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A FLOWERING CALENDAR FOR KARRAGULLEN, A NORTHERN JARRAH FOREST LOCALITY

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ABSTRACT

A 1.2 ha area of Jarrah forest, which was burnt over part of its area in March 1978, was monitored for flowering of plants between February 1978 and April 1979. One hundred and two species flowered during this period with a peak period occurring in October. Specific flower colours, which may be related to the type of pollinating agent, did not seem to be associated with season.

INTRODUCTION

An investigation into the ecology of an ant community in the Jarrah forest near Karragullen, W.A. has just been completed (Majer, unpublished data). Amongst the important influences on the ant community are seasonal environmental factors, fire history and food availability.

The seasonality of flowering was investigated in the area since many ants utilise nectar produced by flowers (Wilson, 1971), and also seeds comprise a major component of the diet of certain species of ants (Berg, 1975). The major aspects of the ant study will be reported elsewhere although the data on flowering are presented here since they provide a record of the plants present in the area, some information on species of plants which flower soon after fire and also because they are of general interest to apiarists and investigators of pollination or general forest and plant ecology. The data may also provide an interesting comparison with simultaneous investigations performed in *Banksia* woodland at Jandakot (Milewski and Davidge, 1980) and at Cannington (Bell and Stephens, 1979), both near Perth, Western Australia.

SITE DESCRIPTION AND METHODS

The 2.4 ha study area was situated near Karragullen in the Forests Department Victoria Block (32°04'S, 116°07'E; Grid AZ65 on Forests Department Mundaring 80 map). The vegetation consisted of tall closed sclerophyllous forest dominated by *Eucalyptus marginata* (Jarrah) and an admixture of *Eucalyptus calophylla* (Marri). There was a dense shrub understorey with a scattered lower tree storey (*Banksia* spp. and *Persoonia longifolia* R.Br.). The soil

was a lateritic, well drained gravel and the climate was typically Mediterranean with cool, wet, winters and hot, dry summers. The site was previously prescription burnt in the spring of 1975 and the forest was generally healthy although Jarrah die-back, caused by *Phytophthora cinnamomi* Rands, had affected vegetation in nearby low-lying areas. The study area occupied gently sloping ground adjacent to Munday Brook (Fig. 1). Two 20 x 25 m plots were selected for mapping of vegetation and ant nests (Fig. 1). Monthly monitoring of ant activity, and ant food source, was then initiated in February 1978. One plot (burn plot), and a surrounding buffer zone, were prescription burnt with a 150-200 kW/m fire on 29 March 1978. This fire removed all green vegetation from the area. Monthly monitoring was then continued until April 1979 in order or observe the effects of fire on the ants and their food sources.

Flowering was recorded by traversing the entire 2.4 ha study area at approximately fourteen-day intervals. Representative specimens were collected from burnt and unburnt areas and preserved. The predominant colour, or colours, of the corolla, calyx, floral bracts, inflorescence or capitulum was noted for each species. In the case of grasses and sedges where flower colour was not obvious, no record of colour was made. Those species flowering in the burnt area were also noted although the method of recording did not state if flowering was confined to the burnt area.

Voucher specimens of species collected during this study are lodged in the herbarium of the Western Australian Institute of Technology Biology Department.

