years.

Conservation of the Water Rat seems to be now a more a local than an Australia or Victoria-wide issue. There is little evidence to indicate that their overall range is much smaller now than it was in 1788, but habitat changes have meant that many populations are now isolated from each other, and there is still the possibility of local extinction due to drainage, development, pollution and so on. We are interested in the problem of maintaining Water Rats along the coast, for example at St Kilda, where *Earthwatch* carry out regular monitoring of the Water Rats that live in the rock jetty, and in the City of Bayside, where there is the added concern of poisoning from chemicals used in marine anti-fouling paints as they leach or wear off boats in the marina. Melbourne Water has a reasonable population of Water Rats at Werribee and surveys have suggested that cleaning out the channels is not good for the rats. There is a growing recognition that Water Rats are nice beasts to have around, but they do share their urban homes with undesirable relatives, and poisoning is often carried out, posing a very real threat to the good guys.

The general perception of rats being bad, with which I began this essay, is widespread, and for good reason – but we need to understand that Water Rats are as much a part of our natural faunal heritage as a kangaroo or Koala, and they deserve to be recognised as such. Some efforts are being made to rid them of the stigma of 'rat', by calling them **Rakali**, an aboriginal name that was used along parts of the Murray River in South Australia. It would be great if we were able to have a local aboriginal name but that does not seem possible. So, Rakali it may have to be, and it is to be hoped that the community will come to recognise that this animal is indeed a valued native beast – as the *Earthwatch* folk have put it in their excellent little book – *The Marvellous Rakali.*

This essay is a slightly revised version of a talk given to the City of Manningham Green Wedge program and to the Ringwood Field Naturalists Club.

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Extra reading

McNally, J. (1960). The biology of the Water Rat *Hydromys chrysogaster* Geoffroy (Muridae: Hydromyinae) in Victoria. *Australian Journal of Zoology* **8**, 170-180

Menkhorst, P.W. (ed.) (1995). 'Mammals of Victoria: Distribution, ecology and conservation'. (Oxford University Press: South Melbourne.)

Olsen, P.D. (1982). Reproductive biology and development of the Water Rat *Hydromys chrysogaster* in captivity. *Australian Wildlife Research* **9**, 39-54.

Strahan, R. (ed.) (1995). 'The Mammals of Australia'. (Australian Museum/Reed New Holland: Sydney.)

Watts, C.H.S. and Aslin, H.J. (1981). 'The Rodents of Australia'. (Angus and Robertson Publishers: Melbourne.)

Woolard, P., Vestjens, W.J.M. and McLean, L. (1978). The ecology of the Eastern Water Rat *Hydromys chrysogaster* at Griffith, N.S.W.: food and feeding habits. *Australian Wildlife Research* **5**, 59-73.

Flora and Fauna Guarantee Act 1988

The Flora and Fauna Guarantee Scientific Advisory Committee has made recommendations in relation to nominations for listing under the provisions of the ***Flora and Fauna Guarantee Act* 1988**. The following reports have been received:

Species/Process/Community		**Recommendation**
Final Recommendations		
Brasenia schreberi	Water-shield	Supported
Caladenia brachyscapa	Short Spider-orchid	Supported
Caladenia pumila	Dwarf Spider-orchid	Supported
Caleana sp. aff. *nigrita*	Grampians Duck-orchid	Supported
Diomedea cauta	Shy Albatross	Not supported (the threatening process occurs in oceanic waters beyond Victorian jurisdiction)
Diomedea exulans	Wandering Albatross	Not supported (the threatening process occurs in oceanic waters beyond Victorian jurisdiction)
Diomedea melanophrys	Black-browed Albatross	Not supported (the threatening process occurs in oceanic waters beyond Victorian jurisdiction)
Diuris tricolor	Donkey-orchid	Supported
Phoebetria fusca	Sooty Albatross	Supported
Prasophyllum suaveolens	Fragrant Leek-orchid	Supported
Pseudocephalozia paludicola	Liverwort	Supported
Pterostylis valida	Robust Greenhood	Supported
Swainsona swainsonioides	Downy Swainson-pea	Supported
Thelymitra gregaria	Basalt Sun-orchid	Supported
Thelymitra hiemalis	Winter Sun-orchid	Supported
Coastal Moonah (*Melaleuca lanceolata* ssp. *lanceolata*) Woodland Community	Listed as a community	Supported
Human activity which results in artificially elevated or epidemic levels of Myrtle Wilt within *Nothofagus*-dominated Cool Temperate Rainforest	Potentially Threatening Process	Supported
Lowland Riverine Fish Community of the southern Murray-Darling Basin	Listed as a community	Supported
Preliminary Recommendations		
Acacia phlebophylla	Buffalo Sallow Wattle	Supported
Acianthus collinus	Inland Pixie Caps	Supported
Babingtonia crenulata	Fern-leaf Baeckea	Supported
Caladenia carnea var. *subulata*	Striped Pink Fingers	Supported
Caladenia colorata	Painted Spider-orchid	Supported
Caladenia cruciformis	Orchid spp.	Supported
Caladenia insularis	French Island Spider-orchid	Supported
Caladenia pilotensis	Mt Pilot Spider-orchid	Supported
Caladenia sp. aff. *venusta*	Kilsyth South Spider-orchid	Supported

