Population and plant growth studies of six species of Eremophila (Myoporaceae) from central Western Australia

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Abstract

Growth of six *Eremophila* (Myoporaceae) species occurring in central Western Australia were investigated over a period of three years. Field studies at Mt Keith Station (Wiluna) and Mt Weld Station (Laverton) indicated that *Eremophila* showed both germination and growth responses after heavy rainfalls. *Eremophila spectabilis brevis* increased in number from 2407 to 17684 plants ha^{-1} after a one in fifteen year rainfall event. *Eremophila fraserii galeata* increased from 2650 to 9640 plants ha^{-1} in the same period. The other species monitored, *E. exilifolia*, *E. forrestii*, *E. latrobei latrobei* and *E. margarethae*, also showed significant population increases. *Eremophila* germination strategies included generation of multiple seedlings as well as staggered germination from the same fruit over a one year period. Seedling survival was as high as 72% for *E. latrobei latrobei* after one year and seedlings reached a mean height of 8.3 cm in this period. Adult plants increased in height and leaf cover even during adverse seasons. A study of the seed bank of an *E. fraseri galeata* community revealed a mean of 56 fruits m^{-2} under shrubs compared to 2 fruits m^{-2} in bare ground.

Introduction

Eremophila species (Myoporaceae) are hardy perennial shrubs and small trees which occur throughout the arid and semi-arid regions of Australia (Chinnock 1981, 1986), and currently number over 315 species and subspecies (Chinnock *pers. comm.*). The main centre of diversity is the Austin phytogeographic region of Western Australia (Beard 1980). Since many species are tolerant to drought, fire, frost, salinity and grazing, interest in this genus is centred on its potential in rangeland revegetation and minesite rehabilitation programmes (Richmond & Ghisalberti 1994a). There have been number of studies on the taxonomy and biology of *Eremophila* (Beard 1965; Barlow 1971; Bowen 1975; Smith 1975) and their propagation potential (Lothian & Holliday 1964; Beard 1968; Wrigley & Fagg 1979). A detailed examination of the reproductive biology, vegetative and floral morphology of *Eremophila* has also been reported (Chinnock 1982).

Knowledge of the population dynamics of species of this genus is limited. Fruit production and germination in *E. gilesii* and *E. mitchellii* were most noted after rains (>40 mm) during the winter months, March-September (Burrows 1971, 1972; Beeston & Webb 1977). Seed bank studies of *E. gilesii* have demonstrated that the soil can contain more than 400 fruits m^{-2}. *Eremophila spectabilis* increased to 700 plants ha^{-1} yr^{-1} in a grazed paddock during a wet period in 1973-76, and decreased to 116 plants ha^{-1} yr^{-1} during a drought period in 1979-82 (Gardiner 1986a,b). *Eremophila delisseri* and *E. maculata* responded favourably to grazing pressure while *E. forrestii* declined in numbers (Hacker 1987). This study describes plant density, seedling recruitment, survival and growth habits of six species in the Laverton and Wiluna areas of WA over a period of three years.

Methods

The sites selected were at Mt Keith Station (27º17'S, 120º31'E) and Mt Weld Station (28º38'S, 122º24'E) in central Western Australia. An initial survey showed that these sites contain a wide range of *Eremophila* species. From the Mt Weld site, two species were selected for detailed study; *E. forrestii* (MWS1) and *E. margarethae* (MWS3) which are co-dominant species throughout the area located within populations of *Atriplex* (saltbush) and *Maireana* (bluebush) species. From the Mt Keith site, five species were chosen; *E. exilifolia* F. Muell. (MKS1), *E. forrestii* (MKS2), *E. fraseri galeata* Chinnock (MKS3), *E. latrobei latrobei* F. Muell. (MKS4) and *E. spectabilis brevis* Chinnock (MKS5). *Eremophila fraseri galeata* dominates the understorey throughout this area, with *E. spectabilis brevis* as a sub-dominant species. The other three species occur at lower densities and are scattered throughout the region (Speck 1963). General details of the location of the selected species and asssociated flora are given in Table 1. Adult plant density, seedling recruitment, survivorship, and growth habits were evaluated for each species. The data were collected over the period September 1990-June 1993

Assessment of seasonal plant growth period

The climate of the two study areas can be described as arid. The average rainfall at Mt Keith and Mt Weld is 218 and 221 mm respectively. Winter rainfall at Mt Keith is due to the passage of westerly frontal systems, while tropical cyclones and thunderstorms account for the precipitation during the summer months. Average monthly rainfall ranges between 4 mm in September to 37 mm in

Table 1

Location and description of selected *Eremophila* species at the two study sites.

