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FNCV Calendar of Activities

March

Tues 1	Fauna Survey Group Meeting. **Vegetation Diversity at Jilpanger Springs** – Damien Cook. Herbarium Hall 8 pm.
Sat 5	General FNCV Excursion. **Bush Regeneration at Alan McMahon's Property, Erica.** Contact Dorothy Mahler 435 8408.
Thurs 10	Botany Group Meeting. **Orchids after the Anglesea Fire** – Ilma Dunn and John Eichler. Herbarium Hall 8 pm.
	No General Meeting – VFNCA Camp from Fri. 11 to Mon. 14, Gippsland.
Sat 12 – Mon 14	Fauna Survey Group Field Survey. **Wilson's Promontory.** Contact Russell Thompson 434 7046.
Wed 16	Microscopical Group Meeting. **Microscopical Freshwater Life** – Dr. Russell Shiel. Astronomer's Residence 8pm.
Wed 23	Geology Group Meeting. **Geology of the North-west Shelf** – Ian Russell. Herbarium Hall 8 pm.
Sat 26	Botany Group Excursion. **Seaweeds and Shore Plants at Flinders.** Leader Tom Sault. Meet Golf Course Road Car Park 10.30 am. Melway I97 G10. Own transport.
Sat 26	Fauna Survey Group Field Survey. **Leadbeaters Possum Survey.** Contact Ray Gibson 874 4408.

April

Fri 1 – Mon 4	Fauna Survey Group Field Survey. **Easter Camp, Ned's Corner.** Contact Ray Gibson 874 4408.
Tues 5	Fauna Survey Group Meeting. **Population Viability and Analysis for Rare Species** – Mark Bergman. Herbarium Hall 8 pm.
Sat 9	**President's Picnic – Wattle Park.** All club members are asked to join in this get together. Meet at Chalet Car P off Riversdale Road 11.30 am. This picnic replaces the excursion.
Mon 11	**Annual General Meeting** – Herbarium Hall 8 pm.
Thurs 14	Botany Group Meeting. **Action Statements under the Flora and Fauna Guarantee Act** – Pam Clunie. Herbarium Hall 8 pm.
Sat 16	Fauna Survey Group Field Survey. **Leadbeaters Possum Survey.** Contact Ray Gibson 874 4408.
Wed 20	Microscopical Group Meeting. **Videos on Live Cell Functions** – Prof. Pickett-Heaps. Melbourne University. Contact Ray Power 717 3511.
Sat 23	Botany Group Excursion. **Boneseeding at Seawinds, Arthurs Seat.** Meet Car Park 10.30 am. Own transport. Contact Joan Harry 850 1347.
Sat 23 – Mon 25	Fauna Survey Group Field Survey. **Brisbane Ranges.** Contact Ray Gibson 874 4408.
Wed 27	Geology Group Meeting. Herbarium Hall 8 pm. Contact Karina Bader 690 4653.

Notice: The distinquished Japanese mycologist Y. Kobayasi died 6 Jan 1994. He was the world expert on *cordyceps.*

The Victorian Naturalist is the bi-monthly publication of The Field Naturalists Club of Victoria.

The Victorian Naturalist

F.N.C.V.

Volume 111 (1) 1994 February

Editor: Robyn Watson
Assistant Editors: Ed and Pat Grey

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ISSN 0042-5184

Cover Photo: A forest of slime moulds, *photographer K. L. Williams* (see article on page 18.)

The Distribution, Habitat and Conservation Status of the Greater Long-eared Bat *Nyctophilus timoriensis* in Victoria

L.F. Lumsden*

Introduction

During the last decade, extensive surveys for bats conducted throughout Victoria (e.g. Emison *et al.* 1984, Robertson *et al.* 1989, Brown and Howley 1990, Lumsden *et al.* 1991) have greatly increased our knowledge of the distribution of the bat fauna throughout the State (Atlas of Victorian Wildlife). Recent taxonomic revisions (e.g. Kitchener *et al.* 1987, Adams *et al.* 1988) have revealed new species for which more detail is required, but the distribution, relative abundance and broad habitat requirements are now known for most species within Victoria. The species with the least number of records is the Greater Long-eared Bat *Nyctophilus timoriensis* (Fig. 1), with only four records from Victoria.

The taxonomy of the genus *Nyctophilus* is under revision, and the status of *N. timoriensis* throughout its range requires clarification (H. Parnaby *pers. comm.*). In Victoria *N. timoriensis* previously included Gould's Long-eared Bat *Nyctophilus gouldi,* which is now recognised as a distinct species (Parnaby 1987). Most records in the early Victorian literature (e.g. Parnaby 1977; Emison *et al.* 1978; Menkhorst and Gilmore 1979) are now known to be *N. gouldi.*

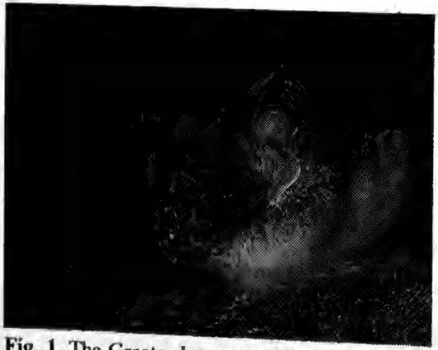

Fig. 1. The Greater Long-eared Bat *Nyctophilus timoriensis.*

Nyctophilus timoriensis is widely distributed throughout southern mainland Australia, generally associated with the semi-arid environment. Within this area however, its distribution is patchy, and it is rarely recorded (Richards 1991). In South Australia, it is restricted to the broad band of mallee vegetation across the mid-north of the State (Reardon and Flavel 1987). In Victoria, all records are from low rainfall areas in the north and north-west of the State.

Due to the paucity of records, *N. timoriensis* is classified as Rare in Victoria (CNR 1993). It is listed as Vulnerable in the Action Plan for Bat Conservation in Australia (Richards and Hall 1993), and as a threatened species in the Murray Mallee region (Stephens 1992).

This paper summarises information on the known distribution, habitat requirements and conservation status of *N. timoriensis* in Victoria, and compares it with that of other species of *Nyctophilus* in this State.

Methods

Extensive surveys for bats have been undertaken in three study areas within the potential distribution of *N. timoriensis* (Fig. 2). Two Land Conservation Council (LCC) areas were surveyed for vertebrate fauna: the Murray Valley between September and November 1982 and the Mallee between August 1985 and May 1987 (Robertson et al. 1989). Recent surveys (January to April 1992 and December 1992 to March 1993) have concentrated on bats in the northern plains as part of a research project into the effects on fauna of habitat fragmentation and the role of remnant native vegetation in rural landscapes.

These study areas are located inland of the Great Dividing Range, within the

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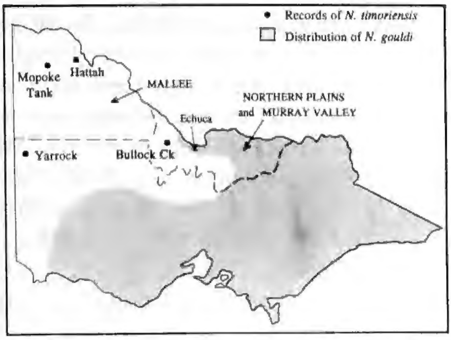

Fig. 2. The four Victorian records of the Greater Long-eared Bat *Nyctophilus timoriensis* and the distribution of Gould's Long-eared Bat *Nyctophilus gouldi* in Victoria. Study area boundaries are indicated by broken lines. The Murray Valley area boundary approximates that of the Northern Plains and is not shown.

Murray Lowlands physiographic region, where the elevation is less than 200 m. Mean annual rainfall varies from 250 to 500 mm.

Bats were trapped using either harp traps (AUSTBAT, 32 Longs Rd., Lower Plenty 3093), or mist nets (nylon and mono- filament) and trip-lines. Traps were placed in potential flight paths, either at or away from water, or adjacent to possible roost trees. Mist nets and trip-lines were employed at water bodies. Captured bats were processed and released later that night or the following morning. The age, sex, reproductive condition, forearm length and weight of each bat was recorded. Habitat and weather conditions were also noted.

Museum specimens and relevant literature were checked for additional records of *N. timoriensis* in Victoria.

Results

Records of N. timoriensis *in Victoria*

During surveys in northern and northwestern Victoria, within the potential range of *N. timoriensis*, 5267 bats of 15 species were caught, only two (0.04%) of which were *N. timoriensis* (Table 1). Details of these two records and two earlier Museum specimens are summarised in Table 2. Trapping results for bats at the three most recent specimen localities are presented in Table 3. A brief description of each locality where *N. timoriensis* has been recorded is provided below.

1. Yarrock, 11 km NNW of Kaniva (36°17'S 141°12'E, elevation 100 m, mean annual rainfall ~ 450 mm)

One specimen originated from Yarrock in 1888. This area is now predominantly private land that has been cleared of native vegetation for wheat cropping and sheep grazing. Remnant vegetation reveals that the Yarrock area is on the border between the broad band of mallee vegetation to the north and Yellow Box *Eucalyptus melliodora* woodlands to the south. Other

Table 1. Capture success rates for bats during surveys in north-western and northern Victoria.

Study area	**Murray Valley**	**Mallee**	**Northern Plains**
Survey dates	**1982**	**1985-7**	**1992-3**
Number of trap-nights	83	595	490
Number of mist net-hours	27	595	0
Number of captures of *N. timoriensis*	0	1	1
N. gouldi	114	0	56
N. geoffroyi	144	564	337
Capture success for N. *timoriensis*			
per bat trap-night	0	0	0.002
per mist net-hour	0	0.002	–
Total number of captures of bats	730	2075	2462
Number of species	11	11	13

habitats within the Yarrock area include Black Box *E. largiflorens* woodland, River Red Gum *E. camaldulensis* swamps, Buloke *Casuarina leuhmanni* and Slender Cypress-pine *Callitris preissii* woodlands.

2. Mopoke Tank, Sunset Country, 48 km W of Hattah (34°49'S 141°45'E, elevation 40 m, mean annual rainfall ~ 300 mm)

One specimen was caught on 5 November 1961. The habitat surrounding this tank is open mallee, predominantly White Mallee *E. gracilis* with a chenopod understorey. Buloke and Cattle-bush *Heterodendrum oleifolium* are present on the nearby dunes. Mallee trees in this area are mature and have numerous hollows. This area is now part of the Murray-Sunset National Park. During three nights trapping at Mopoke Tank in 1986/87, with harp traps and mist nets monitored all

Table 2. Details of the four Victorian records of *Nyctophilus timoriensis*. (SAM South Australian Museum; MV Museum of Victoria).

	Yarrock	Mopoke Tank	Hattah	Bullock Ck
Specimen number	SAM M490	MV C3240	MV C28470	–
Date collected	Aug 1888	5 Nov 1961	24 Jan 1987	23 Mar 1992
Sex	Female	Male	Male	Female
Age		Adult	Adult	Adult
Reproductive condition			Testes enlarged	Pre-parous
Forearm (mm)	46.3	42.2	42.1	47.3
Weight (g)			13.0	15.3

Table 3. Trapping details from bat surveys at the three recent specimen localities of *Nyctophilus timoriensis*.

	Mopoke Tank	Hattah	Bullock Ck
Dates trapped	14-15/12/1986 and 19/1/1987	24/1/1987	22-23/3/1992 and 15-17/12/1992
Trapping effort bat trap-nights	7	0	11
mist net-hours	93	10	0
Numbers of *N. timoriensis* caught	0	1	1
Capture success rate for *N. timoriensis*			
per bat trap-night	0	–	0.1
per mist net-hour	0	0.1	–
Numbers of other species caught			
Mormopterus spp.	9	1	23
Tadarida australis	–	–	1
Chalinolobus gouldii	41	6	7
Chalinolobus morio	–	–	3
Nyctophilus geoffroyi	162	35	12
Scotorepens balstoni	–	–	1
Vespadelus baverstocki	–	1	–
Vespadelus regulus	3	–	2
Vespadelus vulturnus	–	17	17
Overall capture success			
per bat trap-night	14.9	–	6.1
per mist net-hour	1.2	6.1	–

night, 162 Lesser Long-eared Bats *N. geoffroyi* were captured; however, no *N. timoriensis* were caught (Table 3).

3. Hattah-Kulkyne National Park, 7 km NE of Hattah (34°43'S 142°20'E, elevation 60 m, mean annual rainfall ~ 300 mm)

One male was trapped using monofilament mist nets at a tank on the Mournpall Track on 24 January 1987. The habitat immediately surrounding the tank consisted of an open woodland of Buloke, with some Slender Cypress-pine and River Red Gum. Extensive areas of mallee vegetation (*E. socialis, E. dumosa, E. foecunda*) and River Red Gum woodland occurred within one kilometre of the site. Four mist nets were monitored from dusk (2130 hrs) until midnight, with the *N. timoriensis* caught at 2230 hrs. Weather conditions were still, without cloud, moon or rain. Temperature during the trapping period ranged from 27° to 22°C. Sixty individuals of 5 other species, including 35 *N. geoffroyi*, were also caught at the site (Table 3).

4. Bullock Creek, 10 km SE of Pyramid Hill (36°07'S 144°11'E, elevation 100 m, mean annual rainfall ~ 400 mm)

A female *N. timoriensis* was trapped in a harp trap on 23 March 1992, in remnant Black Box woodland along Bullock Creek. Understorey vegetation was dominated by clumps of Tangled Lignum *Muehlenbeckia cunninghamii*. The area was public land water frontage that had been selectively logged in the past and used for grazing stock. The width of the remnant vegetation along the creek at this site was 280 m, with farmland on either side. There were numerous large trees with hollows providing potential roost sites. The bat was trapped sometime after 2200 hrs on a mild night (overnight minimum temperature 17°C) with no wind or rain, and approaching a full moon. Trapping on two consecutive nights at this site resulted in the capture of 17 individuals of 5 species, in addition to the *N. timoriensis*. The site was trapped again in December 1992, when 49 individuals of eight species were trapped (Table 3). Fifteen other sites within a 10 km radius of this location, were also trapped during March and December 1992, with a total capture of 161 individuals of seven species, but no further *N. timoriensis* were caught.

Relationships with other Victorian **Nyctophilus**

Nyctophilus timoriensis and *N. gouldi* (which were previously synonymous) have largely non-overlapping distributions (Parnaby 1987). *N. gouldi* occurs predominantly in the mesic eucalypt forests of the Great Dividing Range. In Victoria its distribution extends into the drier box woodlands inland of the Divide, with the inland limit generally corresponding with the 500 mm isohyet, although it extends into lower rainfall areas along the Murray River in the vicinity of Echuca (Fig. 2). The recent surveys of bats west of Echuca have recorded these two species within 25 km of each other, both within Black Box woodland.

Specimens of *N. gouldi* from the Echuca area are significantly smaller than those further to the south (Students T-test $p< 0.001$) (Table 4), and they are quite distinct from *N. timoriensis*. The head of N. timoriensis is proportionally larger and with a broader snout than *N. gouldi*, and the body is more thickset. The outer width of the upper canines is greater than 5.6 mm in *N. timoriensis* and less than 5.6 mm in *N. gouldi* (Parnaby 1992).

The distribution of *Nyctophilus geoffroyi* is widespread, and includes areas where both *N. gouldi* and *N. timoriensis* occur. It can be distinguished from both by its smaller size and Y-shaped noseleaf. However, in the Echuca area, weights and forearm lengths of *N. gouldi* overlap those of *N. geoffroyi* (Table 4) and identification requires confirmation by noseleaf shape. *N. geoffroyi* was caught, often in large numbers, at all sites where *N. timoriensis* was trapped (Table 3).

Discussion

The paucity of records of *N. timoriensis* in Victoria is believed to reflect its relative abundance. Although little is known of the ecology of *N. timoriensis*, it is likely to be similar to other species of *Nyctophilus*. The flight pattern of the Tasmanian *N. timoriensis* was described as slow, undulating and agile, frequently in the understorey, which was very similar to that of *N. geoffroyi* (O'Neill and Taylor 1986). Hence, it could be expected that if present, *N. timoriensis* would encounter traps and mist nets, especially in north-western Victoria where the canopy height is between 5 and 30 m. If the ability to detect bat traps and mist nets is similar to that of other *Nyctophilus*, the techniques employed during the surveys should have been suitable to catch this species. The capture of 1050 *N. geoffroyi* and only 2 *N. timoriensis* suggests that *N. timoriensis* really is rare.

It is possible that these records represent vagrant individuals to Victoria, however, this is unlikely, as the slow manoeuvrable flight of this species is not conducive to long distance flights. The other species of *Nyctophilus* in Victoria are considered to be sedentary.

The Victorian records of *N. timoriensis* reveal that several broad habitat types are used: mallee vegetation, open woodland of Buloke, and Black Box woodland. These vegetation types are widespread in northern Victoria, and so at this broad level there appears to be extensive areas of potential habitat. Other vegetation types from which *N. timoriensis* has been recorded throughout its mainland range include River Red Gum woodlands (Richards 1983). In Tasmania, *N. timoriensis* has been recorded in wet sclerophyll forest, coastal mallee and Blackwood swamps (Taylor and O'Neill 1986), habitats which are not used on the mainland.

The results of these surveys support the listing of *N. timoriensis* as Rare under the Flora and Fauna Guarantee Act, Victoria. Due to the lack of historical records, it is not known whether the species has suffered a reduction in abundance since European settlement, or if it has always been rare in Victoria. As the reasons for its current rarity are unknown, it is difficult to suggest appropriate management regimes. However, several broad ecological requirements are known. Like most species of insectivorous bats in Victoria, tree hollows are utilised for roosting

Table 4. Morphometric data for *Nyctophilus* spp. in Victoria.
Measurements are from adult individuals. Values are means ± standard deviation with the range in parentheses.

Species	Area	Sex	N	Weight (g)	Forearm length (mm)
Nyctophilus timoriensis	Victoria	M	2	13.0	42.2 ± 0.1 (42.1 - 42.2)
		F	2	15.3	46.8 ± 0.7 (46.3 - 47.3)
Nyctophilus gouldi	Echuca area	M	20	8.6 ± 2.0 (7.2 - 14.4)	39.6 ± 1.9 (38.0 - 45.2)
		F	27	9.3 ± 1.6 (7.4 - 14.6)	40.9 ± 1.4 (38.4 - 45.2)
Nyctophilus gouldi	Southern Vict	M	65	11.0 ± 1.2 (9.0 - 16.0)	43.1 ± 1.1 (40.0 - 46.6)
		F	81	13.4 ± 1.5 (10.0 - 16.5)	44.7 ± 1.2 (41.8 - 47.7)
Nyctophilus geoffroyi	Victoria	M	362	6.6 ± 0.7 (4.6 - 9.2)	35.5 ± 1.3 (32.0 - 39.3)
		F	760	8.9 ± 1.3 (5.6 - 14.5)	37.9 ± 1.4 (33.5 - 41.7)

during the day. In Tasmania it was found to consume mostly non-volant prey (caterpillars and scorpions) (O'Neill and Taylor 1989), assumed to be obtained by gleaning as it foraged in the understorey (O'Neill and Taylor 1986). Therefore the availability of shrubs and other understorey vegetation may be important.

The localities of the three records since 1960 are from public land, two within National Parks. However, as we do not know why this species is so rare, we can not assume that its long term status in Victoria is secure. Therefore further information on the distribution of *N. timoriensis* and of its habitat and ecological requirements are needed.

Acknowledgements

I would like to thank Andrew Bennett and Joan Dixon for improving earlier drafts; Steffan Krasna and John Silins for assistance with trapping; Harry Parnaby for confirming the identity of the Hattah specimen; Joan Dixon for access to the Museum of Victoria records; and Lynette Queale for information on the Yarrock specimen.

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Germination Characteristics of Eight Common Grassland and Woodland Forbs

John W. Morgan and Ian D. Lunt*

Abstract

Seed germination characteristics were examined for eight species of native forbs from lowland grasslands and grassy woodlands in Gippsland, eastern Victoria: *Arthropodium minus, Craspedia variabilis, Dichondra repens, Helichrysum scorpioides, Lagenifera gracilis, Leptorhynchos linearis, Solenogyne dominii and Veronica plebeia.* Two temperature regimes (constant 20°C and alternating 20/10°C) and two light regimes (16h light/8h dark and constant dark) were examined. An additional experiment was undertaken with *Craspedia variabilis* to determine the rate of germination in the dark. Few seeds of *A. minus* or *D. repens* germinated under any treatment, but at least 79% of seeds of all other species except *C. variabilis* germinated under one or more treatments. At least 75% of *H. scorpioides, Lagenifera gracilis* and *Leptorhynchos linearis* seeds germinated in the light and the dark under at least one temperature regime. *V. plebeia* and *S. dominii* germination was inhibited by darkness and significantly fewer *H. scorpioides* seeds germinated in the dark than in the light under constant temperature. *C. variabilis* seeds appeared to germinate faster in the dark than in the light under alternating temperatures, but the final percentage germination was almost identical regardless of the duration of the dark treatment. The eight species studied all responded differently to the four experimental conditions imposed, and grassland forbs did not, as a whole, respond differently to the woodland forbs. Grassland and woodland remnants both include species with a wide variety of germination characteristics.

Introduction

In recent years, increasing use has been made of indigenous herbs for rehabilitating and restoring natural ecosystems (Buchanan 1989; Duggan 1991; Offor and Watson 1991; Kemp and Irvine 1993). Such projects have highlighted the need for detailed information on the germination and establishment requirements of these plants.

A number of recent papers have investigated the germination requirements of selected native forbs (herbs other than grasses) from temperate grasslands and grassy woodlands (Hitchmough *et al.* 1989; McIntyre 1990; DeKock and Taube 1991; Willis and Groves 1991). Twenty-four species have been investigated in these four studies. McIntyre (1990) included species of a range of life-forms and micro-habitats, but Hitchmough *et al.* (1989), DeKock and Taube (1991) and Willis and Groves (1991) concentrated on conspicuous, flowering perennials of relatively open habitats, such as native grasslands and open grassy woodlands. Previous studies have found dramatic differences in germination behaviour between co-occurring species. McIntyre (1990) and Willis and Groves (1991) concluded that much more information is needed before we can confidently predict optimal conditions for seed germination and establishment in the field. In this study, we document the germination characteristics of eight species of perennial forbs from remnant grasslands and grassy woodlands on the lowland Gippsland plains in eastern Victoria.

Methods

Eight species were selected for study (Table 1), including two species that are common in rail-line grasslands *(Craspedia variabilis* and *Helichrysum scorpioides)* and six that are common in remnant woodlands *(Arthropodium minus, Dichondra repens, Lagenifera gracilis, Leptorhynchos linearis, Solenogyne*

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Table1. Seed collection sites, habitats and seed weights.

Species	Family	Collection site	Habitat	Seeds/gram
Arthropodium minus R. Br.	Liliaceae	Briagolong Forest Reserve	*Eucalyptus tereticornis* grassy woodland	960
Craspedia variabilis Everett & Doust	Asteraceae	Munro rail reserve	*Themeda triandra* grassland	4100
Dichondra repens J.R. & G. Forster	*Convolvulaceae*	*Moormurng Flora* and Fauna Reserve	*Eucalyptus tereticornis* grassy woodland	920
Helichrysum scorpioides Labill.	Asteraceae	Munro rail reserve grassland	*Themeda triandra*	2920
Lagenifera gracilis Steetz	Asteraceae	Moormurng Flora and Fauna Reserve	*Eucalyptus tereticornis* grassy woodland	3470
Leptorhynchos linearis Less.	Asteraceae	Moormurng Flora Fauna Reserve	*Eucalyptus tereticornis* grassy woodland	5130
Solenogyne dominii L. Adams	Asteraceae	Stratford Highway Park	*Eucalyptus tereticornis* grassy woodland	3000
Veronica plebeia R. Br.	Scrophulariaceae	Moormurng Flora and Fauna Reserve	*Eucalyptus tereticorni* grassy woodland	16950

dominii and *Veronica plebeia). Arthropodium minus* also occurs rarely in some grassland remnants. Species selection was partly limited by the availability of seed since many perennial herbs produced little seed in late 1991 owing to dry weather.

Seed of all species was collected between May and December 1991, and was stored at room temperature in the dark until used. The germination experiments began in July 1992. All plant names follow Ross (1993). Voucher specimens have been lodged at the National Herbarium of Victoria (MEL).

Experiment 1 - Light and temperature effects

Seeds of all species were placed in two growth cabinets (brand names Clegg and Zankel, 108 and 110 microeinsteins/m^2/s light intensity respectively) under four light and temperature regimes: (1) constant 20°C with a 16/8 hrs light and dark cycle; (2) constant 20°C in the dark; (3) alternating temperature, with 16 hrs light at 20°C, and 8 hrs dark at 10°C; and (4) alternating temperature, 16 hours at 20°C and 8 hrs at 10°C, in the dark. Seed of *L. linearis* was only placed under alternating temperature (i.e. regimes 3 and 4) due to limited quantities of seed.

Twenty seeds of each species were placed on three sheets of moist Whatman No.1 filter paper in a 9 cm petri dish, with five replicates per treatment. The dark treatment dishes were sealed and covered in aluminium foil. The petri dishes were then placed in one of two growth cabinets: one with constant and one with alternating temperatures.

The light treatment seeds were inspected every 2-4 days for 36 days, and all germinated seeds were counted and removed at each inspection. The filter paper was re-moistened with distilled water as necessary. The dark treatment seeds were inspected at the end of the experiment after 36 days.

Because the two temperature treatments, alternating and constant, were studied in different growth cabinets, any apparent differences in germination response could possibly be due to undefined cabinet differences rather than to temperature differences *per se*. To investigate this possibility, the initial experiment was repeated with three species, *H. scorpioides, Lagenifera gracilis* and *V. plebeia.* The experimental conditions were identical to the first trial, but the temperature regime was switched between the two cabinets, and only the light treatments were examined.

Experiment 2 - Germination rates in Craspedia variabilis

The rate of germination in the dark was not determined in experiment (1), as dark treatment samples were only examined at the end of the experiment. To provide information on the relative rate of germination under light and dark treatments, a subsequent experiment was undertaken with one species, *C. variabilis*. Five treatments were examined, all under alternating temperatures at 20°C for 16 hrs in the light and 10°C for 8hrs in the dark: (1) germination in the light for 67 days, (2) dark germination for 7 days, followed by light germination for 60 days, (3) dark germination for 16 days, followed by light germination for 51 days, (4) dark germination for 22 days, followed by light germination for 45 days, (5) dark germination for 28 days, followed by light germination for 39 days. The experimental protocol was the same as in experiment (1), with five replicates of 20 seeds for each treatment. Seeds were examined every 2-3 days after being exposed to the light.

Seed viability

Seeds of three species *(A. minus, C. variabilis* and *D. repens)* germinated poorly in experiment one. To determine whether this response was due to unsuitable germination conditions or to the presence of many non-viable seeds, an additional 100 seeds from the same seed lots were subsequently tested for viability using the tetrazolium test (Freeland 1976).

Statistical analyses

The mean percentage germination of seeds of each species under the four light and temperature treatments in experiment (1) was compared statistically for all species that attained 20% germination under one or more treatments. The results were analysed using arcsine-transformed data. Before transformation, 0% germination values were increased by 0.05% and 100% values were reduced by 0.05%. Germination often differed dramatically between replicates under the same treatment, and arcsine transformations did not eliminate the heterogeneity of variances. Consequently, results were compared using the Games and Howell test for unplanned comparisons between pairs of means, which assumes that variances are heterogeneous (Sokal and Rohlf 1981).

Results

Seeds of the eight species displayed different patterns of germination under the four light and temperature treatments. Less than 25% of seeds of *A. minus, C. variabilis* and *D. repens* germinated in all treatments in the first experiment (Table 2). By contrast, at least 79% of seeds of *H. scorpioides, L. gracilis, S. dominii, V. plebeia* and *Leptorhynchos linearis* germinated under at least one treatment (Table 2). Due to the high variability between the small number of replicates, many of the apparent differences in mean germination in Table 2 are not statistically significant (p>0.05).

The viability tests showed that 98% of *A. minus*, 62% of *C. variabilis* and 13% of *D. repens* seeds were viable. Most nonviable *D. repens* seeds were unfilled. Thus, the poor germination of *C. variabilis* and *D. repens* seeds was partly due to the presence of many non-viable seeds, whereas the poor germination of *A. minus* seeds presumably was due to unsuitable germination conditions.

Germination of *S. dominii* and *V. plebeia* seeds was suppressed by darkness (Table 2). Fewer seeds of both species germinated in the light under alternating temperature than under constant temperature, but this difference was not significant (p>0.05), due to the small number of replicates and considerable variability between replicates under alternating temperature. *H. scorpioides*

Table 2. Mean percentage germination of eight forbs after 35 days under contrasting light and temperature regimes.
Treatment means that are followed by a letter of different case (i.e. A vs. a) are significantly different at the level shown in the column 'p'. N.S. = not sampled.

Species	**Light constant temp.**	**Light alternating temp.**	**Dark constant temp.**	**Dark alternating temp.**	**p**
Arthropodium minus	0	9	0	13	
Craspedia variabilis	18	12	8	20	
Dichondra repens	7	5	3	2	
Helichrysum scorpioides	79^{A}	74	28^{a}	75	0.05
Lagenifera gracilis	97	96	95	61	
Leptorhynchos linearis	N.S.	89	N.S.	90	
Solenogyne dominii	94^{A}	54	3^{a}	1^{a}	0.01
Veronica plebeia	84^{A}	31	8a	9^{a}	0.05

germination was more complex, and was suppressed by darkness only under constant, and not under alternating, temperatures. Only 28% of *H. scorpioides* seeds germinated under constant temperature in the dark, compared to over 74% of seeds in all other treatments. More than 95% of *Lagenifera gracilis* seeds germinated in all treatments except under alternating temperature in the dark, in which, on average, only 61% of seeds germinated, although this difference was not statistically significant ($p>0.05$). Similar quantities of *Leptorhynchos linearis* seeds germinated in the light and the dark under alternating temperatures.

The results from the first experiment suggest that *H. scorpioides, Lagenifera gracilis, S. dominii* and *V. plebeia* seeds germinated faster under constant temperature than under alternating temperature (Fig. 1). However, these apparent differences were not maintained when the experiment was repeated with the treatments swapped between the two cabinets. In the repeated experiment, there was little difference in the rate of germination of *H. scorpioides* and *Lagenifera gracilis* seeds, and the difference in germination rate of *V. plebeia* seeds was considerably reduced (Fig. 1). The apparent differences in germination rate in the first experiment may have been experimental artefacts, perhaps induced by unknown differences between the two growth cabinets or the effects of seed storage, rather than effects caused by the different light regimes.

Many species had clearly attained their maximum germination under the conditions imposed by the end of the experiment. Under at least one light regime, nearly all seeds of *H. scorpioides, L. gracilis, Leptorhynchos linearis, S. dominii* and *V. plebeia* germinated in the first 25 days of the experiment (Fig. 1). For the other species and treatments, however, additional germination may have occurred if the experiment had lasted longer. In such cases, the effects of a particular temperature or light treatment may have been to delay rather than to inhibit seed germination.

The results of the second experiment with *C. variabilis* seeds demonstrate that the maximum germination that was

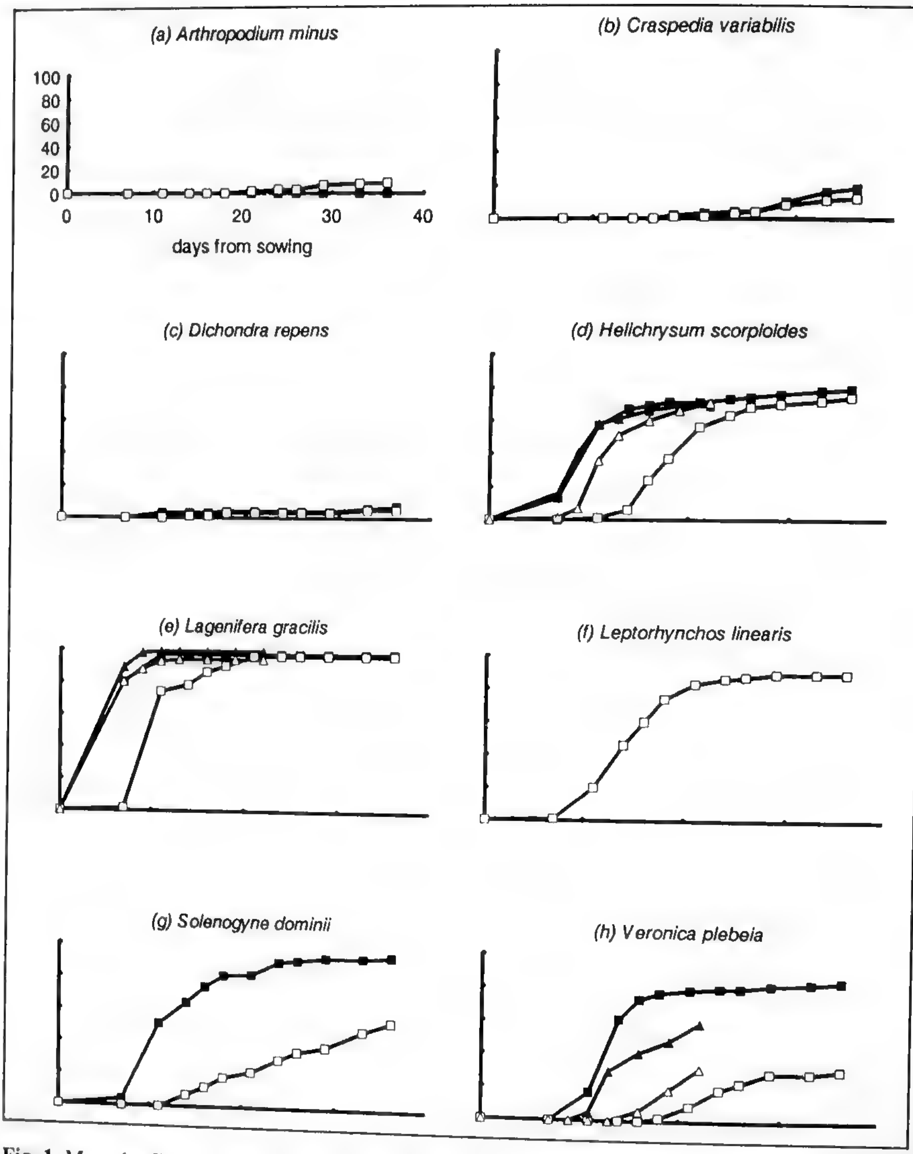

Fig. 1. Mean (n=5) germination rates of eight forbs under constant temperature (closed squares) and alternating temperature (open squares) in the light. Only alternating temperatures were used for *Leptorhynchos linearis*. The experiment was repeated for *H. scorpioides*, *Lagenifera gracilis* and *V. plebeia* seeds, with the temperature regimes swapped between the two growth cabinets. Closed and open triangles show germination under constant and alternating temperature, respectively, in the repeat trial.

achieved in the first experiment (20%) was limited by the short duration of the experiment (36 days). In the second experiment, the mean germination of *C. variabilis* seeds in the light increased from 26% at 36 days to 45% at 67 days (Fig. 2). The total germination of *C. variabilis* seeds after 67 days was not affected by the duration of darkness, and between 44% and 52% of seeds germinated under all

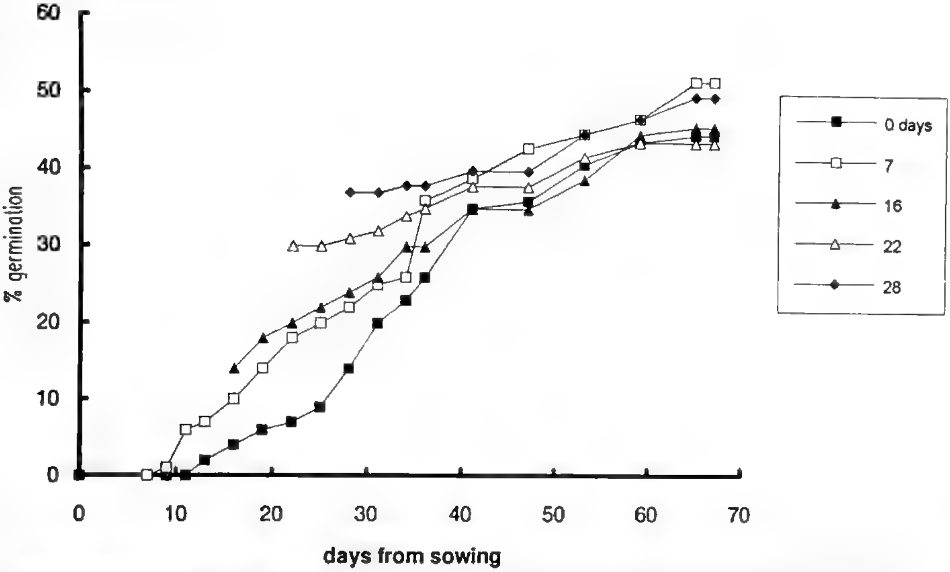

Fig. 2. Germination of *Craspedia variabilis* seeds following dark treatment for specified periods.

treatments (Fig. 2). However, the rate of germination appeared to differ between treatments.

Seeds which were kept in the dark for the first 28 days of the experiment appeared to germinate faster than those kept in the light (Fig. 2). The differences between treatments in mean germination prior to day 28, which are visible in Fig. 2, were not statistically significant ($p>0.05$) due to the high variability between the small number of replicates, but the general trend to faster germination for seeds kept in the dark for longer periods appears unmistakable. Thus, by 28 days, on average only 14% of the seeds that were kept in the light had germinated, compared with 37% of those kept in the dark for 28 days. After 41 days, however, there was little difference in the mean germination between any of the treatments (Fig. 2). Thus, prolonged darkness appeared to increase the rate of germination of *C. variabilis* seeds, but did not alter the final germination achieved.

Discussion

These results demonstrate marked differences in the germination behaviour of the eight species studied. Seed germination was found to be inhibited by darkness for *S. dominii* and *V. plebeia,* and by an interaction between darkness and temperature regime for *H. scorpioides; H. scorpioides* germination was only suppressed in the dark under constant temperature. *C. variabilis* seeds appeared to germinate faster in the dark than in the light but the final proportion of germinated seeds was not affected by the duration of the dark treatment.

The rate of germination differed greatly between species under the same temperature and light regimes. At two extremes, it took over 60 days for 50% of *C. variabilis* seeds to germinate under any treatment, whereas 50% of *L. gracilis* seeds germinated in 7 days under one treatment. Seed germination rates are strongly dependent on temperature for many species (see e.g. Willis and Groves 1991), and the slow rates reported here for *A. minus* and *C. variabilis* might be due to unsuitable temperature regimes. The poor germination of *A. minus* seeds is surprising, as *Arthropodium strictus* seeds germinate readily, although germination is suppressed at temperatures above 15°C

(Hitchmough *et al.* 1989; J. Morgan *unpubl. data*). The poor germination of *D. repens* seeds was primarily due to the presence of non-viable seeds, but additional germination of the few viable seeds may have been obtained by seed scarification. Hitchmough *et al.* (1989) found that scarification enhanced seed germination for another member of the Convolvulaceae family, *Convolvulus erubescens*, and Atwater (1980) suggested that seed scarification may be required by all Convolvulaceae species.

In the initial experiment, many species were found to germinate faster under constant than alternating temperatures, but this pattern was not maintained, particularly for *H. scorpioides* and *L. gracilis* seeds, when the temperature regimes were swapped between the two cabinets (Fig. 1). This phenomenon is likely to have arisen from some unknown differences in the germination conditions imposed by the two cabinets, and it illustrates a fundamental problem in interpreting many published results from growth cabinet studies: i.e. it is often impossible to separate treatment effects from undefined cabinet effects. Most growth-cabinet studies (including Hitchmough *et al.* 1989; McIntyre 1990 and Willis and Groves 1991) involve pseudoreplication, by replicating samples within a treatment (i.e. one temperature regime within the one cabinet), but without replicating the actual treatments (Hurlbert 1984). Consequently, the effects of the treatments imposed (in this case, alternating versus constant temperature) cannot be distinguished from any unknown cabinet effects. Had we not repeated the first experiment with the two temperature treatments swapped between the cabinets, we would have suggested that *H. scorpioides, L. gracilis, S. dominii and V. plebeia* seeds germinated faster under constant than alternating temperature (Fig. 1). These apparent differences were virtually eliminated for *H. scorpioides* and *L. gracilis* when the temperature treatments were swapped between the cabinets. The reality of the 'patterns' for *S. dominii* and *V. plebeia* is debatable. Future researchers could attempt to overcome this problem either by using more than one cabinet for each treatment (which is usually impractical), by calibrating cabinets with an initial bioassay test, or by repeating experiments with the treatments swapped between the cabinets, although the latter approach would lead to variable periods of seed storage between experiments. Except for the artificial differences in germination rates described above, the other germination patterns described in this paper remain valid as they are based on different treatments imposed within the one cabinet (i.e. light versus dark treatments).

The ecological implications of seed germination characteristics were superbly summarised by McIntyre (1990). For example, a requirement for light or alternating temperatures may restrict germination to surface sown seeds, thereby enabling the formation of a permanent seed bank at depth in the soil. Alternatively, these requirements may restrict germination to gaps in the plant canopy, by preventing germination beneath established plants or leaf litter.

If this simple model is applicable, and seed behaviour in the field accords with the results found in this simple laboratory experiment, then germination of *S. dominii* and *V. plebeia* seeds is likely to be restricted to gaps, and shaded or buried seeds might remain dormant, forming a permanent seed bank, until they are exposed to the light. By contrast, seeds of *L. gracilis* germinated well under all conditions imposed, and if similar behaviour occurs in the field, then it seems unlikely that this species would develop a permanent soil seed bank. Further work is needed to investigate whether factors such as high summer temperatures might induce seed dormancy, and thereby enable the formation of a permanent seed bank. *H. scorpioides* may behave in a similar fashion, and good germination might be expected in light or dark sites wherever temperatures alternate regularly. However, the suppression of *H. scorpioides* germination under constant temperature in the dark may enable this species to develop a seed bank at depth in the soil. McIntyre (1990) found that the germination of small, but not large, seeded species was inhibited by darkness. However, one of the two species in this study which required light for germination, *S. dominii*, has moderately large seeds (c. 3000 seeds/g; Table 1), and does not follow this pattern.

The eight species studied responded differently to the four experimental conditions imposed, and the grassland forbs did not, as a whole, respond differently to the woodland forbs. Indeed, the two species with the most similar germination patterns, *H. scorpioides* and *L. gracilis*, occur in different habitats in the region: in grasslands and woodlands respectively. Grasslands and woodlands both include species with a wide variety of germination characteristics, as has been found elsewhere (Hitchmough *et al.* 1989; McIntyre 1990; DeKock and Taube 1991; Willis and Groves 1991).

Seed germination in the field is influenced by many complex factors (e.g. alternate wetting and drying, shading by leaves), and field distributions might be controlled by other, unstudied factors which influence seed germination. Alternatively, the field distributions of many species may not be controlled by seed germination requirements, but might instead be controlled by factors which limit the growth and vigour of seedlings or adult plants, such as moisture and nutrient availability or light intensity. Field studies are required to demonstrate such processes. Unfortunately, few such studies have been conducted on forbs in south-east Australia. In one study, regeneration of the rare daisy, *Rutidosis leptorrhynchoides*, was found to be limited by the habitat requirements of seedlings rather than by seed germination requirements (Morgan 1992).

A wide variety of factors affect plant establishment and survival, and laboratory studies such as this, on their own, give limited information from which to predict establishment success in the field. Field experiments, in which seedling establishment and mortality and flower and seed production are measured, will undoubtedly prove to be of greater value than simple laboratory studies to the pressing requirements of ecosystem restoration and management.

Acknowledgments

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Cellular Slime Moulds: the Simplest Complex Eukaryotes?

Keith L. Williams*

It is surprising to many people that the cellular slime moulds are a common group of simple eukaryote organisms which are found in soils. Even mycologists often overlook these amoeboid organisms because they tend not to be found unless specifically looked for. Nevertheless in rich soils they are present in hundreds and sometimes thousands of amoebae in each gram of soil. The trick in finding cellular slime moulds is to provide them with a lawn of bacteria to eat. Being much more animal-like than fungi, they have quite complicated nutrient requirements; the easiest way to satisfy them is to feed them whole bacteria (Fig. 1E). Slime moulds prefer gram negative bacteria, but will also eat some gram positive bacteria and some yeasts. They are very fussy eaters, and in the laboratory specific genes can be mutated so that they no longer eat particular species of bacteria. For example, three genes are known which when mutated lead to deleting *Bacillus subtilis* from the menu! Presumably these mutations lead to a loss of specific surface molecules (possibly sugars?) that the slime mould amoebae recognise as food, and hence the B. *subtilis* escape being eaten. On the other hand, cellular slime mould amoebae can be tricked into eating indigestible objects,

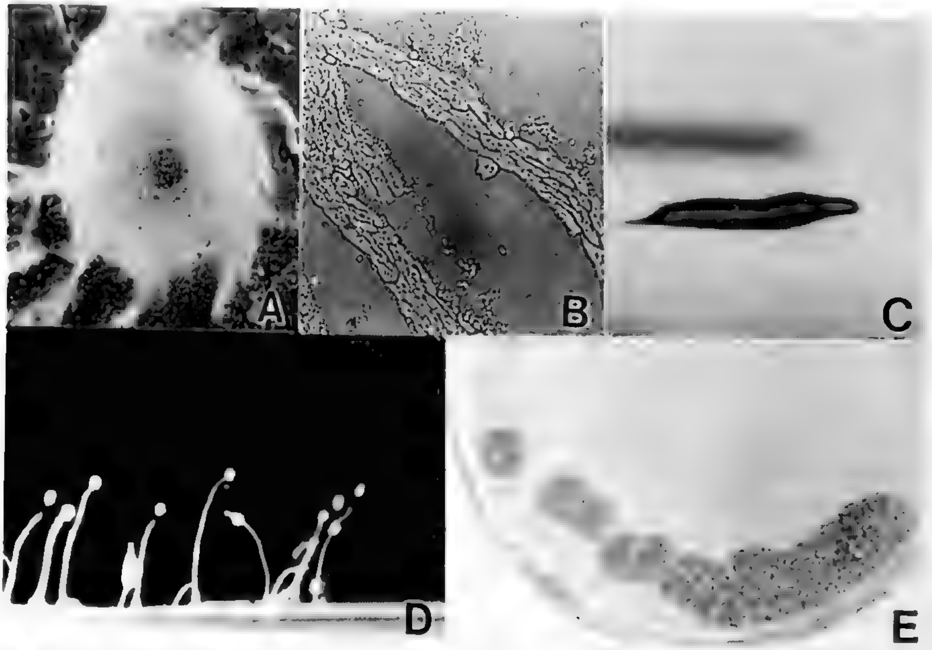

Fig. 1. Steps on the way to multicellularity: A, an aggregate of slime mould amoebae containing approx 100,000 cells (0.2 mm diameter); B, high magnification view of amoebae streaming into an aggregate; each cell is approx 10 μm long; C, a *D. discoideum* slug, approx 100,000 cells, 1 mm long; D, several *D. discoideum* fruiting bodies 1-2 mm tall, each of which is contructed from a slug; E, *D. discoideum* colonies on a 9 cm nutrient agar plate, previously spread with bacteria (*Klebsiella aerogenes*). Slime mould amoebae streaked over the plate to eat the bacteria, forming plaques which first clear the bacteria and then form fruiting bodies.

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for example by sugar coating dextran beads with appropriate sugars. I have seen a picture from Gunther Vogel's laboratory in Germany in which a slime mould amoeba that is 7 microns in diameter attempted to ingest a dextran bead perhaps five times its diameter!

What are cellular slime moulds?

Cellular slime moulds are curious organisms that have features of animals, plants and fungi. They are amoebae with nuclei, mitochondria and other organelles characteristic of eukaryotes. They have a small number of chromosomes and a very small genome size; *Dictyostelium discoideum*, the most studied cellular slime mould has seven chromosomes each of which has only slightly more DNA than an *Escherichia coli* bacterium. Animal-like features include the presence of a naked plasma membrane and movement by extension of pseudopodia. In fact slime mould amoebae closely resemble human white blood cells, and they do much the same things, (eating bacteria etc) except that slime moulds do it as free living cells while white blood cells live in our own bloodstream.

It is when the amoebae run out of food and starve that the organisms undergo a plant-like development. In the most common species amoebae signal each other, aggregate together (Fig. 1A,B) to form a slug-like migrating organism (Fig. 1C), which subsequently transforms into a fruiting body consisting of asexual spores and stalk cells (Fig. 1D). The stalk cells (which die) are plant-like, being highly vacuolated and having cellulosic cell walls. In fact *Dictyostelium* is now a system of great interest for studies on cellulose synthesis as it is the only eukaryote organism in which cellulose synthesis has been achieved in the test tube. Finally, when the cellular slime moulds form sexual structures known as macrocysts, they resemble fungi in having a simple system of mating types.

Usually the slime moulds are classified near the bottom of the tree structures drawn for eukaryote evolution. Exactly where they fit is controversial, but to those of us interested in the cellular slime moulds, the taxonomic position of the organisms is of no great matter. They simply are fun to study.

How to isolate cellular slime moulds

Cellular slime moulds are very easy to isolate from soil. They are most abundant in soils of temperate and tropical regions with rich leaf litter and which support a high bacterial population. Nevertheless they are ubiquitous, being found in arid, alpine and tropical soils. Their population numbers may be indicators of the 'health' of the soil, as a decline in their numbers seems to be associated with degradation of agricultural soils.

All that is required to find cellular slime moulds is some hay or grass to make a weak hay infusion agar (10 g hay boiled in 1 litre of water, strained, 15 g agar, 1.5 g KH_2PO_4, and 0.75 g $Na_2HPO_4.12H_20$, autoclaved). If hay agar plates are spread with a culture of gram negative bacteria (e.g. *E. coli or Klebsiella aerogenes*) and then diluted samples of soil mixed with water are spread over the plates, colonies of slime moulds will be observed after about one week of incubation at 210°C as clearing areas on the agar (Fig. 1E). Once the bacteria are eaten, the cellular slime mould amoebae aggregate and form delicate asexual fruiting bodies. The combination of the hay infusion and a heavy inoculum of bacteria suppresses the growth of fungi so that slime mould colonies are easily observed. The slime moulds can be stored for many years by desiccating the asexual spores on silica gel or by lyophilisation.

Australian cellular slime moulds

No systematic collections have been made of cellular slime moulds in Australia, but Gill Robson (now Whitington) did some surveys around the ACT and in the Northern NSW in the late 1970's (Robson 1978). Since that time people have given me samples to check out from Tasmania through to Lizard Island in Queensland. Essentially all soil samples that I have examined contained cellular slime moulds. Noel Tait from Macquarie University is one of very few people to have seen a fruiting body of a cellular slime mould in the wild. He brought a dung sample back from Tasmania that had a beautiful specimen of *Polysphondylium pallidum*, complete with several whorls of spore heads.

In Australian soils, as in the rest of the world, the *Dictyostelium mucoroides* complex is the most abundant group. *P. pallidum and Dictyostelium purpureum* are also very common. More rarely *Dictyostelium minutum and Polysphondylium violaceum* are encountered. So far *D.discoideum* has not been isolated, but nor has this most studied slime mould been found in Europe or indeed the rest of the world apart from North and Central America and Japan. However, since *D. discoideum* is often rare, the failure to find it in Australia may reflect a lack of serious effort in searching for it.

Why are cellular slime moulds studied?

Cellular slime moulds are the simplest complex organisms as they spend part of their life cycle as single cells and (in most species) part as multicellular organisms. In doing this they exhibit many of the features of organisation that are found in much more complex organisms. Figure 2 shows three levels of organisation found in different cellular slime mould species, that reflect steps on the way to forming a complex organism. Figure 2A shows the fate of starving *Nematostelium*. Single amoebae cover themselves with extracellular matrix and then each amoeba constructs a tiny fruiting body comprising a single spore. In this genus, there is differentiation of amoebae into spores, but no cell association occurs. In Fig. 2B, starving *Acytostelium* amoebae aggregate to form a tissue mass which covers itself with extracellular matrix and undergoes morphogenetic movement to construct a multicellular fruiting body comprising an acellular stalk, on which is nestled a clump of spores. Here a true multicellular organism is formed, and it exhibits polarity (ie it has a front and back) as well as differentiation. However, all cells have the same fate, so there is no specialisation. The final process required for forming multicellular organisms like ourselves involves cell specialisation, and this is observed in Dictyostelium species (and best studied in *D. Discoideum,* Fig. 2C).

The simplicity of the *D. Discoideum* system and the ease of studying it (the whole process requires only 24 hours), have made it popular for understanding how proportion regulation (determining how many of each cell type to make) and polarity (determining where the front is) are combined to make the final shape (pattern formation). This process involves signalling between cells using diffusible morphogens, cell-cell contact, and cell-extracellular matrix interactions. The actual molecules involved in *D. discoideum* development are being discovered. How they are wired up remains a challenge, but one that seems possible to solve. Perhaps the most interesting finding is that many of the features of complex organisms, such as the existence of an epithelium, seem to have their counterparts in the *D. discoideum* slug, although in a very simple form. There certainly is much that escapes the eye in the leaf litter of the forest!

Acknowledgements

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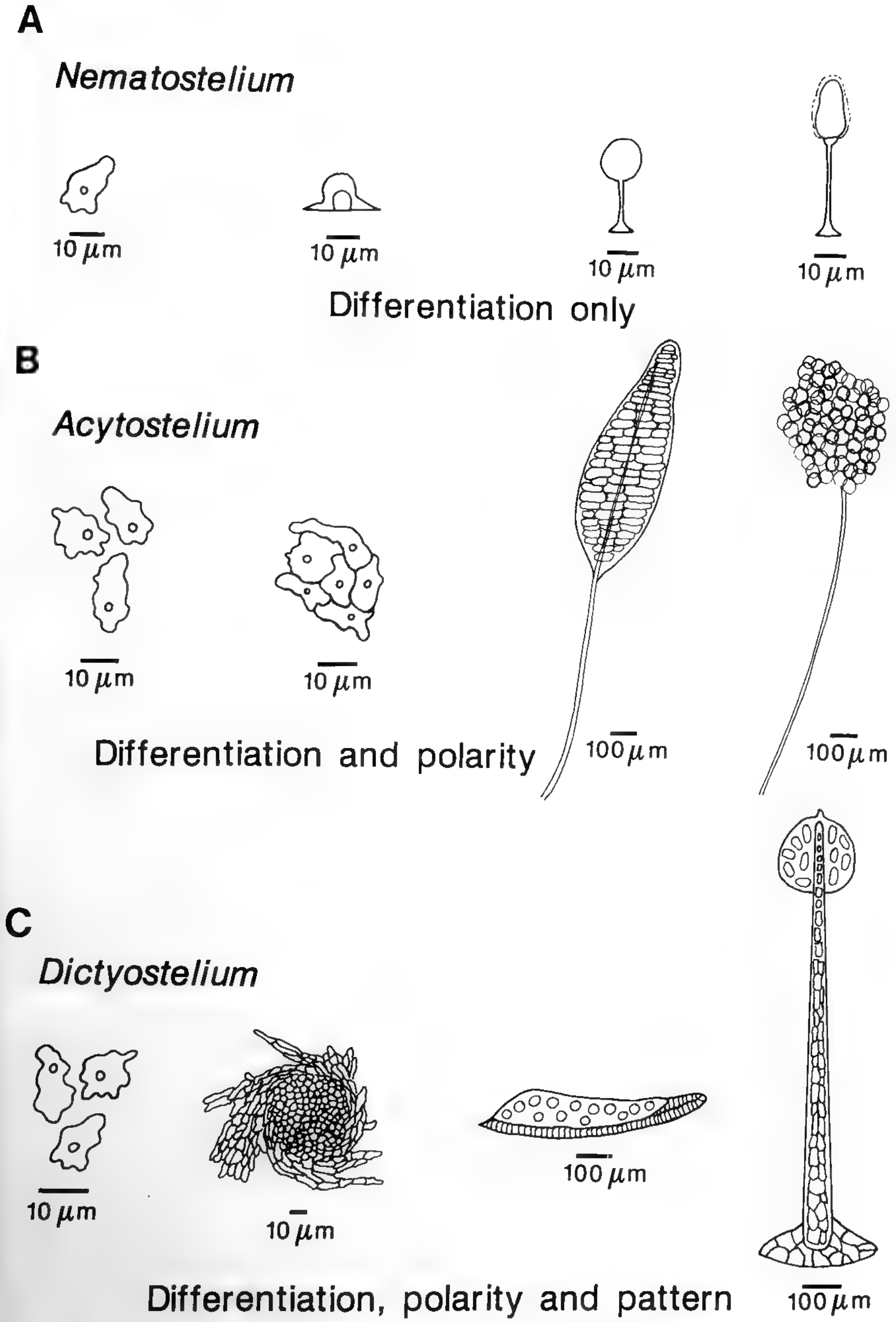

Fig.2 Three stages on the way to complexity; A, single-celled *Nematostelium*, which exhibits differentiation only; B, *Acytostelium*, which is multicellular, but all amoebae differentiate into spores; C, *Dictyostelium*, which is multicellular and exhibits cell specialisation.

Anti-Predator Behaviour of the Brush-Tailed Phascogale *(Phascogale tapoatafa)*

Todd Soderquist*

The Brush-tailed Phascogale *Phascogale tapoatafa* is an arboreal carnivorous marsupial occupying dry forests and woodlands of Australia. This rare nocturnal species has elicited interest among naturalists because of its boldness in the presence of observers, the pilo-erection of its large black 'bottle-brush' tail when excited, and its unusual foot-tapping response to potential predators. Various speculations have been offered for these behaviours, but the lack of extensive observations on wild animals has hindered interpretation. Based on several hundred hours of nocturnal observations of radio-collared phascogales**, I propose that these behaviours are best explained as anti-predator mechanisms.

Several of the behaviours used by phascogales to counter threats from predators are common to many arboreal mammals. On the simplest level, a phascogale avoids diurnal predators by sleeping in a tree hollow with a small entrance that precludes access by larger species. However, secure hollows are not always available, especially in forests lacking older trees, and phascogales often use vulnerable sites. If discovered by a predator (simulated by a researcher checking a nest box), a phascogale flees if possible, burrows deeper into its nest, or presents an open-mouthed threat accompanied by a rasping hiss. This threat is not a bluff: phascogales can bite through the fingernails of incautious humans. Some predators are not deterred by such behaviour as evidenced by the death of six radio-collared phascogales taken by goannas from daytime nests which provided inadequate protection.

Phascogales spend 80-90% of their foraging time in trees (Traill and Coates 1993; Soderquist *unpubl. data*), but also hunt on the ground (Lunt 1988). When frightened, phascogales invariably escape by climbing. Like many small carnivorous marsupials (Dickman 1991), phascogales typically spiral up the trunks of trees as they escape, thereby reducing exposure to an attacking predator. Because phascogales are quick and agile climbers, few quadrupedal predators can catch them when they are active in trees.

In addition to these habits, phascogales have evolved two unusual anti-predator behaviours. The first involves pilo-erection of the long tail hairs (35-55 mm) to form a conspicuous black brush which is nearly the size of the phascogale's body. These tail hairs are relaxed or half-erect while foraging, but are fully erected when the animal is excited. First-time observers of phascogales are often surprised to see how highly visible the black tail is by comparison to the grizzled-grey colour of the body (Fig. 1). Such an attractant would seem counter-productive to predator avoidance, but the function of the tail is probably to distract an attacking predator and deflect its strike. Imagine an owl which has become aware of the rather noisy foraging of a phascogale. The owl is faced with two targets as it closes for the strike: a conspicuous black 'body' and a less obvious grey one. If the owl attacks the black brush, its talons sink through hair and fail to close tightly on the pencil-thin tail. The phascogale escapes.

Variations on such predator distractants are common in nature, including 'tail-targets' which function like that of the phascogale. The effectiveness of distractants in deterring predation has been demonstrated experimentally with Weasels (Powell 1982). During winter, some species of weasels which forage on snow have white coats but prominent black tips on their tails. In trials with hawks trained to attack weasel-shaped models, the predators' success was greatly reduced if the weasel had a distracting black tail tip than if the tail was entirely white. Placing a black dot on the model's

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** In this article phascogales refers to Brush-tailed Phascogales

Fig. 1. The phascogale's erect tail hairs form a conspicuous black brush whereas the grizzled-grey body is relatively camouflaged against the fire-scarred trunk of Messmate eucalypt. This radio-collared female, photographed while feeding on supplemental food, was part of a reintroduction of phasogales into Gippsland.

body improved the hawks' capture rate. Similar results were obtained in trials with Bannertail Kangaroo Rats *Dipodomys spectabilis* of the North American deserts, which have brown bodies and white tail tips. When a white spot was painted on a rat's body (to facilitate nocturnal identification by humans), its vulnerability to owls was increased greatly (W. Radke *pers. comm.*). Likewise, the white tail tip of possums and gliders may afford some degree of predator distraction. However, the incidence of white-tipped tails is not consistent across the Petauridae nor within some species, so the evolutionary benefit of this trait remains speculative.

The second unusual anti-predator behaviour of phascogales is foot tapping. When frightened, phascogales simultaneously slap their front feet on trees (about 1 slap per second), making a tapping noise that can be heard by humans up to 20 m away (depending on substrate). Although foot tapping is performed under various circumstances (interpretable as 'annoyance'), it is most commonly elicited when the phascogale first becomes aware of a potential predator such as a human observer. Tapping can last for several minutes, and, if the observer moves or otherwise conveys a threat, is often re-initiated. Foot tapping occurs only when the phascogale is in a position that is invulnerable to the predator (e.g. on a tree). If frightened while on the ground, it will climb a tree before tapping.

Why does the phascogale appear to draw the attention of a predator? The answer depends on the assumption that the predator is already generally aware of the phascogale's presence through either scent or sound. The function of tapping, then, is to inform the predator that it has been detected, will not successfully ambush the phascogale, and would more profitably hunt elsewhere. This explanation is supported by the specificity of the response: although foot tapping is commonly directed toward terrestrial predators, phascogales become motionless in the presence of owls, perhaps because they are seldom invulnerable to aerial attack. Similar pursuit deterrent signals have evolved among other mammalian species (Hasson 1991). For example, Kangaroo Rats drum on the ground when confronted with snakes (Randall and Stevens 1987), and Hares rise on their hind legs and stare at approaching Foxes (Holley 1993). In both cases, the predator departs without attempting to attack.

The evolution of pilo-erection and foot tapping might be attributed to social interaction among phascogales, but evidence argues against such explanations. Like phascogales, Kowaris *Dasyuroides byrnei* have black tail-hair (20 mm) which can be erected. They use their tail brushes as aggressive signals in confrontations with other Kowaris (Hutson 1982). Wild phascogales often erect their tail hair when agitated by conspecifics, and sometimes rustle the brush, but the tail is held inconspicuously behind the phascogale rather than elevated in the stylised manner observed in Kowaris. As in my research on wild phascogales, Cuttle's (1978) exhaustive study of phascogale behaviour in captivity found no evidence that the brush is important in social communication. The tail of Kowaris may have originally evolved as a predator distractant and its role as a social device has become important subsequently.

Foot tapping potentially serves as an alarm signal (Cuttle 1983) to warn kin of danger. (Altruistic alarms which attract the attention of predators theoretically should be used to help kin rather than genetically unrelated individuals; Sherman 1977). Tapping is sometimes taken up by nearby phascogales in captivity or among young siblings in the wild. However, the sparse density and solitary behaviour of adult phascogales in the wild argues against the explanation that tapping evolved as an alarm. Female phascogales are intra-sexually territorial, occupying large home ranges (20-70 ha), and kin are very rarely nearby while foraging. Males, which disperse from the maternal home range, seldom forage near other phascogales even though their home ranges (about 100 ha) overlap with those of females and other males. Thus, tapping is very unlikely to be heard by another phascogale and is best explained as a benefit to the foot-tapper itself.

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

A.K. Cavanagh*

Introduction

Since my last review (Cavanagh 1989), interest in the biology of banksias has not diminished. Studies of pollination and banksia breeding systems still predominate although it is interesting to note that the factors controlling or limiting seed-set are beginning to be studied in detail. Results from more fundamental field studies are also now being applied in horticulture to improve cut flower production. Research continues to concentrate on the major role of birds in pollination and the important if limited part played by non-flying mammals has not been neglected. Several studies have discussed the feeding habits of bats and flying foxes whose consumption of banksia flowers, along with insect damage to inflorescences, contributes to reduced seed-set. Yet mature banksia plants can hold up to 20,000 viable seeds in canopy seed storage (serotiny) and several surveys have attempted to document the dynamics of this development. In South Africa, so long suffering from the invasion of Australian acacias and hakeas, the serotinous nature of these plants has led to concern that recently introduced banksias may have the potential to spread similarly into the native fynbos vegetation.

Many of the ecological studies of *Banksia* report on the role of fire and are of important practical and theoretical interest. A number of banksias are rare or endangered and others are exploited for the wildflower trade. Consequently, data from these studies can and have been used in both Australia and South Africa to provide guide-lines for fire regimes which can optimise the post-fire recruitment of banksias and indeed other Proteaceae. Additionally, as Cowling *et al.* (1990) state (Ref. 168): '-- banksias provide excellent opportunities for exploring the evolutionary significance of fire-adapted reproductive traits and the mechanisms that promote the co-existence of species.' Yet another field of interest has been the water relations of banksias, with attention being given to groundwater recharge into and evaporation from banksia woodlands and the structure of their root systems and in particular, the nature and chemical properties of the proteoid root mat a modified root system unique to the Proteaceae. Finally, nutrient allocation and other constraints on seed production as well as the factors controlling co-existence and development of seedlings have also been studied.

Along with increasing exploitation of banksias in the wild has come the realisation that many species are either rare in terms of their small, sometimes unprotected, populations or are endangered from commercial picking or other natural or man-made causes such as expansion of agricultural land, *Phytophthora cinnamomi* and droughts and fire. Seven banksias are now declared rare flora in Western Australia while a further five are on a reserve list and are to be carefully monitored to determine their exact conservation status. A practical outcome of these concerns has been the establishment of the Australian Network for Plant Conservation based in the Australian National Botanic Gardens, Canberra, one of whose aims is to form an 'Endangered Species Collection' in the form of a multi-site collection of living plant material (seeds, rooted cuttings or growing plants).

The development of the cut flower industry in Australia with its potentially large overseas market has led to much more study of the horticultural requirements of banksias. While some of the research is relatively fundamental, much of it is more applied and deals with a diversity of topics such as hybridisation

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techniques to improve cut flower production and studies of potting mixes, especially of the iron-phosphorus relation in container-grown banksias and of means to minimise the effect of *Phytophthora*. Several hybrid banksias have now been registered with the Australian Cultivar Registration Authority and the number is bound to increase with the spread of plantation cultivation to areas as diverse as South Africa, Israel, Hawaii and Tenerife.

The bibliography lists material mainly published since 1988. It is arranged alphabetically by author under the following categories: **Books. Taxonomy. Reproductive Biology:** *Pollination - General; Pollination - Birds; Pollination - Mammals; Seed and Flower Predators and Seed Loss; Seed Development and Canopy Storage; Mechanisms of Seed Release; Seed Germination.* **Ecology:** *General Studies; Role of Fire; Role of* Phytophthora; *Rare and Endangered.* **Horticulture:** *General; Propagation, Cultivation and Chemical Studies.*

Numbering follows on from the previous bibliography (Cavanagh 1989). All Banksia taxa recognised by Taylor and Hopper (1988) are listed in the appendix. Each taxon is indexed to relevant papers in the bibliography. Forty-two of the 92 species, sub species and varieties are referred to in the papers listed in the bibliography. In this way it is hoped that the bibliography will also be of use in indicating species on which little or no work has been done.

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Appendix

Listing of all *Banksia* species (sensu Taylor and Hopper 1988). Species are indexed to relevant papers.

Banksia aculeata A.S. George -168
Banksia aemula R. Brown
Banksia ashbyi E.G. Baker -192
Banksia attenuata R. Brown -132, 135, 137, 158, 169, 170, 195
Banksia audax C. Gardner
Banksia baueri R. Brown
Banksia baxteri R. Brown -136
Banksia benthamiana C. Gardner
Banksia blechnifolia F. Meuller
Banksia brownii Baxter ex R. Brown -175,177
Banksia burdetii G. Baker -168
Banksia caleyi R. Brown
Banksia candolleana Meissner -137, 168, 169
Banksia caneii J.H. Willis -190
Banksia chamaephyton A.S. George
Banksia coccinea R. Brown -104,105,136,189,197
Banksia conferta A.S. George var. *conferta*
Banksia conferta A.S. George var. penicillata A.S. George
Banksia cuneata A.S. George -103, 134, 143, 168, 174
Banksia dentata Linnaeus f.
Banksia dryandroides Baxter ex Sweet
Banksia elderiana F. Meull. and Tate
Banksia elegans Meissner -137, 153a, 154, 168
Banksia epica A.S. George
Banksia ericifolia Linnaeus f. var. *ericifolia* - 108, 114, 115, 124, 140, 145, 151, 164, 166, 199, 200, 201, 202
Banksia ericifolia Linnaeus f. var. *macrantha* A.S. George
Banksia gardneri A.S. George var. *brevidentata* A.S. George
Banksia gardneri A.S. George var. *gardneri*
Banksia gardneri A.S. George var. *hiemalis* A.S. George
Banksia goodii R. Brown
Banksia grandis Willdenow - 142
Banksia grossa A.S. George - 132, 137, 185
Banksia hookeriana Meissner - 132, 137, 141a, 155, 158, 168, 169, 188, 194, 198
Banksia ilicifolia R. Brown - 169
Banksia incana A.S. George - 185
Banksia integrifolia Linnaeus f. var. *aquilonia* A.S. George
Banksia integrifolia Linnaeus f. var. *compar* (R. Brown) Bailey
Banksia integrifolia Linnaeus f. var. *integrifolia* - 123, 124, 149, 150, 159
Banksia laevigata Meissner subsp. *fuscolutea* A.S. George
Banksia laevigata Meissner subsp. *laevigata*
Banksia lanata A.S. George -168, 185
Banksia laricina C. Gardner -110, 135, 204
Banksia lemanniana Meissner
Banksia littoralis R. Brown
Banksia lullfitzii C. Gardner - 176
Banksia marginata Cavanilles - 144, 148
Banksia media R. Brown
Banksia meisneri Lehmann var. *ascendens* A.S. George
Banksia meisneri Lehmann var. *meisneri*
Banksia menziesii R. Brown - 104, 106, 109,119, 120, 126, 132, 137, 141a, 158, 168, 169
Banksia micrantha A.S. George - 137, 169, 170, 188, 189, 196, 197
Banksia nutans R. Brown var. *cernuella* A.S. George
Banksia nutans R. Brown var. *nutans*
Banksia oblongifolia Cavanilles var. *minor* (Maiden and Camfield) Conran and Clifford
Banksia oblongifolia Cananilles var. *oblongifolia* - 115, 124
Banksia occidentalis R. Brown subsp. *formosa* S.D. Hopper - 99
Banksia occidentalis R. Brown subsp. *occidentalis* - 195, 203
Banksia oligantha A.S. George
Banksia oreophila A.S. George
Banksia ornata F. Muell. ex Meissner
Banksia paludosa R. Brown - 107, 145
Banksia petiolaris F. Muell.
Banksia pilostylis C. Gardner
Banksia plagiocarpa A.S. George
Banksia praemorsa Andrews
Banksia prionotes Lindley - 137, 168, 187, 188, 192
Banksia pulchella R. Brown
Banksia quercifolia R. Brown
Banksia repens Labillardiere
Banksia robur Cavanilles - 124
Banksia saxicola A.S. George
Banksia scabrella A.S. George - 185
Banksia sceptrum Meissner
Banksia seminuda (A.S. George) B. Rye subsp. *remanens* S.D. Hopper -99
Banksia seminuda (A.S. George) B. Rye subsp. *seminuda*
Banksia serrata Linnaeus f. -115, 124, 145, 163, 164, 165, 166, 182
Banksia solandri R. Brown
Banksia speciosa R. Brown -136, 187, 192
Banksia sphaerocarpa R. Brown var. *caesia* A.S. George
Banksia sphaerocarpa R. Brown var. *dolichostyla* A.S. George
Banksia sphaerocarpa R. Brown var. *sphaerocarpa* A.S. George -185
Banksia spinulosa Smith var. collina (R. Brown) A.S. George
Banksia spinulosa Smith var. *cunninghamii* (Sieber ex Reichenbach) A.S. George -125, 130
Banksia spinulosa Smith var. *neoanglica* A.S. George -111, 112, 113, 121, 122, 131
Banksia spinulosa Smith var. *spinulosa* -107, 114, 123, 124, 141, 145, 191
Banksia telmatiaea A.S. George -185
Banksia tricuspis Meissner -137, 152, 168
Banksia verticillata R. Brown
Banksia victoriae Meissner -187
Banksia violaceae C. Gardner

Butterflies (Pieridae) Eaten by Dragon Lizard and Rainbow Bee-eater

Ian Faithfull*

Predation of Australian butterflies is infrequently recorded in the literature. Nicholson (1927 pp. 81, 88) stated that it had been 'a matter of frequent remark that butterflies are seldom attacked in the adult state' and 'that adult butterflies are seldom seen to be attacked by birds'. Common and Waterhouse (1981 pp. 42-3) stated that 'remarkably little' was known about butterfly parasites and 'even less' about predators. A more recent work (Barker and Vestjens 1990), on the food of birds, listed numerous records of 'moths', 'butterflies' and 'caterpillars' as prey items, but very few specific identifications of the prey. It is therefore worth reporting the predation by a bird and a lizard of two species of pierid butterfly at Mount Isa, Queensland, on 29 May 1989.

In an aerial engagement during the morning of that day, near the Ray Donaldson Memorial Lookout to the east of the city centre, a Rainbow Bee-eater, *Merops ornatus* captured, and then ate, wings and all, a Common Migrant, *Catopsilia pyranthe crokera (W.S.Macleay).* During the afternoon, the gardens of the Civic Centre were found to be the home of several small, prettily coloured, arboreal dragons, *Lophognathus gilberti* Gray which frequented the shrubbery along the north wall of the main building. Two butterflies were captured and consumed by this lizard: a Common Migrant, the wings again being swallowed, and a Common Grass Yellow, *Eurema hecabe phoebus* (Butler).

Butterflies were numerous around the Citrus, Lantana blossom and other flowers in this shrubbery and I estimated their relative abundance to be in the ratio of 15 *E. hecabe*: 5 *C. pyranthe*: 3 *Theclinesthes miskini*: 2 *Anaphaeis java*: 2 *Euploea core*: 1 *Papilio anactus*: 1 large hesperiid. So *L. gilberti* consumed the two most plentiful species.

Vertebrate predation of these two butterflies does not appear to have been previously recorded. The Bee-eater is known to eat the Australian Admiral, *Vanessa itea* (Fabricius) (Lepschi 1993). I am not aware of any record of butterfly predation by *Lophagnathus.*

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Crosbie Morrison, Voice of Nature by Graham Pizzey.
(A Victorian Press Publication, The Law Printer, Melbourne 1992, RRP $26.95).
Philip Crosbie Morrison was a well known radio broadcaster, journalist and photographer with a passion for nature. While chairman of the National Parks Authority he worked tirelessly to improve Victoria's National Parks. He was also a very active member of the FNCV: Hon Sec 1919-1920; President 1941-1943; winner ANHM in 1947 and wrote many articles for *The Victorian Naturalist.* Some of our long-time members may well remember him. In this eloquent biography Graham Pizzey has included memorabilia collected by Crosbie Morrison's wife, and has produced a book that is delightful and evocative to read especially for those who remember Crosbie Morrison's radio programme 'Wildlife'.

Volvox at Albert Park Lake

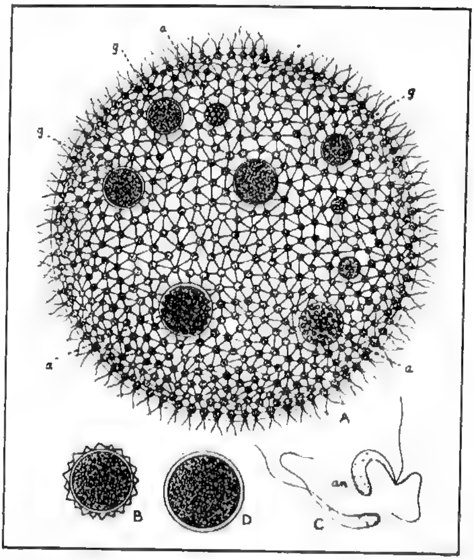
D.E. McInnes*

Albert Park Lake which is just South of Melbourne City is now a different lake to the one it was many years ago. Then it was nearly covered with water weed and all methods were tried to keep it clear enough to allow boat racing of all kinds. They were unsuccessful, but it was a great place to pond hunt. It was often possible to find aquatic caterpillars there, a source of wonder to juniors, and plenty of aquatic insects, water mites bright red and blue and 'water fleas' of all kinds.

Then came a period of killing off the weed by pouring chemicals into the lake. This was very successful and all of the weeds disappeared except the algae *Cladophora* which grew into great long strands attached to the concrete banks, but strangely the 'water fleas' were not affected and at times were in great quantities. A few rotifers would also be found.

Recently the Lake has been emptied (half at a time) cleaned up, made deeper and now refilled with new water. But the new water is not the same as the old water which was always fairly clear. Now the water is quite clayey.

Near the end of October a visit was made to the Lake to pond hunt. Samples were taken from the southern end, then half way and finally at the northern end. There were plenty of 'water fleas' but at one spot at the North there were *surprise, surprise* quite a number of Volvox to be seen. Now, Volvox is one of the green algae regarded by pond hunters as a prize to find. It is a beautiful minute green sphere which just rolls along in the water and inside each sphere can be seen smaller green spheres. Under darkground illumination with the microscope they are a pleasure to observe. The spheres are composed of hundreds of single cells each with two flagella and the action of all these flagella beating in unison enables the sphere to majestically roll along in the water.



Illustrations of Volvox life stages, in this case European specimens, from West, G.S. (1916). 'Algae', volume 1. (Cambridge University Press.) A, C, and D, *Volvox aureus* Ehrenb. A, monoecious sexual colony, x 210; C, two antherozoids (after Klein); D, ripe oospore, x 475. B, ripe oospore of *Volvox globator* (L.) Ehrenb., x 475. a, androgonidia; an, antherozoid; g, gynogonidia.