Species/Process/Community		**Recommendation**
Preliminary Recommendations (cont.)		
Caladenia valida	Robust Spider-orchid	Supported
Caladenia versicolor	Candy Spider-orchid	Supported
Calomnion complanatum	Tree-fern Calomnion	Supported
Chthonicola sagittata	Speckled Warbler	Supported
Egernia coventryi	Swamp Skink	Supported
Engaeus rostrogaleatus	Strzelecki Burrowing Cray	Supported
Eucalyptus mitchelliana	Buffalo Sallee	Not supported
Litoria booroolongensis	Booroolong Frog	Supported
Litoria raniformis	Warty Bell Frog	Supported
Macronectes hallii	Northern Giant-Petrel	Supported
Megaptera novaeangliae	Humpback Whale	Supported
Melanodryas cucullata	Hooded Robin	Supported
Neuropogon acromelanus	Lichen spp.	Supported
Nyctophilus timoriensis	Eastern Long-eared Bat	Supported
Oreoica gutturalis	Crested Bellbird	Supported
Peronomyrmex 'bartoni'	Ant sp.	Supported
Persoonia asperula	Mountain Geebung	Supported
Prasophyllum morganii	Cobungra Leek-orchid	Supported
Pratia gelida	Snow Pratia	Supported
Pterostylis aenigma	Enigmatic Greenhood	Supported
Pultenaea lapidosa	Mt Tambo Bush-pea	Supported
Spyridium nitidum	Shining Spyridium	Supported
Stagonopleura guttata	Diamond Firetail	Supported
Struthidea cinerea	Apostlebird	Supported
Thunnus maccoyii	Southern Bluefin Tuna	Supported
Xanthoparmelia suberadicata	Foliose Lichen	Supported
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	Potentially Threatening Process	Supported
The introduction and spread of the Large Earth Bumblebee *Bombus terrestris* L. into Victorian terrestrial environments	Potentially Threatening Process	Supported
Invalid Items		
Herb-rich Foothill Forest (Limestone) Community	Listed as a community	A decision was not made within the required time limit
Prasophyllum campestre	Plains Leek-orchid	No reliable evidence that the species has occurred in Victoria

Copies of all reports are held in the FNCV library. Recommendation reports will be available shortly on NRE's web page (http://www.nre.vic.gov.au).

Guidelines for Authors - The Victorian Naturalist

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Authors may submit material in the form of research reports, contributions, naturalist notes, letters to the editor and book reviews. Research reports and contributions must be accompanied by an abstract of not more than 200 words. The ***abstract*** should state the scope of the work, give the principle findings and be complete enough for use by abstracting services. Research reports and contributions will be refereed by external referees. A ***Research Report*** is a succinct and original scientific paper written in the traditional format including abstract, introduction, methods, results and discussion. A ***Contribution*** may consist of reports, comments, observations, survey results, bibliographies or other material relating to natural history. The scope of a contribution is broad and little defined to encourage material on a wide range of topics and in a range of styles. This allows inclusion of material that makes a contribution to our knowledge of natural history but for which the traditional format of scientific papers is not appropriate. ***Naturalist Notes*** are generally short, personal accounts of observations made in the field by anyone with an interest in natural history. These may also include reports on excursions and talks, where appropriate. ***Letters to the Editor*** must be no longer than 500 words. ***Book Reviews*** are usually commissioned, but the editors also welcome enquiries from potential reviewers.

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Cite references used for taxonomic names. References used by *The Victorian Naturalist* are listed at the end of these guidelines.

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Italics are used for the following abbreviations: *et al.*; *pers. comm.*; *pers. obs.*; *unpubl. data* and *in press* which are cited in the text – (R.G. Brown 1994 *pers. comm.* 3 May). Note that 'ssp.' is now 'subsp.'

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All illustrations (including photographs) are considered as figures and will be designed to fit within a page (115 mm) or a column (55 mm) width. Tables must also fit into 55 mm/115 mm. **It is important that the legend is clearly visible at these sizes.** For preference, photographs should be of high quality/high contrast which will reproduce clearly in black-and-white and they may be colour slides, colour or black-and-white prints. Line drawings, maps and graphs may be computer generated or in black Indian Ink on stout white or tracing paper. On the back of each figure, write the figure number and the paper's title in pencil. Computer-generated figures should also be submitted on disc as a high-quality TIFF or Encapsulated Postscript file (EPS), or embedded into a MS Word document. All figures and tables should be referred to in the text and numbered consecutively. Their captions must be numbered consecutively (Fig. 1, Fig. 2, etc.) and put on a separate page at the end of the manuscript. Tables should be numbered consecutively (Table 1, Table 2, etc.) and have an explanatory caption at the top.

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The International System of Units (SI units) should be used for exact measurement of physical quantities.

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In all papers, at the first reference of a species, please use both the common name and binomial. However, where a lot of species are mentioned, a list (an appendix at the end), with both common and binomial names, may be preferred. Lists must be in taxonomic order using the order in which they appear in the references listed below.

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Phillips, A. and Watson, R. (1991). *Xanthorrhoea*: Consequences of 'horticultural fashion'. *The Victorian Naturalist* **108**, 130-133.

Smith, A.B. (1995). Flowering plants in north-eastern Victoria. (Unpublished PhD thesis, University of Melbourne.)

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