Species	Location	Description	Associated flora
Mt Weld Station Site	30 km west of Laverton 28º38'S, 122º24'E		
E. forrestii (MWS 1) (Wilcox bush)	Jubilee paddock 28º58'96S, 122º27'22"E	shrub to 2 m, hairy branches, obovate-oblong leaves, tubular flowers	*Acacia aneura, E. latrobei, Templetonia egena, Maireana triptera, Leichardia australis*
E. margarethae (MWS3) (Sandbank Poverty bush)	Brook paddock 28º52'75"S, 122º25'04"E	gray shrub to 1 m, narrowly linear leaves, mauve flowers	*A. aneura, M. triptera, Atriplex nummularia, Ptilotus obovatus*
Mt Keith Site	90 km south of Wiluna 27º17'S, 120º31'E		
E. exilifolia (MKS1)	Jumps Up paddock 27º16'51"S, 120º27'16"E	shrub to 2 m, resinous branches, pink-violet tubular flowers	*A. aneura-A. linopylla, E. latrobei, Calytrix glaucophylla, P. obovatus*
E. forrestii (MKS2) (Wilcox bush)	Red paddock 27º18'96"S, 120º33'56"E	shrub to 2 m, ovate to oblong leaves, pale pink flowers	*A. aneura, E. latrobei, P. obovatus, Cassia* sp.
E. fraserii galeata (MKS3) (Turpentine bush)	Rocky Hills paddock 26º10'82"S, 120º36'20"E	shrub to 3 m, resinous leaves, ovate leaves, red tubular flowers	*A. aneura, Cassia* sp.
E. latrobei latrobei (MKS4) (Warty fuchsia bush)	Red paddock 27º19'01"S, 120º33'54"E	gray, green shrub to 2.5m, warty branches, linear-oblong leaves	*A. aneura, P. obovatus, Cassia* sp., *Triodia basedowii*
E. spectabilis brevis (MKS5) (Showy poverty bush)	Two Tanks paddock 27º13'98"S, 120º36'84"E	shrub to 2 m, resinous branches, linear-lanceolate leaves, purple flowers, dark grey bark	*A. aneura, E. foliosissima, Eragrostis eriopoda, Prosantha* sp.

March. The highest mean maximum monthly temperature was 37.7 ºC in January, and the lowest mean minimum monthly temperature was 5.3 ºC in July (Bureau of Meteorology, Perth); evaporation exceeds 5440 mm yr^{-1}. As a consequence of episodic rainfall and high evaporation rates, short growing seasons and frequent droughts are characteristic. Rainfall at Mt Weld is more dependable during the late summer with precipitation being brought about by cyclonic activity. Average monthly rainfall ranges between 7 mm in October to 31 mm in March. The highest mean maximum monthly temperature was 35.9 ºC in January, and the lowest mean monthly minimum temperature was 5.2 ºC in July; evaporation exceeds 3473 mm yr^{-1} (Beard 1974).

