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INSTRUCTIONS TO AUTHORS

Preparation of manuscripts

1. All material should be double spaced and typed on A4 paper.
2. Two copies of each manuscript, including all tables and figures, should be submitted.
3. Tables and figures should be photoreduced to A4 size if larger. Originals should be held by the author until requested by the Editor.

Use of word processors

Authors using a word processor should submit one copy containing their personal choice of print mode, e.g. italic, bold, underline, and one copy in plain text, entirely free of underlining and special type. They should further indicate whether a disc could be made available later for printing and, if so, the make and model of machine. References should quote titles of periodicals, bulletins and reports in full.

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Western Australian Herbarium, George Street, South Perth,
Western Australia 6151

KINGIA

This new journal *Kingia* replaces the former *Western Australian Herbarium Research Notes*, of which 12 numbers were issued between 1978 and 1986. Though different in format and arranged in volumes and parts, *Kingia* will follow closely the content and editorial policy of its predecessor, containing papers on the flora and vegetation of Western Australia. Taxonomic contributions should be directed to the Herbarium's journal *Nuytsia*.

The title *Kingia* was chosen for a number of reasons. Its cover depicts *Kingia*, an arborescent monocotyledon, endemic in Western Australia; it was drawn by the foundation editor of *Research Notes*, Dr Roger Hnatiuk, and so provides a link between the old journal and the new. *Kingia* was first observed near Albany in 1801 by Robert Brown, who named it in honour of his friend, the surveyor-explorer Captain Phillip Parker King, and also in memory of Captain Philip Gidley King, a Governor of New South Wales who supported botany.

A counterpart of our new journal is the ecological journal of the New South Wales National Herbarium, *Cunninghamia*, named in honour of botanist Allan Cunningham who was Superintendent of the Sydney Botanic Garden in 1837. In view of the association of Cunningham with Phillip Parker King on expeditions between 1817 and 1822, including Western Australia, it is particularly appropriate that the titles of the two journals should parallel the historic association of King and Cunningham.

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Collections of *Lawrencia* Hook. destroyed by fire, April 1984

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Abstract

Lander, N. S. Collections of *Lawrencia* Hook, destroyed by fire, April 1984. Kingia 1(1): 1-8 (1987), Label details of specimens of *Lawrencia* from MEL and HO destroyed in a road accident in April 1984 are provided. Available data includes locality, date of gathering, collector's name and field numbers, species identification and sheet number for each lost specimen.

Introduction

Following the completion of my revision of the genus *Lawrencia* Hook. (Lander 1985), collections on loan to PERTH from HO and MEL were destroyed in their entirety on 4th April 1984 when the truck in which they were contained was gutted by fire near Eucla on the Nullarbor Plain.

In the course of my study, a comprehensive index to specimens examined was maintained. Thus it has been possible to provide the following collection details. For each specimen, the locality, date of gathering, collector's name and field number (where these were noted on the original label) as well as the location of duplicates in other herbaria are recorded. Further, the species identification in accordance with my revision is also indicated.

Amongst the specimens from MEL lost were several types: namely, two possible isotypes of *Plagianthus berthae* F. Muell., an isotype of *Lawrencia glomerata* Hook., seven syntypes of *Plagianthus spicatus* var. *pubescens* Benth., two isotypes of *Lawrencia squamata* Nees ex Miq., ten syntypes of *Halothamnus microphyllus* F. Muell., a syntype of *Plagianthus helmsii* F. Muell. & Tate, the holotype of *Plagianthus monoicus* Helms ex Ewart. Further syntypes are held elsewhere for all the lost syntypes; the appropriate lectotypes have been selected in all cases. The single lost holotype has an isotype at AD which has been designated as a lectotype (Lander 1985).

In the following list, entries are arranged alphabetically by collector's surname. Species numbers (the first number appearing in parenthesis) are those used in my revision of *Lawrencia*: namely,

1. *Lawrencia berthae* (F. Muell.) Melville
2. *Lawrencia spicata* Hook.
3. *Lawrencia glomerata* Hook.
4. *Lawrencia viridi-grisea* Lander
5. *Lawrencia buchananensis* Lander
6. *Lawrencia cinerea* Lander
7. *Lawrencia densiflora* (E. G. Baker) Melville
8. *Lawrencia repens* (S. Moore) Melville
9. *Lawrencia diffusa* (Benth.) Melville
10. *Lawrencia squamata* Nees ex Miq.
11. *Lawrencia chrysoderma* Lander
12. *Lawrencia helmsii* (F. Muell. & Tate) Lander

Specimens Destroyed from the National Herbarium of Victoria (MEL)

Mouth of the Glenelg River, Vict., s.dat., *W. Alitt*, s.n. (2-MEL 98761).

Ooldea, S.A., 1880, *Anonymous* s.n. (3 MEL 98716).

Shark Bay W.A., Oct. 1877, *Anonymous* (4 MEL 98704).

Robertsons Brook, Duke of Orleans Bay, W.A., 33° 55' S, 122° 20' E, s.dat., *Anonymous* (10 MEL 98805).

Wimmera, Vict., s.dat., *Anonymous* (10 MEL 98775).

S.loc., s.dat, *Anonymous* (10 MEL 98809).

Murray River, Nov. 1905, *Anonymous* (10 MEL 98778).

Port Gawler, S.A., s.dat., *Anonymous* (10 MEL 98807).

Shark Bay W.A., Oct. 1877, *Anonymous* (7 MEL 98655 and 98657).

S.loc., s.dat., *Anonymous* (1 MEL 98642).

Trial Bay, W.A., between the mill lake and the flour mill, s.dat., *Anonymous* (9 MEL 98762).

Mallagata Inlet, s.dat., *Anonymous* (2 MEL 98747).

S.loc., s.dat., *Anonymous* (2 MEL 98756).

S.loc., s.dat., *Anonymous* (3 MEL).

South W.A., s.dat., *Anonymous* (10 MEL 98797).

Lake Austin, ca 330 km NE of Geraldton, W.A., 7 Aug. 1970, *A. M. Ashby* 3705 (12 MEL 98767). Duplicate: AD.

Eucla. W.A., 1886, *J. D. Batt* 64 (3 MEL 98715).

Eucla. W.A., 1886, *J. D. Batt* s.n. (3 MEL 98691).

Eucla, W.A., 1887, *J. D. Batt* 38 (3 MEL 98707).

Eucla. W.A., 1887, *J. D. Batt* s.n. (10 MEL 98799).

Eucla, W.A., 1889, *J. D. Batt* s.n. (10 MEL 98806).

Eucla, W.A., 1890, *J. D. Batt* s.n. (10 MEL 98800).

Cobham salt lake, N.S.W., s.dat., *W. Bauerlen* 256 (3 MEL).

Cobham salt lakes, N.S.W., Sept. 1887, *W. Bauerlen* 254 (10 MEL 98801, 98813). Duplicate: NSW.

Hattah Lakes National Park, Vict., Oct. 1948, *A. C. Beauglehole* 989 (10 MEL).

Raak Salt Plain, W of Nowingi, Vict., Sept. 1966, *A. C. Beauglehole* 16088 (3 MEL).

London Bridge area, Port Campbell National Park, Sept. 1966, *A. C. Beauglehole* 21349 (2 MEL 529353).

Wyperfeld National Park, Rubble Lake, S of Pirro Dune, Vict., Oct. 1968, *A. C. Beauglehole* 29357 (3 MEL).

Smaller island near Goat Island, Mallacoota Inlet National Park, Vict., Dec. 1969, *A. C. Beauglehole* 31285 (2 MEL 527061).

Goat Island, Mallacoota Inlet National Park, Vict., Dec. 1969, *A. C. Beauglehole* 32165 (2 MEL 527062).

3.2 km ENE of Mallacoota Post Office, Mallacoota Inlet National Park, Vict., Dec. 1969, *A. C. Beauglehole* 33027 (2 MEL 527073).

Lake Corangamite, Wool Wool area, Jan. 1964, *A. C. Beauglehole* 39124 (2 MEL 529352).

Hattah Lakes National Park, NW of Hattah Lake, Vict., Oct. 1960, *A. C. Beauglehole* 39209 (3 MEL).

Hattah Lakes National Park, Lendrook Plain, Oct. 1960, *A. C. Beauglehole* 39210 (10 MEL).

Pink Lakes, 16 km NNW of Underbool, ca 48 km W of Ouyen Post Office, Vict., Sept. 1972, *A. C. Beauglehole* 40390 (10 MEL).

22 miles NW of Underbool Post Office, 43 miles WSW of Hattah Post Office, Underbool Tank, Vict., Sept. 1972, *A. C. Beauglehole* 40453 (10 MEL).

Raak salt plains 9 miles NNW of Hattah Post Office, Vict., Oct. 1972, *A. C. Beauglehole* 40583 (10 MEL 529793).

Raak Salt Plains, S end near mallee area 10 miles W of Hattah Post Office, Vict., Oct. 1972, *A. C. Beauglehole* 40592 (3 MEL).

Little Desert, Watchegatcheca, Vict., Nov. 1949, *A. C. Beauglehole* 42985 (3 MEL).

Little Desert, Watchegatcheca, Vict., Oct. 1948, *A. C. Beauglehole* 42987 (3 MEL).

Little Desert, Watchegatcheca, Vict., Oct. 1948, *A. C. Beauglehole* 42993, (10 MEL 529363).

North West Mallee Study Area, Towan Plains Flora and Fauna Reserve, ca 26 km SW of Manangatang Post Office, Vict., April 1977, *A. C. Beauglehole* 55731 (3 MEL).

Mallee Study Area, Annuello, ca 23 km NNW of Manangatang Post Office, Vict., April 1977, *A. C. Beauglehole* 55867 (3 MEL).

Mallee study area, Annuello, ca 23 km NNW Manangatang Post Office, Vict., April 1977, *A. C. Beauglehole* 55955 (10 MEL).

Mt Conner, N.T., Sept. 1947, *J. M. Bechervaise* s.n. (3 MEL 98661).

Sources of Thomson River, Qld., 1871, *C. W. Birch* s.n. (3 MEL 98703).

Between Barring Downs & Muellers Range, W.A., s.dat., *C. W. Birch* s.n. (3 MEL 98705).

St Helens, Tas., April 1922, *R. A. Black* s.n. (2 MEL).

Israelite Bay, W.A., 1885, *S. T. C. Brooks (as 'S. Brooke')* s.n. (10 MEL 98793).

Israelite Bay, W.A., 1893, *S. T. C. Brooks (as 'Mrs Brookes')* s.n. (1 MEL 98651).

Israelite Bay, W.A., 1883, *Miss Brooks (as 'Miss Brooke')* s.n. (3 MEL 98698).

Israelite Bay, W.A., 1884, *Miss Brooks (as 'Miss Brooke')* s.n. (3 MEL 98697).

Upper Gascoyne River, W.A., 1890, *C. D. Brown* s.n. (7 MEL 98673).

South Coast, Van Diemans Land (Tas.), 1802, *R. Brown* 5110 (2-MEL).Duplicates: BM, CANB, K.

Port Arthur, Tas., 1892 and 1893, *Rev. J. Bufton* s.n. (2 MEL 98740 and 98734).

Nullarbor Plain, ca 50 miles S of Ooldea towards Colona, near salt lagoons, S.A., 26 Sept. 1955, *H. W. Caulfield* 146a (3 MEL).

Pink Lake State Park, Purnya reference area, Vict., Dec. 1980, *P. D. C. Cheal* s.n. (10 MEL 580047).

Palm Valley, N.T., 24° 04' S, 132° 45' E, Sept. 1963, *G. M. Chippendale* 10611 (3 MEL). Duplicates: AD, BRI, CANB, K, NSW, PERTH.

Palm Valley, N.T., 24° 04' S, 132° 45' E, Sept. 1963, *G. M. Chippendale* 10612 (3 MEL). Duplicates: AD, CANB, NSW.

SW Australia, s.dat., *W. Clarke* s.n., (2 MEL 98758).

Lake Eyre, S.A., Aug. 1971, *M. G. Corrick* 5027 (3 MEL 98815).

Beside Owen Hwy ca 5 km E of Murrayville, Vict., 35° 16' S, 141° 15' E, 28 Aug. 1979, *M. G. Corrick* 6239 (1 MEL).

Big Desert, 13 km S of Murrayville on Nhill road, Vict., 35° 25' S, 141° 14' E, Oct. 1979, *M. G. Corrick* 6367 (1 MEL).

Big Desert, SE of Murrayville on East - West road, 4 km S of Murrayville and 4 km E of junction with Nhill - Murrayville road, Vict., 35° 17' S, 141° 14' E, Oct. 1979, *M. G. Corrick* 6380 (1 MEL).

Far NW, ca 2 km S of Sunset Tank, Vict., 34° 58' S, 141° 30' E, April 1980, *M. G. Corrick* 6656, (10 MEL).

Lake Austin, W.A., 27° 35' S, 117° 55' E, April 1978, *L. A. Craven* 5033 (3 MEL 572424). Duplicates: BRI, NT, PERTH.

Between W end of Great Australian Bight and Victoria Springs, W.A., s.dat., *Crawford* 39 (10 MEL 98798).

Between W end of Great Australian Bight and Victoria Springs, W.A., s.dat., *Crawford* 48, (10 MEL 98802).

Perth, W.A., s.dat., *M. D. Crisp* 1231 (10 MEL).

Northern Plains 30 km SSW of Mildura, 9 km S of Benetook along Meridian Rd, Vict., 34° 26' S, 142° 00' E, Oct. 1977, *M. D. Crisp* 3295 (10 MEL). Duplicate: CBG.

Northern Plains, 46 km N of Mildura, Raak Plain, 3 km S of NW corner, Vict., 34° 36' S, 141° 57' E, Oct. 1977, *M. D. Crisp* 3417 (3 MEL). Duplicate: CBG.

Between the Upper Blackwood River and Lake Lefroy, W.A., 1893, *M. Cronin* s.n., (1 MEL 98664 & 98648).

Lake Wagin, W.A., 1890, *M. Cronin* s.n. (3 MEL 98694).

Lake Weering (as "Lake Waringa"), Vict., 3 Oct. 1860, *J. Dallachy* 237 (3 MEL 98687 pro pte.): a syntype of *Plagianthus spicatus* var. *pubescens* Benth. [= *Lawrencia glomerata* Hook.].

Lake Weering (as "Lake Waringa"), Vict., 3 Oct. 1860, *J. Dallachy* 238 (3 MEL 98685): a syntype of *Plagianthus spicatus* var. *pubescens* Benth. [= *Lawrencia glomerata* Hook.].

Loutitt Bay, Vict., s.dat., *J. Dallachy [as "Dalachi"]* s.n. (2 MEL 98743). Duplicate: NSW, PERTH.

Wimmera District, Vict., Oct. 1889, *St E. D'Alton* s.n. (3 MEL 98679).

Pineplains, Vict., s.dat., *St E. D'Alton 16* (3 MEL 98683).

Swan River, W.A., 1843, *J. Drummond* 55 (3 MEL 98714): an isotype of *Lawrencia glomerata* Hook. The holotype is held at K; further isotypes are at BM and PERTH.

Swan River, W.A., 1845, *J. Drummond* 208 (10 MEL). Duplicates: BM, K, PERTH.