Later, on the 13th November, another visit was made and samples were taken in the same places as previously. What a surprise, this time at every spot the lake was teeming with Volvox and at the centre the pond net was covered with a sheer mass of green Volvox. Just a dip with a jar revealed plenty of the green spheres. The lake was in fact affected by an 'algae bloom', this time with Volvox. Is this unusual or has it happened to other lakes?

Another surprise was the appearance of plenty of the Desmid *Micrasterias hardyi* everywhere in the lake. A point of interest is that it was given the name *hardyi* because a Past President of the F.N.C.V., Mr A.D. Hardy, was doing an algae survey of

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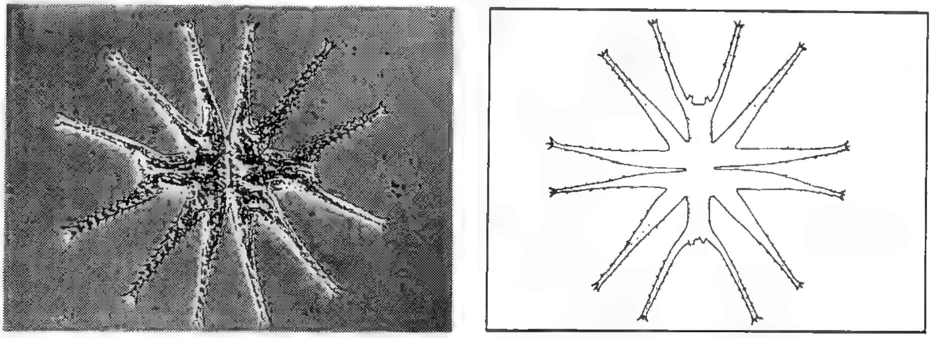
the Yan Yean and described it in *The Victorian Naturalist* Volume 22, 1905. *Micrasterias* is one of the most ornate forms of the Desmids which are minute brilliant green algae with many varied forms that endear them to the pondhunter. *Micrasterias hardyi* has narrow lobes armed with tiny spikes in contrast to the usual wide rounded lobes of other *Micrasterias* spp.

A further interesting find was colonies of the rotifer *Conchilus*. Their colonies are formed by many rotifers that grow outwards from a gelatinous blob forming a sphere with all their ciliary wreaths on the outside. The action of the ciliary wreaths causes the sphere to roll along in the water similar to the action of the Volvox. The colonies were most plentiful at the northern end, so much so, that a sample under the microscope showed over two dozen colonies in the field at the one time. What a sight for the pond hunter!

As the writer, over a period of 40 years, has never before seen in Albert Park Lake any of the three species, it was thought that a Nature Note commenting on the change in the lake might interest other members.

Postscript. On 25th November, on another trip to the Lake, samples were again taken at the same four places; the desmid *Micrasterias* was plentiful at all the spots and the rotifer *Conchilus* was seen everywhere, but not a single specimen of Volvox was sighted anywhere around the Lake, what a contrast. From being an algal bloom all around the Lake to not a single specimen. Is this unusual in such a short time?



Two views of the desmid *Micrasterias hardyi* (dimensions 240µ long, 236µ wide, 20µ isthmus). (a) An electron micrograph by Dr P.A. Tyler and (b) drawing by Joan Powling.

Australian Natural History Medallion Trust Fund

Donations were gratefully received during 1993 from the following societies:

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If you would like to contribute to this fund, which supports the Australian Natural History Medallion, donations should be sent to : The Treasurer, Field Naturalists Club of Victoria, National Herbarium, Birdwood Avenue, South Yarra 3141. Cheques should be made payable to the 'Australian Natural History Medallion Trust Fund'.

The Medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history in the last ten years.

A Dog's Life - But Butchered by a Bird

Arthur J. Farnworth*

Colloquially, 'a dog's life' generally refers to a miserable, harassed or oppressed existence suffered by one human, often at the hands of another, although most modern dogs of the *Canis familiaris* variety seem to live 'very nicely, thank you'.

However, the expression took on a different, sad and somewhat gruesome complexion for one such animal sighted recently at Currawong Bush Park, a 25-hectare conservation bush habitat of open forest and wetland in East Doncaster, an outer suburb of Melbourne.

The small animal (approximately 10 cm in length), unidentified at the time, was found firmly wedged in the fork of a fallen tree, some 1.5-2.0 m from the ground. The initial, and in retrospect foolish, thought was that the animal had found its way up the tree, got itself jammed in the fork and perished in its vain attempt to free itself. However, its general appearance and the force required to remove it rather refuted such a theory.

Inspection of the accompanying photographs by some zoologists at LaTrobe University elicited a consensus view that the animal was most probably a recently-born or aborted foetus of a dog and was almost certainly placed in the tree fork by a Butcherbird.

The only species of Butcherbird found as far south as Melbourne is the Grey Butcherbird *(Cracticus torquatus)*. Most bird books state that their common name originates from their habit of 'hanging up their meat/prey' on thorns, sharp twigs or wedged in small forks of trees, either to assist them in feeding or to create a 'larder' of food to be eaten at leisure. The foods usually cited are larger insects, small reptiles, rodents, birds and their young and occasionally berries, to which should perhaps be added tiny dogs!!

Only the unfortunate dog and its butcher know what happened and they are not saying. However, after considering all the factors - the location of the park, the position of the animal, the punctured lower neck stained with darkened blood and the bright, recently-congealed blood around the muzzle - it seems possible (likely?) that a recently-born dog from one of the houses surrounding the park was 'collected' by a Grey Butcherbird, killed by piercing its throat, transported to the park, forcibly wedged in the fork of the tree during which fresh blood from internal bleeding was squeezed out through the nose and mouth, then left 'hanging' for future consumption - and all within a very short space of time just before I happened by.

However, some experienced 'birdo' with specialised knowledge of the habits of *Cracticus torquatus* may have a much simpler or more profound explanation.

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Exploring Local Seasonality

Alan J. Reid*

Summer, Autumn, Winter, Spring - the four equal seasons framework by which most Australians make sense of environmental events during the year!

In the temperate areas of southern, coastal Australia, it seems to work well as a holiday planner, as a gardening guide or, more importantly, as a land management tool. Spring, for example, is heralded by blossoming fruit trees and daffodils, emerging butterflies and the territory songs and nest-building of birds. The first day of Spring is recognised by most, especially weather forecasters, race commentators and fashion designers, as the 1st of September and the last day as the 30th of November.

But does this European-derived framework really work? It certainly doesn't work in the tropical north where white land managers only recognise a two season Wet and Dry. The four season indicators don't work at all - butterflies emerge throughout the year, many fruits ripen in June and July after April and May flowerings and Scrub Fowl lay eggs in their April mounds.

It certainly doesn't work for tribal aborigines in the north. Their finely-tuned calendars, after 50,000 years of survival in the Australian environment, recognise from five to seven seasons, according to their locality.

The Milingimbi Island people in N.E. Arnhem Land, for example, use a six season calendar. The longest season is Rarranhdarr. It is approximately eleven weeks long and begins in early August. The shortest is Mayaltha, the growth part of the Wet. It lasts five weeks. They live by the coast and the ecosystems on which they depend respond to particular climate patterns and the distinctive topography.

In the Kakadu region, 180 km inland to the south-west, a completely different pattern of seasons exists. The thirteen week wet season of Gudjewg is followed by the four week long Bang Gerang, characterised by receding waters, mating goannas, seeding grevilleas and blossoming melaleucas.

Again it is a different pattern at coastal Aurukun on Cape York. The longest season is the eleven week Onchan Min and the shortest is the three week long Thurpak. In the Kimberley the tiny seasons, Bandemanya (maturing crops) and Golururu (onset of the trade winds), both occur in April. The longest season in the Kimberley is Yirma which lasts for a massive sixteen weeks. It is cool and dry with abundant food. In Alice Springs only five seasons are recognised.

The European four-season framework doesn't work either as you move from the southern coastal regions of Australia. We no longer have aboriginal calendars to refer to, but less than 10 km from the Victorian coast, magpies, plovers, gulls and even thornbills often begin nesting in early July. Some species of wattles are in full bloom then too, and Painted Lady butterflies often appear in early August. As you move inland or closer to the mountains, different provenances or sub-groups of the same plant and animal species exhibit different breeding times.

In mediterranean climates, introduced European plants and animals do appear to respond more or less to the conventional framework. However, native species in neighbouring natural reserves have independent regimes and obviously different response patterns. These patterns vary from locality to locality. These are varied further by the impact of clearing, introduction of exotic plants and animals, creation of impervious and reflective surfaces, modifications of waterways, introduction of large scale farming practices, changes in water and soil quality and the general attitude to and treatment of our wildlife and wild places.

In other words, there are definite local seasonal patterns and there is a need to

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* Glenburn Victoria

understand them if we are to manage effectively.

Local field naturalists are in an excellent position to contribute to this knowledge and practice, either as specialists or generalists. Our local knowledge should allow us to build local timelines of natural events. Such benchmarks especially if accompanied by appropriate data, should allow for the measurement of the rates of change within ecosytems and help provide management guidelines.

Even combing back through our old diaries and journals will be useful in establishing these patterns.

My interest in local seasonality began in 1960. Murray Hodges and I had just completed a 3 year weekly census of waterbirds on the Lake Colac foreshore. Donald Lamm of the U.S. embassy in Canberra had just published a similar study at Lake George. Lamm presented his results as 'Seasonal Counts of Waterbirds on Lake George' and used the framework of Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec.

For the purpose of comparison we decided to frame our data in the same way. The results were alarming. There was a general correspondence of trends and shifts of populations in both studies, but this was markedly different to the conventional Australian frame we had applied earlier. More alarming was the obvious bluntness of this analytical tool. The lumping had obscured the significant surges of Pink-eared Duck populations after rain, the mass movements of cormorants in late February, the flocking of the Black-fronted Plovers in April, the movement of coots and swans onshore during 'winter' and the retreat of the gulls to their nesting islands.

I have kept what I have judged to be 'significant event' data since that time and used it to compile monthly summaries for the 'Casey's Someries' magazine for children in the early sixties and to prepare weekly predictive 'Beachcombing Diary' articles for the *Westernport News* during the same period. More recently I have used this material to produce the predictive Gould League nature diary called 'Gumleaves and Geckoes' and to produce monthly what-to-look-for columns for the *Nunawading Gazette.*

The concept was also the basis for a two year northern Australian nature-event-gathering project for outback children, run through the Schools of the Air program during 1988 and 1989.

I am currently analysing data collected from my 25 year long banding study of bush birds using an artificial lake and its surrounds at our Glenburn property. Some fascinating seasonal patterns are being revealed by the preliminary analyses. One of these is the persistence of mixed species 'winter' feeding flocks of insectivorus birds travelling along the farm fenceline corridors from the state forest to the lake. I first became aware of this movement in 1970 and in 1971 made a detailed analysis of this phenomenon. My latest banding project looks at the effect of extending these corridors.

A typical movement pattern confirmed by analysis of my banding data is the 'spring'/'autumn' migrations of the Yellow-faced Honeyeater, their 'summer' presence (September to April) and the unusual presence of a small flock in early June 1974. One individual returned at least 4 times in 7 years.

As systems evolve or are changed through sudden or slow-moving catastrophic events, so will the local seasonal patterns change. In 1983, the day after the catastrophic Ash Wednesday fires, a small group of Bell Miners arrived in the N.E. corner of the Graceburn property. Whether through successful aggression or through the exploitation of insect-stressed trees, the miners have succeeded in establishing what appears to be an invincible colony of 400+ birds. There does appear to be a small reduction in species and numbers of other bush birds using the corridors, but this could be attributed to the evolving nature and succession sequences of the vegetation complex within the corridors.

Slow-moving changes such as increasing rainfall (perhaps through global climatic changes) could also impact on local wildlife and their seasonal patterning. Rainfall on the Glenburn property has averaged 39.2 inches over the past 20 years. Over the last 5 years it has averaged 45.2 inches. It will be interesting to see if this is reflected in my wildlife census results.

How much more interesting it would be if there was a pooling of local data to relate to such trends! If there was such a scheme, we would almost immediately retrieve the lost aboriginal local calendars. The process would be simple enough - a series of widely-advertised local workshop weekends within a defined natural region of shared climate and topography. Naturalists of all persuasions, who had worked in that region, would bring their notebooks and diaries and work methodically through the calendar, contributing event information. Patterns and key events would then be identified to establish the regional calendar.

I recommend the launching of such a scheme to the FNCV. I know that the Gould League would also be interested in discussing the possibility of a joint project with you. *

Thank you for the honour you have done me in making this award. My thanks go to all the naturalists and fellow enthusiasts I met along the way who profoundly influenced me and inspired me - Roy Wheeler, Jack Hyatt, Graham Browne, Philip Crosbie Morrison, Jim Willis, Laura White, Bill Davis, Marc Gottsch, Susan McInnes, Norm Wakefield, Alan Kaufman, Alan McEvey, Ron Jensz, Sid Cowling, Myron Sutton, Jean Edgecombe, Alexis Beckett and the scores of Gould League personnel who supported me over the past 25 years.

Thanks too to my wife and family who always encouraged my involvement in this most rewarding of fields.

*** Update**

We have had those discussions and I'm pleased to announce the first of those regional meetings along the lines I've suggested.

You are all invited to attend all or part of the weekend of March 25-27, 1994 at Tikalara Park in Doncaster to explore the local seasonal calendar for the Middle Yarra Region. This coincides with the Envirofest '94 celebrations.

The Friday evening launch will feature graphic presentations by prominent specialists who will attempt to identify in their discipline the most significant events and causal factors in that locality. The Saturday workshop will explore and record natural events occurring between the end of March and the end of September. Sunday sessions will deal with the period between October and mid-March.

There will be camping facilities available for those wanting to stay the whole weekend. Please come armed with diary records for the period you intend to be present. We plan to leave the files open for 3 months after the workshop to allow you to contribute other records and look for grandpa's diary too.

We are calling the project 'Timeline Australia' as we hope to explore other localities in Australia in the same fashion, leading to a major presentation of some kind in the 2001 Centenary year.

Alan Reid
January 1994

Recent Publications in Natural History

Birds of Prey and Ground Birds of Australia. Edited by Penny Olson, Francis Crome and Jerry Olson.
(Publisher: *Angus & Robertson. RRP $95.00. Available post-free within Australia from Andrew Isles Bookshop, Prahran, Victoria 3181).*

Door to the Forest

by Ellen Lyndon

Publisher: *South Gippsland Conservation Society Inc, Environment Centre, PO Box 60, Inverloch, Victoria 3996. R.R.P. $10.00.*

Ellen Lyndon has been a member of the FNCV for many years, a contributor to *The Victorian Naturalist* and other journals, and was a founding member of the LaTrobe Valley Field Naturalists' Club. She has been a lover and observer of nature all her life. In this attractive collection of her writings she gives us a vivid picture of life on a South Gippsland farm, as a child, and then of the hardships and triumphs of farming with her husband under the Soldier Settlement scheme after the Second World War. Always her quick eye and insatiable curiosity were directed to the natural world, whether it was in 'Birding from the Kitchen Sink', exploring the Mirboo railway line, studying the alcoholic tastes of butterflies, or watching the reactions of human visitors, who had suddenly become aware that the windows were plastered with frogs having an evening meal of moths and insects. While there is a lament for the flora and fauna which has disappeared, there is also the positive side, in the successful campaign to have Morwell National Park established. The book is enhanced by the delightful illustrations of Marion Kaighin-Chapman, and a final striking photograph by Donald Lyndon of a Great White Egret.

Sheila Houghton

Collecting and Preserving Herbarium Specimens

by David Albrecht

Publisher: *National Herbarium of Victoria, Melbourne,* 1993.

Available from: *Visitors Centre, National Herbarium, Birdwood Avenue, South Yarra, 3141. R.R.P. $6.00 plus postage.*

Everything you need to know about collecting and preserving plants. It also includes specific sections on Bryophytes, Lichens, Macroalgae and Macrofungi. This booklet is written in a logical and clear style that sets out the standards and expectations and requirements for collections that are to be lodged at an Herbarium. The value of the work of collectors is also highlighted, including an important comment on the ethics of collecting and when NOT to collect. Students of botany will greatly appreciate this addition to their library and private collectors will find the additional information on mounting, arranging and maintaining specimens of great value. This information can promote anyone's collection from a mere presentation to one of great value. **Editors**

The Encyclopedia of Australian Animals: Reptiles; Frogs; Mammals and Birds. 4 Volumes.

Publisher: *Angus & Robertson, NSW, 1992.*

R.R.P. $49.95, $29.95, $29.95, $29.95 respectively.

This is a four volume encyclopedia on all Australian species of animals in Australia - reptiles, frogs, mammals and birds. All the volumes include a photographic illustration of each species with a distribution map and notes on the identification, behaviour, habitat and conservation status. A useful addition to the library of anyone with an interest in Australian wildlife. All the photographs are from the National Photographic Index of Australian Wildlife which is a special project of the Australian Museum and they are of an excellent standard. However, with all the recent name changes a reader would be wise to cross-check with other current references.

Notice of the Annual General Meeting

The Annual General Meeting of the Field Naturalists Club of Victoria will be held at the Herbarium, Birdwood Avenue, South Yarra at **8 p.m. on Monday, April 11, 1994.**

Agenda

1. Confirmation of the minutes of the previous Annual General Meeting held on 5 April, 1993.
2. Receipt and adoption of Annual Report for the year ended 31 December, 1993.
3. Receipt and adoption of Financial Statements and associated reports.
4. Election of Members of Council.
5. Election of Office Bearers.
6. Appointment of Auditors (remuneration to be determined by Council).
7. Any other business of which proper notice has been given in accordance with the Articles of Association.
8. President's Address.

Election of Councillors and Office Bearers

All members of Council and Office Bearers retire annually but are eligible for re-election. Nominations by two financial members of the Club are required for the following positions.

Council

President
2 Vice-Presidents
Ten other members

Office Bearers

Secretary
Treasurer
Assistant Treasurer
Editor
Activities Co-ordinator
Librarian
Excursion Secretary
Conservation Co-ordinator
Publicity Officer
Sales Officer (Books)
Sales Officer (Victorian Naturalist)

This is your Club, and all members are urges to ensure its on-going viability by filling **all** the above positions with persons willing and able to contribute to activities, functions and the general work of the Club. Arrange a nomination for yourself or encourage some other appropriate member to be nominated.

Nominations should be in the hands of the Secretary before the Annual General Meeting.

Obituary

Mr Will Lock

In late July 1993, a very well-liked FNCV member, Mr Will Lock died.

Will joined the Club with his twin sister Myrel in 1976 and they lived together at Surrey Hills. He had been a music teacher at Camberwell Grammar School for boys until he retired, then taught privately until near his death.

I remember him coming on Botany and General Excursions, as well as Christmas tours including the one to Mt Kosciusko.

We will all miss him and send our respects to Myrel.

Joan Harry

The Field Naturalists Club of Victoria

In which is incorporated the Microscopical Society of Victoria

Established 1880

Registered Office: FNCV, c/- National Herbarium, Birdwood Avenue, South Yarra, 3141, 650 8661.

OBJECTIVES: To stimulate interest in natural history and to preserve and protect Australian fauna and flora.

Members include beginners as well as experienced naturalists.

Patron

His Excellency, The Honourable Richard E. McGarvie, The Governor of Victoria.

Key Office-Bearers April 1993

President: Dr. MALCOLM CALDER, Pinnacle Lane, Steels Creek, 3775 (059) 65 2372).

Hon. Secretary: Mr. ED GREY, C/- National Herbarium, Birdwood Ave. (650 8661/435 9019 A.H.).

Hon. Treasurer: Mr. NOEL DISKEN, 24 Mayston St., Hawthorn East, 3123 (882 3471).

Subscription-Secretary: FNCV, C/- National Herbarium, Birdwood Avenue, South Yarra, 3141 (650 8661).

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Programme Secretary: Dr. NOEL SCHLEIGER, 1 Astley Street., Montmorency, 3094 (435 8408).

Group Secretaries

Botany: Mr. JOHN EICHLER, 18 Bayview Crescent, Black Rock, 3143 (598 9492).

Geology: Miss KARINA BADER, 73 Richardson Street, Albert Park, 3206 (690 4653).

Fauna Survey: Miss FELICITY GARDE, 30 Oakhill Road, Mt Waverley, 3149 (808 2625 A.H.).

Microscopical: Mr. BRIAN WALDRON, 35 Ropley Avenue, Balwyn, 3103 (717 3511).

The Victorian Naturalist

All material for publication to be sent to FNCV, C/- National Herbarium, Birdwood Avenue, South Yarra 3141. Telephone queries to 650 8661 or A.H. 435 9019.

MEMBERSHIP

Membership of the F.N.C.V. is open to any person interested in natural history. *The Victorian Naturalist* is distributed free to all members, the club's reference and lending library is available and other activities are indicated in reports set out in the several preceding pages of this magazine.

Membership Rates 1994
Individual (Elected Members)
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Single Membership	$30
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The Victorian Naturalist

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since 1884

FNCV Calendar of Activities
(General Meetings May to September Sunday afternoons)

May	
Tues 3	Fauna Survey Group Meeting. ***Population Viability and Analysis for the Helmeted Honeyeater and other Rare Species - Mark Bergman.*** Herbarium Hall 8 p.m.
Sat 7	Fauna Survey Group Field Survey. ***Leadbeaters Possum Survey.*** Contact Ray Gibson 874 4408.
Sat 7	General FNCV Excursion. ***Bandicoots at Gellibrand Hill Park. Leader John Seebeck.*** Own transport. Contact Dorothy Mahler 435 8408.
Sun 8	General FNCV Meeting. ***A Peep into the World of Insects and Spiders - Dr Arthur Farnworth.*** Herbarium Hall **2 p.m.**
Thurs 12	Botany Group Meeting. ***Ecology of Macro-fungi: Four Years Recording at Kinglake - Tom May.*** Herbarium Hall 8 p.m.
Fri 13 - Sun 15	Fauna Survey Group Field Survey. ***Pallisters Reserve.*** Contact Felicity Garde 818 4684.
Wed 18	Microscopical Group Meeting. ***Geological Slides: an Explanation - Dan McInnes, John Stewart et al.*** Astronomers Residence 8 p.m.
Wed 25	Geology Group Meeting. ***The Last 50 Million Years around Ballarat - David Taylor.*** Herbarium Hall 8 p.m.
Sat 28	Botany Group Excursion. ***Fungi at the Kinglake Block. Leader Tom May.*** Own transport. Meet FNCV property 10.30 a.m. Contact Joan Harry 850 1347.
June	
Sun 5	General FNCV Excursion. ***Fungi at Murrindindi Scenic Reserve. Leader Nigel Sinnott.*** Own transport. Contact Dorothy Mahler 435 8408.
Tues 7	Fauna Survey Group Meeting. ***Spotted Tree Frog - Graeme Gillespie.*** Herbarium Hall 8 p.m.
Thurs 9	Botany Group Meeting. ***Members Night.*** Herbarium Hall 8 p.m.
Sat 11 - Mon 13	Fauna Survey Group Field Survey. ***Box - Ironbark Forest.*** Contact Ray Gibson 874 4408.
Sun 12	General FNCV Meeting. ***Serengeti, South Africa - Joan Broadberry.*** Herbarium Hall **2 p.m.**
Wed 15	Microscopical Group Meeting. ***Simple Slide Making - Dan McInnes.*** Astronomers Residence 8 p.m.
Wed 22	Geology Group Meeting. ***Brown Coal of Victoria - Colin Barton.*** Herbarium Hall 8 p.m.
Sat 25	Botany Group Excursion. ***Mosses and Ferns. Leader Arthur Thiess.*** Meet 10.30 a.m Grants Picnic Ground, Melway 75 K4. Contact Joan Harry 850 1347.

Amendments to the Articles of Association of The Field Naturalists Club of Victoria

At an Extraordinary Meeting of The FNCV held at the National Herbarium on Monday 14 February 1994 the following amendments to the Club's Articles of Association were approved and the minutes confirm these changes:

1. to delete the second sentence of article 29 and insert in its place the following sentence: 'Council shall consist of the President, two (2) Vice-presidents, Immediate Past-president (who shall hold office until the next Annual General Meeting only), Secretary, Treasurer, Member nominated by each specialist group and six (6) other members',
2. to delete from the third sentence of article 29 the words 'Secretary, Treasurer',
3. to delete from the sixth sentence of article 29 the words 'The Secretary and Treasurer shall, and',
4. to delete the second sentence of articles 32 and insert in its place the following sentence: 'At all meetings of the Council eight (8) members personally present shall form a quorum'.

The Victorian Naturalist is the bi-monthly publication of The Field Naturalists Club of Victoria.

The Victorian Naturalist

F.N.C.V.

Volume 111 (2) 1994 April

Editor: Robyn Watson
Assistant Editors: Ed and Pat Grey

Index to Volume 110, 1993 is in the centre of this issue.

Letters

Research Reports

Contributions

ISSN 0042-5184

Cover Photo: Common Wombat *Vombatus ursinus.*
Photo courtesy John Seebeck.

Lightning Strikes Again

Dear Editor

As a member of the Field Naturalists' Society of South Australia I was interested to read the published comments of Noel Schleiger (Volume 110 (5) 1993) regarding a lightning strike through a *Eucalyptus sideroxylon.* I suspect that your member suggests an over-complicated mechanism as to what was observed. I have had a long interest in the occurrence and effects of lightning strikes.

Some 40,000 thunderstorms occur world-wide daily with lightning discharges at between 100 to 300 flashes per second representing globally a continuous power flow of about 4,000 million kilowatts. Because of the high potentials often involved the instantaneous current flow can be very high (200 kilo amperes) but short. Temperatures in the narrow discharge path through the air may reach temperatures of up to 30,000°K - five times the surface temperature of the sun.

If the discharge is through wood or other parts of trees, the high power dissipation causes the generation of high steam pressures with forces which would make any effect on the earth's magnetic field insignificant as was probably the case in the two examples I give below. Therefore I would suggest that the path of the greatest conductance in the case of a tree would be under the bark on the southern side of the trunk or branch, or if same has a wet rotted core, more likely through the latter. For example in 1975 when in south-western New South Wales, we noticed that a still-green River Box *Eucalyptus largiflorens* had apparently collapsed, on the flood plain of the River Darling, as if the trunk and main branches had suddenly disappeared. On examination it appeared that the tree had been the victim of a substantial lightning strike. All of the trunk and main branches had been blown apart and the pieces thrown to about 75 metres around, with no pieces being longer than about a half metre, many of which had a cross-section about that of a wooden railway sleeper. At about the same time we noticed a collapsed dry *Callitris* (probably) *columellaris* which had collapsed in a pile of splinters, few of which were larger than a 50 cm ruler. It would appear the generation of steam within the rotted cores of the River Box was the cause of its destruction and collapse. In the second case of the *Callitris,* the wood was apparently of much lower and uniform conductivity resulting in uniform steam generation and therefore uniform disintegration.

It is well known that high objects, in particular trees, and man-made objects such as towers, buildings, masts of ships, etc. are often struck by lightning. Because these are usually better conductors than the adjacent air which is a good insulator until stressed by an electrical potential of abut 10 kilo volts per centimetre, a lightning discharge occurring in the vicinity is likely to be diverted via the object. This means that an isolated object including a person or other large animal becomes more likely to be damaged but there is a relatively protected zone near the base of the object. It is unwise to shelter near the trunk of a tree, particularly an isolated one, as a secondary side flash may leave the tree since a human body may provide an easier path for the discharge. For the same reason a person struck by lightning may escape serious injury because wet clothes may conduct the main discharge. The electrical charges in a thunder cloud are usually negative at the bottom and positive at the top. Discharges can then occur within the cloud or between either the top or base of the cloud to earth, with both sometimes almost simultaneous.

The effect of high current on trees is not only by lightning. Some years ago there was a general power failure in the Adelaide metropolitan area. At the time I was aware that the Electricity Trust of South Australia was stringing second circuits on both of the 275 kv lines between the Torrens Island Power Station and the Para Substation and the one line would be de-energised. My guess was that the fault had occurred near Gawler Street, Salisbury (a northern Adelaide suburb). As a radio news item gave that as the place of failure, I went to the location as soon as possible. The cause of the failure had been an introduced poplar tree which had grown up towards the lower conductor of the 275 kv line resulting in a flashover to ground via the tree. Although the tree had been cut down and removed, I found that the remaining lower one metre of the trunk - diameter about 15 cm - had about one third of the bark blasted off without any sign of burning. Comments from persons who were at the adjacent shopping centre led me to believe the explosion was equivalent to that of a hundred-metre long lightning discharge I since saw from low cloud to a church steeple, but of longer duration until the power was disconnected.

Another similar power failure had a different cause. A bushfire in the Adelaide hills provided an ionised path between the 275 kv conductor and ground resulting in a surging power loss. As the false load was not sufficient to cause the disconnection of the line, the system control, not having experienced the situation before, had to initiate a shut-down. Such a situation is serious because both ends of the 300 km length of the Port Augusta/Adelaide lines (a quarter wavelength at 50 hertz) must be disconnected together.

A similar unusual situation arose when a magnetic storm on the sun resulted in heavy earth currents in the Canadian power system. The result being that some 250 power stations in North America were temporarily taken off-load.

Fifty years ago, while a linesman employed by the former Post-master General's Department at Alice Springs, I noticed other lightning effects. One was that we found while on a maintenance patrol towards Barrow Creek that occasionally insulators were completely smashed into small pieces; the top portion of the wooden spindle was reduced to fibre so it looked like a shaving brush, the copper tie completely missing. The 300-pound-per-mile-wire had stretched some inches, apparently softened due to heating between the point of contact and the insulator.

On 29 September 1979 we attended the opening of the Eyre Highway. The day before, we arrived at the site at the top of the Great Australian Bight at the end of a severe thunderstorm. I had delayed our approach because of the known danger from lightning at such positions. I had passed a large metal warning sign when my wife called out that the sign was hissing. I immediately noticed that the man in front of me had his hair pointing upwards and that there was a 10 metre brush discharge from the sign. Realising that a lightning strike was likely within seconds, I called out to everyone in the vicinity to crouch as low as possible with feet together. Within seconds the strike took place into the sea within 100 metres of the 100 metre-high cliff, just outside of the zone of protection mentioned above.

Early on 14 December 1993 I was near Renmark when an intense thunderstorm swept eastwards about 1 a.m. Conditions remained very humid for the next twelve hours until the arrival of the cold front. Although the front, when approaching, was not accompanied by a thunderstorm, an extensive thunderstorm line built up above the leading edge when it was near the S.A./Victoria border. I have seen this happen on numerous occasions in eastern South Australia. Local residents tell me this is a common occurrence even when there has been no cloud whatever 20 km westwards.

I have long believed that in the Mallee zone, a change of elevation of only perhaps as little as 5 metres results in increased rainfall.

I am interested to hear of any explanation for this thunderstorm activity near the border, particularly, as there were thunderstorms at 2-4 day intervals during the last September - January period (and is being repeated this year).

G.L. Howie
53 Gladys Street,
Clarence Gardens, SA 5039.

The Distribution of the New Holland Mouse *Pseudomys novaehollandiae* (Waterhouse 1843) in the Eastern Otways, Victoria.

Barbara A. Wilson*

Abstract

The results of trapping studies carried out in the Eastern Otways, Victoria between 1981 and 1992 were analysed to determine the distribution of *Pseudomys novaehollandiae.* The species has a patchy distribution and was captured at only ten of the 96 sites trapped. The sites where *P. novaehollandiae* was captured were located on flat to undulating terrain, on soils derived from Tertiary sediments. The species occurred in woodland and low-open forest with heathy understorey and preferred early successional vegetation. An area of approximately 2,300 hectares, located east of the Anglesea River, represents critical habitat for the species. Six of the sites where *P. novaehollandiae* was recorded occur in the Alcoa Lease area, and four in the Flora and Fauna Reserve. A number of processes that represent threats to the survival of this species in the area were identified. They included potential land clearance, recreational pressures and inappropriate fire regimes.

Introduction

The New Holland Mouse (*Pseudomys novaehollandiae*) has been recorded at mainly coastal locations in New South Wales, Victoria and Tasmania (Mahoney and Marlow 1968; Keith and Calaby 1968; Posamentier and Recher 1974; Seebeck and Beste 1970; Hocking 1980). It occurs in heathland and woodland (Posamentier and Recher 1974; Braithwaite and Gullan 1978; Kemper 1977; Hocking 1980), dry sclerophyll forest with dense shrub layer (Keith and Calaby 1968; Seebeck and Beste 1970; Fox and McKay 1981) and on vegetated sand dunes (Keith and Calaby 1968). Posamentier and Recher (1974) proposed that the optimum habitat for the species was heath, actively regenerating after fire. The studies of Fox and McKay (1981) and Fox (1982) showed that *P. novaehollandiae* populations survived wildfire and reached maximum abundance at 2-3 years after the fire. Studies of the species in coastal heath and open-forest regenerating after sand mining showed that the abundance of the species increased with regeneration age (Fox and Fox 1978, 1984; Twigg *et al.* 1989).

Pseudomys novaehollandiae was first recorded in Victoria near Tyabb on the Mornington Peninsula (Seebeck and Beste 1970). It has since been found at a number of sites on the coastal plains including Cranbourne (Braithwaite and Gullan 1978), Langwarrin, Wilson's Promontory and several sites in Gippsland (Norris *et al.* 1979; Department of Conservation and Environment, Wildlife Management Branch, *unpubl. data*). The species has a restricted, disjunct distribution in Victoria, and west of Melbourne has only been found at Anglesea in the Eastern Otway Ranges (Kentish 1982). It is considered to be an endangered species lacking adequate protection (Ahern 1982; Ahern *et al.* 1985; Menkhorst *et al.* 1987) and has recently been listed under the Victorian Flora and Fauna Guarantee Act (1988). Information on the ecology of *P. novaehollandiae* in Victoria is limited. Two studies of the species at Cranbourne (Braithwaite and Gullan 1978) and Langwarrin (Opie 1983) found that *P. novaehollandiae* preferred immature dry heath regenerating after clearing and fire (2-8 years postfire age). In the Eastern Otways two populations were studied between 1985 and 1989, after the 1983 Ash Wednesday wildfire (Wilson *et al.* 1990; Wilson 1991). The population density was low (0-3.1 ha^{-1}). Breeding occurred

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* Biological Sciences, Deakin University, Geelong, Vic. 3217.

from spring to summer. The species exhibited micro-habitat preferences for vegetation of high floristic diversity and within these floristic groups a preference for low, dense vegetation cover (Wilson *et al.* 1990; Wilson 1991). Both of the populations studied in the Eastern Otways declined to extinction in 1989.

The results of a number of small mammal trapping studies carried out in the Eastern Otways are examined in this paper in order to determine the distribution of the species in the area, and to investigate factors that may be important for predicting its distribution.

The study area

The study area in the Eastern Otways (Fig. 1) occurs on a dissected plateau and consists of mainly Tertiary sediments overlying older Cretaceous strata. Pitt (1981) identified four mainland systems based on climate, geology, topography, soil and vegetation: Anglesea; Bald Hills; Gherang Gherang and Mogg's Creek. The soils in the area (e.g. sandy podzols, lateritic podzolic) are of low fertility (Walbran 1971). The vegetation communities consist of a diverse mosaic of mainly sclerophyllous forests, woodlands and heathlands (Land Conservation Council 1985; Meredith 1986; Wark *et al.* 1987).

The area is predominantly public land with a major proportion consisting of the Alcoa Lease area (7,350 ha). Other areas include the Angahook State Park, Flora Reserves, Coastal Reserve and private land such as that previously known as the International Harvester testing grounds. In 1992 approximately 7,500 ha was listed on the Register of the National Estate because of its botanical and faunal values. The 'Ash Wednesday' wildfires in 1983 severely burnt approximately 40,000 ha of the Otway Ranges, including the study area. Several studies of post-fire revegetation and small mammal recolonisation were initiated, and are reported elsewhere (Wilson and Moloney 1985; Wark *et al.*

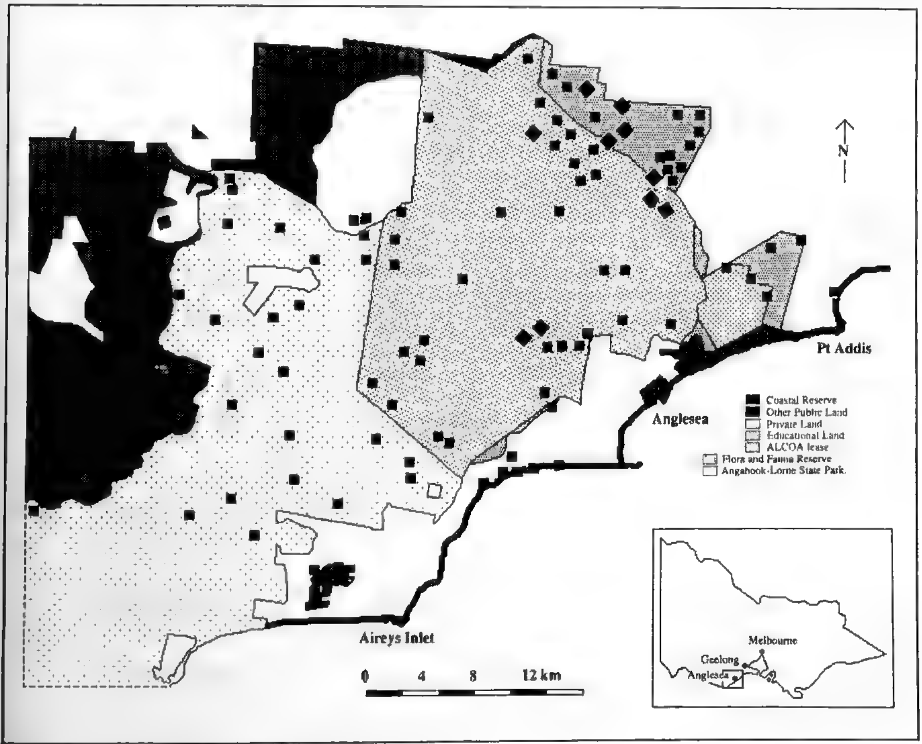

Fig. 1. The study area in the Eastern Otways.

Table 1. Small mammal trapping surveys in the Eastern Otways (1981-1992) (*7 sites in common).

Years	Number of sites	Study
1980-82	10	Kentish (1982)
1983-92	*33	Wilson *et al.* 1990, Aberton unpubl.
1986-87	17	Wilson (1991)
1987	*22	Laidlaw and Wilson (1988)
1990-91	14	Wilson, McLeod and Mills unpubl.
1991	7	Wilson, Belcher and Nichols unpubl.

1987; Wilson *et al.* 1990).

Methods

A number of trapping studies have been carried out in the study area between 1981 and 1992 (Table 1). A total of 96 sites were trapped in a range of vegetation types and the data from these studies have been collated and examined. Live trapping and capture-mark-release techniques were similar to those described previously (Wilson *et al.* 1986, 1990). The trapping intensity ranged from 30-50 traps, set over a period of three to five nights. The identification number of the animal, its site of capture, weight and routine body measurements were recorded. The physical factors and vegetation at sites where *P. novaehollandiae* was captured were described. Topographic, geological and soil information was collated from maps, and observations were made on the sites. The recorded attributes of vegetation structure included the number of strata and their heights, and the percentage of projective foliage cover of the tallest strata. This data was used to describe the structural vegetation types (Specht 1981). The dominant species in the upper-, mid- and understorey were recorded. The age of the vegetation since fire was determined from maps and knowledge of the author. The land tenure of the sites was described and threatening factors or processes for the species were assessed.

Results

Pseudomys novaehollandiae was captured at only ten sites (Fig. 1), and trapping success rates were low (0.5-5.5 per 100 trap nights). The species is currently (1993) present at only four of these ten sites (Table 2). The populations at Coalmine Road were last recorded in 1982 and were eliminated by the Ash Wednesday fire in 1983. No populations have been recorded west of the Anglesea River since 1982. All other populations have been recorded within an area of approximately 2,300 ha east of the Anglesea River. Survey trapping nearby to sites where *P. novaehollandiae* was recorded normally resulted in no captures, indicating that the populations are very localised. Five native and two introduced small mammal species were captured on sites with *P. novaehollandiae* (Table 2).

The sites where *P. novaehollandiae* was captured were located from 2 to 7 km inland on flat to undulating sites at altitudes from 50 to 100 m above sea level.

Table 2. Number of individual *P. novaehollandiae* captured (* sites where *P. novaehollandiae* is present-1992).

Site	Date	Trap nights	Nos. of individuals	**Other species captured
Coalmine Rd. (1)	May 81	200	2	Sle, Rlu, Am, Mm
Coalmine Rd.(2)	July 81	200	1	Sle, Am, Rlu
Forest Rd. (5)	Apr. 85	90	3	Mm
Pipeline Tk.(8)	Apr. 86	90	1	Ast, Mm
Pipeline Tk.(9)	May 86	80	3	Ast, Rlu, Rfu, Mm
Forest Rd. (7)	Sep. 86	80	1	Mm
*Harrisons Tk.(9)	Jan. 91	90	5	-
*Flora Res. (2)	Apr. 91	90	2	Mm, Rn
*Flora Res. (3)	Apr. 91	90	3	Mm
*Flora Res. (8)	June 91	90	4	Ast, Mm

** Species. *Ast (Antechinus stuartii), Am (Antechinus minimus), Sle (Sminthopsis leucopus), Rlu (Rattus*

The sites occur in two of the major land systems, Bald Hills and Gherang Gherang. The species was not recorded on the Anglesea or Mogg's Creek land systems. The sites are on soils derived from Tertiary sediments; in the Bald Hills these sediments are known as the eastern View Formation (Paleocene) and in Gherang Gherang the Demons Bluff (Eocene) formation (Pitt 1981). The soils in the Bald Hills system are of quartz, sand, gravel and clay parent material and include grey sand, yellow gradational and grey gradational soils. In Gherang Gherang the parent material is quartz gravel sand, siliceous sands, laterized sediments. The soils are mottled yellow and grey duplex with ironstone, stony yellow gradational and lateritic podzolics (remnants of younger plateau).

The vegetation where *P. novaehollandiae* was recorded was low woodland to low open-forests with heathy understoreys (Table 3). The species was captured in an old pine plantation, however, the site was adjacent to (<100 m) native vegetation and animals may not have been residents. The predominant species in low woodland and low-open forest included *Eucalyptus obliqua, Eucalyptus willisii, Leptospermum continentale, Leptospermum myrsinoides, Epacris impressa, Acacia myrtifolia, Banksia marginata, Gahnia radula.* At some sites there were small areas of scrub dominated by *L. continentale* associated with wet, damp depressions. The species was not recorded in open forests, scrub (sand dunes), fern gullies or *Melaleuca* swamps.

The age of the vegetation when *P. novaehollandiae* has been recorded ranges from 3 to 20 years (Table 3). The known fire history of the sites included fuel reduction burning and the major wildfire of 1983.

Six of the ten sites where *P. novaehollandiae* was recorded occur on the Alcoa Lease area and four were in the Flora and Fauna Reserve (Table 4). The Alcoa Lease covers an area of 7,350 ha (Fig. 1). It has been leased to Alcoa Australia Pty Ltd since 1961 for brown coal mining.

A range of possible threatening processes has been identified. Current proposals to clear land in the area for use in sewerage treatment could contribute to fragmentation of present populations. Inappropriate fuel reduction burning could threaten the survival of populations. Although the species prefers early stage successional vegetation, burning of extensive areas could eliminate populations and further fragment them. Recreation such as horse riding and trail bike riding occur within the habitat of the species. Resultant trampling and erosion causes damage to the vegetation. The presence of the Cinnamon Fungus (*Phytophthora cinnamomi*) has been recorded in the area. This plant pathogen devastates some vegetation communities and thus disturbs the habitat of animals. *P. novaehollandiae* populations may also be susceptible to predation by cats, dogs and foxes. The impact of predators on the species is unknown.

Discussion

The results of trapping studies over a ten year period show that *P. novaehollandiae* has a patchy distribution in the Eastern Otways. The present known distribution is restricted to an area of approximately 2,300 ha east of the Anglesea River. Prior to 1983 the distribution extended to the west of the river and covered an area of 3,000 ha. The populations recorded west of the river in 1981 (Kentish 1982) were eliminated by the wildfire in 1983. It is likely that the presence of the open-cut coal mine, begun in the late 1950s, contributed to fragmentation of the populations, and that the extensive 1983 wildfire was a stochastic disaster which led to the demise of this part of the distribution. The sites where the species has been located are flat to undulating, between 50 m and 100 m above sea level. They are restricted to two major land systems, Bald Hills and Gherang Gherang on soils derived from Tertiary sediments. The patchy nature of the distribution could be related to local soil variability. *Pseudomys novaehollandiae* inhabits burrows and Fox and Fox (1978, 1984) have shown that softer substrates and topsoil depth are important variables correlated with the biomass of the species.

The vegetation at sites where the species was recorded, consisted of low woodland to low open-forest with heathy understorey. In Victoria the species has been recorded in heathland, woodland and open-forest with heath understorey (Seebeck and Beste 1970; Braithwaite and Gullan 1978; Norris *et al.*1983; Opie 1983). It has also been recorded on primary sand dunes in sedgefield with a coastal shrub layer (Menkhorst 1990 *unpubl. data*). Analyses of the microhabitat use of *P. novaehollandiae* in the Eastern Otways have shown that it prefers two floristically rich vegetation groups (Wilson 1991). One group was dominated by understorey species such as *Epacris impressa, Hibbertia stricta, Acacia myrtifolia, Banksia marginata* and *Leptospermum continentale.* The dominant species in the second group were *Dillwynia glaberrima, Hypolaena fastigiata, Amperea xiphoclada and Empodisma minus.* Although structural factors were not important to overall preference, they did contribute to within group preference where the volume of the vegetation in the lower understorey was important (Wilson 1991). Thus floristic and structural requirements affect the patchy distribution.

The age of the vegetation where *P. novaehollandiae* was captured ranged from 3 to 20 years, most sites being of early successional age (3-4 years). The animals located at the 20 year old site were trapped in a patch of *L. continentale* left unburnt during the 1983 wildfire. Subsequently they moved out of this patch into the surrounding regenerating vegetation (Wilson 1991). Thus the species may survive in old patches, but probably only at very low densities. It is not clear what features of the early successional stage are important. A high floristic diversity may provide a variety of plants to produce seeds for this predominantly granivorous species (Watts and Braithwaite 1978; Cockburn 1980). Another factor worthy of investigation is the productivity of the vegetation. Early successional vegetation may have greater seed production compared to ageing vegetation. The importance of these changes are presently being determined.

The physical and biological data obtained can now be analysed more intensively. The aim will be to produce a predictive model which provides a better definition of the major factors determining the presence and abundance of *P. novaehollandiae* in the area. This can then be used to determine potential habitat more accurately. This data would be valuable to locate further populations and identify potential habitat into which animals may migrate.

The patchy distribution of the species indicates that populations may be spatially associated in a metapopulation. There is a need to determine how a metapopulation structure may contribute to the viability of the species in the Eastern Otways. Preliminary work has been carried out on a population viability analysis (PVA) which may assist in answering such problems (Wilson and Myroniuk 1992). There is evidence that the species has become extinct in recent times (20 years) in reserves east of Melbourne e.g. Tyabb, and Langwarrin reserves (Wilson 1992, 1993). These reserves are small in area (20 and 214 ha respectively) indicating that area may have been a contributing factor to the demise of the species. Attention should be focussed on the populations in the Eastern Otways, where the area of potential habitat is much greater. Isolated populations should be joined so they can act as a metapopulation, and migration and gene flow are enhanced.

Since six of the sites where *P. novaehollandiae* was recorded are located in the Alcoa Lease and four in the adjacent Flora Reserve (Fig. 1), the total area comprising 2,300 ha at present represents critical habitat for *P. novaehollandiae.* It should be managed with care and threatening processes should be addressed. Land

Table 3. General description of sites where *P. novaehollandiae* was captured. The numbers under the locations refer to trapping sites.

Location, Altitude	Topography, Geology, Soils	Vegetation structure (Specht 1981) Dominant species	Fire history Age
Coalmine Rd (1)s9 2km inland 75m	Hillside, well drained. Soils derived from Demon's Bluff, Eastern View formations. Sandy, loam	Low woodland *E. baxteri, E. radiata* (7m), *L. continentale, L. myrsinoides, A. myrtifolia, A. suaveolens, B. marginata, P. obtusangulum*	wildfire 1969 13 years
Coalmine Rd (1)s8 2km inland 50m	Lower hillside, depression Soils derived from Demon's Bluff, Eastern View formations. Sandy, loam	Low woodland, scrub *E. radiata* (7m), *L. continentale, L. myrsinoides, E. impressa, A. suaveolens, B. marginata,*	wildfire 1969 13 years
Forest Rd (05) 5 km inland 100m	Flat to undulating. Soils derived from Demon's Bluff formation. Sandy gravel, loam,clayey quartz	Low open-forest, scrub *E. obliqua, E. willisii* (7-11m), *E. impressa, A. pycnantha, A. myrtifolia, L. continentale, L. myrsinoides, G. radula Lepidosperma semiteres*	old patch 20 years
Forest Rd (1b) 5 km inland 100m	Flat. Soils derived from Demon's Bluff. Sandy gravel,loam, clayey quartz	Low open-forest *E. obliqua, E. willisii* (13m), *L. continentale, L. myrsinoides, Poa spp. P. obtusangulum, A. myrtifolia, G. radula*	wildfire 1983 4 years
Pipeline Tk (1) 4km inland 70 m	Undulating. Soils derived from Demon's Bluff, Eastern View Clayey silt to fine sand	Woodland, scrub *E. obliqua, E. willisii* (7m), *X. australis, P. esculentum, G. radula, L. continentale, L. myrsinoides, L. semiteres, E. impressa, B. marginata, D. glaberrima*	wildfire 1983 4 years
Pipeline Tk (2) 4km inland 70 m	Undulating Soils derived from Demon's Bluff, Eastern View Clayey silt to fine sand	Woodland, scrub *E. obliqua, E. willisii* (7m), *X. australis, P. esculentum, G. radula, L. continentale, L. myrsinoides, L. semiteres, E. impressa, B. marginata, D. glaberrima*	wildfire 1983 4 years
Harrisons Tk. 6km inland 50m	Hillside Loamy coarse sand	Low woodland, scrub *E. obliqua, E. willisii* (7m), *L. myrsinoides, E impressa, H. fastigiata, D. sericea*	wildfire 1983 9 years
Flora Res 2 6 km inland 100m	Flat. Soils from Demon's Bluff. Loamy, sand.	Old pine plantation *P. radiata, A. myrtifolia, A. serrulata, G. radula, H. stricta, P. obtusangulum.*	wildfire 1983 frb 1989 3-4 years
Flora Res 3 6 km inland 100m	Flat. Soils from Demon's Bluff. Loamy, sand.	Low open-forest *E. obliqua, A. myrtifolia, A. serrulata, B. marginata, G. ecostatum, L. virgatus*	wildfire 1983 frb 1989 3-4 years
Flora Res 8 6 km inland 90m	Flat. Soils from Demon's Bluff. Loamy, sand.	Low open-forest *E. obliqua, A. myrtifolia, A. serrulata, B. marginata, G. ecostatum, L. virgatus*	wildfire 1983 frb 1989 3-4 years

clearance and recreation such as trail bike and horse riding which modify and fragment habitats further should be eliminated. The distribution of *P. cinnamomi* should be determined because it has been found to affect the density and diversity of small mammals (Wilson *et al.* 1990; Newell and Wilson 1993), but the

Table 4. Land tenure of trapping sites and localities of *P. novaehollandiae.*

Land Tenure Units

	Alcoa Lease	Angahook State Park	Coastal Reserve	Flora Reserve	International Harvester	Roadside Reserve
Total number of sites	45	22	6	11	2	10
Number of sites for *P. novaehollandiae*	6	0	0	4	0	0

effect on *P. novaehollandiae* and its habitat, however, has not been determined. The effect of introduced predators such as foxes, cats and dogs should also be investigated.

Fire regimes need careful investigation and design, as large extensive fires could wipe out the fragmented populations. Judicious use of small patch burning may be the only way to create suitable patches of preferred early successional habitat and increase its area. An understanding of the spatial structure of populations is required to enable the appropriate patch sizes and distances between them to be determined.

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Field Observations of the Behaviour of Free-ranging Eastern Barred Bandicoots, *Perameles gunnii*, at Hamilton, Victoria.

Anthony C. Dufty*

Abstract

A total of 23 individual and 10 social behavioural acts were observed in a free-ranging population of Eastern Barred Bandicoots at Hamilton. Individual behaviour involved acts relating to body posture during feeding, grooming and investigation. Mating behaviour was promiscuous. Copulations between individuals were rapid and repeated intermittently for up to 45 minutes. Intromissions occurred when the female carried advanced pouch young. Many males gathered and mated with females during their receptive period. Males used olfaction in the location and pursuit of receptive females. Mutual avoidance behaviour was often maintained between bandicoots although several antagonistic interactions were observed. These interactions usually resulted in the flight of the subordinate after strike, chase and/or threat vocalisation occurred.

Introduction

Although relatively widespread in Tasmania, Eastern Barred Bandicoots, *Perameles gunnii* are critically endangered on mainland Australia (Seebeck, *et al* 1990; Dufty 1991a). The remnant free-ranging mainland population persists at Hamilton, Victoria (Moon 1984; Brown 1989) and as a safeguard against extinction, the species has been reintroduced to several locations on the volcanic plains (Seebeck 1990).

Little information regarding individual and social behaviour of the species on mainland Australia has been published. Coulson (1990) reviewed several behavioural studies in Tasmania and Victoria and concluded that there was an urgent need for detailed information. Fagen and Goldman (1977) demonstrated that the recording of unique behavioural acts often increase considerably with increased time devoted to observation of behaviour. Thus, less frequently-exhibited behaviours may not be observed without considerable effort, and it is likely that the complete behavioural repertoire of *P. gunnii* is yet to be revealed. Heinsohn (1966) in Tasmania, and Brown (1989) and Dufty (1991a) in Victoria have commented briefly on observed individual and social behaviours of *P. gunnii* but the only systematic research so far reported is that of Moloney (1982) and Clunie (1987) who undertook 165 and 65 hours of observation respectively on captive bandicoots in Tasmania.

This paper reports on field observations at Hamilton and assists in the compilation of a behavioural reportoire for free-ranging Eastern Barred Bandicoots, *Perameles gunnii.* Also, the paper discussed the implications of *P. gunnii* behaviour to the management of both the free-ranging and captive populations in Victoria.

Methods

Observations of individual and social behaviour were undertaken during monthly spotlighting sessions within the City of Hamilton, Victoria (37°45' S, 142°02' E. A 100 Watt quartz-halogen spotlight powered by a 12 Volt gel type battery was used at night to observe bandicoot behaviour. A total of 42 spotlight hours was logged between 5 July 1989 and 30 September 1990. A raised area of ground that overlooked optimal bandicoot nesting and foraging habitat at the Hamilton Municipal Tip was used to initiate observations of individual and social behavior. Observations were conducted immediately after dusk and were confined to one individual until it moved out of sight (usually between 2-3 hours). Bandicoots appeared to be unperturbed by the spotlight and the observers' presence.

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That is, no escape behaviour that could have been attributed to the observers' presence and no erratic or unusual behaviour (excessive grooming or sniffing of the air) was observed. Information on behavioural acts observed and general notes on the frequency of these acts was recorded. Other information recorded (if possible) during encounters included: individual identification, sex, age class and reproductive state (presence/absence of pouch young or young at foot).

Results

Individual behaviour

A total of 23 distinct individual behavioural acts was observed. They are listed in Table 1, and described using the terminology of Moloney (1982) and Clunie (1987) as reviewed by Coulson (1990). Three behaviours ('bipedal stance', 'prancing' and 'climbing') which were recorded by Moloney (1982) and Clunie (1987) were not observed during this study.

Foraging areas at the Hamilton Municipal Tip were associated with hard shelter and located in a patch arrangement. Travelling within open areas between foraging patches occurred rapidly, and foraging was observed only when individuals were within 30m of shelter. Foraging ('dig', 'feed') was maintained for between 5 and 25 minutes in a single foraging patch before the bandicoot's 'run' to the next patch. Bandicoots appeared to search for food in a random movement, although two individuals were observed following fencelines for 25 and 17 minutes respectively. Nosing the ground with a lateral movement of the snout and loud snuffling noises preceeded all observed 'dig' behaviour. Digging was similar between all individuals and involved thrusting the foreclaws into a very localised area of the ground quickly and alternately and withdrawing them upwards and backwards. During digging, the hindquarters were raised, the back arched and the snout pointed downwards towards the excavation. No attempt was made to remove soil which collected under the body during digging. The snout probed the hole periodically and a sniffing or snuffling noise was audible. When the food item was secured, the individual fed immediately, while adopting a quadrupedal or sitting stance. A high foraging success was observed and often bandicoots would probe and sniff foraging holes that had been dug on other nights, sometimes enlarging these excavations. The excavations made during bandicoot foraging are conical pits, up to 80 mm deep. It is possible that they trap small invertebrates as Mr N. Gunn *(pers. comm.,* 1989) has observed bandicoots

Table 1. Individual behavioural acts observed in free-ranging Eastern Barred Bandicoots at Hamilton.

Act	Description
Quadrupedal	Manus and pes both resting on substrate, body raised and head slightly lower than parallel to body.
Tripedal	As above, but one forepaw retracted to body
Crouch	Complete manus and pes resting on substrate, back arched, head raised and forequarters lowered.
Huddle	As for crouch, but hindquarters relaxed and head lowered to substrate and manus sometimes tilted to one side.
Rear	Hindlimbs in contact with substrate, head vertically extended.
Sit	As for rear but head not extended
Walk	Slow quadrupedal locomotion, cursorial motion of pectoral girdle while saltatorial motion of pelvic girdle.
Run	Faster quadrupedal locomotion
Gallop	Rapid locomotion, wherein forelegs are retracted to body while hindlegs exhibit powerful simultaneous thrusts.
Leap	Vertical spring (up to 1 m), using sudden extension of hindlegs.
Honk	Loud grunt, repeated up to 5 times.
Nose	Lateral movement of snout across the substrate with audible sniff.
Dig	Excavating substrate with forelimbs and inserting snout in hole.
Feed	Ingesting food; large items (e.g. nectarines) held on substrate while smaller items. (e.g. insects) are manipulated while sitting
Manipulate	Clasping and rotating items (generally food) with forepaws.
Push	Hindlegs and tail in contact with substrate, forelimps brought down and away from body during extension.
Scrape	Pulling nesting materials backwards with forepaws.
Scratch	Raking movements of hindfeet to groom fur (especially head and neck).
Wipe	Rubbing the snout with licked forepaws.
Lick	Licking and chewing fur on body (except head and neck).
Shake	Vigorous shaking of body, sometimes while in motion.
Stretch	Forepaws extended under head, body elongated, accompanied by yawning.
Rest	Lying on side in loose coil.

searching and removing invertebrates from foraging holes dug previously.

Occasionally during foraging a bandicoot was observed to 'rear' in an upright stance while smelling the air. When unusual stimuli were encountered, a 'tripedal' or 'crouch' stance was adopted, often followed by a rapid 'gallop' or 'sprint', On three occasions after these responses, the bandicoot was observed to 'leap' up to 1 m into the air and then 'run' away in the direction it faced upon landing. The direction appeared to be random as all three bandicoots turned in a wide arc of up to 180 degrees, passed cover and returned to shelter, close to where they were originally.

Drinking was observed only once. The bandicoot spent four minutes lapping water that had collected in a fold of plastic, with a forward and upward motion of the tongue.

Nest construction behaviour was observed once. Dead grass within 1.5 m of the nest site was scraped from the ground around perennial tussocks and dragged or pulled backwards into an upturned galvanised iron roof gutter by the forelegs (for descriptions of nests see Dufty 1991a).

Four bandicoots were observed emerging from diurnal nests. Movement within the nest increased during the 15 minutes prior to emergence. Immediately after emergence, bandicoots were observed to 'shake' before they ran or walked to nearby foraging areas. Grooming ('scratch', 'wipe', 'lick') behaviour was most often observed after nest emergence when the individual was away from the nest within a foraging area. Upon retiring to the nest after nocturnal foraging, bandicoots were observed to move nest materials (grass and small sticks) across the nest entrance with their snouts.

Social behaviour

Mutual avoidance behaviour predominated throughout the observation periods but on four occasions social interactions were observed. Social behaviour acts are summarised in Table 2.

Aggression ('chasing' and 'striking') was observed on three occasions. During one interaction, the pair of bandicoots faced each other in the 'arched' stance with their mouths agape revealing their incisor, canine and premolar teeth. Eye contact was maintained between bandicoots and after about two minutes in this posture. The subordinate then slowly turned to move away and the aggressor was observed 'striking' the subordinate on its hindquarters. The subordinate fled 'honking' with the aggressor in 'chase'. On another occasion a 'chase' had entered the area where a third bandicoot (male) was being observed. The 'chase' passed the third bandicoot within 4 m and he responded by pursuing the pair for a distance of about 20 m. The male then returned and continued foraging. The third occasion where aggression was observed occurred when an aggressor entered a foraging patch occupied by a subordinate. The aggressor foraged about 15 m away from the subordinate for about 30 minutes, apparently unaware of the subordinate's presence. However, on moving downwind of the subordinate and sensing its presence (indicated by sniffing the air in a reared stance), the aggressor 'chased' the subordinate, causing the subordinate to 'spit' and run for shelter. The aggressor stopped the 'chase' in the area where the subordinate was foraging and continued to forage in that area.

Table 2. Social behavioural acts observed in free-ranging Eastern Barred Bandicoots at Hamilton.
(*observed by Mr K. Drinkell or Mr N. Gunn).

Act	Description
*Perineal	Nosing perineal area of conspecific.
*Follow	Persistent following of female by male.
*Mount	Male rears on hindlimbs and inclines body forward over female.
*Thrust	Pelvic thrusting during mounting.
*Bite	Male bites female.
Arched	As for quadrupedal but head slightly lowered and back arched.
Striking	Striking conspecific on the back with forepaws.
Chase	Chasing retreating subordinate.
Honk	Honking vocalisation given by the retreating subordinate.
Spit	Spitting vocalisation given by the retreating subordinate.

Not all interactions were aggressive: on one occasion three bandicoots were observed foraging within about 10 m of each other for about 20 minutes. During this observation foraging was the principal activity and no overt social interaction (mating, vocalisation, or chase) was observed even when two bandicoots moved to within 2 m of each other. Unfortunately, the sex of only one of the bandicoots (a female with advanced pouch young) was determined and the group gradually dispersed in different directions.

Two local residents at Hamilton (Mr Ken Drinkell and Mr Noel Gunn) have recorded mating behaviour on several occasions. Their descriptions are reported below.

Mr Drinkell has lived adjacent to the Hamilton Municipal Tip for many years and has recorded information on breeding activity since 1988. Two individual females were resident on his property during the study, individuals numbered R41 and L8 R7. Female R41 was first marked on 7 May 1988, south of the Hamilton Municipal Tip when she was about four months old, while L8 R7 was first marked on 6 February 1990 on Mr Drinkell's property when she was also four months old. R41 was first trapped on Mr Drinkell's property (about 400 m from where she was first marked) on 13 September 1988 and was regularly observed there subsequently. R 41 was observed mating with males about every 9 weeks and was the only breeding female to be observed on his property until March 1990, when female L8 R7 was observed mating.

Although many males gathered during the female's receptive period, little aggression appeared to occur between them and avoidance behaviour was maintained. No spatial organisation (e.g. lek) or obvious dominance hierarchy was apparent. Males spent much of their time searching for the females in rapid, erratic movements. These male movements increased when more males were present. When a male picked up the scent of a female, the movements of the female were replicated exactly and males were observed bumping into objects placed by Mr Drinkell on the female scent path. Up to ten males were observed to copulate with a female, three or four times each. Copulation lasted about 20-30 seconds and was repeated every few minutes for more than an hour. During one period, R41 was observed mating with male L8 R53 four times and male L61 R8 six times as well as with other males whose identity was unknown. After mating with one male, the female was observed to move away while the male was foraging and sometimes mated shortly afterwards with another male.

Mr Gunn has maintained a captive breeding pair of bandicoots on his property outside Hamilton since 1984. The bandicoots are maintained within 20 m^2 enclosures and given supplementary food every second night. This has provided Mr Gunn with the opportunity for casual observations of captive bandicoot behaviour. During or before supplementary feeding, Mr Gunn has recorded *P. gunnii* mating activity on four occasions (9 July 1988 for 15 minutes, 4 October 1989 for 45 minutes, 29 July 1990 for 17 minutes, 25 September 1990 for 20 minutes).

All observations of mating were made during late afternoon, before sunset and either during or after light rain. Copulation was initiated by the male checking the female by a 'bite' to the loose skin on her hindquarters. As the male 'mounted', the female lowered her forequarters and raised her hindquarters. On three of the mating occasions, the female was carrying advanced pouch young and during the fourth the dependent juveniles jumped around the copulating pair. Copulation involved rapid 'thrusts' and lasted between 5 and 30 seconds. As copulation progressed, the mail curled his tail under his body from an initial lateral position. Between copulation events, the male was observed to 'follow' the female's scent closely and he was often observed foraging within 1 m of her (the pair usually avoided each other during non-mating periods). The male was often observed to smell the perineal region of the female prior to copulation. Intermissions between copulations usually lasted between 5 and 40 seconds and on 29 July 1990, copulation was observed to take place 17 times in 17 minutes.

Discussion

During this study and others (Heinsohn 1966; Duffy 1991a) bandicoots spent much of their time foraging and feeding, suggesting that dietary items sought are either low in energy or are hard to find. The high success at securing subterranean morsels observed during this study and the depth of foraging holes (up to 80 mm), suggest that bandicoots possess well developed olfaction. The dependence on olfaction to detect food resources has previously been reported by Heinsohn (1966), Moloney (1982) and Quin (1985) in Tasmania, and Dufty (1991a) in Victoria. The observation that bandicoots utilise fencelines during foraging may be due to the lack of structural complexity at Hamilton, although the higher floristic diversity and lower compaction of these areas may also be important. The lack of extensive fat deposits (Lenghaus *et al.* 1990), aggressive defence of foraging patches and rare aggregations of bandicoots suggest that food resources at Hamilton are limited.

Aggressive defence of foraging resources appeared to be the most common social behaviour exhibited during this study. Dominant individuals were observed chasing subordinates from and temporally occupying foraging areas. Heinsohn (1966) suggested that a dominance hierarchy was present and that smaller bandicoots were chased from key foraging patches. At most other times during the study, bandicoots exhibited strict avoidance behaviour and are regarded by Stodart (1977) and Russell (1984) as solitary. Although it was not clear what mechanism operates to maintain the dominance hierarchy, Russell (1985) argued that bandicoot olfaction may have a primary role. Male and female bandicoots possess a sub-auricular gland which exudes a pungent odour (Stoddart 1980) and it is likely that this odour is central to social interactions. Stoddart (1980) speculated that the odour has a calming effect which facilitates mating, while it may also be integral to the maintenance of dominance hierarchy.

Mating acts in Victoria described here by Mr Drinkell and Mr Gunn were similar to those described by Heinsohn (1966) in Tasmania. Heinsohn (1966) observed mating behaviour once in captivity and twice between free-ranging individuals. One striking difference was the high competition for receptive females at Hamilton. Drinkell reported that small aggregations of bandicoots occurred during the female's receptive period and that several males mated with the female.

Principally, the conservation of *Perameles gunnii* in Victoria has involved the establishment of three reintroduction and two captive breeding colonies (Seebeck 1990; Dufty 1991b). The artificial nature of captive breeding may alter the individual and social behaviours observed in free-ranging population and compromise the long-term viability of *P. gunnii.* To avoid this, three strategies were integral to the *P. gunnii* captive breeding programme: avoid domestication (either through human association or selective breeding for individuals that are easy to manage in captivity); minimize antogonistic interactions between colony members, and mimic the free-ranging populations' mating strategy.

Domestication of *P. gunnii* may reduce the species' ability to survive in a natural environment (e.g. forage for food, avoid predators or attract mates). To lessen the effects of domestication, individuals were seldom handled, encouraged to forage and feed without supplementation and after reintroduction, were allowed to select mates without imposition. Antagonism between captive colony residents may cause injuries, increase stress levels and lower reproductive output. To minimise antogonistic interactions, only one male resided in each breeding pen, low densities of individuals were maintained, juveniles were removed as soon as they became independent, food was supplemented when needed, and shelter was provided for fleeing subordinates. Despite a promiscuous mating system prevailing in the free-ranging population, *P. gunnii* were initially bred in pairs to maximise outbreeding and conserve low density alleles. However, individuals were promiscuous in the reintroducted populations that were large, less influenced by genetic stoichasticity, and regulated by naturally selection.

The successful management of *Perameles gunnii* captive breeding and reintroduction in Victoria has been due, in part, to the resolution of many problems that were associated with captivity and the species' individual and social behaviour. The application of behavioural information has aided the conservation of Eastern Barred Bandicoots in Victoria and should be seen as an important component of all wildlife management programmes.

Acknowledgements

I wish to thank Mr Noel Gunn and Mr Ken Drinkell for their many informative discussions regarding bandicoot breeding behaviour and allowing me to use their data in the manuscript. The manuscript was critically reviewd by Mr J.H. Seebeck and Mr G. Coulson.

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The Spotted Tree Frog *Litoria spenceri:* an Addition to the Amphibian Fauna of the Australian Capital Territory

W.S. Osborne*, G.R. Gillespie** and K. Kukolic*

The Spotted Tree Frog (*Litoria spenceri*) has a limited distribution, confined predominantly to the north-west slopes of the Great Dividing Range, between the Central Highlands in Victoria and the Mount Kosciusko region in New South Wales (Watson *et al.* 1991; Gillespie 1992, 1993). Within this area the species historically was known from only 11 streams in Victoria and one in New South Wales (Watson *et al.* 1991). During the 1980's concerns were raised that *L. spenceri* had suffered a considerable population decline. Watson *et al.* (1991) were only able to locate the species at two sites from which it had previously been recorded. Recent extensive surveys for *L. spenceri* throughout its known geographic range have located the species along 13 streams in Victoria (Fig. 1); (Gillespie 1992, 1993, *unpubl. data*). Despite repeated searches by Watson *et al.* 1991) and Gillespie (1992, 1993) the species has not been found along four of the streams from which it was historically recorded. Furthermore, several of the remaining populations appear to have declined in distribution and abundance. There is now considerable concern about its continued survival at many sites and as a consequence it has been listed as a nationally endangered species (ANZECC 1991). Reasons for the decline of *L. spenceri* are unclear, although human disturbances to streams or catchments have been implicated (Watson *et al.* 1991; Gillespie 1993). In this paper we report the occurrence of *L. spenceri* within the Australian Capital Territory, well outside its previously known range.

Spotted Tree Frogs are associated with rivers and large streams at a number of widely separated locations in the eastern highlands of Victoria (Watson *et al.* 1991; Gillespie 1992). There is a single reported occurrence in New South Wales at Bogong Creek in Kosciusko National Park where a specimen was collected in 1975 (H. Cogger *pers. comm.*; see Cogger 1992 for a colour photograph of this specimen). Although the species appears to have disappeared from the collection site (G. Gillespie and W. Osborne *unpubl. data*), a large population was found recently by Ehmann *et al.* (1992) some kilometres upstream on the same river.

Bogong Creek occurs in a particularly moist part of Kosciusko National Park and the capture site has a mean annual precipitation predicted to be about 1900 mm (Adomeit *et al.* 1987). By contrast, mean annual precipitation in the Brindabella and Bimberi Ranges in the A.C.T. reaches a maximum of about 1300 mm.

It was thought that there was little likelihood of *L. spenceri* occurring as far north as the A.C.T., which is ap-

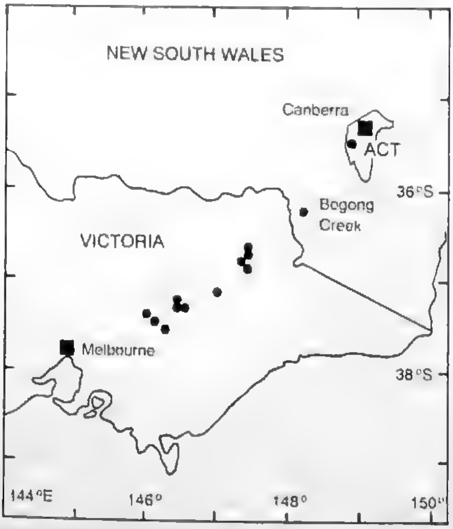

Fig. 1. The current distribution of the Spotted Tree Frog (*Litoria spenceri*). Closed circles indicate locations where the species still occurs (after Gillespie 1992 and Ehmann *et al.* 1992).

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proximately 100 km north of Bogong Creek, until a photograph of the species (Fig. 2) was found in the slide collection of the ACT Parks and Conservation Service. The specimen had been collected by one of us (KK) in daylight on 1 October 1975 on an exposed pebble bank of the Cotter River at the upstream end of Bendora Dam (Fig. 1) at 780 m. At the time information on the different colour morphs of *L. spenceri* was not available and it was tentatively identified as *L. phyllochroa* before preservation. Recently the specimen (now in the Australian National Wildlife Collection; A1925) and photographs were examined by several herpetologists familiar with *L. spenceri* and there was agreement that the specimen was *L. spenceri* (G. Gillespie, J-M Hero and P. Robertson *pers. comm.).*

The specimen collected from the Cotter River has lost all colour and the following description is based on the field notes of KK and subsequent examination of the specimen and colour slides. In life the specimen weighed 1.9 g and had a snout-vent length of 28.2 mm. The preserved specimen has the following measurements (mm): snout-vent length 29.3, hind limb length 41.2 (L), tibia length 14.3 (R), head width 11.0, inter-narial distance 2.58, eye - naris 2.58 (R), and eye length 3.05 (R). The snout is relatively short, slightly pointed when viewed from above and truncated in profile. The nares are obvious and located dorso-laterally close to the end of the snout. The eye is large and prominent and the tympanum is indistinct.

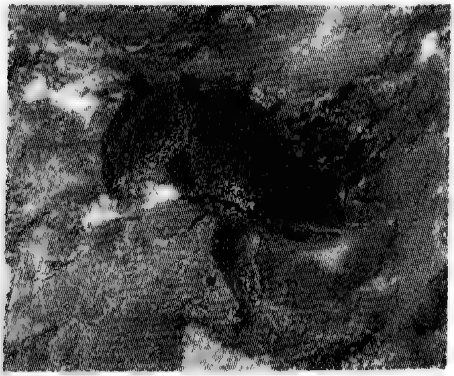

Fig. 2. Adult male Spotted Tree Frog *(L.spenceri)* collected from the Cotter River upstream of Bendora River in the ACT in 1975 (see text for further details). Photograph C.A. Sherwood.

In life the dorsum is dark olive-green with raised brown warts and brown mottling. A narrow dark-coloured stripe, bordered above by a pale-brown zone, runs from the nares to the centre of the eye, then continues beyond the eye and broadens slightly before extending along the flanks where it breaks into a series of dark blotches on the lower flanks. A large pale green zone occurs on either side of the head below the eye and nostril and extending to the line of the jaw. The limbs are mottled in green and brown and the posterior surface of the thighs are brown becoming slightly yellow behind the tibia. The toes are fully webbed whereas the fingers only show basal webbing. The ventral surface including the throat is white and the specimen appears to have slightly enlarged nuptial pads indicating that it is a male.

On 24 April 1993 we carried out a preliminary survey of the site on the Cotter River where the ACT specimen was collected (Fig. 3). The original capture site (Site 1, 780 m altitude) was examined and notes made of the river phenology and of the riparian vegetation and adjacent hillside vegetation. The river bed at this point is 15-20 m wide and has been subject to frequent innundation by the backed-up waters of Bendora Reservoir and is now highly disturbed. The underlying geology consists of Ordivician shales which outcrop as low cliffs and occasional rocky bars near the river. The river has a pebble (cobble) bottom, with intermittent exposed pebble banks and riffles. There is a narrow river terrace which abuts the steep, high slopes of the Tidbinbilla Range (highest point 1615 m) to the east and the Brindabella Range (1640 m) to the west. The terrace and adjacent slopes support an open-forest of *Eucalyptus radiata* and *E. dalrympleana* with a shrubby understorey. The riparian vegetation near the original capture site is still intact and consists of tall dense *Leptospermum* *lanigerum* scrub which also includes *Acacia pravissima, A. melanoxylon, Pomaderris aspera, Kunzea ericoides, Grevillea victoriae* and *Lomatia myricoides.* The river banks appear to be completely free of blackberries upstream of the reservoir.

An intensive search was made of all exposed gravel, rock shingle and boulder cobble for a distance of 1.3 km upstream of the site. At the start of the search the air temperature was 20.1°C and water edge temperature was 12.7°C. Approximately 513 m of stream-edge shingle and pebbles was searched along the edge of the stream using the method described by Gillespie (1992). Five juvenile *Litoria lesueurii* were found at the 1975 collection site (Site 1), but no other species were recorded. However, metamorphs of *L. spenceri* were found at two sites further upstream, both associated with exposed rock shingle adjacent to large shallow pools in the river. Fifteen specimens were found at the first site (Site 2, 780 m), which was approximately 120 m upstream from the 1975 collection site, and a single metamorph was found 600 m further upstream (Site 3, 790 m).

Site 2 consisted of a narrow 20 m long pebble shingle bed which was almost flooded and had flowing water on one side and a still pool attached to the main stream at both ends of the bed. The pebble substrate included rocks of both sedimentary and volcanic origin. Much of the pebble bed was free of vegetation although there were several large *Carex* sp. and *Scirpus polystachus* tussocks and patches of *Gratiola peruviana*. The *L. spenceri* metamorphs were found beneath small flat pebbles which generally were smaller than a hand span in size. The frogs all had completely resorbed tails, weighed between 0.3 and 0.4 g and ranged in snout-urostyle length from 13.3 to 16.6 mm (mean = 14.9). A single adult *L. lesueurii* also was collected. The riparian shrub vegetation and forest type was similar to that described at the original capture site above. The herb layer at the river edge was well-developed and included the following species; *Blechnum penna-marina, Adiantum aethiopicum, Blechnum cartilagineum, Rubus parvifolius, Hydrocotyle laxiflora, Stellaria pungens, Acaena novae-zelandiae, Senecio* sp., *Carex appressa* and *Luzula* sp.