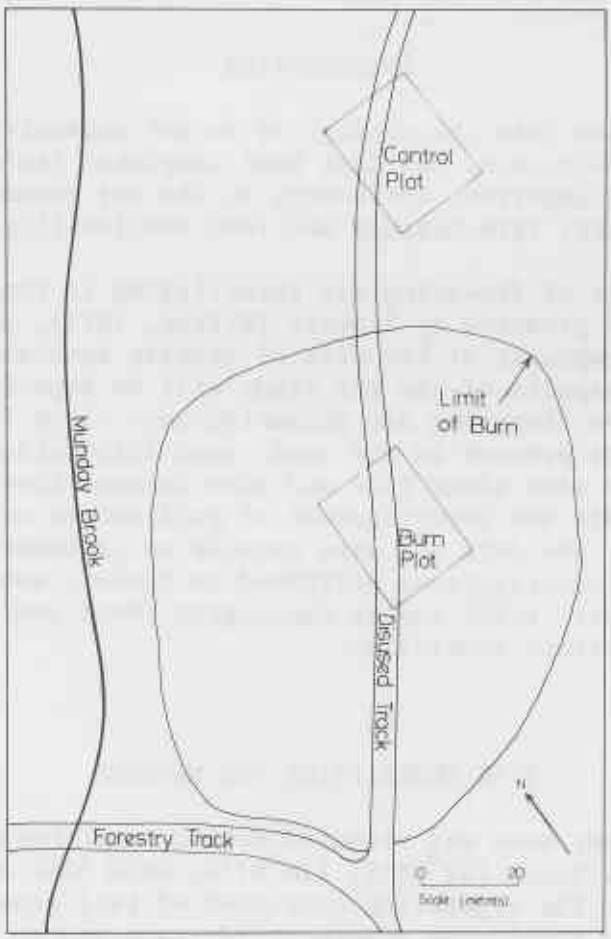

Fig. 1. Map of the 2.4 ha Karragullen study area (delimited by outer box), showing the ant study plots and limit of the March 1978 prescription burn.

Monthly means and totals for meteorological data were taken from the Forests Department Mundaring Weir station which is 14 km north of the study area.

RESULTS

One hundred and two species were observed flowering in the area (Table 1). These belong to 30 families, giving an average of 3.4 species per family. Five species, *Macrozamia riedlei* (Gaud.) C.A. Gardner, Cycadaceae; *Mesomelaena* sp. nov., Cyperaceae; *Leptocarpus scariosus* R.Br., Restionaceae; *Patersonia rudis* Endl., Iridaceae, and *Persoonia longifolia*, Proteaceae were also present in the area but were not observed in flower.

The monthly meteorological summary and total species in flower at each observation period is shown in Figure 2. The majority of the species flowered in spring with the main flush of flowering occurring in late October, a time of decreasing rainfall and rising temperatures. Other species had flowering time coincident with the hotter, drier months of the year. Only one species, *Adenanthos barbigerus* Lindl. flowered continuously throughout the year.