Swan River, W.A., s.dat., *J. Drummond* 252 (10 MEL 98808). Duplicates: BM, K.

Port Gregory, W.A., s.dat., *J. Drummond* s.n. (4 MEL 98692).

S.loc., W.A., s.dat., *J. Drummond* s.n. (1 MEL 98649).

S.loc., W.A., s.dat., *J. Drummond* s.n. (2 MEL 98729, 98730 and 98754). Duplicate: K.

S.loc., W.A., s.dat., *J. Drummond* s.n. (10 MEL 98772).

S.loc., W.A., s.dat., *J. Drummond* s.n. (10 MEL 98781).

S.loc., W.A., s.dat., *J. Drummond* s.n. (10 MEL 98795).

S.loc., W.A., s.dat., *J. Drummond* s.n. (10 MEL 98771).

New Haven, Lake Bennett, N.T., 22° 46' S, 131° 00' E, May 1972, *C. Dunlop* 2541 (3 MEL). Duplicates: AD, NT.

Murray River, 1892, *J.P. Eckert* s.n. (10 MEL 98779).

Little River, (location uncertain), s.dat., *I. Filligan* 3 (2 MEL 98748).

20 miles W of Emu, S.A., 3 Sept. 1956, *N. Forde* 479 (3 MEL). Duplicates: AD, NT.

W.A., 18° 16' S, 122° 04' E, 1879, *A. Forrest* s.n. (3 MEL 98706).

Pierre Springs, W.A., 7 June 1874, *J. & A. Forrest* s.n. (3 MEL 98711).

S.loc., W.A., 28 June 1874, *J. & A. Forrest* s.n. (3 MEL 98712).

Mt Moore, W.A., 30 June 1874, *J. & A. Forrest* s.n. (3 MEL 98710).

Minilya (as 'Manilyalya'), N of Shark Bay, W.A., 1882, *J. Forrest* s.n. (3 MEL 98660).

Altona, Vict., April 1923, *C. French Jnr* s.n., (3 MEL).

Lake Eyre, S.A., 1872-74, *W. E. P. Giles* s.n. (3 MEL 98696).

Great Australian Bight, 1875, *W. E. P. Giles* s.n. (10 MEL 98796).

Upper Ashburton River, W.A., 1876, *W. E. P. Giles* s.n. (3 MEL 98695).

Mt Murchison, W.A., 1876, *W. E. P. Giles* s.n. (3 MEL 98731).

S.loc., W.A., 1876, *W. E. P. Giles* s.n. (6 MEL 98708).

Near Coolgardie W.A., May 1909, *Prof. Gregory* s.n. (12 MEL 98766).

Rigby Island S of Kalimna, Vict., 37° 56' S, 147° 57' E, Aug. 1928, *P.K. Gullan* 384 (2 MEL 573090).

E bank of the Swan River, W.A., 1889, *M. Heal* s.n. (1 MEL 98650).

Fraser Range, W.A., Sept. 1891, *R. Helms* s.n. (1 MEL 98641).

Hunts Slate Well, W.A., 9 Nov. 1891, *R. Helms* s.n. (9 MEL 7605542). Duplicates: AD, K.

Lake Deborah, W.A., Nov. 1891, *R. Helms* s.n. (MEL): the holotype of *Plagianthus monoicus* Helms ex Ewart. [= *Ricinocarpus velutinus* F. Muell.]; two isotypes are held at AD from which a lectotype has been chosen.

Lake Lefroy, W.A. 1891, *R. Helms* s.n. (12 MEL 571607). Duplicate: AD.

Lake Lefroy, W.A., 7 Nov. 1891, *R. Helms* s.n. (12 MEL): a syntype of *Plagianthus helmsii* F. Muell. & Tate [= *Lawrencia helmsii* (F. Muell. & Tate) N. S. Lander]. A duplicate of this collection at AD has been chosen as a lectotype; isolectotypes are held at K and NSW. A further syntype is held at AD.

Lake Bennet, N.T., 22° 47' S, 131° 01' E, Jan. 1972, *N. W. Henry* 378 (4 MEL 89670).

S.loc., W.A., April 1896, *N. O. Holst* s.n. (12 MEL 571605).

Brachina Gorge, Oraparinna National Park, Flinders Range, S.A., Sept. 1971, *E. N. S. Jackson* 1835, (10 MEL).

Napperby Station N.T., 22° 51' S, 132° 33' E, Jan. 1972, *P. K. Latz* 1971 (3 MEL 98671). Duplicate: CANB.

Dalhousie Springs, S.A., 26° 27' S, 135° 28' E, April 1974, *P. K. Latz* 4797 (10 MEL). Duplicates: AD, BH, PERTH.

S of Mongrel Downs Station, S.A., 20° 56' S, 129° 24' E., Aug. 1976, *P. K. Latz* 6567 a & b (3 & 4 MEL). Duplicate: NT.

Clarke Island, Tas., 1894, *E. Maclaine* s.n. (2 MEL 98741).

Lake Neale N.T., 24° 28' S, 130° 13' E, Aug. 1973, *J. R. Maconochie* 1891 (4 MEL). Duplicates: AD, CANB, CGB, NT.

Lake Neale, N.T., 24° 28' S, 130° 13' E, 28 May 1973, *J. R. Maconochie* 1893 (3 MEL). Duplicates: AD, NT.

Margate, Tas., Sept. 1924, *M. D. Maddox* s.n. (2 MEL 98753).

Wyperfield National Park, Vict., 1959, *J. O. Maroske* s.n. (3 MEL 98664).

Gardners River, W.A., s.dat., *G. Maxwell* s.n. (1 MEL 98635, 98636): possible isotypes of *Plagianthus berthae* F. Muell. [= *Lawrencia berthae* (F. Muell.) Melville]. The holotype is held at K; a further possible isotype is at M.

Puttingup, W.A., s.dat., *G. Maxwell* s.n. (10 and 11 MEL 98794).

SW Australia, s.dat., *G. Maxwell* s.n. (1 MEL 98643). Duplicate: K.

Ca 0.5 miles ENE of Southern Cross, around salt pans, Aug. 1952, *R. Melville* 219 (10 MEL). Duplicate: K.

Salt Lake near Kiatta, Vict., Sept. 1952, *R. Melville* 988 (10 MEL). Duplicate: K.

14.4 miles N of Kalgoorlie, W.A., July 1953, *R. Melville* 4011 (3 MEL 98768). Duplicates: AD, BRI, K. NSW, PERTH.

Near Mt Moore, W.A., 1889, *E. Merrall* s.n. (8 MEL 98699).

Parkers Range, W.A., 1890, *E. Merrall* s.n. (1 MEL 98646, 98477).

Parkers Range, W.A., 1890, *E. Merrall* s.n. (8 MEL 98693).

Parkers Range, W.A., 1892, *E. Merrall* s.n. (1 MEL 98653).

Junction of the Murray and Darling Rivers Vict. & N.S.W., Oct. 1887, *J. Minchin* s.n. (3 MEL 98680).

Claremont, W.A., Feb. 1903, *A. Morrison* s.n. (2 MEL 98765). Duplicates: BM, CANB.

Murray Desert, Vict., 14 Oct. 1835, *F. Mueller* s.n., (3 MEL): A syntype of *Plagianthus spicatus* var. *pubescens* Benth. [= *Lawrencia glomerata* Hook.].

Holdfast Bay, S.A., Dec. 1850, *F. Mueller* s.n. (2 MEL 98721, 98722, 98723, 98757).

Yarra River, Vict., Nov. 1852, *F. Mueller* s.n. (2 MEL 98762).

On the Reedy Lake, Murray River, Jan. 1854, *F. Mueller* s.n. (3 MEL 98720).

Spencers Gulf, S.A., Oct. 1857., *F. Mueller* s.n. (10 MEL 98812, 98790, 584132): syntypes of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.].

Spencers Gulf near Port Pirie, S.A., Oct. 1857, *F. Mueller* s.n. (10 MEL 584133): a syntype of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.].

Salt bush plain just north of Stirling Range, W.A., Oct. 1867, *F. Mueller* s.n., (10 MEL 98804).

Shark Bay, W.A., Oct. 1877, *F. Mueller* s.n. (4 MEL 98704).

S.loc., s.dat., *F. Mueller* s.n. (3 MEL 98683).

Lake Hindmarsh, Vict., s.dat., *F. Mueller* s.n. (3 MEL 98684, 98686, 98687 pro pte): syntypes of *Plagianthus spicatus* var. *pubescens* Benth. [= *Lawrencia glomerata* Hook.]. A duplicate of this collection held at NSW has been selected as a lectotype; there is an isolectotype at BM.

S.loc., s.dat., *F. Mueller* s.n. (3 MEL 98688).

Lake Hindmarsh, Vict., s.dat., *F. Mueller* s.n. (3 MEL 98689).

S.loc., s.dat., *F. Mueller* s.n. (3 MEL 98710).

S.loc., s.dat., *F. Mueller* s.n. (3 MEL 98712).

Guichen Bay, S.A., s.dat., *F. Mueller* s.n. (2 MEL 98725, 98755).

Port Gawler, S.A., s.dat., *F. Mueller* s.n. (2 MEL 98732).

Mallagata, (location uncertain), s.dat., *F. Mueller* s.n. (2 MEL 98747).

Lake Victoria, N.S.W., s.dat., *F. Mueller* s.n. (2 MEL 98763). Duplicate: K.

S.loc., s.dat., *F. Mueller* s.n. (10 MEL 98775).

Seaflats on the Murray River, S.A., s.dat., *F. Mueller* s.n. (10 MEL 98787): a syntype of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.].

Murray River, s.dat., *F. Mueller* s.n. (10 MEL 98788, 98789): a syntype of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.]. A duplicate of this collection at K has been chosen as a lectotype; there is an isolectotype at BM.

Murray, s.dat., *F. Mueller* s.n. (10 MEL 98791): a syntype of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.]. Duplicate: K.

Spencers Gulf, S.A., s.dat., *F. Mueller* s.n. (10 MEL 98812).

Between Guichen Bay and Lake Albert, S.A., s.dat., *F. Mueller* s.n. (10 MEL 584131 pro pte.): a syntype of *Plagianthus microphyllus* F. Muell. [= *Lawrencia squamata* Nees ex Miq.].

Guichen Bay, S.A., s.dat., *F. Mueller* s.n. (10 MEL 584131 pro pte).

Dimboola, Vict., 1947, *E. T. Muir* A.C.B. 42987 (3 MEL).

Dimboola, Vict., 1947, *E. T. Muir* A.C.B. 42994 (10 MEL 529364).

Dimboola, Vict., 1948, *E. T. Muir* s.n. (3 MEL 98678).

Lake, 1 mile W. Central Mt Wedge, N.T., 22° 45' S, 132° 09' E, June 1968, *A. O. Nicholls* 818 (3 MEL). Duplicates: AD, CANB, K, NT, PERTH.

Port Gregory, W.A., s.dat., *A. Oldfield* s.n. (4 MEL). Duplicate: K.

45 km SW. of Mongrel Downs Homestead, N.T., Aug. 1970, *S. Parker* 280 (4 MEL 98667). Duplicates: AD, K, NT.

Near Lake Hindmarsh, Vict., Nov. 1968, *J. D. M. Pearson* 2024 (3 MEL).

Gascoyne River, W.A., 1882, *J. Polak (as "Pollack")* s.n. (3 MEL 98660).

Southern River, Perth, Sept. 1841, *J. A. L. Preiss* 1231 (10 MEL 584100, 584134): isotypes of *Lawrencia squamata* Nees ex Miq.: the holotype is at LD. Southern River is a branch of the Canning River, near present day Thornlie.

S.loc., W.A., s.dat., *J. A. L. Preiss* 2381 (2 MEL).

S.loc., W.A., s.dat., *J. A. L. Preiss* 2387 (2 MEL).

S.loc., March 1895, *F. M. Reader* 2 (3 MEL 98702).

Polkemmet near river Wimmera, Vict., Dec. 1895, *F. M. Reader* 8 (2 MEL 98744, 98745).

Lowan, Vict., Oct. 1895, *F. M. Reader* s.n. (10 MEL 98776).

Polkemmet, Vict., Nov. 1898, *F. M. Reader* s.n. (3 MEL).

NW of Dimboola, Vict., Nov. 1892, *J. Reader* 5 (10 MEL 98777).

S.loc., March 1895, *J. Reader* 8 (10 MEL 98774).

Wimmera, N.S.W., March 1895, *J. Reader* s.n. (3 MEL 98677).

Between Eucla and Fowlers Bay, 1875, *T. Richards* s.n. (10 MEL 98810).

Near Fowlers Bay, S.A., 1875, *T. Richards* s.n. (10 MEL 98811).

Eucla, W.A., 1877, *T. Richards* s.n. (3 MEL 98709, 98676).

Fowlers Bay, S.A., 1800, *A. F. Richards* 4 (3 MEL 98690, 98670).

Pedinga, S.A., 1880, *A. F. Richards* s.n. (3 MEL 98701).

Fowlers Bay, S.A., s.dat., *A. F. Richards* s.n. (3 MEL 98674).

Fowlers Bay, S.A., s.dat., *A. F. Richards* s.n. (3 MEL 98700).

Lake Reserve Gippsland Lakes, Vict., Feb. 1960, *H. Ritman* s.n. (2 MEL 98752).

5.6 km along road which runs W of Sunset Tank - Merrinee road, Vict., 34° 44' S, 141° 38' E, Sept. 1980, *P. S. Short* 1185 (3 MEL). Duplicates: AD, CBG.

10 miles S of Broad Arrow, W.A., Sept. 1966, *R. V. Smith* 517 (12 MEL 571582).

Barwidge road, 10 miles S of Yelma turn-off, Eremean Province, W.A., 1 Sept. 1958, *N. H. Speck* 1346 (10 MEL). Duplicates: AD, BRI, K, NSW.

24 miles W of Yelma, Ereamean Province, W.A., 26° 33' S, 121° 22' E, 11 Sept. 1958, *N. H. Speck* 1435 (3 MEL). Duplicates: AD, CANB.

S.loc., Tas., s.dat., *G. F. Sotry* s.n. (2 MEL 98742, 584112).

Murchison River, W.A. 1895, *V. Streich* s.n. (3 MEL 98767).

Wimmera District, Vict., Oct. 1905, *C. S. Sutton* s.n. (2 MEL 98746).

4 miles W of Ardrossan on Maitland Road, Yorke Peninsula, S.A., July 1879, *J. G. O. Tepper* 82 (1 MEL 98640).

4 miles W of Ardrossan on Maitland Road, Yorke Peninsula, S.A., July 1879, *J. G. O. Tepper* 444 (1 MEL 98639).

S.loc., s.dat., *J. G. O. Tepper* 756 (2 MEL 98739).

Earles Farm, Kangaroo Island, S.A., s.dat., *J. G. O. Tepper* 880 (2 MEL 98735).

Yorke Peninsula, S.A., s.dat., *J. G. O. Tepper* 916 (3 MEL 98675).

Yorke Peninsula, S.A., 1880, *J. G. O. Tepper* 932 (2 MEL 98675).

Kangaroo Island, S.A., s.dat., *J. G. O. Tepper* 1209 (2 MEL 98737).

Maitland Road, Yorke Peninsula, S.A., Jan. 1880, *J. G. O. Tepper* s.n. (1 MEL 98654).