Study site design and assessment

Circular study plots (diameter 25 m) were partitioned into 30º sectors in which the exact location of individual plants could be monitored (Lindsey *et al.* 1958; Mueller-Dombois & Ellenberg 1974). The MKS study sites were visited four times a year in the first year (1991), but this was reduced to two per year (December and June) in

Table 2

Monthly rainfall (mm) for the period 1989-1993 recorded at Mt Keith (Mt Keith Station Exploration Camp, Western Mining Corporation) and Mt Weld station (Granny Smith Gold Mine, Placer Pacific Ltd).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mt Keith station													
1989	9.5	31.0	32.5	32.5	13.5	44.0	0.0	0.0	0.0	0.0	13.2	0.0	173.7
1990	100.8	18.3	7.8	1.4	9.2	6.2	12.7	26.5	1.8	1.6	1.0	0.0	187.3
1991	0.0	0.0	14.0	8.1	0.0	33.5	22.6	0.0	5.0	0.0	0.0	8.8	92.0
1992	20.3	5.6	75.6	126.4	16.8	32.2	0.0	29.8	40.4	0.0	4.2	0.9	398.7
1993	0.0	62.0	7.8	41.0	37.2	35.0	-	-	-	-	-	-	
Mt Weld station													
1989	4.4	0.0	0.0	23.0	40.6	29.8	0.0	0.0	0.0	0.0	19.6	2.2	119.4
1990	79.6	2.4	0.0	24.0	21.6	11.8	33.4	343.7	0.3	29.4	0.2	12.1	248.5
1991	0.4	0.0	3.5	25.5	52.0	37.7	12.8	0.8	2.8	7.0	0.5	40.6	183.6
1992	13.5	56.5	64.4	102.7	47.1	29.6	3.2	99.4	46.1	13.5	3.5	1.5	481.0
1993	0.1	20.5	36.0	28.2	100.2	43.7	-	-	-	-	-	-	

1992 and 1993 due to minimal seedling establishment and unfavourable seasonal conditions. The MWS study sites were visited twice per year. All study sites (excluding MKS1 in breakaway country) were fenced to reduce the impact of sheep and kangaroos.

Plant height (H), widest point (W_1) and perpendicular (W_2) width were measured and categorised into two groups. The inverted cone shape described *E. exilifolia, E. latrobei latrobei* and *E. spectabilis brevis,* and canopy volume was calculated using the geometric formula ($^{\pi}/_{3}$ r^2h) (Ludwig *et al.* 1975). The upper half spheroid form (Witkowski *et al.* 1991), $^{4}/_{3}$ π ($W_1/2$) ($W_2/2$) ($H/2$), was used for *E. fraseri galeata, E. forrestii* and *E. margarethae*. Changes in mean shrub height (cm) and canopy volume (m^3) between summer 1990 and winter 1993 were calculated and tested using a one-way ANOVA. Differences between means were contrasted using Scheffe's test.

Germination and seedling establishment

Newly established seedlings were counted on each visit, tagged, labelled and the heights measured. The number of seedlings produced per fruit was individually assessed. The proportion of seedling which had germinated during the winter of 1992 and survived into winter 1993 was assessed.

Seed bank variation of E. fraseri galeata (MKS3)

The seed bank variation for an *E. fraseri galeata* community was investigated during December 1992. Thirty adult shrubs within the height range of 1.5-2.0 m were selected adjacent to MSK3. A further 30 sites, each situated 3 m from the selected shrubs within a bare scalded area, were chosen at random for seed-bank sampling. Since the shrub canopy of this species overhangs the main stem with a radius of approximately 0.5 m, a 1 m soil pit (depth 10 cm) immediately around the central stem was selected. Soil and litter fractions were separated, bagged, and taken to the laboratory for sieving. The soil was sieved using an automated sieve (aperture 140 mm, mesh size 2.5 mm (No.14), diameter 21.5 cm). This fraction was further sieved by hand (wooden sieve, diameter 48.5 cm, mesh size 2.0 mm) for fruit collection.

A statistical comparison of the fruit bank number between the combined soil and litter fraction in vegetated and non-vegetated sites were assessed using a t-test. An evaluation of fruit density within the two litter and soil fractions from the bare ground and under *E. fraseri galeata* shrubs were assessed using a Duncan's Multiple Comparison Test.

Results

Although germination occurred for a number of species during the winter and summer of 1991, these values were minimal and are not discussed in detail. Plant growth and seedling establishment occurred after favourable rainfall events during winter 1992 (Table 1). Mt Keith received 400 mm (twice the yearly average), a situation that has occurred only on eight occasions over the last 100 years. Mt Weld received 480 mm, the highest recorded rainfall since records began in 1900 (Table 2).