Site 3 consisted of a long (40 m) partially vegetated pebble bank. The specimen was found near the edge of the stream beneath a small stone in an area consisting of an expanse of exposed pebbles. Several *Gratiola peruviana* clumps occurred within a metre of the capture site. The riparian vegetation was not as dense at this point and consisted of tall shrubs of *A. pravissima, L. lanigerum, L. myricoides Cassinia aculeata, K. ericoides* and *P. aspera*, with *Pteridium esculentum* and *Rubus parvifolius* providing thick ground cover. The single metamorph captured weighed 0.3 g and was 14.9 mm in SUL. A recently metamorphosed *Litoria lesueuri* also was found at this site.

The sixteen metamorphs which resembled *L. spenceri* had brown dorsal surfaces (some were darker than others) with scattered raised warts. Paler specimens also had numerous dark flecks on the dorsum. All specimens had a faint darker stripe on the side of the head running from the nares to the eye and then from behind the eyes to the flanks. This stripe had a faint pale upper edge. The ventral surface of the metamorphs was speckled with grey and dark brown, with a yellowish tinge beneath the thighs. Because of the difficulty of identifying juvenile frogs, four metamorphs were retained and are being raised in order to check adult appearance, the other individuals were released at the time of capture.

A search also was made at three locations on the river downstream of Bendora Reservoir on 25 April 1993. The sites were located at distances of 3.2, 5.7, and 12.2 km downstream of the reservoir wall. The lengths of river-edge pebbles searched consecutively at each site were 210 m, 300 m and 270 m. No *L. spenceri* were found, although a total of six juvenile *L.*

lesueurii were collected. The river bed at each of these sites appeared to be suitable for *L. spenceri* although it was obvious that stream flow was considerably reduced and there was a fine matrix of silt and sand amongst the gravel and pebbles that reduced the amount of loosely-piled shingle.

The river upstream of Corin Dam appears to be unsuitable for *L. spenceri*. The valley floor is broad and the river is narrower and has extensive areas without exposed river stones. The surrounding vegetation includes *Eucalyptus pauciflora, E. stellulata* and *E. dalrympleana* woodland and forest dominated by subalpine and high-montane species (Helman *et al.* 1988). The length of river between Corin Reservoir and Bendora Reservoir is 14.5 km, and this section of river passes through a deeply dissected montane tract similar to that near the two capture sites. Most of the populations remaining in Victoria occur in similar steeply dissected mountainous country. It is possible, therefore, that this is the only area still supporting *L. spenceri* in the A.C.T. Although the river along this section is remote, without road access and is relatively weed free, the presence of Corin Reservoir upstream of the *L. spenceri* site is likely to have influenced the species. The reservoirs are managed by A.C.T. Electricity and Water (ACTEW) and the bed of the Cotter River provides the means for moving water between the two reservoirs. It is possible that sudden releases of water downstream of Corin Reservoir may impact on *L. spenceri* along this length of river.

The montane and subalpine ranges reach their northern limit in the Brindabella Range and it is therefore likely that the northern-most populations of *L. spenceri* are represented in this area. It remains to be seen if this population is disjunct from the Bogong Creek population or whether other streams in between the two locations also support the species. A recent bioclimatic analysis using BIOCLIM (G. Gillespie *unpubl. data*) indicates that there is considerable potential for the species to occur along suitable rivers on the western side of the Brindabella Range and Kosciusko National Park. Further surveys are required to assess the status of the ACT population of *L. spenceri* and to consider potential impacts on the species in this region.

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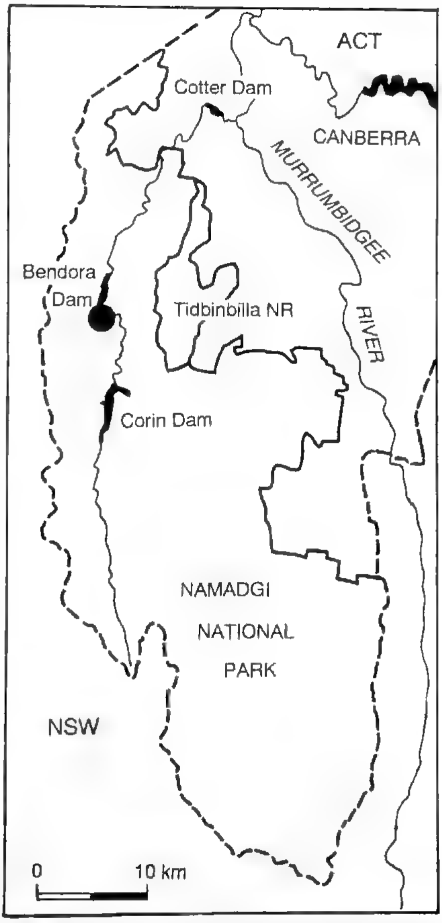

Fig. 3. Location of the Spotted Tree Frog (*L.spenceri*) capture site in the ACT. The closed circle encloses Sites 1, 2 and 3 (see text).

providing accommodation at Bendora Dam, and the Department of Conservation and Natural Resources, Orbost District, for providing assistance with transport to GG.

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Shallow Water Hydroids from Eastern Bass Strait

Jeanette E. Watson*

Introduction

Previous records of hydroids from Bass Strait east of Wilsons Promontory include four species collected by the *Challenger* Expedition (1873-76) from a depth of 70 m off Moncoeur Island (Allman 1888) and four species from the *Endeavour* trawlings in 146-546 m on the eastern slope (Bale 1915). Five species from a depth of 82 m, described by Busk (1852) from the voyage of the *Rattlesnake*, may have been dredged in Banks Strait, off the north-eastern coast of Tasmania.

Until 1915, only three species *Sertularia unguiculata* (Busk 1852), *Stereotheca elongata* (Lamouroux 1816) and *Amphisbetia operculata* (Linnaeus 1758) were recorded from depths of less than 60 m in eastern Bass Strait, the first two from Banks Strait (Busk 1852), *S. unguiculata* from Sealers Cove on the eastern side of Wilsons Promontory (Bale 1884) and *A. operculata* from near Devonport (Bale 1915). The few eastern Victorian shallow water records from previous Australian researchers (e.g. Bale, Spencer, Bartlett, Mulder and Trebilcock) probably reflects the inaccessibility of much of this part of the coastline to earlier workers.

This paper lists hydroids recorded to depths of 60 m in eastern Bass Strait. Most of the material was collected by the author, using SCUBA. The list includes collections from the Kent Group (1974 and 1993) (KGI), from shallow reefs off the Ninety Mile Beach (Woodside Beach to Delray Beach, 1977-1992) (NMB), from Gabo Island, Iron Prince reef and Mallacoota in the east (1973-1975) (GBI), from the Halibut and Marlin oil production platforms in central eastern Bass Strait (1974) (HMP), from the Seal Islands Group and the Nooramunga Reserve near Wilsons Promontory (1983-1992) (NOR) and near Flinders Island (FLI). Localities are shown in Fig. 1.

The list includes 9 species of athecate hydroids and 73 species of thecate hydroids. No doubtful or undescribed species are listed nor has any taxonomic revision been attempted in this paper. Species are listed with locality, depth range of collection and substrate notes where available. These provide an indication of the bathymetric range and habitat preferences of each species.

Ecological notes

While all but one of the records are from the sublittoral zone, some of the epiphytic species listed may be expected to also occur on algae in tide pools on rocky shores in far eastern Victoria. The list gives no indication of the abundance or rarity of species; for example, the very small species, *Calamphora parvula* recorded for the first time from Bass Strait since its original description (Allman 1888), is rare, whereas the large plumose species, *Aglaopohenia divaricata,* is very common on coastal reefs.

Some species, for example *Obelia geniculata, Silicularia rosea, Orthopyxis caliculata* and *Aglaophenia setaceoides*

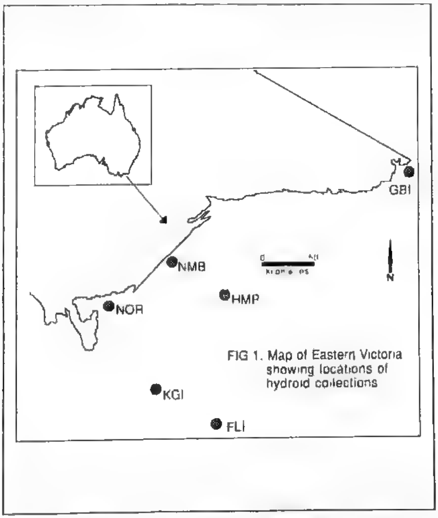

Fig. 1. Map of eastern Victorian showing locations of hydroid collections.

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are epiphytes on brown algae, the most important associations being with *Phyllospora comosa, Ecklonia radiata* and *Sargassum* spp. Other species such as *Aglaophenia plumosa, Halecium delicatulum* and *Halopteris campanula* are epizooites on other invertebrates including bryozoans, many species of sponges and the solitary ascidians *Herdmania momus* (Savigny), *Pyura australis* (Quoy and Gaimard) and *Pyura stolonifera* (Heller). Larger forms including *Aglaophenia divaricata, Aglaophenia whiteleggei* and *Gymnangium superbum,* while listed as epilithic, frequently grow from a rootstock directly attached to rocky substrate. Their larvae may, however, have originally settled on small invertebrates on the rock surface. *Nemertesia wattsi* and *Amphisbetia operculata* are usually not associated with reefs and often form large colonies growing on fragments of shell and rubble in open waters, especially in places of strong current flow. *Clytia hemisphaerica,* a small opportunistic species, favours many different substrates, and rich colonies may grow on artificial surfaces such as buoys or raft on fragments of the seagrass *Heterozostera tasmanica* drifting in ocean currents.

Size, habit and colour are all characteristics useful for recognition of hydroids to generic, and often to specific level. Most epiphytes are stolonal, the colonies usually growing close to the algal thallus; in general these species tend to be white in colour, or almost colourless. Erect-growing species, irrespective of habit, are often brightly coloured. *Aglaophenia divaricata* forms dense brown to black feathery colonies which may grow to 20 cm high while a similar species, *Lytocarpus whiteleggei,* is white. *Halopteris campanula* is lacy in habit and bright orange in colour; *Sertularia macrocarpa* forms large colonies that are silvery white *in situ* but appear black out of the water. Most species of *Gymnangium* have tall plumose stems that vary from green to brown in colour.

Table 1. Hydroid species recorded from depths of 0-60 m from eastern Bass Strait.

Species	Locality	Depth, m	Substrate notes
ATHECATA			
Family Hydractiniidae			
Stylactis betkensis Watson, 1978	GBI	0-1	on gastropod *Parcanassa burchardi*
Family Corynidae			
Sarsia radiata Lendenfeld, 1884	NMB HMP	3-10	buoy lines and mussels *(Mytilus planulatus)*
Family Bougainvilliidae			
Bougainvillia ramosa (Van Beneden, 1844)	NMB	3	buoy lines, mussels *(Mytilus planulatus)*
Family Eudendriidae			
Eudendrium terranovae Watson, 1985	NOR	10	epilithic, in cavern
Eudendrium generale Lendenfeld, 1885	FLI	25	from scallop dredge
Eudendrium merulum Watson, 1985	NOR	6	bryozoan in cavern
Eudendrium balei Watson, 1985	NMB	15	epilithic
THECATA			
Family Haleciidae			
Hydrodendron australis (Bale, 1919)	KGI	3-14	sponge, compound ascidian
Hydrodendron armatum (Stechow, 1924)	KGI	3-33	brown alga
Halecium delicatulum Coughtrey, 1876	NOR HMP GBI	3-23	barnacles, red algae, sponge, ascidian
Halecium sessile Norman, 1867	KGI HMP	10	barnacles
Halecium bruniensis Watson, 1975	GBI	12	ascidian *(Herdmania momus)*
Halecium fragile Hodgson, 1950	HMP	36	solitary ascidian
Halecium beanii (Johnson, 1838)	HMP GBI	17-20	barnacles
Halecium luteum Watson, 1975	KGI	14	epilithic, caverns
Family Lafoeidae			
Hebella scandens (Bale, 1888)	KGI	14-20	hydroid *(Amphisbetia geminata)*
Lafoea amirantensis Millard & Bouillon, 1973	NMB	3	hydroid *(Tubularia exxonia),* mussels *(M. planulatus)*
Lafoea fruticosa (M. Sars, 1851)	FLI	54	fishing nets
Filellum serpens (Hassall, 1848)	KGI	28	red alga *(Jeanerettia sp.)*
Family Campanulariidae			
Obelia geniculata Linnaeus, 1758	KGI GBI	3-17	brown alga *(Ecklonia radiata)*
Obelia australis Lendenfeld, 1885	KGI HMP NMB NOR	6-65	sponge, ascidian, barnacles mussel *(M. planulatus)*

Species	Locality	Depth, m	Substrate notes
Obelia bidentata Clarke, 1875	NMB HMP	7-10	old shell, old cable, barnacles
Orthopyxis caliculata (Hincks, 1853)	KGI HMP	2-20	brown alga *(Ecklonia radiata)*
Campanularia crenata Hartlaub, 1901	KGI	12	red alga
Campanularia pulcratheca Mulder & Trebilcock, 1914	KGI	28	red alga *(Jeanerettia* sp.)
Campanularia integra MacGillivray, 1842	NMB GBI	15	red alga
Campanularia gaussica Stechow, 1923	NOR	15	bryozoan, brown alga
Campanularia ambiplica Mulder & Trebilcock, 1914	NMB	10	no record
Clytia hemisphaerica (Linnaeus, 1767)	KGI NMB HMP NOR	10-30	mussels, barnacles, ascidians, red and brown algae, dead seagrass, man-made objects
Silicularia rosea Meyen, 1834	KGI GBI	10-30	algae, especially *Phyllospora comosa*
Family Syntheciidae			
Synthecium patulum (Busk, 1852)	KGI GBI NMB	22	sponge, ascidian *(Herdmania momus)*
Family Sertulariidae			
Stereotheca elongata (Lamouroux, 1816)	KGI NMB GBI	10-30	red algae
Crateritheca crenata (Bale, 1884)	NOR	10-12	bryozoan
Salacia sinuosa (Bale, 1884)	KGI NOR	15-35	bryozoan
Salacia fenestrata (Bale, 1884)	NOR	15	sheltered epilithic
Thyroscyphus balei (Calder, 1983)	KGI	5	bryozoa, ascidian
Diphasia subcarinata (Busk, 1852)	KGI	28	red alga *(Jeanerettia* sp.)
Parascyphus simplex (Lamouroux, 1816)	KGI	33	ascidian
Amphisbetia operculata (Linnaeus, 1758)	NMB KGI	55	old shell
Amphisbetia minima (Thompson, 1879)	KGI NMB GBI	3-12	ascidian *(Herdmania momus)*, sponge,
Amphisbetia minuta Bale, 1882	KGI	3	ascidian *(Herdmania momus)*
Amphisbetia gracillima (Bale, 1919)	FLI	54	fishing net
Amphisbetia pulchella (Thompson, 1879)	KGI	12-16	bryozoan
Symplectoscyphus indivisus (Bale, 1882)	KGI GBI	2-35	ascidian, red alga, brown alga
Symplectoscyphus subdichotomus (Kirchenpauer, 1884)	KGI NMB GBI	12	epilithic, algae
Symplectoscyphus neglectus (Thompson, 1879)	NOR	5-10	brown alga
Symplectoscyphus epizoicus Watson, 1973	KGI	35	hydroid *(Aglaophenia divaricata)*
Sertularia geminata Bale, 1884	KGI	3-35	ascidian, red alga, hydroid *(Agalophenia divaricata)*
Sertularia turbinata (Lamouroux, 1816)	KGI	27-30	red alga, brown alga *(Sargassum* sp.)
Sertularia macrocarpa Bale, 1884	KGI NMB	6-15	red algal holdfastsa
Sertularia marginata (Kirchenpauer, 1864)	KGI NOR GBI	5-30	red alga *(Jeanerettia sp.)*, brown alga *(Ecklonia radiata)*
Sertularia unguiculata Busk, 1852	KGI	2-30	brown alga
Sertularia bicuspidata Lamarck, 1816	KGI NOR	20	brown alga *(Sargassum sp.)*
Sertularella simplex (Hutton, 1873)	KGI GBI HMP NMB	10-17	oyster *(Crassostrea angasi)*, sponge, ascidian
Sertularella robusta Coughtrey, 1876	KGI HMP	10-20	barnacles
Calamphora parvula Allman, 1888	KGI	21	bryozoan
Family Plumulariidae			
Pycnotheca producta (Bale, 1881)	KGI NOR GBI	10	epilithic, bryozoan, seagrass *(Posidonia australis)*
Antennella campanuliformis (Mulder & Trebilcock, 1909)	NMB	12	epilithic
Antennella secundaria (Gmelin, 1792)	GBI	4-17	sponge, red algae, epilithic
Halopteris buskii (Bale, 1884)	KGI GBI NMB	12-30	ascidian *(Didemnum* sp.), epilithic
Halopteris campanula (Busk, 1852)	NMB	12	epilithic
Plumularia setaceoides Bale, 1882	KGI GBI	12	sponge, brown alga *(Cystophora, Ecklonia radiata)*
Plumularia setacea Ellis, 1755	NMB	9	epilithic, old shell
Plumularia pulchella Bale, 1882	KGI NMB GBI	20	ascidian *(Herdmania momus)* red alga
Plumularia spinulosa Bale, 1882	GBI	12	red alga, ascidian *(Herdmania momus)*
Nemertesia wattsi (Bale, 1887)	NMB	3-18	buoy ropes, old shell
Family Agalopheniidae			
Halicornopsis elegans (Lamarck, 1816)	GBI NMB KGI	14-17	epilithic
Aglaophenia plumosa Bale, 1882	KGI	3	brown alga, sponge
Aglaophenia divaricata (Busk, 1852)	KGI NMB GBI	15-23	epilithic
Agalophenia parvula Bale, 1882	KGI NMB GBI	8-12	ascidians *(Herdmania momus, Pyura australis)*, sponge, epilithic
Aglaophenia bakeri Bale, 1919	NOR	15	epilithic
Aglaophenia sinuosa Bale, 1888	GBI	24	epilithic
Lytocarpus whiteleggei (Bale, 1888)	KGI, NMB	12-15	epilithic
Gymnangium longirostre (Kirchenpauer, 1876)	KGI	12-16	epilithic, bryozoan
Gymnangium superbum (Bale, 1882)	KGI GBI	15	epilithic
Gymnangium proliferum (Bale, 1884)	GBI KGI	3-12	epilithic
Gymnangium ilicistomum (Bale, 1882)	KGI	20	red alga
Gymnangium thetidis (Ritchie, 1911)	GBI	12	epilithic
Gymnangium ascidioides (Bale, 1882)	KGI	16	epilithic
Gymnangium aureum Watson, 1973	GBI	23	epilithic

Recommended reading

General texts which describe hydroid morphology and provide information on common southern Australian species are:

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Australian Spiders: is their Publicity Worse than their Bite?

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Recently, considerable attention has been focussed on the potential threat posed by common Australian house and garden spiders following reports of horrific injuries resulting from presumed spider bites (Sutherland 1983a, 1983b, 1987; Spring 1987). Such bites have been attributed to a wolf spider, *Lycosa* sp., and less certainly, although more frequently, to the white tailed spider, *Lampona cylindrata*, mainly because the resultant symptoms closely resemble those observed following envenomation by the North American brown recluse spider (*Loxosceles reclusa).*

Loxosceles reclusa envenomation produces both local reactions and systemic effects such as nausea and dizziness. The local reactions to the spider bite have been well documented since the late 1950s (Atkins *et al.* 1957) and include the development of severe pain and swelling around the bite site a few hours after envenomation has occurred, and eventual necrosis (tissue death) of the surrounding skin (Foil and Norment 1979; Wasserman and Siegal 1979; Kurpiewski *et al.* 1981). Similarly, the Australian experience has been the development of severe pain in affected areas presumably several hours after painless and usually unnoticed bites, local swelling, ulceration, and, on occasions, necrosis in the affected areas (Sutherland 1983a, 1983b, 1987). Additionally, most people affected by these symptoms had spent considerable time outdoors in an environment populated by the spiders *Lycosa* sp. and *Lampona cylindrata*, and thus these species came to be blamed for causing these reactions.

Despite the fact that the observed responses to envenomation by *Loxosceles reclusa* and the local symptoms associated with the presumed spider bites in Australia are very similar, differences do exist, especially with regard to the systemic reactions observed. *Loxosceles reclusa* venom is known to produce blood related disturbances (Nance, 1961; Foil and Norment 1979; Wasserman and Siegal 1979; Norment and Foil 1980). No such reactions have been observed in Australian patients (Spring 1987; Sutherland 1983b).

Although the similarities between envenomation by *Loxosceles reclusa* and the symptoms presented by Australian patients are remarkable, another issue has created confusion and controversy over the years with regard to establishing the cause of the necrotic lesions that have developed in people suffering 'mystery bites'. The clinical manifestations of infection by *Mycobacterium ulcerans*, a microbe distributed widely in Australasia, Central and South America and the Southern African continent (Hayman 1984), are similar to those following envenomation by Loxosceles reclusa and to those attributed to spider bites in Australia.

They include ulceration and necrosis of the upper layer of skin, inflammation of the subcutaneous layer of fat and further necrosis which may extend down to the muscle tissue (Hayman 1985; Hayman and McQueen 1985; Song *et al.* 1985). Thus, there has been some debate as to whether or not infection by *M. ulcerans* is involved in the local reactions to the bites of wolf and white-tailed spiders#. It has been proposed that by biting and puncturing the skin, spiders enable any mycobacterium already on the surface of the skin to enter the wound and thereby initiate a local dermonecrotic response. Alternatively, it has been suggested that *M. ulcerans* resides on the fangs of spiders and may enter the skin when a spider bites (Sutherland *pers comm*). Preliminary in-

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vestigations into the latter possibility have shown it to be unlikely (Lightfoot *pers comm*). Moreover, recent experiments performed with various spider venom extracts, including those from wolf and white-tailed spiders demonstrated that venom from a wolf spider was capable of producing necrotic lesions in both *in vivo* and *in vitro* situations (Atkinson and Wright 1991, 1992), while the venom of the white-tailed spider was not (Atkinson and Wright 1992). Thus, the possibility does exist that envenomation by wolf spiders may have been the initiating factor for the development of necrotic lesions in some of the reported cases given the widespread distribution of these spiders throughout Queensland, NSW, and Victoria (McKay 1973).

The past decade has seen the characterisation of a number of toxins from several species of spiders which act on the nervous system. Components of venoms obtained from different spiders often share common activities. There are several examples of substances isolated from spider and other venoms being deployed as 'tools' in biological research, particularly in investigations of nerve function (for a review, see Jackson and Usherwood 1988; Jackson and Parks 1989).

Of the Australian spiders currently under investigation, most recent effort has centred on the effects of the Sydney funnel-web spider, *Atrax robustus*. A neurotoxin was isolated from the whole venom of the male spider by Scheumack *et al.* (1985) and since then experiments have confirmed that it is this component which is responsible for the neurotoxic and lethal effects following *A. robustus* envenomation (Mylechrane *et al.* 1989). A modified synthetic analogue of the natural spider toxin has, most recently, been put forward as an immunogen against the native funnel-web spider toxin (Mylechrane *et al.* 1990). Another of the funnel-web spiders, *Hadronyche (Atrax) versutus* found in the Blue Mountains of NSW, has yielded another neurotoxin (Brown *et al.* 1988). The Victorian funnel webs *H. modesta* and *H. meridiana* so far seem to be relatively innocuous, with there being no reports of serious *sequelae* following envenomation (Gray *pers. comm.*).

In a more general study of common Victorian spiders, the venoms of the huntsman spiders *Delena cancerides* and *Isopeda montana*, the sac spider *Clubiona* sp., and two brown house spiders related to the red-back spider, *Steatoda grossa* and *S. capensis*, were recently investigated for any pharmacological activity.

Venom gland extracts from the female huntsman spiders *D. cancerides* and *I. montana* were found to produce increases in heart rate and blood pressure in rats (Korszniak and Story 1993). Furthermore they produced local inflammatory reactions without producing any evident necrotic lesions (Korszniak and Story 1994b). Of all the huntsman spiders, only two species *(Neosparassus [Olios] calligaster* and *N. punctatus)* have been reported as giving painful bites (Mascord 1989). However, it is possible that other species also deliver painful bites. In the case of *D. cancerides* and *I. montana*, any pain at the bite site resulting from envenomation may be due to intense constriction of blood vessels in the area produced by both venoms, leading to a decrease in oxygen supply to the tissues (ischaemia). In addition, the pain produced may be due to the liberation of the body's own chemical mediators of pain as a consequence of the inflammatory response to either venom.

The *Clubiona* sp. spiders investigated are related to the *Chiracanthium* spiders of Europe and North America, and both genera have been reported as giving extremely painful bites (for a review see Bettini and Brignoli 1978). Crude venom gland extracts prepared from glands collected from female *Clubiona* sp. spiders produced increases in blood pressure and heart rate in experimental models, and also produced local inflammatory reactions following injection of the venom into the skin (Korszniak and Story 1992). Each of these effects of the venom could be attributed to the activation of specific nerves in the body (Korszniak and Story 1992). Thus, in the instance of painful bites following *Clubiona* sp. envenomation, the pain may be due to either intense constriction of local blood vessels leading to ischaemia, the liberation of the body's own chemical mediators of pain, or the pain and itching at the bite site may be due to the activation of specific neural pathways (Bradley *et al.* 1986).

It is surprising to note that the venom gland extracts from the two *Steatoda* species exhibited vastly different pharmacological actions. *S. grossa* was largely inactive, its only action being to produce a local inflammatory response in the anaesthetised rat model (Korszniak 1992; Korszniak and Story 1994b).

Conversely, *S. capensis* venom gland extracts produced effects consistent with there being at least two separate active components in this venom (Korszniak and Story 1994a). Thus *S. capensis* venom was found to trigger the release of substances from nerves, leading to increases in heart rate and blood pressure (Korszniak and Story 1994a). The remaining activity of *S. capensis* Hann venom gland extracts may actually be a composite of several different components in the venom. One or more of these components may account for the initial decrease in heart rate produced by the venom as well as being partially responsible for the increases in heart rate observed.

In conclusion, there is a body of evidence which allows some of the specific symptoms of envenomation by some spiders to be linked to particular components of the venoms of those spiders. However, it should be noted that this research is not wholly supportive of many of the claims which have been made recently with respect to injuries that have been attributed to spider bites. Whilst it is possible that some of the reported symptoms in people suffering these 'mystery bites' could have been a result of a spider bite, other causes are equally possible. Further research must be undertaken before it can be conclusively stated that the majority of common Australian house and garden spiders pose a significant threat to humans.

Acknowledgements

Many thanks to Mr Rob Kilpatrick and Dr James Ziogas for their reading of, and insightful comments on, this manuscript. Studies undertaken by the authors (NK & DFS) were supported by a Grant-in-Aid from Rentokil Pty Ltd.

Refer to articles published in 'The Age' (Melbourne, Australia) newspaper: 'Spider's reputation may be worse than its bite' by Heather Kennedy (27.9.90), and 'Rainforest bug bites back in Gippsland' by Tim Entwisle (31.7.89).

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Dr Norman Barnett Tindale, AO.

Norman Barnett Tindale, who died in California in November 1993, at the age of 93, was made an Officer of the Order of Australia in the Australia Day Honours List this year, for service to anthropology, particularly through the study of traditional Aboriginal society.

Although best known for his work in anthropology, Norman Tindale was also a keen entomologist, beginning his career as Assistant to the Entomologist at the South Australian Museum. The expedition to Groote Eylandt in the Gulf of Carpentaria in 1921 changed the emphasis of his studies, and he held the position of Curator of Anthropology at the South Australian Museum from 1928 until his retirement in 1965. He maintained his interest in entomology, together with those in ornithology, botany and geology. His extensive field work and subsequent publications in all these fields led to his being awarded the Australian Natural History Medallion in 1968.

Sheila Houghton

Some Urban Wombats

John Seebeck*

On 19 August 1991, as I was driving to work, my attention was drawn to the body of a medium-sized mammal lying on the road. The location was the east-bound lanes of Banksia St., Heidelberg, some 50 m east of Dora St., and adjacent to the Yarra River Parklands. The body had been dragged from the point of impact (and presumed point of death) onto the grassed median strip which divides Banksia St. at the site. The time was 0900 hrs (*i.e.* peak-hour), and the traffic was quite heavy in both directions. I recovered the body for examination.

It was a female Common Wombat, *Vombatus ursinus*. It weighed approximately 31 kg (it had to be weighed after dissection and therefore there was some fluid loss). Standard museum measurements were taken: total length 866 mm; tail length 30 mm; head length 220 mm; hind foot length 102 mm; ear length 62 mm. These measurements indicate that it was an adult, although the head and body length (for a wombat this is very nearly the same as total length) is somewhat less than given by McIlroy (1988) who quoted a range of 900-1150 mm, with a mean of 985 mm.

The animal was in good body condition, subjectively assessed. The ears were scarred, the result of old, healed wounds. A large number of ticks were either loose in the fur or attached to the skin. No pouch young was present, nor was there sign of lactation or, indeed, recent breeding. The right nipple was slightly longer than the left, but both were very small. The stomach was full, and contained mainly grass. The skull was extensively fractured and both lungs were ruptured. Road trauma was presumed to be the cause of death. There was nothing to suggest that this animal had been in captivity. It appeared to be a perfectly normal wild wombat.

The skull, gonads, ectoparasites and stomach contents are all in the collection of the Department, registration number 14906.

In the Atlas of Victorian Wildlife there are a number of records of Common Wombat in the Greater Melbourne area (Fig. 1). Most are in the Yarra River valley, or in the Dandenong Ranges.

The earliest 'metropolitan' record in the Atlas is from Beaumaris in 1931 (Colliver 1931). The skull of a wombat was exhibited at the December meeting of the Field Naturalists Club of Victoria; it was reported to have come from 'Kalimnan', Beaumaris. 'Kalimnan' is a fossil series from the cliffs at Beaumaris, which is Tertiary in age. Colliver (1937) described the site and listed a number of fossils from there, including whales and seals, but did not list the wombat he had reported several years earlier, nor the fox also reported at that time. Certainly the fox must have been a modern intrusion, but the wombat is intriguing. There are a number of records in the Atlas of the species in recent years on the Mornington Peninsula, but none closer to the city than Greens Bush.

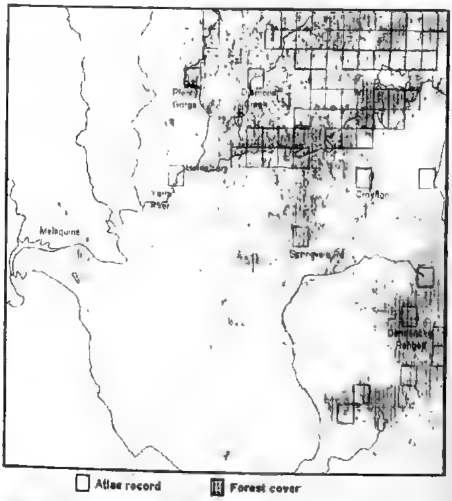

Fig. 1. Distribution of Wombats near Melbourne.

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* Department of Conservation and Natural Resources, Flora and Fauna Branch, 123 Brown St, Heidelberg 3084 Victoria.

In June 1968 an adult wombat was found, presumed to be a road-kill, in Springvale Rd., Nunawading, about 0.5 km north of the Burwood Highway, by P.A. Rhodes, a Fisheries and Wildlife Officer. It was recorded as being 'reddish coloured' but no other details survive. The site is about 2.5 km from the Dandenong Creek valley, from where Wallis *et al.* (1990) and Brunner *et al.* (1991) reported the presence of Common Wombat hair in a carnivore scat from the Dandenong Valley Metropolitan Park. In both papers it was suggested that the sample, a single guard hair in a cat scat, originated from remains washed downstream. Wallis *et al.* (1990) stated that, although several of their sources had reported the species in the park area, their continued existence was not supported by recent evidence. The most recent reports were from rangers who believed that wombats had been present at one or two sites near the Burwood Highway until the early 1980s.

Seebeck (1977) reported that 'small numbers of wombats were present along the river at Lower Plenty until urban development in the 1960s'. The record had been obtained from I. Temby (DCNR) who was resident at Lower Plenty during that period.

The Atlas records (Fig. 1) are, as indicated above, mostly from near-metropolitan hills or river valleys. Indeed, almost all are from the Yarra valley, upstream from the Mullum Creek junction with the Yarra River. Other records are from Brushy Creek north of Croydon, Diamond Creek near Diamond Creek township and the Plenty Gorge, and most were obtained during extensive searches of the valley environs in the late 1980s.

The 'urban' stronghold of the Common Wombat appears to be the Yarra valley, much of which is incorporated in the linear parks system of Melbourne Parks and Waterways or the Warrandyte State Park, where the species is reported as 'quite common' (DCE 1990). The unfortunate female who met her death at Heidelberg was probably part of the population still extant in that reserve system.

Acknowledgements

Thanks to Peter Menkhorst and Barbara Baxter, DCNR, for arranging ready access to the Atlas of Victorian Wildlife, and to Ian Temby, also of DCNR for recollections of wombats near the Plenty River. Lindy Lumsden, Andrew Bennett and Peter Menkhorst commented upon and thereby materially improved the manuscript. Simon Bennett prepared the figure.

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Erratum

Cellular Slime Moulds: The Simplest Complex Eukaryotes.
On page 19 the incubation temperature should read 21°C and not 210°C.

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The Victorian Naturalist

Volume 111 (3) 1994 June

'Ground Flora - Restoration and Management' Conference

Greening Australia Victoria
Selected Papers

Published by The Field Naturalists Club of Victoria
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FNCV Calendar of Events

(General Meetings July to September, Sunday afternoons)

July	
Sat 2	General FNCV Excursion. ***A Day in the Western Highlands. Leader John Stewart.*** Bus trip only. Contact John Stewart 306 2009 for bookings.
Sun 3	Botany Research. ***Fungi Survey at Wattle Park.*** Meet car part 10.30 a.m. Contact John Julian 830 4795.
Tues 5	Fauna Survey Group Meeting. ***Tiger Quolls - Chris Belcher.*** Herbarium Hall 8 p.m.
Wed 6	Botany Research Meeting. ***Planning Meeting.*** Kew Community House 8 p.m. Contact John Julian 830 4795.
Sun 10	General FNCV Meeting. Herbarium Hall 2 p.m.
Thurs 14	Botany Group Meeting. ***Islands of Antartica-plant and bird life - Trevor Blake.*** Herbarium Hall 8 p.m.
Wed 20	Microscopical Group Meeting. ***Polarised Light in the Microscope - Brian Waldron.*** Astronomers Residence 8 p.m.
Wed 27	Geology Group Meeting. Herbarium Hall 8 p.m.
Sat 23	Botany Group Excursion. Contact Joan Harry 850 1347.
August	
Tues 2	Fauna Survey Group Meeting. Herbarium Hall 8 p.m.
Wed 3	Botany Research Meeting. Kew Community House 8 p.m. Contact John Julian 830 4795.
Sat 6	Botany Research. ***Fungi Survey at Wattle Park.*** Meet car park 10.30 a.m. Contact John Julian 830 4795.
Sun 7	General FNCV Excursion. ***The Pines, Frankston North.*** Contact Dorothy Mahler 435 8408.
Thurs 11	Botany Group Meeting. Herbarium Hall 8 p.m.
Sun 14	General FNCV Meeting. ***Natural History of Irian Jaya - Margaret Cameron.*** Herbarium Hall 2 p.m.
Wed 17	Microscopical Group Meeting. ***The Algal Monitoring of City Lakes - A Possible Group Project - Tim Entwisle.*** Astronomers Residence 8 p.m.
Wed 24	Geology Group Meeting. Herbarium Hall 8 p.m.
Sat 27	Botany Group Excursion. Contact John Harry 850 1347.

Books Available from FNCV

The Club has, over the years, published a number of books on natural history topics. It is currently distributing four of these as follows, which titles can be purchased from the Book Sales Officer or at any of the club's meetings.

What Fossil Plant is That? (J.G. Douglas) $8.00
A guide to the ancient flora of Victoria, with notes on localities and fossil collection.

Wildflowers of the Stirling Ranges (Fuhrer & Marchant $7.95
144 magnificent illustrations of the spectacular flora of this region.

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The Victorian Naturalist

F.N.C.V.

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Editor: Robyn Watson
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Proceedings

Research Reports

Contributions

Notice

ISSN 0042-5184

Cover Photo: Themeda grasslands can have a diverse range of ground flora. On this roadside grassland reserve near Wickcliffe, Western Victoria, are the feathery flowerheads of *Ptilotus macrocephalus*. Photo courtesy Ian Shears.

Proceedings of the 'Ground Flora-Restoration and Management' Conference, Greening Australia Victoria, August 1991. Part one of a four-part series.

The conference was organised by Greening Australia Victoria with support from VicRoads and sponsorship by the Department of Conservation and Natural Resources. Greening Australia Victoria would like to thank Greg Hore, Pamela Trigg, Tamzin Rolloson, Shirley Diez and David Lloyd for editorial assistance.

Ground Flora - Diversity and Associations in Victoria

Tim Entwisle*, David Albrecht** and Neville Walsh*

Abstract

Vegetation about half a metre high or less is usually termed the 'ground flora'. Most major taxonomic groups are represented in this stratum. Elements of the ground flora can be also classified by their life-form or habit, allowing us to generalise about ground flora associations. In this paper, two systems of life-form classification are provided, followed by a survey of the ground floras found in the major vegetation communities in Victoria.

Diversity

Definition of ground flora

Vegetation classification has been based traditionally on the dominant upper stratum (or storey) species, which means that for forests and woodlands, the ground flora was hardly mentioned (e.g. early Land Conservation Council surveys). Although the upper stratum may contain the bulk of the total biomass (it receives most of the available solar energy; Specht 1972), in temperate communities the lower strata usually include a greater number of species. Associated with this taxonomic diversity is a diversity in life-forms, giving rise to a range of habitats and interactions vital for the functioning of the entire ecosystem. Vegetation classification today attempts to deal with the whole composition of the vascular flora.

In forests and woodland, the lower strata (or understorey) may include small trees and shrubs to tiny herbs. The ground stratum is the lowest level of such an understorey and includes woody, succulent and herbaceous plants. In heaths, low shrublands, grasslands, herbfields and sedgelands, the entire vegetation may be included in this ground stratum. The 'ground flora' relevant to this conference comprises all plants which are less than half a metre tall (or at most up to one metre). More picturesque definitions include 'things you can mow or slash' (Dale Tonkinson *pers. comm.*) or 'vegetation you can put your foot on' (Neville Walsh).

Taxonomic diversity of ground flora

The ground flora as defined above includes most major groupings of photosynthetic organisms, from algae and lichenised fungi, to bryophytes (mosses and liverworts), ferns and fern allies (clubmosses, etc.), gymnosperms (e.g. *Podocarpus lawrencei*) and of course flowering plants (both monocotyledons and dicotyledons). The non-lichenised fungi, both macroscopic (e.g. toadstools and bracket fungi) and microscopic, may also be considered part of the flora.

Life-form diversity of the ground flora

A widely used system of life-forms was devised by Raunkiaer (1934). It is a difficult system to remember and probably unnecessary for the broad generalisations we are making in this paper. However, as it is widely used in the literature, we include it here for reference (Table 1). Halloy (1990) provides an even more complex system of life-form classification, but it does overcome the 'one character' restriction of Raunkier's system.

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** Arid Zone Research Institute, Alice Springs, NT, 0871.

A simpler system is often used in environmental surveys (Table 2), with categories based on the overall morphology (size and shape) of the plant, sometimes in combination with its longevity (i.e. annual vs perennial). These categories overlap to some extent but because they reflect general usage they are easier to remember.

Table 1. Raunkiaer life-form categories represented in the ground flora (simplified from Kershaw 1973).

Phanerophyte (*phanero* = conspicuous): with perennating buds or shoot apices on aerial shoots. Three subcategories are relevant to the ground flora.
- **Nanophanerophyte:** less than 2 m in height.
- **Epiphytic phanerophyte:** mostly small twining plants in the ground flora.
- **Stem-succulent phanerophyte:** subset of nanophanerophytes.

Chamaephyte (*chamae* = lowly, on the ground or creeping): with perennating buds or shoot apices borne close to (0-25 cm above) the ground. There are 4 subcategories recognised, based on the orientation of the shoots.
- **Suffruticose chamaephyte:** erect.
- **Passive chamaephyte:** with weakened erect axis which fall over (buds arising along horizontal stems).
- **Active chamaephyte:** vegetative shoots persistently along the ground, usually rooting along their length.
- **Cushion plant:** a reduced and compact form of active chamaephytes. Absent in Victoria, but important in Tasmania and New Zealand.

Hemicryptophyte (*hemi* = half, *crypto* = hidden): perennating buds at or just below ground level. Three subcategories are recognised.
- **Proto-hemicryptophyte:** lowermost leaves on stem less perfectly developed than the upper ones.
- **Partial rosette plant:** best developed leaves in rosette at base of aerial stem.
- **Rosette plant:** leaves restricted to rosette at base of aerial stem.

Cryptophyte: perennating buds below ground level or submerged in water. Four sub-categories are recognised.
- **Geophyte:** with rhizome, bulb or tuber.
- **Helophyte:** perennating organs in soil or mud below water-level with aerial shoots above water-level.
- **Hydrophyte:** most of plant below water, with leaves floating or submerged.
- **Therophyte:** (*theros* = summer): annuals.

Table 2. Some life-form categories used in general survey work in Victoria (adapted from those devised by Ecological Horticulture Pty Ltd, e.g. Carr 1983). Note that the following is a simplified system: e.g. parasitic herbs or shrubs are not segregated from free-living plants and all aquatic plants are grouped together.

Low shrub e.g. *Epacris impressa.*
Sub-shrub (shrublet) e.g. prostrate species, some chenopods.
Succulent herb e.g. *Crassula, Carpobrotus,* includes plants which would be otherwise called herbaceous perennials.
Graminoid (tufted or tussock-forming herb) mainly monocotyledons.
Rhizomatous or **stoloniferous perennial herb** e.g. *Viola* spp.
Herbaceous perennial (not or shortly rhizomatous) e.g. rosette-forming plants such as *Brunonia.*
Annual herb (including some which are sometimes or always biennial) e.g. some *Brachyscome* spp., some *Senecio* spp.
Tuberous herb (with tubers, tuberoids, corms, bulb, etc., and dormancy) e.g. orchids, many lilies, sundews.
Vine, twiner or scrambler e.g. *Hardenbergia, Clematis, Kennedia prostrata.*
Aquatic including free-floating, submerged and emergent aquatics.
Fern or fern ally although a taxonomic grouping, these plants often have a similar life-form; note that they could also be included in other categories, such as rhizomatous perennial herb or annual herb.
Non-vascular plant i.e. bryophytes, lichenized and non-lichenized fungi, and algae. Although often inconspicuous, these organisms can have a major role in soil-binding and the break-down of rocks and leaf-litter in primary succession.

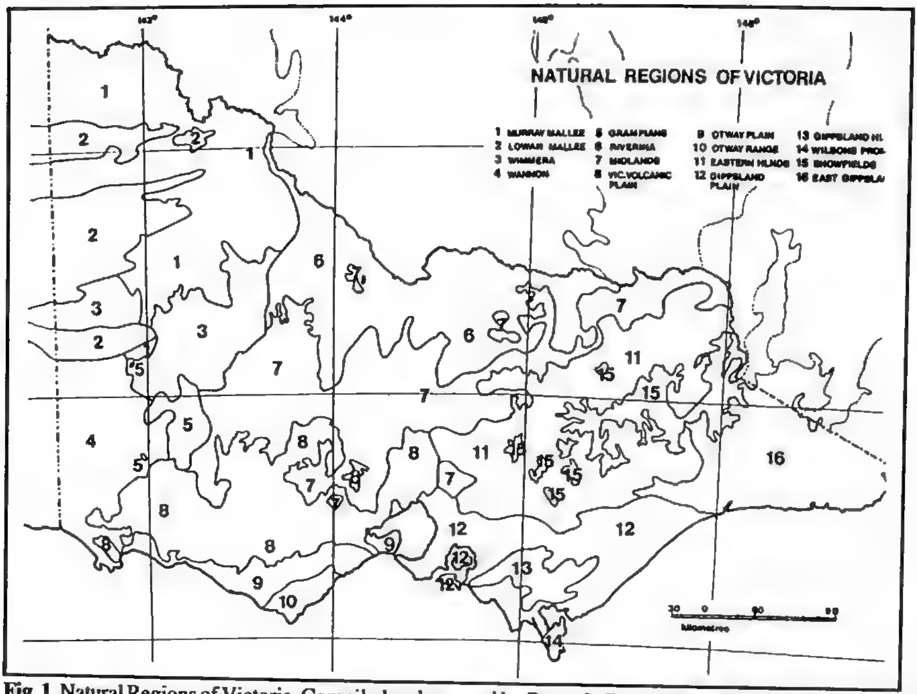

Fig. 1. Natural Regions of Victoria. Compiled and pepared by Barry J. Conn for the National Herbarium of Victoria, and kindly reproduced in black and white by Anita Barley. The original, colour version of this map can be found in the Flora of Victoria (Foreman and Walsh, 1993).

Associations

Ground flora associations found in the major vegetation communities of Victoria

The vegetation in Victoria can be divided in various ways to show flora diversity and associations. The *Flora of Victoria* (Foreman and Walsh, 1993) uses a system of sixteen Natural Regions which reflect, to some degree, areas sharing a range of natural features including their flora (Fig. 1). Each of these Natural Regions includes a number of different plant communities, most of which occur in more than one Natural Region.

Although there is no standard classification of plant communities available for Victoria, the major groupings are fairly well known. Within these broadly circumscribed communities, the composition and species richness of the ground flora varies appreciably depending on fire history (e.g. the time since the last fire), soil fertility, soil moisture, aspect, topography, grazing, extent of waterlogging, pH, salinity and climate. Nevertheless, the vegetation communities listed below provide a useful framework for surveying the ground flora associations found in Victoria.

Information on the structure and composition of the ground flora has been taken from a number of sources, including Beadle (1981), Frood and Calder (1987), Opie *et al.* (1984), Parsons *et al.* (1977), Specht (1972), various LCC and prelogging reports, and our own personal observations. For those wishing to seek more detailed information, one or two useful references are provided for each community considered below.

Key to terms used in Ground Flora Associations section

closed = 70-100% cover by top stratum
open = 30-70% cover by top stratum
very open = % cover by top stratum
sclerophyllous = with hard, stiff or leathery leaves
herbaceous = soft-leaved and not producing wood

Warm Temperate Rainforest
Distribution: East Gippsland, Wilsons Promontory.
Ground Flora: The ground is characteristically covered by masses of leaf and stem litter. The flora consists mainly of ground-ferns and occasional graminoids (sedges and grasses). Vines or climbers are sometimes at ground level. Suppressed seedlings of overstorey species may be common and can be considered part of the ground flora. Beneath canopy gaps there are specialised colonizers, usually twiners and short-lived herbs. See Rainforest Technical Committee (1986).

Cool Temperate Rainforest
(e.g. Nothofagus Rainforest)
Distribution: Otways, Eastern Highlands, Wilsons Promontory (in gullies within Mountain Ash forest); East Gippsland (e.g. Errinundra Plateau).
Ground Flora: In life-form, if not in species composition, the ground flora of cool temperate rainforest is like that of warm temperate rainforest. The former, however, has more ferns and fewer climbers/vines at ground level. See Rainforest Technical Committee (1986).

Montane Forest (e.g. Alpine Ash Forest)
Distribution: Eastern Highlands
Ground Flora: Ferns common but less diverse than in the rainforests or wet sclerophyll forest, but species richness of graminoids and broadleaf herbs higher. A few tuberous herbs are present (e.g. *Chiloglottis valida* and *Arthropodium milleflorum*). See Mueck (1990).

Tall Open Forest or Wet Sclerophyll Forest (e.g. Mountain Ash Forest)
Distribution: Otways, Eastern Highlands, Gippsland Highlans, East Gippsland; between 160 and 1000m above sea level.
Ground Flora: Similar to Cool Temperate Rainforest, with ground ferns (e.g. *Blechnum* and *Polystichum*) dominant and occasional broad-leaf herbs (e.g. the nettles Australina and Urtica) and graminoids. Sometimes graminoids can dominate the understorey (e.g. *Lepidosperma elatius* and/or *Tetrarrhena juncea* Wire Grass; or in wetter areas, *Gahnia* spp.). In the first few years following fire, the ground flora can be dominated by rhizomatous ferns and tree ferns and a few flowering plants (*Senecio* spp., *Dryopoa dives* Giant Mountain-grass). See Mueck (1990).

Moist/Damp Sclerophyll Forest
Distribution: Otways, Eastern Highlands, Gippsland Highlands, Wilsons Promontory, East Gippsland.
Ground Flora: A broad category with numerous subcommunities, including various proportions of ferns (e.g. *Pteridium* Bracken and *Calochlaena*, syn. *Culcita*), low shrubs (e.g. *Platylobium formosum*) and grasses (*Poa ensiformis* and *Tetrarrhena juncea*). In drier areas, bracken is common, particularly if the land has been cleared or regularly burnt. See Frood and Calder (1987).

Dry Sclerophyll Forest or Woodland
(e.g. Box-Stringybark Forest)
Distribution: Midlands (mostly southern areas), Eastern Highlands; on skeletal soils derived from Silurian/Ordovician sandstones and mudstones.
Ground Flora: Understorey ranges from heathy to open and grassy. Tussock grasses (notably *Chionochloa pallida* and *Poa* spp.) and a very wide range of sclerophyllous shrubs, particularly Fabaceae (peas), Mimosaceae (wattles) and Epacridaceae (heaths). Herbaceous perennials and tuberous herbs, e.g. orchids, lilies and *Drosera* (sundews), are often conspicuous in inter-tussock spaces. Species diversity of native grasses can be as high as in grasslands on the basalt plains. See Frood and Calder (1987) and Yugovic *et al.* (1990).

Box-Ironbark Forest and Woodland
Distribution: Midlands (mostly northern areas).
Ground Flora: Understorey can be very sparse. Drier forest and woodlands often have tussock grasses (*Danthonia* and *Stipa* spp.) and a diverse array of low shrubs. Orchids can be seasonally conspicuous and some annuals are present. In

the 'goldfields' area, everlastings (e.g. *Bracteantha viscosa*) and *Grevillea alpina* are common. In general, as the tree canopy becomes more open (e.g. from forest to woodland) in any of the communities discussed, the biomass of the ground flora increases because more solar energy reaches the lower strata. See Carr *et al.* (1987), Frood and Calder (1987) and Walsh (1987).

Riverine Red Gum Forest and Woodland

Distribution: Riverina, Wannon.
Ground Flora: Near river courses, grasses (e.g. *Pseudoraphis spinescens* Moira Grass in Barmah Forest) and sedges are abundant and the broadleaf herbaceous flora is often sparse. Aquatic plants may be present. In the Wannon region, sedges are common, with grasses and herbs. Wet depressions may only support ferns and fern allies such as *Isoetes*, *Pilularia* or *Ophioglossum*. On drier sites, there may be fields of *Bulbine* and other lilies (e.g. *Arthropodium*). Much of this area has been cleared and modified for grazing. See Chesterfield *et al.* (1984).

Lowland Grassy Woodland and Grassland

Distribution: Wimmera, Riverina, Victorian Volcanic Plain, Gippsland Plain.
Ground Flora: The volcanic plan was once covered by extensive areas of treeless grassland, of which little remains today. *Themeda triandra* (Kangaroo Grass) is the major dominant, replaced under higher rainfall conditions or in locally wet sites by *Poa* spp. Other grasses (e.g. *Stipa* and *Danthonia* spp.) are also conspicuous. A wide range of broadleaf herbs (particulary Asteraceae spp.) occur in the inter-tussock spaces, but shrubs are rare. Grassy or savannah woodlands on the Northern, Wimmera and Sale Plains, and on the southern margins of the Great Dividing Range, also have a grass-dominated understorey. In addition to grasses and broadleaf perennial herbs, annuals and tuberous herbs can be common. Such vegetation can be exceptionally species rich, with up to 45 species per square metre. See Lunt (1990).

Alpine Gippsland

Distribution: Snowfields.
Ground Flora: Dominated by tussock grasses, particularly *Poa hiemata*. About 90% of biomass due to *Poa* spp. Other ground flora only conspicuous in spring/summer (when flowering), but including a wide range of graminoids, some orchids and daisies (e.g. everlastings and related genera). Small shrubs sometimes present, and ground flora similar to that found under Snow Gum Woodland. See Walsh *et al.* (1984).

Snow Gum Woodland

Distribution: Snowfields (mostly).
Ground Flora: Almost all plants in the understorey are low and can be included in the ground flora. Some areas are dominated by grasses (particularly *Poa* spp.) and broadleaf herbs (e.g. *Wahlenbergia* spp.), while others are covered by dense low shrubs. While the soil, topography and microclimate affect the floristic composition of the ground flora, the grass/Shrub balance can be also swayed by fire and/or grazing histroy. See Walsh *et al.* (1984).

Heathland and Heathy Woodland

Distribution: Grampians, Wannon, Otway Plan, Gippsland Plain, Wilsons Promontory, East Gippsland (usually on sand)

Ground Flora: A wide range of shrubs, from families such as Fabaceae, Epacridaceae and Myrtaceae, are represented. If shrubs are low, all vegetation may be considered ground flora. Sclerophyllous monocotyledons such as *Lomandra*, Restionaceae and Cyperaceae can be important in the overall structure of the heathland. Orchids, lilies and sundews are an important floristic component of the ground flora. Bracken can dominate in frequently burnt areas. See Opie *et al.* (1984).

Swamp Shrubland (e.g. *Leptospermum-Melaleuca* Thicket)

Distribution: As for Heathland and Heathy Woodland.
Ground Flora: Often with a sedge-rush dominated ground flora, and some grasses (e.g. *Hemarthria*). Broadleaf herbs are usually sparse. Some tuberous herbs, such as the greenhood orchids *Pterostylis tenuissima* and *P. furcata* and the lily *Hypoxis*, are characteristics of this community. See Opie *et al.* (1984).

Coast Banksia Woodland

Distribution: Gippsland Plain, Wilsons Promontory.
Ground Flora: Broadleaf herbs (e.g. *Dichondra*), graminoids (e.g. *Lomandra longifolia*), bracken and some subshrubs are common. Plants with a scrambling habit and/or succulence (e.g. *Carpobrotus* and *Tetragonia*) are also present. See Gullan *et al.* (1981).

Coast Dune Scrub

Distribution: Wannon, Otway Plain, Gippsland Plain, East Gippsland.
Ground Flora: Native dune colonists such as *Spinifex, Scaevola aemula, Stackhousia* and *Senecio* are replaced in many areas by the introduced *Ammophila arenaria* (Marram) and *Cakile* spp. (sea-rockets). Rhizomatous perennials are important in stabilisation of dunes. See Gullan *et al.* (1981).

Coastal and Inland Saltmarsh

Distribution: coastal - Otway Plain, Gippsland Plain, Wilsons Promontory; inland - Victorian Volcanic Plain, Murray Mallee.
Ground Flora: The structure of saltmarshes can vary from shrublands to herbfields and grasslands. In most cases all vegetation can be considered ground flora. Chenopods are generally abundant. Succulent broadleaf herbs (e.g. *Disphyma clavellatum, Wilsonia* spp.) can be common in some areas, as can salt-tolerant (halophytic) grasses and rushes (e.g. *Distichlis distichopylla* and *Juncus kraussii*). On the edges of saltmarsh, and on slightly elevated habitats within saltmarshes (particularly inland), a range of annual species are present. See Yugovic (1985).

Mallee communities

Distribution: Murray Mallee, Lowan Mallee, Midland (Whipstick and Long Forest).
Ground Flora: Understoreys vary with soil type, salinity, and fire and grazing history. On richer loams and clays of broad flat dune swales (in mallee eucalypt communities with sclerophyllous shrubs and shrubby chenopods), the ground flora includes grasses and herbs, with many annuals. On fertile sands, the understorey grades from tussock grass to hummock grass (*Triodia scariosa*), the latter found in drier areas and including a very open low shrub layer and some annuals. On deep, infertile sands, heathy and scrubby communities have a ground flora with varying amounts of annuals. The Whipstick (near Bendigo) and Long Forest (near Melton) mallees generally have a sparse, shrubby understorey with grasses and annuals. See Cheal *et al.* (1989) and Frood and Calder (1987).

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Centenary of the 1894 Horn Expedition to Central Australia

To celebrate the centenary of the 1894 Horn scientific expedition to central Australia, the Museum of Victoria is organising an expedition in October 1994 and in March 1995. The original 1894 party had representatives from the Field Naturalists Club of Victoria. Unlike the 1894 expedition, which collected vertebrate, invertebrate, botanical, geological and anthropological material, the 1994-1995 expedition will concentrate primarily on the **invertebrate** fauna. There have been significant advances on our knowledge on the vertebrate fauna, the plants, geology and anthropology since 1894, but our knowledge of the invertebrate fauna is still very fragmented.

The Museum of Victoria will co-ordinate the participation of approximately 20 invertebrate specialist scientists from across Australia to undertake field work in four selected areas that the Horn expedition visited in 1894: West MacDonnell Ranges, Finke Gorge National Park, Watarrka National Park (Kings Canyon) and Uluru-Kata Tjuta National Park (Ayers Rock and the Olgas).

Volunteers who are willing to pay their own expenses are being sought to assist the scientists with field work. No invertebrate knowledge is required - just the willingness to help and learn. The work will not be easy, and will involve long hours and much walking.

The cost of participation is approximately $850 per fortnight, which includes all transport from Alice Springs, all meals and camping accommodation (sleeping bags, swags and tents provided). The cost does not include return travel costs to Alice Springs; the Museum is attempting to obtain a discount airfare for expedition participants. For insurance purposes, participants will be required to become members of the Friends of the Museum of Victoria, who will be handling bookings.

For more detailed information, please contact: Dr Alan Yen, Invertebrate Survey Department, Museum of Victoria, 71 Victoria Crescent, Abbotsford 3067 Phone: 419 5200, Fax: 416 0475.

The Ecology of Grasses and Grasslands in Lowland Victoria

John W. Morgan*

Abstract

The complexity of native grasslands arises because of the diverse range of native plants (and animals) that contribute to the community and to variations in community composition under different environmental conditions. Whilst we can identify and classify the types of plants that occur in grasslands, we know very little of the relationships that occur between most species. The arrival of a whole suite of exotic species has further enhanced the complexity of grasslands. Grasslands prior to European settlement were shaped by macropod grazing, burning and interactions between the two. Recent management, however, has produced the remnants that we see today. A simple return to 'natural' regimes is impossible and will not conserve these ecosystems. Exotic species, for one, now play a significant role in the management of grassy communities.

Introduction

At first glance, grasslands may appear to be simple communities by virtue of their seemingly simple structure, i.e. just one apparent layer (Lunt 1991). Grasslands, however, may be extremely complex at the small scale (Patton 1935). Their complexity arises from the diverse floristic and faunal composition and their interactions with one another (Lunt 1991). Native grasslands are, after all, an ecosystem.

Before we can discuss how best to manage or restore such communities, we must first understand their component parts, i.e. what exactly is it that goes to make up a grassland? To say that the community consists of grasses interspersed with forbs is a gross simplification of the system. Whilst crudely true, it is the types of grasses and forbs which contribute to the grassland that will substantially influence the way in which the flora is managed.

Characteristics of grasses

The structure of grasslands is dominated by a single type of plant morphology - the grass plant. The more careful observer, however, comes to know the diversity of structure and life history that exists within the grasses. To illustrate how diverse grasses can be, and to start to understand how this diversity may effect the management of the flora, grasses can be classified in the following ways:

(i) **Origin** - grasses can be classified as being either native to a site (indigenous) or exotic. This is the simplest grouping but the most important. The aim of conservation mangement is to encourage the regeneration and survival of the native species whilst simultaneously discouraging the exotic species.

(ii) **Longevity of the individual** - the life-span of a grass is usually annual or perennial. Annuals are plants which live for a single growing season. The whole plant will die after having flowered and set seed. Annuals produce comparatively few shoots and most of these will bear inflorescences. Perennials are longer-lived plants. Many shoots may be produced but relatively few will produce flowers at any given time.

(iii) **Growth habit** - four growth habits may be recognised for perennial grasses but only three are of importance to most ground flora managers. The most common growth habit to be encountered in Victorian grasslands is that of the tussock-forming grass. A tussock consists of numerous tillers. A tiller has its own roots, stem and leaves. Each tiller arises from protected basal buds and can function independently of all other tillers. The major genera in native grasslands, *Themeda, Danthonia, Stipa* and *Poa* are all tussock grasses.

Other grasses produce horizontal stems either above or below the ground. Such grasses are termed stoloniferous if the stems occur on the soil surface, e.g.

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**Stenotaphrum secundatum* Buffalo Grass, or rhizomatous if the stems grow below ground. Both rhizomes and stolons may be found in the same species, e.g. **Cynodon dactylon* Couch Grass. Stolons and rhizomes both root at the nodes and if the internodes between the rooted nodes are broken, each piece can develop into a new plant.

The fourth, and least common, growth habitat exhibited by some grasses is that of the hummock. It is found in some of the inland grasses such as *Triodia* spp. Spinifex and will not be considered further here.

(iv) **Growth period** - the optimum temperature for growth of some species such as *Themeda triandra* Kangaroo Grass occurs in late spring and early summer (Groves 1975). Such species have therefore been termed **warm season** grasses. However, growth of these species seems to be as reliant on adequate soil moisture as it is on high temperature (McDougall 1989). *Themeda* usually grows most rapidly in late spring when there is abundant soil moisture. During summer and autumn, soil, moisture is often limiting and growth slows. During winter, growth is slow but true vegetative dormancy cannot be assumed since McDougall (1989) found that the winter growth rate of *Themeda* was much greater than the late summer growth rate. **Cool season** grasses grow over the winter months. Growth continues into spring when flowering and seed set occurs. As temperatures rise and soil moisture levels fall during summer, very little or no vegetative growth occurs. *Elymus* spp. (wheat grasses) are examples of native cool season grasses. Most annual exotic species also fall into this category. **Yearlong-green** species (Lodder *et al.* 1986) are generally capable of flowering in late spring and again in autumn given sufficient soil moisture and appropriate air temperatures. Vegetative growth occurs in spring and may continue into summer if soil moisture is not limiting. Yearlong-green species may include some of the *Danthonia* sp. wallaby grasses and *Microlaena stipoides* Weeping Grass.

The concept of warm season, cool season and yearlong-green species applies to optimum seasons. In the average season, however, there is likely to be considerable overlap in growth and flowering between species. The distinction between the growth period of grasses in southern Australian can therefore become blurred.

(v) **Physiology** - grasses can be categorised as either C3 or C4 species according to the way in which they assimilate carbon during the process of photosynthesis. C4 species are also typically warm season species. The importance of this classification is that the dominant grass of many grassland remnants, *Themeda triandra*, is a C4 species whereas many of the most troublesome grassy weeds of grasslands are C3 species, e.g. **Phalaris aquatica*, **Nassella neesiana*. The manager of the community may therefore be able to exploit the differences in physiology between C3 and C4 grasses as a means of controlling the exotic species (McDougall 1989).

The above classifications, although detailed for grasses, can also be applied in part to grassland forbs. Indeed, Lunt (in press) suggests that both the growth form and life form are the most useful means of classifying grassland forbs. Such schemes are vital to understanding the functioning of grasslands and may provide a useful means of predicting their response to a management.

What characterises Victoria's grassy flora?

Victoria's once extensive natural grasslands (Lunt 1991) were dominated by perennial, tussock forming grasses such as *Themeda, Stipa, Danthonia, Poa* and *Enteropogon*. Very few annuals were found in *Themeda*-dominated grassland communities (Willis 1964) although their contribution was more significant in the less productive northern and Wimmera plains grasslands (McDougall *et al.* 1993). By contrast, the introduced flora found in grasslands today is dominated by annual species (Table 1).

Table 1. The percentage of annuals in the native and exotic floras of a range of lowland grasslands in Victoria.

Region (site location)	% of native species as annual	as annual	% of exotic species Source
Basalt Plains	9	nd	Willis (1964)
Basalt Plains (St Albans Rail Reserve)	14	76	Groves (1965)
Basalt Plains	10	52	Stuwe and Parsons (1977)
Basalt Plains (Derrimut Grassland Reserve)	14	57	Lunt (1990c)
Basalt Plains (Mt Mercer Rd)	3	50	McDougall *et al.* (1992)
Basalt Plains	9	nd	McDougall *et al.* (1992)
Murray Valley Riverine (Northern) Plains	21	60	McDougall *et al.* (1993)
Wimmera Plains	17	55	McDougall *et al.* (1993)

nd = no data available

The implications of these high numbers of exotic annual species in grasslands are varied:

(i) As C4 grasses such as *Themeda* enter their main growth period in late spring, annual grasses have finished their life cycle. The annual grasses therefore do not compete directly for the same resources as *Themeda* (McDougall 1989). The germination and establishment of *Themeda* in the presence of weeds is also unaffected (Hagon 1977; McDougall 1989). However, since *Themeda* seedling establishment is inhibited by a thick cover in a natural grassland (McDougall 1989), there is likely to be a degree of competition beyond which successful establishment will not occur.

(ii) The occupation of space by exotic annual species may restrict or narrow the opportunity for re-establishment by native species (Scarlett and Parsons 1982). Seedlings of native forbs may be particulary vulnerable to competition from annual grasses as many forbs have similar growth patterns to exotic annual grasses (i.e. are cool season species).

(iii) The assumed competitiveness of many exotic annuals (e.g. high rates of biomass production, high levels of seed production, etc.) has been suggested by Adair (1985) to lead to the displacement of the native species most closely paralleling the same ecological strategy, i.e. annual or short-lived species. Alternatively, native species of poor competitive ability may be lost from a community when exotic species exceed some critical minimum density and cover. Carr *et al.* (1988), for instance, demonstrated that at high cover (50-60%) and density (>200 plants/m^2), *Briza maxima* reduced the total native species richness of a Box-Stringybark Woodland by approximately 75%. These effects began to occur when the cover of *Briza* exceeded 10% and density exceeded 50 plants/m^2. The mechanisms causing the reduced species diversity are unknown but are likely to include severe root competition, shading and soil moisture stress.

(iv) Since annuals are short-lived as individuals, their main means of persisting at a site is to form an enormous soil seed bank (Lunt 1990a). The disturbances which are necessary to maintain native species diversity (e.g. burning) are therefore likely to promote exotic species as much as, if not more than, natives (Lunt 1990a,b). For example, Lunt (1990b) found that three species of exotic annuals accounted for 60% of all individuals after an autumn fire in a *Themeda* grassland. Any benefit bestowed by burning to the diversity of native species may be offset by the dramatic promotion of exotics. Many exotic annuals may therefore have to be considered permanent members of our grassland communities, particularly in degraded remnants (Lunt 1990a).

Some basic grassland ecology

Native grasslands consist largely of tussock forming grasses which are seperated by distinct intertussock spaces (Patton 1935). These intertussock spaces are often carpeted with cryptogramic soil crusts (Scarlett 1944) and support a whole suite of smaller plant species. These are often forbs, among which members of the Asteraceae, Fabaceae and Liliaceae are particularly abundant (Willis 1964).

In grasslands dominated by vigorous species such as *Themeda*, some form of disturbance or stress is required to prevent the dominant grass from outcompeting the smaller plants. In the absence of disturbance to the vegetation (not the soil), vigorous species accumulate biomass and cause lower species richness due to competitive exclusion (Grime 1979). Low diversity may result from the capture and utilisation by the dominant species of light, water or nutrients, or from restrictions on niche availability, particularly for regeneration.

Prior to European settlement, the biomass of some grasslands would have been reduced by macropod grazing and periodic burning by Koories. We know very little of the original intensity of grazing by macropods, nor the frequency and season of burning by Koories in these communities. However, from research that has been conducted in (often degraded) grassland remnants, the following points about burning and grazing by native herbivores can be made:

(i) although probably frequently subjected to fire, most native grassland species do not need fire *per se* to regenerate. Rather, it is the release from competition with the dominant grass and the removal of surface litter that allows species to regenerate.

(ii) the diverse grassland flora found in frequently burnt rail and road reserves compared with those sites that are grazed (by domestic stock) or unmanaged (Stuwe and Parsons 1977; McDougall *et al.* 1992) suggests that most grassland species are well adapted to fire. Those that are not would have disappeared long ago. Some grasses such as *Themeda* and *Stipa* possess seeds with long awns. These awns help to drill the seed into the soil and therefore protect them from the heat of a fire (Lock and Milburn 1970). Most perennial species are capable of regrowing as individuals after a fire. They regrow from protected basal apices, tubers, underground buds, etc. Indeed, Lunt (1990a) found very few native perennials regenerating by seed after an autumn fire in a long-grazed and long-unburnt *Themeda* grassland. Where seedlings of a perennial species did not occur, they were considerably less abundant than were plants of the same species that regenerated vegetatively.

(iii) a burnt *Themeda* grassland can return to pre-disturbance biomass levels within 2-4 years (Robertson 1985; McDougall 1989). To have maintained their species diversity, *Themeda* grasslands must have been frequently burnt (or otherwise disturbed) prior to European settlement.

(iv) given that many native species can regenerate vegetatively after a fire and that there are few obligate seed regenerators in grasslands (at least in the remnants that survive to this day), the destruction of a single years crop of seeds will be inconsequential for the survival of most native species. It is therefore unlikely that the season of burning alone would have greatly affected grassland floristics, although Scarlett and Parsons (1982) hypothesise that the rarity of late-flowering native peas, e.g. *Glycine*, *Psoralea*, in some rail reserves is due to late spring/summer burning. **It is the frequency of burning that is the important determinant of the effect of season burning** (Scarlett and Parsons 1982; Robertson 1985; McDougall 1989), e.g. annual spring burning may prevent a species from flowering, setting seed and ultimately from regenerating by seed although the fire itself may have little or no adverse effect on the survival of the standing population of that species.

(v) native herbivores would have had an important effect on the ecology of native grasslands. This would have been due to localised grazing, trampling and digging and their effects on plant survival, reproduction and recruitment (Pyrke 1993).

(vi) Eastern grey kangaroos have been shown to be highly selective grazers (Robertson 1985). Their diet in a grassy woodland at Gellibrand Hill near Melbourne consisted mostly of monocots, particularly grasses. Where grazing of the dominant grass occurs, subordinate species such as forbs may benefit due to a release from competition. The complexity of macropod grazing is shown, however, by Allen (1987). He studied Swamp Wallabies at Gellibrand Hill and found them to browse woody and broadleaf plants more than grasses. To make generalisations about the effects of native herbivores in grasslands is therefore very difficult.

(vii) the combined effects of kangaroo grazing and burning were greater than the effects of kangaroo grazing or burning in isolation when studied in a *Themeda* dominated understorey (Robertson 1985). In pre-European grasslands with potentially high (localised) numbers of macropods and frequent Koorie burning, this interaction would have been a significant factor in the shaping of natural grasslands.

Whilst Koorie burning regimes and macropod grazing were obviously important factors in the ecology of pre-settlement grasslands, a simple return to these presumed ecological regimes will not be sufficient to ensure the proper management of remnant grasslands. Firstly, it is recent management that has produced the remnants that we see today (McDougall *et al.* 1992). Many roadside remnants of *Themeda* grassland in western Victoria have been burnt annually since the land was subdivided for soldier settlements. This ecologically 'unnatural' regime has produced some grassland remnants of national significance that are best conserved by maintaining the existing management unless there is an overwhelming ecological justification to do otherwise.

Secondly, the presence of exotic species, both in the standing vegetation and in the soil seed bank, means that today's 'native' grasslands will respond differently to burning and macropod grazing than did the original grasslands. Burning, for instance, may not significantly improve native species diversity (McDougall 1989; Lunt 1990a) presumably because many natives do not form persistent seed banks. Some exotic species, however, possess very large soil stored seed banks (Lunt 1990a) and burning will promote the establishment of these species. Lunt (1990b), for instance, found that both **Vulpia bromoides* and **Briza minor* increased 100-fold after an autumn fire. The imposition of a regular burning regime will, therefore, undoubtedly maintain high densities of these exotic species.

Similarly, the reintroduction of macropod grazing may lead to an increase in unpalatable exotic species. Robertson (1985) found that **Arctotheca calendula* and **Trifolium* spp. became particularly abundant in a grassy woodland since the kangaroos that graze the community favoured eating grasses over dicot species.

Clearly, when the aim of ground flora management is the promotion of native species at the expense of exotic species, an integrated approach is required. In degraded remnants, fire and native herbivores cannot be expected to achieve these aims on their own (Lunt 1990b).

Conclusion

We generally have a good knowledge of the species that contribute to grassland systems. We even have a basic understanding about some of the ecological relationships that exist between species in grasslands. However, we still do not have sufficient knowledge to prescribe proper management guidelines for all sites and species. Although ecological studies have shown the importance of burning and macropod grazing, the data are scarce. Much of it comes from 'once-off' events at only a few localities and applies to only a limited number of species. Very little is known for communities other than

Themeda grasslands. Before we can confidently recommend a burning or grazing regime for a particular site with a particular suite of native and exotic species, research will be needed to define more accurately the impact of our actions on individual species, particularly the rare and endangered ones, and on the community as a whole. One thing is sure - we will have to live with exotic species in our grasslands. The challenge for vegetation management will be how to best manipulate the system to the advantage of the native species.

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The Role of Fire in Ground Flora Ecology

John Stuwe*

Introduction

The effect of fire on ground flora will vary according to features of the fire itself such as:

The thoroughness of the fire (i.e. how patchy the burn is). This is related to the intensity of the fire but is also related to site features such as the presence of large rocks or fallen logs which can break the continuity of the burn and leave some unburnt vegetation.

The season of the fire. A fire in spring which removes seed or flowers will presumably have a different effect to a fire in autumn when most species have shed seed. The survival of plants which have germinated from seed following the fire will also be affected by the season of the fire - fewer seedlings would be expected to survive a summer immediately after a spring fire compared to the winter after an autumn fire.

The effect of fire on the floristic composition and structure of ground flora also varies according to the vegetation itself (e.g. the structure and floristics of the vegetation) and according to site parameters such as climate and soils.

In productive habitats, where plant growth is not inhibited by lack of nutrients or water, biomass increase is limited by 'external' factors such as fire, grazing and parasitism. In unproductive habitats, the lack of available nutrients or water also inhibits plant growth.

Species richness (the number of species per unit area) is affected by environmental (edaphic, climatic) stress and by 'external' stress. In productive habitats, in the absence of grazing, burning and other processes which decrease plant size and/or vigour, those species which are able to efficiently exploit the environment may exclude other species by competition. Grime (1973) identified a number of characteristics of species capable of competitive exclusion. These include: tall stature in relation to associated species, an expanded tussock growth form, and an ability to deposit a dense layer of litter - features exhibited by *Themeda triandra* Kangaroo Grass (Stuwe and Parsons 1977). This species is the major dominant of many of Victoria's grasslands and grassy woodlands.

Two grassy ecosystems with a ground layer dominated by *Themeda* are discussed here - Basalt Plains grasslands, and plains grassy woodlands on soils of sedimentary or grantic origin. The *Chionochloa pallida* and *Poa sieberiana* dominated growth layer of Box-Stringybark Forests and woodlands are also discussed briefly.

Basalt Plains grasslands

The flat, virtually treeless and relatively fertile basaltic plains of south-western Victoria offered ideal pastoral land ready for immediate stocking with sheep. Agricultural development was rapid and thorough with the result that 99.9% of the grasslands have now been lost and the few surviving remnants have all suffered some form of disturbance and weed invasion.

The basalt itself is very recent, having being laid down between the end of the Miocene and a few thousand years ago. The flora is therefore also very young in geological terms, and people (and their use of fire) have had a major influence on the flora for a signficant proportion of its development.

Fire is one likely reason for the absence of trees and shrubs on the plains but is not the only reason - soil structure, topography, climate and competition from *Themeda* undoubtly have played a role.

In the absence of fire and intensive grazing, *Themeda* forms a dense sward that produces abundant plant litter. *Themeda*

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grasslands from long unburnt sites are usually poorer in the number of associated species than either regularly burnt sites or those grazed by stock. Both burning and grazing can be seen as factors which reduce the competitive ability of *Themeda* and allow the growth of a range of associated species (in terms of Grime's 'competitive exclusion').

Grasslands on the fertile plains would have experienced frequent natural fires. The arrival of people tens of thousands of years ago would have increased the fire frequency on the plains due to their deliberate use of fire for hunting, (directly, and indirectly to attract animals to the new growth following the burn) and presumably accidentally, with escapes from camp-fires. The flora would certainly have been adapted to frequent fire at the time of European settlement - any species which were not adapted would have already been eliminated or occupied particular micro-environments which would have escaped regular burning.

The effect of frequent burning before European settlement would have been the reduction of size and vigour of the dominant species and the growth of a suite of associated native herbs. All remnants now carry some introduced species and all are surrounded by areas of predomiantly introduced species. The effect of reducing size and vigour of the dominant species is now to allow the growth of introduced as well as native species. Grazing, in addition to fire, is likely to further favour introduced species due to associated soil disturbance. The vegetation surrounding the remnant (the surrounding vegetation will be particularly important for small remnants), and the character of the soil stored seed within the remnant will now largely influence the effects of fire. Lunt (1990a) studied the impact of a single autumn burn on a long-grazed *Themeda* Grassland at Derrimut, 14 km west of Melbourne. He found that 'The fire promoted abundant regeneration of exotics from seed, particularly *Vulpia bromoides, Romulea rosea, Briza minor* and *Aira cupaniana*. However, few native species regenerated from seed.' There was not, however, a consistent change in vegetation composition following the fire. The species present in the soil seed bank studied was composed of 59% exotic species and 41% native species. The proportions of individual seeds, however, was 91% exotic and 9% native (Lung 1990b).