S.loc., s.dat., *J. G. O. Tepper* s.n. (1 MEL 98637, 98638).

Ooldea, S.A., 1880, *Teitkens* s.n. (3 MEL 98716).

Lake Tyers, Vict., April 1977, *J. Turner* s.n. (2 MEL 537665).

Upper Murchison River, W.A., 1892, *I. Tyson* s.n. (7 MEL 98658).

S.loc., 1893, *I. Tyson* 18 (10 MEL 98792).

St Francis Island, ca 60 km SW of Ceduna, S.A., 11 Jan. 1971, *N. M. Wace* 219 (3 MEL). Duplicate: AD.

Near Annuello, Vict., Sept. 1971, *R. Wade* s.n. (10 MEL 98785).

Rabbit Island, Mallacoota Inlet, Vict., Oct. 1948, *N. A. Wakefield* 2243 (2 MEL 1509247).

Trial Bay, W.A., s.dat., *Maj. P. E. Warburton* s.n. (2 MEL 98724).

Trial Bay, W.A., s.dat., *Maj. P. E. Warburton* s.n. (3 MEL): a syntype of *Plagianthus spicatus* var. *pubescens* Benth. [= *Lawrencia glomerata* Hook.].

Lake Eyre Basin - South, ca 150 km W of Marree on the road to Oodnadata, S.A., June 1968, *J. Z. Weber* 774 (3 MEL). Duplicate: AD.

Point Cook, Vict., Jan. 1902, *G. Weindorfer* 222 (2 and 3 MEL 581579).

Murchison River, W.A., 1892, *A. Weston* s.n. (7 MEL 98656).

Flinders Island, Bass Strait, Tas., Oct. 1966, *J. Whinray* 17 (2 MEL 521242).

Theringa, S.A., s.dat., *C. Wilhelmi* s.n. (2 MEL 98738).

Coffin Bay, S.A., s.dat., *C. Wilhelmi* s.n. (2 MEL 98719).

Port Lincoln, S.A., s.dat., *C. Wilhelmi* s.n. (10 MEL 98770).

Lake Hamilton, Port Lincoln, S.A., Jan. 1852, *C. Wilhelmi* s.n. (10 MEL 98814).

8 miles S of White Wells, S.A., Aug. 1947, *J. H. Willis* s.n. (10 MEL 98780).

Colona Homestead, S.A., 50 miles E of Head of Great Australian Bight, Aug. 1947, *J. H. Willis* s.n. (10 MEL 98782). Duplicate: K.

Gypsum workings, 4 miles SW of Nowingi, Vict., Aug. 1955, *J. H. Willis* s.n. (3 MEL 98672).

Mildura Vict., Oct. 1932, *W. J. Zimmer* s.n. (1 MEL 98652).

Specimens Destroyed from the Tasmanian Herbarium (HO)

Flinders Island, Tas., 1956, *Anonymous* (2 HO 12972).

Boomer Marsh, Dunalley, Tas., Jan. 1944, *W. M. Curtis* s.n. (2 HO 12983).

Ralphs Bay Canal, Tas., Jan. 1946, *W. M. Curtis* s.n. (2 HO).

Ralphs Bay Canal, Tas., Dec. 1946, *W. M. Curtis* s.n. (2 HO).

Browns River Kingston, Tas., April 1953, *W. M. Curtis* s.n. (2 HO 29653).

Ralphs Bay Canal, towards Sandford, Tas., Feb. 1966, *W. M. Curtis* (2 HO 29655).

Georges Bay, N of St Helens, Tas., 1893, *W. V. Fitzgerald* s.n. (2 HO 12974).

Ralphs Bay (43° 01' S, 147° 26' E), Tas., Feb. 1930, *F. H. Long* 137 (2 HO 12980).

Ralphs Bay, Tas., Jan. 1930, *F. H. Long* s.n. (2 HO 12979).

Flinders Island, Tas., Feb. 1844, *J. Milligan* s.n. (2 HO 12977).

Double Creek, on main road between Orford and Triabunna, Tas., Feb. 1976, *J. W. Parham* s.n. (2 HO 12976).

Georges Bay, Tas., s.dat. *L. Rodway* s.n. (2 HO 12978).

Georges Bay, N of St Helens, Tas., Jan. 1897, *L. Rodway* s.n. (2 HO 12975).

Coles Bay, Tas., April 1930, *L. Rodway* s.n. (2 HO 12982). Duplicate: K.

The Neck, South Arm, Tas.. Dec. 1960, *J. Somerville* s.n. (2 HO 12970).

Acknowledgements

I am particularly grateful to Mr R.M. Olive for technical assistance in the compilation of this list.

Reference

Lander, N. S. (1985). Revision of the Australian genus *Lawrencia* Hook. (Malvaceae: Malveae). Nutysia 5 (2): 201-271.

Asteraceae specimens collected by Johann August Ludwig Preiss

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Abstract

Lander, N. S. Asteraceae specimens collected by Johann August Ludwig Preiss. Kingia 1(1): 9-19 (1987). All specimens of Asteraceae collected by J. A. L. Preiss during his visit to Western Australia from 1838 to 1842 located in herbaria at Lund (LD) and Geneva (G) are listed. For each specimen the original Preiss field collection number (if cited) and the number under which it is recorded in Lehmann's "Plantae Preissianae" are noted as well as its type status. location and current name.

Of a total of 117 Preiss Asteraceae specimens located at LD, 57 are types of taxa described in "Plantae Preissianae". Of 80 such specimens held at G, 40 are types.

Preiss specimens of *Olearia* species located at CGE, CO, FL,K,L, MEL, P and WRSL and are also listed. It is suggested that the extent of Preiss specimens represented at K may be far greater than has hitherto been realised.

Introduction

In the course of my year as Australian Botanical Liaison Officer at Kew, 1984-5, I visited several European herbaria, principally in order to examine specimens of *Olearia*, the genus I am currently revising. In herbaria at the Botaniska Museum, Lund (LD) and the Conservatoire et Jardin Botaniques, Geneva (G) I am confident that I have located all, or nearly all of the specimens of Asteraceae collected by the German naturalist Johann August Ludwig Preiss during his visit to Western Australia from 1838 to 1842. Since a large proportion of these specimens are types of taxa described in J. G. C. Lehmann's "Plantae Preissianae" (1844-8) I present the following list of my findings as being of general interest.

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
0010	-[1]	(a) P (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
0058	-[1]	(a) G (b) *Sonchus oleraceus* L.
0112	-[1]	(a) G (b) *Brachycome iberidifolia* Benth.
0149	-[1]	(a) G (b) *Senecio glossanthus* (Sonder) Belcher
0151	-[1]	(a) G (b) *Olearia homolepis* (F. Muell.) F. Muell. ex Benth.
0152	-[1]	(a) G (b) *Helipterum heteranthum* Turcz.
0154	-[1]	(a) G (b) *Podolepis canescens* Cunn. ex DC.

54609-2

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
0155	-[1]	(a) G (b) *Podolepis gracilis* (Lehm.) Graham
0156	-[1]	(a) G (b) *Helipterum tenellum* Turcz.
0157	-[1]	(a) G (b) *Helipterum chlorocephalum* (Turcz.) Benth.
0162	-[1]	(a) G (b) *Myriocephalus nudus* A. Gray
0163	-[1]	(a) G (b) *Pluchea squarrosa* Benth.
0902	-[1]	(a) G (b) *Senecio lautus* ssp. *maritimus* Ali
-	-[1]	(a) LD (b) *Senecio ramosissimus* DC.
-	-[1]	(a) LD (b) *Waitzia aurea* (Benth.) Steetz
-	-[2]	(a) (b) *Brachycome radicans* Steetz
-	-[2]	(a) *Eurybia aspera* Steetz - holo: MEL (b) *Olearia strigosa* (Steetz) Benth.
-	-[2]	(a) (b) *Helichrysum macranthum* Benth.
-	-[2,3]	(a) (b) *Lagenifera stipitata* (Labill.) Druce [as *Lagenophora gracilis* Steetz]
-	-	(a) *Pithocarpa major* Steetz - type: LD (b) *Pithocarpa pulchella* Lindley
-	-[2]	(a) (b) *Schoenia cassiniana* (Gaudich.) Steetz [as *Schoenia oppositifolia* Steetz
-	-	(a) *Waitzia acuminata* Steetz - syn: LD (b) *Waitzia acuminata* Steetz
-	0001	(a) G, LD (b) *Helichrysum macranthum* Benth.
-	0002	(a) G, LD (b) *Waitzia aurea* (Benth.) Steetz
-	0003	(a) G, LD (b) *Helichrysum bracteatum* (Vent.) Andrews
-	0004 ex parte	(a) LD (b) *Helichrysum bracteatum* (Vent.) Andrews
-	0004 ex parte	(a) LD (b) *Waitzia aurea* (Benth.) Steetz-
	0005	(a) G, LD (b) *Waitzia aurea* (Benth.) Steetz
-	0006	(a) *Waitzia steetziana* Lehm. - holo: LD, iso: G (b) *Waitzia citrina* (Benth.) Steetz
-	0007	(a) *Waitzia sulphurea* Steetz - type: LD (b) *Waitzia citrina* (Benth.) Steetz

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(*a*) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0008	(*a*) G, LD (b) *Waitzia aurea* (Benth.) Steetz
-	0009	(*a*) G, LD (b) *Waitzia aurea* (Benth.) Steetz
-	0010	(*a*) G, LD (b) *Waitzia citrina* (Benth.) Steetz
-	0011	(*a*) *Helipterum niveum* Steetz - type: LD (b) *Helipterum niveum* Steetz
0158	0012	(a) G, LD (b) *Waitzia suaveolens* (Benth.) Druce
-	0013	(a) G, LD (b) *Waitzia suaveolens* (Benth.) Druce
-	0014	(a) *Anisolepis pyrethrum* Steetz - type: LD (b) *Helipterum pyrethrum* (Steetz) Benth.
-	0015	(*a*) *Waitzia brevirostris* Steetz - type: G, LD (b) *Waitzia citrina* (Benth.) Steetz
-	0016	(*a*) G, LD (b) *Helipterum cotula* (Benth.) DC.
-	0017	(*a*) *Helipterum cotula* var. *simplex* Steetz - type: LD (b) *Helipterum cotula* (Benth.) DC.
-	0018	(*a*) *Helipterum simplex* Steetz - type: G, LD (b) *Helipterum cotula* (Benth.) DC.
-	0019	(a) *Hyalospermum glutinosum* Steetz - type: G, LD (b) *Helipterum hyalospermum* F. Muell. ex Benth.
-	0020	(a) *Hyalospermum strictum* Steetz - type: G, LD (b) *Helipterum hyalospermum* F. Muell. ex Benth.
-	0021	(a) *Helipterum citrinum* Steetz - type: G, LD (b) *Helipterum cotula* (Benth.) DC.
-	0022	(a) LD (b) *Helichrysum semipapposum* (Labill.) DC.
-	0023	(a) G, LD (b) *Helichrysum semipapposum* (Labill.) DC.
-	0024	(*a*) *Pteropogon spicatus* Steetz - type: G, LD (b) *Helipterum spicatum* (Steetz) F. Muell. ex Benth.
-	0025[2]	(*a*) (b) *Helichrysum apiculatum* (Labill.) D. Don [as *Chrysocephalum flavissimum* (DC.) Steetz]
-	0026	(*a*) G, LD (b) *Helichrysum ramosum* DC.
-	0027	(a) LD (b) *Pithocarpa achilleoides* P. Lewis & Summerh.
-	0028	(a) *Ozothamnus lepidophyllus* Steetz non J.D. Hook. - syn: LD, isosyn: G (see Burbidge 1958) (b) *Helichrysum lepidophyllum* (Steetz) Benth.
-	0029	(a) G, LD (b) *Helichrysum cordatum* DC.
-	0030	(a) G, LD (b) *Angianthus cunninghamii* (DC.) Benth.

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(*a*) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0031	(a) *Leucophyta brownii* var. *candidissima* Steetz - types: G, LD (b) *Calocephalus brownii* (Cass.) F. Muell.
-	0032[2]	(*a*) (b) *Calocephalus brownii* (Cass.) F. Muell. [as *Leucophyta brownii* var. *virescens* Steetz]
-	0033	(a) LD (b) *Pseudognaphalium luteo-album* (L.) Hilliard & B.L. Burtt
-	0034	(*a*) LD (b) *Pseudognaphalium luteo-album* (L.) Hilliard & B.L. Burtt
-	0035	(a) *Pterochaeta paniculata* Steetz - type: G, LD (b) *Waitzia paniculata* (Steetz) F. Muell. ex Benth.
-	0036	(a) FI-W, G, LD (b) *Angianthus micropodioides* (Benth.) Benth.
-	0037	(*a*) *Phyllocalymma filaginoides* Steetz - isolecto: FI-W, G, LD (see Short 1981a). (b) *Angianthus micropodioides* (Benth.) Benth.
-	0038	(a) *Skirrhophorus preissianus* Steetz - isolecto: G, LD (see Short 1981*a*) (b) *Angianthus preissianus* (Steetz) Benth.
-	0039	(a) *Pogonolepis stricta* Steetz - isolecto: G, LD (see Short 1968) (b) *Pogonolepis stricta* Steetz
0826	0040	(a) G, LD (b) *Siloxerus humifusus* Labill.
-	0041	(*a*) *Styloncerus cylindraceus* Steetz - isolecto: G, LD (see Short 1981b) (b) *Siloxerus humifusus* Labill.
-	0042	(a) *Styloncerus suberectus* Steetz - isolecto: G, LD (see Short 1981b) (b) *Siloxerus humifusus* Labill.
-	0043	(*a*) LD (b) *Helipterum corymbosum* (A. Gray) Benth.
0161	0044	(a) *Pachysurus angianthoides* Steetz - type: FI-W, G, LD (b) *Calocephalus angianthoides* (Steetz) Benth.
-	0045	(a) G, LD (b) *Chrysocoryne pusilla* (Benth.) Endl.
-	0046[4]	(*a*) (b) *Gnaphalium* [as *Gnaphalium involucratum* var. *undulatum* Steetz]
-	0047[4]	(a) (b) *Gnaphalium* [as *Gnaphalium involucratum* var. *planifolium* Steetz]
-	0048[4]	(a) G (b) *Helichrysum lindleyi* H. Eichler
-	0049	(*a*) G, LD (b) *Helipterum manglesii* (Lindley) F. Muell. ex Benth.
-	0050	(a) G, LD (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0051	(*a*) G, LD (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0052[2]	(*a*) (b) *Podolepis cancescens* A. Cunn. ex DC. [as *Podolepis aristata* var. *chrysantha* (Endl.) Steetz]