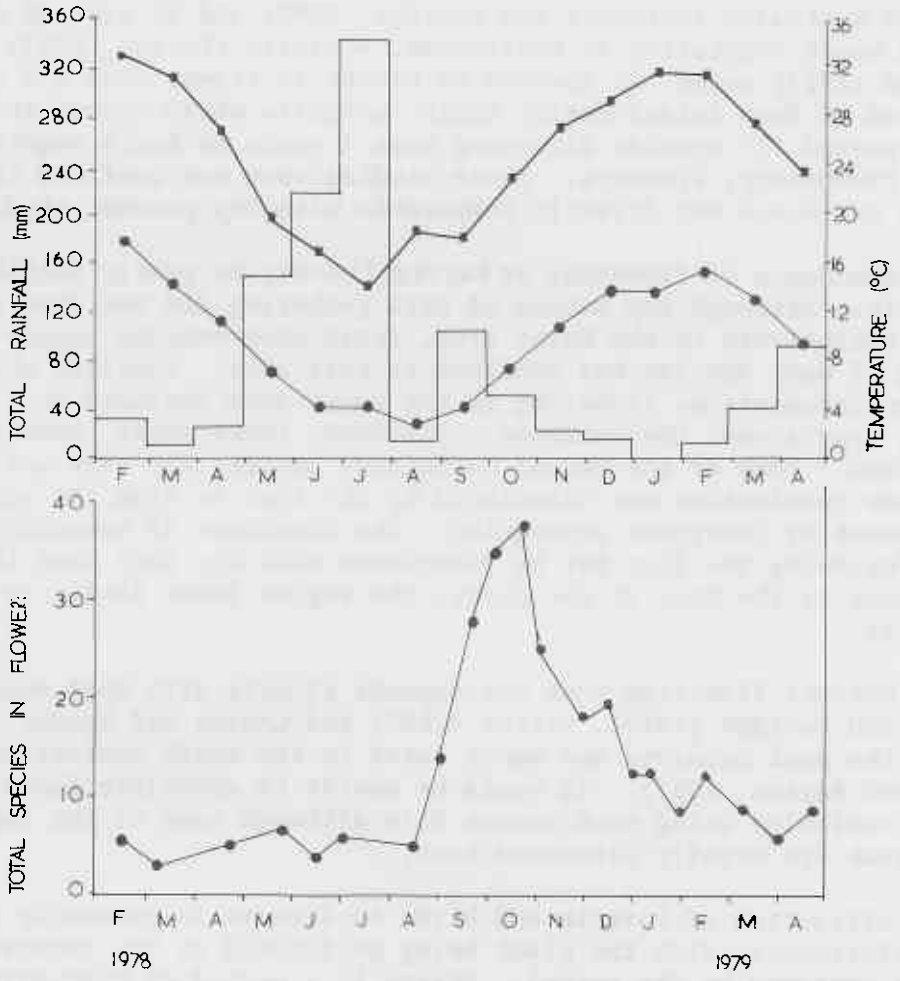

Fig. 2. Monthly rainfall (histogram), mean monthly maximum temperature (■—■), and minimum temperature (●—●) for the Forests Department Mundaring Weir recording station. The lower graph shows the total species in flower at each recording time.

Forty of the 102 species flowered in the burnt area within one year of the fire. Many of these were herbaceous species, some of which were annuals. It is noteworthy that 33 per cent of the dicotyledonous species flowered in the burnt area while 56 per cent of the monocotyledonous species produced flowers here.

In order to see if there was any trend in flower colouration, which in turn may be associated with pollinating agent (Morcombe, 1968), the total number of species in each broad flower colour class was summed for each season (Table 2). The expected number of plants flowering in each class was then calculated for each season using the actual number of species flowering and the overall proportion of species in each flower colour class. It was not possible to statistically analyse the trends in flower colour in view of the low expected frequencies in certain cells of the Table. However, visual inspection of data suggests that there is no relationship between flower colour and season.

DISCUSSION

The number of species flowering in this area is high compared with that reported elsewhere by other workers (e.g. 75 over 2 years for *Banksia* woodland in Western Australia (Milewski and Davidge, 1980) and 85 over an unspecified period in heath vegetation at Cheltenham, Victoria (Patton, 1933). Specht and Rayson (1957) noted 102 species of plants in flower over a 3 year observation period at Dark Island Heath, South Australia while Groves and Specht (1965) reported 117 species flowering over 4 years in heath vegetation on Wilson's Promontory, Victoria. These studies were not confined to small plots and are hence not directly comparable with the present study.

The abundance of flowering at Karragullen may be partly attributed to the recent burn. Although the method of data gathering did not show which species flowered exclusively in the burnt area, field observations suggested that the flowering of many species was confined to this area. Families which had several representatives flowering in the burnt area included Asteraceae, Apiaceae, Cyperaceae, Goodeniaceae, Liliaceae, Lobeliaceae, Orchidaceae and Stylidiaceae. Some of the annual herbaceous species may have arisen from seeds whose germination was stimulated by the fire or from the successful establishment of immigrant propagules. The abundance of monocotyledonous species following the fire may be associated with the fact that their growing point occurs at the base of the plant, the region least likely to be affected by the fire.

The October flowering peak corresponds closely with that observed by Milewski and Davidge (1980), Patton (1933) and Groves and Specht (1965) although the peak occurred one month later in the South Australian heath study (Specht and Rayson, 1957). It would be unwise to correlate flowering with climatic variables using such sparse data although some of the implications of this peak are briefly discussed here.

The attraction of insects and birds to flowers is generally part of a mutual relationship, with the plant being pollinated at the expense of pollen or nectar consumed by the animal. Spring is a period of high primary productivity and therefore abundance and activity of insects associated with plants. Late spring sees an abundance of winged insects, (Majer, unpublished data) making this an ideal time for flowers to be pollinated by insects. It is likely that spring flowering is partly an adaptation for

ensuring success of pollination. Most spring flowering plants set seed in late spring or early summer. Seed production therefore coincides with the period of maximum activity of seed taking ants, such as *Melophorus* sp. 1 (Australian National Insect Collection species code) and *Rhytidoponera inornata* (Crawley), in the northern Jarrah forest (Majer, unpublished data). Berg (1975) suggests that plants with seeds bearing ant attractive appendages, termed elaiosomes, may derive benefit from ants by having their seeds dispersed and buried by ants which feed on this seed-associated structure. The close timing between ant activity and seed production may therefore be an additional facet of this mutually beneficial relationship.