Weed invasion following fire has obvious consequences for using fire as a management tool in grassland remanants to either simulate natural processes or to reduce the representation of introduced species while increasing the representation of native species. Where there is an abundant source of introduced seeds an increase in these species (at least initially) can be expected. In many cases this may not be a serious problem - or at least one outweighed by the benefits of encouraging native species. In other cases, few native species may benefit and/or serious and persistent weeds may be encouraged. Chilean Needle-grass *Nassella neesiana* is an example of such a weed of grassland remnants; this species threatens to dominate several grassland remnants near Melbourne. Burning should not occur in infested areas without follow-up treatment to remove the weed (unfortunately this currently means spraying with herbicide).

Without burning, however, most associated native species will be lost or drastically reduced in abundance. Much research is needed into grassland management lest the few remaining remnants become weedy paddocks or virtual monocultures of *Themeda*.

Sedimentary plains grassy woodlands

Areas of sedimentary soil carrying *Themeda* dominated grassy woodland occur on the Western Plains of Victoria. The vegetation is in some ways similar to that of the Basalt Plains but with some significant differences. Stuwe (1980) found *Themeda* grassland on sedimentary soils near Mortlake to be richer in the number of species than those of the Basalt Plains. The floristic composition also differed - in the representation of species or the degree of representation. Native species persisted far better than would have been expected of basalt grasslands given a similar degree of disturbance, possibly due to less fertile soils. Lunt (1990c) studied grassy woodlands in the Grampians and at Langi Ghiran on alluvial soil and soil derived from granite. He found these to be among the most species-rich terrestrial vegetations of the world with up to 45 species recorded from one square metre. The areas had been grass tussocks to less than 5 cm high at all sites. While grazing is unlikely to have contributed significantly to species-richness, it is likely to help maintain it by decreasing competition from the dominant grasses (Lunt 1990c). Fire and grazing probably both helped maintain species richness at these sites prior to European settlement.

Such areas do not seem to be as productive as some of the basalt grasslands, probably due to poorer soils, and natural fires were presumably far less frequent than on the more productive sites. The dominant grasses at some sites, on very poor soils, may not ever form a dense sward capable of excluding other species by competition, as even minor grazing would be sufficient to keep biomass low and decomposers would similarly deal with litter accumulation.

Grassy dry sclerophyll forest

Open forests with a grassy and/or shrubby understorey occur on soils of generally poor structure and low nutrient levels, such as those derived from Ordovician and Silurian sediments north-east of Melbourne. The ground layer is often dominated by *Poa sieberiana* Grey Tussock-grass and *Chionochloa pallida* Silvertop Wallaby-grass. *Themeda triandra* may dominate the ground layer of some sites.

These sites would presumably have burnt at a lower frequency than those mentioned above, probably around every 15 to 20 years or more. The ground-layer dominants tend to grow into discrete (albeit relatively large tussocks with large spaces in between, in contrast to the dense swards in *Themeda* Grasslands where virtually no spaces between tussocks in the absence of fire or grazing. Competition from the shrub and tree layers, and often low productivity of the sites are likely to contribute to the relatively open nature of the ground layer.

Even in the long-term absence of fire, it is unlikely that many species would be excluded by competition from the dominant grasses in this vegetation type. Some shrubs, such as peas and wattles, may decrease as a result of the lack of fire, as fire stimulates seed to germinate from the soil seedbank. In contrast, fire at a frequency greater than the time required for the plant to germinate, grow and set seed again may also result in the loss of these species.

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Buried Soil in Volcanic Ash Sequence at Bullenmerri and Gnotuk Maars, Western Victoria, Australia

E. B. Joyce* and S. M. Hill**

Introduction

A section exposed in a road cutting between Lakes Bullenmerri and Gnotuk in Western Victoria provides the opportunity for a detailed study of the volcanic sequence and soils. This report records the result of examination of the cutting and contributes to the knowledge of the environmental history of the area.

Lakes Bullenmerri and Gnotuk are located on the western edge of the township of Camperdown, approximately 170 km west-southwest of Melbourne, within the Pliocene to Recent Western Victorian Newer Volcanic Province (Ollier and Joyce 1964). The lake areas represent maar craters that formed as a result of phreatomagmatic explosions (due to the explosive interaction of hot magma with ground or surface water). During these explosions fine volcanic fragments and gas were erupted. The result was the formation of wide craters, with deposition of ejected material around the crater rim to give tuff rings.

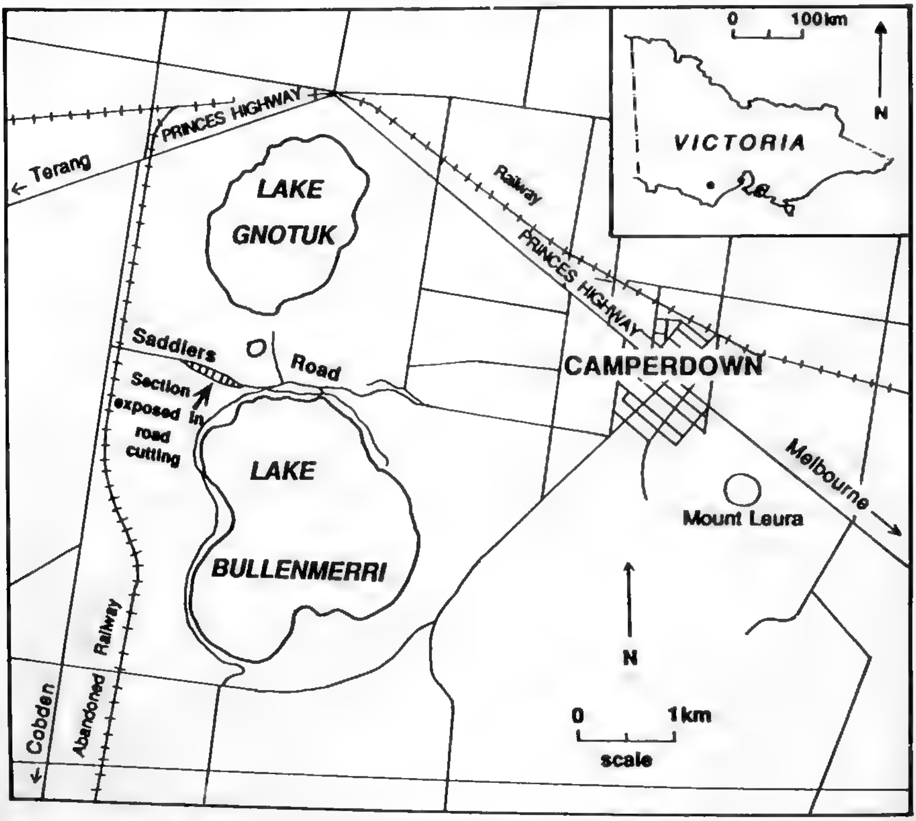

Fig. 1. Map of the Camperdown area showing the location of the road cutting.

Descriptions of the general features of the area have been by Grayson and Mahony (1910), Ollier (1967), Joyce and Knight (1973), Joyce and Evans (1976),

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Timms (1976), De Deckker (1982) and the area is covered by the Colac 1:250,000 sheet of the Geological Survey of Victoria. Grayson and Mahony (1910), Gill (1953) and Joyce (1988) have made specific references to the section exposed in this cutting. The figure and description by Gill (1953) suggested that the sequence represented violent and short-lived volcanic activity with an absence of any signs of intermission. This study has found the sequence to be more complex than was previously suggested with evidence for major intermissions in the volcanic activity.

Volcanic activity in this area is generally regarded as youthful, and Gill (1978) suggested that the eruption of nearby Mt Leura was about 22,000 years ago, based on radiocarbon dating related to ash deposits at Lake Colongulac, to the north. A minimum age for Bullenmerri of 16,000 years ago is indicated by radiocarbon dating of the base of a lake sediment core obtained for pollen study (Dodson 1979). A recent estimate of between 25,000 to 15,000 years ago for the final activity at Bullenmerri which built the crater rim, and thus the upper layer in the road cutting, is provided in a new study by Scutter (1993). Activity for any one of these maar volcanoes was probably short-lived, and measured in weeks or months rather than years or hundreds of years.

The cutting

The north-facing road cutting is on Saddlers Road which passes along the ridge between the two crater lakes (Fig. 1). Exposures occur along a distance of approximately 500 m, but are now becoming increasingly concealed beneath grass and slope deposits. The cutting and the road slope down towards the east, progressively exposing older volcanic deposits and finally the underlying Tertiary strata (Fig. 2).

The sequence

The sequence exposed in the road cutting is shown schematically in Figure 3.

Tertiary limestone - unit 1

The volcanic deposits rest unconformably on Tertiary limestone, which is exposed at the far eastern end of the cutting with a yellow and red lateritic podsol soil. Less weathered areas are a light whitish-grey and contain shelly marine fossils.

Basaltic lavas - unit 2

Basaltic lavas of the 'Gnotuk Basalt' (Gill 1953) occur at the base of the volcanic sequence. At least four different basalt units can be identified varying from

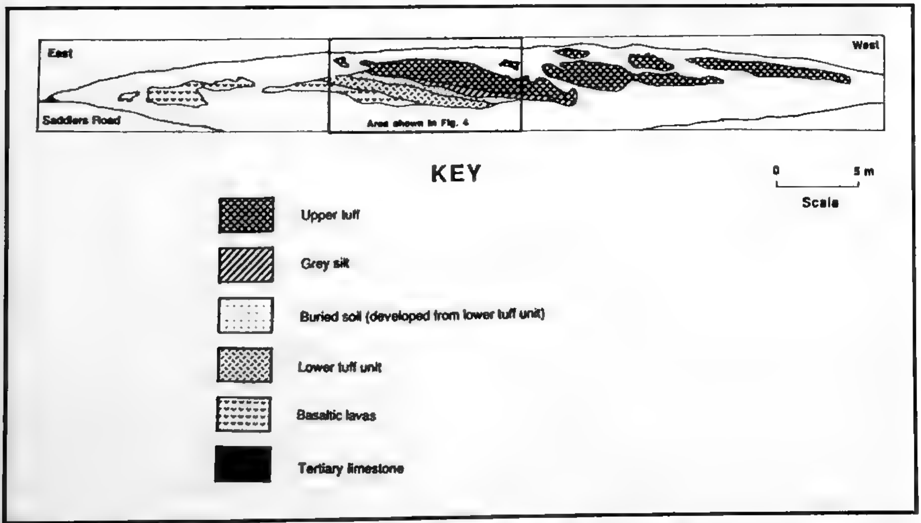

Fig. 2. Sketch looking south at the road cutting showing the relative positions of the main units.

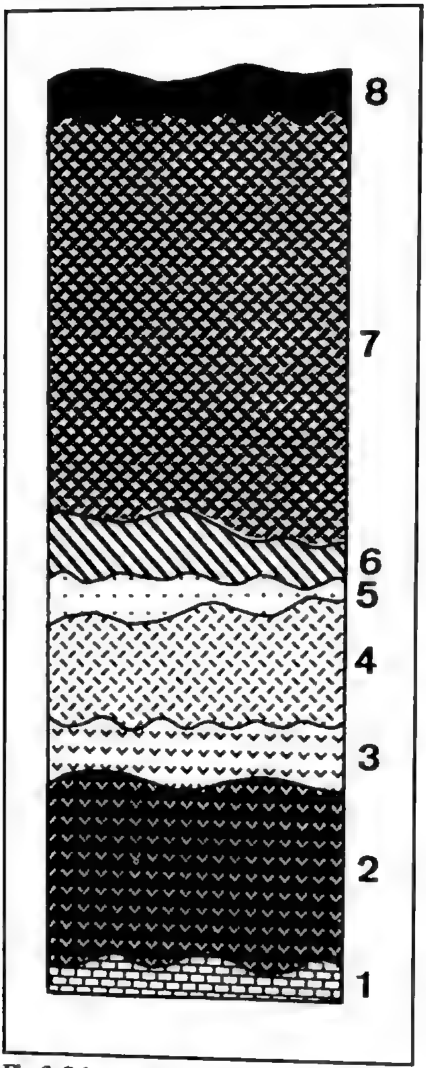

Fig. 3. Schematic representation of the sequence in the road cutting. (1 = Tertiary limestone, 2 = Basaltic lavas, 3 = Soil developed on basaltic lavas, 4 = Lower tuff unit, 5 = Buried soil developed on lower tuff unit, 6 = Grey silt, 7 = Upper tuff, 8 = Soil developed on upper tuff).

dark grey to red-brown and from highly vesicular to massive basalt. Some units have a distinct, fine-grained upper surface. Red, 'spatter-like' units suggest a pyroclastic origin for part of the sequence. The upper part of the basaltic lavas and its soil is affected by recent landsliding.

Soil developed on basaltic lavas - unit 3

The upper metre of the basalt has been weathered to a friable red-brown clay earth. Pedogenic structures are poorly developed, although the upper 40 cm of the profile consist of sub-angular polyhedral peds up to 5 cm in diameter. Also associated with the upper part of this profile are areas of dark purple staining (possibly manganese oxides/hydroxides) and salt efflorescence. Sub-angular 'buckshot' gravel (iron oxide/hydroxide concretions) occur throughout this weathering profile, particularly between 10 to 40 cm from its top. These have formed where iron oxides/hydroxides have precipitated from soil solutions due to the oxidation potential and greater susceptibility to dessication of this zone.

Younger tuffs bury this weathering profile, which represents a significant time interval between the effusion of the basalts and the deposition of the overlying tuffs.

Lower tuff unit - unit 4

At least 85 cm of thinly bedded grey-buff coloured ash, with occasional thin beds rich in fine grained, non-vesiculated basalt fragments overlie the basaltic weathering profile. This ash has been lithified, and bedding is clearly seen in Figure 4.

Buried soil developed on lower tuff unit - unit 5

The upper 50 cm of the lower tuff unit has weathered to a green-grey clay soil. This soil consists of angular polyhedral peds up to 3 cm in diameter that easily break down into angular fragments less than 1 cm in diameter. Carbonate concretions are abundant, mainly in the forms of rhizomorphs and sub-horizontal carbonate 'pans' that also extend down vertical cracks into the underlying tuff. The rhizomorphs are up to 5 cm in diameter and are evidence of colonisation of this soil by a well-developed vegetation community. The development of this soil and its associated features occurred during a significant cessation in volcanic activity.

Dark brown clayey areas within this soil

Fig. 4. Photograph of the central portion of the road cutting, looking south. (Numbers refer to the units shown in Fig. 3.)

represent contamination from the present surface soil that has moved down joints within the overlying upper tuff.

Grey silt - unit 6

A well-sorted grey clayey silt (Fig. 4) up to 35 cm thick overlies the undulating surface of the soil developed on the lower tuff unit. This unit has poorly developed sedimentary and pedogenic structures, although there is an abundance of carbonate concretions particularly in the form of rhizomorphs. The rhizomorphs within this unit continue down into the soil developed on the lower tuff unit indicating that the vegetation colonisation occurred after deposition of the grey silt. An even distribution of rounded 'buckshot' gravel less than 5 mm in diameter occurs throughout the silt.

X-ray diffraction analysis of a sample of this silt showed a dominance of quartz, indicating a non-basaltic source. The fine silt grain size, the rounded grain shapes and poor development of sedimentary structures, as well as the mineralogy, suggest that this deposit is of aeolian origin. Previous studies have documented similar deposits of aeolian origin from other parts of western Victoria (Gill 1953, Jackson *et al.* 1972) and it is possible that this deposit is related to them. Likely source areas for this quartz silt are the Tertiary to Quaternary beach ridges and quartz sand sheets found further to the west. In another study, oxygen isotope signatures of quartz grains from such source areas have been found to be similar to aeolian quartz accessions found in basaltic soils in western Victoria (Jackson *et al.* 1972).

Aeolian sand deposits are particularly sensitive to climate changes, being fixed by vegetation during wetter phases and mobilised during drier periods (Bowler 1976). The association of this grey silt with known arid periods during the Quaternary provides some potential in determining the age of the volcanic sequence.

There is a general acceptance that the last major dry period in southern Australia associated with dune activation occurred between 25,000 and 16,000 years ago

(Wasson 1986). If the grey silt deposit is related to this last arid period then the deposition of the lower tuff unit must have pre-dated this period and the upper tuff unit must post-date it. However the grey silt may instead be associated with one of the earlier arid phases that have occurred within the past 700,000 years (Bowler 1982).

Upper tuff - unit 7

The grey silt is overlain by more than 6 m of well-bedded brown-grey tuff. Beds are typically thicker than in the lower tuff unit although they are mostly less than 10 cm thick. This tuff unit is generally coarser grained than the lower tuff unit and contains a greater range of particle sizes including ash, lapilli and bomb-size fragments. Most of the beds are poorly sorted, although some are dominated by ash or lapilli size particles deposited during more explosive periods of volcanism. The lapilli-size fragments consist of accretionary lapilli, and basalt and limestone fragments. Bomb-size fragments of basalt or limestone are associated with impact structures which disrupt the underlying bedding, such as the large 'U-shaped' structure within the bedding approximately 10 m eastwards from the western end of the cutting. The upper tuff represents a resumption of eruptive activity following the weathering of the lower tuff unit and the deposition of the grey silt.

Soil developed on upper tuff - unit 8

The exposed upper tuff has weathered to form a dark brown earth which is the modern surface soil.

Discussion

Whilst this study has shown the presence of a break in the volcanic sequence exposed in the cutting, the interpretation of the origins of the associated events is open to discussion. Although Gill (1953) did not recognise this significant interval in volcanic activity, he was still able to distinguish between the two different tuff units. He suggested that the lower tuff unit was comparable in appearance to buff coloured tuffs that originated from Mt Leura (Fig. 1) and that the upper tuff originated from the Bullenmerri and Gnotuk craters. If this is so, then in the light of the evidence presented in this paper Mt Leura must have erupted well before the Gnotuk and Bullenmerri eruptions.

The large difference in grain size and unit thicknesses noted between the two tuff units suggests that the finer grained and better sorted lower tuff unit has originated from a more distal source than the upper tuff. If the lower tuff unit is from a more distal source then Gill's suggestion is of some merit, as Mt Leura is approximately six km east of this section while the craters of Bullenmerri and Gnotuk are adjacent to the section. The lower tuff unit also does not appear to extend very much further to the west (away from Mt Leura) as this unit is absent from sections exposed within an abandoned railway cutting west of Lake Bullenmerri. Such a distribution would not be surprising if the lower tuff did in fact originate from the Mt Leura eruption, as prevailing westerly winds which are known to have been associated with the dispersal of ash from other volcanoes in this region would have limited the distribution of ash from Mt Leura to the west.

Joyce (1988) however put forward the suggestion that the separate tuff units may have originated from separate eruptions of Bullenmerri and Gnotuk. The differences between the characteristics of the two tuff units may be due to different conditions during separate explosive eruptions of the Bullenmerri and Gnotuk maars. For example, different intensities of phreatomagmatic explosion or changes in prevailing wind directions at the times of eruptions might have produced variations in the deposits at any one point. Further investigation of the sequence in other sections within the area and the study of subtle geochemical differences between deposits originating from separate volcanic centres may provide the evidence necessary to resolve this problem.

Allowing for the weathering of the lower tuff unit, an event which must have taken at the very least several thousand years, and using Scutter's (1993) estimate of up to 25,000 years for the age of the eruption of the upper tuff, we can conclude that explosive maar activity from at least two major centres has taken place over perhaps 30,000 years or more. The underlying basalt lavas and the development of their soil cover are even older events.

Conclusion

A sequence of events for the units described within this cutting is as follows:

1. Deposition of Tertiary marine sediments followed by exposure and lateritic weathering of the emerged sediments.
2. Effusion of basaltic lava flows.
3. Weathering of lava flows and pedogenesis to form a red-brown clay earth soil.
   4. Deposition of volcanic ash (lower tuff unit) either by eruption from Mt Leura or from one of the eruptions of Gnotuk or Bullenmerri.
5. Major intermission in volcanic activity, with weathering and pedogenesis of the lower tuff unit.
6. Aeolian deposition of grey silt followed by stabilisation and coloni- sation by vegetation.
7. Resumption of volcanic activity in the form of phreatomagmatic explosive activity resulting in further lapilli and ash deposition (the upper tuff).
8. Lakes formed in Bullenmerri and Gnotuk craters. Colonisation of the modern landsurface by vegetation. Weathering and pedogenesis with localised erosion and deposition on slopes to the present.

Evidence within the volcanic succession exposed within this road cutting indicates that two separate periods of volcanic eruption have occurred. The intermission between these two periods of activity was significant enough to allow for weathering and pedogenesis of the lower tuff unit to occur, followed by the deposition and stabilisation of a grey silt. The interpretation of this exposure has provided greater insight into the volcanic and environmental history of the Camperdown area.

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Host-ectoparasite Interactions in the Bell Miner *Manorina melanophrys* (Meliphagidae) and other Sympatric Passerines

Aldo Poiani*

Summary

Several hypotheses were tested regarding the relationship between avian hosts and their ectoparasites using the Bell Miner *Manorina melanophrys* Latham and other sympatric passerines as a model. Richness of ectoparasitic genera decreased as age increased in Bell Miners, and infestation by ixodid ticks decreased when the colony density increased in the same host species; the latter result, however, was confounded by the different distribution of the understorey in the study site. Ectoparasite intensity tended to be positively correlated with Bell Miner body mass thus suggesting that the levels of parasitism observed did not have a dramatic effect on the development of hosts. Finally, cooperatively breeding and sedentary host genera tended to share more ectoparasite genera than migratory and non-cooperative hosts suggesting that philopatry may favour transmission of ectoparasites.

Host-parasite interactions have recently become the focus of intense debate especially with regard to the role of parasites in the evolution of mating systems and their importance in the process of epigamic selection (Hamilton and Zuk 1982; Borgia and Collis 1989). However, our knowledge of the relationships between Australian avian hosts and their ectoparasites is still relatively scant with few published works - outside the field of taxonomy- addressing questions of evolutionary significance (e.g. Borgia and Collis 1989).

Several variables can affect the relationship between host and ectoparasite. Age is a possible variable affecting the suitability of a bird as a host to ectoparasites (Arlian and Vyszenski-Möher 1987). Kuris *et al.* (1980) applied island biogeography theory to host-parasite interactions and predicted that older individuals (as well as long-lived host species) should harbour more ectoparasites than young individuals (or short-lived hosts). Borgia and Collis (1989), however, found that Satin Bowerbird *(Ptilonorhynchus violaceus)* males in juvenile plumage harboured more bird lice *(Myrsidea ptilonorhynchi,* Menoponidae) than adult males.

Following ontogenetic considerations it is possible to argue that younger birds may have less developed defences (both physiological and behavioural) against ectoparasites leading to differences in the ectoparasitic burdens of juvenile and adult birds; e.g. juveniles may be less skilful at preening, or they may need to develop immunological defences against ectoparasites, etc.

It is also expected that high colony density (Hoogland and Sherman 1976; Hoogland 1979; Hoogland 1981; Møller 1987; Shields and Brooke 1987) and sociality (e.g. cooperative breeding) (Alexander 1974; Poiani 1992a) should favour transmission of ectoparasites. Cooperative breeding is characterised by the presence of helpers, that is individuals careing for offspring which are not their own. Cooperatively breeding avian genera are mainly sedentary, whereas non-cooperatively breeding genera are mainly migrant or semi-migrant (Dow 1980; Brown 1987; Poiani 1992a). Sedentariness and sympatry among cooperatively breeding passerines may also favour invasion of new hosts by ectoparasites harboured by any host species, since hosts living close to each other are also more likely to transmit their parasites from one to the other. If this is true then cooperatively breeding genera should share more ectoparasite genera among themselves, than with non-cooperatively breeding hosts, and the former should also share more ectoparasites than non-

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cooperatively breeding host genera share among themselves.

Any hypothesis which suggests that a particular behaviour is an adaptation against ectoparasitism relies on the implicit (or explicit) assumption that fitness is negatively correlated with the degree of parasitism. There is good evidence that ectoparasitism affects growth rate and probability of survival of nestlings (see review in Poiani 1992b). However, negative effects on adult birds have also been detected. Møller (1991) found that haematophagous mites caused anaemia in male Barn Swallows *(Hirundo rustica)*, while ticks, which may transmit viral diseases (Ali 1963; Anderson and Magnarelli 1984), may be a cause of mortality among adult birds (reviewed in Feare 1976).

Here I test the hypotheses, that ectoparasitic loads change with the age and population density of the host, using data available for the cooperatively breeding Bell Miner *Manorina melanophrys*. The effect of ectoparasitic loads on morphometric measurements of Bell Miners was also investigated. Finally, I studied the effect that the breeding system and sedentariness has on the degree of overlap of ectoparasitic genera found among sympatric passerines.

Materials and methods

The study was carried out at the Sir Colin Mackenzie Zoological Park, Healesville, south-eastern Victoria. Birds were mist-netted from October 1988 to January 1989 (breeding season) continuously from 0800-1900.

Bell Miners were aged following Clarke and Heathcote (1988) (see Poiani and Fletcher (1994) for more details on the definition of age class 25.4 months). Body measurements were taken from the bird in the hand with calipers (tarsus) or a ruler (wing and tail) with a precision of 0.1 mm and 1 mm respectively. Body mass was measured with a 50g Pesola spring balance and 0.1 g precision.

Ectoparasites were sampled by exposing the bird's body to an environment saturated with chloroform vapours in a Kilner Jar apparatus (Fowler and Cohen 1983) for 1.5 min. This time of exposure allows for 100% efficiency in sampling mobile ectoparasites (i.e. hippoboscid flies) and about 25% efficiency for contagious ectoparasites (i.e. mites, bird lice and free-dwelling ticks) in the Bell Miner (Poiani 1992a,b). Parasites from the neck and head were counted by direct inspection.

Bell Miner density within the Park was not homogeneous. Two zones were identified by Poiani *et al.* (1990) which differed in local density of birds: zone A (with about 87 Bell Miners/ha) and zone B (with 22 Bell Miners/ha) therefore it was predicted that Bell Miners in zone A would harbour more contagious ectoparasites than in zone B. To test this hypothesis the intensity (i.e. number of ectoparasite individuals in each host) of ixodid ticks (which are contagious ectoparasites very easy to count) was compared among Bell Miners in both zones.

The following parasite sharing index was used in order to study the effect of sociality and sedentariness (since most of the sedentary species studied are also cooperative breeders (Poiani 1992a) whereas migrant or semi-migrant species are mainly non-cooperative (Dow 1980; Brown 1987; Poiani 1992a)) on the overlap in the ectoparasitic fauna of sympatric host species:

$$S_{AB} = 2R_{AB} / (R_A + R_B)$$

where R_A = total ectoparasite genera (contagious and mobile) in host A, R_B = total ectoparasite genera in host B, and R_{AB} = ectoparasite genera common to host genera A and B. If $R_A = R_B$ then there is complete similarity in the ectoparasitic fauna of both hosts and therefore $S_{AB} = 1$, if no ectoparasite is shared then $R_{AB} = 0$ and $S_{AB} = 0$.

Parametric and nonparametric statistical tests are given throughout. Parasitological variables used (i.e. richness (R), diversity (H'), prevalence (P), mean intensity (MI), relative density (RD) and intensity (I)) in this work are defined as per Margolis *et al.* (1982, see also Poiani 1992a).

Results

a) Effect of age on Bell Miner ectoparasitic loads.

Table 1 shows the data for five parasitological variables (all ectoparasites are considered) for Bell Miners of different ages. Bell Miners reach sexual maturity at about 9 months of age (Clarke 1988). It is clear from Table 1 that as the bird becomes older the body mass also tends to increase. In order to eliminate the effect of body mass on the parasitological variables I first found a regression curve between log (parasitological variable) (i.e. R, H', P, MI or RD) and log (body mass) of the kind:

$$\log y = a + b \log x$$

where y = any parasitological variable and x = body mass in grams. The linear regression curves were then used to calculate log y-predicted for each body mass value. Log y-predicted was then subtracted from log y-observed to obtain a value of log-residual (Harvey and Pagel 1991). Table 2 shows the log-residual values for each parasitological variable and age class. All log-residuals were normally distributed (Shapiro-Wilk test for normality: log R-residuals (nu = 0.379, G = -1.20, n = 5, P>0.50); log H'-residuals (nu = 2.916, G = 1.40, n = 5, P>0.90); log P-residuals (nu = 1.755, G = 0.37, n = 5, P>0.60); log MI-residuals (nu = 2.32, G = 0.80, n = 5, P>0.70); and log RD-residuals (nu = 1.652, G = 0.14, n = 5, P>0.50).

Table 1. Values of the parasitological variables for Bell Miners of different ages. All ectoparasites are included (contagious and mobile).

Age (months)	Mean Body Mass ± SD (gr)	(n)	Parasitological variables				
			R	H'	P	MI	RD
25.4	30.31 ± 1.68	(38)	6	0.668	50.0	2.10	1.05
9.2	29.28 ± 1.69	(26)	6	0.566	46.1	2.41	1.11
5.6	28.90 ± 1.81	(11)	2	0.294	63.6	1.71	1.09
3.8	29.00 ± 0.70	(2)	5	0.412	100.0	17.00	17.00
1.3	27.56 ± 2.49	(16)	6	0.432	93.7	14.93	14.00

Table 2. Log-residual values for the parasitological variables for Bell Miners of different ages.

Age (months)	R	H'	P	MI	RD
25.4	0.153	-1.735	0.006	0.057	0.062
9.2	0.497	-1.807	-0.137	-0.198	-0.335
5.6	0.118	-2.091	-0.037	-0.466	-0.503
3.8	0.715	-1.945	0.171	0.563	0.732
1.3	1.159	-1.920	-0.017	0.044	0.020

Table 3 summarises the Pearson's product-moment correlations between log-age and log-residuals. The general trend is for log-residuals to be negatively correlated with log-age but for the case of the ectoparasite diversity index (H'), however, the only significant correlation was for log R-residuals. Richness of ectoparasitic genera (R) which is independent from body size significantly decreased with age (P<0.05).

b) Effect of colony density on ixodid tick loads of Bell Miners.

A total of 176 Bell Miners was sampled: 88 in the dense zone (A) and 88 in the less dense zone (B). The distribution of ticks of the genus *Ixodes* on the birds was compared between zones using a Kolmogorov-Smirnov two-sample test.

Table 3. Pearson's product-moment correlations (r) between log-age and log-residuals of the parasitological variables for Bell Miners.

Parasitological variable	r	n	P
R	-0.833	5	< 0.05
H'	0.507	5	> 0.15
P	-0.204	5	> 0.30
MI	-0.176	5	> 0.30

Table 4 shows the frequency distribution of hosts with different tick intensities. Results of the Kolmogorov-Smirnov two-sample test are significant (D = 0.159, P<0.05). However, Table 4 clearly shows that birds harboured more ticks in zone B (the less dense zone) than in zone A (the more dense zone) thus falsifying the initial hypothesis.

c) Effect of ectoparasitic loads on Bell Miner body size measurements.

Table 5 shows median intensity of ectoparasitism, range and sample sizes for Bell Miners of different ages for which I have morphometric measurements. Values of intensity were not corrected for the efficiency of sampling (Poiani 1992a) which, in this case, is approximately constant throughout the age classes (minimum

Table 4. Frequency distributions of tick intensities on Bell Miners from a densely populated zone (A) and a less densely populated zone (B).

Zone	Intensity of ticks 0	1	2	3
A	77	9	1	1
B	63	19	5	1

Table 5. Median values, ranges and sample sizes for intensity of ectoparasitism (total ectoparasites) for Bell Miners of different ages.

Age class (months)	Median Intensity	Range	Sample size
25.4	0.00	0 - 8	38
9.2	0.61	0 - 13	26
5.6	0.61	0 - 5	11
3.8	17.00	5 - 29	2
1.3	8.00	0 - 63	16

= 24.6%, maximum = 25.6%). To make the test more conservative I restricted my analyses to birds 1.3 months old since they have by far the largest range of intensities and the second largest median value (Table 5). Furthermore, juveniles are still growing, although at a slow rate, therefore any possible effect of ectoparasitism on the body condition should be magnified at this age.

Figures 1a-e show the change in body mass (in grams), total head length (mm), tarsus length (mm), tail length (mm), and wing length (mm) with intensity of ec-

Fig. 1. Relationship between ectoparasite (contagious and mobile) intensity values and different body measurements of immature Bell Miners: a) body mass, b) total head length, c) tarsus length, d) tail length, e) wing length.

Figure 1a
Body mass vs intensity of ectoparasitism.

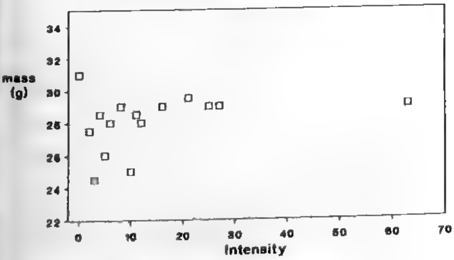


Figure 1b
Total head length vs intensity of ectoparasitism.

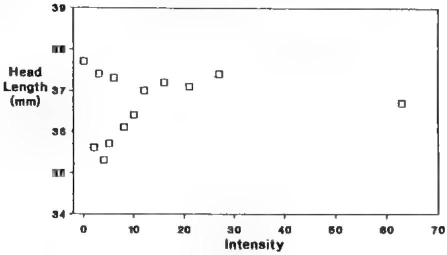


Figure 1c
Tarsus vs intensity of ectoparasitism.

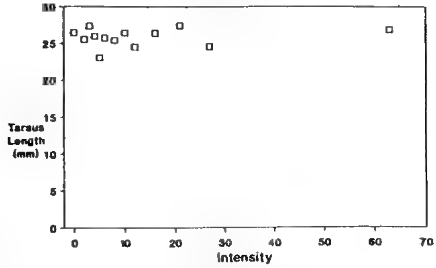


Figure 1d
Tail length vs intensity of ectoparasitism.

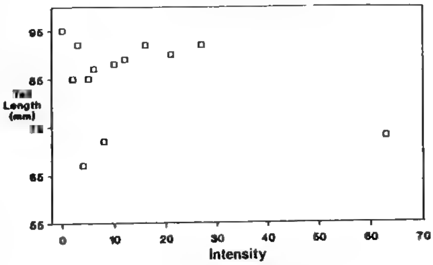
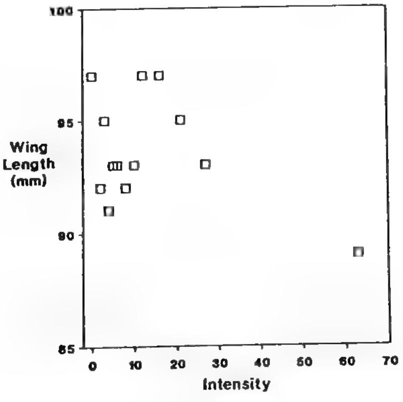


Figure 1e
Wing length vs intensity of ectoparasitism.



toparasitism at 1.3 months of age.

A Spearman's rank nonparametric correlation indicates that intensity of ectoparasites increases with body mass, although the value of rho is marginally not significant (rho = 0.394, n = 15, P = 0.07). Positive but not significant correlations are also found for total head length (rho = 0.101, n = 13, P>0.30), and tail length (rho = 0.140, n = 13, P>0.30). The only negative value of rho is for wing length (rho = -0.056, n = 13, P>0.40) which was not significant.

d) Comparison of the parasite sharing index between cooperative and non-cooperative host genera.

Table 6 summarises the values of the index for each pairwise comparison. Lists of parasites and sample sizes are available in Poiani (1992a,b). The mean value of S is larger for comparisons among cooperatively breeding passerines (S = 0.43) than for cooperative/non-cooperative comparisons (S = 0.33), and the latter value is larger than the value of S for non-cooperative/non-cooperative comparisons (S = 0.24).

The above result is consistent with the hypothesis that cooperatively breeding (and hence sedentary) host genera share more ectoparasites than migrant hosts. This result, however, can be confounded by phylogenetic relationships among the host genera. In fact, although most of the host genera pertain to the Australasian parvorder Corvida, *Zosterops* and *Aegintha* are a more recent inclusion in the Australian avifauna, representing the parvorder Passerida. Phylogenetic relationships between hosts and parasites have long been recognized (Waage 1979; Kuris *et al.* 1980). Therefore, I repeated the test excluding the Passerida genera in order to control for phylogenetic effects. Mean S values remained virtually unchanged: $S_{(coop/coop)} = 0.43$, $S_{(coop/non\text{-}coop)} = 0.35$, $S_{(non\text{-}coop/non\text{-}coop)} = 0.25$, with similarity decreasing as we change from comparisons among cooperative breeders to comparisons among non-cooperative breeders.

Unfortunately, a direct statistical test of the mean values of S between cooperative and non-cooperative breeders cannot be easily carried out. This is because statistical tests usually require independence among observations, but in this case S values sharing one host genus cannot be considered independent. A possible way out of this problem is to use a method initially devised to analyse similarity indices in DNA-fingerprinting. The method is especially designed to account for the covariance among similarity indices shar-

Table 6. Values of the ectoparasite sharing index for cooperatively and non-cooperatively breeding Australian passerines (see text for details).

Host Genera	Cooperative Breeders							Non-cooperative Breeders						
	S	E	M	C	Ma	Me	A	P	R	L	Ac	D	Z	Ae
S	--	0.00	0.25	0.00	0.18	0.25	1.00	0.20	0.00	0.15	0.00	0.00	0.00	0.00
E		--	0.71	0.50	0.58	0.71	0.00	0.62	0.20	0.73	0.60	0.20	0.20	0.40
M			--	0.50	0.58	0.71	0.25	0.62	0.20	0.73	0.40	0.00	0.20	0.20
C				--	0.40	0.50	0.00	0.57	0.25	0.47	0.50	0.00	0.25	0.50
Ma					--	0.58	0.18	0.52	0.30	0.63	0.30	0.15	0.30	0.30
Me						--	0.25	0.75	0.40	0.73	0.60	0.40	0.20	0.40
A							--	0.20	0.00	0.15	0.00	0.00	0.00	0.00
P								--	0.50	0.76	0.33	0.16	0.33	0.50
R									--	0.40	0.00	0.33	0.33	0.66
L										--	0.40	0.26	0.26	0.40
Ac											--	0.33	0.00	0.33
D												--	0.00	0.00
Z													--	0.33
Ae														--

S = *Sericornis*, E = *Eopsaltria*, M = *Malurus*, C = *Climacteris*, Ma = *Manorina*, Me = *Melithreptus*, A = *Acanthiza*, P = *Pachycephala*, R = *Rhipidura*, L = *Lichenostomus*, Ac = *Acanthorhynchus*, D = *Dicaeum*, Z = *Zosterops*, Ae = *Aegintha*.

ing one element (Lynch 1990; Lynch and Crease 1990). I am currently studying the possibility of adapting Lynch's (1990) method to any similarity index which takes the same form as the S index (see Materials and Methods section).

Discussion

The results obtained in the comparison of ectoparasitic loads between Bell Miners of different age classes support the findings of Borgia and Collis (1989) for the Satin Bowerbird which indicated that young birds harboured more ectoparasites than older ones. I do not know which mechanism(s) actually explain this difference between adult and juvenile Bell Miners. The Miners (genus *Manorina*) do not seem to allopreen, or at least they do not do it very frequently. I have never seen two Bell Miners allopreening during my study although they do preen. This contrasts with observations on other cooperatively breeding species (e.g. Superb Fairy-wren *Malurus cyaneus*) which have been observed allopreening in the study site *(pers. obs.)*. If Bell Miners must rely on their ability to preen themselves in order to control their ectoparasitic loads, and if the skills required to do so improve with age, then larger parasitic loads on juveniles can be the outcome of this ontogenetic process. However, other possible differences between juveniles and adults such as physiological condition, biochemical and histological properties of the skin, etc. (Arlian and Vyszenski-Möher 1987) may also help explain the same pattern.

An unexpected result was obtained in the comparison of tick loads on Bell Miners sampled in two colonies of different density. Bell Miners sampled in the relatively sparse colony (zone B of Poiani *et al.* 1990) harboured more ixodid ticks than Bell Miners sampled in the denser colony (zone A). A possible explanation is the unequal distribution of very low and dense bushes of *Coprosma quadrifida* in the two zones. Zone A clearly had fewer overall and also a smaller density of *C. quadrifida* plants than did zone B *(pers. obs.)*. Ticks may get onto their hosts while the latter are roosting in the low bushes. Bell Miners roost in the understorey (Poiani 1990), sometimes in small roosting parties, although in zone A they have also been observed roosting solitarily in the canopy of *Eucalyptus* trees. The higher branches of trees are places inaccessible to ticks which, in order to prevent dessiccation, do not normally leave the understorey (Arlian and Vyszenski-Möher 1987). Therefore, any possible effect of colony density on tick transmission is swamped in this case, by other factors which may be related to the distribution of the dense *C. quadrifida* understorey in the study site and the roosting behaviour of Bell Miners.

Ectoparasitism is not negatively correlated with body conditions among juvenile Bell Miners. Quite the contrary, heavier birds seem to harbour slightly more ectoparasites. Unfortunately, I could not follow those juveniles through their subsequent development in order to establish a possible effect of persistent ectoparasitism on the same morphological variables and on survivorship. However, this effect may not be very significant in this species since, as it is shown in Table 5, both the median value and the range of intensity decreased with age. The effect would be significant if low ectoparasitism at older ages is a result of differential mortality of highly parasitized juvenile birds.

Freeland (1976) suggested that the patterns of social behaviour in primates are a result (at least in part) of minimizing the probability of acquisition of new parasites and pathogens. Therefore group-living organisms are expected to limit the flow of individuals between social groups to those which are likely to harbour the same parasites as the host group. In this way social animals would avoid disrupting physiological adaptations to their parasites. If Freeland's (1976) hypothesis is correct then cooperatively breeding genera should harbour very specialised parasites while non-cooperative host genera should have more generalist parasites; if there is a limited flow of ectoparasites within a population of social hosts (i.e. between social groups), divergence of characters and perhaps speciation might have been favoured among parasites. In this case the values of S should have increased from coop/coop comparisons to non-coop/non-coop comparisons. Although a statistical test could not be carried out on the data set (the reasons for this are given in the Results section), the trend found was the reverse of that expected from Freeland's hypothesis: S values for coop/coop comparisons tended to be larger than for non-coop/non-coop comparisons. In the best case, a statistical test performed on my data will show that the similarity indices are similar (subject to limitations set by the statistical power of the analysis). The evolutionary event of a parasitic genus colonising a new host seems to be favoured by sedentariness of the host and it does not seem to be prevented by group living. This trend is not affected by differences in host sample size, and host body size between the two samples. Richness of parasites can increase with both the size of the sample (the larger the sample of hosts the more likely is to detect an uncommon parasite) and body size of the host. Cooperatively breeding hosts are both more represented in the sample (Poiani 1992a) and have larger body sizes, this may account for part of the difference between cooperative and non-cooperative hosts. If we eliminate the effect of body size and size of the sample on the probability of sampling rare parasites, the similarity indices for the Corvida show the same trend as above ($S_{\text{coop/coop}} > S_{\text{coop/non-coop}} > S_{\text{non-coop/non-coop}}$) although the differences in the S values are much reduced (unpubl. results).

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Predation of Butterflies by Birds

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Relatively few instances of predation of Australian butterflies by birds have been published. Although many naturalists have watched birds chase butterflies, the actual capture of a specimen seems to be an uncommon event. Here I summarise some of my own findings together with records extracted from the literature.

McFarland (1978) provided a detailed account of a female *Ogyris amaryllis* Hewitson being captured and consumed by a Singing Honeyeater *Lichenostomus virescens* in Western Australia. The capture occurred during the cooler, early hours of the morning when the butterfly appeared rather sluggish. Crosby (1988) noted that five specimens in his collection representing four temperate satyrines, Shouldered Brown *Heteronympha penelope* Waterhouse, Bright-eyed Brown *H. cordace* (Geyer), Kershaw's Brown *Oreixenica kershawi* (Miskin), and Silver Xenica *O. lathoniella* (Westwood), had beak marks, indicating that these species presumably had managed to escape from potential bird predators. Similarly, Faithfull (1988) recorded and illustrated three examples, Macleay's *Graphium macleayanus* (Leach), Monarch *Danaus plexippus* (Linnaeus) and Admiral *Vanessa itea* (Fabricius), which also possessed beak marks on the hind-wing. Brown (1988) observed a Black-faced Cuckoo-shrike *Coracina novaehollandiae* take a Cabbage White *Pieris rapae* (Linnaeus) and a Dollar Bird *Eurystomus orientalis* capture and devour an adult Blue Triangle *Graphium sarpendon,* both in New South Wales, and T.A. Woodger *(pers. comm.)* observed a *Graphium* sp. (probably *aristeus*) captured by a small honeyeater at

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Mt. White, Coen, northern Queensland on 5 October 1989. Faithfull (1988) observed a Willy Wagtail *Rhipidura leucophrys* capture and eat a small lycaenid butterfly near Melbourne in 1983, and then in 1986 observed the same species of bird capture a female Common Brown *Heteronympha merope* (Fabricius), also near Melbourne. An early reference to *H. merope* concerns the observations by W.C. Tonge at Eltham in January 1925 where a pair of Leaden Flycatchers *Myiagra rubecula* were recorded feeding their young on many adult *H. merope* (Barrett 1925). More recently, Faithfull (1994) observed a Rainbow Bee-eater *Merops ornatus* capture and eat, wings and all, a White Migrant *Catopsilia pyranthe crokera* (W.S. Macleay at Mt. Isa, western Queensland on 29 May 1989, whilst Lepschi (1993) recorded the same species of bird feeding on the Admiral *Vanessa ita.* Near Brisbane Dunn (1993) observed an Australian Magpie-lark *Grallina cyanoleuca* with an adult Yellow Palm-dart *Cephrenes trichopepla* (Lower) in its beak, and Hutchinson (1988) noted Willy Wagtails preying on adult Orange Palm-darts *C. augiades sperthias* (Felder) at Perth.

An interesting account is given by Scheermyer (1987) and Ford and Ford (1993) who describe the feeding behaviour of White-breasted Woodswallows *Artamus leucorhynchus* on the Blue Tiger *Tirumala hamata* (W.S. Macleay). In this instance the captured butterflies were dismembered and eaten in flight, so that the wings fluttered to the ground below. The birds apparently accomplish this by transferring the insect from the beak to the feet and then bending the head under the body to consume the insect. Ford and Ford (1983) also noted two other species of birds, Spangled Drongo *Dicrurus hottentottus* and a friarbird *Philemon* sp., taking *T. hamata*, each on a single occasion.

On 24 December 1985 at 8.00 am (EST) I observed a Magpie-lark capture and consume an adult *Heteronympha merope* at Eltham. Then, later in the season during January-March 1986 I observed many adults (mostly females) of this butterfly being eaten by Willy Wagtails during field studies at Gresswell Forest, La Trobe University, Victoria. After capture a bird would descend to a favorite patch on the ground and eat the bodies of the butterflies leaving behind the wings. When several adults had been eaten in this fashion a large pile of (accumulated) butterfly wings would remain! I have also witnessed a White-breasted Woodswallow capture and eat a Common Crow *Euploea core corinna* (W.S. Macleay) apparently without ill effects, on the Town Common, Townsville, Queensland, in late 1989. More recently, in 1991-92 I made three separate observations of bird predation by the Northern Fantail *Rhipidura rufiventris* in the Coastal Paperbark woodlands near Cardwell, north-eastern Queensland. On the first occasion an adult of the Evening Brown *Melanitis leda* (Fabricius) was captured and eaten at 1355 hrs (EST) on 5 June 1991. On 3 June 1992 I witnessed another *M. leda* captured and devoured, this time at 0758 hrs (EST). On 17 September 1991 I observed an adult male of the Cedar Bush-brown *Mycalesis sirius* (Fabricius) taken and eaten by a Northern Fantail soon after dawn at 0650 hrs (EST) when conditions were rather cool. In each case the fantails caught the butterflies with their beak whilst the insects were flying. In *M. leda,* the flight of both individuals was typical of the species, being fairly fast and erratic, but in *M. sirius* the individual moved somewhat uncharacteristically as it flew very slowly and more directly over the grassy understorey, possibly because its flight muscles were insufficiently warmed at that time of day. The captures of these two satyrines by Northern Fantails were extremely rapid and very precise giving little chance of escape for the individual butterflies concerned. After capture the bird, on each occasion, would fly a short distance to a nearby perch and consume the butterfly in its entirety.

On 3 October 1993 I was collecting several Azures *Ogyris* spp. as they came

Fig. 1. Male *Ogyris olane* from near Paluma, north-eastern Queensland. Arrows indicate location of beak marks. Wingspan approximately 30 mm.

in to feed on the flowers of a clump of mistletoe *Amyema bifurcatum* in the dry upland country west of Paluma, north-eastern Queensland. Five specimens (all males) were *O. olane* Hewitson. On setting them the next day I noticed one particular individual (Fig. 1) possessed a pair of obvious beak marks to the wings above, and the left hind-wing was very badly chipped. In this instance the butterfly had clearly been captured by a bird, but somehow managed to avoid being eaten. The record is interesting because members of this genus are extremely fast and erratic fliers, and with the exception of McFarland's (1978) record, one finds it hard to imagine that the species of *Ogyris* could ever be captured by birds!

At present we know very little of the escape tactics employed by Australian butterflies. In view of the paucity of our knowledge of butterfly predation, especially by birds, it would clearly be worthwhile to keep careful records when such instances are observed in the field. Studies overseas have shown that some adult butterflies are very toxic to birds, other species appear to defend themselves by a variety of behavioural mechanisms including rapid, jerky flight and crypsis when at rest. For example, I have watched Xenicas *Geitoneura klugii* being hotly pursued by Willy Wagtails but have yet to witness an adult of this butterful being eaten - their fast erratic fligh pattern seems to work well in preventing capture.

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Elementary Reflections on the Biology of Bryophytes

George A.M. Scott*

Introduction

Bryophytes are a group of plants known to most naturalists only in general terms, sometimes confused or mistakenly confounded with lichens, often depreciated as 'just moss'. In reality, they are a relatively small and ancient group of plants, clearly distinct and with no intermediates linking them to other groups. Even the puzzling genus *Takakia* which, since its discovery in the 1950s, has been the sole candidate for a connecting link with other groups such as algae or pteridophytes (ferns and their allies), or for a totally new group of plants within or without the bryophytes, has recently been shown, by the discovery of reproductive structures, to be unambiguously a moss.

Not only are bryophytes, both world-wide and in Australia, small in size and in number of species (1,500 to 2,000 in Australia, perhaps 20,000 world-wide) they have a comparatively small number of devotees, compared with flowering plants in Australia a dozen or two. But there is at present a good deal of activity in their taxonomy, some in ecology, and an increasing recognition of their value in experimental biology.

There are 3 groups which form the Bryophytes: Mosses (Musci), Liverworts (Hepaticae) both leafy and thallose, and Hornworts (Anthocerotae) although the precise level at which these groups are recognised taxonomically varies, and the forms of these names vary to match. Victoria is moderately rich in species with roughly 600, 250, and 6 in the 3 groups respectively. Moreover, Victoria played a large part in the post-war revival of bryology in Australia. From about the time of World War I to the 1950s, there was very little bryological activity in Australia. Then Jim Willis at the National Herbarium of Victoria, almost single handedly initiated the revival of the study of Australian bryophyte taxonomy (incidentally publishing the results of his research mostly in *The Victorian Naturalist),* closely followed by Ilma Stone and David Catcheside. Further impetus was provided by the publication of *The Mosses of Southern Australia* (Scott and Stone, 1976), *Mosses of South Australia* (Catcheside 1980.) and *Southern Australian Liverworts* (Scott, 1985). Now there is much current work on the bryophyte volumes for the *Flora of Australia* in the expectation of publication around the turn of the century. Bryophytes show half a dozen key characteristics, which direct their biology and ecology. These are explained in the following sections: (1) alternation of gener- ations with a dominant gametophyte, (2) lack of lignin, (3) sexual reproduction requiring free water but, paradoxically, (4) spore discharge requiring dry air, (5) totipotency and (6) a high proportion of species that are poikilohydric.

Alternation of generations

There is a life-cycle of two so-called 'generations'. One, the gametophyte, is haploid; that is, each chromosome in the nucleus of each cell is present only once. This is the generation which is always present and which is intimately dependent upon, and hence reflects, the ambient environment; the generation we mostly see and handle and think of as 'the moss'. In probably all cases, because of its totipotency (see below), this generation may reproduce itself vegetatively thus short-circuiting the full life-cycle. The second generation, the sporophyte, is diploid; that is, each chromosome in the nucleus of each cell is duplicated, just as in human beings. This generation, which has the form of a spore-producing capsule, arises only when there has been successful sexual reproduction of the gametophyte. In all cases it remains permanently attached to, and parasitic upon, the gametophyte, and at least partially dependent on it. Despite experimental attempts, and occasional dubious claims of success, the sporophyte generation cannot survive and develop by itself any more than the human foetus can continue to survive in the absence of the mother. One day, both of

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A moss, *Bryum* sp. with sporophytes. Photograph Bruce Fuhrer.

these may be possible experimentally, but not yet.

This kind of alternation of generations contrasts with that of the pteridophytes (such as ferns or clubmosses and their allies), where the sporophyte is the main generation and the gametophyte, a tiny transparent and flimsy plate, the prothallus, is a transitory part of the life history on which the sporophyte's dependence is only short-lived; and with the flowering plants and gymnosperms, where the gametophytes consist of little more than the haploid elements of fertilisation - the pollen grains and the ovules - which form the seeds.

In some bryophytes, for example the rare moss *Buxbaumia,* despite the dependent relationship between the two generations, their sizes are nearly equal. If anything the sporophyte is bigger although, in nature, the gametophyte may be much larger than is generally appreciated, being in the form of branching, alga-like filaments some of which are underground. Even without such rather bizarre cases, the two bryophyte generations are more nearly equal than in pteridophytes.

Of the many consequences of this life-cycle, one is of particular note. The gametophyte is the generation directly exposed to environmental selection, unlike the sporophyte which is partially insulated from most direct environmental stress by dependence on its maternal gametophyte. But in evolutionary terms a sporophyte, having two of each chrom- osome and hence of every gene, can accumulate mutations of single genes, each sheltered by the other matching gene which remains unchanged and functioning as before. Such a condition where there are two different forms of the same gene existing together is said to be heterozygous for that gene. In this way a sporophyte can accumulate hidden variability without exposing these new mutated variants to immediate environmental selection, but having them available for trial, as it were, in the future. This allows a sporophyte a much greater chance of coming up with a successful answer to new environmental challenges in the future, since it has a bank of possible variants in waiting, sheltered by the heterozygous condition. There is therefore a higher chance of the species evolving to meet new demands. In a gametophyte, by contrast, the haploid condition where there are no duplicate genes, means that all changes in genetic composition through mutation and through interchange at sexual reproduction, are unshielded and immediately exposed to environmental selection. The chance of any change being beneficial at any one instant is, of course, negligibly small, so the vast majority of changes will be eliminated immediately. That means that the bryophytes are unlikely to evolve rapidly. They are an ancient group, going back 350 million years or more, to the Devonian or earlier, which is another way of saying that they have not evolved greatly since that time. All plants - or at least all plants of a single ancestral strain - are of similar antiquity, but the groups that we call old are those whose crucial characteristics have remained unchanged over very long periods. The others have changed so much that their ancestors are no longer recognisable as such. i.e. they have evolved into new (and therefore 'younger') groups.

Lignin

There have been reports of lignin in some mosses but none (I believe) substantiated. This lack imposes limits to the erect height which bryophytes can reach. Although there are stories of some mosses reaching almost 1m in height, the usual limit is about half a metre and even that is a very big moss indeed. Lengths of nearer 3 m have been recorded, stretched out and floating in water, but the self-supporting height of an individual stem, lacking the strengthening power of lignin, is very limited and it is probably this feature more than anything else, that has kept bryophytes small. Being small seems to be correlated with a general lack of specialised conducting tissue, although one has to be careful not to argue cause and effect here. The group of mosses which contains our largest species, *Dawsonia, Polytrichum* and their allies, may have quite elaborate internal differentiation into tissues which are very similar to xylem and phloem in both form and function, but lack lignin and hence are conventionally classed as non-vascular. For the majority of leafy mosses and liverworts, probably most of the water conduction takes place externally (ectohydric) in the capillary spaces between the leaves and the stem. which act as wicks.

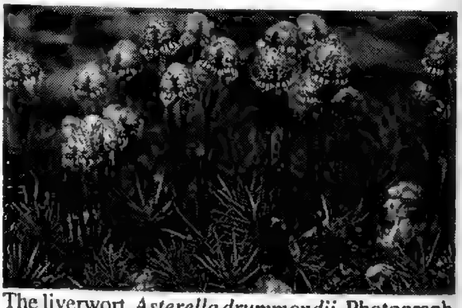
There is a further interesting aspect of the effect of the size limits imposed by lack of lignin. The plant bodies of the largest flowering plants are mostly dead tissue, wood, kept in place and kept functioning by the structural strength of lignin. Some bryophytes, especially thallose liverworts, may - like some lichens - be very old indeed, capable of indefinite growth at the apex while remaining small by the matching process of decay at the rear. In the absence of lignin, this dead tissue leaves no residue, and without serological matching it is impossible to tell whether or not all the plants of a particular species in an area are parts of the same original plant separated by branching and decay, but kept growing through centuries or even millennia. It is far from an unthinkable proposition that a thallose liverwort in Victoria could be part of the same plant as one in South America, separated in Gondwanaland and growing continuously ever since. The same, of course, could in theory be true of creeping flowering plant species of sufficient antiquity, but in that case lignin would tend to leave revealing traces. A further consequence of the lack of lignin is, in a sense, the exact inverse. Not only are bryophytes, lacking the strength of lignin, unable to rise very far vertically upwards, they are also unable for the same reason to penetrate very far vertically downwards. It is true that fungi penetrate the soil to considerable depths and in considerable intensity without the help of lignin, but they are saprophytic , finding their food underground. For an auto- trophic organism , like all known bryophytes bar one (the European *Cryptothallus mirabilis*), photosynthesis is the basis of life. *Sine lumine omnia pereunt.* To colonise effectively, below ground, requires the strength of lignin to keep open lines of communication and nutrition. Underground trains will not run if the tunnels collapse; nor will food and water and nutrients flow in a plant unless the channels of conduction are kept stiff and open.

Sexual Reproduction

This cannot take place in the absence of water. Free liquid water is required for the motile sperm (antherozoid) to swim to the female non-motile egg and accomplish fertilisation. This absolute requirement, which is overcome in the flowering plants and gymnosperms by bringing the male and female together beforehand by the process of pollination, imposes an ecological limit on bryophytes and may be partly the reason why bryophytes seem unable to colonise the driest habitats where lichens are abundant.

Spore discharge

Conversely the sporophyte generally requires dry air to accomplish spore discharge and this too may place an ecological limitation on the habitats easily occupied by



The liverwort, *Asterella drummondii*. Photograph Bruce Fuhrer.

bryophytes. There is a whole range of mechanisms, mostly based on hygroscopic movement of peristome teeth round the capsule mouth in mosses, or of spirally thickened long cells, elaters, in liverworts, which encourage spore discharge. Dr Ilma Stone has recently suggested *(pers. comm.)* the possibility that some aquatic mosses (*Fissidens* spp.) may release spores under water or on the water surface, even though they have normal dry-air discharge mechanisms, but there is little in the way of detailed observations on the subject. Possible mech- anisms could include squeezing the spores out by contraction of the capsule, or release when the capsule wall is eroded or rots. There are certainly other cases where moss spores are sticky and spread by agents such as flies instead of the customary air currents; and cleistocarpic (i.e. closed capsule) mosses which have no mechanism for dehiscence, but release their spores by erosion or irregular bursting or splitting of the capsule wall. Some liverworts such as *Riccia* have no other way of releasing spores than by rotting and erosion of the spore-containing tissues.

Totipotency

Bryophytes have a remarkable ability to regenerate entire plants from fragments or even individual cells. This is totipotency. Flowering plants can do so too from large portions such as cuttings, but generally not from small fragments in nature, and it took many years of experimentation before it was possible to bring this about in the laboratory. Bryophytes achieve it apparently without difficulty and without special conditions. Many species of both mosses and liverworts have special reproductive particles called gemmae, in the form of groups of one or more cells, which are dispersed and 'germinate' to produce new plants, but there are many other ways of vegetative propagation as well as gemmae and branching and decay (see under Lignin above): whole deciduous shoot tips, leaves, and even more commonly, parts of leaves either specialised for the purpose or casual fragments. I have seen a collection of moorland mosses dried, blended to a powder and sprinkled on a block of peat which was then kept moist; the particles of moss tissue, mostly only one or a few cells in size, grew into new individuals. For many bryophytes, this rather casual process must be the major method of propagation and indeed there are many species for which spore production is not known. Walk through a mossy forest in a gale and you will see fragments of mosses and liverworts being blown about like confetti, each capable of producing a new plant if it lands in a suitable habitat.

Poikilohydry

Many bryophytes, especially the mosses of dry areas, are resurrection plants. That is, they are capable of being desiccated without dying, able to resume metabolism and growth soon after being re-moistened. Such plants are poikilohydric and many lichens, but only a few pteridophytes and flowering plants, have the same capacity. It is this ability which allows mosses (and lichens) to grow on bare rock surfaces where they can withstand being baked to a crisp by full sun - in which condition, of course, any damage will also tend to lead to fragmentation and hence propagation (see Totipotency above). Sand dune plants, too, may show this capability and one Australian species from this habitat has been recorded as surviving in a greenhouse without water for 18 months but still resuming full photosynthetic activity within hours of being re-wetted. On the other hand, it does seem difficult for bryophytes to withstand full sun when moist, and in the hot wet tropics bryophyte growth seems to be predominantly in shade , where the moist plants can evade the damaging effects of sunlight. They can stand being baked but not boiled. It is the same, after all, for human beings.

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Soil Condition, Treatment and Disturbance Factors in the Management and Re-establishment of Vegetation.

Dale Tonkinson[1] and Russell Costello[2]

The importance of the soil in re-establishing the various components of the vegetation should not be underestimated nor should the long-term management of the soil be neglected.

What is soil?

Defined in a technical sense as the thin layer of weathered rock usually within a few metres of the earth's surface. For the purpose of this discussion, however, we shall extend this to include the crust which is compacted and/or chemically altered (oxidized) by constant weathering and the algae, mosses, liverworts and fungi that are inextricably associated with this crust (see Scarlett, this issue).

Characteristics of the soil

Below the thin soil crust mentioned in the definition above, is a region rich in organic matter derived from the decomposition of dead plants and animals; the depth of this layer (horizon) varies greatly with slope, vegetation and climate. Beneath the organic layer is a horizon of leached mineral soil where water has percolated through and leached out many of the minerals carrying them to the depth at which percolation ceases and redepositing them there. The clearest sign of this redeposition is a deep red colour where oxidized iron compounds have been deposited. The water table usually lies immediately below this area. The next horizon is unleached mineral soil and/or the parent material.

Most problems with soil structure and most soil disturbance in natural ecosystems affect the uppermost 5-10 cm comprising the surface or crust, the organic horizon and the top of the leached soil horizon.

Soil provides a number of requirements for plants: physical support for the plant's growth, water retention and availability, drainage, and nutrition. Its characteristics can be seasonally affected by variations in water supply and drainage, e.g. in the Basalt Plains of western Victoria, where, in summer, the soil dries and cracks causing damage to plant roots. Soil nutrition is significantly affected by the fertility of the soil and its pH level. Extremes of pH cause certain elements in the soil to become unavailable and other poisonous ones to become mobilised. Soil also acts as a host medium for many other organisms that interact with plants e.g. pathogens and mycorrhizae (see Keane, this issue). Seed dispersal agents (e.g. reptiles and ants) and predators (e.g. insects, ground-dwelling mammals and birds) interact with the nature of the soil.

Victorian Soils

Soils in Victoria vary enormously from sands to heavy clays and organic peats; many have fancy names but for our purposes it is sufficient to understand that clays, earths and loams, and sands form a continuum with generally increasing particle size and therefore with increasing friability and aeration. Within these mineral soils smaller particle sizes lead to denser (heavier) soils with greater water holding capacity, and soil fertility increases with the proportion of clay (small particles). Water holding capacity is not always as desirable for plants as it may seem because in wetter climates denser soils may become waterlogged and limit plant growth, whilst in dry climates clay soils may 'hold' all the water from a small to moderate rainfall i.e. bind it tightly to

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the clay particles, and very little, if any, will be available to plants. In dry situations, from an equivalent rain event, much more water is available to plants growing in sandy soils. Many soils are a complex mix of different soil types at different depths (e.g. sand over clay) and these different types vary in their water holding and nutritional characteristics.

Condition of the soil

The vast majority of Victoria's soils have been modified since European settlement, even mountainous forest lands have experienced altered fire regimes (affecting nutrient recycling), logging and public land grazing. Vegetation alteration by clearing, grazing and pasture works have often lead to a simplified vegetative cover that cannot withstand regular climatic fluctuations and does not interact with the soil in the same way as did the previously existing vegetation. These changes have lead to increased waterlogging and raised water tables often resulting in salinity problems. Inadequate vegetation cover has resulted in widespread wind and water erosion producing significantly altered surface characteristics of the soil. Compaction of the soil by grazing animals and vehicles alters the physical structure of the soil, making it less permeable to water and plant roots; in addition, it can cause localised microtopographic changes that may initiate sheet and gully erosion (e.g. regularly used walking and stock tracks across and down hillsides).

Chemical changes may also occur in some soils through nutrient decline caused by cropping or erosion which leads to loss of topsoil. Conversely, nutrient addition may occur from grazing animals, fertiliser use or point sources such as sewerage or sullage outlets. Nutrient addition often promotes the growth of weeds that out-compete desirable plants.

The effects of these changes to the soil vary across all soil types with some types being more susceptible than others to some changes. For example, waterlogging is usually only a problem of clay soils or shallow soils overlaying clays; salinity and compaction are most likely to occur on heavier loams and clays, while nutrient decline predominantly occurs in sandy or very shallow loamy soils. Water erosion, such as stream-bank, sheet and gully erosion, is more likely to occur on shallow coarse sands, loams and those clay soils with a hard setting surface (known as duplex soils). Wind erosion is mainly a problem with loams and clays in drier areas (evidenced by the dust storms of February 1983), but may also have localised effects in poorly vegetated sandy areas exposed to strong winds such as coastal dunes or sandy rises adjacent to flat plains, for example in north-west Victoria.

What is disturbance?

Disturbance is defined here as a rapid change to the status quo, it therefore does not include most of the changes described above. In relation to soil disturbance it is useful to distinguish different scales of disturbance as their causes and outcomes for the vegetation differ. Major disturbance, such as that resulting from most human activities, is that which covers more than 5 m^2 in a contiguous area and/or is deeper than 5 cm over a significant portion of the area disturbed; minor disturbance that rarely exceeds these dimensions, usually results from natural processes.

Natural disturbances and their effects

The most frequent and obvious source of natural disturbance in south-eastern Australia is the action of animals. Most diggings and scratchings affect a small area but the effects on the vegetation may be significant. The soil crust is broken, allowing easier water and root penetration and reducing local competition for water in particular. Other temporary changes, such as altered pH of the newly exposed soil not yet oxidized, have been implicated in promoting mycorrhizal activity and in turn orchid germination e.g. echidna diggings in coastal south-west Victoria (Calder *et al.*, 1989). Other mammals including wombats, bandicoots and rodents dig for food and the resultant disturbance presents germination opportunities in a wide range of environments. Most diggings are selective to a greater or lesser extent and therefore result in dispersed or patchy disturbance in both space and time.

The ultimate value of soil disturbance lies in its ability to provide suitable germination conditions for a wide range of plant species and in particular those species that rarely find such conditions otherwise. It may promote germination of soil-stored seed by physical disturbance of a hard seed coat in, for example, legumes. The scratching and feeding of some birds (e.g. lyrebirds) may be quite intense locally but rarely over a sufficient area to qualify as a major disturbance. Swamphens *Porphyrio porphyrio* and some Native Hens *Gallinula spp.* feed by pulling up seedlings, bulbous leaf bases and underground storage organs of mature plants from damp soil; at times, these birds will systematically and intensively work particular areas removing a large part of the original vegetation and turning the soil. Ant colonies cause intense localised disturbance of soil and vegetation around their nests that at times may even constitute major disturbance, not to mention a visual spectacle. Ants further disturb the environment by concentrating seed collected over a wide area in their nests. Burrows and nests of ground dwelling animals may also concentrate nutrients in addition to the physical disturbance of diggings and entry pads. Death of large animals and plants also results in local soil disturbance. Large carcasses flatten existing vegetation, encourage microbial and invertebrate activity that results in the localised addition of nutrients and possibly pH changes. The death of larger plants that remain standing for a time affects the soil surface by allowing increased light and water penetration as well as additional leaf litter. Uprooted trees, dead or alive, create obvious disturbance to their surrounds.

Soil cracking and movement due to climatic factors such as wetting and drying or freezing and thawing may help the movement of seeds into and within the soil profile and aid water infiltration. Fire, in addition to removing much of the vegetation, affects the soil surface structure, altering pH and nutrient levels in the soil.

An area that requires further investigation is a study of those conditions most suited to the germination of a wide range of indigenous species with few weeds and those conditions that encourage weeds. General observations suggest that major disturbance events are predominantly followed by weed germination and that minor events are more likely to encourage local species to colonise if sufficient quantities of seed are available.

Treating the soil, unnatural disturbance

In rehabilitating a site, the type and extent of treatment depends on the degree of naturalness of the soil. It is most important to minimise the long term effect of the treatment on the soil structure. One of the other crucial factors is to stop weed development.

With a less natural site it is less important what you do because the substrate has already undergone a change, but on reasonable soils i.e. those not degraded, it is possible to get back to a reasonable level of indigenous vegetation cover without any heavy site preparation. For example, to return some farm paddocks to a proportion of natural vegetation, it is often enough just to fence the area and exclude grazing. This may allow healthy young trees to establish, and once they are established other species can develop or can be planted. In shelter belts with a stand of trees growing, an under-storey often develops and sometimes even spreads beyond the belt. On the other hand, some sites need preparation. The yellow Duplex soils that are found in the eastern suburbs of Melbourne and many hill-country areas located from Broadford west to the Wimmera, set hard on the top and compact very tightly. This tightness prevents plant roots from getting established in the soil. Compacted soil has a bulk density of 2 whereas that of uncompacted soil is about 1.5 and water is 1. In an area of this type which is fairly natural, apart from the loss of top soil, it is advisable not to do too much. For natural regeneration or direct seeding a slight surface disturbance may be useful. Just tickle the surface with a cultivator, this will enable the seeds to establish themselves. A useful implement for this is the rake-hoe; a forestry tool, which has a flat blade one side and toothed blade on the other. The soil surface can then be chipped with the flat hoe blade and raked with the toothed edge. Seeds (from the area or nearby) are scattered over the area and tamped down with the hoe. Large areas can be regenerated quite cheaply by this method. The seeds that actually survive here will hang on after this initial help, and then nature should be left to take her course. Again it is important to exclude the weeds by as little disturbance of the soil as possible.

In some areas of highly compressed soils a clay breaker or conditioner and mulch may be required, but this is not advisable unless the top soil is totally gone and there are only the sub-soil clays left. The clay-breaker will create a top soil, but it also attracts weeds.

Where there is tunnel erosion it can be removed with a ripper, but as this destroys any of the propagules remaining on the site, indigenous species from surrounding areas should be planted and care taken to exclude weeds.

Some Alpine areas have a problem when their protective layer of upper soil is disturbed by cattle and traffic. This means that the plants are unable to re-establish themselves under the harsh winter conditions and a layer of mulch may be needed to overcome this problem.

In areas of severe disturbance it is important to get something established. These sites include areas of salinity and erosion where there are high levels of salt in the soil and the indigenous vegetation is unlikely to return. First it is important to deal with the catchment, the cause of the problem. The rehabilitation of the site then includes some drastic measures such as deep ripping, heavy fertilisation, growing cover crops (non-indigenous) and establishing salt tolerant species (non-indigenous). By a series of these phases it is possible to work towards a natural site. The reason for not using indigenous salt tolerant species is because their seed can enter the seed bank and alter the vegetation regime, while introduced plants are so characteristic they can be ripped out with impunity. An example of this has shown up in the use of salt tolerant River Red Gum *Eucalyptus camaldulensis* in saline areas of northern Victoria and the introduced form of the River Red Gum has spread its seed amongst adjacent indigenous forms - intraspecific hybrid forms may be produced that are not well adapted to either the saline or non-saline sites in the long-term.

Some heavily disturbed sites, mainly associated with mining, have a problem with pollutants and as with the salinity problem it is probably best to work through a series of unnatural vegetation types using introduced plants to recondition the soil by increasing the organic matter. After this see if nature will take over, if not use a cover crop, like rye corn (which dies after a year) to improve the soil condition until it is possible for the natural processes to take over.

Some areas may suffer from a chemical problem, usually an excess of fertiliser. This has come with the advent of agriculture. Since Australian soils are phosphorus deficient it is impossible to grow introduced cash crops. As a result superphosphate has been spread right across Victoria's agricultural land. Phosphorus is the most dangerous of chemicals when dealing with regeneration of indigenous species. It is non-volatile and persistent and in a natural area when weeds invade they grow more vigorously. In agriculture this is not so much of a problem because with cropping every season the phosphorus runs down. However, if a site is so degraded and poor that chemicals must be used, use nitrogen, in minimal amounts and place it close to the seed. Nitrogen is better because it remains only a short while in the soil before returning to the atmosphere. In highly disturbed areas even indigenous plants respond to nitrogen.

Soil acidification has only come to prominence in recent years and is usually associated with fertilised agricultural land. Soil sampling kits can be used to determine the pH of an area and its suitability for planting. Test the top soil of an area of indigenous vegetation close to the site, then test the site to be revegetated and note the comparative acidity. If there are only a few points difference do not worry. If there is a drastic difference, e.g. too acidic, add lime to the soil.

Another major problem in some sites is that of disease, specifically *Phytophthora cinnamomi*. In these cases it is best not to mess with the soil which would spread the problem. Since *Phytophthora cinnamomi* seems to have a cycle of a few decades it is important to establish resistant indigenous species.

In some areas the soil and other conditions seem to be good and yet the plants will not grow, this may be a microbiological problem. Around the 1930's it was discovered that some introduced plants such as Sub-clover *Trifolium subterraneum* needed specific soil microbes in order to grow satisfactorily in poor soils and it has now been discovered that this also applies to a lot of our indigenous plants. These microbes have a rhizosphere with a living symbiotic relationship with the plant and these microbes make the nutrients in poor soils available to the plant. Therefore, it may be necessary to inoculate badly disturbed sites. The simplest way is to take some soil from a nearby good area with indigenous plants and then dilute the amount and spread it over the area to be regenerated.

It is difficult to establish vegetation on sandy soils because of their poor water-holding capacity, the coarse grains allow the water to rapidly sink. A solution may be to mulch the area, or to add a hydrophilic polymer, a new product, which holds about 200 times its weight of water.

It is impossible to emphasise enough that the use of these treatments should be considered only as a last resort where the problem is so severe that normal, minimal impact techniques for re-vegetation have not, or will not, work.

Managing disturbance regimes in natural and semi-natural areas

Once we have realised the importance of disturbance in the on-going regeneration of vegetation we may wish to consider 'replacement therapy', i.e. the manager tries to mimic natural processes as a management tool. This requires clear objectives for both the vegetation as a whole and the use of disturbance itself. The objectives for the vegetation fall into three main categories: management for high species diversity of indigenous plants (e.g. to encourage the return of ground dwelling vertebrate fauna to a suburban flora reserve); management for the maintenance of good populations of rare or threatened plants and management for the continuance or re-establishment of natural processes and evolutionary potential. The first two objectives require high management inputs on a continuing basis which is unlikely to be sustainable in the long term. The third objective underpins the State Conservation Strategy and the Flora and Fauna Guarantee Act and in the long term should require more modest resources to manage a larger number of species. Achieving the first two objectives is critical to achieving the third but we must not lose sight of the greater efficiency possible by re-instating natural processes - our human desires to control the environment must be tempered.

Acknowledgments

Discussions with Dr R.F. Parsons and Neville Scarlett over many years have clarified many points.

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Soil Crusts, Germination and Weeds - Issues to Consider

Neville Scarlett[1]

I am currently working on the re-establishment of a number of rare and endangered plant species of the *Themeda triandra* Kangaroo Grass grassland communities of south-eastern Australia. All of my target species are dicotyledonous herbs whose natural occurrence is now restricted to a few sites on the lowland plains of western Victoria or in montane grassland in the Eastern Highlands of Gippsland. The aim of my work is to establish viable populations of these species in secure reserves. In general, plants established by seedling planting or direct seed broadcast reach maturity and set abundant viable seed, but subsequent germination and seedling survival is unsatisfactory. Consequently, the factors controlling seed regeneration in the *Themeda* grassland communities is of particular interest to me.

John White (1986), an American prairie worker has said: '...the first rule of intelligent tinkering is to save all the parts (that is, save the species). Another rule might be as important: before tinkering, set aside a working model (that is, save the ecosystems)'. I would further add - while tinkering, develop some working hypotheses from your working model by observation or experiment. My working model is the species-rich, regularly summer-burnt *Themeda* grassland inside fenced rail-reserves which has not been grazed by domestic stock. The gradual abandonment of burning in these reserves over the past twelve years has reduced my working model areas to distinct rarities.

Field observations of rail-reserve *Themeda* grassland

A noticeable and constant feature of this regularly-burnt grassland was the relatively low density of *Themeda* and the correspondingly high area of inter-tussock spaces. The soil surface of the inter-tussock spaces was normally covered with a continuous crust or mat composed of liverworts, mosses, lichens and algae - the soil crust, cryptogamic crust or moss-mat. In general, the dicoty-ledonous herb component of the grassland was also found in the inter-tussock spaces.