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0053	(a) *Podolepis rosea* var. *mollissima* Steetz - isolecto: G, LD (see Davis 1957) (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0054	(a) *Podolepis subulata* Steetz - syn: LD, isosyn: G (see Davis 1957) (b) *Podolepis canescens* A. Cunn. ex DC.
0569	0055	(a) *Podolepis rosea* Steetz - isolecto: G, LD (see Burbidge 1957) (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0056	(a) G, LD (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0057	(a) *Podolepis filiformis* Steetz - syn: LD, isosyn: G (see Davis 1957) (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0058	(a) *Podolepis nutans* Steetz - isolecto: G, LD (see Davis 1957) (b) *Podolepis nutans* Steetz
-	0059	(a) LD (b) *Podolepis lessonii* (Cass.) Benth.
-	0060[4]	(a) (b) *Podolepis canescens* Cunn. ex DC. [as *Podolepis aristata* Benth.]
-	0061	(a) *Podolepis rosea* var. *mollissima* Steetz - lectopara: LD (see Davis 1957) (b) *Podolepis gracilis* (Lehm.) R. Graham
-	0062	(a) LD (b) *Angianthus tomentosus* Wendl.
0548	0063	(a) CGE, G, K, L, LD, MEL, P (b) *Olearia rudis* (Benth.) F. Muell. ex Benth.
-	0064	(a) LD (b) *Microseris scapigera* (Sol. ex Cunn.) Schultz - Bip.
-	0065	(a) *Athrixia australia* Steetz - syn: LD, isosyn: G (see Kroner 1980) (b) *Asteridea pulverulenta* Lindley
0545	0066	(a) G, LD (b) *Millotia myosotidifolia* (Benth.)
-	0067	(a) *Millotia robusta* Steetz - syn: LD, isosyn: G (see Schodde 1963) (b) *Millotia myosotidifolia* (Benth.) Steetz
-	0068	(a) G, LD (b) *Millotia tenuifolia* Cass.
-	0069	(a) *Chrysodiscus niveus* Steetz - type: G, LD (b) *Asteridea nivea* (Steetz) Kroner
0180	0070[4]	(a) *Senecio cygnorum* Steetz - type: G (b) *Senecio ramosissimus* DC.
-	0071	(a) LD (b) *Chrysocoryne pusilla* (Benth.) Endl.
-	0072	(a) *Siemssenia capillaris* Steetz - isolecto: LD (see Davis 1957) (b) *Podolepis capillaris* (Steetz) Diels
-	0073	(a) LD (b) *Senecio quadridentatus* Labill.
-	0074	(a) *Eurybia paucidentata* var. *glabrata* Steetz - syn: LD, MEL, isosyn: G, P (b) *Olearia paucidentata* (Steetz) Benth.
-	0075	(a) LD, MEL (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0076	(a) LD, MEL (b) *Olearia ciliata* (Benth.) Benth.
-	0077[2]	(a) MEL (b) *Olearia ciliata* (Benth.) Benth.
-	0078	(a) LD, MEL (b) *Olearia ciliata* (Benth.) Benth
0147	0079	(a) *Eurybia lehmanniana* Steetz - syn: MEL, LD, isosyn: CO, FI, FI-W, G, K, MEL, P, WRSL (b) *Olearia paucidentata* (Steetz) Benth.
-	0080 ex parte	(a) *Eurybia affinis* Steetz - syn: LD, MEL, isosyn: P (b) *Olearia elaeophila* (DC.) F. Muell. ex Benth.
0032	0080 ex parte	(a) *Eurybia paucidentata* var. *subracemosa* Steetz - syn: LD, MEL, isosyn: K, P (b) *Olearia paucidentata* (Steetz) Benth.
-	0081	(a) *Eurybia paniculata* Steetz - syn: LD, MEL (b) *Olearia elaeophila* (DC.) F. Muell. ex Benth.
-	0082	(a) *Eurybia muricata* Steetz - syn: LD, MEL, isosyn: G, MEL (b) *Olearia muricata* (Steetz) Benth.
-	0083	(a) *Eurybia strigosa* Steetz - syn: LD, MEL, isosyn: G (b) *Olearia strigosa* (Steetz) Benth.
-	0084	(a) *Eurybia paucidentata* var. *hispida* Steetz - type: K, MEL (b) *Olearia paucidentata* (Steetz) Benth.
-	0085	(a) *Brachycome lanuginosa* Steetz - isolecto: G, LD (see Davis 1948) (b) *Brachycome ciliaris* var. *lanuginosa* (Steetz) Benth.
-	0086	(a) *Brachycome pusilla* Steetz - isolecto: G, LD (see Davis 1948) (b) *Brachycome pusilla* Steetz
-	0087	(a) G, LD (b) *Brachycome ciliaris* (Labill.) Less.
-	0088[1,2]	(a) (b)
-	0089	(a) LD, MEL (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
-	0090	(a) *Eurybia candidissima* Steetz - syn: LD, MEL, isosyn: G, P (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
-	0091	(a) LD, MEL, TCD (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
-	0092	(a) G, LD, MEL, P (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
-	0093	(a) *Eurybia axillaris* var. *exaltata* Steetz - syn: LD, MEL, isosyn: CO, G, K, L, MEL, P, WRSL (b) *Olearia axillaris* (DC.) F. Muell. ex Benth.
-	0094[5]	(a) G, LD (b) *Brachycome iberidifolia* Benth.
-	0095	(a) *Brachycome iberidifolia* var. *major* Steetz - isolecto: G, LD (see Davis 1948) (b) *Brachycome iberidifolia* Benth.
-	0096	(a) *Brachycome iberidifolia* var. *divergens* Steetz - isolecto: LD (see Davis 1948) (b) *Brachycome iberidifolia* Benth.

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0097	(a) *Brachycome iberidifolia* var. *alba* Steetz - isolecto: LD (see Davis 1948) (b) *Brachycome iberidifolia* Benth.
-	0098	(a) *Brachycome pusilla* Steetz - *lectopara*: LD (see Davis 1948) (b) *Brachycome pusilla* Steetz
	0099	(a) *Brachycome bellidioides* Steetz - isolecto: G, LD (see Davis 1948) (b) *Brachycome bellidioides* Steetz
-	0100	(a) *Millotia glabra* Steetz - syn: LD, isosyn: G (see Schodde 1963) (b) *Milotia myosotidifolia* (Benth.) Steetz
-	0101	(a) *Gymnogyne cotuloides* Steetz - type: LD (b) *Cotula cotuloides* (Steetz) Druce
-	0102[2]	(a) (b) *Vittadinia*
-	0103	(a) *Silphiosperma glandulosum* Steetz - *isolecto*: LD (see Davis 1948) (b) *Brachycome glandulosa* (Steetz) Benth.
-	0104[2]	(a) TCD (b) *Vittadinia*
-	0105	(a) *Ixiolaena chrysantha* Steetz - type: FI-W, LD (b) *Podotheca chrysantha* (Steetz) Benth.
-	0106	(a) LD (b) *Podotheca angustifolia* (Labill.) Less.
-	0107	(a) LD (b) *Podotheca gnaphalioides* Graham
-	0108 ex parte	(a) *Picris squarrosa* Steetz - type: LD (b) *Picris squarrosa* Steetz
-	0108 ex parte[4]	(a) (b) *Senecia lautus* G. Forster ex Willd. [as *Senecio carnulentus* var. *angustissima* Steetz]
-	0109	(a) *Senecia carnulentus* var. *angustissima* Steetz - syn LD, isosyn: G (see Ali 1969) (b) *Senecio lautus* G. Forster ex Willd.
-	0110	(a) *Senecio carnulentus* var. *latiloba* Steetz - syn: LD, isosyn: G (see Ali 1969) (b) *Senecio lautus* G. Forster ex Willd.
-	0111	(a) LD (b) *Senecio ramosissimus* DC.
-	0112	(a) LD (b) *Senecio lautus* G. Forster ex Willd.
-	0113	(a) (b)
-	0114[2]	(a) (b) *Senecio lautus* G. Forster ex Willd. [as *Senecio crithmifolius* A. Rich.
	0115[2]	(a) (b) *Senecio* [as *Erechtites*]
-	0116	(a) LD (b) *Sonchus asper* Hill
-	0117	(a) LD (b) *Sonchus oleraceus* L.
-	0118	(a) G, LD (b) *Lagenifera huegelii* Benth.

PREISS FIELD NUMBER	PL. PREISS. NUMBER	(a) TYPE STATUS AND LOCATION (b) CURRENT NAME
-	0119	(a) LD (b) *Hypochaeris glabra* L.
-	0120	(a) G, LD (b) *Ixiolaena viscosa* Benth.
-	0121	(a) G, LD (b) *Craspedia* sp. [as *Craspedia richea* Cass.]
-	0122	(a) LD (b) *Centipeda minuta* (L.) A. Braun & Asch.
-	0123	(a) LD (b) *Senecio ramosissima* DC.
-	0124[1,2]	(a) (b)
-	0125[2]	(a) (b) *Senecio* [as *Erechtites*]
-	0126	(a) LD (b) *Senecio quadridentatus* Labill.
-	0127	(a) *Styloncerus multiflorus* Nees - type: LD (b) *Rutidosis multiflorus* (Nees) Robinson
-	0128[4]	(a) (b) *Cotula coronopifolia* L.
-	0129[4]	(a) (b) *Arctotheca calendula* (L.) Levyns [as *Cryptostemma calendulaceum* R. Br.]
-	0130	(a) *Cymbonotus preissianus* Steetz - type: LD (b) *Cymbonotus preissianus* Steetz
-	1361	(a) FI-W, LD (b) *Siloxerus humifusus* Labill.
-	2414b	(a) *Chthonocephalus pseudevax* Steetz - type: LD (b) *Chthonocephalus pseudevax* Steetz
-	2416	(a) *Silphiosperma perpusillum* Steetz - isolecto G, LD (see Davis 1948) (b) *Brachycome perpusilla* (Steetz) Benth.
-	2427	(a) *Calotis erinacea* Steetz - isolecto: LD (see Davis 1952) (b) *Calotis erinacea* Steetz

[1] Specimens not cited in "Plantae Preissianae".

[2] Specimens not located at LD or G.

[3] The sole record of this species in Western Australia. Davis (1950) records a possible syntype of *Lagenophora gracilis* Steetz [= *Lagenifera stipitata* (Labill.) Druce] in Melbourne (MEL).

[4] Specimens noted by Agardh in his personal copy of Lehmann's "Plantae Preissianae" as present at LD, but not found there despite an exhaustive search.

[5] Burbidge (1948) has incorrectly nominated duplicates of this gathering as lectotype and lectoparatypes of *Brachycome iberidifolia* var. *huegeliana* Steetz. In his notes on this taxon Steetz cites the type of *Brachycome iberidifolia* Benth. collected by Huegel. Thus the name *Brachycome iberidifolia* var. *huegeliana* Steetz is not validly published.

Discussion

An account of Preiss's activities in Australia has been presented by McGillivray (1975). General background concerning the specimens at Lund and evidence that they are in fact from Lehmann's personal herbarium has been given by Wilson (1983) and Crisp (1983).

As can be seen from the above list the representation at Lund of Asteraceae collected by Preiss is high indeed. Of 142 collections recorded in "Plantae Preissianae" 115 are represented at Lund, 57 of which are types of taxa described therein, 55 by J. Steetz, the botanist responsible for the account of Asteraceae, one by Nees and one by Lehmann himself. Each of these specimens has full details of locality and date corresponding to those in "Plantae Preissianae". Furthermore, each has been annotated by Steetz. Thus, as Crisp (1983) argues, where lectotypification has not yet been made the Lund specimens have equal status with those from Steetz's own herbarium (now at MEL) and should be considered when names from "Plantae Preissianae" are lectotypified.

A further two Preiss Asteraceae specimens were found at Lund which lack the numbers and collecting details that would allow them to be related to those recorded in "Plantae Preissianae".

At the Geneva herbarium a large suite of Preiss Asteraceae specimens was located in the main collection. A smaller number bearing what appear to be original Preiss field numbers were found amongst undetermined material at the end of the family. Several more similarly numbered sheets of Asteraceae were found at other European herbaria visited. These collections, 23 in all, span the period 17 December 1838 to 8 November 1840, and the numbers are in an irregular chronological order. In some cases these specimens bear details of locality and date which allow them to be correlated with those of "Plantae Preissianae"; others represent taxa not considered there.

The Preiss specimens at Geneva appear to have come from four independent sources, namely:

(a) specimens with Plantae Preissianae numbers labelled "in col. Swan River" in an unknown hand, received in 1843, with separate labels bearing Plantae Preissianae names;

(b) specimens with Plantae Preissianae numbers and names, and printed labels reading "Mr L. Preiss, Swan River, 1837-40";

(c) specimens with Preiss' original numbers, labelled with full details of locality and date in an unknown hand, without names, each with a second printed label reading "Swan-River Colony. - Nouvelle Holland 1839-1840, Preis.", received in July 1842;

(d) specimens donated by the Candolle family in 1921 with Preiss' original numbers, labelled "Nov. Holland., Swan River", without date, without names, received in 1854, each with "Ferd. Muller" crossed out, some with number tags.

Clearly, series (a) and (c) above were distributed not long after Preiss returned to Europe in early 1842 where the general systematic arrangement of his collections was completed and the organisation of "Plantae Preissianae" commenced under the guidance and supervision of Lehmann at Hamburg. It seems likely that the name labels for series (a) were provided at some later date, perhaps after publication of the relevant parts of "Plantae Preissianae".

Of the 80 Preiss Asteraceae specimens located at Geneva, 40 are types of taxa described in "Plantae Preissianae".

In the course of my examination of specimens of *Olearia* in European herbaria I encountered Preiss collections in CGE, CO, FI, K, L and P. These are listed above.

It is worth noting here that Preiss' Asteraceae specimens held at Florence (FI) are labelled "Comm. dal Signore Preiss in Febrio 1846" and bear Plantae Preissianae numbers and names. It seems that Preiss himself was distributing material as late as 1846. This and the preceding observations provide confirmation of Crisp's (1983) surmise that material not distributed to the various authors of "Plantae Preissianae" was retained by Preiss and offered for sale.

Burbidge (1972) has catalogued Preiss specimens held at Kew and Missouri (MO). In her list only a single *Olearia* collection is noted for Kew. However, I myself encountered a total of five Preiss *Olearia* specimens at Kew. The additional four bear Preiss field numbers which, by virtue of the collection details, can easily be related to those of "Plantae Preissianae". Presumably they are from amongst specimens purchased by William Hooker in London before Preiss continued on to Hamburg. Thus they might be expected to bear Preiss field numbers rather than those allocated later by Lehmann.

Although this sample is rather small it suggests that the total of Preiss specimens represented at Kew may be far greater than has hitherto been realised.

All the Preiss Asteraceae specimens at Lund of type status were photographed. Black and white negatives and prints are lodged at the Western Australian Herbarium (PERTH).

Acknowledgements

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The distribution of introduced *Rumex* (Polygonaceae) in Western Australia

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Abstract

Moore, John and Scott, John K. The distribution of introduced *Rumex* (Polygonaceae) in Western Australia. Kingia 1(1) : 21-26(1987). The paper records nine alien species of *Rumex (R. acetosella* L., *R. bucephalophorus* L., *R. conglomeratus* Murray, *R. crispus* L., *R. frutescens* Thouars, *R. obtusifolius* L., *R. pulcher* L., *R. sagittatus* Thunb., *R. vesicarius* L.) for Western Australia, of which three *(R. bucephalophorus, R. frutescens* and *R. sagittatus)* are considered to be no longer present. A distribution map based on a 1° lat. x 1.5° long. grid is given for each species.