ACKNOWLEDGEMENTS

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Table 1. Flowering times (+) of the 102 species of plants observed in flower at the Karragullen study site. For ease of data presentation, the observation dates have been adjusted to the middle and end of each month. Species are arranged by sequence of flowering. Flower colour and incidence of flowering in the burn plot are also given.

+ Family abbreviations: Amarantaceae, Apiaceae, Asteraceae, Cyperaceae, Dilleniaceae, Droseraceae, Epacridaceae, Euphorbiaceae, Goodeniaceae, Haemodoraceae, Iridaceae, Lamiaceae, Lauraceae, Leguminosae, Liliaceae, Lobeliaceae, Myrtaceae, Olacaceae, Orchidaceae, Pittosporaceae, Poaceae, Polygalaceae, Proteaceae, Rhamnaceae, Rubiaceae Rutaceae, Santalaceae, Stylidiaceae, Thymeliaceae, Tremandraceae

* Species recorded as flowering in the burnt area produced flowers at some time during the 15 month post-fire observation period. The Table does not specify the actual time of flowering in the burnt area since control and burnt area records are amalgamated.

° Flower colour code: B, blue; Br, brown; G, green; O, orange; P, pink, purple or mauve; R, red; W, white or cream; Y, yellow

Species	Family+	Flowering* in burnt area	Flower° colour	1978 F	M	A	M	J	J	A	S	O	N	D	1979 J	F	M	A
Platysace compressa (Labill.) Norman	Ap	+	W	+	+	+	+	.	.	.	.	.	.	.	.	.	+	+	+	.
Ptilotus manglesii (Lindl.) F. Muell.	Am	-	P	+	+	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.
Pentapeltis peltigera (Hook.) Bunge	Ap	+	W	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.
Comesperma virgatum Labill.	Pol	+	P	+	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.
Adenanthos barbigerus Lindl.	Pr	+	R	+	.	.	+	.	+	+	+	+	+	+	+	+	.	+	+	.
Lobelia gibbosa Labill.	Lo	+	B	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.
Styphelia tenuiflora Lindl.	Ep	+	W	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	+	.
Olearia paucidentata (Steetz) F. Muell.	As	-	W	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.
Eriochilus dilatatus Lindl.	Or	-	W	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Astroloma ciliatum (Lindl.) Druce	Ep	-	R	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Lepidosperma leptostachyum Benth.	Cy	+	-	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.
Drosera erythrorrhiza Lindl.	Dr.	-	W	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucopogon oxycedrus Sond.	Ep	+	W	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.
Hibbertia hypericoides (DC.) Benth.	Di	-	Y	.	.	.	.	+	+	+	+	+	+	+	+	.	.	.	.	.