I have not systematically surveyed the soil crusts of *Themeda* grassland in Victoria. The impressionistic account of their characteristics which follows is intended to provide some background for those working on ground flora restoration and management in other plant communities. In rail-reserve *Themeda* grassland on level terrain with relatively deep soils ('non-stony rise' sites) prostrate leafy and thallose liverworts form a dense, continuous tightly woven 'mat'. The major species are *Lethocolea pansa, Fossombronia intestinalis, Fossombronia pusilla, Riccia crozalsii* and *Asterella drummondii*. Other elements of this 'mat' are *Fissidens* spp., *Tortella calycina* (mosses) and *Cladia* sp. (squamulose lichen). The large mosses such as *Breutelia affinis, Triquetrella papillata* and *Campylopus clavatus* are prominent mainly around the shaded bases of *Themeda* tussocks. On stony rise sites these latter mosses, with *Polytrichum juniperinum* (moss), are of higher cover between the rocks. Liverworts also occur with a high diversity of *Riccia* species, *Fossombronia intestinalis* and *Lophocolea* spp. The latter species is especially characteristic of shaded areas in rock crevices. Thallose and crustose lichens cover the rock surfaces, and blue-green algae (cyanobacteria) are prominent around rock pools. Exposed, dry sites often have a soil crust dominated by crustose lichens and algae.

The most notable feature of the soil crusts of *Themeda* grasslands is the relative rarity of thick moss-mats made up of species such as *Hypnum cupressiforme, Thuidium furfurosum* and *Sematophyllum* spp. - a notable feature of many areas of grassy woodland/open forest in the same

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climatic zone. Interestingly, dominant species composition of the *Themeda* grassland soil crust is more or less identical from the Keilor-Werribee Plains with 500 mm of rainfall per year to the wetter (approximately 600 mm per annum) and higher plateau areas south and west of Ballarat (e.g. Skipton and Middle Creek near Beaufort). However, further study may well reveal differences in the occurrence of other species.

Themeda grassland grazed by sheep (and seldom burnt) has soil crusts in various degrees of degradation. At grazing levels at or below 1 sheep/0.4 ha (1 sheep/acre) trampling damage is relatively minor, though the soil crust tends to be discontinuous. In 'unimproved pasture' with grazing levels at about 1 sheep/0.2 ha (2 sheep/acre), which is usually dominated by species of the grass genera *Stipa* Spear Grasses, *Danthonia* Wallaby Grasses and *Poa* Tussock Grasses, the soil crust is more discontinuous but it is still a notable feature of the soil surface. At higher levels of grazing, which are usual in pastures which have been fertilised with superphosphate, the soil crust may be totally absent or evident only around fence posts or under fence lines. Sheep graze but do not trample such areas. Cultivation of grassland removes the soil crust entirely, at least in the short-term.

In *Themeda* grassland which has not been burnt for over 5 years the soil crust is also weakly developed; increased earthworm activity, litter accumulation and shading by a closed *Themeda* canopy are the major reasons for this phenomenon.

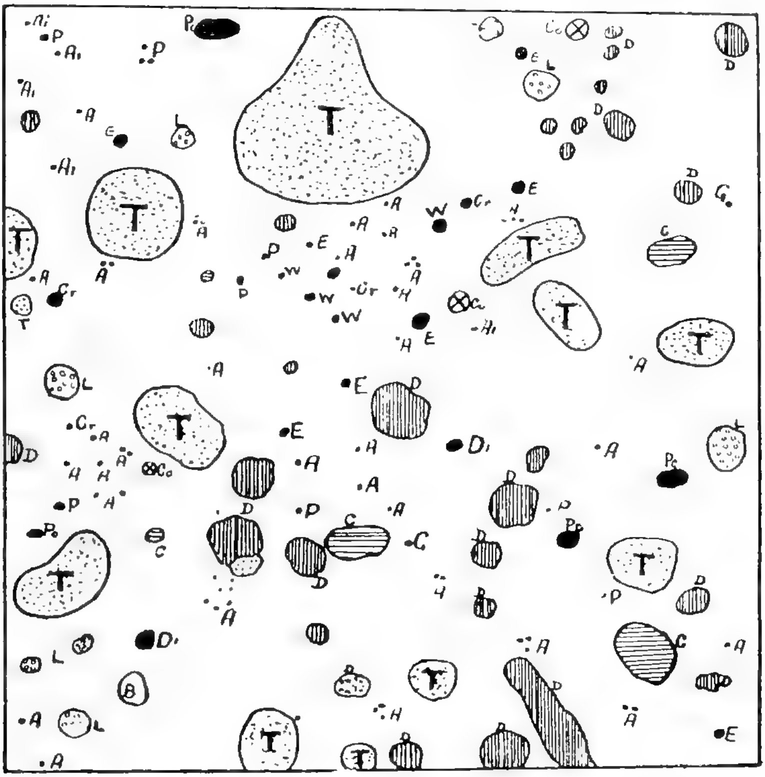
Historical evidence supports the selection of the open rail-reserve *Themeda* grassland as a working model for the pre-settlement communities. For example, James Fleming, gardener with the Grimes expedition to Port Phillip, described the basalt plains west of Skeleton Waterholes Creek (Werribee district) as follows (Friday, 11 February, 1803): 'Went to the top of the hill; it is stony; could see about 10 miles around us a level plain with a few straggling bushes. The face of the ground is one-third grass, one-do stone and one-do earth, mostly newly burnt' (Fleming 1972).

G.A. Robinson, Chief Protector of Aborigines wrote of the basalt plains near Carisbrook (Maryborough area): "The soil of this upland plain is red with bare patches, a root of anthistiria' to 1 and 2 square feet barren soil', (Friday, 21 February, 1840) (Presland 1977). He applied a similar description to the wetter areas further south around Clunes later in 1840 (Presland 1977), and to the drier Campaspe Plains in 1843 (Clark 1988). A charted square yard (0.8-m^2) quadrat from the Keilor basalt plains published by Dr. R.T. Patton in 1935 (Lunt 1987 from Patton 1935, see Fig. 1) closely fits these 19th century observations. Indeed, G.A. Robinson's higher estimate of *Themeda* density of 9 plants per square yard (= 1 per square foot) is close to Patton's quadrat figure of 12 plants per square yard.

As pointed out by Ian Lunt (1987), such 'open herbfield' vegetation now occurs only on restricted sites within unburnt (or infrequently burnt) *Themeda* grassland. While nutrient or moisture stress may be maintaining these open areas, as Lunt suggests, regular early summer burning also maintained an open vegetation as I have pointed out above. In contrast, McDougall (1989) reports a minimum density of 30 *Themeda* plants/m^2 for grassland remnants near the Organ Pipes National Park (formerly grazed, but rarely burnt). In the Laverton North Native Grassland Reserve densities as high as 152 plants/m^2 have developed in formerly grazed areas which are now burnt in autumn at 3-4 year intervals (McDougall 1989). Soil crusts are poorly developed in these areas, although some of the component species survive.

Why bother with soil crusts?

On the principle of 'save the parts', any project which aims at a complete restoration of *Themeda* grassland must include the soil crust and its species if it has been destroyed, damaged or depleted. Moreover, the soil crust is also an important component of *Themeda* grassland struc-



A.	*Asperula scoparia*	E.	*Eryngium rostratum*
Ai.	**Aira caryophyllea*	G.	*Goddenia pinnatifida*
B.	*Brachycome calocarpa*	L.	*Leptorhynchus squamatus*
C.	*Calocephalus citreus*	P.	*Plantago varia*
Co.	*Convolvulus erubescens*	Pc.	*Poa caespitosa*
Cr.	*Crassula citreus*	Po.	*Podolepis acuminata*
D.	*Danthonia semiannularis*	T.	*Themeda triandra*
Dg.	*D. geniculata*	W.	*Wahlenbergia gracilis*
Di	*Dichelachne crinita*		

Fig. 1. Vegetation of a square yard (0.8m^2) quadrat in a *Themeda* grassland on the Keilor basalt plains (Patton 1935). In the absence of disturbance such open vegetation is unusual. Note also the low abundance of introduced species. *Introduced species.
Brachycome calocarpa = Brachyscome dentata
Podolepis acuminata = Podolepis jaceoides
Danthonia semiannularis = Danthonia sp. probably *D. setacea.*

ture. It delays the invasion of some alien weeds and minimises their cover/abundance when they are already established in the community. Two lines of evidence support this hypothesis.

Field Observations

Narrow strips of *Themeda* grassland in rail-reserves have survived for over 130 years without the 'one-way' conversion of inter-tussock spaces to domination by aliens. Damage to soil crusts by stock trampling or light mechanical soil disturbance usually facilitates the invasion and rapid increase of introduced aliens such as *Romulea rosea*, *Holcus lanatus*, *Briza maxima*, *Bromus hordeaceus* and *Vulpia* spp. Even if regular burning is maintained, a continuation of trampling or mechanical disturbance maintains or increases the cover and abundance of aliens. It is notable that the application of regular burning to *Themeda* grassland with a long grazing and trampling history rarely has a dramatic controlling effect on alien annual species, although *Bromus hordeaceus* may decrease in abundance (McDougall 1989; Lunt 1990).

Experimental Evidence

In this brief review of experimental evidence for the influence of soil crusts on seed germination, seedling survival and seedling growth I am excluding the results of work done in arid and semi-arid areas, since they are marginally relevant to the *Themeda* grassland situation.

Soil crusts dominated by bryophytes (moss-mats) may have either positive or negative effects on seed germination and emergence and subsequent seedling survival and growth (Tooren 1990; Ryser 1990). Tooren (1990) presents evidence for:

i) the delay or inhibition of germination of certain species due to a reduced red/far red light ratio and (possibly) an overall reduction in light intensity, and

ii) the inhibition of germination of some species by leachates (aqueous extracts) from bryophytes.

Ryser (1990) explains the positive effects of the bryophyte layer in terms of a more humid microclimate at ground level.

Hobbs and Atkins (1988), working in the Western Australian wheat belt, have shown that an intact soil crust will significantly reduce both density and dry matter production of the invasive weeds *Avena fatua* (a grass) and *Ursinia anthemoides* (a composite) even with the addition of a complete fertiliser. A combination of soil crust disturbance and fertilisation produced the greatest response in those species. The response of native annual species was mainly to fertilisation alone. Few native annuals responded significantly to the combination of soil crust disturbance and fertilisation. The factors which may be responsible were not investigated.

Inferences from the Available Evidence

In the case of *Themeda* grasslands, the experimental and observational evidence available supports the following inferences:

i) soil crusts increase the time-aboveground of dispersed seed, thus increasing the chances of destruction by fire and predation. Seed with effective burial mechanisms such as awns or barbed hairs will be less vulnerable to this 'lag factor';

ii) seeds which exude mucous (sticky or mucous seeds) attach readily to the soil crust and are protected somewhat from desiccation. Species with mucous seeds (e.g. *Senecio macrocarpus, Rhodanthe albicans*) are likely to regenerate from seed more successfully than species lacking mucous seeds where lichen/liverwort soil crusts occur. Where thick moss mats occur, mucous seed species may have no advantage.

iii) alien annual grasses and herbs are early germinators with fast initial growth, the 'gap grabbers' of Newsome and Noble (1988). Apart from the 'lag factor' mentioned above, the dense layer of moss and liverwort rhizoids in the soil crust could be expected to restrict root growth in the inter-tussock spaces and thus reduce their competitive advantage over native species.

Considering these points, soil crusts are unlikely to function simply to aid the exclusion of all alien weeds, or facilitate seed regeneration of all native species. For example, aliens such as *Nassella neesiana* Chilean Spear-grass and *Nassella trichotoma* Serrated Tussock, which have strongly-awned seeds can avoid the 'lag factor' - as also do the natives *Themeda triandra* and *Stipa* species. *Arctotheca calendula* Cape Weed and *Hypochoeris radicata* Flatweed are affected by the 'lag factor', except on stony rises where thick moss mats 'catch' and protect the seeds from fire and desiccation.

Re-establishing soil crusts

In my re-establishment work, 'grader scraping' is a useful technique for the establishment of populations of dicot herbs in grazing-disturbed, depleted grassland. The grader removes 5-8 cm of topsoil, and this is followed-up by either seedling planting or seed broadcast. Aliens such as *Holcus lanatus*, *Bromus hordeaceus*, *Vulpia bromoides* and *Arctotheca calendula* are initially greatly reduced by this method, but they invariably invade the plots in the following year. While mulching would exclude the aliens in the short term, it would also prevent the regeneration from seed of the native species. Accepting the evidence for the weed-inhibiting role of soil crusts in the working model sites, direct re-establishment of soil crusts was deemed worthy of investigation. My trials had two aims:

i) the development of methods for broad-scale soil crust re-establishment which could be integrated with seedling planting and seed broadcast;

ii) the testing of the hypothesis that soil crusts can inhibit the invasion and proliferation of the alien 'gap grabbers'.

Naturally, the second aim can only be seriously approached if the soil crust re-establishment is successful. The account below applies only to the first aim of the trials.

Methods

Piece Placing - 'saving the species'

Soil crust is cut from the soil surface in pieces of about 5 cm x 5 cm, 3-5 mm thick. Larger pieces tend to break. In the glasshouse these are then placed on the surface of pots or tubs filled with soil of the same or similar soil-type to the donor site. The tubs can then be retained either in a shade-house or outdoors for future species identification and expansion of the crust for further work. In the field, pieces can be placed directly on a mildly scarified soil surface. An ordinary table-fork is useful for scarifying. I have used donor area to recipient area ratios between 1:10 and 1:25. At the donor site, disturbed weedy grassland is avoided, and pieces are removed in winter or early spring so that weeds and weed seedlings can be removed. Soil-stored weed seeds, if they are present, will be at a minimum at this time of the year. Removal of pieces at other times may result in the transport of high numbers of weed seeds from the donor to the recipient site.

Slurry Spreading

Pieces of soil crust are made into a slurry using about 200 ml of water to about 150-cm^2 of crust pieces which are 3-5 mm thick. This can then be spread over soil surfaces. The soil should be mildly scarified prior to this to prevent excessive movement under heavy rain storms. I have used donor site to recipient site ratios of 1:4.5, 1:9 and 1:18. The trials were done in the glasshouse and in the field. The most effective time to spread the soil crust slurry in the field is the autumn-winter period after the first significant 'break' in rainfall. High surface soil temperatures in spring, summer and early autumn may kill physiologically active bryophtyes and algae. Care must be taken to minimise the transport of weed seedlings and/or seeds from the donor to the recipient site as described above.

Results

Bryophyte growth rates are relatively slow, and 3-4 years are needed for reliable results. However, my observations over 18 months indicate that:

Piece Placing - 'saving the species'

Piece placing will transfer all species successfully if soil type and micro-environments are matched. It is too labour intensive for broad-scale re-establishment. Two person hours, excluding travel time, are needed to collect soil crust from a 0.1 m^2 area and place it over 1-m^2, a donor site to recipient site ratio of 1:10.

In a shadehouse with daily overhead watering in spring and summer, the weedy liverworts *Lunularia cruciata* and *Marchantia* spp. can out-compete the *Themeda* grassland soil crust species. After an initial 1-2 month period, shadehouse populations should be placed outside. This inhibits weedy liverwort growth. The crusts should not be watered in summer when high surface soil temperatures develop as physiologically active bryophytes and algae may be killed.

Slurry Spreading

Of the 8 species of high cover - *Lethocolea pansa, Riccia crozalsii, Cladia* sp., *Fissidens* sp. 1, *Fissidens* sp. 2, *Campylopus clavatus, Anthoceros* sp. and *Bryum* sp. - only *Riccia crozalsii* and *Cladia* sp. were established over the entire recipient area, although *Lethocolea pansa* and *Fissidens* spp. showed sporadic establishment. The 'weedy' moss *Pottia truncata* had meanwhile established itself over the entire recipient area, perhaps from airborne spores. Approximately 1 person hour is needed to collect soil crust from 1 m^2, prepare it and spread it at a donor site to recipient site ratio of 1:9, again excluding travel time.

Discussion

Piece placing is probably only suitable for setting up founder populations or small areas for detailed study of soil-crust growth. However I do not as yet have any data on the rate of lateral spread of soil crusts, and the method may be more efficacious than indicated by the early results.

Slurry spreading has greater potential, but as many species failed to establish satisfactorily using my current method, more work on refining the method is needed.

Re-establishment by spore broadcast may be the only feasible method of re-establishing soil-crusts over large areas. Cultivation of founder populations in the glasshouse and developing efficient spore collection methods will be necessary before this can be tried.

Acknowledgements

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+ *Anthistiria australis* R.Br., a synonym of *Themeda triandra* Forssk.

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Soil Microflora and its Importance in the Restoration and Management of Vegetation.

P. J. Keane[1]

Components of the soil microflora, mainly bacteria and fungi, play a crucial and often overlooked role in ecosystem functioning and stability.

Soil bacteria and fungi have many ecological roles, both as free-living saprophytic organisms involved in decomposition of organic matter and recycling of nutrients, and as symbionts, forming intimate associations with plants and animals, which may benefit or damage the host organism.

Decomposers

Many saprophytic microbes obtain their nutrients from dead organic matter, and are crucial in breaking down complex, insoluble polymers such as cellulose, lignin and proteins into their soluble components, thus recycling the nutrients from those substances. Materials such as leaf litter, twigs, bark and wood, composed largely of cellulose and lignin, and animal remains and dung, are decomposed and incorporated into the organic matter in soil which contains nutrients available for further plant growth. Thus fungi, bacteria and associated soil-inhabiting arthropods are critical for the humification of soil, which contributes so much to its fertility and structure. Fungi are particularly important in this role because of their ability to produce a wide range of digestive enzymes and to penetrate into dead organic substrates; this gives them an advantage over bacteria, which have little penetrative ability.

Fungi living in soil and leaf litter have an important role as nutrient accumulators. Through their network of hyphae they are able to accumulate dispersed nutrients into concentrated nutrient sources such as fruiting bodies, which are an important source of food for small ground dwelling animals.

Some free-living bacteria, which live in association with soil organic matter, are able to fix atmospheric nitrogen, converting it into soluble nitrogen-containing compounds available for plant nutrition. Other bacteria are of critical importance in carrying out various nutrient conversions required for maintenance of soil fertility.

Symbionts

Many microbes form symbiotic associations with other organisms. If both organisms benefit, the symbiosis is said to be 'mutualistic', if the microbe benefits at the expense of the larger organism, the symbiosis is said to be 'parasitic'. The microbes involved in symbioses with plants obtain their sugar nutrition directly from their hosts. Mutualistic symbioses that are of great importance in vegetation establishment and stability, include the following:

Mycorrhiza (fungus-root associations)

The great majority of plants form a mutualistic symbiosis between their roots and fungi. The fungi obtain sugars from the plants and in return the fungi give the plants access to the phosphate from a much larger volume of soil. These symbioses are thought to be important in the adaptation of Australian plants to the generally phosphate-deficient soils on the continent. Again it is the penetrative ability of the fungal hyphae which is crucial for the functioning of mycorrhiza; the hyphae act as an extension of the root system. The main plant families which do not commonly form mycorrhizae are the Proteaceae, which, instead, form very finely divided 'proteoid' roots, and some families associated with either very wet (Juncaceae, Cyperaceae) or arid (Chenopodeaceae) conditions.

Most eucalypts form ectomycorrhizae

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in which the fungus forms a sheath of tissue around the outside of the roots and changes the morphology of lateral roots, converting them into highly branched, coralloid structures. The fungi involved include many types of gilled mushrooms and puffballs which produce their spore-forming structures under the trees in autumn.

Some trees, including eucalypts and many native shrubs, herbs, grasses and even non-vascular plants, form vesicular-arbuscular mycorrhiza, which are entirely different from the ectomycorrhizae; the fungi form little bush-like growths inside the root cells and large, swollen vesicles within the roots, but do not damage the plant cells or alter the root morphology. The fungi involved are a very restricted group of primitive zygomycetes which are very common in soils but have never been grown in pure culture. They survive as resting spores when they are not infecting roots. These fungi absorb sugar from the plants and in return act as an extension of the root system, assisting the uptake of phosphate by the plant.

Heath plants form another specialised type of mycorrhiza with a restricted group of fungi, which have also never been grown in culture. These fungi invade the roots, forming hyphal coils within the cells, without altering the morphology of the roots. Again the fungi derive sugar from the plants and assist in phosphate uptake by the plants.

Orchids form a further special type of mycorrhiza, in which the balance of nutrient flow between the partners is more complicated. A group of fungi, many in the genus *Rhizoctonia*, with the ability to derive nutrients from dead organic matter, invade orchid roots and form hyphal coils within the root cells. The plants in turn obtain organic nutrients from, and are thus to some extent parasitic on, the fungi. It is well known that growth of orchid seedlings in culture is greatly stimulated by the presence of these fungi, and microscopic study of root sections clearly shows the digestion of the hyphal coils by the root cells. Many so-called 'saprophytic' orchids, which form very little photosynthetic tissue throughout their lives, must rely heavily on the associated fungus for their nutrition.

Many experiments with a wide range of plants and mycorrhiza types have shown that the presence of these mycorrhiza stimulates plant growth, particularly in poor soils.

Rhizobium *bacteria in root nodules of legumes.*

Nodules formed on the roots of legumes by *Rhizobium* bacteria are critical in the adaptation of the legumes to soils deficient in nitrogen. These nodules are able to convert atmospheric nitrogen gas into soluble nitrogen compounds available for plant growth. As the nodules or the legumes themselves decompose, these nitrogenous compounds are released and contribute greatly to the fertility of the soil. It is thought that legumes, especially acacias, play an important role in the growth of most Australian vegetation. Because of their nitrogen-fixing ability, legumes are an important component of flora restoration on damaged sites.

Actinorhizal nodules on Casuarina

Species of *Casuarina* and *Allocasuarina* are adapted to poor soils and contribute to soil fertility through nitrogen fixation carried out by actinomycetes in their root nodules.

Plant-cyanobacteria associations

Many vascular plants (e.g. cycads and some herbs) and non-vascular plants (e.g. some liverworts and water ferns) form beneficial associations with cyanobacteria ('blue-green algae'). As the cyanobacteria are capable of fixing atmospheric nitrogen, it is likely that the plants benefit through improved nitrogen nutrition. The cyanobacteria involved are in the genera *Anabaena* and *Nostoc*, which can occur as free-living organisms in soil. The developing plants are infected by the symbionts from the soil, and so the cyanobacterial populations in soil can also be important in revegetation.

Lichens

Lichens often form a crust on the soil surface which contributes to soil stability and, ultimately, to soil organic matter. Lichens are the result of a mutualistic symbiosis between an alga (or cyanobacterium) and a fungus. The fungus derives sugar (and nitrogenous compounds if the partner is a nitrogen-fixing cyanobacterium) from the photosynthetic partner, and the fungus assists in absorption of nutrients, particularly in the form of gases, and protects the alga from UV radiation by holding the algal cells in a plant-like thallus. Lichens are often particularly important as early colonisers of disturbed or rocky soils.

Parasites

The mutualistic symbioses discussed above all contribute to the healthy growth of vegetation. However, soils harbour a range of parasitic microbes which have detrimental effects on plant growth. These are often not evident in undisturbed vegetation, where the microbes may be part of the normal process of plant decomposition and recycling. Disturbance of ecosystems has often resulted in development of new plant disease problems. Disturbance can take the form of changes in the environment that may enable an otherwise unnoticed native parasite to become destructive, as in the case of the mushroom, *Armillaria luteo-bubalina*, the cause of patch dieback of eucalypts in certain forests of central Victoria and Tasmania. There is evidence that logging provides food sources for the fungus in the form of remnant tree stumps, from which the fungus is able to invade and kill nearby healthy trees.

Other aspects of vegetation disturbance such as road making and logging have introduced new pathogens. This has been the case with *Phytophthora cinnamomi* in many forests and heathlands of southern Australia. There is very strong evidence that this fungus evolved in the tropics where it is not particularly destructive in native vegetation (although it has been very damaging in agricultural crops). Upon introduction to forests and heathlands in Victoria, Tasmania, South Australia and Western Australia, however, it has caused dramatic death of large areas of vegetation which have evolved little resistance to attack by the fungus. Many fungal pathogens are very restricted in their host range, but *P. cinnamomi* is exceptional in attacking over 400 Australian plant species in about 48 families. Patches of large hardwood production forest have been destroyed in South and East Gippsland. Many of these sites have become dominated by grasses and sedges, although some sites have been regenerated with mixtures of resistant and susceptible eucalypts and associated plants. Drier, low open forests in the Brisbane Ranges and the East Otway Ranges have also been damaged and are being converted into woodlands consisting of surviving eucalypts and resistant grasses and sedges. In these forests the distinctive understorey genus, *Xanthorrhoea*, proved to be extremely susceptible to the disease and clearly marks the extent of infestation by the fungus. It is unlikely that this genus will be re-established on diseased sites, its place being taken by grasses and sedges which tend to be resistant to the fungus.

P. cinnamomi has been particularly destructive in the Jarrah forests of Western Australia, killing an estimated 250,000 ha of forest and spreading at a rate of 20,000 ha per year. The understorey species, *Banksia grandis*, is very susceptible and tends to act as an indicator of fungal infestation. Indeed it is thought that the proliferation of *B. grandis* - at the expense of the resistant, fire-dependent species, *Acacia pulchella*, following the introduction of fuel reduction burning - has facilitated development of the disease. Not only has a new pathogen been introduced to the forests, but changes in the forest environment have probably favoured activity of the pathogen. A similar situation may have occurred in East Gippsland, where selective logging of eucalypts in the subgenus *Symphyomyrtus*, which are mostly resistant to *P. cinnamomi*, and leaving behind mostly susceptible *Monocalyptus* species, may have made the forests more vulnerable to damage by the pathogen.

P. cinnamomi has been most destructive in coastal forests. It is unlikely that it will cause much damage to highland forests where the soil is rarely warm enough for fungal activity. Recently the fungus has been spreading in the heathlands of south-western Western Australia, where quarantine restrictions will be needed to prevent further spread and destruction of the vegetation.

Management of soil microflora

Most of the above elements of the soil microflora, being microscopic, are often overlooked in considering management of vegetation. There are many well-documented instances in agriculture and forestry of manipulation of microflora for the benefit of plant production. Inoculation of legumes with appropriate strains of Rhizobium, and inoculation of tree nursery beds with soil and leaf litter containing mycorrhizal fungi, have been important in establishing some plant species in areas outside their natural range (e.g. *Pinus radiata* in Australia). Inoculation of orchid seedlings with mycorrhizal fungi has also been important in propagation of orchids. Augmentation of populations of saprophytic microbes by increasing the organic matter content of soils has been a successful method of biological control of soil-borne plant pathogens. It is hypothesised that reduction of the organic matter content of eucalypt forest soils following regular fuel reduction burning, leading to reduced populations of saprophytes in the soil, may have allowed greater activity of *P. cinnamomi*. Reduced growth of plants sown into soil sterilised by fumigation has been documented; it was concluded that fumigation had destroyed the mycorrhizal fungi required for optimal growth of the particular plants.

However, very often there is little that can be done to manipulate soil microflora in management of native vegetation. A useful approach is to be aware that many plants require associations with particular microbes for optimum growth and that, generally, reasonable levels of soil organic matter promote the survival of mycorrhiza- or root nodule-forming microbes and also promote the activity of soil saprophytes that contribute to soil fertility or are antagonistic to soil-borne plant pathogens such as *P. cinnamomi* and *Pythium*. If an attempt is being made to rehabilitate land that has been severely denuded or disturbed, especially by removal of topsoil containing the bulk of soil organic matter and associated beneficial microbial flora, a useful first step would be to restore a reasonable accumulation of natural organic matter. While the bulk of the organic matter could consist of material such as leaf mulch, it would be worthwhile ensuring that some leaf litter or topsoil from nearby, less disturbed vegetation, is incorporated to ensure that populations of any beneficial microbes specific for that vegetation are re-established on the restored site. Of course in any such attempt at restoring natural soil organic matter levels, care must be taken to ensure that soil fertility is not increased excessively, leading to proliferation of weeds.

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Observations on the Behaviour of *Antechinus minimus maritimus* (Marsupialia: Dasyuridae)

John G. Aberton[1], Barbara A. Wilson[1], and Ken Chenery[1].

Introduction

In Victoria, the Swamp Antechinus (*Antechinus minimus maritimus*), usually inhabits dense, wet, coastal tussock grassland or closed heathland, often close to a swamp or river area. It is frequently found in isolated patches along the coastline. Specimens have been recorded inland near Dartmoor, Heywood, Casterton, Wonthaggi and Gellibrand and on offshore islands in the Gippsland region - Glennie, Rabbit, Snake and Sunday Islands. Records indicate that there have been no observations east of Sunday Island in southern Gippsland (Atlas of Victorian Wildlife 1992). In a recent study in the Cape Otway National Park (Moro 1991), trapping success of the species was significantly positively correlated with vegetation cover 1 m in height and significantly negatively correlated with the presence of logs and tree canopy.

The species is terrestrial and is considered to be insectivorous, digging for food with well developed fore-claws (Wainer and Gibson, 1976). It exhibits sexual dimorphism, with adult males reaching 100 g weight and females 60 g. Females come into oestrus once a year and all males appear to die soon after one mating, although a study of animals on Rabbit Island found males alive up to 16 months after birth (*pers. comm.*). The number of young raised varies with the number of teats of the female. The number of teats on mainland animals is 6 and 8 in Tasmania (Wainer 1983). Females may survive a second or some a third year. A gestation period of 30±1 days for animals mated in the laboratory has been recorded (Wilson 1986). Breeding appears to be synchronous within the one locality each year, although variation does exist between geographically isolated populations. For example, births have occurred in a population near Port Campbell in July, in a population near Anglesea in August, (Wilson *et al.* 1986) and in a population in south Gippsland in September (Wainer 1983). The species is rare and restricted. There is a perceived need for more conservation parks in wet heathlands to decrease the risk to its survival .

Swamp antechinus *Antechinus minimus maritimus.*

Observations and captures of the Swamp Antechinus were made in the Anglesea region prior to the 1983 Ash Wednesday fire (Wilson *et al.* 1986; Victorian Atlas of Wildlife), but despite subsequent annual trapping of the area only four captures of this species were recorded in 1984 and one in 1986 (Wilson *et al.* 1990).

The objectives of this study were to locate and study the Swamp Antechinus in native habitat and to reintroduce some members of that population to part of the former range near Anglesea. An immediate goal of the reintroduction was for these animals to successfully breed at the new site. This article refer to initial work at the capture sites near Port Campbell.

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Methods

1. Trapping and Telemetry

In an attempt to monitor an established population, transect trapping of likely habitats was conducted near the mouth of Skenes Creek in the Otway ranges, near Gellibrand and near Blanket Bay in the Cape Otway National Park in June 1992. Minimal trapping success and limited vehicle access in most of these areas resulted in the ongoing trapping effort being based at Port Campbell, about 200 km. south-west of Melbourne. Preliminary trapping was carried out a few kilometres east of Port Campbell. In early July 1992, 60 Elliott traps baited with a mixture of rolled oats, peanut butter, and honey were set in a 6 x 10 grid pattern in closed heathland at the Port Campbell Rifle Range (38^0 37' 20" S., 142^0 58' 56" E). Traps were set about 10 m apart, and were checked each morning and late afternoon for 3 days. Two transect lines of 15 traps each were set at Two Mile Bay, immediately adjacent to the rifle range in the Port Campbell National Park. A similar trapping regime was undertaken in late-July 1992, December 1992, May 1993, December 1993.

Single stage radio transmitters and collars weighing about 1.5 g (Titley Electronics) were attached around the necks of a total of 5 adult Swamp Antechinus females and 1 adult and 1 juvenile male during these trapping periods. These animals were released at the point of capture and were tracked with hand held antennae and receivers. Positional fixes were taken a minimum 4 times a day for a period of up to 7 days per animal. During the trapping period, weight, sex, and identification recordings were made on all species of small mammals captured. Radio tracking data was analysed using the computer software package Ranges 4.

2. Vegetation

At each trap station, the plant species observed in a 1 m x 1 m area were recorded and structural features of the vegetation including height and density measures were taken.

Swamp antechinus showing position of radio collar.

Results and Discussion

1. Trapping and Telemetry

Captures of Swamp Antechinus were made in June 1992 in the Port Campbell National Park near Loch Ard cemetery (1 capture of the species for 40 traps set for 1 night) and near Two Mile Bay (2 captures for 10 traps set over 1 night). Trapping in mid July at the Two Mile Bay site and on the nearby Rifle Range resulted in 10 captures of the species from 90 traps for 1 night. The 7 males ranged from 75-103 g in weight and the 3 females 45-52 g. All males and 2 females showed evidence of hair loss, ticks in the ears and orange coloured mites around the bare

Swamp antechinus showing size relative to hand.

skin in the anal and female pouch region. During the last week of July 1992, only 4 females were trapped over 90 trap nights at the Port Campbell Rifle Range. Three of these showed no major pouch development, the other was carrying 6 offspring, each approximately 6 mm long. Weights of the captured animals ranged from 47-54 g. The absence of males suggested that male die-off had occurred during mid to late July since they had appeared in such poor condition 2 weeks previously. The other species captured during trapping sessions were the Swamp Rat (*Rattus lutreolus*), which was located in densities of 40 per 100 trapnights, the Bush Rat (*Rattus fuscipes*), at 14 per 100 trapnights and the White Footed Dunnart (*Sminthopsis leucopus*) found in sparse vegetation covering a salt pan, 3 per 100 trapnights.

The first collared female was radio tracked and 14 fix positions were taken over a 24 hour period. The minimum convex area enclosed by all these readings was 0.53 ha. Soon after dusk the animal was traced to a burrow in the sandy podsolic soil about 100 m from the release site. The burrow entrance was about 4 cm in diameter. Later examination showed that the burrow was a 25 cm long sloping tunnel which reached an estimated depth of 10-15 cm. Another opening was located adjacent to the entrance. It led to a tunnel just above the soil surface but below the dense 5 cm deep litter layer. This litter tunnel was later used as an escape route when the animal had been released in the subterranean tunnel after subsequent recapture and collar removal. Dense shrubs of *Allocasuarina paludosa* 80-100 cm high obscured the burrow. Nearby two similar but not as extensive burrows were found. These ended after about 15 cm. The female was located in the burrow at half hourly intervals until 10 p.m. after which tracking ceased. The animal was present in the burrow at 7.30 a.m. the following day but had moved into dense *Melaleuca squarrosa* scrub by 11.30 a.m. It was later recaptured within 20 m of the burrow.

Another female with collar was traced to a burrow in a decayed *Xanthorrhoea minor* bole near a living *X. minor,* about 120 m from the release site for this animal. The whole area was covered by a 2-3 m high spreading *Eucalyptus ovata.* An extensive burrow system was located with at least two subterranean side tunnels exiting to the outside. The burrow entrance was also about 4 cm in diameter and the underground portion of the bole was used as a side wall in tunnel construction. The radio collar of this animal was retrieved from where it had been dropped in one of the side tunnels. The side tunnel was more than 20 cm long and was subterranean. However, over the top of most of the tunnel system a 10-20 cm mound of old leaf and stem material was present. It was assumed that this resulted from natural leaf accumulation over a number of years. Deep leaf litter nearby showed recent signs of digging by a small animal. When this litter was investigated, arthropods 0-2 cm long were uncovered. Later analysis of trap scats from 8 animals revealed arthropod remains, chiefly Orders Coleoptera and Blattaria representing insects, and Order Aranae the spiders.

Evidence of daylight movement by all Swamp Antechinus radio-tracked at irregular intervals was supported by trap captures during the day; traps cleared and then reset in the morning were found to have Swamp Antechinus captures that afternoon. This occurred on 9 occasions.

2. Vegetation

The vegetation where the animals were trapped at Two Mile Bay was about 1-1.5 m in height and the dominant plant species consisted of *Leucopogon parviflorus* and *Leptospermum continentale* as well as some *Gahnia seiberiana, Banksia marginata* and *Xanthorrhoea minor.* Scattered stands of *Casuarina stricta* often reaching 4 m in height were present within 5m of trap settings. Frequent captures of different individual Swamp Antechinus took place near these trees. The more dense vegetation of the rifle range was dominated by *A. paludosa, L. parviflorus, M. squarrosa* and *L. continentale*. This wind-pruned vegetation on and near the Port Campbell Rifle Range presents a closed canopy at a height of 1-1.2 m which results in zero wind velocity at ground level. In wetter areas where some open ground was observed, conspicuous species included *Juncus australis, Poa poiformis, Banksia marginata*, and *Gahnia* and *Lepidosperma* species.

Conclusions

The study found that *Antechinus minimus maritimus* utilise underground burrow systems, and are active during daylight hours. It appears that the males die-off in late July in this locality (Port Campbell). The mid-winter diet of the animals was mainly insectivorous, a finding consistent with other studies (Wainer, 1983). The species is sympatric with an omnivorous species (*Rattus fuscipes*), a herbivore (*R. lutreolus*), and a small carnivore (*Sminthopsis leucopus*).

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Library News

The following books have been added to the Club's library:

Bennet, I. (1992). 'Australian seashores'. (Angus and Robertson: Pymble.)

Cogger, H. (1992). 'Reptiles and amphibians of Australia', 5th ed. (Reed: Chatswood.)

Cropper, S.C. (1993). 'Management of endangered plants'. (CSIRO: Melbourne.)

Ehmann, H. (1992). 'Reptiles'. (Encyclopedia of Australian animals) (Angus and Robertson: Pymble.)

Hoffman, N., Brown, A. (1992). 'Orchids of south-west Australia', 2nd ed. (University of Western Australia Press: Nedlands.)

Kitching, R.L. (1993?). 'Ecology, biodiversity and the future of Australia'. (Griffith University: Nathan.)

Lamp, C, Collet, F. (1989). 'Field guide to weeds in Australia', 3rd ed. (Inkata: Melbourne.)

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Walraven, E. (1990). 'Taronga Zoo's guide to the care of urban wildlife'. (Allen and Unwin: Sydney.)

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Womersley, H.B.S. (1984). 'The marine benthic flora of Southern Australia', Part 1. (Government Printer: Adelaide.)

Womersley, H.B.S. (1987). 'The marine benthic flora of Southern Australia', Part 2. (Government Printer: Adelaide.)

Books may be borrowed for two months, and renewed up to six months, unless required by another member. The library is open before General Meetings 7.15 p.m. or 1.15 p.m. before Sunday meetings, and on Tuesdays from 11 a.m. to 2 p.m.

Sheila Houghton
Hon Librarian

A Review on the Geology of the Beaumaris Cliffs.

R. P. Irwin[1]

Introduction

The Beaumaris cliffs on the north-east coast of Port Phillip Bay attain a height of 15 m and consist of a richly fossiliferous Late Miocene to Early Pliocene sequence. The abrupt indentation of the coastline at Table Rock Point marks the ascension of the cliffs which extend 1.5 km in a north-easterly direction before deteriorating into a vegetated bluff at Mentone Beach (Fig. 1). The scientific and recreational/aesthetic importance of this geological feature has been recognised by King (1988) and Rosengren (1988), both assigning international significance to various aspects of the Beaumaris cliffs, particularly in terms of the fossil sites which enable correlation of Late T[illegible] land mammal faunas and marine sequences in Australia.

This review is aimed at summarising the geological aspects of the Beaumaris cliffs, particularly in terms of the origin, composition and nature of the pertinent rock types which occur at this locality. The earliest geological interpretations, e.g. Selwyn (1855), consisted of little more than lithological descriptions. Later, stratigraphical subdivisions were proposed, and culminated in Singleton's (194[illegible]) section which has remained unchanged since its inception. Revision of the spatial

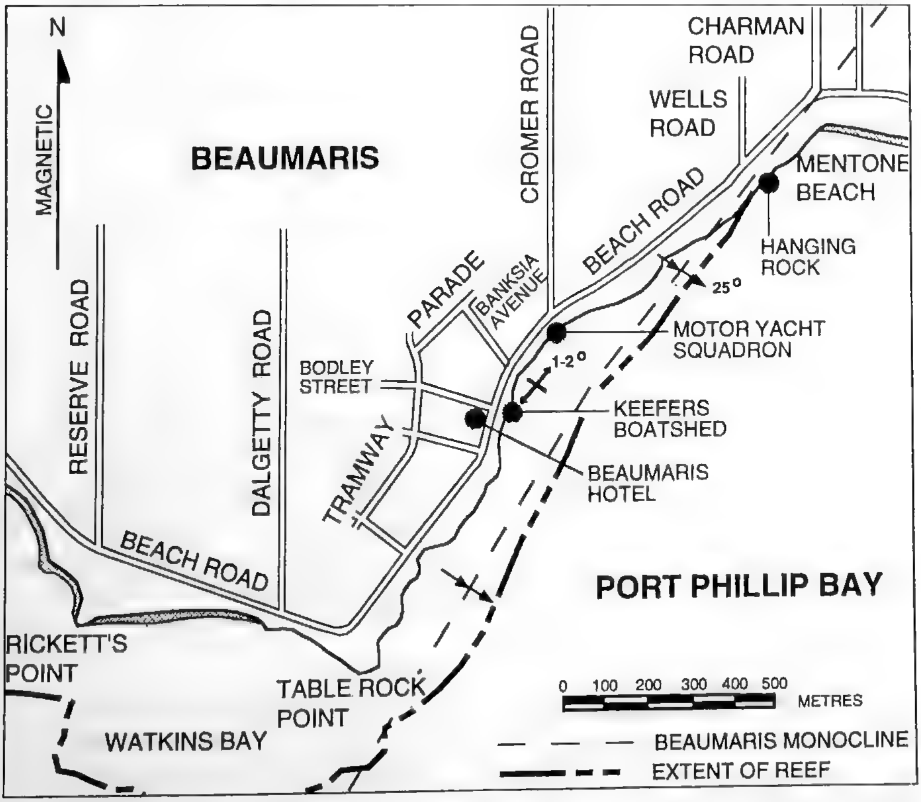

Fig. 1. Locality map of Beaumaris (adapted from Gill 1957).

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distributions of the lithological units required the reinterpretation of this cliff section and also led to a greater understanding of the structural influence of the Beaumaris monocline.

Stratigraphy

The current stratigraphical scheme (Table 1) for the Tertiary sequence of the Beaumaris cliffs has been derived from interpretations throughout the century. The earliest stratigraphical profiles were given by Etheridge (1875) and Hart (1893) who considered the cliffs to consist of a four part sequence. However, with the exception of iron content, Hall and Pritchard (1897) and Hall (1909) found nothing to separate the upper and lower beds. Carroll (1949) also found no lithological or mineralogical evidence for subdividing the sequence in the cliffs.

Singleton (1941) considered that the stratigraphical break marked by the development of an 8 cm thick nodule bed, separated the underlying 'Balcombian' (=Bairnsdalian) clays and marls, from the 6 m of fossiliferous ferruginous sandy marls which, together with the nodule bed, constitute the Cheltenhamian Stage type locality. The succeeding ironstones and ferruginous sandstones which were considered (by Singleton) to be younger, therefore represented the Kalimnan stage. Both Gill (1957) and Wilkins (1963) accepted Singleton's Cheltenhamian stage despite Crespin (1943) integrating the stage as a facies of the Kalimnan.

Table 1. Current stratigraphical scheme for the Beaumaris cliffs after Abele *et al.* (1988).

Singleton's Section (A)		Revised section	
ix (4 ft)	White sands	d (1m)	Red Bluff Sands Formation
viii (6 ft)	Ferruginous sandstone	c (2m)	Ferruginous sandstone
vii (8 ft)	Ironstones		
vi (14 ft)	Ferruginous sandy marl	b (7m)	Ferruginous sandy marl containing shell lags and *Lovenia*
v (9 ft)	Sandy marl with *Lovenia*		
iv (6 in)	*Eucrassatella* zone		
iii (8 ft)	Marly sands with calcareous concretions	a (2.5m)	Marly sands with calcareous concretions
ii (1 ft)	Fine sandy marl (laminated)		Present beach level
i (6 in +)	calcareous sandstone		
	Past beach level		

Between Melbourne and Mentone can be found the 'Red Beds' of Hall (1909), later renamed to the Sandringham Sands by Gill (1950) who subsequently subdivided the formation into the Black Rock Sandstone and Red Bluff Sands members (Gill 1957). With elevation of both these members to full formational status on the basis that the Black Rock Sandstone, having been ferruginized, indicated a definite time break, Kenley (1967) upgraded the Sandringham Sands to group status. However, Kenley (1967) adopted the name Brighton Group, proposed by Gill (1950) to replace the term Brighton Beds, in preference to the almost synonomous Sandringham Group.

Mallett and Holdgate (1985) and Abele *et al.* (1988) indicated that the Brighton Group rested disconformably on the Fyansford Formation which comprises the upper marly sections of the Torquay Group (Singleton's (1941) 'Balcombian' clays and marls) within south-eastern Port Phillip Bay. The Newport Formation, proposed by Thomas and Baragwanath (1950), was considered by VandenBerg (1971, 1973) to be disconformably overlain by the Black Rock Sandstone. The Newport Formation and Fyansford Formation represent a lateral facies change (Abele *et al.* 1988), but being lithologically similar are considered difficult to distinguish. Therefore, all strata of the Torquay Group in the Port Phillip Basin, except the Batesford Limestone, were referred by Abele *et al.* (1988) to the Fyansford Formation.

Structure

The Beaumaris coastline abruptly changes direction at Table Rock Point where the Beaumaris cliffs run in a north-easterly direction parallel to the downthrow of the Beaumaris monocline (Fig.1). The monocline is traceable from the coast inland as a low diminishing escarpment, reportedly trending 34 magnetic (Kenley 1967). The monocline elevated the Black Rock Sandstone from the typical near sea-level position observed between Elwood and Ricketts Point (VandenBerg 1971), to form cliffs 15 m high, and reflecting the presence of a bedrock fault.

Hall and Pritchard (1897) recognised an asymmetrical pitching anticline and determined the strike of this anticline to follow closely that of the shore. Singleton (1941) and Pritchard (1976) both observed a pronounced roll within beds of the Black Rock Sandstone. The anticlinal axis is believed to be located immediately north-east of Keefers Boatshed between Bodley Street and Banksia Avenue, the beds descending away from this stratigraphic high point with apparent dips of 1-2. Gill (1957) attributed the gradual rise of the Black Rock Sandstone to this anticline and noticed that in the vicinity of Charman Road the dip steepened and swung eastward, the effect being visible in the ironstone reef.

Sedimentology (Brighton Group)

The general features of both the Black Rock Sandstone and Red Bluff Sands of the Brighton Group have been summarised in Table 2.

According to Singleton (1941) the basal nodule bed is a conglomeratic layer of grit forming the base of the Black Rock Sandstone, containing glauconite and concentrations of cylindrical calcareous and ferruginous nodules up to 15 cm in length. Mallett and Holdgate (1985) however, relegated the nodule bed to the underlying Fyansford Formation. The nodule bed has a rich vertebrate fauna and a diverse but poorly collected invertebrate fauna.

Palaeoenvironmental interpretation

The Black Rock Sandstone is a near shore facies as indicated by a marine fauna comprising specifically shallow water taxa such as molluscs and barnacles (Gill 1957). It is widely accepted that glauconite is formed in shallow waters (Deer *et al.*1985) and the presence of terrestrial animal bones together with the sediment, leaves and wood at the top of the formation, indicate progressive shallowing. VandenBerg (1971) indicated that the molluscan fauna from beds immediately above the nodule bed were deep water forms (20-30 m), but molluscs from higher in the cliffs indicated a very shallow water environment.

The Red Bluff Sands, according to Gill (1957), are mainly fluviatile, based on the presence of fossil wood, clay balls and lenticles containing *Nothofagus*-like leaves and freshwater sponge spicules. VandenBerg (1971) suggested that this fluviatile environment was fairly active and was probably supplied by a series of streams. The basal carbonaceous seam (Gill 1957) and the progression from marine to estuarine fossils and accumulation of land plant remains, indicates the progressive shallowing (Bird *et al.* 1973).

Revised stratigraphical and structural concepts

Previously only recognised at Table Rock Point and Mentone Beach, the Red Bluff Sands are continuous from Table Rock Point along the top of the Black Rock Sandstone, progressively thinning

Table 2. Distinguishing features of the Black Rock Sandstone and Red Bluff Sands Formations. Derived from Hart (1893), Gill (1957), Kenley (1967) and VandenBerg (1973).

Lag	Thickness	Separation	Lithology
Upper	25 cm	75 cm	Strongly cemented, fossils complete, most shell material removed leaving blackened moulds. Skeletal material diminishing either side of concentrated central 5 cm.
Middle	5 cm	60 cm	Concentrated decomposed shell fragments.
Lower	40 cm	50 cm	Divisible into an upper red layer containing whole bivalves and an equally thick grey/green layer containing sparse shell fragments.
Bed (iv)	30 cm		Decomposed shell fragments diminishing in concentration upward. Few rounded quartz pebbles near base.

from a maximum of 3 m at the southern limit of the cliff, to apparently disappear adjacent to Keefers Boatshed, 100 m before the axis of the anticline (Fig. 1). Vegetation obscures the top few m of the cliff in the vicinity of the anticlinal axis and north-east of Keefers Boatshed the cliff deteriorates into a vegetated bluff, persisting beyond the Motor Yacht Squadron. The Red Bluff Sands Formation reappears as a thin veneer 300 m beyond Keefers Boatshed, progressively thickening toward Mentone Beach; its true thickness unknown as eroded sands that adhere to the cliff face obscure the disconformity. Sudden thickening of the formation occurs 250 m south-west of Mentone Beach and this continues until opposite Charman Road, where the Red Bluff Sands comprise the entire section with the resultant development of a steep vegetated bluff.

The abrupt north-easterly dominance of the Red Bluff Formation is due to the emergence of the Beaumaris monocline from the cliff 300 m south-west of Charman Road. Contrary to previous reports of the monoclinal axis passing out of the cliff at Charman Road and then abruptly deviating to run parallel with the cliff face (Gill 1957; Kenley 1967), the attitude of the beds immediately south-west of Charman Road to 'Hanging Rock' indicates a later emergence. Measured dips along the cliff in the order of 20-25^0 ESE reveal that turnover was induced by the monocline along an axis within the cliff. The monoclinal axis exits the cliff 300 m from Charman Road with a strike of 15^0, which is maintained until the Motor Yacht Squadron pier, where a deviation in the reef indicates rotation and a strike parallel to the cliff face (Fig. 1).

Table 3. Modification of Singleton's (1941) section.

Stratigraphical Sequence		Age
Brighton Group	Red Bluff Sands	Kalimnan
	Black Rock Sandstone	Cheltenhamian
Torquay Group	Fyansford Formation	Bairnsdalian

Modification of Singleton's (1941) stratigraphical section (A) is expressed in Table 3 with the revised stratigraphy depicted in Fig. 2. A reinterpretation of the currently preserved cliff section is detailed below.

Bed **(vii)** of Singleton (1941) is not divisible as a separate unit as it is irregular in its extent and distribution, being a post-depositional impregnation encompassing both the sandstones above and the sandy marl below.

Within bed **(v)** are three distinctive lag deposits whose distribution and composition are summarised in Table 4 along with

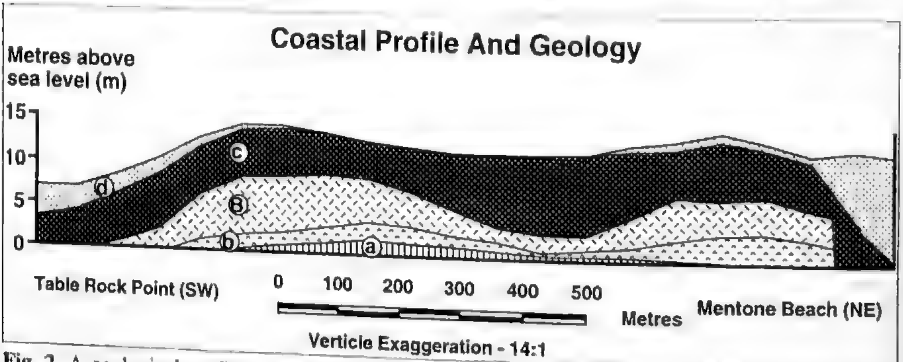

Fig. 2. A geological profile of the Beaumaris cliff from Table Rock Point to Mentone Beach. (a) represents **unit a** composed of marly sands with calcareous concretions; (b) is the lower half of **unit b** representing the *Lovenia* zone in the ferruginous sandy marl; (B) is the upper half of **unit b**; (c) indicates the proposed extent of the ferruginous sandstone, **unit c**, and the beginning of the Kalimnan Stage; (d) marks the distribution of the Red Bluff Sands, **unit d**.

bed **(iv)**. *Lovenia woodsii* Etheridge is found extending upward from bed **(iv)** to 50 cm beyond the upper lag. Bed **(v)** and the overlying bed **(vi)** are lithologically identical except for the presence of calcareous concretions in bed **(v)** and ironstone in bed **(vi)**, both components being post-depositional. These two beds are therefore united with a line of demarcation indicating the absence of *L. woodsii*. Bed **(iv)** which possesses *L. woodsii* is integrated with beds **(v)** and **(vi)** to complete the unit **(b)**. Bed **(iv)** bifurcates 140 m south-west of Keefers Boatshed with an upper lag forming, consisting chiefly of *Lovenia* tests. This upper lag of bed **(iv)** is obscured by vegetation further to the south-west and is not represented north-east of the Motor Yacht Squadron.

Bed **(iv)** is evident near high water mark north-east of the Motor Yacht Squadron but subsides below the present beach level 100 m beyond the Motor Yacht Squadron pier. Singleton (1941), however, was unable to recognise beds **(iii)** and **(iv)** at this location. Beds **(iv)** to **(vi)** representing unit **(b)** can attain a thickness of 7 m suggesting that half of the cliff north-east of the Motor Yacht Squadron is composed of this one unit. Above this is the ferruginous sandstone, bed **(viii)**, equivalent to unit **(c)**, which marks the beginning of the Kalimnan and is itself disconformably overlain by the Red Bluff Sands, referred to here as unit **(d)**. A reliable boundary between the ferruginous sandstone and the sandy marl cannot be established due to inaccessibility and their similar appearance in outcrop.

Table 4: Summary of lag deposits within revised unit **(b)**.

Brighton Group	
Black Rock Sandstone	**Red Bluff Sands**
Sandstones and marly sands	Fine sands, grits and gravels
Heavy limonite cement derived from oxidation of glauconite	Clay matrix
Moderately lithified	Poorly consolidated
Ferruginous with locally developed ironstone bands	Iron oxide prevalent but less than in Black Rock Sandstone
Calcareous in part, or originally so	Non-calcareous
No clay seams	Clay balls and lenticles
Non-carbonaceous	Beds and lenses of carbonaceous material at base
Yellowish red to reddish brown	Pastel shades of red, brown, yellow, grey, etc.
Reasonably well stratified	Poorly bedded
Only minor development of current bedding	Cross bedding common

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Book Review

Kangaroo Island's Native Plants

by Ivan Holliday, Bev and Dean Overton

Publisher: *Swift Printing Service, Adelaide, 1994.*
Available from: *'Environmental Realist', 1 Nepean Avenue, Kingscote, SA, 5223.*
RRP: *$12.00 (plus $1.50 postage) per copy.*

With small colour plates (4 or 5 per page) featuring 236 species, this 63-page booklet is by far the most comprehensively illustrated (and probably most useful) guide to the flora of enchanting Kangaroo Island, S. Aust. Each picture is accompanied by the vernacular name (in large capital letters), up-to-date botanical binomial (italicized), plant family, brief description, flowering time (where applicable), habitat, and distribution within and beyond Kangaroo Island - altogether a mine of information condensed into a limited space, none of which is wasted. If only this little volume had been available during the FNCV's two-week excursion to the Island in October 1993, it would have much lightened the identification efforts of our botanical participants; but we were indeed fortunate to have been joined on several outings by co-author Bev Overton who could, on sight, name all the flowers we saw, as well a lead us to the exact locations of several rare items. Her book portrays 28 of the 40 taxa that are restricted to this Island (i.e. endemic plants). On the whole, reproduction of Ivan Holliday's and Dean Overton's colour photographs are clear enough, but in one or two plates the essential details are too fuzzy for recognition - e.g. Slaty Sheoak (p. 4), Coast Spear-grass (p. 54) and coastal cliff vegetation (p. 59). 'Kangaroo Island's Native Plants' is certainly in the "must" category for any visiting and inquisitive wildflower fancier.

J.H. Willis

A Case of Your Longyfolia

Glen Jameson[1]

What is quite remarkable, is that despite the relentless, savage destruction of much of our indigenous plant and animal communities over the past 200 years, we can still almost imagine what the landscape must have been like in those days in the wilds of old Melbourne.

In Warrandyte we are more than extremely fortunate, in having quality bushland remnants around us, you don't need to be a Plant Detective to begin to piece the puzzle together. But there are difficulties trying to imagine the original, complete Melbourne landscape, as different and beautiful as any in Wild Australia. A National Park scenic wonder up and down Collins Street. Koalas down by the Wharves. Kangaroos on Museum lawns, lazily loafing through a chapter of Owls.

How much do we know about our Natural Environment? It's an enormous subject with an index file longer than you'll ever have time to read. Perhaps it should be observed and experienced as much as possible as it remains a mystery of Mythical proportions. There is so little natural bushland left in the urban areas and all that remains is in a desperate bid for survival. We need to know much more if we are to share the future with the rest of the Planeteers into the next generations.

The question, as to whether or not *Acacia longifolia* is an indigenous plant of Warrandyte, that is, does it occur naturally in the local Forests as a bona fide member of the floral communities, or is it a weed, is an illustration of how we are learning to ask the right questions. Or at least, coming to terms with the complexities of the ecology of the natural environment. Attempting to comprehend the wonder and mystical allure of the Original Garden. Although it may seem to be a trivial argument to some, this question is of the essence to knowledge of Bushland Management. You must know precisely what you are managing, its composition and how it relates to the other components. We have already established that there are around 600 plant species in the Warrandyte State Park[1]. Approximately 376 are indigenous to the Forests of Warrandyte and 221 are weeds.

We have worked out the parameters to a large degree and now it is only less than one percent that we are in doubt over. However, it is an important one percent because of the destructive nature of weeds to the natural environment. We know that there are 51 species of Orchids, 20 Grass species, 10 Eucalypts, 15 Acacias (another 8 species of Acacia are weeds in Warrandyte) and so forth. Although much of the vast detail of the landscape has been lost, including the stream of local extinctions, there still remains a lot of information we are sure of. How do we know this? Firstly, through the remnants that remain and the communities that they form both here in Warrandyte and throughout the Bushlands of Victoria. Often there are Geological clues to Flora distribution, for example, the distribution of the Red Box in Warrandyte is due to the underlying Silurian Mudstones and the Hilly Gorge country. Secondly through the historical records that document the Indigenous vegetation.

Botany and the pursuit of knowledge in the Natural World, were passionate European pursuits in the sedate times of the late 19th Century. Field Naturalist Clubs were begun to foster interest and protection of the natural assets of the World. People boarded boats, crossed seas, Banking on a quest of discovery. As early as 1863, Baron Von Mueller, had produced the manuscript draft of 'Plants Indigenous to Victoria'.[2] Alas, it was never published in his time, not given the recognition it deserved, like so much of

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[1] P.O. Box 156, Templestowe, Victoria 3106.

our indigenous knowledge. But, the good Baron did manage to include a description of the distribution of *Acacia longifolia* at the time as '... in forest valleys of the eastern part of Gippsland; thence through New South Wales ...'

In 1886, Frances Vautier, a young and enthusiastic youth comes to the old Goldfield town of Warrandyte. Fired with Naturalist zeal to learn all that he can about this new and excitingly wild country, Frances compiles a list of the indigenous plants of Warrandyte. He floats along the Yarra, past Wetlands in a Bark Canoe. A Wurundjeri named Borruba had made the canoe from the bark of a River Red downstream of Warrandyte. Frances carefully observes that three pieces of Yellow Box had been shaped to internally frame the Canoe[3]. Frances made lots of notes on the Wurundjeri when he lived in the Red Box hills of Warrandyte, where are they?

In June 1985, debate arose under the Red Box and Messmate on the southern slopes of Fourth Hill. We are working to repair some erosion near the old Tin Shed just above the Gold Memorial Cairn. Some people did not want to plant *Acacia longifolia*, some did. Those who did want the plant offered these thoughts. (1) *Acacia longifolia* is an Australian Native plant that presently is found in most of the vegetation communities in Warrandyte. (2) There are some old specimens in the Park eg. the Scout Camp site in Galatlys Lane. (3) It is mentioned in Frances Vautier's notes and letter of 1886[4]. (4) Vautier also records a possible Wurundjeri connection with the plant.

Those who didn't want the plant countered with (1) *Acacia longifolia* was a proven Environmental Weed with the ability to invade many vegetation communities. (2) It had been planted widely over the past 20 years in local Gardens during the surge of interest in Australian Native Plants. (3) The plant is normally a component of the East Gippsland forests. (4) There are also some large Spotted Gums in the Scout Camp, but this doesn't make them indigenous. (5) Finally, they'd like to see Vautier's letter as it looks like investigations are needed.

Why is all this necessary to know I hear you ask? What damage could an Australian Native wattle possibly do to a Native Forest?

The problem is that there exists a suite of Wattles that are components of the various vegetation communities throughout Warrandyte. These Wattles are, as the other indigenous plants and animals are, interlocking pieces of a complex ecology, that have natural constraints and pressures, keeping all the individual components in balance. These constraints and pressures hold the power of the Forests together. They bind the Web of Life with strands of life, connecting all the individual plants and animals into a dynamic, living system.

When you throw a plant or animal from outside into this very specifically controlled system, the balances are thrown out. There is a spill of the rules. Chaos enters the ecology. Wrong plants in the wrong environment spells environmental disaster. This is true for all vegetation communities, in all Countries, for all the Planet. Australian Hakeas are destroying South African Bushlands. Tumbling Tumbleweeds from the American Cowboy Deserts, are a weed from Russia. The wrong Australian Native Plants in the wrong Native Vegetation Community is just as destructive as a weed from another continent. A Fog Grass from Yorkshire. A Fox, a Rabbit, a Goat from Europe. A bird from Asia or a Raven from India. All put the ecology, already severely damaged by our actions, into risk of destruction and extinction. Some weeds, such as 'Rib Weed' invaded North America so fast, that it was given the name by the indigenous Indians 'Whiteman's Footprint'. Brush-tail Possums, just like the indigenous ones that run over our roofs at night, has caused ecological mayhem in New Zealand when introduced there from Australia. The plant communities have never had to deal with Possum behaviour before and consequently have been easily destroyed by the invader.

Weeds compete with the indigenous plants for space, light and nutrients. Where they establish themselves, they will displace Plants from the natural community by occupying the different ecological niches. They alter the flora around them by changing the shade, water and nutrient regimes. They can dramatically alter the Fauna around them, even unbalancing the indigenous fauna. Weeds set in motion a chain of degrading processes and change the very dynamics of the forests, leading them to destruction. Weeds can be very expensive to remove and most of them escape into the Warrandyte State Park from Our Gardens. Weeds threaten the ecology of the World.

Things have been escaping into the bushlands for a very long time. A Flora list for the Mitcham area compiled by J.W. Audas, a senior Botanist at the National Herbarium in Melbourne, was published from a lecture given at the Mitcham Naturalists Club on 18 November, 1937[5]. One hundred and two years after Melbourne's settlement by Europeans, Audas recorded a total of 411 plants, of which 136 were introduced weeds. Interestingly, Audas records *Acacia longifolia* as Garden escape (also Sweet Pittosporum and two other Native Wattles as Garden escapes). Already, by then, the use of Native plants in Gardens was well established in local suburbs and documented as invading Bushlands.

On the 14 July 1986, Ross Williamson, Botanist for the then National Parks Service, wrote in reply to an inquiry regarding the natural distribution of *Acacia longifolia*, '...I have discussed the problem with numerous Botanists including David Cheal, David Cameron, Dr. Paul Gullan and Dr. Jim Willis. All of them agree with me in believing that *Acacia longifolia* is not native to Warrandyte or anywhere near it...'. The letter went on a little further, '...David Cameron postulated that *Acacia mucronata*, the 'Variable Sallow Wattle'; may have had intermittent and short lived populations along the Yarra after seed was brought down by flooding'.[6]

Well, that was that perhaps. A possible case of mistaken identity, certainly the natural distribution of *Acacia mucronata* covers the Traditional area of the Wurundjeri and I knew that the plant had been recorded at the Bend of Islands in Kangaroo Ground in recent times. There are more variations to the story. To complicate the matter there is another Wattle, the 'Coastal Wattle' *Acacia sophorae*, which was also a weed in the Park and is often confused with *Acacia longifolia*. It is strictly coastal in distribution and escaped into the Warrandyte State Park from Garden plantings. The experts had spoken, their word was thus, but what was the response of the Planters.

They pointed to the Wurundjeri connection in Vautier's letter. Surely if there was an Aboriginal connection to the plant, it must have been here for some amount of time. Vautier wrote, '...Joseph Shaw, the Superintendent at Corranderk (the Aboriginal Mission at Healesville), told me an interesting legend in regard to the Sallow Wattle (*Acacia longifolia*). This legend told to him by William Barak Chief of the Wurundjeri says that when the last of the Wurundjeri dies (this includes those of mixed ancestry), the Sallow Wattle shall never bloom again in the Land of the Wurundjeri. This was told to him to explain why this once plentiful tree was fast disappearing from the area'.[7]

It was hardly disappearing now, a good sign for the Wurundjeri perhaps but never-the-less, it was a powerful story that needed further investigation. Curiously in Vautier's meticulous Botanical notes he gives two common names to *Acacia dealbata*: 'Silver Wattle' and 'Barak's Wattle'. There is no Wurundjeri connection noted for any of the 'Sallow Wattles' in his Plant List. I was in need of more information and expertise. I rang an Archaeological author, who had just completed a book on the Wurundjeri and the Kulin Nation[8], on how to assess the strength of the Vautier letter. He held that if the words were not recorded directly from the person credited with the quote, it is not strongly creditable Ethno-history. So much for the Bible I thought. I wrote to another author who had published a book based on quotes from Barak[9]. The title involved the image of Wattles blooming and I asked the Author if the identity of the Wattle that was mentioned in the title and seemed to be of cultural significance to Barak. The author did not know the identity of the Wattle. In the book, Barak had predicted that when the Wattles bloomed he would die, just as his father had and many other Wurundjeri people. Barak died in early August, just when *Acacia dealbata* begins blooming along the Yarra River. This ties into Vautier's notes on the common name of *Acacia dealbata* being 'Barak's Wattle' or 'Silver Wattle'. To complicate things, *Acacia longifolia* also flowers in early August.

However, *Acacia longifolia* is not mentioned in a 1911 report by G. Coghill about a Field Naturalists Club excursion to Warrandyte[10]. It had been arranged to '...see the Silver Wattles, *Acacia dealbata,* in full bloom.... Our first view of the golden blossoms was secured as we crossed the bridge at Heidelberg ... here and there through Templestowe further glimpses were obtained ... in Warrandyte ... feasted our eyes ... on some splendid trees in full bloom ...'. Barak's Wattle and a delightful slice of Eco-Tourism in 1911 in which the participants ended with lunch in the local Grand Hotel. Still a good idea after all these years.

Beth Gott, a Botanist at Monash University with a long interest in, and an author on, Plant and Aboriginal relationships, came down strongly on the side of the mistaken identity theory. Beth believed that Vautier had mixed up the 'Variable Sallow Wattle' and the 'Sallow Wattle'.[11] Cliff Bueglehole's 'Distribution of Vascular Plants of Victoria' series did list *Acacia longifolia* for the local area[12]. In response to my letter, he stated that he was dependant on lists sent to him and that there was bound to be some mistaken records (Vautier's?). Cliff was not prepared to vouch for the validity of *Acacia longifolia* as local. Furthermore, he sent me his article about the destruction of local Bushlands near his home by the closely related *Acacia sophorae.*

In fact there was no one of any Botanical stature who was willing to support *Acacia longifolia* as being local and I sought quite a few opinions other than those mentioned.

At the Museum of Victoria, there is a Koorie Keeping Centre and Graeme Aitkenson is the bloke to see. I showed the letter to Graeme and he places it into the file not being able to comment on the letter much. Graeme is from the Yorta Yorta tribe in the Murray River region and knows plenty about his people and his country, but cannot comment on Wurundjeri matters. I visited the La Trobe Library and researched many of the references on the Wurundjeri (including Smyth[13] and Howitt[14]), for surely if the Wattle is tied to the fate of a Tribe, then there should be mention of it. I get lots of great information, but nothing concerning *Acacia longifolia.* I must contact the Wurundjeri.

There are many strong perceptions that sections of the Australian community hold when it comes to Aboriginals. One of those perceptions is that to be an Aboriginal, one must have a vast storehouse of knowledge on the Natural World. Plenty of this knowledge still remains, especially the instinctive connection and relevance of the Natural World to Human Society. However, the crushing of Aboriginal society by the European society, in some circumstances, made such knowledge non-essential for their own survival. Communing with Nature was frowned upon by the settlers, Authorities and those that ran the Missions. The Wurundjeri were forced to give up the external manifestations of their Traditional connections with the Land. Lost were many of the intimate details of that relationship. Much of the Language was destroyed; the Legends, the Songlines, the Mythology fractured with prolonged contact.

The Wurundjeri, as with many other indigenous people who have faced such pressures, have used their own parameters to define themselves. Things, such as the centrality of Family and the importance of Relatives, the manner in which children are brought up, the Spiritual centrality of the Earth, are strongly integral to the self definition of the Wurundjeri. Even with the veneer of those things by which we define Aboriginality, sheared away from their day to day activity, it is these inner values that define and give strength to the Wurundjeri. Consequently, the Wurundjeri could not help me in this investigation except to confirm the Cultural importance of the Silver Wattle.

If anybody wants to identify local plants now, there are some marvellous references around. Local guides, regional lists, Flora Surveys, identification Guides on Grasses, Orchids or Eucalypts. In fact a wealth of reference books. However did Vautier manage to identify the range of plants that he did? What references were available then? I'm sure that he wouldn't have had a photocopied version of Von Mueller's Victorian Plant List. Vautier's grandson, Arthur Williamson (no relation to Ross Williamson), a local Naturalist around Warrandyte, well known for his own list of Warrandyte indigenous plants that covers three generations of local Botanising, told me that most of Vautier's letters had been destroyed in a house fire.

In fact Vautier's list from Warrandyte is only part of the list, the rest has been lost. How did Vautier identify his plants? Arthur showed me Vautier's original copy of 'Plants of N.S.W., According to the Census of Baron F. Von Mueller, Government Botanist of Victoria', by William Woolls, (1885). It was purchased in 1886, the year Frances Vautier arrived in Australia, no doubt an expensive tome at the time. There was probably nothing available in print for Victorian Plants at the time.

Sleuthing down at the Herbarium, once the haunt of Von Mueller and still the residence of cocooned Botanists, I was put on the trail of someone doing research on Plant Catalogues. They were able to show me a copy of a Seed Catalogue from a Melbourne Company advertising sale of *Acacia longifolia* seed. The year was 1856. No doubt it was a popular selection then, growing in many situations. Sydneysiders had discovered its reliability and hardiness even before Melbourne was a twinkle in Batman's eyes.

The possibility that *Acacia longifolia* was grown as a Garden Plant in Warrandyte and began invading local bushlands even before Frances Vautier was born, is a valid scenario. The massive vegetation clearance and disturbance during the Gold Mining in Warrandyte, set ideal conditions for weed invasion of the Bushlands.

As soon as Europeans began arriving in Warrandyte and elsewhere, the push was on to create a Colonial style Paradise. Old photographs from the Warrandyte Historical Society's collection show Willows well established along the Yarra River by the 1870's. The Tradition of using Australian Native Plants was also well established in England in the Nineteenth Century, with many species being sought after and grown by collectors. Landscape Gardeners had selected favourites that were used in many rural Australian settings. Bunya Bunya Pines, Lilly Pillies, Sydney Blue Gums, Lemon Scented Gums and many other natives adorn old Farm gardens, rural and metropolitan Botanical Gardens and Private Gardens. From the first, there has been an interest and excitement produced by the Flora of Australia. Arthur Streeton was smitten by the Silver Wattles wreathing the snaking Yarra River as he painted down by Heidelberg.

I have camped in the Gippsland Forests where *Acacia longifolia* is a natural member of the Floral communities (as is Sweet Pittosporum). There it doesn't go wild and take over. It behaves like a good member of the community by filling its niche, being held in check by all the natural constraints of that ecology. The same for the Sweet Pittosporum. They both look comfortable in the Gippsland Forests and there is a sense of belonging for these plants in these places. But the same cannot be said when they are growing in the Forests of Warrandyte. Here, they run riot, uncontrolled by the local Flora Community Laws. They look out of place. Here they don't look comfortable or feel right. Here they do not belong, this is not their Country.

There are still stands of *Acacia longifolia* planted in the Warrandyte State Park, planted by those who believed it was the right thing to do. Some of the Planters still believe this. The seed provenance of these Plants would be interesting to investigate, with the invasion of so much *Acacia longifolia* into the Park it would be impossible to find the original plants, if there were ever any!

Acacia longifolia has been a useful Wattle. It has helped the return of Native Birds into the suburbs of Melbourne when it was planted widely in the last Twenty years as Gardens began returning to Australian plants. I imagine it possibly could have protected the Bushlands in some instances, by invading areas of soil disturbance and stopping erosion and by sheltering Native Animals when so much of their habitat was being destroyed. It has inspired local Theatre to create plays on the mythological importance of our Bushlands. It has made us investigate the essence of the local Bushland and test us to see how much we know about it. However, despite this, it still remains from my investigations, a plant that is not an indigenous plant of Warrandyte or anywhere nearby.

***Acacia longifolia*, I salute you and then I must uproot you.**

Acknowledgements

I would like to thank the cast of thousands within the Indigenous Flora and Fauna interest groups and personalities who gave me advice , direction and encouragement during my investigations. Also thanks to Robyn Watson, Pat Grey and Ed Grey for editorial advice and comment.

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Dual Occupancy! Daytime Use of a Tree by Two Species of Possum

Rob Wallis[1]

On the morning of 3 May 1994 my children observed a Common Ringtail Possum *Pzeudocheirus peregrinus* resting in the fork of a Lilly-pilly *Acmena smithii* tree in our back-yard in Burwood. The unusual feature was that the animal was sleeping in a fork of the tree in a pose reminiscent of that of Koalas. It was about 3 m above the ground.

When I went to observe the possum, I noticed a Common Brushtail Possum *Trichosurus vulpecula* also resting in the same tree but near its top, about 4 m above the gound. It was quite alert and watched me but made no attempt to move. About one hour later I went to the tree again and noticed that the ringtail possum had moved higher in the tree and was asleep about half a metre from the brushtail. About an hour later it had returned to its original fork where it remained for the rest of the day.

About 8 p.m. that evening our dog barked at a Brushtail Possum (presumably the same one) as it ran along the top of the fence near the tree where it had rested.

The Lilly-pilly is next to a fruiting *Feijoa sellowiana* tree which, judging by the condition of scats in our yard, has been used by both possums as a food source. Perhaps both animals had been feeding in the Feijoa when dawn broke and they were left 'stranded' in the corner of our yard. Our dog was lying at the base of the Lilly-pilly for most of the day; it might have prevented the possums returning to their normal day-time rest sites around dawn.

We have a Common Brushtail Possum (a large male) which sleeps in our roof. At dusk I heard it shuffling about preparing to exit, and went to check if it and the one in the Lilly-pilly may be the same animal. There were not - the one in the tree was still there and was somewhat smaller than our resident possum.

The next day we went away. When we returned home ten days later, we found the Common Ringtail Possum back resting in the fork of the Lilly-pilly, but the Common Brushtail Possum was dead by the fence.

What I consider unusual is the occupancy of the one tree by the two animals without any apparent audible or visible interaction. Furthermore, it is unusual for the possums not be to resting during the day in a shelter such as a drey (Ringtail Possum), tree hollow (both species) or in part of a building such as under a roof (Brushtail Possum). Both animals may well have been juveniles which had been born during spring and which were dispersing from parental home territories. This is a time of high mortality in both species.

Common Ringtail Possum sleeping in fork of Lilly-pilly, Burwood.

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[1] School of Aquatic Science and Natural Resources Management, Deakin University - Rusden Campus, Clayton, Victoria 3168

Leathery Turtle (Luth) *Dermochelys coriacea*

On 6 February 1993 a dead, beach-washed specimen of the Leathery Turtle *Dermochelys coriacea* was found 1.5 km north of the Darby River mouth on the north-west side of Wilson's Promontory.

This specimen was small with a head and body length of 1.2 m and a probable live weight of 100 to 150 kg. The animal was most likely sub-adult.

The species is identified by a series of seven prominent longitudinal ridges above, and four ridges along, the plastron which is covered by a thick, smooth, leathery skin usually a uniform dark brownish-black above. Some specimens can attain a length of 3 m and a weight up to 900 kg.

Nine records of the turtle have been made in Victoria since 1970 either as sightings at sea or strandings (Table 1) and the species is most frequently located around Australia in temperate waters. The species is rare though widespread and is found in all temperate and tropical seas.

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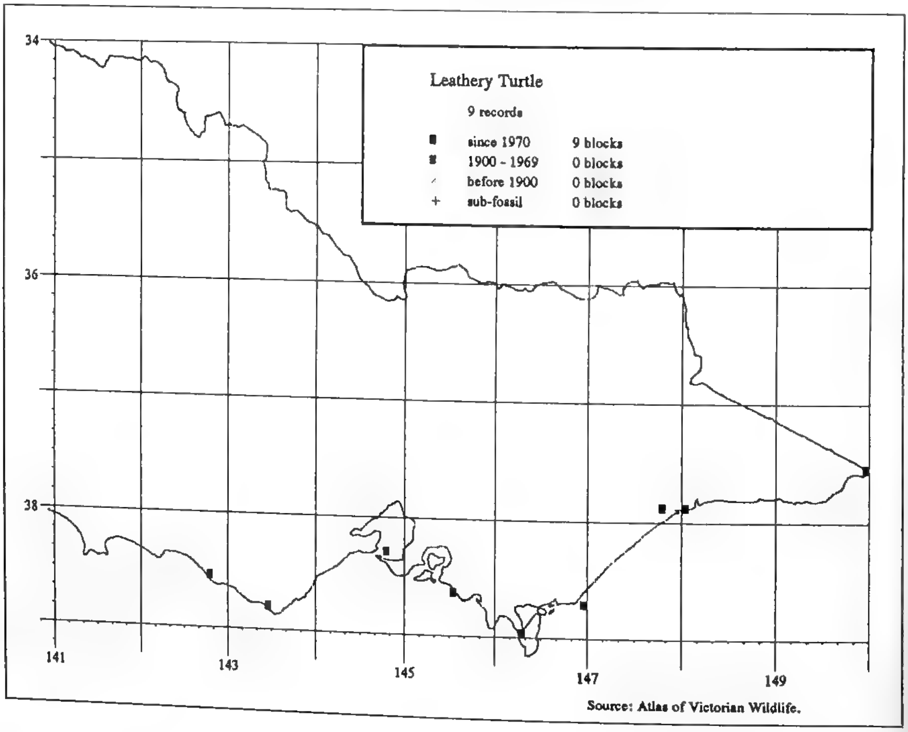
The following letter with additional information is copied with authority from the writer:

Dear Russell,

Many thanks for the skull of the Luth which you brought into the museum recently. This has been registered into the collection as D66968.