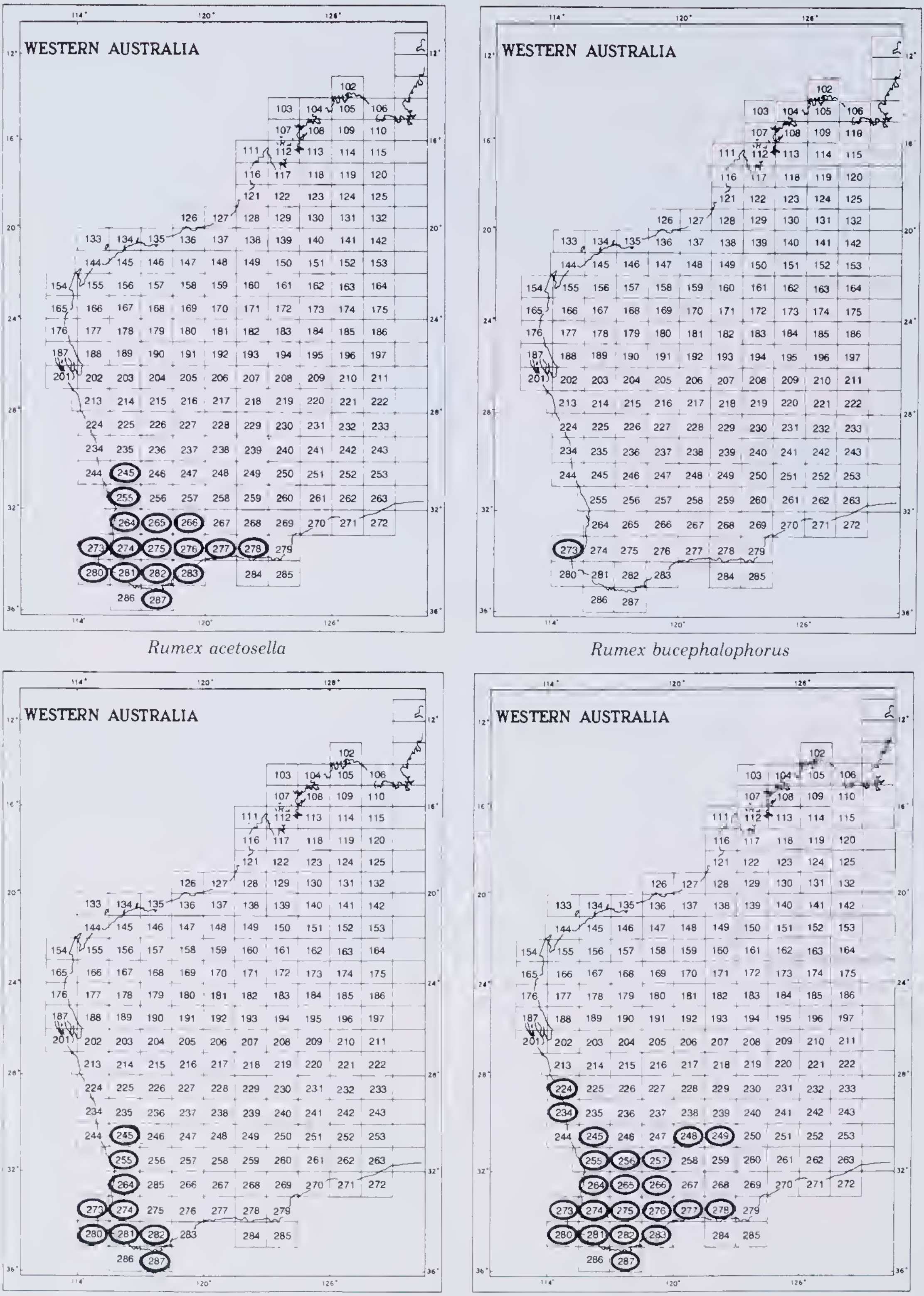
Introduction

The genus *Rumex* (Polygonaceae) in Australia consists of eight indigenous and nine introduced species (Rechinger 1984). The distribution within Australia is given for the indigenous species by Rechinger (1984) and amongst the introduced species; *R. acetosella* L. has been mapped across all states (Archer and Martin 1979), in Victoria (Churchill and Corona 1972, Willis 1972) and in Queensland (Kleinschmidt and Johnson 1977); *R. crispus* L., *R. conglomeratus* Murray, *R. pulcher* L., *R. obtusifolius* L. and *R. sagittatus* Thunb. have been mapped in Victoria by Churchill and Corona (1972), and Willis (1972). *Rumex vesicarius* L. has been noted as occurring in central Australia and not the northern half of the Northern Territory (Chippendale 1972). In this paper we give the distribution of the introduced species in Western Australia.

Methods

The methods used to map *Rumex* followed that of Hnatiuk and Maslin (1980 a&b). The nine species mapped were arranged alphabetically and the occurrence in a grid cell were indicated.

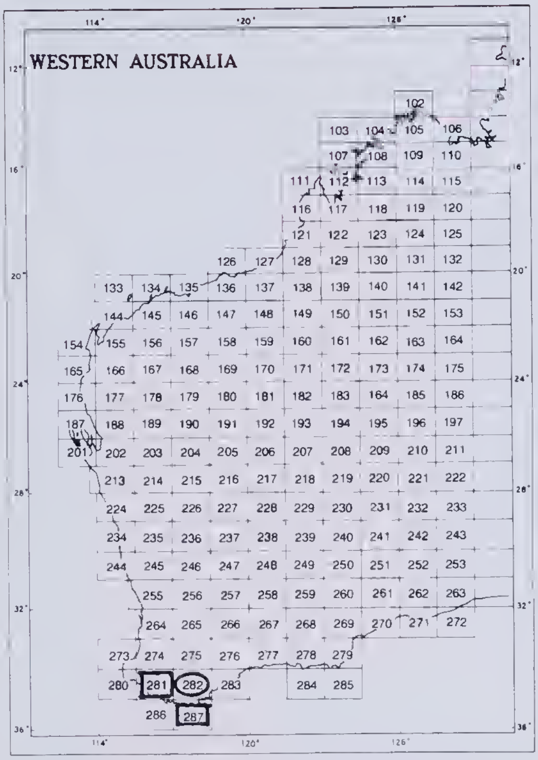
The maps are based partly on specimens in the Western Australian Herbarium (PERTH). As well ground surveys were made covering all the grid cells included in the area bounded by Carnarvon, Kalgoorlie and Esperance. The ground survey method was to examine plants seen alongside roadsides and in adjoining farmland. This was done opportunistically between 1981 and 1984. A questionnaire distributed to farmers throughout the south west region also gave an indication of where to search. Field identification of species was based on fruiting plants and Rechinger's recent survey (1984). As well surveys were carried out with Rechinger to confirm field identifications.



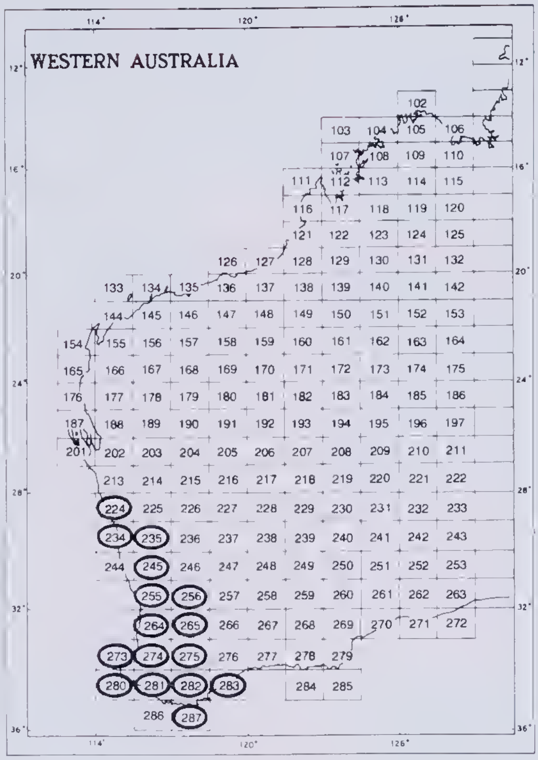
Rumex acetosella *Rumex bucephalophorus*

Rumex conglomeratus *Rumex crispus*

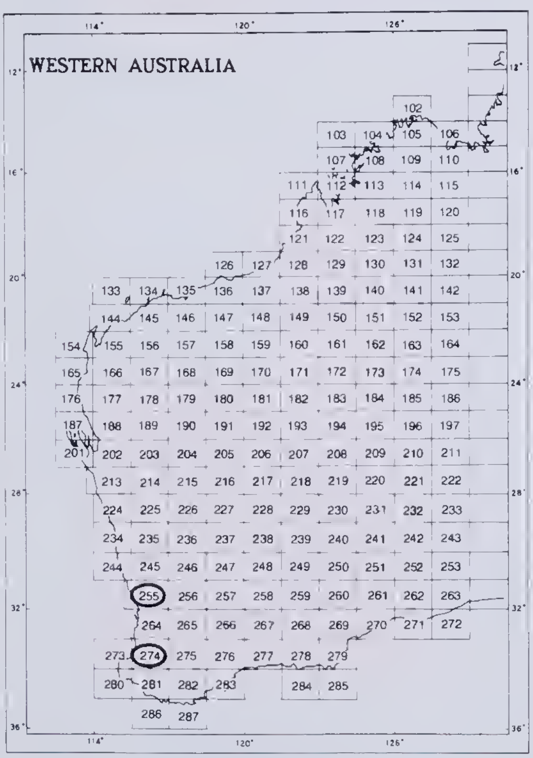
Figure 1. Distribution of *Rumex* species introduced in Western Australia.



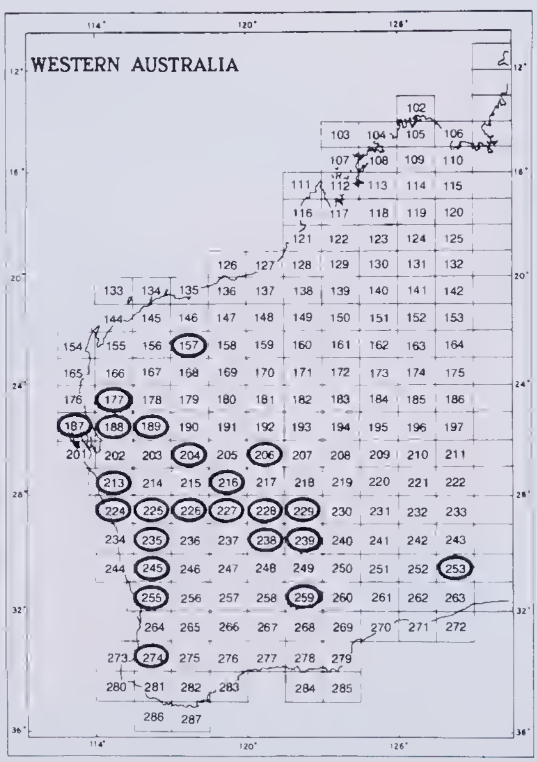
Rumex frutesescens (circled) and *Rumex obtusifolius*



Rumex pulcher



Rumex sagittatus



Rumex vesicarius

Figure 1 (continued). Distribution of *Rumex* species introduced in Western Australia.

Results and Discussion

Figure 1 shows the distribution of *Rumex* species introduced in Western Australia. All the introduced species, except *R. vesicarius,* are restricted to the south west of Western Australia (Figure 1). In this area *R. crispus* was the most widespread species, being found in 22 grid cells. This number is however inflated by single occurrences in the dryer areas such as for Kalgoorlie where the plants are found near water sources in townships. *Rumex pulcher* and *R. acetosella* were both found in 16 grid cells. The distribution given here for *R. acetosella* corresponds with that published in Archer and Martin (1979). The next most abundant species in the south west was *R. conglomeratus* which occurred in nine grid cells, most of which were restricted to the extreme south west corner. Only one other species, *R. obtusifolius,* is known to be definitely present in the south west. It is restricted to two grid cells on the south coast.

The remaining three recorded introduced species in the south west are possibly no longer extant. All are only known from herbarium specimens. In 1981 both authors examined the collection area of *R. bucephalophorus* but no plants were found. This plant was collected once in 1963. *Rumex sagittatus* has only been collected from the urban areas of Perth and Bunbury (Rechinger 1984) and is not known from agricultural areas. Lastly the only known specimen of *R. frutescens* was collected by one of us (Moore) in 1981. Since then visits to the collection site by the authors in 1982 and 1984, and Rechinger (1984) have failed to find further plants.

Rumex vesicarius will probably prove to be the most widespread species with further collecting in the centre of Western Australia. At present it is known from 23 grid cells however at least two, 255 and 274, in the wetter south west area are probably incidental records.

Only one region, the far north of Western Australia, has neither introduced nor native species of *Rumex* (Rechinger 1984).

In conclusion nine species of *Rumex* have been recorded as introduced into Western Australia and six are definitely established. Eight species are found in the south west while the remaining species occurs mainly in the central dryer areas.

Acknowledgements

We thank the Western Australian Herbarium for access to their collections. We also thank the Entomology Branch and the Albany Office of the Western Australian Department of Agriculture for various assistance. The project was funded in part from a grant from the Australian Meat Research Committee.

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Ecology of Pinnaroo Valley Memorial Park, Western Australia: floristics and nutrient status

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Abstract

Foulds, W. Ecology of Pinnaroo Valley Memorial Park, Western Australia: floristics and nutrient status. Kingia 1(1): 27-48 (1987). The floristics and nutrient status of Pinnaroo Valley Memorial Park, Perth, are described. The vegetation was represented by a low, open *Banksia* woodland with emergent *Eucalyptus marginata*, on neutral yellow sands belonging to the Spearwood Dune System. One hundred and eighty three plant species were recorded, of which 41 were introduced. The tree canopy comprised five species with *Banksia attenuata* dominant. *Xanthorrhoea preissii* was the most abundant understorey species. Macro- and micronutrient analyses were conducted on soil, plant and litter samples. The soil was found to be deficient in carbon, phosphorus and nitrate nitrogen, but relatively high in potassium. Species belonging to the Leguminosae family contained nearly twice the nitrate nitrogen content in above-ground tissue compared to species in other families.

Introduction

Pinnaroo Valley Memorial Park, occupying an area of 11 hectares in the Perth suburb of Padbury, Western Australia (31° 45'S; 115° 52'E), is a reserve set aside as a cemetery and recreation area. The Park is situated approximately 2 km from the Indian Ocean on the Spearwood Dune System (Bettenay *et al.* 1960). The vegetation consists of low open *Banksia* woodland.

The Spearwood dunes have had a complex history, being subjected to both deposition and later erosion (Seddon 1972). In its natural state the Spearwood System supports a high open forest of *Eucalyptus gomphocephala, E. marginata* and *E. calophylla*. In the western portion the dunes are generally younger and the shallower soils are referred to as the Cottesloe Soil Association (Seddon 1972). These soils support a similar species composition as the deeper Karrakatta soils to the east. *E. gomphocephala*, however, is much more common than *E. marginata* and *E. calophylla*, and limestone usually occurs within 2 metres of the surface in the Cottesloe soils. A nearby *Banksia* woodland at Star Swamp, which lies within the Cottesloe Association, is dominated by *Banksia attenuata, B. menziesii* and *B. prionotes*, with minor contributions of *E. gomphocephala*, and *Allocasuarina fraseriana* (Bell *et al.* 1979). The top soil is generally dark grey-brown becoming yellowish-brown deeper, with a neutral pH value. In general, the soils of the Spearwood System are moderately to weakly leached with low calcium levels, high iron content and weakly acidic pH values (Havel 1976). The Star Swamp understorey includes *Xanthorrhoea preissii, Jacksonia sternbergiana* and *Dryanda nivea*, while the more common introduced species are *Ehrharta longiflora, Avena barbata, Hypochaeris glabra* and *Romulea rosea* (Bell *et al.* 1979). The percentage of plant cover from introduced species is 36%.