Species	Family[+]	Flowering* in burnt area	Flower[o] colour	1978 F	M	A	M	J	J	A	S	O	N	D	1979 J	F	M	A
Hovea chorizemifolia (Sweet) DC.	Le	-	P	..	..	..	..	.+	.+	+.	..	..	..	..	..	..	..	..
Olax benthamiana Miq.	Ol	-	Y	..	..	..	..	.+	..	..	..	..	..	..	..	..	..	..
Hakea lissocarpha R.Br.	Pr	-	W	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..	..
Trymalium ledifolium Fenzl	Rh	-	W	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..	..
Bossiaea aquifolium Benth.	Le	-	O/Y	..	..	..	..	..	..	++	..	..	..	..	..	..	..	..
Hovea trisperma Benth.	Le	-	P	..	..	..	..	..	..	++	++	..	..	..	..	..	..	..
Dryandra nivea (Labill.) R.Br.	Pr	-	Br	..	..	..	..	..	..	+.	+.	..	..	..	..	..	..	..
Hibbertia montana Steud.	Di	-	Y	..	..	..	..	..	..	++	++	++	..	..	..	..	..	..
Acacia alata R.Br.	Le	-	Y	..	..	..	..	..	..	++	+.	..	..	..	..	..	..	..
Chaemaescilla spiralis (Endl.) F. Muell.	Li	+	B	..	..	..	..	..	..	++	..	..	..	..	..	..	..	..
Caladenia deformis R.Br.	Or	+	B	..	..	..	..	..	..	+.	..	..	..	..	..	..	..	..
Craspedia sp.	As	+	Y	..	..	..	..	..	..	++	++	..	..	..	..	..	..	..
Eriochilis scaber Lindl.	Or	-	P	..	..	..	..	..	..	+.	..	..	..	..	..	..	..	..
Daviesia pectinata Lindl.	Le	-	O/R	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..	..
Acacia varia Maslin	Le	-	W	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..	..
Leucopogon capitellatus DC.	Ep	-	W	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..	..
Burchardia umbellata R.Br.	Li	-	W	..	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..
Caladenia sericea Lindl.	Or	+	B	..	..	..	..	..	..	.+	..	..	..	..	..	..	..	..
Lomandra endlicheri (F. Muell.) Ewart	Li	+	W	..	..	..	..	..	..	.+	++	..	..	..	..	..	..	..
Pimelea suaveolens (Endl.) Meisn.	Th	-	Y	..	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..
Pterostylis recurva Benth.	Or	-	G/W	..	..	..	..	..	..	.+	..	..	..	..	..	..	..	..
Grevillea synapheae R.Br.	Pr	-	W/Y	..	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..
Leptomeria cunninghamii Miq.	Sa	-	Y/Br	..	..	..	..	..	..	.+	++	..	..	..	..	..	..	..
Kennedia coccinea Vent.	Le	-	R	..	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..
Agonis linearifolia (DC.) Schauer	My	-	W	..	..	..	..	..	..	.+	..	.+	..	.+	+.	.+	..	..
Hypocalymma angustifolium Endl.	My	-	W	..	..	..	..	..	..	.+	++	+.	.+	..	..	..	..	..
Tetrariopsis octandra (Nees) C.B. Clarke	Cy	+	-	..	..	..	..	..	..	.+	++	+.	..	..	..	..	..	..
Caladenia longiclavata Coleman	Or	+	Y/R	..	..	..	..	..	..	.+	..	..	..	..	..	..	..	..
Acacia pulchella R.Br.	Le	-	Y	..	..	..	..	..	..	..	++	+.	..	..	..	..	..	..
Dampiera linearis R.Br.	Go	+	B	..	..	..	..	..	..	..	++	++	.+	++	..	..	..	..
Eriostemon spicatus A. Rich	Rut	-	P	..	..	..	..	..	..	..	++	++	..	..	..	..	..	..
Hakea amplexicaulis R.Br.	Pr	-	W	..	..	..	..	..	..	..	++	++	..	..	..	..	..	..