The museum does not keep records of strandings of marine turtles in Victoria, as we only hear of some of them. I believe that the Department of Conservation & Natural Resources keep records. We usually hear of strandings of marine turtles on the average of 1

Table 1. Victorian records of the Leathery Turtle *Dermochelys coriacea.*



Source: Atlas of Victorian Wildlife.

every two or three years, although they seem to come in spates. Specifically on the Luth, I have only heard of two sightings of this species within Victoria over the past 15 to 20 years. Both of these specimens had been caught in nets by professional fishermen.

Worldwide, this species is possibly the most threatened species of marine turtle, with most rookeries being over exploited for eggs. I know of no Australian rookeries.

Yours faithfully

A.J. Coventry
Curator of Herpetology, Museum of Victoria

The Recovery of Two Crested Terns *(Sterna bergii)*

Two beach-washed Crested Terns *Sterna bergii* were recovered on an area of coastline 6-7 km west of Ram Head, Croajingolong, East Gippsland, Victoria. Both were banded as nestlings on Mud Island, Port Phillip Bay, Victoria, on the 19/12/92 by The Victorian Wader Study Group.

Information on banding details is provided by the Australian Bird and Bat Banding Schemes when bands are returned to them. The time between banding and recovery was 5 months and 28 days and both birds had moved at least a distance of 335 km on a bearing of 64°. Band numbers were 072-23880 and 072-23586.

Russell Thompson
10 Nokes Court,
Montmorency, Victoria 3094

Book Review

The Story of Mossvale Park

by Ellen Lyndon (O.A.M.)

Publisher: *Woorayl Shire Historical Society*

Francis Moss never lived at Mossvale. The nursery which he established in 1853 was at Mt. Buninyong, but in the 1890's he bought land on the western branch of the Tarwin River between Mirboo North and Leongatha. Here he established another nursery, Mossmont-on-Tarwin, in the care of a manager. After Francis Moss' death the property was offered for sale, and there was a succession of owners, all of whom seem to have been happy to allow school picnics and sports to be held in the paddock along the river. In 1946 the Shires of Woorayl and Mirboo jointly purchased the land as a reserve, and from the mid-sixties the Shire of Woorayl has been responsible for the management of the park.

In the 1980's Ellen Lyndon asked the Mossvale Committee of Management what was the history of the park. The result, to coincide with the 25th anniversary of the Mossvale Summer Concert, is this booklet, in which she traces the history of this land from a 'riverside picnic ground' to the park which today caters for a variety of activities, from camping to pony riding to the summer concerts, or simply enjoying the autumn splendour of the deciduous trees. The appendices contain details of the exotic trees which have survived from the original planting; those planted in 1987, 1988 and 1992, many by Francis Moss' descendants; the 1979 survey of fish in the Tarwin River and the 'Music of the People' held in the park.

Sheila Houghton

Census of the Vascular Plants of Victoria
Update Bulletin No. 4.3

Compiled by T.J. Entwisle[1]

Introduction

For the last three and a half years, the National Herbarium of Victoria has distributed an update bulletin to publicise changes to the most recent edition of *A Census of Vascular Plants of Victoria.* These bulletins have had a restricted distribution and it was felt that a wider audience might be interested in receiving such information. To this end, the update bulletins will be published in *The Victorian Naturalist* at appropriate intervals (depending on the number of additions and alterations to the *Census*). The number (4.3) refers to the edition of the *Census* (currently edition four) and to the number of update bulletins produced since that edition (this is the third).

The fourth edition of the *Census* is available for sale ($18 over the counter, $23 posted) from the Visitor Centre, Royal Botanic Gardens Melbourne, Birdwood Ave, South Yarra, Victoria 3141 (Ph: 03-655 2300). Additions and corrections to the *Census* should be submitted in writing to Dr Jim Ross at the same address.

Minor corrections and alterations - such as changes to the spelling of a species epithet, e.g. *Acacia brownei* to *Acacia brownii,* or the addition of a subspecific name without any change to the species name or the circumscription of the taxon in Victoria, e.g. *Acacia mucronata* to *Acacia mucronata* var. *longifolia* (the other two varieties are in Tasmania) - are not included in the update bulletins. The quality and quantity of information provided for each taxon depends on the available literature and the source of the record (diagnostic characters are taken from the original publication where possible). Note that there may be some delay between the publication of new records or species and their appearance in these updates. An asterisk (*) indicates that the taxon is naturalised in Victoria (i.e. it is native outside Victoria but has become established in this State).

Conifers
CUPRESSACEAE

Callitris gracilis R. Baker, *J. & Proc. Roy. Soc. New South Wales* ser. 2, 38: 839 (1904).

Name change for *Callitris preissii* in Victoria. The type of *C. preissii,* from Rottnest Is. in Western Australia, differs from what has been widely known as '*C. preissii*' in the rest of Australia and *C. gracilis* is the next available name for the more widespread taxon.

Monocotyledons
LILIACEAE

Calostemma luteum Sims, *Bot. Mag.* 46, t. 2101 (1819).

New record for Victoria. This species, known from inland South Australia, New South Wales and Queensland, has been found west of Merbein in far north-west Victoria. It differs from *C. purpureum* in having flowers wholly bright yellow except for 6 vertical red stripes in the lower third of the corona (between the perianth and the stamens) and in having generally larger flowers (perianth about 3 cm long and corona about 9 mm long).

***Ornithogalum longibracteatum** Jacq, *Hort. Bot. Vindob.* 3: 18 (1776-77).

New weed record for Victoria. Commonly called the Pregnant Onion, *O. longibracteatum* is an erect herb to 1.5 m high, producing numerous bulbils, with leaves 20-50 cm wide and up to 300 flowers per inflorescence. It has become established at Parwan South, Lake Lonsdale and in the Long Forest Flora and Fauna Reserve.

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[1] National Herbarium of Victoria, Royal Botanic Gardens Melbourne, Birdwood Ave, South Yarra, Victoria 3141.

LOMANDRACEAE

Lomandra oreophila Conn & Quirico, *Muelleria* 8: 129 (1994).

New name for *Lomandra micrantha* var. *sororia* (included in the *Census* as part of *L. micrantha* subsp. *tuberculata*), a species of mountain areas near Mt Wellington, with an outlying population at Mt Tingaringy. *Lomandra oreophila* differs from *L. micrantha* in its broader (3.3-5 mm), almost flat leaves.

ORCHIDACEAE

Caladenia amoena D.L. Jones, *Muelleria* 8: 177 (1994).

New record for Victoria. Previously confused with the New South Wales species *Caladenia concinna* but distinguished from that species by its generally smaller flowers with the lateral sepals and petals curved downwards towards the ovary (giving flower a drooping appearance). *Caladenia toxochila* is a similar Victorian species but it has darker coloured flowers with sepals more prominently clubbed, and the labellum has thicker, blackish, congested lamina calli. *Caladenia toxochila* is limited to north-west Victoria and South Australia, while *C. amoena* is known only from a few dry forest habitats near to Melbourne.

Diuris ochroma D.L. Jones, *Muelleria* 8: 182 (1994).

New name for *Diuris* sp. aff. *lanceolata* (Wonnangatta). Although known thus far only from the Wonnangatta Valley, this species may be more widespread. It differs from *D. lanceolata* in having dark striations on the perianth segments and in having labella with a complexly lobed lamina callus which extends by faint accessory ridges on to the midlobe.

Prasophyllum correctum D.L. Jones, *Novon* 4: 106 (1994).

New name for *Prasophyllum chasmogamum*. Due to an error in choosing the type specimen of *P. chasmogamum*, a new name was needed for this rare taxon from eastern Victoria.

Prasophyllum suaveolens D.L. Jones & R.J. Bates, *Muelleria* 8: 184 (1994).

New name for *Prasophyllum* sp. aff. *fuscum* (Basalt Plains). Restricted to relic grassland on the Volcanic Plain west of Melbourne and characterised by its relatively small stature (flowering plant to 25 cm tall) and its small (4-5 mm across) flowers emitting a strong, spicy fragrance and with a broad, smooth labellum callus which is prominently thickened in the distal third.

Pterostylis atrans D.L. Jones, *Muelleria* 8: 185 (1994).

New name for *Pterostylis obtusa* in Victoria. *Pterostylis obtusa* is now considered to be restricted to central and northern New South Wales (and possibly Queensland) leaving the Victorian plants long known as *P. obtusa* without a name. *Pterostylis atrans* differs from *P. obtusa* (in its new restricted sense) in flower size and colour, and in the slightly clubbed lateral sepals.

Pterostylis monticola D.L. Jones, *Muelleria* 8: 189 (1994).

New name for *Pterostylis* aff. *alpina* (Large flowers). As suggested by the interim designation used in the *Census*, *P. monticola* has larger flowers than *P. alpina* (4-5 cm long cf. about 3 cm long). In addition, the sinus formed by the fused sepals protrudes in a shallow rather than abrupt curve when viewed from the side, and the free points of the sepals are erect rather than reflexed behind the hood. *Pterostylis monticola* seems to be widespread throughout south-eastern Australia but is so far known from only a few (montane) sites in Victoria.

Pterostylis tasmanica D.L. Jones, *Muelleria* 8: 190 (1994).

New record for Victoria. Apparently widespread in southern Victoria, Tasmania and New Zealand, *Pterostylis tasmanica* has been hidden within *P. plumosa*, but it differs from that species in being shorter (to 14 cm tall), with smaller (to 7 mm long and 2.4 cm wide) leaves arranged in a relatively tight rosette and small, self-pollinating flowers with a more densely plumose labellum and a short apical point on the hood (giving the flower a somewhat blunt appearance). *Pterostylis plumosa* in its new restricted sense is still considered to be a widespread species in Victoria.

Pterostylis valida (Nicholls) D.L. Jones, *Muelleria* 8: 191 (1994).

New name for *Pterostylis squamata* var. *valida* ('= *Pterostylis* sp. aff. *excelsa*' in *Census*). This taxon from the Maldon area is now presumed extinct. It is (or was) characterised by its narrow green flowers and narrow labellum attenuated at the apex, with few marginal calli and poorly developed basal lobe without any hairs.

POACEAE

***Hordeum vulgare** subsp. **distichon** (L.) Körn, *Zeitschr. Ges. Brauw.* 5: 125 (1882).

***Hordeum vulgare** subsp. **vulgare**

New weed record for Victoria. Two subspecies of *Hordeum vulgare* are now recognised in this State but var. *vulgare* is known only from Gardiners Creek at Box Hill South. The widespread subsp. *distichon* differs from subsp. *vulgare* in having only 2 rows of spikelets maturing seed (hence the common name Two-row Barley) rather than 6 rows in subsp. *vulgare*.

***Spartina anglica** C.E. Hubb., *Bot. J. Linn. Soc.* 76: 364 (1978).

New weed record for Victoria. Previously overlooked as part of *Spartina x townsendii*, this species forms extensive 'cord-grass' meadows in south Gippsland, presumably the result of recent expansion. *Spartina anglica* differs from the hybrid taxon in having longer anthers (8-13 mm cf. 5-8 mm long) that produce fertile pollen (not malformed as in *S. x townsendii*). *Spartina anglica* is derived (by doubling the number of chromosomes) from *S. x townsendii*.

Dicotyledons

AMARANTHACEAE

Alternanthera sp. (plains)

New record for Victoria. Previously confused with *Alternanthera denticulata*, but differing from that species in having shorter (ovate to obovate), broader leaves; broader perianth segments; a tap-root; and in being perennial rather than annual. Widespread mostly in northern Victoria (also on Volcanic Plain west of Melbourne) but not growing near rivers and lakes (as *A. denticulata* does).

ASTERACEAE

Senecio pinnatifolius A. Rich, *Sert. Astrolab.* 117 (1834).

Name change for *Senecio lautus*. *Senecio lautus* is considered to be a New Zealand endemic and the name *S. pinnatifolius* has been applied to all Australian members of this variable taxon.

Senecio psilocarpus Belcher & Albr., *Muelleria* 8: 113 (1994).

New name for *Senecio* sp. aff. *squarrosus* (South West Swamps), a taxon with a scattered distribution between Wallan and south-eastern South Australia. It differs from *S. squarrosus* in having fruits which are reddish-brown to brown and entirely glabrous.

CACTACEAE

***Opuntia leucotricha** DC., *Mém. Mus. Hist. Nat. Paris* 17: 118 (1828).

New weed record for Victoria. *Opuntia leucotricha* is the only naturalised species of Opuntia in Victoria with (minutely) pubescent segments. The spines are more or less pliable and sometimes curved irregularly. It has thus far become established on roadsides near Bacchus Marsh and Merbein.

FABACEAE

***Chamaecytisus palmensis** (Christ) Bisby & K. Nicholls, *J. Linn. Soc. Bot.* 74: 114 (1977).

New name for *Cytisus palmensis*. Following a revision of *Cytisus*, this Canary

Island native has been returned to the genus *Chamaecytisus* based on the pale cream flowers (usually yellow in *Cytisus*) with a tubular calyx (campanulate in *Cytisus*).

***Lathyrus odoratus** L., *Sp. Pl.* 2: 732 (1753).

New weed record for Victoria. Native to Europe and collected once in Victoria, from near Nhill. It differs from the 3 other species of *Lathyrus* naturalised in Victoria in having pubescent calyx and pods.

***Lathyrus tingitanus** L., *Sp. Pl.* 2: 732 (1753).

New weed record for Victoria. A Mediterranean species which has become established in the Portland and Mt Eccles areas of south-western Victoria. It differs from the 3 other species naturalised in Victoria in having long (more than 7 mm) peduncles and glabrous calyx and pods.

***Lotus corniculatus** var. **tenuifolius** L., *Sp. Pl.* 776 (1753).

Name change for *Lotus tenuis.* Native to Europe, Asia and northern Africa, it is established across southern Victoria, most notably at Glengarry near Traralgon and Princetown near Port Campbell. This nomenclatural change follows the 1984 revision of the *Lotus corniculatus* complex in *Can. J. Bot.* 62: 1044-53.

***Lotus preslii** Ten., *Fl. Napol.* 5: 160 (1836).

New record for Victoria. Specimens have been collected from Walwa in north-east Victoria and Ferntree Gully near Melbourne. It is distinguished from other members of the *Lotus corniculatus* complex in having a generally longer calyx with teeth about 1.5 times longer than the tube.

***Lupinus angustifolius** L., *Sp. Pl.* 721 (1753).

Previously misidentified as *Lupinus cosentinii,* this weed from the Mediterranean region has been collected from pastureland near Ballarat and along a disturbed roadside near Warragul.

Pultenaea lapidosa Corrick, *Muelleria* 8: 119 (1994).

New name for *Pultenaea* sp. aff. *subspicata* Benth. Known only from near Omeo and near Beechworth, it differs from *P. subspicata* in having larger flowers, longer leaves with a long hair-like tip, and longer stipules less closely appressed to the stem and with a long, recurved tip.

Sphaerolobium acanthos Crisp, *Muelleria* 8: 151 (1994).

New name for *Sphaerolobium* sp. (Grampians). Previously confused with *S. daviesioides,* a Western Australian endemic, it differs from the other two Victorian species of *Sphaerolobium (S. vimineum* and *S. minus)* in its distinctive branches which are numerous, short (to 15 mm), divergent, and spinesent.

***Trifolium squamosum** L., *Amoen. Acad.* 4: 105 (1759).

New weed record for Victoria. A European and north African species which has been collected once from Codrington near Portland in south-west Victoria. It differs from *Trifolium lappaceum* in the corolla being substantially longer than the often hairy and 10-veined calyx.

HALORAGACEAE

Haloragis odontocarpa f. **octoforma** Orchard, *Bull. Auckland Inst. & Mus.* 10: 93 (1975).

New record for Victoria. This taxon is not uncommon in open dune areas in the Hattah Kulkyne National Park. It differs from the more widespread f. *odontocarpa* in having fruits 4-winged longitudinally between the sepals, the wings constricted in the centre.

MIMOSACEAE

Acacia ancistrophylla C.R.P. Andrews, *J. Western Australian Nat. Hist. Soc.* 1: 40 (1904) var. **lissophylla** Cowan & Maslin in Simon & Whibley, *Acacias of South Australia* edn 2, 206 (1992).

New name for *Acacia lineolata* as used in Victoria: *A. lineolata* (in its restricted sense) is only found in Western Australia.

Acacia lanigera var. **gracilipes** Benth., *Fl. Austral.* 2: 325 (1864).

Acacia lanigera var. **lanigera**

Acacia lanigera var. **whanii** (F. Muell. ex Benth.) Pescott, *Census Acacia* 24 (1914).

New records for Victoria. *Acacia lanigera* has been split into three varieties which are distinguished in the following key:

1. Peduncles 6-9 m long; phyllodes narrowly elliptic with gland at or near base; East Gippsland.....var. *gracilipes*
1. Peduncles 2-3.5 mm long; phyllodes linear-oblanceolate or elliptic with gland 2--13 mm above base................2
2. Branchlets with dense, spreading hairs; phyllodes elliptic to linear-elliptic; north-east Victoria..........var. *lanigera*
2. Branchlets with more or less sparse hairs; phyllodes linear-elliptic to linear-oblanceolate............var. *whanii*

Acacia montana

The two varieties, var. *psilocarpa* and var. *montana*, are no longer recognised since the presence of glabrous pods (in var. *psilocarpa*) is no longer considered to be a reliable taxonomic character in this species.

MOLLUGINACEAE

***Mollugo verticillata** L., *Sp. Pl.* 89 (1753).

New weed record for Victoria. This prostrate plant growing on recently inundated flats beside the Ovens River south of Peechelba is native to Africa, North America and presumed to be introduced in Queensland and now Victoria (collected 1994); however it is accepted as a native species in New South Wales. It resembles *Glinus oppositifolius* but has seeds without a conspicuous caruncle and smooth except for 3-7 narrow dorsal ridges.

MYRTACEAE

Eucalyptus pauciflora subsp. **acerina** K. Rule, *Muelleria* 8: 223 (1994).

Eucalyptus pauciflora subsp. **hedraia** K. Rule, *Muelleria* 8: 227 (1994).

Eucalyptus pauciflora subsp. **parvifructa** K. Rule, *Muelleria* 8: 229 (1994).

Eucalyptus pauciflora subsp. **pauciflora**

Eucalyptus pauciflora subsp. **niphophila** (Maiden & Blakely) L. Johnson & Blaxell, *Contr. New South Wales Natl Herb.* 4: 379 (1973).

New records for Victoria and a resurrected rank for an existing taxon. Subsp. *acerina*, restricted to the Baw Baw Plateau, is non-waxy and has fruits 4-7 mm long and 5-8 mm in diameter. Subsp. *hedraia*, restricted to near Falls Creek, Mt Bogong and Mt Arthur, is characterised by being waxy, in having sessile buds, and in having fruits 7-10 mm long and 10-15 mm in diameter. Subsp. *parvifructa* is known only from the Mt William Range in the Grampians, and has juvenile leaves with waxy petioles, pedicellate buds, and fruits 5-8 mm long and 6-8 mm in diameter. *Eucalyptus niphophila*, with its relatively broad adult leaves, has been reduced, again, to subspecific rank.

Eucalyptus serraensis Ladiges & Whiffin, *Austral. Syst. Bot.* 6: 367 (1993).

Eucalyptus verrucosa Ladiges & Whiffin, *Austral. Syst. Bot.* 6: 367 (1993), *nom. illeg.* [unfortunately this is a later homonym of *E. verrucosa* Colla (1834) and a new name must be devised for the taxon described by Ladiges & Whiffin].

Eucalyptus victoriana Ladiges & Whiffin, *Austral. Syst. Bot.* 6: 366 (1993).

New records for Victoria. These 3 taxa replace *Eucalyptus alpina* in the sense of J.H. Willis, *Handb. Pl. Victoria* 2: 411 (1973), the type specimen of which is now considered to be a hybrid. The following key separates the three new taxa:

1. Usually a tall tree; leaves broad-lanceolate, not coriaceous; flower buds 7-11 per cluster, only slightly warty; Victoria Range in Grampians ....*E. victoriana*
1. Small tree, mallee or shrub; adult leaves ovate to circular, coriaceous; flower buds 1-7 per cluster, warty......2
2. Adult leaves ovate, oblique, ter-

minated by short point; flower buds often 1-3 (but up to 7) per cluster; northern Serra Range and Wonderland Range in Grampians.......*E. serraensis*

2. Adult leaves nearly circular, apex notched; flower buds 3-7 per cluster; southern Serra Range in Grampians ....*E. verrucosa nom. illeg.*

Eucalyptus silvestris K. Rule, *Muelleria* 8: 193 (1994).

New record for Victoria. Included in the informal 'superspecies' *odorata*, a group of taxa related to the non-Victorian species *E. odorata*. The following key separates the 3 taxa in Victoria.

1. Adult leaves dull; St Arnaud to Inglewood......................*E. polybractea*
1. Adult leaves sub-lustrous or lustrous; west of Horsham...............................2
2. Stems box-barked; well-drained loams ....*E. silvestris*
2. Box bark basal or confined to lower stem; infertile ridges or sandy rises ....*E. wimmerensis*

PLUMBAGINACEAE

***Limonium hyblaeum** Brullo, *Bot. Not.* 133: 282 (1980).

Previously misidentified as *L. bellidifolium*. A Sicilian weed species of saltmarsh areas.

PORTULACACEAE

Montia fontana subsp. **amporitàna** Sennen, *Bull. Geogr. Bot.* 20: 110 (1911).

Montia fontana subsp. **fontana**

Two new records for Victoria. Subsp. *chondrosperma* was previously the only recorded subspecies of *M. fontana* from this State. A key to the 3 subspecies follows:

1. Seed virtually smooth, 1.3-1.8 mm in diameter; flowers both solitary and in clusters or all clustered; Baw Baw plateau.............................var. *fontana*
1. Seed distinctly tuberculate, 0.6-1.2 mm in diameter; flowers all or mostly solitary in axils...................................2
2. Seed-tubercles of dorsal rows conic, elsewhere elongated and less raised; Snowy Range, Strathbogie-Merton area, Benalla..............var. *amporitana*
2. Seed-tubercles rounded at apex, virtually equal in size, shape and distribution across surface; widespread.................var. *chondrosperma*

RANUNCULACEAE

***Ranunculus acris** L, *Sp. Pl.* 554 (1753).

New weed record for mainland Australia. This European species, found near Poowong in Gippsland, is similar to *R. repens* but is not stoloniferous, the flowers have a glabrous receptacle and the beak is less than 1 mm long.

VERBENACEAE

***Phyla canescens** (Kunth) E. Greene, *Pittonia* 4: 48 (1899).

Change of rank for *Phyla nodiflora* var. *canescens*. Following a recent revision in *J. Adelaide Bot. Gard.* 15: 109-28 (1993) this variety has been raised to species level.

WINTERACEAE

Tasmannia vickeriana (A.C. Smith) A.C. Smith, *Taxon* 18: 287 (1969).

Tasmannia xerophila subsp. **robusta** Raleigh, *Muelleria* 8: 255 (1994).

Resurrected name for *Tasmannia* aff. *xerophila* (Baw Baws) and a new name for *T.* aff. *xerophila* (Errinundra Plateau) respectively. *Tasmannia vickeriana* is restricted to the Baw Baw Plateau and is similar to *T. xerophila* but has smaller leaves (usually less than 2 cm long) and burgundy coloured berries. Subsp. *robusta* differs from the type subspecies of *T. xerophila* in its habit – it is a shrub to small tree 2.5-4 m tall – and in having leaves 7-14 cm long and 2-3 cm wide; it is known only from Goonmirk Rocks and Mt Ellery in East Gippsland.

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The following provided information or read the manuscript: Ian Clarke, Jeff Jeanes, Jim Ross, Val Stajsic, Neville Walsh.

The Field Naturalists Club of Victoria

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The Victorian Naturalist

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'Ground Flora - Restoration and Management' Conference

Greening Australia Victoria
Selected Papers

y The Field Naturalists Club of Victoria
since 1884

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Scope

The Victorian Naturalist publishes articles on all facets of natural history. Its primary aims are to stimulate interest in natural history and to encourage the publication of articles in both formal and informal styles on a wide range of natural history topics. Authors may submit material in the following forms.

Research Reports - succinct and original scientific communications. The style for reports should follow the traditional format of scientific papers in the Australian literature.

Contributions - may consist of reports, comments, observations, survey results, bibliographies or other material relation to natural history. The scope is broad and little defined to encourage material on a wide range of topics and in arange 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.

Preference will be given to short articles not exceeding 2500 words.

Naturalist Notes - short and informal natural history communications. These may include reports on excursions, talks or observations.

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Review Procedures

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Authors Copies

Five complimentary copies of the journal will be sent to authors for their use. Reprints and addtional copies of the journal can be arranged at the time of the final submission of the paper.

CONGRATULATIONS !

JEAN GALBRAITH

All members of The Field Naturalists Club of Victoria join in heartily congratulating Jean Galbraith in having a plant named after her; a boronia that she dicovered. *Boronia galbraithiae* is a charming and dainty member of the family and found near Mt Difficult in South Gippsland. Jean is a long-time and deeply valued club member and her dedicated botanical work has been justly rewarded.

The Victorian Naturalist

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Contributions

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Proceedings of the 'Ground Flora - Restoration and Management' Conference, Greening Australia Victoria, August 1991. Part three of a four-part series.

First Things First - Planning a Restoration Project

Ian Sluiter[1]

Introduction

The present landscape of Australia has been moulded by at least 60 000 years of anthropogenic influence, although the current level of environmental degradation - which is indeed the major reason we attended the seminar - is a direct legacy of European man's 200 years of occupation.

I have started with an historic and prehistoric reflection, principally to impress upon participants the importance of embracing a temporal or time transient perspective to any landscape rehabilitation project. It is easy to remember or imagine a landscape from a photograph or historic record, it is far more difficult to conceive where that landscape came from, what stage it was at - indeed where it may have gone if it had not become degraded. I will return to this concept later in the paper when we examine a current rehabilitation programme I am presently involved with in semi-arid north-west Vicoria.

The principal aim of this paper is to establish some guidelines as to how to go about planning a restoration project. Other participants have contracted to limit their discussions to the ground flora. I fully intend to take a broader perspective and include larger and longer-lived perennial vegetation in my discussion. Indeed, grasslands and wetlands excluded, in most cases others have dealt with ground flora but here I will include the overstorey or future overstorey in my considerations.

Why restore landscapes?

This is a simple question for which a multitude of answers might be received. On examining the philosophy for the creation and maintenance of National Parks, Shepherd and Caughley (1987) suggest that seven points of view are currently in existence. They are to conserve (1) scenery and nice animals, (2) soil and plants, (3) the physical and biological state of the land at an arbitrary date, (4) representative examples of plant and animal associations, (5) biological diversity, (6) genetic variability, (7) biological processes. Shepherd and Caughley contend that the above viewpoints need not be mutually exclusive and although referring to National Parks, are not too distant from the thinking of any group or individual concerned with environmental restoration anywhere. The only omission with respect to the above is that the word 'enhancement' could be added as this concept is implicit with any environmental restoration project. Indeed to 'conserve and enhance' is not too distant from the pivotal words of the Victorian Government's Flora and Fauna Guarantee (FFG Act 1988) - to 'service and flourish' in the wild.

In reality most environmental restoration projects, either by accident or design, manage to create what Bridgewater (1990) terms 'synthetic vegetation' or a modified landscape. In other words a new form of vegetation originating from the fusion of 'exotic/adventive/invasive species' along with the indigenous plant species. The ideal of 'naturalness' or 'indigeneity' may, in actual fact, be just that - an ideal or abstract concept. Notwithstanding, there is nothing wrong in aiming to restore a degraded block of land to near original condition. As stated earlier, others may simply be interested in conserving and enhancing the soil, plants or nice animals. In short an environmental restoration project might be undertaken for a variety of reasons. These will depend on the project originators ideals, concepts and backgrounds. The criteria for acceptance of these reasons, be it by governments, committees of management or public opinion - is another story for another day.

The planning process

In the following discussion I will at-

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tempt to argue that landscape restoration projects involve a series of carefully considered stages. If they are not followed, more or less in order, difficulties can arise and implementation of the project can be delayed or even worse, become impossible. Depending on the project, in particular on the urgency for works implementation, some shuffling of the order may be appropriate.

Stage 1: The status of the land

The first energy of any group planning a restoration project should be expended on establishing all aspects of the status of the land. A check-list of questions should be assembled. For instance: who **owns** the land? (e.g. government, private individual, financial institution, the public); who **manages** the land? (e.g. committee of management, owner, tenant, licensee, squatter); are there any **covenants** on the land?; is the land subject to an antagonistic **zoning proposal**?; are there potentially **conflicting interests** or interest groups? The answers to these questions provide the statutory and legal justification to pursue a restoration project.

Stage 2: The inventory

This stage in the planning process is basically an information gathering exercise which provides the background information for the next stage - the development of a management plant. Information about the land in question can be gathered from a number of sources. A useful starting point is to again make a check-list. For instance:

Maps, plants and photographs - can usually be obtained from Government Department offices such as the Department of Conservation and Natural Resources (DCNR), Department of Industry, Technology and Resources. Local Government or Map Sales Victoria. Depending on the size of the area, decide on a base mapping scale and map the important features (geological, biological, hydrological, etc.).

Historical records, reports and accounts are particularly useful with a good starting point being the Land File at the Regional Offices of DCNR. Occasionally, a published account may exist of the area. The Country Fire Authority or DCNR may even have some idea of the fire history of the area.

If the site occurs on public land, check with the Land Conservation Council Study Area series. These publications provide probably the most up-to-date and relevant multidisciplinary information on public land in Victoria.

Compile flora and fauna lists for the site. Various local clubs may have previously taken an interest in the area e.g. Bird Observers, Field Naturalists. These groups may actually have lists already. If not, ask for their help in compiling them. Liaise with your local office of DCNR. Some of the plants and animals could be rare or threatened which may necessitate special action.

Assess the location of the land in relation to other areas of vegetated land. Are they, or can they, be connected?

What is the condition of the land? What is left? Topsoil, pest plant and animal infestations, potential for soil seed store of indigenous plants?

What are the threats to the land? Are they to continue or can they be mitigated?

The information gathered in this process provides the biological, physical, environmental and historical reasons for pursuing an environmental restoration project.

Stage 3: The management plan

In almost all cases, a management plan should then be developed. The plan should incorporate all of the data collected in Stages 1 and 2 and should be logically structured. An example of how this should be done is provided by Buchanan (1989) in a very useful publication entitled 'Bush Regeneration: Recovering Australian Landscapes'.

No matter what the structure adopted, however, the management plan should

(a) have a clearly defined aim (e.g. to restore a degraded remnant of urban bushland to near original condition),

(b) set realistic objectives on how the primary aim is to be achieved,

(c) set certain guidelines on how the plan is to be implemented,

(d) follow-up with some assessment of the success of the project (e.g. on-going monitoring).

The management plant should also contain a detailed staged costing for the project and the contributions from volunteer sources. An important point to note here is that a number of potential sources of both funds and labour exist that may not be immediately obvious. I have outlined just a few in Table 1.

Stage 4: Implementation of the plan

With all approval and documentation in place, implementation of the plan can proceed. From personal experience I can testify that the rewards obtained during this stage can be great indeed and certainly more than compensate for the inevitable frustration experienced during stages 1-3. The latter is an important consideration as with any project, time and resources may be either wasted or better utilised. Keep the central aim of the project clearly in view.

A number of aspects should be emphasised here. No matter what the project, the human dimension should not be overlooked. In short, the project should be enjoyable, achievable and well explained to volunteers, neighbours and the broader public alike. A public relations or liaison officer could be appointed to assist in this area. This will help facilitate a spirit of co-operation. The project should also be well supervised and co-ordinated with the safety of volunteers and protection of assets paramount. Project supervisors should maintain a variety of jobs to be performed and be aware of the diverse skills represented within a volunteer task force. Progress should be well documented - take photographs and videos. Hold regular social functions (e.g. an onsite BBQ, slide nights, guest speakers) - all of this will help to maintain group enthusiasm, which is undoubtedly the major ingredient to ensuring success.

An example - rehabilitation of Pine-Buloke Woodlands in north-west Victoria

I have chosen to reinforce the above planning process by applying it to a current program - the rehabilitation of Pine-Buloke Woodlands in north-west Victoria by officers of DCNR based at Mildura. The planning process in this circumstance ought to be relatively easily followed, although as we shall see, difficulties arise.

Table 1. Sources of funds for environmental restoration projects

A Federal
1 One Billion Trees (Greening Australia)
2 National Estate Grants Program (Australian Heritage Commission)
3 Voluntary Community Conservation Grants
4 National Resource Management Strategy (Murray-Darling Basin Commission)
5 Stream Management Fund (RWC)
6 Land and Water Resources Development Program
7 Endangered Species Program (ANPWS)
8 World Wildlife Fund

B State
1 Tree Victoria (DCNR)
2 Community Salinity Grants (Salinity Bureau
3 National Soil Conservation Program (DCNR)
4 Recreation Development Program
5 Save the Bush (ANPWS)

C Other
1 Philanthropic Trusts

Stage 1: land status

For the greater part, the project is confined to public land and, in most cases, National Parks (e.g. Wyperfeld National Park, Hattah-Kulkyne National Park and Murray-Sunset National Park). Because of this most of the programs can proceed unhindered as there are no problems with respect to the ownership of the land (i.e. the public), or with managers (i.e. the project originators are the land manager). Some short-term conflict of interests exists, however, in that some of the area will continue to be grazed over the ensuing four years.

Stage 2: the inventory

In this circumstance DCNR as the land manager is extremely fortunate as much of the background information abut Pine-Buloke Woodlands is summarised in the LCC Mallee Area Review (1987). I will summarise the status of the plant community as described by the LCC: Pine-Buloke Woodlands are considered to be one of the most threatened plant communities in north-west Victoria; over 20 species of plants listed as rare or threatened in Victoria by Gullan et al. (1990) are mostly restricted to this community (see Table 2); the loss, degradation and fragmentation of the community has placed considerable pressure on three rare or threatened bird species - the White-browed Treecreeper, Spotted Bowerbird and Pink Cockatoo; the plant community has been extensively cleared for agriculture; those areas remaining on public land have all been grazed with most being extensively logged as well; over large areas the grazing impact has resulted in an essentially exotic ground flora; natural regeneration of the woody perennial vegetation under present circumstances is impossible because of high total grazing pressures. The LCC has recognised the conservation value of this community and recommended that the largest remaining areas be included in the new Murray-Sunset National Park and an extension to Wyperfeld National Park. The past, present and future threats to the community have also been recognised by DCNR (see Table 3) and plans put in place to counter them. Grazing by domestic stock is currently being phased out; massive rabbit control programs are currently under way in areas where licences have ceased; vegetation monitoring programs incorporating photopoints, biomass sampling and floristic surveys have commenced and kangaroo populations are monitored annually with some culling initiated in areas with acute problems.

At this stage no overall management plan has been written specifically for Pine-Buloke Woodlands, although a rehabilitation strategy for the community has been developed.

Table 2. List of rare or threatened plants which are mostly restricted in Victoria to Pine-Buloke Woodlands or degraded remnants thereof.

Taxa	Status*
Glycine canescens	Endangered
Santalum lanceolatum	Endangered
Scaevola depauperata	Endangered
Swainsona sericea	Endangered
Amyema linophyllum	Vulnerable
Jasminum didymum var. *lineare*	Vulnerable
Marsdenia australis	Vulnerable
Ryncharrhena linearis	Vulnerable
Sida ammophila	Vulnerable
Sida fibulifera	Vulnerable
Acacia oswaldii	Depleted
Alectryon oleifolius	Depleted
Allocasuarina luehmanni	Depleted
Eremophila deserti	Depleted
Hakea leucoptera	Depleted
Hakea tephrosperma	Depleted
Santalum acuminatum	Depleted
Templetonia egena	Depleted
Acacia colletioides	Rare
Corynotheca licrota	Rare
Stipa setacea	Rare
Triraphis mollis	Rare

*Status = Victorian Conservation Status (Status) is from Gullen *et al.* (1990).

NB: This list is preliminary and may not contain all woodland rare or threatened taxa.

Table 3. Threats to Pine-Buloke Woodlands

		Management Option	**Outcome**
Past Threats			
Clearing	High	N/A	Loss & fragmentation of habitat
Logging (loss of habitat)	High	Sell resource	Loss of gene pool
Grazing			
- domestic stock	High	Some advice	Degradation of habitat and lack of natural vegetation
- feral (goats, rabbits)	High	Advice	
Weed invasion	High	N/A	
Present Threats			
Grazing			
- kangaroos	Locally High	Monitor & control	Aim: to arrest habitat degradation, revegetate degraded areas, conserve and enhance habitat
- domestic stock	Moderate	Removal	
- rabbits	Low-Mod	Rabbit Control	
- goats	Low	? Monitor	
Weeds	High		
The Future			
Grazing	Low	Control grazing pressure. Reintroduce locally extinct flora & fauna	Conserve and enhance habitat, revegetate degraded areas

The four aims of this strategy are: to describe the synecology of the community; to outline the autecology of the key plant species; to investigate the association between threatened fauna which depend for their survival on the long-term existence of the community; to use the above information in order to develop management plans and programmes aimed at conserving and enhancing the community.

At this stage it is probably worth reflecting on some previous comments. I suggested earlier that for most restoration projects a carefully considered series of stages should be followed more or less in order. I then deviated from this line of thought and outlined an example where flexiblility has been necessary in the planning and implementation stages because of the urgency of the problem. That is, the high degree of threat faced by Pine-Buloke Woodlands and characteristic species. I make no apology for this and maintain that the actions implemented thus far in Hattah-Kulkyne, Murray-Sunset and Wyperfeld National Parks necessarily must proceed a detailed management plan because of the reality faced by DCNR in actually instigating a management plan under the present land management conditions. Most of the preliminary actions, I believe, will be supported and continued in the future.

The most important immediate direction that DCNR can take with Pine-Buloke Woodlands or their future synthetic equivalents is to enhance the present habitat and conserve the inherent biodiversity. This message could be echoed for all other restoration projects.

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Does Sydney have Ground Flora ?

Judie Rawling[1]

"At the beginning of 1788 the bushland of Sydney - a mosaic of forests, woodlands heaths, scrub, sedgelands and swamps - stretched from the coast, west to the Nepean-Hawkesbury River. Forests occupied the most fertile and well-watered lands - those close to the coast or associated with the rich floodplains of Nepean-Hawkesbury River. Rich grasslands spread across the clay soils of the drier Cumberland Plain, shrubby woodlands covered the poorer sandy soils of the Hawkesbury Sandstone ridges. Heath and scrub occupied shallow, sandy soils or very exposed coastal sites. Swamps filled poorly drained depressions, and mangroves and saltmarsh fringed sheltered coastal estuaries" (Benson and Howell 1990).

Although this landscape had been occupied and modified by Aboriginal peoples for thousands of years, the most devastating changes to Sydney's bushland have taken place in the two hundred years since European settlement. From the birth of the new colony, clearing and cultivation removed bushland completely and changes in burning frequencies and intensities and replacement of the native fauna with domestic stock, altered the bushland irrevocably. In the twentieth century, the encroachment of suburban development and, in fringe areas, the spread of the ubiquitous 'hobby farm' have resulted in the fragmentation and alienation of remnant bushland.

In 1788 there would have been about 1,500 native species indigenous to the Sydney region (Benson and Howell 1990), of which about 150 were trees and the remainder shrubs, climbers, grasses, sedges, herbs and ferns. There were also mosses, lichens and fungi. Since then, the introduction of exotic weeds has added considerably to this number, at last reckoning the exotics making up about 10% of our total vascular flora.

Yet in 1991 Sydney is virtually unique amongst cities of comparable size in its natural assets - proximity to the ocean, extensive inland waterways and large areas of relatively natural vegetation. Approximately 41,300 ha of natural bushland is dedicated as public open-space, of which 30,000 is conserved in four National Parks, 1,800 in three State Recreation Areas and the remainder in small suburban reserves under the care and control of local councils. Perhaps an additional 9,000 ha remains in private ownership - although, to date, no-one has made a thorough inventory.

Sydney's bush, outside the National Parks and SRA's is now 'suburban bush', largely confined to creeks or steep slopes and in spaces unsuitable for housing or other development. Their management problems are all those of suburban origin: weed invasion from upstream or up-slope residential area; rubbish dumping; changes in fire regimes; theft of bush rock and plants and the effects of intensive recreational use.

The cumulative effects of the suburban sprawl on Sydney's remnant bushland and, in particular, its effects on the remaining ground flora have been devastating, yet the persistence of a varied and rich ground flora, even in degraded suburban remnants, is often surprising. Its survival has been dependent on a number of factors: location; topography; soil type and land-use history.

The bushland on the shallow nutrient-poor Hawkesbury sandstones remains surprisingly weed-free and away from the suburban interface, virtually intact floristically. Located on the rugged landscape of the plateau to south, north and north-east, sclerophyllous vegetation, largely dominated by species of Eucalyptus,

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boasts a rich ground flora. However, where housing and major roadways have been developed on the ridges and upper slopes, the insidious effects of urban run-off and of frequent hazard-control burning (or conversely, the total suppression of fire) have acted to eradicate much of the native ground flora in small urban reserves.

Coping particularly poorly with the steady influx of nutrient-rich drainage waters, the sandstone soils undergo dramatic structural and chemical changes which act to eliminate most native understorey species. The indigenous vegetation is gradually replaced by succulent or moisture-tolerant exotics: Spider Wort or Wandering Jew *Tradescantia albiflora*; *Ludwigia peruviana*; Kikuyu Grass *Pennisetum clandestinum*; scramblers and vines such as Morning Glory *Ipomoea indica* and *I. cairica*; Madeira Vine *Anredera cordifolia* and Honeysuckle *Lonicera japonica* and, of course, the ubiquitous Privet *Ligustrum sinense* and *L. lucidum*. Nowhere is this more evident than along the creeks and gullies of Sydney's North Shore where the long-term use of these areas as service corridors has resulted in gross disturbance and almost total destruction of the indigenous plant communities. An airline flight into Sydney approaching from the north dramatically illustrates the extent of the problem - as all major creek systems are seen to be lined with dead and dying trees.

The restoration of these degraded areas in current economic circumstances may prove to be impossible or, at best, highly unlikely. Given the high cost of rectifying the problems inherent in the established drainage system and the equally high cost of labour for bush regeneration projects, there is little chance that most of these degraded areas will be rehabilitated. Even if funds could be found to re-structure the drainage system; to pipe stormwater outlets to the main creeks, to create wetland filters and retention basins and to persuade town planners to avoid sensitive areas, we face the very practical problems of revegetating degraded bushland with indigenous species which may no longer exist in the area, or which may not be able to adapt to the altered environmental conditions.

On a more optimistic note, recognising that its earlier actions have contributed to the degradation of suburban bushland, the Sydney Water Board has commenced work on a five-year bushland rehabilitation program. Funded through the $80 household environmental levy, bush regeneration work is currently underway in up to a dozen sites in the greater Sydney area- sites which have been carefully chosen for their ability to respond to effective treatment and for the long-term viability of the remaining plant communities. However, only a very small number of bushland areas can be treated with existing funding and, although the Board originally undertook the work on the understanding that local government would step in when Board funds were exhausted and take on local responsibility for bushland maintenance, there would seem to be little evidence of that happening.

The shale-based vegetation communities throughout Sydney have fared badly, particularly on the western plain which stretches towards the Blue Mountains Escarpment. The inherently richer soils of the Wianamatta Shales and the gentle topography made these area early targets for agricultural development. In more recent years the farmlands have been replaced by factories and suburban houses as Sydney reaches west, almost to the foot of the Blue Mountains.

On the Cumberland Plain west of Sydney city, less than 6% of the original woodland survives, only 3% of the river-flat forests and only half of one percent of the Turpentine-Ironbark Forest - a singular plant community which once covered some 36,000 ha (Benson and McDougall 1991). When compared to the 85% of woodland and heath remaining on the Hawkesbury Sandstone, these figures are particularly alarming and even more so when one considers that the great majority of bush regeneration projects target bushland on sandstone soils.

Despite its history of intensive use, isolated stands of remnant native trees may still be found in Western Sydney, usually retaining a shrubby or grassy understorey but this depends on past disturbances or grazing treatment. Where the soils have remained largely undisturbed, perennial native grasses such as *Themeda triandra*, *Eragrostis* spp and *Microlaena stipoides* still occur and close inspection will reveal a variety of herbs, ferns and ground orchids.

In western Sydney, on the gently undulating plain, the bushland suffers less than its eastern and northern neighbours from suburban run-off problems but more from the early introduction of agricultural grasses and crops, and their accompanying pastoral weeds. Where the soils have been ploughed or fertilised, exotic grasses such as *Paspalum urvillei* and *P. dilatatum* predominate and the early introduction of woody species such as African Olive *Olea africana*, Boxthorn *Lycium ferocissimum* and Blackberry *Rubus fruticosus* has seen these plants spread alarmingly through the open grasslands and woodlands - in many areas displacing the shrub layer and totally suppressing the ground flora.

Opportunities to rehabilitate remnant bushland areas in Sydney's west are rare, especially when compared to those on Sydney's North Shore where bush regeneration projects are almost an integral part of local government policy. Fortunately things are changing. With the publication of several popular books, the adoption of the western suburbs bushland project by the National Herbarium and the increased availability of government grant moneys in the past two years, at least four Western Sydney councils have taken small but definite steps towards establishing bushland rehabilitation programs. The challenge for the Sydney bush regeneration fraternity, whose methods and techniques have been pioneered on the sandstone, will be to develop new strategies and new management policies to cope with a highly specialised group of plant communities, each with its own inherent set of values and problems. In this task it is vital that experience and knowledge gained in other parts of Australia, especially in Victoria's grasslands, be applied to the Sydney scene.

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CAN YOU HELP?

The FNCV office has no stock of *The Vic.Nat.* **111** (3) 1994, June. We need some to send to new members so if anyone can spare their copy we would be deeply appreciative. If you are able to help please mail your copy to the office or hand it to Felicity Garde at a general meeting.

Rapid Growth in Brisbane - The Weeds are Willing

Maureen See[1]

Introduction

Greening Australia - Queensland (Inc.) first became directly involved in urban bush regeneration with a Brisbane City Council project in 1986 at Raven St Reserve, a 23 ha eucalypt woodland in Brisbane's northern suburbs.

With the construction of a community bushland education and management facility on the site in late 1988, Council's role has broadened to encompass strategic planning and community education. The on-site regeneration work has continued and five years down the track, the Raven St Reserve site represents a valuable resource in terms of demonstration and experimentation with regeneration strategies and techniques.

The emphasis on ground flora re-establishment in disturbed areas of the reserve has increased significantly in the past two years, as a result of lessons learned from early work and the development of planning programs and necessary support services.

This paper provides an introduction to the flora, specifically to the ground flora of Raven St Reserve and outlines the approaches taken to re-establish this stratum at sites exhibiting various degrees of disturbance.

The Vegetation of Raven St Reserve

The reserve exhibits a diversity of vegetation types within a relatively small area. These include eucalypt woodland with a grassy understorey, eucalypt woodland with a heath understorey, casuarina thickets and moist gully and creekside communities. The healthy understorey in the south-west of the area presents a tangle of low growing prickly small-leaved shrubs in addition to herbs and grasses. The common ground flora species of the reserve are listed in Table 1.

Table 1. Common understorey flora of Raven St Reserve.
Key: s = successful; e = experimenting; t = to be tried

Botanical Name	Common Name	Propagation Technique	Present Usage
DICOTYLEDONS			
Apocynaceae			
Parsonsia straminea	Monkey Vine	Seed	s
Asteraceae			
Helichrysum diosmifolium	Sago Flower	Seed	s
Helichrysum ramosissimum	Yellow Buttons	Seed	s
Dilleniaceae			
Hibbertia cistoidea	Guinea-flower	Cuttings	t
Hibbertia linearis	Guinea-flower	Cuttings	t
Epacridaceae			
Acrotriche aggregata	Native Tomato	Seed	s
Monotoca scoparia	Prickly Broom-heath	Seed	s
Fabaceae			
Daviesia ulicifolia	Native Gorse	Seed, Cuttings	t
Daviesia umbellulata	Native Gorse	Seed, Cuttings	s
Dillwynia retorta	Small-leaved Parrot-pea	Cuttings	t
Gompholobium pinnatum	Poor Mans' Gold	Seed	t
Hardenbergia violacea	Native Sarsparilla	Seed	s
Hovea acutifolia	Pointed-leaf Hovea	Seed	s
Jacksonia scoparia	Dogwood	Seed, Cuttings	s

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[1] Greening Australia - Queensland (Inc.)

Botanical Name	Common Name	Propagation Technique	Present Usage
Fabaceae cont.			
Kennedia rubicunda	Dusky Coral-pea	Seed	s
Oxylobium scandens	Oxylobium	Cuttings	t
Phyllota phylicoides	Phyllota	Seed, Cuttings	t
Psoralea tenax	Bullamon Lucerne	Seed	s
Pultenea cunninghamii	Grey Bush-pea	Seed, Cuttings	t
Goodeniaceae			
Goodenia rotundifolia	Goodenia	Cuttings	t
Melastomaceae			
Melastoma affine	Blue tongue	Cuttings	s
Myrtaceae			
Leptospermum flavescens	Wild May	Seed	s
Oleaceae			
Notolea ovata	Native Olive	Cuttings	e
Polygalaceae			
Comesperma defoliatum	Matchsticks	Seed, Cuttings	t
Proteaceae			
Banksia spinulosa	Golden Candles	Seed	s
Hakea florulenta	Hakea	Seed, Cuttings	s
Lomatia silaifolia	Crinkle Bush	Cuttings	e
Persoonia cornifolia	Geebung	Cuttings	t
Petrophile shirleyae	Conesticks	Cuttings	t
Rubiaceae			
Pomax umbellata	Pomax	Seed, Cuttings	e
Thymeleaceae			
Pimelea linifolia	Slender Rice-flower	Cuttings	e
MONOCOTYLEDONS			
Iridaceae			
Patersonia sericea	Silky Purple-flag	Seed	t
Liliaceae			
Bulbine bulbosa	Native Leek	Seed	t
Dianella laevis	Pale Flax-lily	Seed	s
Dianella caerula	Blue Flax-lily	Seed	s
Laxmania gracilis	Slender Wire-lily	Seed	t
Thysanotus multiflora	Fringe-lily	Seed	t
Orchidaceae			
Dipodium variegatum	Hyacinth Orchid	Seed	t
Geodorum neocaledonicum	Pink Nodding-orchid	Seed	t
Microtis unifolia	Common Onion-orchid	Seed	t
Smilacaceae			
Eustrephus latifolius	Wombat Berry	Seed	s
Geitonoplesium cymosum	Scrambling Lily	Seed	s
Poaceae			
Cymbopogon refractus	Barbwire Grass	Seed	e
Themeda triandra	Kangaroo Grass	Seed	s
Xanthorrhoeaceae			
Lomandra filiformis	Wattle Mat-rush	Seed	t
Lomandra longifolia	Spiny-headed Mat-rush	Seed	s
Lomandra multiflora	Many-flowered Mat-rush	Seed	t
Xanthorrhoea johnsonii	Grass-tree	Seed (fresh)	s

Approximately three quarters of the area is eucalypt woodland with an open grassy understorey dominated by Kangaroo Grass *Themeda triandra*. The dominant families of this vegetation type are the grasses Poaceae, peas Fabaceae, the lilies Liliaceae and lomandras Xanthorrhoeaceae.

Apart from the creek banks, where engineering work has caused significant damage, this community has sustained major impact from vehicle access, grazing, dumping and burning. Away from drainage lines enriched by urban runoff, this area exhibits little weed invasion because of its characteristically poor soil which is derived from quartz.

Species diversity is richest in the heath with at least 30 families and over 120 species of understorey plants. The dominant families in terms of species and/or abundance include Fabaceae, Epacridaceae, Proteaceae, Xanthorrhoeaceae and Liliaceae.

A series of narrow moist gullies criss-cross the reserve bordered by bottlebrush Callistemon, native hops and buttonwood. Two main species of ferns carpet the gully floors; Mountain Bracken *Culcita dubia* and Common Bracken *Pteridium esculentum*. Water flow occurs only after rain and weed levels are generally low since the catchment lies within the reserve area.

Creekside vegetation is generally highly disturbed along the length of the permanent watercourse, Downfall Creek, which runs along the north-eastern boundary. The natural understorey of Wild May *Leptospermum flavescens*, *Lomandra*, other shrubs, ferns and grasses has been largely replaced by exotic grasses and *Lantana*.

The known weed flora comprise over 60 species with high representation in both the daisy Asteraceae and grass Poaceae families.

Development of a Ground Flora Re-establishment Program

For a number of mainly practical reasons, in the early stages of regeneration work in the reserve emphasis was not placed on re-establishing ground flora in moderate to severely disturbed areas . These reasons included: suitable seed and tubestock material of the understorey plants was not readily available from nurseries; staff and volunteers were unskilled in correct seed collection, processing and storage techniques; the Brisbane City Council nursery was not set up to propagate and return dedicated plant material collected at specific sites; the woody tall shrub and canopy species such as wattles and eucalypts were well known and easy to collect and propagate so they received greater attention; planning was not carried out far enough ahead to grow suitable material at the required time; rampant weed re-growth problems on such sites, especially with vines and pasture grasses, discouraged the use of such low-growing species; tall shrub and canopy species provided a rapid physical dominance of the site and allowed easier site maintenance by Council staff using herbicides.

In the past two years, with the establishment of a planned bush regeneration program and additional resources, these issues have been addressed in the following ways: training of volunteers in the collection, processing and storage techniques; assigning a small team of individuals to this task has been most successful; targeting the collection of cuttings for those species that have proven difficult to propagate by seed; devising a flowering and fruiting calendar of native flora to plan for efficient collection of seed; keeping detailed records of all material collected; devising a system in conjunction with the Council nursery for the labelling, propagation and return of all Raven St Reserve plant material; ensuring that adequate staffing is available for maintenance of disturbed sites and addressing weed growth and ground flora conflict on severely disturbed sites through experimentation with commercial weed control products.

Assessing the Sites and Selecting Strategies

The specific approach taken to re-establishing ground flora at the reserve at a given site depends on the classification of that site into one of three broad categories of disturbance - minor, moderate and severe. Each is described below:

Category	***Description***
Minor	- presence of all native forest strata and ground and shrub layer not strongly invaded by exotics.
	- minimal physical and chemical soil disturbance.
	- few weeds.
	- low weed seed bank present.
	- absence of highly invasive weeds.
Moderate	- representatives of all native forest strata present but ground and shrub layers strongly invaded by exotics.
	- often good bush surrounds the site.
	- minimal to moderate physical and chemical soil disturbance.
	- moderate weed seed bank present.
	- highly invasive weeds may be present.
Severe	- native forest strata virtually replaced by exotics; some canopy trees may remain.
	- large areas involved.
	- major physical and chemical soil disturbance.
	- wide range of weeds present generally including highly invasive types.

Minor

In areas judged to be minor, replanting of tubestock is not usually undertaken. Weeds are removed by hand or by chemical means and native seed comprising a range of species and strata is broadcast on any areas of bare soil. Brushmatting with cut branches containing ripe fruit has been found useful in promoting recolonisation of such sites. The ground flora species broadcast have included Kangaroo Grass, Wombat Berry, Hardenbergia, Kennedia and Banksia. Mulch is raked from surrounding areas onto the site. Any compacted areas such as previous trail-bike and walking tracks are drained with trenches - to shed runoff and to allow mulch and seed accumulation. The surface is also broken up with tools such as crowbars to create a better seed-bed. Branches and other debris are strewn across old tracks to deter foot traffic. Signage is also used on previously well used tracks and, in some cases, letterboxing is undertaken to notify residents of the reasons for closure.

Moderate

Similar techniques are applied to moderately degraded areas except that replanting nearly always accompanies weed removal, and burning may be advisable to provide favourable seed bed conditions and to assist in trash disposal. The latter point has been found to be an important but often overlooked consideration when working in areas remote from vehicle access. Clearing of a thick Lantana area amidst good bush caused significant damage to the site by increased foot traffic from curious walkers. Appropriate signs solved this problem but was ineffective against wallabies who feasted on the tender Kangaroo Grass plants so lovingly planted. Burning may be highly desirable in ecological terms but due to current community concern in Brisbane City this is not always an option. Maintenance on such sites includes checking barriers, cleaning out drainage trenches, weeding and reseeding.

Severe

Such degraded sites present a quite different challenge. The dominance of weed plants and their propagules combined with subtropical growth patterns and often permanent physical and chemical soil disturbance has particular significance for ground flora reinstatement.

Early work in regeneration of such sites in Raven St Reserve highlighted three particular problems:

(1) The wind dispersed exotic pasture grass, Green Panic *Panicum maximum* grows to 2m under optimal conditions and rapidly colonises such sites following clearing, irrespective of the previous weed cover. These weeds, able to grow even in deep shade and with peak growth rates of up to 30 cm per week, physically smothered delicate ground plants and starved them of nutrients, water and light.

(2) Two particular vines, Morning Glory *Ipomoea indica* and Madeira Vine *Anredera cordifolia* were usually present on bad sites. Both possessed excellent dispersal mechanisms (tubers or seed) and growth rates that spelt disaster for the slower growing plants around them.

(3) Sloping sites presented an added problem of erosion, especially along creek banks, following weed clearance. Replanting does not provide stabilisation of such areas.

The general procedure on severely degraded sites has, up until recently, focussed on clearance by machinery, hand or chemical means, followed by replanting with tube stock. Control of weed regrowth is carried out by a combination of brushcutting and spraying with Glyphosate. Currently, a number of commercial weed control products are being trialed to assess their value on disturbed sites. Although, these products may possibly restrict regeneration, it is believed they are efficacious in specific situations. These include sites where highly invasive vines are present and creek bank sites where stabilising the slope after weed clearance is vital.

Trials to date have focussed on three products.

(a) *Enviromat*, designed for erosion control rather than weed suppression, was used on steep slopes at the perimeter of the reserve which were replanted following removal of household refuse and weeds. Although useful for stabilising banks, it has been rejected for use in future works because its nylon netting traps and chokes small wildlife such as bearded dragons. Furthermore, it performs little, if any weed control function. Interestingly, its unnatural appearance which some people feel is incompatible for bushland areas, was responsible for stopping householders from dumping on the site. Feedback indicates that they respected what appeared to be someone's project, but would have continued to dump if the area had simply been cleared and planted.

(b) *Bidim*, a geotextile has been used in road building and by the landscape industry for many years as a weed suppressant. It comes in various thicknesses. However, it is not recommended for general use because its synthetic construction is likely to suppress regrowth of native species as well as the weeds, it is unlikely to break down and is aesthetically unappealing. On the other hand, it has been used to great advantage on a gully site badly infested with Madeira Vine. This vine which regenerates from large numbers of tubers dropping off into the soil has been effectively controlled by the Bidim overlay and ground cover plants have been successfully established. Erosion has also been controlled on the steep bank and, again residents have ceased rubbish dumping there. Although the Bidim overlay will have to be removed at some future date, this is only a small area.

(c) *Jute*, being totally organic, has the advantage of not requiring later removal, is aesthetically appealing and will rot to allow native seed to germinate. This product is to be investigated by the Brisbane City Council/ Department of Primary Industries in a joint project with the commercial company that developed it. Initial tests by DPI scientists indicate that seed (grasses) can germinate in the lighter grades whilst thicker grades offer effective weed control. All grades are very successful in controlling bank erosion because the fibre has excellent ground hugging properties. It is intended that direct seeding of native plants (grasses, shrubs and trees) into the Jute mesh will be carried out in addition to tubestock trials.

Further trials with on other materials such as *Bagasse* (a by-product of sugarcane use) and *Coconut fibre* are planned in the near future.

Further considerations in tackling regeneration of very degraded areas include (1), clearing large areas of disturbed bush tends to encourage traffic through the area. This has been prevented to some degree at the reserve by leaving a visual barrier uncleared between the worksite and walking trails. Signs can also help by explaining what is happening on-site. Publicity, education and involvement of local people is always important. (2), where permanent drainage changes have caused wetting and nutrient enrichment of previously dry soils, the original ground flora may not survive or flourish in the altered conditions. Native species which prefer the new environment have been used with success at Raven St Reserve. (3), while the cost of commercial mattings is considerable, the reduction in maintenance costs when used in severely disturbed sites appears to justify the initial establishment cost.

Conclusion

The current work being undertaken in ground flora re-establishment by Greening Australia at the Raven St Reserve is still at a highly experimental stage. The main foci in this area in the future will be in the extension of our seed/cuttings collection program, to trial a wide range of commercial weed control products and experiment with techniques such as hydroseeding and direct seeding.

It appears that there is a lack of written documentation of trial work by practitioners currently working in the field of bush regeneration. It is likely that considerable time and effort could be saved if greater sharing of information on the subject was encouraged.

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Australian Natural History Medallion

The ANHM for 1994 has been awarded to Joan W. Cribb, a botanist specialising in mycology. Joan was nominated by the Queensland Naturalist Club. The presentation will be made at the FNCV meeting on Monday, 14 November and Joan will talk on 'Enjoying Plants'. Everyone is welcome to come.

The Discovery of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy, Resident in a Lowland Swamp Woodland

Ian J. Smales[1]

Introduction

Leadbeater's Possum *Gymnobelideus leadbeateri* was discovered in a lowland swamp woodland at Yellingbo State Nature Reserve in August 1986. Since that time, the population has been alluded to (Lindenmayer *et al.* 1989; Macfarlane and Seebeck 1991; L.C.C. 1993), and some aspects of its ecology have been investigated by Thomas (1989). This report documents the circumstances of the discovery, describes the habitat occupied by the possum at this locality and compares it with the markedly different habitats which it occupies elsewhere, and with historical site records.

Site description

Leadbeater's Possums were found at Cockatoo Swamp, 3.7 km south-west of Yellingbo P.O. (37° 50'S, 145° 29'E) at 110 metres above sea level in Yellingbo State Nature Reserve. Cockatoo Swamp is a floodplain of about 6 km long, rarely exceeding 200 m wide, and encompassing an area of approximately 170 ha. Cockatoo Creek and the lower reaches of its tributary, Macclesfield Creek, flow through this depression, seasonally inundating it with flowing water for at least ten months of most years. Water depth varies but at the time of this discovery it was approximately 50 cm.

The vegetation of the Yellingbo State Nature Reserve has been investigated in detail by McMahon *et al.* (1991). The site inhabited by *G. leadbeateri* is within a floristic community they have designated *Eucalyptus camphora* swamp woodland, sub-community 1.1. It is characterised by Mountain Swamp Gum *E. camphora* , Tassel Sedge *Carex fascicularis* and Soft Twig-sedge *Baumea rubiginosa*. *E. camphora* is the sole eucalypt of the floodplain and at this location it grows densely forming an interconnected canopy at heights varying from 12 to 25 m. Bole diameters at breast height of these trees generally range from 10 to 30 cm. The ground layer is composed of a prolific variety of sedges, reeds and herbs. A distinct thicket community, *Leptospermum lanigerum* Woolly Tea-tree shrubland, grows along permanent channels through the swamp. Two other *E. camphora* sub-communities occur in the Cockatoo Swamp basin, as do other shrub alliances dominated by Scented Paperbark *Melaleuca squarrosa* and Swamp Paperbark *M. ericifolia* .

Despite its small total area, the *E. camphora* woodland community of Cockatoo Swamp is the largest patch of this community known to exist (McMahon and Franklin 1993). McMahon *et al.* (1991) consider it to be of national significance for both its rarity and its essentially undisturbed condition.

Discovery of Leadbeater's Possum

The population of the Helmeted Honeyeater *Lichenostomus melanops cassidix* is under investigation at Cockatoo Swamp. Canvas hides have been used for some observation of the bird's nesting behaviour. In 1985 a hide was folded and left at the site for future use. It was positioned on the trunks of some fallen Mountain Swamp Gums about 70 cm above the ground.

On 25th August 1986, finding this hide to be only 20 cm above water level, G.J. Covington checked its condition at 1540 hrs. He and the author examined a nest composed of strips of *E. camphora* bark, which was found between the horizontal folds of the canvas. The nest was ap-

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proximately 35 cm in diameter and 12 cm deep. Four possums ran from the nest, whilst one remained within it. This animal was hand-caught, identified as *G. leadbeateri* and released. On 26th August the nest was revisited and was vacant at 1100 hrs.

Efforts were made to obtain further evidence of the existence of the species there. On 29th August 30 hair sampling tubes (after Suckling 1978), and seven nest boxes were positioned within a radius of 40 m of the original find. Five boxes were cleaned plastic ICI chemical containers with internal dimensions of approximately 30 cm high, 30 cm wide and 25 cm deep. Two boxes were made of sawn treated pine with internal dimensions of 30 cm high, 28 cm wide and 10 cm deep. All were fitted with removable wooden lids and had 4-5 cm diameter entrance holes. The nest boxes were erected at an average height of 4 m on the south side of *E. camphora* trunks.

On 1st September 1986 at 1300 hrs, one wooden box was found to be filled to a depth of about 10 cm with strips of *E. camphora* bark similar to those from which the original nest was constructed. This box was checked again at 1345 hrs on 3rd September and found to contain five Leadbeater's Possums in a nest which now virtually filled the box. Three animals (a mature female and two young males) were examined and photographed. One young male was retained for examination and was ear-tagged and released back at the site on 5th September.

On 16th January 1987 the same nest box was found still to contain animals, although they were not counted. They included a fully furred juvenile male with eyes open, approximately 120 mm in length from snout to tail-tip and which was not on a nipple when found. A juvenile was still present when a more thorough examination of all the animals in the box was carried out on 5th March 1987. Three males, two of mature size and one sub-adult, and two females, one mature and one probably immature, were there in addition to the juvenile. The mature female was lactating, with one nipple enlarged. All of the possums from the box were ear-tagged on that occasion.

All nest boxes have been checked occasionally since then, and Leadbeater's Possums have been seen in a number of them up to the time of writing, in May 1994.

During a seven month period of 1989 Thomas (1989) studied the spatial distribution, population dynamics and social organisation of Leadbeater's Possum in a three hectare area of Cockatoo Swamp which included the colony found in 1986. Her study site was also inhabited by a second colony, and she found that these two groups interacted both with each other and with a further two from areas adjacent to her study site.

There is evidence that *G. leadbeateri* is distributed along a much greater length of Cockatoo Swamp. In October 1989 M. Miller (Healesville Sanctuary) examined an abandoned nest of shredded bark in a fallen eucalypt, approximately 1.5 km downstream from the first colony. It was consistent with those constructed by Leadbeater's Possums in the nest boxes (M. Miller *pers. comm. 1989*). In September 1990, D. Franklin, M. Miller, R. Edwards and S. Vaartjes (Department of Conservation and Natural Resources and Healesville Sanctuary) observed three Leadbeater's Possums in Cockatoo Swamp, at Macclesfield Ck., 1.6 km upstream of the first location. The animals emerged from, and then returned to, a drey approximately seven metres high in a *Melaleuca squarrosa* thicket. (D. Franklin pers. comm. 1990). The drey was typical of the twig structures of Common Ringtail Possums *Pseudocheirus peregrinus* which are very common there, but with the addition of much shredded eucalyptus bark when examined a few days later by the author. In February 1993 two Common Ringtail Possums emerged from this drey when it was checked by the author.

Comparisons with other sites and records

Since the rediscovery of Leadbeater's Possum in 1961 (Wilkinson 1961) it has been found at numerous sites within the Victorian Central Highlands where it is restricted to moist, montane, ash-type forests at elevations between 520 and 1200 metres above sea level (Lindenmayer *et al.* 1989, 1990). These forests are dominated by Mountain Ash *Eucalyptus regnans* , Alpine Ash *E. delegatensis* or Shining Gum *E. nitens*. In such forests the distribution of the possum is positively correlated with both a dense understorey of *Acacia* spp. and large hollow-bearing eucalypts (Lindenmayer 1989).

A number of the key requirements identified for Leadbeater's Possum in montane forests are not present at the site they inhabit at Cockatoo Swamp. *E. camphora* at this location have no hollows and the occupation of both a canvas hide and the ready utilisation of nest boxes indicates the paucity of natural nest sites within the swamp itself. The terrace on the immediate edge of the swamp supports some hollow-bearing Green Scentbark *E. ignorabilis*, Swamp Gum *E. ovata* and Narrow-leafed Peppermint *E. radiata*. Thomas (1989) found one active Leadbeater's Possum nest in each of these three species.

Smith (1984b) studied the diet of Leadbeater's Possum in *E. regnans* forest. He considered that Acacia exudates formed a very significant portion of the animals' diet in that environment. Acacias are an insignificant component of the *E. camphora* swamp woodland sub-community in which the possum lives at Cockatoo Swamp and are only represented by occasional specimens of Blackwood *A. melanoxylon*. Sallow Wattle *A. mucronata* and Silver Wattle *A. dealbata* are found in the drier vegetation communities adjacent to the swamp, but not in dense stands. However, other sources of dietary carbohydrates which Smith found to be important, such as honeydew and manna, are present within this *E. camphora* woodland.

Thomas (1989) found that the spatial distribution, abundance and social organisation of the possums she studied at Cockatoo Swamp were similar to those reported for montane ash forests.

There is only one previous record of *G. leadbeateri* specifically from a lowland swamp. It is a specimen in the Museum of Victoria collection (no. C4378), donated by F.V. Mason who collected it in 1909. Brazenor (1932) records Mason's information about the animal, 'It was taken many years ago... from the edge of Koo-Wee-Rup Swamp (long before the swamp was drained), about three miles due south from Tynong Railway Station. We were felling a tree and as it fell the little animal came from a hollow branch. I had never seen one before, though we had lived for many years on the place.'

Mason's location is at 38° 07'S, 145° 37'E and at approximately 20 metres above sea level. It is 32 km south of Cockatoo Swamp. Commencing in 1857, Koo-Wee-Rup Swamp was progressively drained and cleared of natural vegetation (Roberts 1985). The alienation of Koo-Wee-Rup Swamp was so thorough, in fact, that consideration of its former vegetation is rather speculative (McMahon *pers. comm.* 1993). However, remnant *Melaleuca ericifolia* and *Eucalyptus ovata* (Opie *et al.* 1984) as well as anecdotal historical information (Roberts 1985) indicate close similarities of floristics and structure between the vegetation communities it supported then and those present today at Cockatoo Swamp.

Loyn and McNabb (1982) have discussed the Koo-Wee-Rup Swamp record following their finding of *G. leadbeateri* in montane vegetation of the upper reaches of that swamp's catchment. They considered it, 'a perplexing record as it comes from lowland forest (now cleared) very different from habitats known to be used by the possum at present.' They postulated that, 'Perhaps the Tynong animal could have moved into lowland forest in response to population pressures, or temporary habitat changes in the mountain ash forest.[1] The existence of Leadbeater's Possums resident in Cockatoo Swamp demonstrates that the animal is not reliant exclusively upon montane forests and that such an explanation for the Tynong record is unnecessary.

Three historical specimens came from Bass River (M.V. nos. C4379, C438, C1965). The first two of these are the type specimens. Exactly where on the river they, or the third, was obtained, is uncertain. McCoy's (1867) description states simply that the types were from 'the scrub on the banks of the Bass River in Victoria.' Kemp (1979) says that they were collected by J. Peters, 'near the village of Woodleigh in the Bass Valley'. The Bass River rises at about 280 metres above sea level near Ranceby and Woodleigh is situated at an elevation of about 50 metres. Hence, whilst uncertainty about the exact location obviates any meaningful comment about the vegetation community inhabited by the possum there, the elevation from which they came is much more like that of Cockatoo Swamp than the elevations at which it lives in the Central Highlands.

Thomas (1989) and Macfarlane and Seebeck (1991) have both suggested the need for further study of the Leadbeater's Possum population described here. Initially a broad survey of its distribution in this area is clearly warranted. Whilst it is of considerable interest that the animal exists in this habitat, it is also unfortunate that lowland eucalypt swamp communities are themselves so rare that the present record adds little to the conservation status of Leadbeater's Possum.

Acknowledgments

Graham Covington asked me to look with him at 'a nest of possums', the first described here, and I am very grateful that he did. Don Franklin and Michael Miller happily provided details of their observations. Virginia Thomas and Malcolm Macfarlane contributed to valuable discussions about Leadbeater's Possums at Yellingbo and Malcolm, Steve Craig, Peter Menkhorst and Andy McMahon made valuable comments on earlier drafts of this paper. I also appreciate the support of Lawson Willoughby and Gary Backhouse in my early work on Helmeted Honeyeaters which permitted me to be in the right place at the right time to make this fortuitous discovery.

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Update on the Status of the Spotted Tree Frog (*Litoria spenceri*) in the Australian Capital Territory

G. R. Gillespie[1] and W. S. Osborne[2]

We reported recently in this journal (Osborne *et al.*1994) on the discovery of a previously unknown historic record of the Spotted Tree Frog *Litoria spenceri* from the Cotter River in the Australian Capital Territory in 1993 (Osborne *et al.*1994). An examination of the original collection area was also reported, during which 16 newly metamorphosed frogs were located. These frogs strongly resembled juvenile *L. spenceri*. In our previous article (Vol 111, 62) we referred to these juvenile frogs as *L. spenceri*; however, this was premature. Another morphologically similar species, the Leaf-green Tree Frog *L. phyllochroa* (form A after Littlejohn 1967), has been recorded from some streams draining the north west slopes of the Great Dividing Range in north eastern Victoria and southern New South Wales (Gillespie and Hollis *unpubl. data*; Osborne *unpubl. data*). Indeed the original *L. spenceri* specimen collected from the Cotter River had been mistaken for this species. Because of the added difficulty of identifying juvenile frogs, four of the metamorphs located were retained and raised in captivity in order to confirm identification. By December 1993, they had attained snout-vent lengths of 28 mm and had developed adult colour markings (Fig. 1).

The four specimens were carefully examined and compared to several living *L. spenceri* and *L. phyllochroa* individuals.

Litoria spenceri is distinguished from *L. phyllochroa* primarily by having full webbing between the toes. The latter has only three quarter webbing (Cogger 1992). *Litoria spenceri* has a warty dorsum while

Fig. 1. One of the Cotter River frogs raised in captivity. (Photo: Will Osborne.)

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L. phyllochroa is invariably smooth. The other differences between the species relate to coloration which may be less reliable. *Litoria phyllochroa* has a uniform green, olive or brown dorsum, which is bordered dorso-laterally by a cream or gold-coloured stripe. Behind the forelimbs this stripe generally becomes wider and is bordered below by a wide brown or black area along the flanks. In comparison most *L. spenceri* have mottled grey, brown, gold or olive dorsal surfaces, but some populations in the Central Highlands of Victoria are predominantly green. However, on these individuals the green is usually interspersed with gold flecks and the dorso-lateral stripe is much thicker than in *L. phyllochroa*. In addition, the dark lateral band typical of *L. phyllochroa* is absent in *L. spenceri*. Interestingly, all four juveniles from the Cotter River shared morphological characteristics of both species. All were immaculate green to olive dorsally, which made them look like *L. phyllochroa* superficially, however, they had scattered large warts on their backs and hind limbs typical of *L. spenceri*. In addition, the webbing between the toes was intermediate in extent between the two species. All individuals had a gold-coloured dorso-lateral stripe. Numerous dark flecks were present along the flanks, particularly above the arms, but the more solid, dark lateral area typical of *L. phyllochroa* was absent.

On the basis of these observations, the four specimens were included in a genetic analysis carried out on the *L. phyllochroa* group by the South Australian Museum. This analysis included material from numerous *L. phyllochroa* populations and also *L. spenceri*. Preliminary results of this work have indicated that the Cotter River Frogs are clearly a different species from *L. spenceri* and are also genetically distinct from *L. phyllochroa* (S. Donellan, South Australian Museum, *pers. comm.*). *Litoria phyllochroa* exhibits considerable regional variation; two distinct forms are currently recognised (Littlejohn 1967), along with at least one very closely related taxa in northern New South Wales (McDonald and Davies 1990). While none of these resemble the Cotter River frogs it highlights the potential for much morphological variation and taxonomic subdivision within this group. Accordingly it is possible that the Cotter River Frogs represent a new species. Further genetic analyses are required before the taxonomic status of the Cotter River Frogs is fully understood.

So where does this leave *L. spenceri*? We have re-examined the original specimen collected from the Cotter River in 1975 and the accompanying photographs and are confident that this individual was *L. spenceri*. However, the current status of *L. spenceri* in the Cotter River remains unknown. Subsequent searches during the 1993/94 season failed to locate any additional frogs (Gillespie and Hollis *unpubl. data*; Osborne *pers. obs.*) and a more comprehensive survey is now planned for late 1994.

Acknowledgements

We thank Peter Robertson and Greg Hollis from the Department of Conservation and Natural Resources, Victoria) for sharing their knowledge of *Litoria spenceri* and *L. phyllochroa*. Steve Donellan provided us with preliminary results of the electrophoretic analyses.

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Some Granite Landforms of Wilsons Promontory, Southern Victoria

S. M Hill[1]

Introduction

This paper describes and accounts for some of the granite landforms that are a part of the landscape at Wilsons Promontory, Victoria. Rounded and irregularly shaped tors, cavernous hollows in fresh granite, cave systems and fluted surface channels are some of the individual landforms that are features of the area. This study complements other papers that essentially consider the large scale landscape features of Wilsons Promontory (Hill 1992; Hill *et al.* 1994).