Table 3

Shrub community density, recruitment and mortality of *Eremophila* species at the Mt Keith (MKS) and Mt Weld sites (MWS); Su = summer, Au = autumn, Wi = winter, Sp = spring. Seedling survived refers to those seedling that had germinated in previous seasons and were still surviving at the time of the observation

Season	Shrub number per plot			
	adults	seedlings		
		germinated	survived	dead
E. exilifolia (MKS1)				
Su90	73	0	-	-
Au91	73	0	0	0
Wi91	73	0	0	0
Sp91	72	1	0	0
Su91	72	0	1	0
Wi92	69	98	1	0
Su92	64	63	86	12
Wi93	64	21	80	69
E. forrestii (MKS2)				
Su90	32	0	-	-
Au91	32	0	0	0
Wi91	31	0	0	0
Sp91	31	0	0	0
Su91	31	0	0	0
Wi92	19	32	0	0
Su92	17	17	32	0
Wi93	17	14	49	18
E. fraseri galeata (MKS3)				
Su90	132	0	-	-
Au91	132	0	0	0
Wi91	131	0	0	0
Sp91	130	0	0	0
Su91	130	0	0	0
Wi92	122	148	0	0
Su92	115	237	121	27
Wi93	108	11	183	175
E. latrobei latrobei (MKS4)				
Su90	42	0	-	-
Au91	42	0	0	0
Wi91	42	0	0	0
Sp91	42	0	0	0
Su91	42	2	0	0
Wi92	33	108	2	0
Su92	33	145	100	8
Wi93	31	33	66	79
E. spectabilis brevis (MKS5)				
Su90	118	0	-	-
Au91	118	0	0	0
Wi91	118	0	0	0
Sp91	118	0	0	0
Su91	118	0	0	0
Wi92	111	756	0	0
Su92	110	34	625	131
Wi93	109	16	349	310
E. forrestii (MWS1)				
Su90	31	0	-	-
Wi91	31	2	0	0
Su91	31	1	2	0
Wi92	28	27	0	3
Su92	28	42	27	0
Wi93	28	3	42	27
E. margarethae (MWS3)				
Su90	42	0	-	-
Wi91	42	4	0	0
Su91	42	0	2	2
Wi92	38	13	0	2
Su92	38	13	13	0
Wi93	38	0	12	14

characterised by an aggregation around old plant remains and under canopies of existing shrubs and small trees. Within the E. fraseri galeata community, germinants aggregated within the canopy drip line of adult plants as noted by Hacker (1984). Increased accumulation of nutrients, water availability and soil depth beneath adult plants may contribute towards the establishment and maintenance of E. forrestii within the arid shrublands (Hacker 1979, 1984).

A study of the seed bank variation within the soil and litter layer of an E. fraseri galeata community revealed a mean concentration of 56 fruits m^{-2} under each shrub compared to 2 fruits m^{-2} in bare ground. This highlights the point that the litter and detritus layers may play a role in maintaining favourable edaphic factors and microclimate, thereby promoting seedling germination and survival when better environmental conditions occur (Hacker 1984). The total fruit count was 26402 fruits ha^{-1} and is an important topsoil seed bank for this community. The fruit bank for E. gilesii is far greater, with 4285000 ha^{-1} being calculated by Burrows (1971) for a plant community comprising 60000 adults ha^{-1}. It is interesting to note that E. gilesii is a prolific seeder with a life span of approximately 10 years (Burrows 1974), whereas E. fraserii has a life span of 100 years (Chinnock 1974). For E. sturtii and E. mitchellii, 170000 fruits ha^{-1} have been recorded (Hodgkinson et al. 1980).

Germination and growth of Eremophila species occur on relatively impoverished soils when favourable conditions occur. This has been illustrated by the large increase in population of E. spectabilis brevis after high rainfall, and is indicative of the ability of this genus to regenerate at high levels. A species' ability to survive both in time and space is associated and enhanced by the germination characteristics, particular if multiple seedlings emerge from one fruit.

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