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Species	Family[+]	Flowering* in burnt area	Flower[o] colour	1978 F	M	A	M	J	J	A	S	O	N	D	1979 J	F	M	A
Hakea trifurcata (Sm.) R.Br.	Pr	-	W	..	..	..	..	..	..	..	+.	..	..	..	..	..	..	..
Dampiera alata Lindl.	Go	-	B	..	..	..	..	..	..	..	+.	..	..	..	..	..	..	..
Caladenia flava R.Br.	Or	+	Y/R	..	..	..	..	..	..	..	++	+.	..	..	..	..	..	..
Burchardia multiflora Lindl.	Li	-	W	..	..	..	..	..	..	..	++	..	..	..	..	..	..	..
Phyllanthus calycinus Labill.	Eu	+	W	..	..	..	..	..	..	..	++	+.	..	..	..	..	..	..
Stylidium sp. indet.	St	-	W	..	..	..	..	..	..	..	++	..	..	..	..	..	..	..
Astroloma pallidum R.Br.	Ep	-	W	..	..	..	..	..	..	..	+.	..	..	..	..	..	..	..
Opercularia hispidula Endl.	Rub	-	G	..	..	..	..	..	..	..	+.	..	..	..	..	..	..	..
Bossiaea ornata (Lindl.) Benth.	Le	-	R/Y	..	..	..	..	..	..	..	++	+.	..	..	..	..	..	..
Leucopogon verticillatus R.Br.	Ep	-	W	..	..	..	..	..	..	..	+.	+.	..	..	..	..	..	..
Stylidium junceum R.Br.	St	+	P	..	..	..	..	..	..	..	++	+.	..	..	..	..	..	..
Tetratheca hirsuta Lindl.	Tr	-	P	..	..	..	..	..	..	..	.+	++	..	..	..	..	..	..
Synaphea aff. *petiolaris* R.Br.	Pr	-	Y	..	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..
Elythranthera brunonis (Endl.) A.S. George	Or	-	P	..	..	..	..	..	..	..	.+	..	..	..	..	..	..	..
Helipterum cotula (Benth.) DC.	As	+	W/Y	..	..	..	..	..	..	..	.+	++	..	..	..	..	..	..
Stylidium schoenoides DC.	St	-	Y/R	..	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..
Drosera pallida Lindl.	Dr	+	W	..	..	..	..	..	..	..	.+	+.	..	..	..	..	..	..
Lechnaultia biloba Lindl.	Go	+	B	..	..	..	..	..	..	..	.+	++	..	..	..	..	..	..
Hibbertia amplexicaulis Steud.	Di	-	Y	..	..	..	..	..	..	..	.+	+.	..	.+	+.	..	..	..
Opercularia sp. indet.	Rub	-	G	..	..	..	..	..	..	..	.+	..	..	..	..	..	..	..
Conostylis setosa Lindl.	Ha	+	W/P	..	..	..	..	..	..	..	..	++	.+	..	..	..	..	..
Patersonia juncea Lindl.	Ir	+	P	..	..	..	..	..	.	..	..	++	..	..	..	..	..	..
Scaevola striata R.Br.	Go	+	B	..	..	..	..	..	..	..	..	++	.+	..	..	..	..	..
Pimelea spectabilis (Fisch. & Mey.) Lindl.	Th	-	W	..	..	..	..	..	..	..	..	++	..	..	..	..	..	..
Conostylis setigera R.Br.	Ha	-	Y	..	..	..	..	..	..	..	..	+.	..	..	..	..	..	..
Thelymitra crinita Lindl.	Or	-	B	..	..	..	..	..	..	..	..	+.	..	..	..	..	..	..
Sphaerolobium medium R.Br.	Le	-	Y	..	..	..	..	..	..	..	..	++	.+	+.	..	..	..	..
Comesperma volubile Labill.	Pol	-	B	..	..	..	..	..	..	..	..	++	..	..	..	..	..	..
Lobelia rhombifolia De Vriese	Lo	+	B	..	..	..	..	..	..	..	..	++	..	+.	..	..	..	..
Stylidium calcaratum R.Br.	St	+	W	..	..	..	..	..	..	..	..	++	..	..	..	..	..	..
Mirbelia dilatata R.Br.	Le	-	P	..	..	..	..	..	..	..	..	++	.+	++	+.	..	..	..