The study area has a dry Mediterranean climate with average annual rainfalls of ca 740 mm per year. About 80% of the yearly total falls in winter between the months of May and August. The winters are mild with mean temperatures of: maximum 18.7°C and minimum 9.9°C, while summers are warm to hot with mean temperatues of: maximum 29.9°C and minimum 18.6°C.

Methods

Three areas of native woodland within Pinnaroo Valley Memorial Park were selected for this study: 4, 6 and 11 (Figure 1). They were similar with respect to topography and vegetation. Area 11 was burned in 1979, but the fire histories of the other areas were unknown. The study was conducted mainly in September of 1981 and 1982, although visits were made each month to record flowering data.

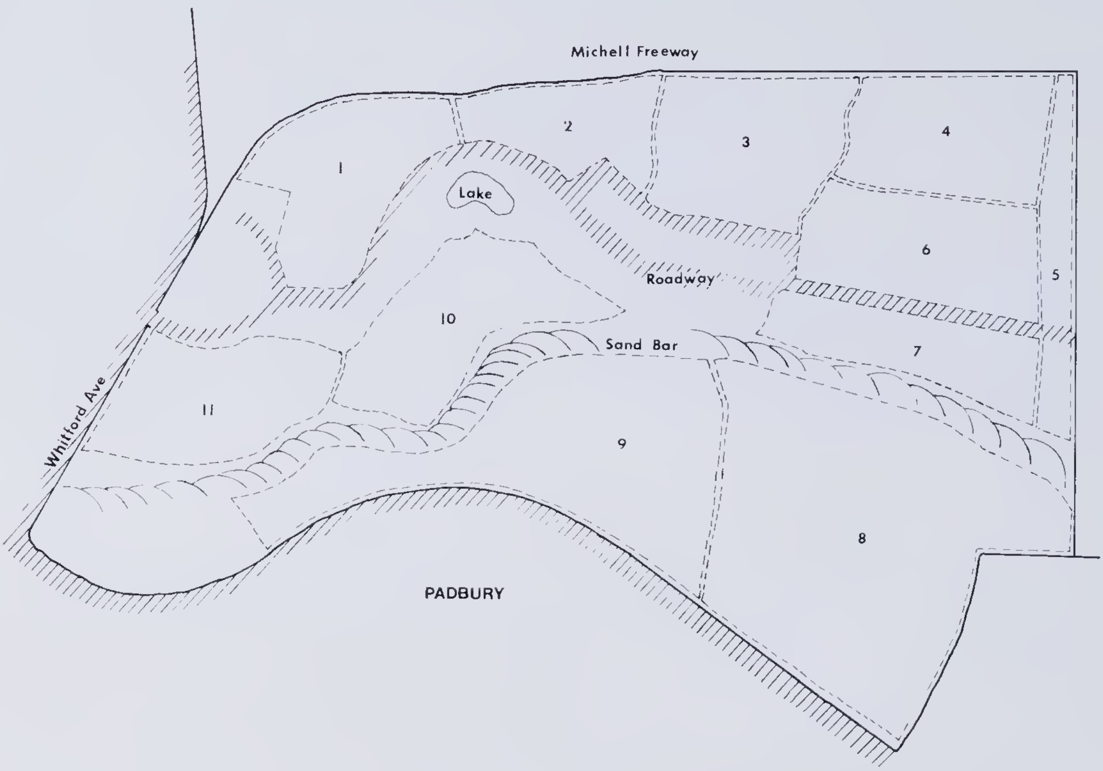

Figure 1. Map of Pinnaroo Valley Memorial Park.

Vegetation

A number of plots, each 10 m^2 in area, were established at each of the three areas and a list of vascular plants was constructed. The nomenclature followed Green (1985). A voucher specimen for each plant species was deposited in the Western Australian Herbarium (PERTH). All perennial species were given a cover/abundance value on the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). To determine the frequency and percentage cover of herbaceous species a 1 m^2 quadrat was divided into 100 equal subsections. Each occurrence of a plant in a subsection was recorded. This was repeated ten times for each area.

Measurements of the tree canopy were made by recording tree height, diameter at breast height (dbh) and number of stems ($\geqq$ 4 cm) within 30 m x 30 m quadrats. Two such quadrats were sampled in each of the three areas. The biomass of the shrub and herb layers was determined by collecting above ground living plant material in four random 1 m^2 quadrats at each site. The litter retained by a 1 mm sieve was also gathered from the same 1 m^2 quadrats. The litter and plant material were oven dried at 95°C to constant weight.

The frequency (%) and the relative cover abundance (%) for herbaceous species and the relative dry weight contribution (%) for the perennial shrub species were calculated as follows:

F(%) = number of quadrats including a species x 100/total number of quadrats
RCA(%) = total % cover for a species x 100/total % cover for all species
RDW(%) = dry weight of a single species x 100/total dry weight for all species.

Nutrients

Five soil samples from the surface 10 cm were collected at each site and analysed by C.S.B.P. and Farmers. Spectrophotometric determinations were undertaken on sodium bicarbonate extractable phosphorus and potassium. The water soluble nitrate-nitrogen (NO_3-N) was calculated with a nitrate specific ion electrode at 30°C. D.T.P.A. extractable copper, zinc and manganese concentrations were determined by atomic absorption.

Samples of above ground living plant material were harvested for nutrient analyses in October. At least ten herbaceous plants and ca 10 cm of new growth (both stem and leaf) from a minimum of ten shrubs, were collected per sample.

Analyses of the shoot and litter material after acid digestion gave the total P, K and N as mg g^{-1} and the Cu, Zn and Mn as $\mu g\ g^{-1}$.

The carbon content was determined by oven drying at 100°C overnight and then heating to 500°C for eight hours.

Results

Vegetation

The vegetation was a low open *Banksia* woodland with emergent *Eucalyptus marginata* trees. The flora was relatively rich and varied, with 183 species recorded within 50 families (Appendix 1). There were 69 woody perennial and 114 herbaceous species. The flora excluded the numerous planted trees and shrubs in the gardens and 10 species associated with a nearby lake (Appendix 2). The herbs included 39 introduced annual species, but only 2 introduced perennials, *Solanum sodomeum* and *Pelargonium capitatum*.

Table 1. Tree canopy parameters.

Species	No. stems ha^{-1}	Basal area ($m^2\ ha^{-1}$)	Average height (m)
Eucalyptus gomphocephala	5.5	9.6	14.2 (30)*
E. marginata	93.6	24.1	9.3 (18)
Banksia attenuata	338.7	22.9	3.0 (8)
B. menziesii	51.4	4.8	4.5 (9)
Allocasuarina fraseriana	14.8	2.4	4.0 (9)
Total	504.0	63.8	

* Height of tallest tree in woodland shown in parenthesis.

The tree canopy was made up of five species of which *Banksia attenuata* was dominant (Table 1 and Appendix 1) with a density of 338.7 stems ha^{-1}, a basal area of 22.9 $m^2\ ha^{-1}$, an average height of 3 m, and a frequency of 82%. *E. marginata* was the next most common species, while all other species had little influence on the density of the upper stratum. *Banksia menziesii* was interesting in that all three flower colour variants (red, yellow and rusty brown) were present in the park.

Xanthorrhoea preissii was the most abundant understorey species with a frequency of 100% and a biomass contribution of over 25% for the whole of the lower stratum (Appendix 1). Other common shrubs included four *Daviesia* species, mostly with frequencies greater than 50%, while *Daviesia nudiflora* contributed 6% of the total biomass. Members of this genus flowered in winter and a yellow-flowered variant of *D. nudiflora* was observed. Three *Hibbertia* species were recorded, with the ubiquitous *Hibbertia hypericoides* contributing 3% of the total dry weight. Another common south-western Australian species, *Bossiaea eriocarpa*, was also frequently found.

The predominant herbaceous species in the southern site was *Mesomelaena stygia* which contributed 27% of the total biomass, 14% cover and had a frequency of 80% occurrence. *Loxocarya flexuosa* and *Restio* aff. *sphacelatus* were dominant in the northern site, each contributing over 10% of the cover and biomass. The most common introduced species were the two geophytes, *Romulea rosea* and *Homeria flaccida*, which were 4.7% and 1% of the total biomass and had frequencies of 50% and 27%, respectively. They were followed by three annuals, in order of decreasing cover abundance, *Hypochaeris glabra*, *Briza maxima*, and *Trifolium campestre*. Introduced species provided 52% of ground floor cover (Table 2). Although there was a similar number of introduced species at both sites, the northern sites had 30% more cover. The northern sites had double the dry weight of litter compared to the southern sites (Table 3). This was probably due to the greater density of *Banksia attenuata* trees and their consequent leaf fall, rather than to any small differences in understorey densities.

Table 2. Total number and cover abundance (m^2) of native and introdueed herbaceous species in the northern (roadside) and southern sites.

Species types	Northern site		Southern site		Total Park	
	No. spp.	Cover	No. spp.	Cover	No. spp	Cover
Native	20	51.5	23	33.6	31	85.1
Introduced	13	45.0	12	24.7	18	69.7

Only those species recorded in quadrat data are included.

Table 3. Average dry weight ($g\ m^{-2}$) of living vegetation and litter of the Northern and Southern sites.

Species Types	Sites		
	Northern	Southern	Park Average
Woody perennials	120.6 (4)	159.6 (8)	146.6
Native herbs	96.8 (4)	117.6 (8)	110.6
Introduced herbs	21.8 (4)	0.0 (8)	7.3
Litter	127.3 (7)	63.0 (10)	89.5

Number of samples shown in parenthesis

The main flowering period for most species was early spring (Figure 2). The response to the winter rains was reflected in the spring flowering winter annuals. Although the dry summer usually inhibits growth and reproduction, *Banksia attenuata*, *Leucopogon propinquus*, *Melaleuca acerosa* and *Calytrix fraseri* of the shrub component and *Restio* aff. *sphacelatus*, *Ptilotus caespitulosus*, *Thysanotus patersonii* and *Tricoryne elatior* of the herb layer flowered mostly at this time of year. The natives *Jacksonia sternbergiana* and *Scaevola paludosa* and the well adapted exotics *Pelargonium capitatum* and *Solanum nigrum* flowered all year round, while *Corynotheca micrantha* possessed flowers for only a few days. *Drosera erythrorhiza* and *Conostylis teretifolia* were never observed to bloom between 1979 and 1983.

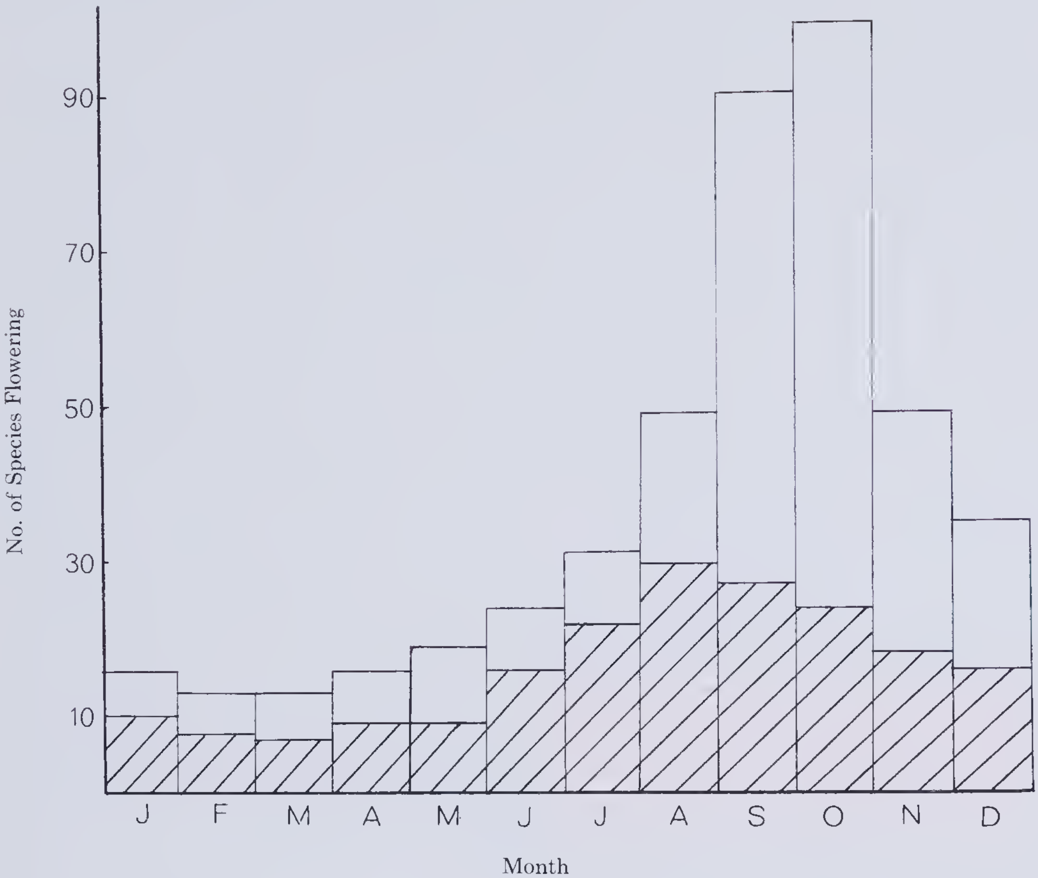

Figure 2. Number of species flowering during each month of the year. The data summarize observations from 1981 and 1982 (shrubs, hatched; herbs, open).

Mineral Nutrient Status

The soils were neutral yellow sands varying in depth from zero to 11 metres over pinnacles of limestone. The carbon content was low compared to darker soils such as sand heaths (Table 4).

As in the case with most Australian soils there was a paucity of nutrients (Table 4), particularly phosphorus and nitrate nitrogen, but compared to Quindalup and Bassendean soils the potassium level was relatively high ($24.8 \mu g\ g^{-1}$). The low chloride content of $20 \mu g\ g^{-1}$, compared with $261.5 \mu g\ g^{-1}$ for foredunes, could be attributed to the distance of the study area from the sea and a decrease in deposition of aerosol salt.

Table 5 shows that the average phosphorus content of the litter, $0.2\ mg\ g^{-1}$, and plant tissues, $0.08\ mg\ g^{-1}$, were like the soil, very low compared with other macronutrients tested such as K, $9.8\ mg\ g^{-1}$ and NO_3-N, $10.3\ mg\ g^{-1}$. Members of the family Papilionaceae possessed twice the NO_3-N content compared with other species analysed (Table 5). The species dominating the ecosystem, *Banksia attenuata*, was relatively low in N, P and K. Along with *Banksia menziesii* and *Dryandra nivea* it contained massive quantities of manganese. This rich source of Mn probably accounts for the high levels recorded in the litter.