Wilsons Promontory, the most southerly point of the Australian mainland, consists of granite bedrock flanked by Late Cenozoic sediments (Wallis 1980, 1988). Weathering of the granites, since their emplacement in the Late Devonian, led to the development of deep weathering profiles by the Mesozoic. Since this time, regional stripping of the deeply weathered material has been at a greater rate than the continued weathering of the granite resulting in the exposure of fresh granite bedrock as well as unveiling a range of granite landforms. Further landform development has also occurred by modification of the granite by surface processes.

Landform Features

Tors

Residual boulders of granite known a tors are a common landform feature of Wilsons Promontory. Stripping of weathered material from between corestones of fresh granite in deep weathering profiles results in the exposure of tors (Linton 1955). Granite is basically impermeable to water, except along joints and fractures. These structures are therefore a major influence on the access of weathering solutions and the subsequent development of corestones and tors. Tor development is best where joint spacing is close enough to create the initial compartments of fresh rock, but not so close that waters moving along the joint planes completely weather all the granite. The road cuttings between the Mt Oberon quarry and the Telegraph Saddle car park show the joint bounded corestones within a weathering profile and their genetic relationship with the overlying tors (Fig. 1).

Summit tors (Gerrard 1974; Ehlen 1992), also called nubbins or castle koppies (Twidale 1982) occur as major outcrops of large tors (up to 20 m diameter) on mountain summits or on the high points of ridges, such as at South Peak and Mt Bishop. Other tors occur on steep valley sides, 'valley side tors' (Gerard 1974), such as at Great Glennie Island (Fig. 2), or occur along spur lines, 'spur tors' (Gerard 1974), as in the Boulder and Vereker Ranges.

In many areas such as in the Boulder Range, the Vereker Range and the Glennie Group of islands (Fig. 2) there is a relationship between tor morphology and altitude, where tors essentially become smaller and more rounded in higher areas of the landscape. This relationship is due to a regular increase in the weathering of granite corestones within the upper zones of the extensive, deep weathering profile that developed into the Mesozoic Era (Hill 1992; Hill *et al.* 1994). Tectonic uplift of Wilsons Promontory since this time has instigated the stripping of this profile to reveal the regular arrangement of tors now seen.

Erosion of corestones and weathered material by colluvial and alluvial processes can expose large dome-shaped outcrops of fresh granite with widely spaced joints, such as on the slopes of Mt

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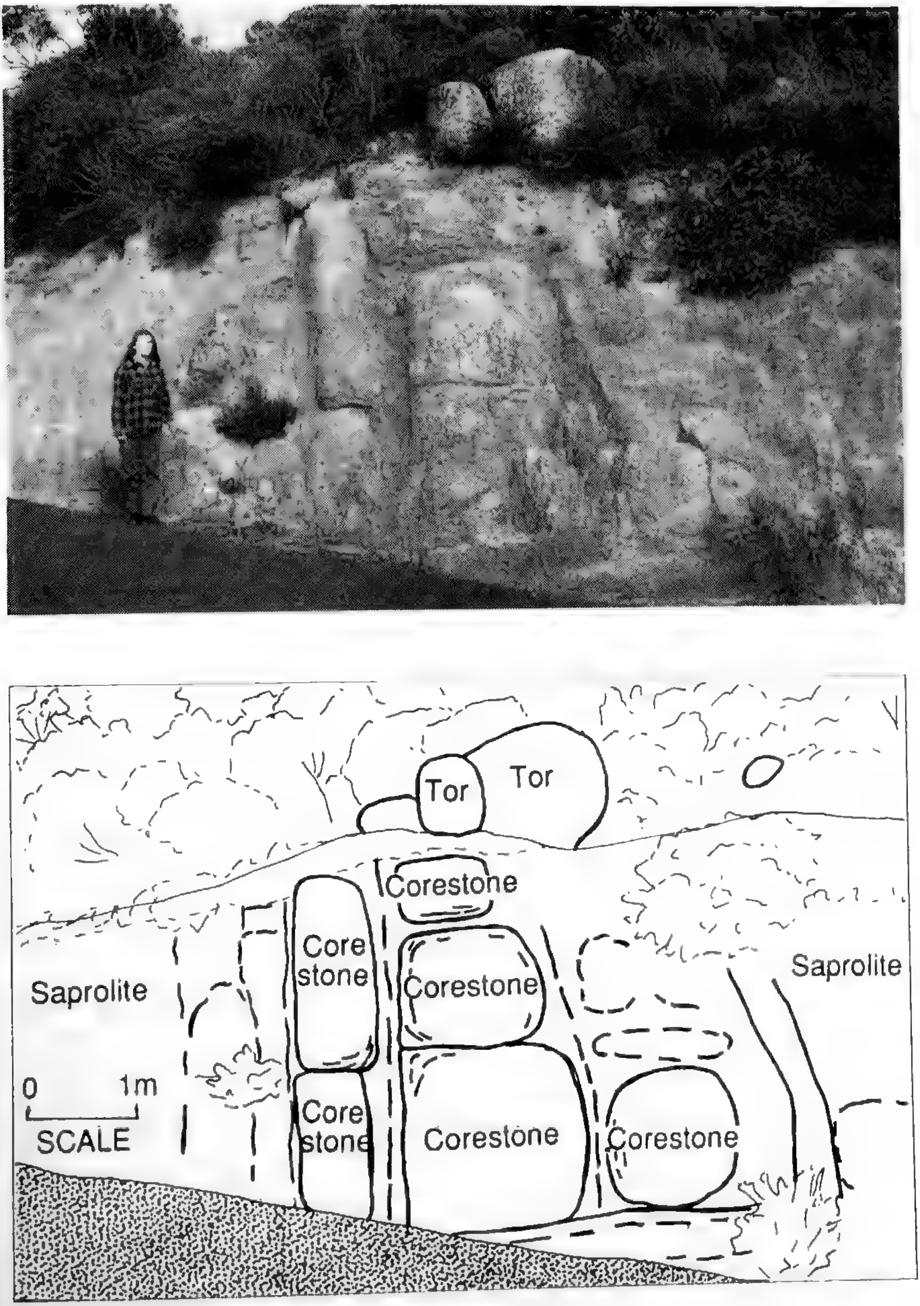

Fig. 1. Granite weathering profile on Mt Oberon road approximately 100 m north of Telegraph Saddle. Note the joint bounded corestones in the centre of the figure and their genetic relationship with corestones (tors) exposed at the surface. a) Photograph, b) Annotated field sketch.

Fig. 2. Low oblique air photograph looking south over Great Glennie Island and the Glennie Group. Note the greater regolith stripping along the west coast, the structurally controlled north-south trend of the island ridge, spur and valleyside tors and a slight rounding and decrease in tor size with altitude

Fig. 3. Low oblique air photograph looking south towards Cleft Island (Skull Rock). The cavernous feature on the northern side of this island is approximately 50 m in height. The base of this cavern is strongly controlled by the sub-horizontal joints that can be seen on the north-eastern (left hand) side of

Oberon (Hill 1992). The tors that have been mobilised downslope tend to be irregularly arranged at the ground surface, in contrast to the regular arrangement of *in situ* tors that often reflects the original joint pattern of the bedrock.

Cavernous features

Cavernous features at Wilsons Promontory range in size from centimetre scale honeycomb-shaped hollows (honeycomb weathering), to larger more irregularly arranged caverns over tens of centimetres in diameter (tafoni), to complex cave systems tens of metres long.

Honeycomb weathering and Tafoni

Honeycomb weathering and tafoni are common in areas of coastal exposure, particularly on prominent headlands along the west and south coast. At South-East Point, large cavernous tors up to 10 m high occur within the lighthouse reserve. The development of similar features in other parts of Australia has been a contentious issue (Dragovich 1969; Bradley *et al.* 1978, 1979; Winkler 1979; Twidale 1982). Most workers tend to agree, however, that the development of these features is due to moisture attack along with granular disintegration from salt crystallisation.

The large cavern on the northern side of Cleft Island (also known as Skull Rock, because of the skull-like appearance of the domical granite exposure and its caverns) is an enlarged tafone (Fig. 3). This cavern is approximately 50 m high and almost 100 m wide. Disintegrated granite debris and wind blown sand cover the cavern floor and have accumulated to form a dune at the entrance. The outer surface of the granite on the island is indurated by a red-brown coloured material. Thin section and X-ray diffraction examinations of samples taken from similar exposures at Wilsons Promontory found this red-brown staining to be a surface coating consisting of a mixture of iron oxides/hydroxides and goethite, mostly derived from the weathering of iron rich silicate minerals such as biotite (Hill 1992).

The development of the Cleft island cavern began along a sub-horizontal joint approximately 15 m above sea level (Fig. 3), that breached the indurated veneer of the granite exposing it to moisture attack and salt laden coastal winds. Granular disintegration of the non-indurated interior of the granite has progressed upwards from this joint. Earlier explanations for the development of this cavern, requiring sea levels to have been 15 m higher than present (Wallis 1981), or for there to have been localised tectonic uplift of approximately 15 m (Spurgeon 1980) have not recognised the significance of the sub-horizontal joint in accounting for the elevation of the cavern's sub-horizontal floor.

Tafoni also occur within the highland areas of Wilsons Promontory, particularly in the north, such as in the Vereker Ranges (Fig. 4) and on the low hills inland of Corner Inlet. These features are unexpected in such high rainfall areas away from the coast. Their development is probably the result of the transportation of large amounts of cyclic salts well into the highlands of Wilsons Promontory (Parsons and Gill 1968; D. Ashton *pers. comm.* 1992). Scanning Electron Microscope and associated Energy Dispersive X-ray analysis found that a white efflorescence visible in the caverns consists of halite crystals that have grown in microfractures and between mineral grain boundaries (Hill 1992).

Caves

Enclosed cavernous features are common within the granitic areas of Wilsons Promontory. They are essentially due to subsurface stream or coastal erosion of the weathered rock along the joint planes between cores of fresh granite. Sea caves at the northern and southern ends of Waterloo Bay and at the north-eastern end of Great Glennie Island are due to weathering and subsequent coastal erosion along joint planes.

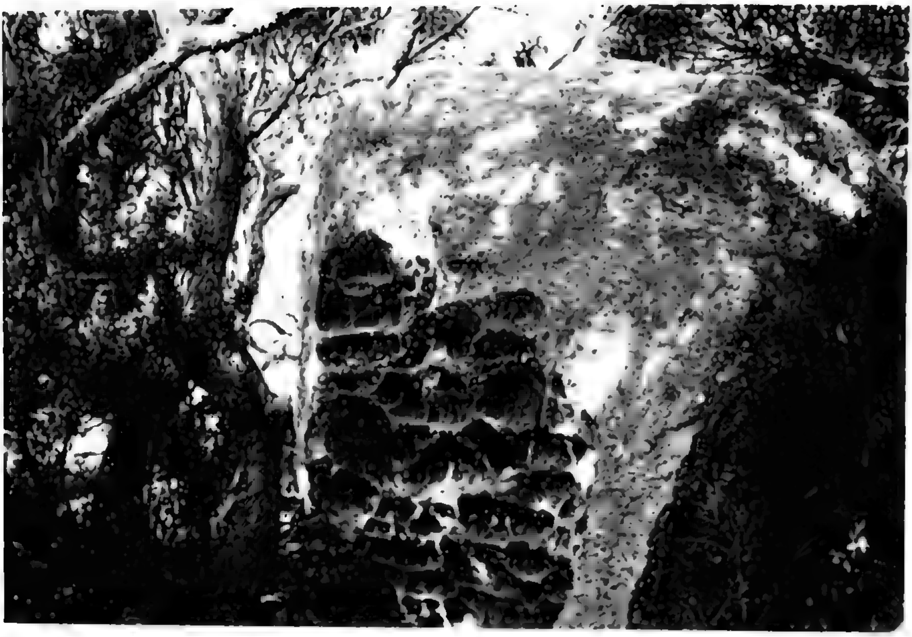

Fig. 4 Tafoni within the Vereker Ranges near Lookout Rocks, along the Vereker Outlook Walking Track. These features are well developed at approximately 200 m altitude, often several kilometres from the present coastline.

Fig. 5. Well developed flutings on the upper surface of an approximately 7 m high tor at the western end of Tongue Point. Also note the later development of cavernous weathering in the centre of the figure.

An extensive cave with an entrance along the Sealers cove Walking Track approximately 2 km east of Windy Saddle, contains a series of caverns over 10 m long and 2 m in diameter. A small stream flowing through the lower-most cavern is responsible for the subsurface erosion of weathered material from between zones of fresh rock. The walls of the cave consist of *in situ* saprolite and corestones. Coralline speleothems, similar to those described elsewhere by Finlayson and Webb (1985) and Webb and Finlayson (1984), occur in areas of water seepage. An eroded joint opening near the summit of Mt Oberon also contains similar coralloid speleothems, that consist of opaline silica (opal-A) and allophane (Hill 1992). The speleothems have precipitated from waters enriched in silica derived from the weathering of silicate mineral in the granite.

Dry valleys with sub-surface streams and caverns enclosed by an irregular arrangement of tors also occur. Their formation is the result of downslope movement of tors into valleys where they enclose the underlying stream. The Sealers Cove Walking Track crosses many such streams, particularly on the southern slopes of Mt Ramsay.

Fluting

Some coastal exposures of fresh granite contain surface channels or flutings. The best examples occur at the western tip of Tongue Point (Fig. 5) and near the mouth of Freshwater Creek at Waterloo Bay.

Sea-spray and rainwater draining down the surface of these rocks facilitates chemical attack and mechanical abrasion, forming channels. Once initiated they will tend to gather more water, augmenting these processes. The channels stop approximately 2 m above the high tide level because of their obliteration by marine abrasion.

Similarly, but dendritically branching grooves occur within fresh granite near the summits of Mt Latrobe and South Peak. Ashton and Webb (1977) made a detailed description of these grooves. They found charred root material in some of the grooves at Mt Latrobe, suggesting that their formation is the result of an increase in weathering along the moss-covered roots of an extensive Myrtle Beech *Nothofagus cunninghamii* forest. This forest was burnt in the 1943 and 1951 bushfires. The release of carbon dioxide and organic acids from the roots would facilitate this localised increase in weathering.

Conclusion

A variety of granite landforms have been described and explained from Wilsons Promontory, Victoria. Of particular interest are the tors, the cavernous weathering features and the examples of surface flutings and grooves in many of the outcrops. These landforms have essentially evolved as a result of deep weathering and later stripping of the weathered material to expose areas of granite bedrock. As a result joint bounded corestones of fresh granite are seen outcropping as tors. Further alteration of the granite by surface processes, including physical, chemical and biological weathering, and coastal and fluvial erosion has led to the development of surface features such as honeycomb weathering, cavernous features and flutings.

Acknowledgements

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Predator Calls and Prey Response.

Edward G. McNabb[1]

In recent years the tape recorder has become a tool regularly used by biologists when conducting fauna surveys. Nocturnal birds are located by their response, usually territorial, to replays of taped calls of their species. For example, this method was used with success by the author when assisting with a fauna survey of Westernport Catchment in Victoria during 1980-1981 (Andrew *et al.* 1981). The rare Sooty Owl *Tyto tenebricosa* was located at several sites by this method. Over a period of 16 years I have observed the response, (sometimes unexpected) of species other than that in the recording, in many cases by potential prey. These responses have been aggressive and therefore demonstrate that some prey species are willing to bluff, or even attack a predator. Similar behaviour has been observed in their diurnal counterparts, e.g. a Willy Wagtail *Rhipidura leucophrys* 'dive-bombing' a perching Australian Hobby *Falco longipennis*, or an Australian Magpie *Gymnorhina tibicen* pursuing a White-bellied Sea-Eagle *Haliaeetus leucogaster* out of its (the Magpie's) nest area (*pers obs*). It has also been observed that a predator can sometimes be lured by the playing of a recording of a potential prey item. These notes recount a number of these occurrences, many of which show the Yellow-bellied Glider *Petaurus australis* to be quite aggressive toward large owls. It also describes interesting responses of

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some smaller potential prey species such as Leadbeater's Possum *Gymnobelideus leadbeateri.*

Observations

Response by Yellow-bellied Gliders and Leadbeater's Possums

19 November 1980

Ash Landing Rd., Gembrook State Forest (now Gembrook Regional Park, 37° 57'S, 145° 37'E) 2100-2200 hrs accompanied by K.McNabb. A tape-recorded Sooty Owl territorial scream was played whilst surveying the area. Several Yellow-bellied Gliders had been noted earlier and one gave a loud growl as it launched into a long glide, following the centre of the road alignment, down toward us. This volplaning phalanger seemed to be targeting me as a likely landing site so just as it was braking for a landing on some part of my torso I ducked down. The landing was instantly aborted and a nearby tree trunk was chosen. The glider paused on this, 2.5 m above ground then scampered to the upper branches to escape the spotlight beam.

20 May 1981

Yellingbo State Faunal Reserve, Yellingbo (37° 50'S, 145° 31'E). A tape recording of the Powerful Owl *Ninox strenua* "whoo whoo..." was played near the Woori Yallock Creek where a Powerful Owl had recently been observed. A Yellow-bellied Glider made the typical 'gurgling, shrieking' calls from approximately 100 metres away and within a few minutes had arrived in a Manna Gum *E. viminalis* directly above me. While the tape was kept running it climbed down the tree trunk and was 6 m away when the spotlight was trained on it. This light seemed to irritate the glider, as it returned 3 m back up the tree to another branch, where it watched silently as photographs were taken, then moved back out of sight into the tree canopy. A Long-nosed Bandicoot *Perameles nasuta* in the roadside vegetation also responded to the 'owl call' by making the 'sneezing' alarm call of the species.

7 August 1981

Grey River Reserve, Otway Ranges (38° 40'S 143° 51'E), accompanied by M.., D. and K. McNabb and N. Eyre-Walker. This site was visited to investigate an unconfirmed report that a Sooty Owl had recently been heard in the area. In clear, calm moonlit conditions, a tape recording of the Sooty Owl's territorial downscale scream was played to attract the species. After 5 minutes of no response, a tape recording of the "whoo whoo....." call of a female Powerful Owl was played for about two minutes in an attempt to attract a Powerful Owl. No owl responded but a Yellow-bellied Glider started to 'growl and gurgle' from roadside eucalypts 150 m away. The tape was then stopped for 3-4 minutes; the glider seemed to settle down and the vocalisations subsided. When the tape was restarted the glider resumed calling as it climbed to upper branches. It then glided 100 m toward us and alighted on a roadside tree trunk 50 m away. As the tape continued to run the glider 'gurgled' again as it climbed to the upper branches and launched itself into a glide directly toward the source of the 'owl call', i.e. myself, standing on the road, playing the tape recorder. Once again it seemed that I was to become a landing site so appropriate evasive action was taken. This caused the glider to veer off and alight on an acacia trunk 20 m to the left of me. It then scaled the acacia and was observed in the lower branches for a few minutes before disappearing quietly.

23 September 1981

Gembrook Regional Park, accompanied by D. Andrew and B. Gillies. A Yellow-bellied Glider was observed approximately 100 m away, feeding quietly in a known Messmate *Eucalyptus obliqua* 'feed tree' over a period of 5 minutes. A tape recording of the female Powerful Owl "whoo whoo...." call was played for only a few minutes when the glider became vocal. While uttering the typical 'gurgling shriek' calls it homed in on us rapidly by climbing to high points and gliding from tree to tree. It glided down into the ground cover approximately 10 m from us and stayed nearby, vocalising occasionally, even after we had made ourselves visible to it. A little later a recording of the Sooty Owl territorial scream was played but the glider made no response.

10 October 1981

Gembrook Regional Park, accompanied by D. Baker-Gabb. Whilst listening for a Sooty Owl a Yellow-bellied Glider was heard calling approximately 50 m away. To attract a Sooty Owl the downscale territorial scream was played; the glider showed no interest. Having no success with the Sooty Owl tape we decided to play the Powerful Owl "whoo whoo...." tape to find out if this species was resident in the gully. Two Yellow-bellied Gliders responded by first calling, then gliding closer until they arrived in trees near us. One came close enough to be identified, by using binoculars, as a male.

30 October 1981

Gembrook Regional Park, accompanied by J. and P. Klapste, P. Peake and A. Ur. A tape recording of the Sooty Owl scream was played beside Black Snake Creek; two Yellow-bellied Gliders 'homed in' on us.

12 December 1981

Gembrook Regional Park, accompanied by members of Ringwood Field Naturalists' Club. Yellow-bellied Gliders vocalised in response to the playing of Powerful Owl and Sooty Owl tapes, over a period of 30 minutes.

23 March 1983

Gembrook Regional Park, Ash Landing Rd., accompanied by M. Varty, at a site where she had observed a Sooty Owl perched in a Tree-fern during daylight a few days earlier. The Sooty Owl scream recording was played. Within a few minutes a Yellow-bellied Glider arrived on the trunk of a Messmate beside us. Another arrived soon after.

2 February, 1985

Tweed Spur Rd, approximately 1 kilometre outside the eastern boundary of Cathedral Range State Park (37° 23'S, 145° 46'E). While spotlighting in Mountain Ash *E. regnans* forest at 2130 hours, a Leadbeater's Possum was observed running down the trunk of a young Ash. When dazzled by the spotlight it hesitated long enough for a photograph to be taken from about 5 m below it, then disappeared up into the canopy. Twenty minutes later I started to imitate the "whoo whoo....." call of the Powerful Owl to try and attract a Yellow-bellied Glider which had called from the tree tops 50 m away. The glider responded by gliding to a trackside Ash almost beside me but I was distracted by the return of the/a Leadbeater's Possum which was now only 1-2 m above ground, 4 m away on another Ash sapling. I continued to make the owl calls and photographed this possum several times as it seemed to be seeking the 'owl'. Another Leadbeater's Possum arrived within minutes and scampered up and down several saplings, jumping from trunk to trunk, obviously also looking for the 'owl'. The Yellow-bellied Glider watched silently from a branch 10 m above me.

3 February 1985

Little River Track, Cathedral Range State Park (37° 22'S, 145° 46'E). In another Mountain Ash area I mimicked the Powerful Owl call hoping to again attract a Leadbeater's Possum. A Southern Boobook *Ninox novaeseelandiae* was the first to respond, gliding silently onto a trackside tree branch about 15 m away. Soon however, a Yellow-bellied Glider called from down the gully and began to work its way toward me. I continued to call "whoo whoo..." and within 10 minutes it glided overhead and landed on an Ash 30 m away. The "whoo whooing" was continued and the glider passed back overhead to land in another tree 30 m past me in the opposite direction. After a 'gurgling' call it glided back to the previous tree. This back and forth behaviour was repeated several times. A second Yellow-bellied Glider arrived during the above activity and called from a high branch. The 'Powerful Owl' call also stimulated 3 Owlet Nightjars *Aegotheles tristatus* to call.

5 September 1987

'Jack the Miners', Dandenong Ranges National Park (37° 55'S, 145° 22'E), accompanied by S. Craig. In a known Yellow-bellied Glider area, the Powerful Owl "whoo whoo..." recording was played for 5 minutes, with intention to demonstrate the response of these gliders to the call. No discernible response occurred. A recording of the Yellow-bellied Gliders' typical 'gurgling shrieking' call was then played. Two Yellow-bellied Gliders replied immediately from 100 m away then glided in and alighted on tree trunks directly over us.

30 March 1991

Garvey Track, Otway Ranges (38° 34'S 143° 55'E), accompanied by C. Compton. A Yellow-bellied Glider was heard approximately 150 m away soon after dark. The Powerful Owl "whoo whoo..." tape was played and the glider came toward us, uttering loud gurgling calls from each of several trees used as it climbed up to glide closer. It arrived in a trackside tree 15 m from us and climbed up to the canopy, then became quiet after a spotlight was used to illuminate it.

9 January 1992

Blanket Bay Track, Otway Ranges (37° 49'S, 143° 32'E), accompanied by S. Dewar-McNabb. The tape recording of the Powerful Owl "whoo whoo...." calls was answered repeatedly by a Yellow-bellied Glider. This glider came to within approximately 40 m and uttered the 'gurgling shriek' several times in response to the owl call. Another two Yellow-bellied Gliders arrived from other directions. None 'homed in' any closer than 40 m from us.

17 June 1992

Butterfield Reserve, Monbulk (37° 54'S, 145° 26'E). Powerful Owl "whoo whoo...." calls were mimicked several times over twenty minutes. A Yellow-bellied Glider responded by calling immediately on each occasion. Some time later a tape recording of the owl call evoked the same response. The glider was not seen.

Response by Southern Boobooks

3 January 1981

Fern Tree Gully Sector, Dandenong Ranges National Park (37° 52'S, 145° 18'E). A resident pair of Powerful Owls had raised one chick during the previous winter. The "whoo whoo...." tape was played at 2120 hours to ascertain whether the owlet was still present in its parents' territory. Within one minute all three Powerful Owls had arrived beside the track in response to the tape. They were immediately attacked by a Southern Boobook which swooped on them repeatedly, making duck-like "quack" calls. The adult Powerful Owls left the area quickly but the owlet seemed a little confused and remained nearby, trilling occasionally as if hoping for its parents to return. This was in spite of the Boobook's vigorous assault, which at least once involved contact as the young Powerful Owl's head feathers were 'parted'. The Boobook eventually (after 10 minutes) flew off toward its nest tree, 70 m away. Subsequent observations revealed 2 young Boobooks.

14 December 1990

'Ferndale' The Basin, Dandenong Ranges (37° 51'S, 145° 21'E). In a gully inhabited by a resident breeding pair of Powerful Owls, the "whoo whoo..." call was mimicked in an attempt to attract the two juvenile offspring. A Southern Boobook appeared, gliding down silently, at speed, between the tree trunks, straight at the source of the 'Powerful Owl call', i.e. my head. After taking evasive action as the attacker passed, the "whoo whoo...." call was resumed. The Boobook did not venture close again, probably because it had recognised the caller to be a fraud.

Sooty Owl Response to Prey Recording
15 December 1981

Gembrook State Forest. When surveying a gully for Leadbeater's Possum, an ancient, hollow, living Manna Gum stag was watched to see if nocturnal mammals, particularly Leadbeater's Possum, emerged at dusk. No such mammals emerged. At 2118 hours a Sooty Owl screamed some distance away, up the gully. Ten minutes later it screamed close by. Nothing more was heard from this owl for the next 22 minutes. At 2150 hours I began playing a tape of Leadbeater's Possum 'chittering' calls. Within 2 minutes the Sooty Owl landed 4 m from me, on a vertical Messmate trunk, about 25 cm. in diameter. The bird remained in this position, seemingly unworried by my spotlight, for 4 minutes, watching me as I admired its large taloned feet clamped onto the tree trunk. After flying away it was heard to scream further down the gully. Earlier, on 8 April 1981, also in Gembrook Regional Park, the Leadbeater's Possum tape was played. No owls responded but a single Leadbeater's Possum arrived (Loyn and McNabb 1982).

Discussion

Gliders, Possums and Bandicoots.

The above reports demonstrate that Yellow-bellied Gliders and to a lesser degree, other potential prey species, are intolerant of large owls in their area. Even in a known Powerful Owl territory the playing of the owl tape often (with exceptions, see 5 September 87) attracts an aggressive glider/s before the Owl actually responds. As described above a Yellow-bellied Glider may even glide directly at the tape recorder operator, apparently intent on attack. A few years ago at Healesville Sanctuary, Victoria, (c. 1990), a free-ranging Yellow-bellied Glider was observed running out along a limb, 10 m above ground, of a creek-side eucalypt. It ran up to a clump of coppice growth vocalising loudly, then turned around and returned to the tree trunk. The glider ran approximately 1 m up the trunk, paused to look down at a dark shape beside the outer side of the coppice, then repeated its charge down to and out along the branch. With the aid of a strong torch the dark shape was identified as a Powerful Owl. The agitated glider repeated its 'attack' many times over 10 minutes, running to within 0.5 m of the owl, separated only by the coppice, before each retreat. (K. Mason *pers. comm.*).

In 2nd of February 1985 incident the Leadbeater's Possums' response seemed to be more investigative than aggressive but had an owl actually been encountered it seems logical to assume that their mood would have changed to the latter.

To hear the alarm call of a potential prey species has not been surprising, such was the response of the Long-nosed Bandicoot (20 May 1981). Other species to react to the tapes have been Common Brushtails *Trichosurus vulpecula* and Bobuck *T. caninus*, in both cases by making their alarm call.

Sugar Gliders *P.breviceps* have often responded vocally to predator calls, uttering their "yap--yap" alarm call, therefore warning others of their kind that an owl is nearby. The only occasion in which an active response was observed involved a captive colony of Sugar Gliders and Leadbeater's Possums which shared an enclosure. When a possum or glider was taken in hand both species reacted by dashing around the enclosure, the former growling and latter chittering furiously. Leadbeater's Possums showed more courage and some individuals jumped onto the handler (*pers. obs.*).

Owls and Nightjars

The response by Southern Boobooks during their breeding season was not unexpected. In both cases they were defending their nest and young from predators and demonstrated their ferocity in doing so. Boobooks have also attacked humans who venture near their nest or newly fledged young (P. Lewis *pers. comm.*).

The Sooty Owl's response to the Leadbeater's Possum sounds was also explicable as the owl was already close by, and if hunting would investigate any sound which could suggest the presence of prey. At a site in the Dandenong Ranges in 1991 a young Sooty Owl came down to investigate a softly squeaking audio cassette which was recording the owl's calls. Both of these experiences suggest a less aggressive technique for luring birds to a photographer or observer. The Owlet Nightjars' response (3 February 1985) was also probably a warning.

Using Taped Calls

While the inappropriate use of taped calls is to be discouraged, these experiences show some interesting less known interactions of nocturnal species; avian, arboreal and terrestrial. The 'call up' technique involves some degree of stress for both the predator and prey species. The playing of owl calls often provokes resident birds to come and 'defend' territory. Such a distraction can linger for an hour or more (*pers. obs.*) and therefore disadvantage a pair of owls during critical stages in their breeding cycle e.g. if the female is absent from newly hatched chicks for too long, or when energy is expended seeking 'trespassers' instead of hunting for prey during peak feeding (of young) time. Potential prey species such as Yellow-bellied Gliders also demonstrate stress by their level of aggression when a Powerful Owl call is heard. It is therefore obvious that the techniques described must not be over-used! Some points to consider if intending to use tape recorded calls are: Is the species being 'called up' for a valid reason such as a genuine survey, or just for entertainment? Is the species already known to be resident? If so then there probably is no valid reason to disturb them. When the species has a known breeding season, e.g. Powerful Owl, winter/spring, avoid 'call ups' at this time (see above). As owls are more likely to respond during this period don't persist with the tape once you have your data. You need only to hear or sight it once for positive identification. These can be effective methods of locating some of the cryptic nocturnal species but are by no means the only ones. A preferred method is to 'stake-out' an area at dusk, morning or evening, listening for calls. Owls are more vocal during their courting and breeding season, and are likely to communicate with each other as they first become active at night and when going to roost in the morning. Yellow-bellied Gliders also are usually vocal soon after dusk so to hear their calls at this time gives an indication of where they live. The well known mammal survey method of 'stag watching' is often successful and does not cause stress to the animals. This involves quietly watching likely nest/roost trees at dusk to see if an animal or bird emerges. (e.g. as in Loyn and McNabb 1982). Of course the time honoured method of 'spotlight walking', i.e. walking through the forest scanning the trees and understorey for 'eye-shine', the light reflecting off the subject's retina, is still applicable when surveying forests. This is a pleasant way to spend a few night hours enjoying the outdoors and causes little stress to the creatures sought.

Acknowledgements

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Search for Tropical Seeds and Fruits on Victorian Beaches

J.M.B.Smith[1]

Introduction

Tropical fruits and seeds have long been known to wash onto beaches in north-west Europe, and a rich if fanciful folklore developed concerning their origins and properties (Nelson 1983). It is now recognised that these somewhat rare objects, rather than coming from eagles' nests or submarine trees, are the buoyant propagules of certain land plants growing in the Caribbean region, having travelled north-east across the Atlantic Ocean over a period of about 15 months in the North Atlantic Drift. Study of tropical fruit and seed transport over very long distances by sea drift has also been extended to other regions, both temperate (e.g. Gunn *et al.* 1976; Nakanishi 1987; Nelson 1978, 1988) and tropical (particularly Pacific, e.g. Guppy 1906, 1917; Ridley 1930; Smith 1990).

Recently, interest in the topic has developed in Australia. On the east coast, studies have been undertaken in the Great Barrier Reef area on fruits and seeds drifting to small cays lacking mature plants of the same species (Buckley and Knedlhans 1986; Hacker 1990; Smith 1992; Smith *et al.* 1990). It has been concluded that the great majority of them come from islands to the east or north-east, in the Solomons-Fiji-Vanuatu-New Caledonia region (Smith 1992; Smith *et al.* 1990). Many of the same sorts of fruits and seeds have also been found, in dwindling numbers southward, on the New South Wales coast (Smith 1991), and in northernmost New Zealand (Mason 1961). Inspection of wind and current patterns suggests southward drift in the East Australian Current down the east coast of Australia (Fig. 1), and subsequent drift at more southerly latitudes across the Tasman Sea (Smith 1991).

However, records of tropical fruits and seeds from beaches in southern and western Australia are few, and it would be of great interest to discover more about the tropical drift reaching this area and the routes by which it travels. Kenneally (1972) reported finds from the south-western corner of Western Australia, though several of the specimens he described lacked collection details. He showed that fruits or seeds of at least seven species drifted there from tropical sources, one or two others probably owing their presence to human-assisted transport. At least two of the types he recorded were collected on the south coast of Western Australia, and these have also been found further east. Nelson (1990) recorded four seeds of the widespread tropical liane *Entada* (probably *E. phaseoloides*) found at Twilight Cove on the Great Australian Bight, Western Australia. Guppy (1917) noted that two seeds of *Caesalpinia bonduc* had been found at unidentified locations in South Australia.

Detailed and extensive study of strandline materials at Anxious Bay (South Australia), during an investigation of oceanic pollution by floating debris in 1991, turned up no specimens (N.M.Wace, *pers.comm.* 1992). In western Victoria, there is one report of a coconut found in 1988 at Discovery Bay (D. Booth, *pers.comm.* 1988), and in eastern Victoria one record of an *Entada* seed in 1986 from a beach north of Rame Head (G.J.Andrews, *pers. comm. 1988*, in Smith 1991). No records at all are known to me from Tasmania, but a seed of *Caesalpinia bonduc* has been found at subantarctic Macquarie Island, and later grown into a substantial plant (Costin 1965). Approximate locations of known tropical drift fruit and seed discoveries along the southern coastline of Australia are included in Fig. 1.

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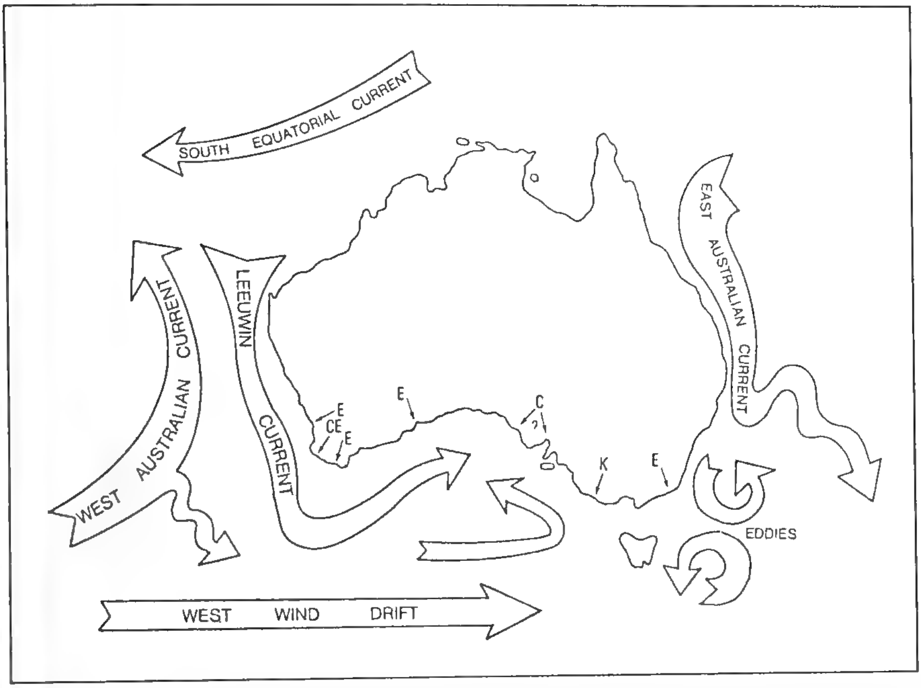

Fig. 1. General pattern of surface currents around Australia (after Cresswell 1987) and approximate locations of tropical drift fruits and seeds found between south-west Western Australia and Victoria, **C** - *Caesalpinia bonduc*, **E** - *Entada phaseoloides*, **K** - *Cocos nucifera;* records from Western Australia whose collection locations are not known, or of specimens which were probably transported by people, are not included.

Drift dispersal is the most spectacular and easily studied example of seed dispersal over very long distances. Most plant species demonstrating long distance drift dispersal are tropical, and most have wide distributions reflecting the efficacy of this dispersal mechanism. Some drift seeds remain viable over years of flotation in seawater and thousands of kilometres of drift. Drift into temperate latitudes is, of course, likely to have no biogeographical or ecological consequence because prevailing climatic conditions will not permit establishment after germination even in those cases where the seed remains viable. Nevertheless, the topic has interest in demonstrating the potential of some plants to spread in this way, as well as in helping unravel the complex factors and patterns that result in floating objects and materials being transported over considerable distances.

The purpose of the present note is to alert naturalists to the possibility of finding tropical fruits and seeds on beaches in Victoria and elsewhere in southern Australia, and hopefully thereby to collect a larger number of records and build up a picture of drift patterns in the region. As well as having great intrinsic interest, such a study is relevant to understanding and predicting the drift of a variety of other buoyant objects and materials such as oil, floating solid pollutants, and debris and survivors from transport accidents. Below, I discuss possible drift patterns, describe some of the fruits and seeds most likely to be found, and invite correspondence with any potential or actual finders of specimens.

Likely Drift Directions

The general current pattern in the southern Australia region is shown in Fig.1. Two major currents converge in the area east of Tasmania. The East Australian Current passes southward off Queensland, before typically developing into a series of large clockwise eddies off the New South Wales coast which drift south until they lose their identity in the south-east Tasman Sea; there is also irregular eastward drift towards New Zealand across the Tasman Sea (Cresswell 1987). To the south of the continent, the West Wind Drift sweeps eastwards. Kenneally (1972) suggested that tropical fruits and seeds he recorded on beaches in the south-west of Western Australia were carried there by the West Wind Drift from the African region, although as some were apparently South-east Asian in origin, this also involved anticlockwise drift around the Indian Ocean, feeding Asian specimens into the West Wind Drift via the south-flowing currents off East Africa. Since the publication of Kenneally's paper, another current has been identified, the Leeuwin, flowing south then east around Western Australia from the tropical seas in the Timor region to the Great Australian Bight (Cresswell 1990). There appears to be a clockwise current in the Bight, and currents near the coast further east (including those in Bass Strait) seem to be rather variable.

However, floating objects are not propelled simply by currents since wind can sweep the shallowest layer of the water in directions different from those of the underlying current if it blows in the same direction for a day or more. Objects floating high in the water (or bobbing above the surface of rough water) are, of course, affected even more directly by the wind. The tracks followed by floating objects are therefore far from simple and in any one area are probably rather variable from time to time. Overall, it seems likely that most tropical seeds and fruits which might be found on beaches in eastern Victoria and eastern Tasmania derive from the Coral Sea, while most of those in Western and South Australia, and in western Victoria and Tasmania, would come from the Timor Sea region via the Leeuwin Current. However, for the most durable floaters which have pantropical distributions (such as *Caesalpinia bonduc*), origins in Africa or elsewhere cannot be ruled out. Further collections of specimens from the region may help elucidate details of drift tracks, as it already has in the Coral and Tasman Seas.

Descriptions of Common Drift Fruits and Seeds

Photographs of drift fruits and seeds found on beaches in south-western Western Australia and in New South Wales have been published by Kenneally (1972) and Smith (1991) respectively. Here I provide some descriptive notes on the three types already recorded on the Australian south coast from south-west Western Australia to Victoria, and eight other types which seem likely to be found there. This is to give beachcombers some guidance, but it must be appreciated (and hoped!) that other types may also be collected in the area. Drawings of the eleven types described are provided in Fig. 2.

Aleurites moluccana **(Candlenut,** Fig. 2b): a widespread rainforest tree in the South-east Asian/Melanesian region, also native to north-east Queensland and occasionally planted for its seeds as far south as northern New South Wales. The seed is used as a source of oil and in preparing some Indonesian dishes. It is frequently found washed up on tropical beaches in the Coral Sea region and has been recorded south to near Sydney, and in New Zealand. Sea-drifted specimens are invariably dead, often oozing malodorous oil, and on beaches are often found in pieces. The seed has been called 'fossil prune' due to its wrinkled, black appearance. It is about 3 cm long and the same wide, and about 2 cm thick, with a smooth but lumpy surface, usually black

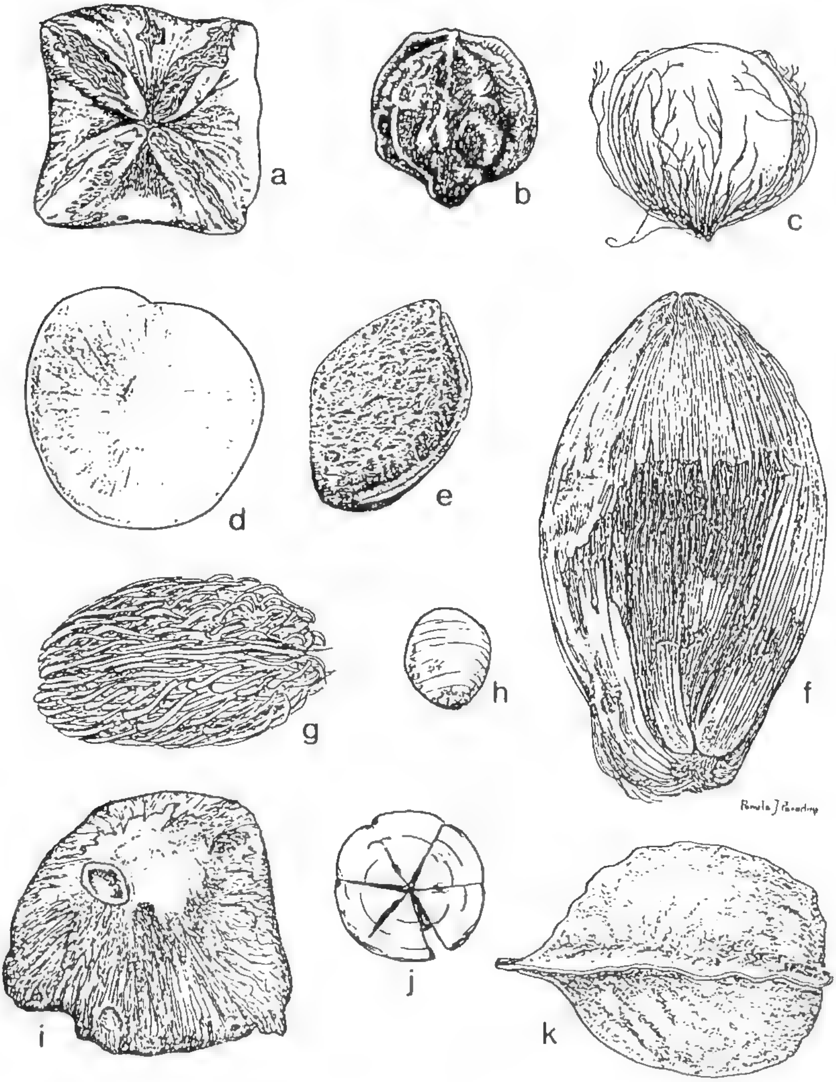

Fig 2. Drawings of the drift fruits and seeds described in the text and likely to be found on southern Australian beaches (originally by P.J. Paradine, in Gunn *et al.* 1976, except for *E. indica*; not to scale). **a** - *Barringtonia asiatica*, **b** - *Aleurites moluccana*, **c** - *Calophyllum inophyllum*, **d** - *Entada phaseoloides*, **e** - *Pangium edule*, **f** - *Cocos nucifera*, **g** - *Neisosperma oppositifolium*, **h** - *Caesalpinia bonduc*, **i**- *Xylocarpus moluccensis*, **j** - *Excoecaria indica*, **k** - *Heritiera littoralis*.

but commonly with marine encrustations. Broken specimens show the shell to be about 3 mm thick, with a prismatic structure.

Barringtonia asiatica (**Boxfruit**, Fig. 2a): a small tree of coastal habitats throughout the South-east Asian/Melanesian region, including north-east Queensland. Its fibrous fruits contain a hard seed which, however, is always dead (if not missing) in far-drifted specimens. Fruits are 8-13 cm long and nearly as wide, with several (usually four) pronounced ridges running from base to apex which have led them to be described as 'square coconuts'. They have been used as fishnet floats in parts of Melanesia, and are common on beaches in Queensland, having also been recorded as far south as Moruya in southern New South Wales, and New Zealand.

Caesalpinia bonduc (**Grey Nickar, Nickernut**, Fig 2h): an abominably spiny, scrambling shrub growing on bouldery headlands and in other habitats throughout the tropics, including northern Australia. Its seed is hard, pale grey, spheroidal, with fine concentric surface cracks, and about 1.5 cm across. It is perhaps the best driftseed in the world, having been found on beaches as remote from the tropics as Svalbard (Spitzbergen) in the Arctic, and Macquarie Island in the Subantarctic, the seeds usually proving viable if the hard outer testa is nicked to allow entry of moisture before they are sown. They have been recorded in Western Australia, South Australia, New South Wales and New Zealand, and might be anticipated to turn up on almost any beach receiving ocean drift.

Calophyllum inophyllum (Fig. 2c): a spreading, shady tree growing beside beaches throughout the South-east Asian/Melanesian region including northern Australia. Its spheroidal fruits have an outer green skin, browning and wrinkling after it is shed, over a thin layer of fibrous tissue, but after drifting for some time these outer layers disappear leaving a smooth, brown or grey nut-like organ which is often nearly perfectly spherical except for an apical point. It is 2-5 cm across, and often rattles when shaken due to the loose contained seed, which in a few cases is viable even after prolonged transport. Broken specimens show the shell to be 1-2 mm thick with a corky layer inside it. Drift fruits of this species have been found on beaches as far south as Ulladulla in southern New South Wales, and are widespread on beaches further north.

Cocos nucifera (**Coconut**, Fig 2f): this palm is typical of beach environments all over the tropics, but its native range is certainly more restricted and probably included the Melanesian region but not Australia or South-east Asia. Narrow, small nuts are thought to represent the original, ancestral form, while the commoner and more widespread large, rounded nuts are the result of selection over many centuries. The coconut palm is, of course, a most important plant in many ways, the fruits, fronds, trunks and buds all having valued uses. Although dehusked coconuts may also float, the main flotation tissue is the thick husk; coconuts lacking the husk are likely to have come from ships rather than travelled entirely by drift. When found on beaches, coconuts may be variously damaged or broken, but when intact are typically 20-30 cm long, and often nearly as wide. They have been recorded south to Moruya in southern New South Wales, in New Zealand, and with a single record in western Victoria.

Entada phaseoloides (**Matchbox bean**, Fig 2d): a massive, woody climber occupying a variety of forest habitats including the inland margins of mangrove swamps, over most of the South-east Asian/Melanesian area, including north-east Australia. The seeds are smooth, dark reddish brown, irregularly disc-shaped, 4-6 cm in diameter and 1-1.5 cm thick, with a scar (hilum) in a notch at one side where the seed was connected to its containing pod. Other species of *Entada* may also produce similar driftseeds in the region. Most seeds are viable, even after prolonged drift. They have been found in south-west Western Australia, eastern Victoria, New South Wales and New Zealand, and are common on Queensland beaches.

Excoecaria indica (syn. ***Sapium indicum***, Fig. 2j): a mangrove tree whose distribution extends from India to the Solomon Islands, but does not include Australia. Its fruit is brown, woody and spheroidal, 2-3 cm across, cracking easily into three (rarely four) segments to reveal seeds within, which in far-drifted specimens are always dead. Each segment is itself divided by a longitudinal suture. Separate segments may be found on beaches, as well as intact fruits. They have been found on Great Barrier Reef cays, especially in the north, as well as in south-west Western Australia.

Heritiera littoralis (**Looking-glass Mangrove**, Fig. 2k): a widespread tree of mangrove swamps and other coastal habitats throughout South-east Asia and Melanesia, and in Queensland. Its fruit is woody, grey-brown, ovoid, tapered at one end, 4-7 cm long, and marked by a prominent, diagnostic ridge or crest running from base to apex. They have been found as far south as Woolgoolga in northern New South Wales, and in south-west Western Australia.

Neisosperma oppositifolium (syn. ***Cerbera odollam***, Fig. 2g): a small beachside tree found throughout the South-east Asian/Melanesian region, but apparently absent from Queensland where it is replaced by closely related species. It produces an avocado-like fruit, whose outer tissues rot after it is shed from the tree leaving a corky, longitudinally divided 'brain-like' organ, 6-8 cm long, about 5 cm wide and 4 cm thick, covered by coarse, pale brown fibres. When found on beaches after lengthy drift, the fibrous covering may largely have eroded away, or it may be partly covered by marine encrustations. They have been recorded south to Sydney, and in south-west Western Australia.

Pangium edule (Fig. 2e): a rainforest tree, also widely cultivated in the South-east Asian/Melanesian region for its seeds which are edible after cooking, but absent from Australia. The woody seeds are rather irregularly shaped, 3-5 cm long, the grey or brown surface being marked by a wavy pattern of fine ridges, with a large scar (hilum, where the seed was joined to the containing fruit) resembling lips. Far-drifted specimens are always dead. They have been recorded on cays of the Great Barrier Reef, and in south-west Western Australia.

Xylocarpus moluccensis (**Cannonball Mangrove**, Fig. 2i): a widespread tree of mangrove swamps throughout South-east Asia and Melanesia, and in far northern parts of Australia. The spheroidal fruits, from which the tree gets its common name, split open to release large, irregularly shaped corky seeds which can drift long distances. However, far-drifted specimens usually become broken and unviable, and may be hollow and occupied by encrusting fauna. They have been found as far south as Woolgoolga in northern New South Wales, as well as in south-west Western Australia.

A Request to Beachcombing Naturalists

I hope the above discussion and descriptions might arouse interest among those with the opportunity to investigate the cast-up debris on strandlines of beaches in southern Australia, and who may indeed already have found tropical drift fruits or seeds in such places without, perhaps, fully realising their nature or significance. It is impossible for a single person to investigate beaches in all parts of a large region, but as has already been proved in my studies of drift fruits and seeds reaching beaches on Australia's east coast, information and specimens from many people can be collated to produce a coherent and meaningful overall picture.

I curate a large, expanding and unique collection from the Australian region, and am happy to identify specimens (if I can) and either incorporate them into the collection or return them to their finder, as requested. Records without specimens are also welcome, provided the identification is beyond doubt, but in all cases it is important for the place and preferably the date of the finding to be known.

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Field Guide to the Birds of Australia (Fourth Edition)

by Ken Simpson & Nicolas Day

Publisher: *Penguin Books Australia Ltd, 1993*

392 pp, numerous colour and black-and-white illustrations and distribution maps

RRP $29.95

This edition retains an attractive, colourful dust-jacket and a protective vinyl cover. As with previous editions, it is superbly illustrated and contains sufficient pertinent text with which accurate identifications of Australian birds can be made. It includes 11 colour plates that have been improved upon or added to, 52 extra or replacement black-and-white drawings, 93 amended distribution maps and a new section, the 'Rare bird bulletin', that includes identification and other information on new species recorded for Australia. It is however, still too heavy and broad for a field guide and would improve markedly if it was reduced in size and if the handbook section, excluding 'Hints for bird-watchers', 'Where the birds live...' and 'Australian island territories' checklists' was omitted. The handbook section, although very interesting, is more suited to the CD-ROM version of this publication. As this field guide is an Australian contribution to ornithology it would have been preferable for it to have been printed and bound in Australia and not Hong Kong. It is competitively priced (cf. Pizzey 1991: $24.95; Slater *et al.* 1989: $29.95) and is well worth purchasing.

The following improvements and corrections are suggested:-

Dust-jacket: refers to 'third' instead of 'fourth' edition*. Ken Simpson is interested in 'birds, other animals and fossils' or 'birds, mammals and fossils' but not 'birds, animals and fossils' as this promotes the common misconception that birds are not animals.

Front inner: the text '27, 28 Giant Petrels' is printed upside down. The profile of the White-faced Storm-Petrel should be exchanged with that of the Flesh-footed Shearwater on the back inner.

Back inner: 51 Fulmar Prion Width should read '10-14.5 mm' not '10-14.7 mm' as all other given measurements are to the nearest 0.5 mm.

Contents: DNA-DNA hybridization begins on p290 not p291. The Index of Common names begins on p387 not p382.

Introduction: the vultures of south and central America are not a relevant example in an Australian field guide.

How to use this book... : the legend for distribution maps should explain the use of thick boundaries on the maps for Night Parrot, Paradise Parrot, Plains-wanderer and Northern Scrub-robin. Non-breeding distribution should be separated from records of vagrants: retain the hatching for the former and perhaps use small open circles for the latter. The legend for breeding bars could use 'unseasonal rainfall' instead of the awkward but correct 'unseasonable rainfall'.

Stop Press: New Bird for Australia: distribution map does not require the text 'RAOU Atlas'.

Key to Families: the small-type summary text could include number of species extinct in Australia. For instance for Emus it could read 'Species: World 1; Australia 1 (2 extinct)'. The terms 'True', 'Long-tailed' and 'Broad-tailed' to describe groups of parrots could be dropped as they imply that the last two are not true parrots; the use of 'Parrots' for each group with the family name beside is sufficient.

Field Information: a bold-type sub-heading such as 'Remarks' or 'Other comments' is required to separate text that follows the 'Habitat' sub-heading as text that refers to habitat often merges with text that does not. **96** White-faced Heron: comparative illustration of the head of 102 Reef Egret should be labelled Grey 'morph' not 'phase'. **101** Intermediate Egret: only breeds along the Murray River in Victoria (Emison *et al.* 1987). **102** Eastern Reef Egret - White morph: 'Legs yellow' in the text but green in the plate. **106** Yellow Bittern: 'only one Aust. record' in the text but two on the map. **138** Osprey: comparative colour illustration should be labelled '143' not '145'. **139** Black-shouldered Kite: 'Juv.' in the text but 'Imm.' in the plate. **140** Letter-winged Kite: sometimes breeds in Victoria; 'Juv.' in the text but 'Imm.' in the plate. **142** Black Kite: dark 'phase' Little Eagle in the text should be 'morph'. **143** Brahminy Kite: both '1st year' and 'Imm.' in the text. **145** Square-tailed Kite: breeds in north-central Victoria (Debus and Silveira 1989); 'light morph' of Black-breasted Buzzard in the text should be '1st year' and/or '2-3 year'. **146** Black-breasted Buzzard: '2-3 year' should be illustrated. **147** Brown Goshawk: '1st year' and '2nd year' in the text but 'Imm.' in the plate. **149** Grey Goshawk: breeding distribution in Victoria is very restricted and not widespread as shown; '1st year' in the text and 'Imm.' in the text and the plate. **151** White-bellied Sea-Eagle: '1st year' in the text and 'Juv.' in one plate (p73) and 'Imm. 1st year' in another (p67). **154** Spotted Harrier: '2nd year' is illustrated but not described in the text. **160** Grey Falcon: '1st year' in the text but 'Imm.' in the plate. **161** Brown Falcon: '1st year' in the text but 'Imm.' in the plate. **162** Australian Kestrel: '1st year' in the text but 'Imm.' in the plate; 'Szie' in the text should be 'Size'. **164** Malleefowl: isolated breeding populations in the Wychitella-Wedderburn area and the Little Desert, Victoria are not shown. **203** Bush Thick-knee: distribution is exaggerated for Victoria. **204** Beach Thick-knee: vagrant/s recorded at Mallacoota, Victoria (Emison *et al.* 1987). **327** Crested Pigeon: not a breeding resident south of the Great Dividing Range in Victoria. **336B** White-tailed Black-Cockatoo: requires colour illustrations showing the bird perched and in flight, and a black-and-white comparative illustration of the head. **366** Crimson Rosella: three races described and illustrated but 'Seven races exist' in the text; distribution of each race is not labelled on the map. **381** Elegant Parrot: breeding is unconfirmed for Victoria (Emison *et al.* 1987). **384** Turquoise Parrot: breeds in East Gippsland, Victoria (LCC 1985). **405** Masked Owl: should be 'morph' not 'phase' in the text; illustrations should not be labelled 'Race *kimberleyi*' or 'Race *castanops*'; map needs adjusting in line with Debus (1993). **407** Sooty Owl: illustration should not be labelled 'Light morph'. **427** Red-backed Kingfisher: voice could be described as a 'repeated mournful whistle'. **428** Sacred Kingfisher: too much lemon in the illustration. **433** Rainbow Bee-eater: 'Imm.' correctly lacks extended central tail-feathers in the plate but not mentioned in the text. **464A** Bassian Thrush: colour illustration of the race *cuneata*is required; the race *lunulata* should be numbered '464A' not '464' in the plate. **464B** Russet-tailed Thrush: colour illustration is required. **470** Pink Robin: 'ticks' while foraging and occasionally sings. **515B** Mangrove Fantail: colour illustration is required. **522** Chirruping Wedgebill: not confirmed for Victoria (Emison *et al.* 1987). **550B** Mallee Emu-wren: occurs in porcupine grass*Triodia* spp. not spinifex; also occurs in sand-plain heath. **555** Striated Grasswren: Juv. has a shorter tail than adult; voice includes a sweet melodious song. **561** Western Bristlebird: does not occur in Victoria but in SW of Western Australia. **582** Western Gerygone: does not occur in mallee in Victoria but does sometimes occur in woodlands (e.g. Black Box, Callitris and Casuarina) in the Victorian Mallee region. **594** Slender-billed Thornbill race *hedleyi*: does not occur in mallee but in sand-plain heath; distribution of *hedleyi* is not labelled on the map. **601** Varied Sittella: races are illustrated but distributions are not labelled on the map. **610A** Little Wattlebird: colour illustration is required. **622** Black-eared Miner: not confirmed for NSW as no specimens exist from there; colour illustration must be adjusted in line with the contemporary definition of a Black-eared Miner (McLaughlin 1993). Observers must be made aware that for positive identification, a miner must be examined in the hand and be shown to possess all 17 definitive Black-eared Miner plumage characters. Observers must also be made aware that a continuum of intergrades occurs between the Black-eared Miner at one extreme and the Yellow-throated Miner at the other (Ford 1981, Joseph 1986, McLaughlin 1993); and that, of the 17 definitive plumage characters, an intergrade may display at least one that may vary any-where between the Black-eared Miner and the Yellow-throated Miner (McLaughlin 1993). **659** White-cheeked Honeyeater: distribution should include far eastern Victoria. **686** Striated Pardalote: races illustrated but distributions not labelled on the map. **689** Silvereye: races illustrated but distributions not labelled on the map. **712** Black-headed Mannikin: does not occur in Victoria (Emison *et al.*1987). **744** Little Woodswallow: vagrants to SW Victoria (Emison *et al.*1987).

* This has been corrected in a later printing

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Charles E. Silveira

The Status of *Tradescantia virginiana L. (Commelinaceae)* in Australia: Naturalised or Historical curiosity?

J.G. Conran[1]

The Commelinaceae are a world-wide family of herbaceous monocotyledons with about 25 native and introduced species in Australia (Morley and Toelken 1983). Nevertheless, although many of the species are weedy, including the native *Commelina cyanea* R.Br. (Auld and Medd 1987), there is only a single species reported for Victoria: *Tradescantia fluminensis* Vell., which is also known as *T. albiflora* Kunth (Willis 1970; Wilson 1994; Conn *in press*) - a Brazilian species and weed throughout warmer regions of the world (Green 1994). This plant is commonly known as Spiderwort or Wandering Jew (Mabberly 1987). Although as the latter common name is derived from allusion to a pejorative and anti-Semitic Medieval curse/legend, Spiderwort should be encouraged as its common name. Although this species is abundant in many Australian gardens and along creeks in disturbed areas, especially in settled areas, it has been very poorly collected, reflecting the problem of under-collection of naturalised introduced plants.

During the examination of herbarium collections as part of an account of the Commelinaceae for the Flora of Australia project (Conran *in prep.*), a single accession of the Common Spiderwort Tradescantia virginiana L. was found in the collections at the National Herbarium of Victoria (MEL) in Melbourne. Native to north-eastern and north-central North America, *T. virginiana* grows in a wide range of habitats including woods, meadows, hillsides, rocky outcrops and stream edges (Small 1933), and also occurs along roadsides (Peterson and McKenny 1968). It has spread as an adventive to other areas in the eastern United States and Canada (Nova Scotia), and is also widely cultivated as an ornamental with numerous horticultural varieties (Bailey 1949).

The MEL specimen was collected by J.W. Audas in January 1924, and is labelled as coming from 'Anderson's Creek near Mt Beenak where it was growing along the creek. The nearest equivalent place names listed in the 1:250,000 Gazetteer (Division of National Mapping 1975) to Mt Beenak (37°53'S, 145°42'E) are for two different Anderson Creeks located at 38°08'S, 14621'E (near Yallourn North) and 37°47'S, 145°12'E (near Warrandyte). As these creeks are 63 km SE and 45 km WNW of Mt Beenak respectively, neither are likely candidates for Audas' location.

Although the plant was from an apparently isolated locality, it was in an area where there was considerable logging activity late last century and early this century. There are numerous abandoned logging camps around the Mt Beenak area, although again none called or located on 'Anderson's Creek', and it is presumably from the garden of one of these now defunct camps that the propagules of *T. virginiana* escaped, establishing itself along the banks of an adjacent creek.

The question remains whether this taxon should now be considered to be naturalised in Australia. No material has been collected from any location since 1924, and it is now not possible to determine the precise location of Audas' collecting locality. The simplest solution to this problem would be to assume that

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T. virginiana was naturalised in the early part of this century, and has failed to persist. Nevertheless, this species is a rhizomatous perennial which can, if conditions remain favourable, continue to grow and reproduce vegetatively. In addition, the specimens at MEL have most of the flowers in the inflorescence with developing fruits. This suggests that, rather than failing to persist, there is a good chance that *T. virginiana* would have continued to grow in the area.

Accordingly, this paper is designed to bring the need for the collection of introduced plants to the attention of interested members, with the request that anyone finding naturalised material of this species, either near Mt Beenak or anywhere else, make collections (recording the location and habitat details accurately so that others can easily find the site of infestation) and submit the material to the National Herbarium of Victoria at the Royal Botanic Gardens, Melbourne.

This request for accurate distribution data and collections applies similarly to any other garden plants encountered in apparently 'natural' settings where they appear to have self-seeded or to have arrived without being planted there deliberately. For example, the lilies Peruvian Lily *Alstroemeria aurea* Graham, Red Hot Poker *Kniphofia uvaria* L. and Agapanthus *Agapanthus praecox* Willd. subsp. *orientalis* (F.M. Leighton) F.M. Leighton are relatively common as weedy garden escapes in the Dandenong Ranges, but there are virtually no collections of these species in MEL. The collection of such taxa not only provides information for the preparation of flora accounts, but more importantly, allows for the monitoring of the rate of spread and/or persistence of potential weeds so that they might be controlled if necessary before they become widespread and impossible to control. For example, the reproductive potential of *Kniphofia* as a weed in Victoria was documented by Conran (1987). Unless such plants are controlled or at least monitored early, they can spread to such an extent that it becomes prohibitively expensive to remove them. This applies particularly in bushland settings where the introduced plants are generally not perceived by authorities to be causing an economic threat until the environment has been degraded substantially. Therefore, the importance of collecting accurate data detailing the locations, and rates of spread by garden escapes monitored through collections deposited in MEL, cannot be over-emphasised.

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Taxon description and figure legend

Tradescantia virginiana (Fig. 1) is an erect, frequently hairy, herbaceous perennial with numerous single or sometimes basally branched stems 20-50 cm tall. The leaves are few, up to 25 cm long, 1-2 cm wide and grass-like. The several to numerous flowers are borne in an umbel at the stem apex in a leaf-like sheath. The sepals are ovate, 10-20 mm long, generally finely hairy, and tend to persist during fruiting. The three petals are broadly ovate, 15-20 mm long, short-lived and generally bluish-purple, although they can also be blue, pink or white depending upon the variety. The six anthers are yellow and borne on hairy stamen filaments. The smooth capsular fruits are 4-5 mm long, sessile dehiscent at maturity. The reddish-brown seeds are 2-3 mm long. The main flowering period is from Spring to Summer, with fruits maturing through Summer and Autumn.

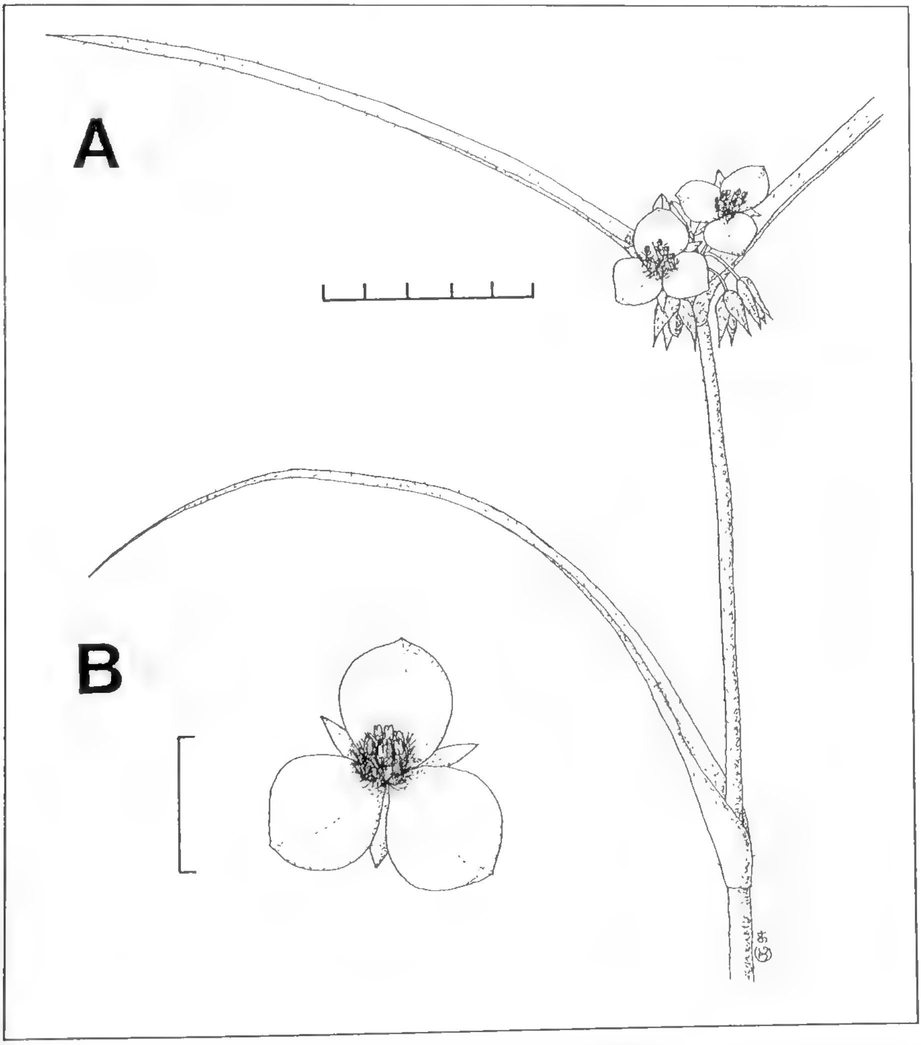

Fig. 1. A: *Tradescantia virginiana* L. apical portion of plant showing the umbellate inflorescence enclosed in an apical leaf-like sheath; B: Detail of the flower. Scale units = cm.

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The editors want to thank all our authors and referees for their support, time, effort and assistance in preparing articles for publication in *The Victorian Naturalist*. Also we particularly want to thank our proof readers whose help this year has been invaluable.

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Cover photo: Joan Winifred Cribb, awarded the Australian Natural History Medallion 1994 for outstanding achievement in natural history (see page 212).

Australian Natural History Medallion 1994

Joan Winifred Cribb

As a botanist, Joan Cribb has exercised a very great influence in the field of natural history in Queensland and is known throughout Australia for her books, written in collaboration with her husband, Dr Alan Cribb, on native plants of traditional and modern use.

Natural history has always been part of Joan Cribb's life. Both her parents were botanists and her father, D A Herbert, was Professor of Botany in the University of Queensland, where Joan graduated with 1st class honours in botany, following this up with an MSc. She lectured in biology and microbiology at Queensland University of Technology and also for a while at Queensland University. Together with her husband she developed an interest in edible native plants, which, they claim, were often tried out on their two sons! This interest led to the publication of 'Wild Food in Australia' (2nd ed 1987), to be followed by 'Useful Wild Plants in Australia (1981), 'Wild Medicine in Australia (1981) and 'Plant Life of the Great Barrier Reef and Adjacent Shores' (1985).

Joan's main research area is mycology, particularly into Gasteromycetes and marine fungi. She has described thirty-nine new species, as well as recording numerous species previously unknown for Queensland and some for Australia. In 1992 she took part in the Cape York Scientific Expedition conducted by the Royal Queensland Geographical Society, collecting fungi, and is currently serving on the Scientific Committee for the Royal Queensland Geographical Society Expedition to Musselbrook Reserve, Lawn Hill, Queensland.

She has written more than thirty scientific papers and the sections on Shore Vegetation and Aboriginal Uses of Plants in 'Lake Broadwater: the natural history of an inland lake and its environs' (1988).

Joan, a member of the Queensland Naturalist Club since 1950, has played an important role in the Club's activities, as councillor, twice as president, and as editor of the 'Queensland Naturalist' since 1985, during which time the journal has been significantly expanded. She has led numerous one-day excursions and several extended ones, where her good-humour and willingness to identify specimens and help beginners has done much to foster an interest in natural history. She has lectured to a wide variety of community groups, run evening classes on plant identification, traditional uses of Australian plants and, jointly with her husband, several weekend courses on wild food. She has appeared on the children's television programme 'Wombat', presenting segments on native plants; helped train rangers on Fraser Island and conducted programmes for the public, both there and at Brisbane Forest Park.

In 1992 she was awarded the inaugural Queensland Natural History Award, instituted by the Queensland Naturalists Club.

A love of natural history fills all Joan Cribb's work and it is characteristic of her that the title of her Medallion address was 'Enjoying Plants'.

Joan Cribb was nominated for the medallion by Queensland Naturalists Club.

Sheila Houghton

Proceedings of the 'Ground Flora - Restoration and Management' Conference, Greening Australia Victoria, August 1991. Final part of a four-part series.

Orchids: Indicators of Management Success?

Marita Sydes[1]

Abstract

Orchids are a very specialised group of plants displaying complex interactions with the environment through their mycorrhizal associations and specialised pollination mechanisms. These interactions cause orchids to respond in a specific and measurable way to some components of changing environmental conditions. These characteristics suggest that orchids have great potential as indicators of aspects of community health. As indicators, orchids could be used in parklands and reserves to assist in the development of management programs.

Introduction

Since the early 1900's there has been an interest in the use of bio-indicators to assess the impact of pollution and other activities on community and ecosystem structure. These earlier studies documented the plant and animal species inhabiting streams and rivers that were receiving sewage and other organic wastes (Majer 1983). These studies suggested certain assemblages of organisms represented different quality and magnitude of disturbance. In Australia, orchids have not been used as indicator species but here I hope to put forward a case outlining the possible use of orchids as indicator species of successful land management. For the purpose of this paper I will use the following working definition of an indicator:

1. Its presence is indicative of the existence of certain environmental conditions and its absence is indicative of the absence of these conditions (Majer 1983).
2. The health of the indicator must somehow reflect the health of the community.
3. The indicator should interact with different 'levels' in the community.

Traditionally, complex food webs such as those found in freshwater ecosystems have been used to monitor community health. The complex mycorrhizal associations and elaborate pollination mechanisms of orchids are of comparable complexity to animal food webs. The stability of these orchid associations would also be dependent on community health. In this paper I have chosen the goal of management success to be the maintenance of habitat diversity. By managing for habitat diversity an overall high species diversity may be maintained. To achieve habitat diversity, regular patchy disturbance may be required in some habitats; it is probably in these situations that orchids could be of most use as indicators. Such disturbances could include small, local events such as animal scratchings and individual plant deaths, or the less frequent but more widespread natural disturbances such as fire.

Limitations of orchids as indicator species

There are, however, several factors to consider in using orchid species as indicators:

1. Orchids are not abundant in all habitat types, e.g. dense forests,
2. Terrestrial orchids exist as underground tubers for part of their life cycle, making monitoring of many species difficult at certain times of the year,
3. Many orchid species readily colonise disturbed sites, *e.g. Thelymitra pauciflora* and *Microtis unifolia*.

A manager would need to be careful in selecting species of orchid for use as indicators. 'Weedy' or colonising species are not likely to provide useful information for management of the community as a whole.

Orchids as indicator species

The orchid family makes up ap-

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proximately 10% of the worlds flowering plants and is viewed as one of the most successful plant groups. The family has adapted to many of the worlds different ecosystems. There are over 250 orchid species currently recognised in Victoria (Ross 1990), inhabiting a variety of areas including coastal, alpine and desert areas. Their wide distribution and relative ease of identification suggests that orchids may be a good source of possible indicator species. Orchid indicator species could be used to examine both the biotic and abiotic components of an ecosystem. The biotic interactions of orchids include complex mycorrhizal associations and elaborate pollination mechanisms. While the abiotic components of the ecosystem such as moisture, temperature, light and pollutants can also have significant effects on orchids. We can learn a lot not only about orchids but also the ecosystems in which they survive by studying or monitoring in detail their responses to different environmental conditions. Examples of information gathered while monitoring individual orchid species and orchid diversity are discussed below.

Competition by other plant species

A decline in orchid species richness in some cases can be attributed to a lack of suitable management practices to prevent competitive exclusion of plant species. For example, past records for the Hochkins Ridge Flora Reserve North Croydon and the Tindals Road Wildflower Reserve Warrandyte list approximately 40 orchid species in each reserve (McMahon *et al.* 1990). Recent reports on these reserves show a dramatic drop in the number of species present in each reserve. The study of the Hochkins Ridge Reserve (Carr *et al.* 1991) revealed only 16 orchid species and at the Tindals Road Reserve (McMahon *et al.* 1990), only 5 species were recorded. Competitive exclusion by both indigenous and non-indigenous plants is thought to be largely responsible for the decline of orchids. For example a large population of the Nodding Greenhood *Pterostylis nutans* monitored at Hochkins Ridge Flora Reserve has been eliminated over a 7-year study period. This elimination of the population was attributed to the invasion of the orchid colony by Large Quaking Grass *Briza maxima*. It is thought that weed invasion such as this directly competes with the orchids for light and moisture.

The long-term absence of fire in both the Hochkins Ridge and Tindals Road Reserves may also be responsible for the decline in orchid species numbers. At these sites the indigenous ground stratum, Silver-topped Wallaby Grass Chionochloa *pallida*, may without the presence of fire become so dense that it adversely affects the orchid populations. If fire was implemented as a management tool it is likely that the gaps formed in the vegetation would be suitable for many orchids and other plants present. These plants could be present in the soil seed bank or as dormant underground stems which have been unable to compete with the dense vegetation. Thus decline in orchid species in these cases may be indicative of the lack of fire in these communities. This work also shows that other species have become extinct. This is probably chiefly due to the increased competition by plants present. It is possible more species will disappear if active management is not undertaken. So in this example it appears that the monitoring of the orchids at these reserves may reflect the changes of other plant species in the reserves as well.

Competitive exclusion of orchids by indigenous flora due to the lack of fire or opening up of the vegetation has also been documented for *Thelymitra epipactoides* (Cropper *et al.* 1989). Observations on plants subjected to competition from neighbouring shrubs and grasses suggest that the leaf size and the number of flowering individuals is related to nutrient levels and light availability. At one of the sites studied which had not been burnt for nearly ten years the population mainly consisted of non-flowering mature plants, while after disturbances such as burns, nearly all individuals flower. The important factor here is that inter-plant spaces need to be present to reduce competition, and allow herbaceous plants such as orchids to grow and flower. Fire, however, is not needed in all vegetation types or for all species. The open woodland vegetation of the Deep Lead Flora Reserve has no record of fire in the area yet it still contains 60 species (Carr *pers. comm.*) of orchids. This may be because the vegetation is naturally very open and disturbance or opening up of the vegetation is not required for further recruitment of new plants such as orchids.

Orchid mycorrhiza associations – ochids as indicators of soil flora?

A mycorrhiza is a symbiotic association of a specific fungus with the roots or other absorbing organs of a vascular plant (Bates and Webber 1990). This type of symbiosis benefits both members of the association; the fungus obtaining carbon compounds for growth from the host, and the host obtains nutrients such as phosphates from the fungus. In many Australian soils nutrients and, in particular, phosphates are naturally low. In these conditions plants that do not form myccorhizae are often disadvantaged and show poor growth.

As early as the start of germination of orchid seeds there is an obligate requirement for a symbiotic association with a fungus. Unlike the vast majority of seed plants which are self supporting from the commencement of germination, orchid seed has very little food reserve for embryo development. The orchid seed relies on the supply of nutrients from the fungus until the photosynthetic tissue is produced. In some cases leafless non-photosynthetic orchids depend on fungi for the duration of their life. But the majority of orchids become more or less autotrophic (self reliant) and dependence on the fungus is reduced. All species of orchid studied to date were seen to be associated with mycorrhizal fungi. Orchid mycorrhizae are usually basidiomycetes belonging to the genera *Thanatephorus, Ceratobasidium, Tulasnella* and *Sebacina.* Most terrestrial orchid species have a dormant phase in their life cycle, pereniating as underground tubers or rhizomes that give rise to the new root system when dormancy is broken. The mycorrhizal fungi may not be present, or may be present in a less active state with the dormant tuber. Reinfection occurs in new roots put out by the dormant tuber. The source of reinfection is thought to be either from soil or from tissue in the tuber (Harley 1982). Orchid tubers may remain underground for several years and in suitable conditions reappear. Whilst underground it is possible that the orchid obtains the nutrients needed for survival from an associated mycorrhiza (Wells 1967).