Species	Family[+]	Flowering* in burnt area	Flower[o] colour	1978 F	M	A	M	J	J	A	S	O	N	D	1979 J	F	M	A
Levenhookia dubia Sond.	St	+	W	..	..	..	..	..	..	..	..	++	..	..	..	..	..	..
Banksia grandis Willd.	Pr	-	Y	..	..	..	..	..	..	..	..	.+	.+	+.	..	..	..	..
Isotoma hypocrateriformis (R.Br.) Druce	Lo	+	P	..	..	..	..	..	..	..	..	.+	.+	+.	..	..	..	..
Agrostocrinum scabrum (R.Br.) Bail.	Li	+	B	..	..	..	..	..	..	..	..	.+	.+	..	..	..	..	..
Xanthorrhoea gracilis Endl.	Li	+	W	..	..	..	..	..	..	..	..	.+	..	+.	..	..	..	..
Trachymene pilosa Sm.	Ap	-	W	..	..	..	..	..	..	..	..	.+	..	..	..	..	..	..
Xanthorrhoea preissii Endl.	Li	+	W	..	..	..	..	..	..	..	..	..	.+	+.	..	..	..	..
Tetrarrhena laevis R.Br.	Poa	-	-	..	..	..	..	..	..	..	..	.+	.+	..	..	..	..	..
Chorizema aciculare (DC.) C.A. Gardner	Le	+	Y/O	..	..	..	..	..	..	..	..	..	.+	+.	..	..	..	..
Hemigenia pritzelii S. Moore	Lam	-	W	..	..	..	..	..	..	..	..	..	.+	+.	..	..	..	..
Gompholobium polymorphum R.Br.	Le	-	O/R	..	..	..	..	..	..	..	..	..	.+	++	..	..	..	..
Tricoryne elatior R.Br.	Li	-	Y	..	..	..	..	..	..	..	..	..	.+	+.	+.	..	..	..
Levenhookia stipitata F. Muell.	St	+	P	..	..	..	..	..	..	..	..	..	.+	+.	..	..	..	..
Eucalyptus marginata Donn ex Sm.	My	-	W	..	..	..	..	..	..	..	..	..	..	++	..	..	..	..
Cassytha glabella R.Br.	Lau	-	W	..	..	..	..	..	..	..	..	..	..	++	+.	..	..	..
Sollya heterophylla Lindl.	Pi	-	B	..	..	..	..	..	..	..	..	..	..	+.	..	..	..	..
Xanthosia atkinsoniana F. Muell.	Ap	+	W	..	..	..	..	..	..	..	..	..	..	++	++	..	+.	..
Comesperma calymega Labill.	Pol	-	B	..	..	..	..	..	..	..	..	..	..	+.	..	..	..	..
Acacia barbinervis Benth.	Le	+	Y	..	..	..	..	..	..	..	..	..	..	.+	++	+.	..	..
Baeckea camphorosmae Endl.	My	+	P	..	..	..	..	..	..	..	..	..	..	.+	++	+.	++	..
Billardiera variifolia Turcz.	Pi	+	B	..	..	..	..	..	..	..	..	..	..	..	++	+.	+.	..
Cyathochaete clandestina (R.Br.) Benth.	Cy	+	-	..	..	..	..	..	..	..	..	..	..	..	++	+.	..	..
Eucalyptus calophylla R.Br. x Lindl.	My	-	W	..	..	..	..	..	..	..	..	..	..	..	..	+.	+.	..
Banksia littoralis R.Br.	Pr	-	Y	..	..	..	..	..	..	..	..	..	..	..	..	+.	+.	..
Lomandra preissii (Endl.) Ewart	Li	-	Y	..	..	..	..	..	..	..	..	..	..	..	..	..	.+	..

Table 2. Number of species, classified by predominant flower colour, flowering in each of the four seasons. The column and row totals are not equal because some plants flower in more than one season. The numbers in brackets are the expected contribution that each colour class should make to the seasons flowering total assuming that there are no trends in flower colour.

	White	Yellow	Pink/ Purple	Blue	Red	Green	Orange	Brown	No predominant colour	Total species in flower
Autumn	9 (6.8)	2 (3.5)	4 (2.3)	1 (2.6)	2 (1.2)	(0.5)	(0.1)	(0.1)	(0.7)	18
Winter	3 (6.4)	6 (3.3)	3 (2.1)	2 (2.5)	1 (1.1)	(0.5)	(0.1)	1 (0.1)	1 (0.7)	17
Spring	28 (29.5)	19 (15.1)	9 (9.8)	10 (11.4)	5 (5.3)	2 (2.2)	1 (0.8)	1 (0.8)	3 (3.0)	78
Summer	10 (12.9)	7 (6.6)	8 (4.3)	6 (5.0)	3 (2.3)	(1.0)	(0.3)	(0.3)	(1.3)	34
Total species in colour class	39	20	13	15	7	2	1	1	4	