Table 4. Nutrient Status of Quindalup, Spearwood and Bassendean Soil Association.

Soil Association / Habitat	W.A. District	Distance from sea	Annual rainfall (mm)	pH	C (%)	Fe ($\mu g\ g^{-1}$)	P	K	NO_3-N	Cu	Zn	Mn	Cl
QUINDALUP													
Fore-Dune	Greenough	20 m	505	9.2	0.9	2.6	20.0	23.8	26.5	0.27	0.33	0.90	261.5
Shrubland	Green Head	500 m	541	8.2	7.0	4.2	11.5	31.0	20.3	0.11	0.40	0.90	107.6
SPEARWOOD													
Banksia Woodland	Pinnaroo	2 km	740	7.0	2.2	16.0	3.0	24.8	8.2	0.38	0.46	2.10	< 20
BASSENDEAN													
Banksia Woodland	Gnangara	14 km	896	5.8	2.4	-	1.7	7.3	2.0	-	-	-	< 20

Table 5. Nutrient Status of the more common plant species and the litter layer.

	$mg\ g^{-1}$			$\mu g\ g^{-1}$		
	P	K	NO_3-N	Cu	Zn	Mn
Litter	0.2	2.0		1.4	8.1	39.5
POACEAE						
**Briza maxima*	1.2	13.5	7.1	2.6	9.9	49
**Lagurus ovatus*	1.0	14.6	5.2	1.8	19.5	23
Stipa compressa	1.1	12.1	5.8	2.2	10.9	21
CYPERACEAE						
Lepidosperma gracile	0.4	9.6	5.5	3.3	11.8	41
Mesomelaena stygia	0.5	6.3	5.4	2.4	8.3	25
RESTIONACEAE						
Loxocarya flexuosa	0.6	10.7	6.3	2.4	14.2	63
Restio aff. *sphacelatus*	0.4	7.8	8.0	1.0	8.0	71
XANTHORRHOEACEAE						
Xanthorrhoea preissii	0.5	9.5	4.5	1.8	5.1	10
CASUARINACEAE						
Allocasuarina fraseriana	0.5	6.8	5.6	2.2	28.6	20
PROTEACEAE						
Banksia attenuata	0.5	4.5	7.6	10.4	11.4	241
Banksia menziesii	0.6	3.2	5.5	4.0	10.2	220
Dryanda nivea	0.6	5.0	4.4	2.7	7.4	135
Petrophile linearis	0.6	5.8	4.7	1.3	10.0	21
PAPILIONACEAE						
Daviesia decurrens	0.8	8.5	12.7	5.3	12.5	33
Daviesia divaricata	0.8	4.8	8.4	7.9	6.3	7
Daviesia gracilis	0.5	6.0	10.5	3.1	5.6	28
Daviesia nudiflora	0.8	8.8	14.5	6.2	7.3	15
Hardenbergia comptoniana	1.2	17.4	15.2	2.4	10.3	20
Jacksonia sternbergiana	1.0	9.2	13.1	2.4	12.8	11
Kennedia prostrata	1.1	13.4	17.9	4.2	21.2	69
Oxylobium capitatum	0.6	8.2	13.9	2.9	13.1	29
**Trifolium campestre*	1.7	14.8	26.8	5.2	27.8	39
DILLENIACEAE						
Hibbertia hypericoides	0.6	7.1	9.9	3.1	10.8	38
Hibbertia racemosa	0.6	7.9	7.9	11.2	23.4	38
MYRTACEAE						
Eucalyptus gomphocephala	0.9	6.2	7.1	2.4	11.8	33
Eucalyptus marginata	1.1	5.9	7.5	10.5	15.2	31
GOODENIACEAE						
Scaevola canescens	0.7	13.4	8.9	1.6	11.1	15
Scaevola paludosa	0.7	16.9	7.0	2.5	13.0	18
ASTERACEAE						
**Hypochaeris glabra*	1.6	23.5	7.8	2.5	32.7	19
Waitzia suaveolens	1.0	13.6	9.2	7.4	29.7	30
MEAN	0.8	9.8	10.3	4.0	14.0	47.1

* Naturalized alien species.

Discussion

The *Banksia* community at Pinnaroo Valley Memorial Park was similar to the nearby woodland at Star Swamp (Bell *et al.* 1979) which was dominated by *Banksia* species and with minor contributions by *Eucalyptus gomphocephala* and *Allocasuarina fraseriana*. However, the frequency of *Eucalyptus marginata* in Pinnaroo Park was much greater and the understorey layer also showed local variations. *Xanthorrhoea preissii* was predominant and although the ubiquitous *Hibbertia hypericoides* was commonly seen, the shrub canopy was dominated by the four *Daviesia* species.

Pinnaroo Park was floristically similar to other *Banksia* communities found in Spearwood sand north of Perth, e.g. Type D of Havel (1976), but lacked certain shrub species such as *Synaphea polymorpha*. The *Banksia* woodland described by Milewski and Daridge (1981) at Jandakot Airport occupies deep, highly leached white over yellow sand between the Bassendean and Spearwood Dune Systems, and differs mainly in the composition of the shrub stratum. At that site *Beaufortia elegans* and *Leucopogon kingianus* are common, but both are absent at Pinnaroo. In areas where yellow sand reached the surface mutually common components were *Mesomelaena stygia*, *Hibbertia racemosa* and *Daviesia nudiflora*.

The Pinnaroo woodland had a typical Western Australian ground floor vegetation, with few grasses and the ground cover predominantly *Mesomelaena stygia* and two species of Restionaceae.

Degradation of vegetation, similar to that seen at Star Swamp, is evident from the high frequency of introduced 'weedy' species and the presence of pyrogenic grasses, typical of often-burnt vegetation. This was particularly true in the case of the northern section of the Park where secondary succession was occurring faster than in the southern areas. Here a new floristic composition is evolving, caused by the introduction of alien species. In this altered community there was no regeneration of *Eucalyptus gomphocephala*, although young *Banksia* and *E. marginata* saplings were common.

The woodland community, which developed in mildy leached soils, contained a large number of species. Areas where severe conditions prevail are reported to support fewer species (Bell 1980). The presence of *Xanthorrhoea preissii* suggested a relatively moist habitat whereas the presence of *Hibbertia hypericoides*, *Mesomelaena stygia* and *Petrophile macrostachya* indicated a substratum of a weakly leached sandy soil, typical of the Spearwood Series (Havel 1976). This was confirmed by the level of soil nutrients which although well below that of coastal sand dune areas had more than double the amount of macronutrients (PKN) of the leached Bassendean sands (Table 4).

The plant tissues that had been shown to act as a means of storage of nutrients in woodland communities, (Ovington 1962) were relatively low in P but did possess larger quantities of other minerals. Legume species were a common component of the understorey and with their high nitrogen content, the soil N should be maintained.

Excessive leaching of the nutrients through the permeable sandy, humus-depleted soil by the winter rains may be prevented by the *Banksia* trees acting as reservoirs. Slow growing species, gradual leaf fall and low litter component caused a slow recycling of nutrients, although fire probably speeds up the turnover to some degree.

Nutrient input by clearfall rain was low compared to that in a nearby coastal heathland area located at Ocean Reef (Foulds unpublished data). Although the July K recording was the same, 1.2 kg ha^{-1}, no phosphorus, nitrate nitrogen or trace elements were found.

Estimates of canopy nutrient leaching from tree leaves and stems by throughfall rain in Eucalypt forests (Smith 1974) suggests that some mineral replacement in the *Banksia* woodland would occurr in this manner. This is probably true for manganese which was present in extremely large quantities in the shoots of *Banksia menziesii* and *B. attenuata*. The accumulation of ions, such as Mn, by indigenous plants from nutrient deficient soil suggests a specialised adaptation. In the case of the Banksias and *Dryanda nivea*, which contained a high amount of Mn, their success may have been due to the presence of proteiod roots (Lamont 1974).

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Appendix 1. Name, family, type, origin, frequency, cover and biomass of species in the woodland area of Pinnaroo Valley Memorial Park

W = Woody perennial; H = herb; n = native; i = introduced; F = frequency; RCA = Relative cover abundance (herbs); RDW = dry weight contribution; ECA = estimated cover abundance (shrubs) [o = occasional plant; r = rare (0.1%); f = few (0.1-1%); c = common (1-5%); ab = abundant (5-25%)] nf = no flowers.

Species (nomenclature after Green 1985)	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Acacia cochlearis (Labill.) H.L. Wendl. Rigid Wattle	Mimosaceae	W(n)	-	-	-	o	Aug
Acacia cyclops Cunn. ex Don	Mimosaceae	W(n)	-	-	-	o	Sept
Acacia lasiocarpa Benth.	Mimosaceae	W(n)	-	-	-	o	Sept
Acacia pulchella R.Br. Prickly Moses	Mimosaceae	W(n)	5.9	-	-	r	Sept
Acacia rostellifera Benth.	Mimosaceae	W(n)	-	-	-	o	Aug-Oct
Acacia saligna (Labill.) H.L. Wendl. Orange Wattle	Mimosaceae	W(n)	17.6	-	-	r	Sept
Acacia willdenowiana H.L. Wendl. Wattle Grass	Mimosaceae	W(n)	5.9	-	-	r	Jul-Aug
Acanthocarpus preissii Lehm. Prickly Lily	Dasypogonaceae	W(n)	3.3	0.8	-	o	Apr-Aug
Agropyron scabrum (Labill.) P. Beauv. Common Wheatgrass	Poaceae	H(n)	13.3	4.7	-	-	Oct
Agrostocrinum scabrum (R.Br.) Baillon False Blind Grass	Anthericaceae	H(n)	6.7	0.1	-	-	Sept-Oct
Allocasuarina fraseriana (Miq.) L. Johnson	Casuarinaceae	W(n)	17.6	-	-	f	Aug-Oct
Allocasuarina humilis (Otto & Dietr.) L. Johnson Dwarf Casuarina	Casuarinaceae	W(n)	-	-	-	o	Aug-Oct
Anagallis arvensis var. *caerulea* (L.) Gouan Blue Pimpernel	Primulaceae	H(i)	-	-	-	-	Sept-Oct

Anigozanthos humilis Lindley Cat's Paw	Haemodoraceae	H(n)	-	-	-	-	Sept-Nov
Anthocercis littorea Labill. Yellow Tailflower	Solanaceae	W(n)	5.9	-	-	r	June-Sept
Arctotheca calendula (L.) Levyns Capeweed	Asteraceae	H(i)	-	-	-	-	Sept-Oct
Asteridea pulverulenta Lindley	Asteraceae	H(n)	-	-	-	-	Oct-Dec
Avena barbata Link Bearded Oat	Poaceae	H(i)	3.3	0.1	-	-	Oct-Nov
Banksia attenuata R.Br. Sandplain Banksia	Proteaceae	W(n)	82.4	-	-	ab	Nov-Feb
Banksia grandis Willd. Bull Banksia	Proteaceae	W(n)	-	-	-	o	Aug
Banksia menziesii R.Br. Menzies' Banksia	Proteaceae	W(n)	35.3	-	-	c	Apr-Sept
Banksia prionotes Lindley Orange Banksia	Proteaceae	W(n)	-	-	-	r	May-Jul
Bossiaea eriocarpa Benth. Granny's Bonnets	Papilionaceae	W(n)	53.0	-	4.4	c	Oct-Nov
Brassica tournefortii Gouan Wild Turnip	Brassicaceae	H(i)	-	-	-	-	Jul-Aug
Brassicaceae sp. indet. (WFP1)	Brassicaceae	H(i)	-	-	-	-	Sept
Briza maxima L. Quaking Grass	Poaceae	H(i)	46.7	8.2	-	-	Sept-Nov
Briza minor L. Lesser Quaking Grass	Poaceae	H(i)	16.7	1.1	-	-	Sept-Oct
Bromus diandrus Roth Great Brome	Poaceae	H(i)	-	-	-	-	Sept
Burchardia umbellata R.Br. Milkmaids	Colchicaceae	H(n)	-	-	-	-	Sept-Oct

Species	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Caladenia deformis R.Br. Blue Fairy Orchid	Orchidaceae	H(n)	-	-	-	-	Jul-Sept
Caladenia ferruginea Nicholls Rusty Spider Orchid	Orchidaceae	H(n)	-	-	-	-	Oct
Caladenia filamentosa R.Br. Spider Orchid	Orchidaceae	H(n)	-	-	-	-	Sept-Oct
Caladenia flava R.Br. Primrose Orchid	Orchidaceae	H(n)	-	-	-	-	Sept-Oct
Caladenia longicauda Lindley White Spider Orchid	Orchidaceae	H(n)	-	-	-	-	Sept-Oct
Calandrinia liniflora Fenzl	Portulacaceae	H(n)	-	-	-	-	Oct-Nov
Calocephalus brownii (Cass.) F. Muell.	Asteraceae	W(n)	-	-	-	o	Jan
Calothamnus sanguineus Labill. Silky Leaved Blood Flower	Myrtaceae	W(n)	-	-	-	o	Jul-Aug
Calytrix fraseri Cunn.	Myrtaceae	W(n)	-	-	-	o	Jan-Feb
Carpobrotus edulis (L.) L. Bolus Hottentot Fig	Aizoaceae	H(i)	6.7	1.6	0.6	-	May-Nov
Cerastium glomeratum Thuill. Mouse Ear Chickweed	Caryophyllaceae	H(i)	-	-	-	-	Aug-Sept
Clematis microphylla DC. Small Leaf Clematis	Ranunculaceae	W(n)	-	-	-	o	Aug-Sept
Comesperma confertum Labill.	Polygalaceae	W(n)	-	-	-	o	Sept-Oct
Conospermum distichum R.Br.	Proteaceae	W(n)	-	-	-	o	Oct
Conospermum triplinervium R.Br. Tree Smoke Bush	Proteaceae	W(n)	-	-	-	o	Oct-Nov
Conostephium pendulum Benth. Pearl Flower	Epacridaceae	W(n)	29.4	-	2.1	f	Apr-Aug

Conostephium preissii Sonder Lesser Pearl Flower	Epacridaceae	W(n)	17.6	-	-	f	Dec
Conostylis aculeata subsp. *bracteata* R.Br. Spiny Cotton Head	Haemodoraceae	H(n)	16.7	0.7	-	-	Jul-Nov
Conostylis teretifolia J.W. Green Spiny Conostylis	Haemodoraceae	H(n)	-	-	-	-	July
Conyza bonariensis (L.) Cronq. Flaxleaf Fleabane	Asteraceae	H(i)	-	-	-	-	Dec
Corynotheca micrantha (Lindley) J.F. MacBr.	Anthericaceae	H(n)	3.3	0.1	-	-	Dec
Crassula colorata (Nees) Ostenf. Dense Stonecrop	Crassulaceae	H(n)	3.3	0.1	-	-	Sept-Oct
Cynodon dactylon (L.) Pers. Couch	Poaceae	H(n)	-	-	-	-	nf
Cyperaceae sp. indet. (WFP2)	Cyperaceae	H(n)	6.7	0.7	-	-	nf
Daucus glochidiatus (Labill.) Fischer, C. Meyer & Ave-Lall. Australian Carrot	Apiaceae	H(n)	13.3	1.3	-	-	Sept
Daviesia decurrens Meissner Thorny Bitter Pea	Papilionaceae	W(n)	41.2	-	-	f	June-Aug
Daviesia divaricata Benth.	Papilionaceae	W(n)	76.5	-	2.0	c	Aug-Oct
Daviesia gracilis M.D. Crisp	Papilionaceae	W(n)	52.9	-	-	c	June-Jul
Daviesia nudiflora Meissner	Papilionaceae	W(n)	76.5	-	6.0	c	Jul-Oct
Dianella revoluta R.Br. Spreading Flax Lily	Phormiaceae	H(n)	-	-	-	-	Nov-Sept
Diplotaxis muralis (L.) DC. Wall Rocket	Brassicaceae	H(i)	-	-	-	-	Nov-Dec
Diuris longifolia R.Br. Donkey Orchid	Orchidaceae	H(n)	-	-	-	-	Sept-Oct