Non-photosynthetic orchids such as Hyacinth Orchid *Dipodium punctatum* appear to have more complex relationships. With *Dipodium* the fungus is essential as the orchid does not produce a photosynthetic leaf. The orchid relies on the fungus for its supply of nutrients. Upon unearthing the root systems of *Dipodium* there always appears to be the presence of a woody root. It may be possible in this case that there is a complex relationship between woody plants (usually Myrtaceae) and the orchid via the mycorrhizal fungi. The possession of such complex mycorrhizal associations may mean that orchids as a group may reflect the health of the soil flora. The persistence of the correct fungus species is required for the survival of the orchids as the soil is the source of the initial infection of the seed and reinfection of the underground tubers. If the orchid mycorrhiza are present then it is likely that the conditions present will also be suitable for the fungi which are involved in mycorrhizal associations with other plants in the community

Pollination of orchids - Orchids as indicators of insects?

Orchids have evolved very complex pollination mechanisms. This is reflected in the diverse floral structures observed in the family. Floral morphology in the majority of orchid species promotes cross pollination. **Table 1** documents the diversity of pollination mechanisms and pollinators serving a select group of terrestrial orchid genera.

By looking at the natural pollination rates of predominantly cross-pollinated orchid species we may be able to infer the health of the natural insect population of the area. For example, in the study of *Thelymitra epipactoides* (Cropper *et al.* 1989) no natural pollination was observed at one of the study sites. Despite careful observation of the area, no native bees (the natural pollinators of this species) were seen in the vicinity. No bees were observed working typically bee pollinated plants in the area either, although numerous flies including hoverflies were seen on nearby *Leptospermum scoparium*. The lack of pollination at this site is possibly due to the local absence of the natural pollinator since other sites had 35% of flowers producing seed. The observation of natural pollination rates of cross pollinated orchid species may provide information on the insect community present in the area. A reduced pollination rate may reflect the absence of a specific pollinator from the area. Orchids having a wide range of specific pollinators may then be used to gain information on a variety of insects.

Gaseous emissions

G. Carr, while monitoring the recovery of Mellblom's Spider-orchid *Caladenia hastata* populations after fire found that orchids and other plant species regenerating after a burn were showing a loss of vigour and some were not regenerating (Carr 1988). Some of the plants regenerating were showing signs of necrosis and distortion of their leaves. At the time that this heath was burnt the neighbouring aluminium smelter began operating and it is thought that the gaseous emissions (namely fluoride) from the smelter were affecting the regenerating plants. *Caladenia hastata* was observed to decline dramatically in numbers after this fire while on another neighbouring plot, after a previous fire and before the smelter was operating, orchid numbers were seen to increase dramatically. However, not only this orchid species was affected. Plants that appeared to be sensitive to the fluoride emissions included: *Burchardia umbellata, Xanthorrhoea australis, Patersonia occidentalis, Exocarpos cupressiformis, Hypolaena fastigata, Restio complanatus* and *Leptocarpus brownii*. Carr postulated that the fire, by removing protective vegetation, may have increased the effect of the fluoride poisoning. In this example the decline in the orchid flora appears to be related to the decline in other species present and may reflect the general health of the community in response to the commencement of operation of the smelter.

Table 1. Pollination mechanisms and pollinators for a select group of terrestrial orchid genera.

Genera	Insect pollinator	Attractant/ Reward
Acianthus	Fungus gnats	Scent, nectar
Caladenia	Wasps	Pseudocopulation
Calochilus	Wasps	Pseudocopulation
Chiloglottis	Wasps	Pseudocopulation
Cryptostylis	Wasps	Pseudocopulation
Dipodium	Native bee	Mimic nectar flowers
Diuris	Native bee	Floral mimicry
Leperella	Flying ants	Pseudocopulation
Microtis	Ants	Nectar
Prasophyllum	Wasps, bees, beetles, flies	Nectar, scent
Pterostylis	Fungus gnats	Pseudocopulation
Thelymitra	Native bees, wasps	Pseudocopulation ?? Floral mimicry

Predation by introduced animals

Introduced invertebrates such as slugs, snails and millipedes are well established in many bushland reserves. Of these, slugs are probably the most significant orchid predators and are encouraged by, or are dependent on, invasions of exotic herbs such as Flatweed *Hypochoeris radicata* (McMahon *et al.* 1990; Carr *et al.* 1991). Predation by slugs on a large population of *Pterostylis nutans* was observed to have an effect on the colony, which, due to a combination of this grazing and weed invasion, was lost (Carr *et al.* 1991). Other introduced animals such as rabbits have enormous potential to devastate orchid populations (McMahon *et al.* 1990, Carr *et al.* 1991).

Summary

Orchids appear to respond to changes in environmental conditions. Their complex interactions with the environment cause a sensitivity to a number of ecologically important changes in the habitat. The changes include weed invasion, plant competition, changes in availability of pollinators and changes to the soil microflora. By monitoring the health and diversity of orchids in particular habitats we may be able to gain information on the general health of the ecosystem. However, the use of orchids must be viewed as being limited as it is unreasonable to assume that the health of one species or family indicates the health of a whole community. It may be more valuable to use orchids in combination with other organisms as part of an indicator group (e.g. with *Drosera* species and butterflies). The use of orchids as indicator species will also be dependent on the conservation goals of the area in question. Orchids are usually associated with disturbance and thus would be best suited as management tools for species rich communities accustomed to regular burning such as heathland, grassland and grassy woodland. This type of management may not be optimal for other species and communities. Thus care should be taken when trying to use a single species or family as indicators of management success.

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The Impact of Terrestrial Molluscs on Native Vegetation in South-eastern Australia

Adrian Daniell[1]

Introduction

There are, in fact, more species of terrestrial snails and slugs than those found in marine or freshwater environments (Abbott 1989). Molluscs are well known as sensitive environmental indicators in aquatic systems, but their ability to act as monitors in terrestrial systems is largely untested. A significant fauna of introduced species also exists in south-eastern Australia whose impact is yet to be fully assessed. It is the role that snails and slugs have on ecosystems which will be examined in this paper.

The Australian endemic fauna

Snails and slugs are prominent features of most terrestrial ecosystems. However, the Australian molluscan fauna has been far from comprehensively studied and with most species details of their ecology is not known (Bishop 1981). The Australian landscape is dominated by a few families, with the Camaenidae and Charopidae having the largest numbers of species (Smith 1992). The continent as a whole, with a generally dry climate, is far from a suitable place for snails and slugs. The areas of higher rainfall along the eastern sea-board generally have poor soils (low in calcium which can restrict shell building) and large areas where seasonal dry periods restrict mollusc populations. However, significant faunas are found in many regions of Australia, in particular, the tropical and sub-tropical regions with their generally more favourable climates and soils. High species diversity can be found in rainforest (Scott 1989) and in some dry areas such as the Kimberley Ranges (Solem 1988). With something like 500 species Australia-wide the fauna has been considered depauperate in comparison to other similar sized landmasses (Bishop 1981). More recent work by Solem (1992) and Stanisic (1990, 1994) would suggest that, in fact, many more species are yet to be described, with a possible doubling of the existing number of species (Smith 1984).

Indigenous species of southern Australia

The native species in south-eastern Australia range from minute endodonts (shell diameter approximately 1.5 mm), to the large carnivorous species of the Rhytididae (shell diameter approximately 34 mm) to the largest land snail in the region *Pygmipanda atomata* (shell up to 65 mm high). There are also a number of species of slugs, the Cystopeltidae and semi-slugs, the Helicarionidae. The endodonts make up the bulk of all terrestrial mollusc species of south-eastern Australia with around 61 named species, although many are not fully described and the total number of species is yet to be determined (Smith 1984).

Ecology of Australian snails and slugs

The Australian slugs and snails are largely feeders on leaf litter, fungi and bacteria. Some species are thought to occasionally feed on live material, but the amount in their diet is probably very small. The carnivorous species feed on a diet of soft-bodied animals, principally other snails and earthworms (Smith, 1971). In the case of forest species, such as *Cystopelta* and *Helicarion*, they may help in the break-down of leaf litter and cycling of soil nutrients. The Cystopeltids primarily feed on microalgae and bacteria which grow on the surface of bark and leaves (Daniell 1992). The extent to which this occurs is related to the size and numbers of individuals of species in a given area. Little is actually known about the extent of this nutrient cycling but it

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cannot be discounted in the total system. In grassland and woodland, where the endodonts represent the most abundant native species, the effect that they have is likely to be minimal due to small size and low population densities. These small species appear to congregate around rocks, fallen timber and large, mature trees (e.g. *Eucalyptus camaldulensis*), so that their distribution is fairly patchy at any given site. This congregation is probably due to the increased moisture associated with these microhabitats as well as shelter from periodic fires. In the case of congregation around mature trees this is probably an artifact of local habitat changes resulting in these small snails surviving in the leaf and bark litter around the base of trees.

Another role which appears, at least with some arboreal species, is the movement of fungal spores. Fungal spores are usually tough enough to resist digestive actions in snails guts and so every time snails deposit some faeces they deposit some spores. This may be important in species which feed largely on fungi.

Endodonts as indicators of habitat 'health'

While not much is known about the ecology of the smaller snails, what is known about their biology, suggests that they could provide important clues to the impact of various management practices. These species are restricted within a particular microhabitat and because of their low mobility, colonisation of new areas proceeds at a slow pace. Species which inhabit grassland and woodland are active during periods when soil moisture is high enough for activity, although they may still be restricted in overall distribution. Practices such as burning have a large impact on such leaf litter invertebrates, particularly if fires occur at periods when the litter fauna is close to the surface such as during autumn. Furthermore, endodonts seek shelter under rocks and fallen timber and excessive burning may eliminate these shelter sites or at least degrade their quality in a given area. Given the role of soil invertebrates in nutrient cycling, soil sterilisation through fire or alteration in the characteristics of the soil environment could affect nutrients and this may be observed in the soil fauna. Animals sensitive to such changes will reflect this and so act as indicators. The small endodonts with their low vagility and low ability to re-invade once removed from an area are ideal in this respect. Shells which are preserved in the soil can be used as indicators. Use of all these indicators may make it possible to monitor the impact of changes in management practices.

An examination of several grassland areas of high conservation value revealed no native species (St Albans and Laverton North) or few species (Cooper St. and Cherry St.). This was particularly striking at Laverton North where the conditions appeared to be ideal for endodonts i.e. abundant rocks. It is possible the conditions which led to the loss of species may have occurred long before the areas were recognised for their significance, although continued monitoring will be required at these sites to confirm the results. The refuge provided by mature trees means that unless these are present at a site then there is probably little chance of finding any native molluscs. At the La Trobe University Wildlife Reserve, the endodonts *Paralaoma caputspinulae* can be found up to 1 m from the base of mature *E. camaldulensis* but no further out, indicating the importance of these microhabitats as refugia.

Introduced species

Since the arrival of the first Australians, humans have been involved in the transportation of animals and plants. Slugs and snails have been an important part of this. Despite their soft, slimy bodies many molluscs are good travellers being able to aestivate for long periods or squeeze into small crevices. Much of this travel has been in the last 200 years via soil around plant roots and other agricultural products. Several species of introduced slugs were described as native species because they had been found far from settlements (Smith1975).

A number of introduced molluscs are now resident in Australia **(Table 1)**, with new species likely to be introduced in the future.

What impact do these introduced molluscs have on indigenous plant species?

While the data is currently a bit sketchy, enough observations have been made which suggests their impact maybe significant. The most significant species in most habitats are the slugs. Despite the lack of a protective shell, slugs are in many ways better adapted to the seasonally dry south-east of Australia than the more well known snails such as *Helix aspersa.* The evolution of the molluscan shell is thought to be an adaptation for water retention rather than protection. For slugs the ability to squeeze into small cracks in the soil means that they are able to inhabit dry grassland as well as moister environments. They also have the advantage that they can survive on soils low in calcium, avoiding the burden of shell construction. They are also able, unlike snails, to avoid predators by sheltering in inaccessible places.

Research overseas has shown that slugs are a major factor in seedling establishment in various species of ground flora. When slugs were eliminated from experimental plots there was a 37% increase in plant size (Rees and Brown 1992). Other studies on slugs (Dirzo and Harper 1980) and on *Helix aspersa* (Weiner 1993) found that molluscan herbivory also had an impact on plant size and species composition. The effect of changing the composition of plants through mollusc grazing also appears to have an effect on nutrient levels in the soil (Thompson *et al* 1993). It is quite clear that the interactions between molluscs and plants are significant, but the extent of this in the Australian context is not clear. Importantly the native mollusc fauna, in particular that of the grasslands, is of a completely different nature to that of the northern hemisphere. The southern Australian fauna lacks the large slugs and snails and therefore it is likely that most species of ground flora lack adaptations to avoid or respond to this type of herbivory. Indeed, no native slugs are found in grasslands, contrasting strongly with grasslands in other temperate regions of the world. Observations of slug and snail attack have been made on some species but there is still insufficient data on how significant it maybe. The silvery trails and chewed leaves are a good indication that slugs and snails have been active. In the case of geophytes, such as orchids, the underground tubers are eaten as well as the above ground parts. The endangered species *Rutidosis leptorrhynchoides* was found to have been attacked by the slug *Milax gagates*, a well known crop pest. In this case the plants lost about 25% of their foliage. Other native species attacked were *Helichrysum spiculatum* and *Velleia paradoxa* (John Morgan *pers. comm.*). If herbivory is selective this may lead to the alteration of species composition and may also affect succession and possibly nutrient balance.

Table 1. Introduced molluscs in southern Australia.

Slugs	Snails
Arion intermedius	*Candidula intersecta*
A. hortensis	*Cernuella neglecta*
A. ater	*C. vestita*
Deroceras reticulatum	*C. virgata*
D. caruanae	*Cochlicella acuta*
Lehmannia nyctelia	*C. ventrosa*
L. flava	*Eobania vermicuala*
L. maximus	*Helix aspersa*
Milax gagates	*Oxychilus cellarius*
Testacella haliotidea	*O. draparnaldi*
	O. alliarius
	Theba pisana

The impact of these introduced molluscs will probably depend on the species present and the density at which they occur as well as the vegetation type. In native grassland, slugs can occur at very high densities while in woodland and forest, densities are usually much lower, but there are no accurate figures. Densities also are not known for other native vegetation types throughout southern Australia. The only snails which are thought to have caused a significant impact on Australian native vegetation are the so-called 'white snails' of the Helicidae. These thrive in the calcium rich coastal areas and parts of the Murray Basin. One species, *Theba pisana*, occurs in extremely high densities; over 1350 snails per square metre have been recorded in some native vegetation (Smith 1967). The effect of these high densities on the local vegetation is not clear, but anecdotal evidence would suggest that the impact is extreme on many of the native species, in particular, low-growing herbs. Slugs and snails are active during the wetter months of the year, which includes the periods when seedlings are developing and geophytes, such as orchids, emerge. They attack the newly developing buds causing death or developmental retardation. In the case of geophytes, slugs will attack the bulb. Indeed the slugs and snails almost appear to 'sniff-out' new shoots as any grower of terrestrial orchids will testify. Slugs are able to detect damaged tubers at a distance greater than 50 cm. The damage itself may not kill the plant but the damaged tissue seems to be more prone to subsequent fungal invasion, tissue necrosis and death. Slugs are also known to transmit viruses to tuberous plants such as carrots (Runham and Hunter 1970), but the extent to which this occurs with indigenous species is not known.

In general, invasion of undisturbed native vegetation seems to be very low, although grasslands maybe an exception. There is some suggestion that some species of introduced plants may promote invasive molluscs by providing altered soil conditions and probably nutrients.

Introduced molluscs also invade along areas of altered vegetation strips which run through undisturbed vegetation, such as tracks to toilets. This is commonly observed in National Parks where introduced species of molluscs appear to be restricted to walking tracks especially where some exotic plant species can survive. Some species of introduced plants appear to offer prime shelter in otherwise inhospitable conditions. In native grassland slugs can be seen sheltering under the leaves of the introduced *Hypochoeris* spp. (N. Scarlett *pers. comm.*). Grasslands appear to be more readily invaded by slugs, probably because many of the molluscs are of 'Mediterranean' origin and are well adapted to the conditions.

At grassland sites such as along the Merri Creek where *Themeda* grasses predominate, the three introduced species *Deroceras reticulatum*, *D. caruanae* and *Lehmannia nyctelia* are common throughout the ground litter. However, there has been no study of the invasion of undisturbed stands of grasslands and therefore it is impossible to say for certain whether some introduced vegetation is required for the invasion of these introduced molluscs.

Conclusions

There are two distinct mollusc faunas in Australia, one of indigenous species which has little impact on local plant species, and an introduced species which has an impact on the local flora. Native species of molluscs are unlikely to be involved in the loss of terrestrial plants, but are important in monitoring local changes in soil conditions. They may also provide clues to past 'management' conditions.

The impact of these introduced molluscs is probably to reduce the abundance of some ground flora species. This is largely through their lack of defence against molluscan herbivory and by the large numbers of certain species of slugs and snails found in some native vegetation. Selective grazing by molluscs could also alter species composition. This has been shown in those parts of the world where molluscs now introduced into Australia are native. One worrying fact is that, as with environmental weeds, the distribution of these molluscs is still changing so that while currently there may be no problem in some areas, this may not be so in the future. The movement of soil and other plant material is likely to transport slugs, snails and their eggs. In some instances plants being brought in for revegetation programs probably carry with them many species of slugs. Ground flora species are likely to be most adversely affected and the evidence so far suggests that this is occurring to species such as orchids and other geophytes. The damage they cause varies with vegetation types, but further changes in mollusc distribution probably associated with environmental weed invasion could mean more problems in the future.

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The M.A. Ingram Trust

The M.A. Ingram Trust for over forty-five years has been making grants for the preservation and study of the mammals and birds of Australa. Its founders, John and Will Ingram, were active members of the FNCV in the early part of this century.

It is a perpetual Trust and over the years, because of inflation, the real value of the money available has diminished while the number of applicants worthy of assistance has increased. Any member of the FNCV desiring to contribute to the ongoing preservation and research of Australian wildlife could consider making a bequest to the M.A. Ingram Trust.

More information can be obtained from Eric Allen (885 4559).

Weed Control in the Ground Flora

Kim Robinson[1]

Background

Typically weed control in the ground flora has been the domain of farmers and Shire or Lands officers who have undertaken broad scale herbicide treatments to prevent contamination of crops by noxious plant material. Such works have traditionally involved reducing the impact of plants with the ability to taint produce, foul machinery or reduce crop yield, and those plants with spines. Much information is available in this particular area.

In controlling weeds for conservation purposes, the larger overstorey weeds are usually the main target, while the understory is often overlooked. In restoration of denuded areas where total revegetation is required, the quick herbicide treatment prior to planting is often the only thought given to weed control.

Increasingly we are realising that weed control cannot be separated from vegetation management as a whole, and where it is carried out in isolation it usually fails to achieve control in the most efficient way.

Ground flora is often ignored in vegetation management. This is not surprising when our eyes usually focus on the larger trees and shrubs as we drive through the country admiring the roadsides. It is often only a spectacular display of flowers that brings the ground flora to our attention.

Where are the weeds? What are they?

Some communities are more susceptible to weed invasion than others. This is due to the presence of ecological niches similar to those found in the place of origin (mainly the Meditteranean) of many of our weeds. (Fig. 1) gives an indication of the numbers of weed species present in the main plant communities found in Victoria. Grasslands are the worst affected due to the high levels of disturbance (from grazing) and the ability of introduced grasses to compete successfully with native species under these modified disturbance regimes. Other areas subject to major or frequent natural disturbance (i.e. coasts and rivers) are also badly affected by weed invasion.

Approximately 540 weed species capable of invading bushland have been recorded from Victoria (Carr *et al* in prep). Of these, 74% are understorey plants capable of directly competing with native species. The grass family (Poaceae) is most prominent with 89 species. (Fig. 2) shows the ten major ground flora weed families found in the understorey of native vegetation.

Weed control for revegetation

One aspect for discussion is restoration, where land previously used for other purposes is now being targeted for revegetation.

Establishment

Establishment of vegetation in bare areas may call for more drastic action. Removing the top layer of weeds and soil (scalping) is common for large scale projects. Herbicide use is often a major component. Preplanting 'rings' or 'strip spraying' is usually necessary for good tree establishment in planting projects or use of residual herbicides and soil discing before direct seeding.

Post-emergent weed control

Other ideas such as sowing a living 'mulch' with trees and shrubs can provide post-emergent weed control. Direct seeding of the Otways National Park coastline with tree and shrub species has also inadvertently given rise to a native *Brachyscome* species which grows neatly around individual plants, providing protection for the young seedlings.

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[1] National Parks and Public Land, DCNR, 250 Victoria Parade, East Melbourne, Victoria 3002.

More conventional methods include using commercially available matting of cardboard or plastic, woodchip mulch and 'recycled' felt carpet underlay from the local tips (not the type with the nylon threads). Mowing prior to placement of materials (where possible) assists in achieving better control.

Plants that may be getting swamped with weeds have had plastic bags tied over them (or plastic/metal pipes over smaller plants) and non-selective herbicides such as Glyphosate used to control the weeds. Use of shields around spray nozzles can also help if the number of plants prohibits physically protecting individual trees from spray drift.

Mass planting or direct seeding with fast growing understorey plants such as species of *Goodenia*, *Helichrysum*, *Acacia* and *Senecio* may also play a role in keeping on top of weeds.

Managing remnant vegetation

When considering action for managing remnant vegetation the more apparent species such as the trees and shrubs e.g. *Pittosporum undulatum* are usually removed. These 'keystone' species are also able to radically alter the understorey and sometimes removal of these species is enough to ensure that the degradation process is slowed or stopped (Fox 1988). Often other measures will be required. Chemical methods such as wick wipers, wands or spot placement of granules may be an option. Be aware that some herbicides designed to work on particular species, such as dicotyledons will also have severe effects on native dicots if wind or vapour drift occurs. Some selectivity tests have occurred and are continuing on grass herbicides and tolerance by native grasses.

Manual removal is often time consuming and if consideration is given to the variety of weeds that may be present then some discretion will need to be used in determining priority species for removal.

Specific manual methods are available for different types of weeds and these are outlined in books such as the Bush Regeneration Manual by the National Trust in NSW. Knowledge of the biology of the plants you are dealing with is important and some modification of accepted control methods is often required.

In remnant vegetation, prevention of weeds becoming established through minimizing major disturbances is the most cost effective measure. Use of mowers (either mechanical or four legged animal variety) to lessen fire hazards can promote more weedy species which may have higher fuel loadings. Using fire is often suggested but the timing of operations is not always compatible, either to (a) reduce fuel, (b) control weeds or (c) promote native species.

The conflicting requirements and overall objectives of managing the reserve or roadside in question need to be clearly understood. The constraints of fire season restrictions, legislative responsiblities to remove fire hazards at low cost and in a short time together with the intrusion of some strong local personalities can all become the overriding influences in managing a small patch of bush.

The consideration of adjoining land uses may also influence the level of control. Adjacent agricultural landowners will push for control of noxious weeds capable of invading their property or control of non-noxious weeds such as Creeping Bent Grass that threaten pasture improvements. A Flora Reserve may have quite different priorities for species.

The placement of drainage easements is common in roadsides and other small reserves. Culverts, regular grading and the occasional placement of utility services such an an underground communications cable can all add up to changed water flow patterns and volumes. Waterlogging of sites will alter understorey vegetation considerably and potentially impact on overstorey trees through the introduction of fungal diseases such as *Phytophthora cinnamomi*.

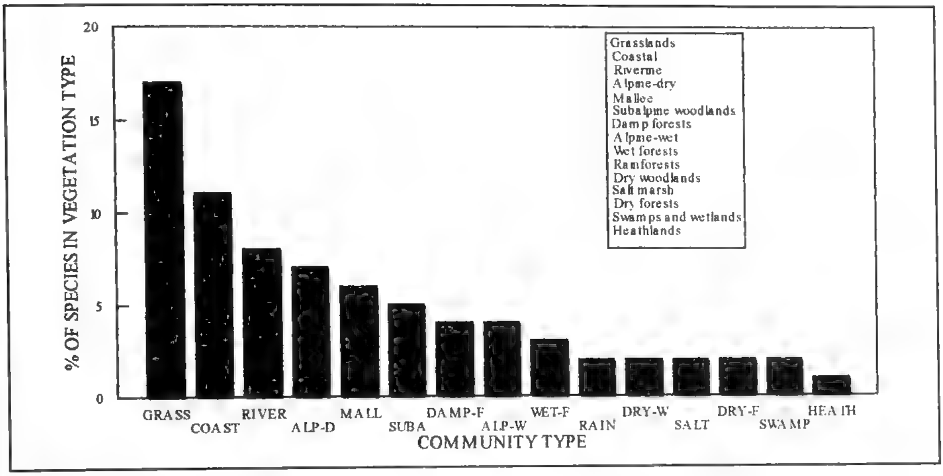

Fig. 1. Weed species in Vegetation Communities. (Reproduced with permission of P.Gullan, Flora Information System, Kew).

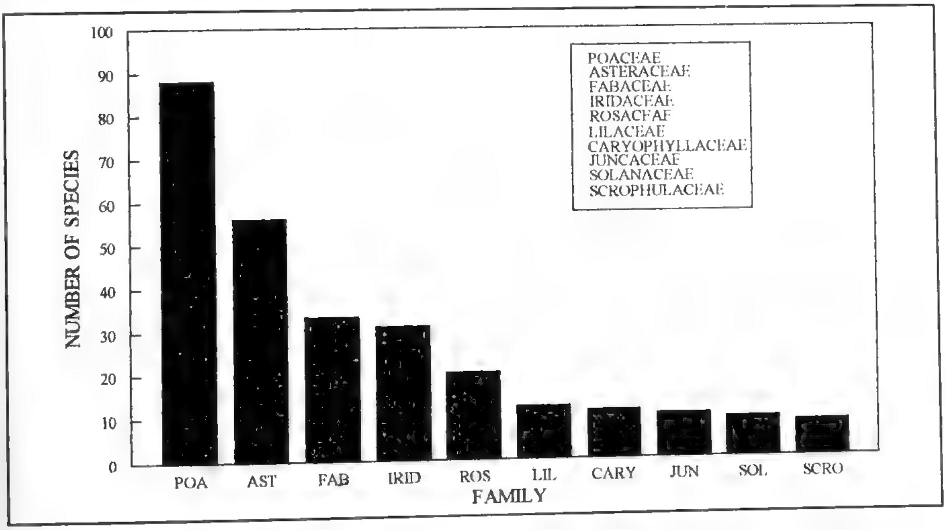

Fig. 2. The ten most common ground flora weed families found in native vegetation in Victoria. (Carr *et al.* in prep).

Soil conservation measures such as run off bays or settling ponds can be used to control weeds by keeping them in a confined area. Bulbs, corms, vegetative sections, tubers, and seeds can be contained in one location rather than contaminating larger areas.

Movement of seeds and vegetative parts of weeds can also be regularly seen occurring when graders work along the sides of roads. Use of disturbance-loving indigenous plants can change these areas from sources of infestation into spectacular wildflower scenes such as in the Mallee with the purple flowering *Dampiera* and yellow *Senecio*. Many species of native plants have the potential to provide such displays and in Western Australia these roadsides form a feature of their regional tourist drives. Thus careful observations of local disturbance-loving natives and some experimentation with timing, chores seen as necessary evils, can become an important vegetation management tool.

The methods of attacking ground flora weeds need to account for weeds that may come in from outside the area, or that may become established during the removal of existing weeds. The impact of growth of the overstorey species on some weeds such as Cape Weed, may mean that control is not needed. Factors such as reduced light intensity on the ground may eliminate weeds in the long term.

Spot application of fire, herbicides and mulch may control aggressive invaders, as may the judicious use of whippersnippers or mowing on edges to prevent particular species of weeds from flowering or seeding.

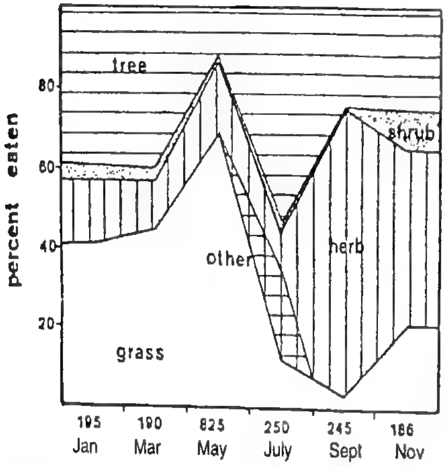

Fig. 3. Eastern Rosella feeding habits (Wyndham *et al* 1980).

Of interest is the use of understorey weed species by native birds. In a report on habitat requirements of the Regent Parrot along the Murray river (A.Burbridge, 1985) it was noted that in cultivated situations such as orchards, the Regent Parrot actively sought out the culms of introduced weeds such as Soursob *Oxalis pescaprae* as well as barley grass, flatweeds and thistle species. Other more common birds such as the Eastern Rosella spend quite considerable amounts of time feeding on the ground flora as (Fig. 3) clearly displays.

The role of native birds in controlling these introduced species is unknown but it is a factor to consider if removing particular weed species. Common birds such as Galahs are known to feed on the seeds of Cape Weed *Arctotheca calendula*, Thistle *Cirsium vulgare*, Ribwort *Plantago* spp, and clover *Trifolium* spp. (Barker *et al* 1980). The efforts of controlling some species e.g. thistles along continually disturbed areas such as roadsides may be a waste of time and perhaps should be reconsidered in cases where there is little threat that thistles will spread into adjoining areas.

In tight budgetary times the maintenance of small reserves or roadsides often declines. Many years of work can be undone in the short flowering period of some weeds. The development of new methods to control particular weeds is occuring regularly. Manual and chemical methods in a variety of combinations will often be required. The use of local plant species to assist in the restoration of ground flora is essential to successful manipulation of plant communities.

The task of setting realistic goals for those areas of prime importance must be part of any strategy to seriously control weeds in the ground flora.

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I acknowledge the fact that she has been mentioned in various books and articles pertaining to him but information about her has often been derived from secondary sources which have not always been accurate. The purpose of this paper is to tell the untold half of the story and to extend not destroy the legend by revealing the woman who stood resolutely behind him and supported him in every way she could. Acknowledgment of Kate, Weindorfer's wife, partner and best friend, and her role in the establishment of Tasmania's beautiful Cradle Mountain-Lake St. Clair National Park is long overdue.

The legend of Weindorfer as the 'hermit of Cradle Mountain' and the lone man who tamed a wilderness is not the reality. It is true that he created the concept of wilderness holidays whilst spending much time alone at the mountain, but he did not choose to be a loner. He enjoyed the company of other people and after Kate's death he was forced to move to the mountain because of the anti-German attitude of the people from the Devonport/Ulverstone area and from Kate's family. Rumours were spread that he was a German spy, his dog was poisoned and he was asked to sever his connections with the Ulverstone Club. Members of Kate's family were hostile towards him for the same reasons and also blamed him for her death. They made it difficult for the farm to be sold and for him to receive the proceeds as Kate had directed in a Codicil attached to her Will. The farm was not sold until 1926, ten years after her death.

Although he was alone for the remaining 16 years of his life, Weindorfer was not alone for the first ten years of the Cradle Mountain endeavour. He was supported and joined regularly by his wife, his partner in the venture, who expressed her love for him by giving him the means and freedom to realise his dreams. She was the woman whose letters he kept until the day he died and whom he called 'my best friend'.

Footnotes

[1] Kate and Gustav each owned 200 acres of land at Cradle Mountain. They called their combined acreage the Cradle Mountain National Park. Source of information: Conversation with Parks and Wildlife Ranger, Bob Hamilton, Cradle Mountain, 1994.

[2] In the 1905 diary of Dan Cowle, Kate's brother, Dan states that Weindorfer came to Tasmania to marry Kate and "learn farming" as Dan's brother-in-law on his property, *Lauriston*, at Kindred. I think Weindorfer's statement to Dan portrays his shrewd and humourous character because according to Bergman's biography,Weindorfer was a qualified Estate Manager!

[3] Bergman, G.F.J., *Gustav Weindorfer of Cradle Mountain*, Mercury Press Pty. Ltd., Hobart, 1959, p.19: Bergman states that Weindorfer was disillusioned with his employment in Melbourne and when he failed to secure the position of Government Botanist with the Department of Agriculture in Victoria in 1905 he decided to return home and sought permission to return on the Austrian-Hungarian warship *S.M.S. Panther*. His application was refused and by the winter of that year he and Kate had decided to marry.

[4] Register of Births, Deaths & Marriages, Fingal District, Tasmania, 1863.

[5] Conversation with the Reverend Hugh Hadrill, Hobart, grand nephew of Kate.

[6] The establishment at which Emma Cowle (nee Cleaver) was educated is unknown to me.

[7] Gill, J., *The Dame Schools*, lecture presented at the Tasmanian Local History and Genealogical Societies 2nd Biennial History Conference, Launceston, 16 October 1993.

[8] Diaries of T.P. Cowle II, held by Lord Evelyn Graves, Deloraine.

[9] loc. cit.

[10] loc. cit.

[11] loc. cit.

[12] loc. cit.

[13] loc. cit.

[14] Letters of Emma Cowle, held by Mr. R. Hadrill, Launceston.

[15] Conversation with the Reverend Hugh Hadrill, Hobart.

[16] The Field Naturalists Club of Victoria Minute Book, 1901-1907, 87; 92.

[17] Telephone conversation with Sheila Houghton, FNCV librarian, 4.11.93.

[18] Cowle, K.J., 'Notes of a Visit to Mount Roland, Tasmania' and 'Excursion to Yan Yean', *The Victorian Naturalist* **20**, 1903.

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[20] *ibid*, 12 December 1904; 16 January 1905; 13 February 1905; 10 April 1905; 11 September 1905.

[21] FNCV, *The Victorian Naturalist*, vol. 22, 1905, p.106.

[22] Hardy, A.D., *The Victorian Naturalist*, vol. 21, 1905, p.106.

[23] The Victorian Field Naturalists Club, Minutes of Meeting 11 April 1904, regarding an excursion to Yarra Glen.

[24] Bergman, *op. cit*, p. 20.

[25] *loc. cit.*

[26] Dan Cowle's diary, 1905.

[27] *loc. cit.*

[28] Conversation with the Reverend Hugh Hadrill, Hobart.

[29] Weindorfer's diary, 1906.

[30] Tasmanian State Archives File No. NS234/19/16, Ronald Smith's Diaries.

[31] Weindorder's diary, 1913.

[32] Tasmanian State Archives File No. NS234/12/3, Kate's letters to Weindorfer, 8 November 1915.

[33] *ibid*, undated letter written between November and December 1915.

[34] Conversation with the Reverend Hugh Hadrill, Hobart.

[35] Dan Cowle's diary, 1926.

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Ms Ann Stocks, Weindorfer memorial Committee.

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Declining Frogs - Think Locally, Act Locally

Sid Larwill[1] and Alex Kutt[1]

The increase in the level of evidence pointing to a decline in frog populations in Australia has been alarming (e.g. Czechura *et al.* 1990; McDonald 1990; Osborne 1989; Ingram *et al.* 1993; Richards *et al.* 1993). Due to the apparent rapid speed of the phenomenon and the perceived urgency in the need to bring the decline to the attention of the public some of the most often quoted published material on the decline has been anecdotal (e.g. Barinaga 1990; Hero 1991; Tyler 1991; Young 1990). There is little doubt that over the last 10-15 years gradual and catastrophic decline of frog species has occurred in some parts of Australia as reported in other parts of the world. Due to the paucity of long term population studies not only are the underlying causes for the observed declines generally unknown but in most cases there is insufficient evidence to discount natural population fluctuations as a possible cause (Pechmann *et al.* 1994; Blaustein 1994). Perhaps because of this uncertainty it has been common practice to attribute observed declines to a general notion of global environmental change (e.g. Tyler 1991; Johnson 1994).

A response to the plight of a threatened species must strike a balance between the need for immediate action and the need to be cautious in interpreting the available data. This balance is termed by McCoy (1994) as 'the problem of standards of proof' and is the means to bridge the gap between scientific understanding and action (McCoy 1994). The decline of frog species is an example where the difficulties of striking this balance is demonstrated and, in some cases, the perceived need for action has outweighed due attention to scientific process. For example the overuse of generalised explanations, in association with anecdotal data, may delay the identification of local and regional population patterns (declines or increases) and their causes. Of particular concern is the tendency to accept anecdotal information as fact, which may lead to a failure to clearly identify conservation and research priorities within local areas.

The Growling Grass Frog *Litoria raniformis* has been described by various researchers as being in a state of decline throughout its range in south-east Australia (e.g. Tyler 1994; Sadlier 1994) and in the Melbourne region (e.g. Johnson 1994). Much of the evidence supporting the decline has been anecdotal and is at odds with the data currently available for the Melbourne region. Johnson (1994) asserted that in the Melbourne region only a single remnant population remains in two wetlands near Moorabbin. In our own fauna survey work we have recorded the Growling Grass Frog in moderate numbers at seven separate locations in the Melbourne region since 1991, many of which were degraded in habitat quality. The records of the Atlas of Victorian Wildlife database (Wildlife Branch, Department of Conservation and Natural Resources) show that the species has been recorded at over 180 additional sites in the Melbourne region in the last ten years.

The Growling Grass Frog has become a high profile species in conservation planning in the Melbourne region; yet reference to the available data supports neither the assertion that it is declining in the region, nor the general assertion that the species is in decline throughout its range. This is an example of the risks associated with the incautious acceptance of anecdotal information that can quickly become accepted in the conservation community and influence the allocation of resources for conservation.

Reports of the decline of the Growling Grass Frog are doubtless worthy of investigation. However, until such time as the decline is found to be a real phenomenon,

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[1] Biosis Research, 322 Bay Street, Port Melbourne, Victoria 3207.

management authorities and conservation organisations may best be advised to focus on allocation of resources to the conservation of habitat. Over-emphasis on the status of the species to justify conservation resource allocation has the potential to be counter-productive to long-term conservation goals if the supposed decline is unsubstantiated by further work. Conservation resources and public attention should be targeted to potential immediate local threats to amphibian fauna, such as habitat loss and fragmentation, which is the most likely cause of any decline. The use of the decline of the Growling Grass Frog as an example of the effects of global environmental change has outlived its usefulness for helping the prospects of survival of this and other amphibian species.

A recent review of reportedly declining frog species in Queensland indicated that now at least seven species cannot be relocated and a further four species are noticeably declining (Ingram *et al.* 1993). In reporting these results the authors noted that the phenomenon of catastrophic decline is restricted to Queensland with the only southern Australian example being the Green and Golden Bell Frog *Litoria aurea*. There are published accounts of frog declines in Australia that are at odds with this assertion (e.g. Osborne 1989; Tyler 1994). Pechmann *et al.* (1994) cite a number of published accounts of amphibian decline, including four of the Queensland case studies, which may be examples of natural population fluctuations being mistaken for declines caused by human activities. Evidently there remains considerable uncertainty and some disagreement regarding the issue of frog decline within the scientific community.

What is needed at a local level is clear research directives by conservation authorities that aim to clarify the status, distribution and threats to endangered and declining species. One positive example in Victoria has been recent survey work associated with the Spotted Tree Frog *Litoria speceri* (Watson *et al.* 1991; Gillespie 1992; Osborne *et al.* 1994). In this case there was evidence of a decline of this montane river species from sites where it was previously known to occur. The response was to undertake targeted surveys aimed to reassess the species status, conduct ongoing monitoring of known populations and search for new populations (Watson *et al.* 1991; Gillespie 1992). As a result, new populations in the ACT and in NSW have been identified (Osborne *et al.* 1994; Ehmann *et al.* 1992), w have increased understanding of the species biology and potential threatening processes affecting the species survival have been identified (Watson *et al.* 1991; Gillespie 1992). This is an example where positive regional action, including a cooperation with interstate researchers, has greatly increased the understanding of the biology and conservation status of a declining frog specie.

In setting priorities for use of limited conservation resources we must make adequate use of all the available information in order to maximise the chances of success. This should include rigorous and thorough research that concentrates on identifying causes and solutions for local and regional patterns of species decline. There is clear evidence that a number of frog species are declining around Australia, however, the focus needs to shift away from the notion of a global phenomenon and towards local action.

Aknowledgements

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And a response

The Nature of Anecdotes or Anecdotes of Nature?

George Appleby[1]

An examination of scientific and amateur comments on frog population declines reveals that 'global environmental change' has been cited as a possible factor in few cases (e.g. DCNR 1994; Tyler 1993; Barinaga 1990). To clarify this issue, it is useful to note what global environmental change may refer to: the 'Greenhouse Effect'; ozone holes; acid rain; cyclical effects such as *El Nino* or a combination of these. One of these possibilities, the ozone hole/UV radiation link, has been examined in Blaustein *et al.* (1994). Other factors that may have caused declines in populations of specific species are listed in Watson *et al* (1991) - specifically for the Spotted Tree Frog *Litoria spenceri* - and in Williams (1994).

The authors of 'Declining Frogs - Think locally, act locally' (see this issue) quite rightly urge caution in interpreting the available (mainly anecdotal) data. Nevertheless, anecdotal information is very valuable as a pointer for further conservation and research work. In this context, we should be noting exactly what anecdotal information is: observation recorded in an unofficial way or'... unpublished narratives or details of history...the narrative of an interesting or striking incident or event' (definitions of 'anecdote' from the Shorter Oxford English Dictionary).

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[1] Frogwatch Co-Ordinator, DCNR Melbourne.

Clearly, generalised explanations are not an integral part of anecdotes but can be a consequence of them. Anecdotes thus stand distinctly as valuable sources of information.

The comment about the population of the Growling Grass Frog *Litoria raniformis* near Moorabbin (Johnson 1994) - 'it is now only found in a single cluster of remnant, unprotected wetlands near Moorabbin' - should have read **'A significant population** is now only found........near Moorabbin'. (P. Johnson *pers. comm.*). Unfortunately, this error has led to the conflict between his data and that of the 'Atlas of Victorian Wildlife' on this species in the Melbourne area.

There is widespread anecdotal information from around Melbourne, some country areas and interstate - ACT, southern NSW and northern Tasmania (Tyler 1993) - which suggests that Growling Grass Frog populations are declining. This species is quite distinct and relatively easy to record since it is large, mainly green and has a loud unusual call, so relatively unskilled observers can note its presence and hence population changes. The next step in the inquiry, namely the explanation for the species' decline, is where we have to be rigorous. Research should certainly be directed towards factors such as habitat loss and fragmentation but further anecdotal information may point to more subtle effects. With some local declines of the Growling Grass Frog, observers have noted disproportional high numbers of other species remaining in the same habitat. To find explanations for observations such as this, some lateral thinking by both scientists and amateurs, is required.

Recent research from the USA has shown strong evidence that UV radiation is a cause of declines in frog and toad eggs and embryos (Blaustein *et al.* 1994). The research noted the differential hatching rates of some species in relation to the level of the 'UV-damage-specific repair enzyme, photolyase' and amount of UV radiation.

It is unreasonable to say that anecdotal evidence supporting a decline in the Growling Grass Frog is at odds with official survey data. Two separate parameters need to be examined, namely *occurrence* and *abundance*. Recent fauna survey work may show 'moderate numbers' of Growling Grass Frogs in several areas in Melbourne (including those with degraded habitat) but comparable historic (anecdotal) information may have shown there to be relatively great numbers occurring in more areas.

While the model of threatened species investigation used by the author(s) for the Spotted Tree Frog is excellent, it has taken much time and effort. As such, the model is not easily applicable to more widespread species that show declines (e.g. Bibron's Toadlet *Pseudophryne bibroni*) due to the difficulty of covering large areas of suitable habitat and the lack of available skilled surveyors. A program such as Frogwatch helps to provide an organisation of surveyors by encouraging people to become skilled in frog survey thus allowing more extensive monitoring of populations or species. To provide quantitative data on changes in frog populations, however, surveyors have to make observations over at least a few years. Many surveyors make the effort to revisit areas where they previously heard frogs and may be able to deduce factors causing contemporary and historic changes in populations of frogs generally and of individual species. To scientists and conservation authorities, this information is useful to show local and regional differences in changes in frog numbers and possible causes for changes. Surveyors who identify causal factors of changes in frog numbers are able to modify management practices on their own land (their garden or their farm) thereby 'thinking locally, acting locally'. This is one of the intended outcomes of several community conservation programs including Frogwatch, Landcare and Land for Wildlife. Inevitably, much of this amateur data will be perceived by some to be anecdotal and therefore unreliable. But can we afford to wait for funds for research projects or for anecdotal evidence of declines to become scientifically-proven before any action is taken? To prevent loss of populations, declines and their causes must be identified earlier, so it is in the frogs' interests that scientists and amateur frogwatchers pool their resources to initiate vital research before declines become irreversible.

Aknowledgements

Thanks are due to Murray Littlejohn for supplying information on frog declines and to Peter Johnson for comments.

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Postscript

Since October 1994, Frogwatch (Victoria) has closed down but inquiries about the following frog matters can be referred to several organisations:

Research, conservation and education - Victorian Frog Group, PO Box 424 Brunswick 3056, (03) 354 4718;

Licensing of collection of frog eggs, tadpoles and adults - Wildlife Licensing Branch, DCNR, Arthur Rylah Institute, 123 Brown St, Heidelberg, 3084, (03)450 8600;

Endangered species research - Graeme Gillespie, DCNR, Arthur Rylah Institute, 123 Brown St, Heidelberg, 3084, (03)450 8600;

Husbandry - Melbourne Zoo, Elliot Avenue, Parkville, 3052 (03)285 9300;

Community water quality monitoring - Waterwatch, DCNR, 2/250 Victoria Parade, East Melbourne, 3002, (03) 412 4011.

Books Available from FNCV

The Club has, over the years, published a number of books on natural history topics which can be purchased from the Book Sales Officer. It is currently distributing four of these as follows:

'What Fossil Plant is That?' (J.G. Douglas)	$12.50
A guide to the ancient flora of Victoria, with notes on localities and fossil collection.	
'Wildflowers of the Stirling Ranges' (Fuhrer and Marchant)	$7.95
144 magnificent illustrations of the spectacular flora of this region.	
'Down Under at the Prom (M. O'Toole and M. Turner)	$16.95
A guide to the marine sites and dives at Wilson's Promontory (with maps and numerous colour illustrations.	
'A Field Companion to Australian Fungi' (B. Fuhrer)	$19.95
A reprint of the earlier book with additional photographs and changes of name incorporated.	

Alan Parkin
Book Sales Officer
850 2617(H) 565 4974(B)

Some Insects found on Blackthorn, *Bursaria spinosa* Cav. (Pittosporaceae) Flowers at Bombala, New South Wales

G.A. Webb[1]

Abstract

A wide range of insects, mostly beetles (Coleoptera), were recorded visiting flowers of *Bursaria spinosa* at two sites in southern New South Wales. The abundance and diversity of Coleoptera appeared to be related to the floral resources available, with more species present where a range of other flowering species were available.

Introduction

Bursaria spinosa Cav. (Pittosporaceae) is a highly variable shrub which occurs in a wide range of habitats from coastal to montane regions throughout most of Australia and Tasmania (Elliot and Jones 1982). The flowers of *B. spinosa* are arranged in terminal pyramidal panicles (Beadle *et al.* 1982) and when in full flower during summer, plants may be covered in masses of white, sweet smelling flowers.

Insects are strongly attracted to the flowers of *B. spinosa*. Beetles, moths, butterflies, flies, wasps and bees have been recorded visiting *B. spinosa* flowers (Armstrong 1979; Bernhardt and Burns - Balogh 1983; Best 1881, 1882, 1920; Clifford and Drake 1979; Common 1970; Hawkeswood 1978, 1981a, b, 1990a, 1990b; Michener 1965; Nikitin 1979; Rayment 1930, 1935, 1953). However, few quantitative data have been gathered so far. Hawkeswood (1990a) recently examined the insect fauna of *B. spinosa* in northern New South Wales, recording a wide range of insects from the orders Coleoptera, Lepidoptera, Diptera and Hymenoptera.

This paper reports on a collection of insects from flowering *B. spinosa* plants at two sites in a young *Pinus radiata* (D. Don) plantation near Bombala (New South Wales) in January 1985.

Study areas and methods

Insects were collected from or observed on flowers of *B. spinosa* in two sites near Bombala (New South Wales):

a. Nalbaugh State Forest (23 January 1985): young (2 year old) *Pinus radiata* plantation with scattered *B. spinosa, Derwentia derwentiana* (Andrews) B. Briggs et Ehrendorfer, *Cassinia longifolia* R. Br. and *Polyscias sambucifolia* (Sieb ex DC.) Harms. Insects were collected over a two hour period from 2p.m. (eastern summer time) in bright sunshine (ca. 30°C);

b. Nalbaugh State Forest (20 January 1985) - young (2 year old) *Pinus radiata* plantation but with mainly grass understorey and few of the above native shrubs flowering. Insects collected over a two hour period from 3pm (eastern summer time) in slightly overcast conditions (ca. 25°C).

Insects were collected by hand and with a manually operated suction aspirator and transferred to killing jars. Gross pollen loads were assessed under a stereo microscope in the laboratory in Sydney. Pollen from *B. spinosa* was not distinguished from other pollen sources.

Results and discussion

Insect fauna

Beetles were the most abundant and conspicuous group of insects on *B. spinosa* flowers, represented by 11 families and 29 species (several species are included under *Mordella* spp.) (Table 1). The most abundant taxa, in order, were *Mordella* spp. (Mordellidae), *Chromomea deparchei* (Tenebrionidae, Alleculinae), *Chauliognathus pulchellus* (Cantharidae), *Eleale* spp. (Cleridae) and the scarabaeids *Polystigma punctata* and *Phyllotocus marginipennis*.

A large number of beetle taxa have now been recorded from *B. spinosa* flowers (Table 2), of which the Buprestidae,

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[1] Rhone-Poulenc Rural Australia Pty Ltd, 3-5 Railway St, Baulkham Hills, NSW, 2153.

Table 1 - Insects found on *Bursaria spinosa* flowers at Bombala, New South Wales.

Pollen load: * light (scattered covering or isolated patches);
** medium (concentrated isolated patches or moderate covering);
*** heavy (heavy covering over all or most of body).

Abundance: R = 1 - 3 individuals; U = 4 - 10 individuals; C = 11 - 100 individuals; A = + 100 individuals.

	Site A	Site B
Coleoptera		
Alleculidae		
Chromomea deparchei Fauv.	U*	
Buprestidae		
Neocuris gracilis Macleay.	R*	
Stigmodera bifasciata (Hope)	R*	
Stigmodera vigilans Kerremans	R**	
Stigmodera rufipennis (Kirby)	R*	
Stigmodera delectabilis Hope	R**	
Stigmodera hilaris Hope	R**	
Cantharidae		
Chauliognathus pulchellus Macleay	U*	
Cerambycidae		
Ancita lineola Newman	R*	
Obrida fascialis White	R**	
Stenoderus suturalis Olivier	U*	U**
Cleridae		
Eleale nr. *aspera* Newman	C**	
Eleale pulchra Newman	R**	
Eleale simplex Newman	U**	
Eleale nr. *viridis* Guerin	R*	
Scrobiger splendidus Newman	R***	R***
Elateridae		
Analicus xanthomus (Macleay)	U**	
Lycidae		
Metriorrhynchus rhipidius Macleay	U***	R***
Metriorrhynchus rufipennis Fabricius	U***	
Mordellidae		
Mordella dumbrelli Lea	R*	
Mordella leucosticta German	R*	
Mordella spp.	A*	C*
Oedemeridae		
Pseudonanca ruficollis Blackburn	R**	
Rhipiphoridae		
Pelecotomoides conicollis Gerst.	R*	
Scarabaeidae		
Anoplognathus suturalis Blackburn	R***	
Eupoecila australasiae (Donovan)	U***	
Microvalgus scutellaris Blackburn	R*	
Phyllotocus macleayi Fischer	U**	U**
Phyllotocus marginipennis Macleay	C**	C**
Polystigma punctata (Donovan)	C***	C***
Mecoptera		
Bittacidae		
Harpobittacus sp.	R*	
Hemiptera		
sp.1	R***	
sp.2	R*	
Mantodea		
sp.1	R*	

Table 2. Coleoptera recorded visiting flowers of *Bursaria spinosa* (various sources).

Key to references

1. This study **2.** Best 1881 **3.** Best 1882 **4.** Best 1920 **5.** Duffy 1963 **6.** Hawkeswood 1978 **7.** Hawkeswood 1981a **8.** Hawkeswood 1981b **9.** Hawkeswood 1990a.

Coleoptera	
Alleculidae	
Chromomea deparchei Fauv.	1
Buprestidae	
Curis caloptera (Boisduval)	8
Curis splendens Macleay	8, 9
Neocuris gracilis Macleay	1
Stigmodera bifasciata (Hope)	1
Stigmodera cruenta Laport and Gray	6
Stigmodera delectabilis Hope	1
Stigmodera hilaris Hope	1, 9
Stigmodera inflata Barker	8, 9
Stigmodera oblita (Carter)	8, 9
Stigmodera rufipennis (Kirby)	1
Stigmodera vigilans Kerremans	1
Cantharidae	
Chauliognathus nobilitatus (Erichson)	9
Chauliognathus pulchellus Macleay	1. 9
Cerambycidae	
Amphirhoe sloanei Blackburn	9
Ancita lineola Newman	1
Aridaeus thoracicus (Donovan)	9
Distichocera thompsonella (White)	2
Hesthesis cingulata (Kirby)*	4
Hesthesis ferruginea (Boisduval)	9
Obrida fascialis White	1
Pempsamacra tillides Newman	9
Stenocentrus concolor (Macleay)	9
Stenocentrus ostracilla (Newman)	9
Stenocentrus suturalis (Olivier)	1, 3, 5
Tropocalymma dimidiatum (Newman)	9
Cleridae	
Eleale nr. *aspera* Newman	1
Eleale pulchra Newman	1
Eleale simplex Newman	1
Eleale nr. *viridis* Guerin	1
Scrobiger splendidus Newman	1
Elateridae	
Analicus xanthomus (Macleay)	1
Lycidae	
Metriorrhynchus rhipidius Macleay	1, 9
Metriorrhynchus rufipennis Fabricius	1
Mordellidae	
Mordella dumbrelli Lea	1
Mordella leucosticta German	1, 9
Mordella spp.	1, 9
Oedemeridae	
Pseudonanca ruficollis Blackburn	1
Rhipiphoridae	
Pelecotomoides conicollis Gerst.	1
Scarabaeidae	
Anoplognathus suturalis Blackburn	1
Cacochroa gymnopleura var. gymnopleura (Fischer)	
Cacochroa gymnopleura var. concolor Laporte and Gory	9
Eupoecila australasiae (Donovan)	1, 7, 9
Microvalgus scutellaris Blackburn	1
Phyllotocus macleayi Fischer	1
Phyllotocus marginipennis Macleay	1
Polystigma punctatum (Donovan)	1, 7, 9
spp.	8

*Suspected occurrence on flowers only.

Cerambycidae and Scarabaeidae form the dominant components.

Other insect fauna present included species of Bittacidae (Mecoptera), Hemiptera and Mantodea. Flies (Diptera: Syrphidae, Tabanidae and Tachinidae) were also commonly observed on flowers but were too difficult to catch and identify. Few wasps (Hymenoptera) and no honeybees, moths or butterflies were observed on flowers. Given the short duration of observation it is difficult to assess the importance, as pollen vectors, of these other more mobile groups.

In northern New South Wales (Hawkeswood 1990a) beetles were the dominant group found visiting *B. spinosa* flowers but flies and wasps were also common. Hawkeswood judged that *B. spinosa* was a generalist entomophile but possessed characters which fitted various pollination syndromes: Cantharophily (beetles), Myophily (flies) and Melittophily (bees).

The range of beetles observed at Bombala was similar to that recorded by Hawkeswood (1990a) with Mordellids and Scarabaeids numerically most abundant. However, closer comparison of the respective faunas is not warranted given the limited observations at Bombala.

Pollen Loads

The heaviest pollen loads were carried by the clerids (*Scrobiger splendidus*), lycids *(Metriorrhynchus* spp.), scarabaeids (*Anoplognathus sututalis, Eupoecila australasiae, Polystigma punctata*) and the unidentified species of Hemiptera. However, all of these taxa, with the exception of *P. punctata* were rarely observed. Of the more abundant taxa (Abundant and Common in Table 1), the mordellids carried little pollen while the scarabaeid *Phyllotocus marginipennis* and the clerid *Eleale* nr. *aspera* carried moderate coverings of pollen.

Given the short duration of observation and lack of separation of pollen into species, it is difficult to quantify the relative importance of these taxa as pollen vectors. Nevertheless, the relatively heavy pollen loads observed one some species suggests they may be important vectors.

Differences between Sites

There was a substantial difference in the number of beetle species observed at the two sites despite the similar amount of time spent at each site. At Site B, *Bursaria spinosa* occurred as scattered plants amongst *Poa* sp. and young *P. radiata* trees. There were few other species of plants present in abundance and in flower at the time. In contrast, at Site A, *Bursaria spinosa* was more abundant and often occurred in thickets. Other species of plants were present and in flower at the time. In particular, *Cassinia longifolia* and *Derwentia derwentiana*, were flowering profusely and attracted a diverse insect fauna. Many of these species were present on *B. spinosa* as well. The greater abundance of insects observed at Site A appears to be related to the greater abundance and diversity of floral resources at this site.

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The Editors are very pleased to announce that Cecily Falkingham has accepted an invitation to be our 'naturalist in residence' for 1995. The article which follows is the first in a series of naturalist notes from Cecily which, we hope, will encourage other members to submit interesting observations.

Dear Editor

In the last 15 years I have noticed a decline in the amount of natural history writings. I keep a daily diary, I am sure many other nature lovers, naturalists, bird observers, volunteer bush regenerators etc. etc., could also contribute interesting observations.

Cecily Falkingham
27 Chippewa Ave, Mitcham, Vic 3132

The Raven and the Leaf Case Moth

On 27 June this year (1994) I noticed two Ravens feeding high up in a leafless Liquid Amber tree. They were approximately 20 m from the ground and appeared to be struggling with some difficult prey.

With the help of binoculars I watched one Raven trying to tear the tough outer casing off a Leaf Case Moth *Hyalarcta hibneri* cocoon. The Leaf Case Moth camouflages its cocoon with leaves from a wide range of plants and can be a serious threat because large numbers can breed up in one season and completely defoliate the host tree or shrub.

The Raven eventually, after some minutes, succeeded in wrenching the case moth cocoon off the branch. It flew to our *Leucoxylon rosea* where I was able to watch more closely its frenzied attempts to open the tough silk case and extract the larva. It took five minutes of effort with the proposed meal always in danger of slipping from the branch. It held onto the cocoon with both feet whilst stabbing and tearing fiercely with its strong sharp beak. Eventually it succeeded and I then turned my attention to the other bird.

.... *And Another Raven*

This Raven was having a similar struggle with a Leaf Case Moth, and was trying to remove the whole case from the branch, as the first bird had done. Then it seemed to work it out that it was an advantage to leave the silk attached to the branch and with a deft flick of the beak it positioned the cocoon along the branch, stretching the 5 cm food parcel between its feet. The cocoon remained steady on the branch and within 2 minutes the larva was devoured.

We have since observed Pied Currawongs feeding on the same Leaf Case Moth larvae. According to Leach (1922 and 1952, editions of 'Australian Nature Studies') Silvereyes, Mistletoe Birds and Shrike Tits are said to be able to extract larvae from case moth cocoons, but there is no mention of Ravens or Currawongs.

In January this year (1994) I had hundreds of these Leaf Case Moth larvae defoliating *Banksia spinulosa* in my garden. I managed to successfully rear one to adulthood and to examine the emerged adult. A male moth with a jet-black 1 cm body, transparent wings and pale brown feathered antennae emerged from a black pupal case from within the cocoon.

I would be very interested to hear from anyone else who has observed species of birds (other than those mentioned) feeding on *Hyalarcta hibneri.*

Cecily Falkingham

How to be a Field Naturalist

The world of the Field Naturalist stretches from Astronomy to Zoology with all sorts of plants, animals, rocks and places in between. Beginning in this issue we are presenting a series of articles that will help you to get started in each of the many aspects of Natural History.

Good naturalists spend their time between making observations in the field, looking up references in the library, and doing experiments in the laboratory or on the kitchen bench. Each of the articles will start with a list of the sorts of activities that you could expect to enjoy if you take up this new interest. We will be giving you advice on the books and field guides that could be useful and the sorts of equipment which you will need to get started. If there are any specialist societies we will list them for you and we will tell you about any journals that cover the subject. Finally we will try to include the name of one of our members who can give you more advice on how you might proceed.

The first guide is for potential birdwatchers and in the next issue of the *The Victorian Naturalist* we will look at insects. After that will probably come fossils and we have at least twenty subjects that we can cover. That is enough material to last for three years. If you want your interest to be presented early in the series please let the editors know; they might be able to oblige.

Ian Endersby

Bird Watching

Ian Endersby[1]

Activities

As a Field Naturalist specialising in Bird Watching you can look forward to participating in:

Field trips for bird identification or other studies; Preparing your own lists of sightings and species' distribution;

Participation in organised surveys - counts of birds, nesting records and similar surveys;

Field studies of bird behaviour, diet or ecology;

Bird banding for migration studies;

Conservation of rare species and vulnerable habitats;

Bird photography.

You might specialise in a particular group of birds, such as the waders, birds of prey, seabirds, or waterfowl.

Field Guides/Handbooks

The Slater Field Guide to Australian Birds. Peter, Pat and Raoul Slater

A Field Guide to the Birds of Australia. Graham Pizzey

Field Guide to The Birds of Australia. Ken Simpson and Nicholas Day

Where to Find Birds in Australia. John Bransbury (Waymark)

Australian Birds - a popular guide to bird life. J. McDonald (Reed)

Bird Life. Ian Rowley(Collins)

Equipment

As soon as you take birdwatching seriously you will find that you need a pair of ***binoculars***. 7x50 and 10x40 are the most popular models as they give good magnification and light grasp without being unwieldy. Some people use 9x20 roof prism binoculars as they are very compact and give a short working distance that is

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[1] 56 Looker Rd, Montmorency, Victoria 3094.

essential with small bush birds. Wader and waterbird specialists will probably want to invest in a spotting telescope of at least 20x magnification with a sturdy tripod.

Mist nets and bird ***banding equipment*** can only be purchased by registered "A" grade banders so it is best to pursue that interest with a group who specialise in that aspect of ornithology.

Photographers need a ***camera*** that takes a telephoto lens but they can build their own "hide" from scrap materials and ingenuity

Clubs and Societies

Royal Australasian Ornithologists Union

Bird Observers Club of Australia

Victorian Ornithological Research Group

Victorian Wader Study Group

Journals

As well as the newsletters that each club produces there are some good journals available in Australia.

The Emu, produced by the RAOU, contains refereed scientific papers on all aspects of bird taxonomy, behaviour and distribution.

Corella, produced by the Australian Bird Banding Association, concentrates on survey methods and the results of survey and banding projects.

Australian Bird Watcher, produced by BOCA, specialises in reporting field observations of bird behaviour and distribution.

The Stilt, produced by the Australasian Wader Study Group, covers all aspects of wader biology and conservation in Australia and the Asian flyway.

Enquiries

Your FNCV Contact for *Bird Watching* is Ian Endersby. You can contact him on (03) 435 4781 or write to 56 Looker Road, Montmorency 3094. He will be able to answer many of your questions and direct you to others who can help.

Beach-washed Little Penguin

Peter McAlley (RMIT, Sciences Education Department, Coburg Campus) has supplied details about the finding of a dead Little Penguin at Port Campbell in January. The letter from the Australian Bird and Bat Banding Schemes is copied below:

> Dear Peter
>
> Thank you for reporting the details of the bird band that you recently found. We appreciate your action in reporting this find which will contribute to our understanding of Australian birds.
>
> Please check the details given below. If not correct please amend and return the form to me at the above address.
>
> **Finding Details** - Band number: 190-80198 was recovered on: 24/02/94 at: Sherbrook River, nr Port Campbell Vic; Latitude: 38deg 39min 0sec S; Longitude 143deg 4min 0 sec E; the bird was: Found dead, cause unknown and: Was dead and the band was removed.
>
> **Banding Details** - the band that you found was placed on a (n): Little Penguin or scientific name: *Eudyptula minor*, on 27/01/94; at Northern Shore Phillip Island Vic. Latitude 38deg 31 min 0sec D; Longitude 145deg 8min 0sec E. The bird was age: Nestling and its sex was: Unknown. It was banded by: The Penguin Study Group. The time between banding and recovery is 0 years 0 months 28 days and the bird had moved at least a distance of: 180 km on a bearing of 265 degrees.
>
> Thank you for participating in the Australian Bird and Bat Banding Schemes. Please do not hesitate to contact me should you need to know more about the activities of the schemes.
>
> Yours sincerely
> Lisa J Hardy for Tom Scotney

Common Australian Fungi

by Tony Young. Revised edition (1994).

Publisher: *University of New South Wales Press, Kensington, N.S.W.*
154 pages, with 32 colour plates, 9 figures, and numerous line drawings.
RRP $19.95.

'Common Australian Fungi' first appeared in 1982 and was reprinted with minor corrections in 1986. This latest version is a more substantial revision of text and plates and the format has been altered to a 21.5 x 11 cm. soft back. The basic layout of the text remains the same - with an introduction covering structure, ecology and other aspects such as edibility, followed by a key to common genera, with the bulk of the text being concise descriptions of 209 species. Most of these descriptions are accompanied by line drawings of fruiting body cross-sections, and spores. There is a list of 'further reading', reduced from the much more comprehensive bibliography which was a useful feature of the original edition. The most significant difference in this latest version is that the original 16 plates of watercolours by Kay Smith have been rearranged and supplemented so that 80 species are now illustrated, and 22 colour photographs by the author are also added to make up a further 16 plates.

The paintings of various genera are arranged more or less alphabetically, which does not exactly reflect the text, in which genera are grouped within a number of major taxonomic groups. Thus descriptions of *Clavulinopsis miniata* and *Ramaria fumigata* are on facing pages, whilst their illustrations are widely separated. The photographs are in no particular order at all. The plates are not referred to in the text, but can only be located through the index. Only when consulting the index is it apparent that a number of species which are illustrated by photographs (such as *Auricularia delicata* and *Banksiamyces toomansis*) are not mentioned at all in the text.

Whilst the new format is generally agreeable, the quality of the reproduction of the plates and of the line drawings has deteriorated, in some cases considerably. Some of the plates are rather blurry, as are many of the line drawings, with that of *Hygrocybe gramminicolor* being particularly rough. The lack of clarity of many of the line drawings, whilst unattractive, is not a serious defect, but where spores have ornamented surfaces, the nature of the ornamentation is often difficult to make out.

The colour illustrations are on the whole adequate depictions of the species - sometimes barely so. The photographs seem to capture the characteristics of the species better, as can be seen from comparison of the several cases where species are illustrated by both watercolours and by photographs (*Amauroderma rude*, *Boletellus emodensis*, *Chlorophyllum molybdites* and *Omphalotus nidiformis*). The depth of focus of the photographs is rather shallow in some cases, and the photograph of *Omphalotus nidiformis* (plate 26) appears to have been reproduced upside down.

A flaw in the arrangement of 'Common Australian Fungi' is that species sometimes appear in the text under old names, with the current name in brackets, although confusingly in a few cases, as for *Amauroderma rude*, the name in brackets is in fact an older synonym. Here and there outdated names are used with no indication of the name currently used (for example *Scutellinia scutellata* is entered only as *Peziza scutellata*). The use of older names as the main heading for some species is frankly misleading and confusing. It is not right to place *Tricholoma acerbum*, *T. nudum* and *T. rutilans* next to each other, when the latter two species are now accepted as belonging to two entirely different genera (*Lepista and Tricholomopsis* respectively). The explanation given for this practice is that it is easier to key out together some species which used to be placed in the same genus. There are indeed problems in keys of readily separating some genera without extensive use of microscopic characters, but in such cases it should have been possible to find some characters which separate at least the species dealt with, or else it would have been quite acceptable to key to a group of genera.

The illustration of *Dictyophora multicolor* (plate 11) appears to be misidentified (looking more like *D. indusiata*); but according to the author (*pers. comm.*) the typical red colour of the indusium has not come out in the plate. *Podoserpula pusio* is described under *Cantharellus pusio*, but this latter name relates in fact to an entirely different fungus. Some spelling errors are *Cytarria* for *Cyttaria* (plate 27), *pelliculosis* for *pelliculosus* (p. 37), *scuttelata* for *scutellata* (p. 144), *sanipicolor* for *sinapicolor* (p. 154) and *Schleroderma* for *Scleroderma* (p. 154).

As an identification guide the key to genera seems to work as well as can be expected without frequent recourse to microscopic characters. It is not, however, made clear that there are many genera, and a huge number of species, which are not included in the book, and some of these could reasonably be considered common. Just how to deal with the hundreds if not thousands of additional species of Australian macrofungi (many of which are yet to be formally described) has not yet been solved by any of the available field guides to Australian fungi. Comprehensive field guides are available for other groups such as birds or butterflies but there is a long way to go before there is anything like a complete guide to even the common fungi.

Like it or not, a knowledge of microscopic characters is essential for anyone wishing to really come to grips with the study of fungi, and so a major advantage of 'Common Australian Fungi' over other available works of similar scope is that drawings of spores are included for most species. The spore drawings do seem to have been done freehand, rather than by more accurate methods, but are nonetheless adequate for a book of this nature. It is, however, unfortunate that the spores of different species are reproduced at unspecified and wildly varying scales, thus, for example, making the spores of *Stereum illudens* appear much smaller than those of the adjacent *Trametes cinnabarina*, whereas the reverse is true. Various other microscopic characters which are mentioned in the text, such as cheilocystidia, are occasionally also illustrated, although what they are is nowhere indicated on the drawings.

'Common Australian Fungi' also has an advantage over some other field guides to Australian fungi in that concise descriptions of the characters of each species are provided, and furthermore these descriptions are based on first hand experience of the species, or else the author is careful to specify when he takes information from other sources. Another strong point of the work from a scientific point of view is that I believe that there are voucher collections for most if not all of the species dealt with, which means that the identity of species can be verified in future when species concepts are altered (as is bound to happen).

Jim Willis enthusiastically reviewed the first version of 'Common Australian Fungi' (see *The Victorian Naturalist* **100**, 40-42), and whilst recommending the book, did provide some comments on improvements which could be made. Regrettably, few of these suggestions have been addressed, even the most unquestionable errors remain uncorrected despite considerable revision of various parts of the text. For example, the list of states where *Cortinarius archeri* occurs does not include Tasmania, yet this is the state of origin of the type collection.

The fact that 'Common Australian Fungi' is still in print 12 years after its initial appearance testifies to the demand for an introductory work on Australian fungi. The most recent version does not, however, take advantage of having been reprinted, and there is much room for improvement, notably the entering of species under up-to-date names and the addition of cross references in the text to the plates. 'Common Australian Fungi' can nevertheless be recommended as the best introduction to the larger fungi of Australia in print - in that it combines a key, descriptions of each species and details of microscopic chacters, and is comprehensively illustrated. The best is still far from what might be possible. For the moment, the student of Australian fungi must be content to use 'Common Australian Fungi' alongide other available field guides, especially those with better quality illustrations.

Tom May
(National Herbarium of Victoria)

AFTER THE GREENING
The Browning of Australia

by Mary E White

Publisher: *Kangaroo Press* *RRP $59.95*

Mary White, in 1986, came up with a winner in her 'Greening of Gondwana' superbly illustrated by the photographs of Jim Frazier. Palaeontological endeavour had been dying in the Universities and this presentation was perhaps the first (and perhaps most successful) of a number of timely reprieves in the form of major publications.

Now 'Browning' continues her story and the question is, how successfully?

Well, there's no doubt that it is a beautiful book. Decently bound, good quality paper, first class colour plates many again emanating from Frazier (with a laudable number of the authors own efforts). My old eyes preferred the type font in 'Greening', but nonetheless that used is quite satisfactory. The general layout is excellent and segments adequately signposted. I do not like, however, the chopping and changing from black and white to colour plate in maps and figures. RIFTING 4 (page 41) is a much more effective presentation than its fellows on pages 42 and 43. Now this is because pages 42 and 43 were not part of a colour sheet on the press, but the book suffers a little because of a perceived 'no more than xxx colour pages' limitation.

A couple of the special boxes e.g. pages 22 and 23, on darkened background seem to be poorly produced whereas others (see page 62) are of higher quality. Too many of the figures e.g. map on page 45 with the Divide petering out on the Vic-NSW border, and map on page 62 with completely misleading 'extent of Cretaceous sediment' suffer from uncritical acceptance of previously published material, and I could go on and on, but this is book reviewers stuff and nothing to deter would-be purchasers.

'Browning' offers a great deal more than a pictorial essay on the vegetation history of earth. It has far more text and the author bravely ventures to comment on a multitude of subjects. This could make it more attractive to some, less to others, I believe the straightforward fossil flora story presented in 'Greening' is a lot more assimilatable than the plethora of fact, theory and suggestion provided in the new book. There is dogmatic assertion of this and that, often on flimsy evidence, and some contradiction in places. There again this sort of overall assessment becomes unreadable and wishy-washy if handled as a thesis or scientific paper where every statement has to be justified to the nth degree.

So, to sum up, we receive a well presented picture of our continent in the past, and, apart from the hiccups of the kind suggested, I see an invaluable reference for those who want to know more about our most recent ice ages, earliest inhabitants, and a myriad of other questions that are not discussed in the literature at hand in most households. Well done Mary White, I'll be buying a copy!

Jack Douglas

Obituary

Alexander Noble Burns

1899-1994

Alex Burns, who died in June 1994, was one of the longest-serving members of the Field Naturalists Club of Victoria. He was elected at a General Meeting on 12 June 1916; became an Honorary Member after 40 years and in September 1987 was awarded a Citation for Outstanding Service, which he greatly valued.

Born in Ferntree Gully, Alex Burns' early interest in entomology was fostered when he became acquainted with F.P. Spry, Entomologist at the National Museum of Victoria. In his early years he worked in Queensland for the Commonwealth Prickly Pear Board and later at the Queensland Bureau of Sugar Experiment Stations. In 1936 he obtained his BSc. from Melbourne University, and then went to England, where he worked at the British Museum (Natural History) and the Royal Botanic Gardens, Kew. In 1944 he was appointed to the staff of the National Museum, where he undertook the immense task of rehabilitating the entomological collections. He became Curator of Entomology in 1946, and was appointed Assistant Director in 1959, a position he held until his retirement in 1964. In 1953 he obtained his MSc. from Melbourne University and in 1986 was awarded a DSc. from the World University Roundtable, Arizona.

'Butterflies of Australia and New Guinea', written in collaboration with Charles Barrett, was published in 1951, followed by 'Notes on Collecting and Mounting Insects' (1954, 1964) and 'Australian Butterflies in Colour' (1969, 1979, 1983). Alex Burns' first contribution to *The Victorian Naturalist* appeared in 1924, an account of butterfly collection in northern New South Wales and Queensland. The occasional article appeared during the 1930's and 1940's but from 1952 onwards he became a regular contributor, writing articles mainly on butterflies but also on insects in general and spiders. After his retirement to Queensland he began a series 'Nature-Notes from the Gold Coast' which ran from 1973-1975, with a final article in 1979. Numerous scientific papers were published in the 'Proceedings of the Royal Society of Victoria' and the 'Memoirs of the National Museum of Victoria', and in 1957 he produced a checklist of Australian Cicadidae in '*Entomologischeb Arbeiten aus dem Museum G. Frey*' (Tutzingbei-Munchen:Germany).

Alex Burns was a Fellow of the Linnean Society of London and the Royal Entomological Society, London, a foundation member of the Entomological Section of the Zoological Society of New South Wales and a Fellow of the Royal Horticultural Society and the Royal Society of Victoria.

In his retirement Alex Burns developed an interest in orchid-growing, astronomy and cosmology. Between 1970 and 1975 he established a plant and seeding nursery at the Bird Sanctuary which was then being developed at Currumbin, Queensland. In his article on Alex Burns' retirement (*The Victorian Naturalist* 81, 169) R.T.M. Pescott described him as 'an excellent field man' who collected extensively throughout Australia and whose handling of specimens was always 'near to perfection'. He also made a significant contribution to the taxonomy of certain groups of Australian insects, particularly the butterflies and cicadas. As Alex Burns had been encouraged in his youth by F.P. Spry, so he later trained and encouraged amateur collectors sharing with them his enthusiasm.

I am indebted to Dr Alan Beasley for much of this information; he remembers his colleague and friend as 'a valued and popular member of the staff of the National Museum of Victoria' and as a very great entomologist.

Sheila Houghton

Australian Natural History Medallion

In 1993 it became necessary to obtain a new Australian Natural History Medallion and Council decided that it would be timely to return to a traditional medal, while retaining the natural history theme of the free-standing sculpture which had been used since 1981. Tony Gilevski of The Works, RMIT Design Consultancy, created the design chosen.

The three concentric circles, each set a few millimetres below the outer one, represent air, earth and water. The centre circle (water) features a platypus; the middle one (earth) has a lizard, gum nuts and leaves and an aboriginal style figure; the outer circle (air contains a ring-tail possum, a dragonfly and a brolga. The background in each circle is textured to represent the relevant element.

The reverse side repeats the circular theme: 'Australian Natural History Medallion' in the outer circle, the inscription 'For furthering interest and knowledge in Australian Natural History' in the middle and the central disc bears the name of the recipient and the date. The first medallion of this design was presented to Alan J Reid in 1993.

The medallion was sculpted and cast in bronze by Victor Kalinowski. The presentation box, crafted in River Red Gum, from the Barmah Forest, was made by Cameron Miller, of The Small Hours Studio, Eltham.

Sheila Houghton

The Victorian Naturalist

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Compiled by K.N. Bell

Part 1 (Feb.)-conference proceedings on Box and Ironbark Woodland Conservation.
Part 2 (April)-issue devoted to Fungi.