Species	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Drosera erythrorhiza Lindley Red-ink Sundew	Droseraceae	H(n)	10.0	0.7	-	-	nf
Drosera macrantha Endl.	Droseraceae	H(n)	16.7	0.2	-	-	Jul-Oct
Dryandra nivea (Labill.) R.Br. Dwarf Dryandra	Proteaceae	W(n)	29.4	-	-	f	Aug-Sept
Dryandra sessilis (Knight) Domin Parrot Bush	Proteaceae	W(n)	-	-	-	o	Jul-Oct
Ehrharta calycina Smith Perennial Veldtgrass	Poaceae	H(i)	10.0	0.9	-	-	Sept-Oct
Emex australis Steinh. Doublegee	Polygonaceae	H(n)	-	-	-	-	Aug-Sept
Eremaea pauciflora (Endl.) Druce	Myrtaceae	W(n)	-	-	-	o	Nov
Eriostemon spicatus A. Rich. Pepper and Salt	Rutaceae	W(n)	11.7	-	-	f	Oct
Erodium cicutarium (L.) L'Her. Common Crowfoot	Geraniaceae	H(i)	3.3	-	-	-	Aug-Oct
Erodium cygnorum Nees Blue Storksbill	Geraniaceae	H(i)	-	-	-	-	Sept
Eryngium rostratum Cav. Blue Devil	Apiaceae	H(n)	-	-	-	-	Oct
Eucalyptus gomphocephala DC. Tuart	Myrtaceae	W(n)	11.7	-	-	f	Jan
Eucalyptus marginata Donn ex Smith Jarrah	Myrtaceae	W(n)	47.7	-	-	c	Dec
Freesia leichtlinii Klatt Freesia	Iridaceae	H(i)	-	-	-	-	Oct
Geranium molle L. Dove's foot Cranesbill	Geraniaceae	H(i)	3.3	0.05	-	-	Sept

Hibbertia hypericoides (DC.) Benth. Guinea Flower	Dilleniaceae	W(n)	58.8	-	3.0	c	Aug-Dec
Hibbertia polystachya Benth.	Dilleniaceae	W(n)	5.9	-	-	o	Sept-Oct
Hibbertia racemosa (Endl.) Gilg Stalked Guinea Flower	Dilleniaceae	W(n)	58.8	-	-	c	June-Oct
Homeria flaccida Sweet Oneleaf Cape Tulip	Iridaceae	H(i)	26.7	2.2	1.1	-	Sept-Oct
Hovea trisperma Benth. Hovea	Papilionaceae	W(n)	29.4	-	-	f	June-Aug
Hybanthus calycinus (DC. ex Ging.) F. Muell. Wild Violet	Violaceae	H(n)	-	-	-	-	Sept-Nov
Hypocalymma robustum Endl. Swan River Myrtle	Myrtaceae	W(n)	35.3	-	-	f	Aug-Oct
Hypochaeris glabra L. Smooth Catsear	Asteraceae	H(i)	40.0	10.8	0.01	-	May-Nov
Isolepis marginata (Thunb.) A. Dietr.	Cyperaceae	H(n)	26.7	3.1	1.5	-	Sept-Oct
Isolepis sp. (WFP3)	Cyperaceae	H(n)	-	-	-	-	Sept
Isotoma hypocrateriformis (R.Br.) Druce Woodbridge Poison	Lobeliaceae	H(n)	3.3	0.1	-	-	Oct-Nov
Isotropis cunefolia (Smith) Benth. ex B.D. Jackson Lamb Poison	Papilionaceae	H(n)	10.0	0.7	-	-	Sept-Oct
Jacksonia furcellata (Bonpl.) DC.	Papilionaceae	W(n)	-	-	-	o	June-Oct
Jacksonia sericea Benth.	Papilionaceae	W(n)	5.9	-	-	r	June-Oct
Jacksonia sternbergiana Huegel Stink Bush	Papilionaceae	W(n)	11.7	-	-	f	Jan-Dec
Kennedia prostrata R.Br. Scarlet Runner	Papilionaceae	W(n)	41.2	-	-	f	Jul-Oct

Species	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Lachenalia reflexa Thunb.	Hyacinthaceae	H(i)	-	-	-	-	Aug
Lagenifera huegelii Benth. Common Lagenifera	Asteraceae	H(n)	23.3	0.8	-	-	Jul-Sept
Lagurus ovatus L. Hare's tail Grass	Poaceae	H(i)	3.3	0.1	0.01	-	Nov
Lechenaultia linarioides DC. Yellow Lechenaultia	Goodeniaceae	W(n)	-	-	-	o	Oct-Jan
Lepidosperma gracile R.Br. Slender Sword Sedge	Cyperaceae	H(n)	6.7	0.05	-	-	Nov
Leucopogon nutans E. Pritzel	Epacridaceae	W(n)	-	-	-	o	Aug
Leucopogon propinquus R.Br.	Epacridaceae	W(n)	5.9	-	-	r	Feb-Apr
Lobelia rarifolia F. Wimmer	Lobeliaceae	H(n)	-	-	-	-	Dec
Lomandra preissii (Endl.) Ewart	Dasypogonaceae	H(n)	20.0	0.8	0.1	-	May-June
Loxocarya flexuosa (R.Br.) Benth. Cord Rush	Restionaceae	H(n)	50.0	11.7	10.1	-	Sept
Lupinus cosentinii Guss. Sandplain Lupin	Papilionaceae	H(i)	-	-	-	-	Oct-Dec
Luzula meridionalis Nordensk.	Juncaceae	H(n)	-	-	-	-	Oct
Macrozamia riedlei (Fischer ex Gaudich.) C. Gardner Western Zamia	Zamiaceae	W(n)	-	-	-	o	Aug
Medicago polymorpha L. Burr Medic	Papilionaceae	H(i)	-	-	-	-	Sept-Oct
Melaleuca acerosa Schauer	Myrtaceae	W(n)	17.6	-	-	f	Dec-Apr
Melaleuca huegelii Endl. Chenille Honey Myrtle	Myrtaceae	W(n)	-	-	-	o	Dec
Melilotus indica (L.) All. Hexham Scent	Papilionaceae	H(i)	-	-	-	-	Nov

Mesomelaena stygia (R.Br.) Nees	Cyperaceae	H(n)	80.0	17.8	27.1	-	Apr-June
Mesomelaena tetragona (R.Br.) Benth. Semaphore Sedge	Cyperaceae	H(n)	6.7	2.1	-	-	Aug
Millotia myosotidifolia (Benth.) Steetz	Asteraceae	H(n)	6.7	0.05	-	-	Sept-Oct
Olearia axillaris (DC.) F. Muell. ex Benth. Native Rosemary	Asteraceae	W(n)	-	-	-	o	May
Opercularia spermacocea Labill.	Rubiaceae	H(n)	3.3	0.5	0.02	-	Sept-Nov
Orobanche minor Smith	Orobanchaceae	H(i)	-	-	-	-	Oct
Orthrosanthus laxus (Endl.) Benth. Morning Iris	Iridaceae	H(n)	-	-	-	-	Sept-Nov
Oxylobium capitatum Benth. Bacon and Eggs	Papilionaceae	W(n)	35.3	-	-	c	Aug-Oct
Parentucellia latifolia (L.) Caruel Common Bartsia	Scrophulariaceae	H(i)	3.3	-	-	-	Sept
Pelargonium capitatum (L.) L'Her.	Geraniaceae	W(i)	-	-	-	o	Jan-Dec
Pentaschistis airoides (Nees) Stapf	Poaceae	H(i)	16.7	3.9	-	-	Sept-Oct
Persoonia saccata R.Br.	Proteaceae	W(n)	-	-	0.2	o	Nov-Dec
Petrophile linearis R.Br. Pixie Mops	Proteaceae	W(n)	23.5	-	3.0	c	Sept-Nov
Petrophile macrostachya R.Br.	Proteaceae	W(n)	-	-	-	o	June
Petrorhagia velutina (Guss.) P. Ball & Heyw. Proliferous Pink	Caryophyllaceae	W(i)	30.0	1.5	-	-	Sept-Oct
Pimelea floribunda Meissner	Thymelaeaceae	W(n)	-	-	-	o	Oct
Pimelea rosea R.Br. Native Rose	Thymelaeaceae	W(n)	17.6	-	-	r	Oct
Pimelea suaveolens Meissner	Thymelaeaceae	W(n)	-	-	-	o	Oct

Species	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Poa drummondiana Nees Knotted Poa	Poaceae	H(n)	3.3	0.2	-	-	Oct
Poa poiformis (Labill.) Druce Blue Tussock Grass	Poaceae	H(n)	-	-	-	-	Sept
Podolepis gracilis (Lehm.) R.A. Graham Slender Podolepis	Asteraceae	H(n)	-	-	-		Sept
Podotheca chrysantha (Steetz) Benth. Yellow Podotheca	Asteraceae	H(n)	-	-	-	-	Sept
Podotheca gnaphalioides R.A. Graham Golden Long-heads	Asteraceae	H(n)	-	-	-	-	Sept
Polypogon tenellus R.Br. Lesser Beardgrass	Poaceae	H(n)	-	-	-	-	Oct
Pterostylis recurva Benth. Jug Greenhood	Orchidaceae	H(n)	-	-	-	-	Aug
Ptilotus caespitulosus F. Muell.	Amaranthaceae	H(n)	3.3	0.1	-	-	Oct-June
Ptilotus exaltatus Nees Tall Mulla Mulla	Amaranthaceae	H(n)	-	-	-	-	Oct-June
Ptilotus manglesii (Lindley) F. Muell. Rose Tipped Mulla Mulla	Amaranthaceae	H(n)	-	-	-	-	Oct-Jan
Regelia ciliata Schauer	Myrtaceae	W(n)	5.9	-	-	r	Nov-Dec
Restio aff. *sphacelatus* R.Br. (WFP4) Cord Rush	Restionaceae	H(n)	40.0	13.1	7.0	-	Mar-Apr
Rhagodia baccata (Labill.) Moq. Camel Berry	Chenopodiaceae	W(n)	11.7	-	-	r	Dec
Ricinocarpos glaucus Endl. Wedding Bush	Euphorbiaceae	W(n)	35.3	-	-	f	Sept-Nov
Romulea rosea (L.) Ecklon Guildford Grass	Iridaceae	H(i)	50.0	14.3	4.7	-	Aug-Sept

Scaevola canescens Benth. Grey Scaevola	Goodeniaceae	W(n)	70.6	-	0.2	c	Mar-Dec
Scaevola paludosa R.Br. Marsh Scaevola	Goodeniaceae	W(n)	23.5	-	-	f	Jan-Dec
Schoenus grandiflorus (Nees) F. Muell. Large-flowered Bog Rush	Cyperaceae	H(n)	-	-	-	-	Apr-Nov
Senecio hispidulus A. Rich Hispid Fireweed	Asteraceae	H(n)	-	-	-	-	Sept
Senecio lautus G. Forster *ex* Willd. Fireweed	Asteraceae	H(n)	3.3	1.3	-	-	Aug-Nov
Silene gallica L. French Catchfly	Caryophyllaceae	H(i)	13.3	0.6	-	-	Aug-Oct
Solanum nigrum L. Black Berry Nightshade	Solanaceae	H(i)	-	-	-	-	Jan-Dec
Solanum sodomeum L. Apple of Sodom	Solanaceae	W(i)	-	-	-	o	Nov-Feb
Sonchus oleraceus L. Common Sowthistle	Asteraceae	H(i)	16.7	0.8	-	-	Aug-Dec
Sowerbaea laxiflora Lindley Vanilla Lily	Anthericaceae	H(n)	13.3	0.3	-	-	Aug-Oct
Stenopetalum robustum Endl.	Brassicaceae	H(n)	-	-	-	-	Sept
Stipa compressa R.Br. Compressed Speargrass	Poaceae	H(n)	-	-	-	-	Oct-Nov
Stipa aff. *eremophila* Reader (WPF5)	Poaceae	H(n)	-	-	-	-	Oct
Stirlingia latifolia (R.Br.) Steudel Blueboy	Proteaceae	W(n)	17.6	-	-	f	June
Stylidium brunonianum Benth. subsp. *brunonianum* Pink Fountain Trigger Plant	Stylidiaceae	H(n)	3.3	0.05	-	-	Oct
Stylidium calcaratum R.Br. Book Trigger Plant	Stylidiaceae	H(n)	-	-	-	-	Sept-Oct

Species	Family	Type	F%	RCA%	RDW%	ECA	Flowering Period
Stylidium guttatum R.Br. Dotted Trigger Plant	Stylidiaceae	H(n)	3.3	0.05	-	-	Oct-Nov
Stylidium repens R.Br. Matted Trigger Plant	Stylidiaceae	H(n)	-	-	-	-	May
Stylidium schoenoides DC. Cow-kicks	Stylidiaceae	H(n)	-	-	-	-	Oct
Styphelia tenuiflora Lindley Slender-flowered Heath	Epacridaceae	W(n)	5.9	-	-	r	May-June
Tersonia cyathiflora (Fenzl) A.S. George	Gyrostemonaceae	H(n)	-	-	-	-	Sept
Thelymitra fuscolutea R.Br. Leopard Sun Orchid	Orchidaceae	H(n)	-	-	-	-	Oct
Thysanotus banksii R.Br. Common Fringe Lily	Anthericaceae	H(n)	-	-	-	-	Dec
Thysanotus dichotomus (Labill.) R.Br. Branching Fringe Lily	Anthericaceae	H(n)	-	-	-	-	Dec-Feb
Thysanotus multiflorus R.Br. Many Flowered Fringe Lily	Anthericaceae	H(n)	-	-	-	-	Oct
Thysanotus patersonii R.Br. Twining Fringe Lily	Anthericaceae	H(n)	3.3	0.1	-	-	Oct
Thysanotus tenellus Endl.	Anthericaceae	H(n)	-	-	-	-	Oct
Trachyandra divaricata (Jacq.) Kunth	Asphodelaceae	H(i)	-	-	-	-	Oct
Trachymene pilosa Smith Dwarf Parsnip	Apiaceae	H(n)	6.7	0.4	0.2	-	Sept-Oct
Tricoryne elatior R.Br. Yellow Autumn Lily	Anthericaceae	H(n)	6.7	0.4	-	-	Nov-Dec, Mar-Apr
Trifolium campestre Schreber Hop Clover	Papilionaceae	H(i)	46.7	6.3	1.0	-	Sept-Nov

Trifolium glomeratum L. Cluster Clover	Papilionaceae	H(i)	-	-	-	-	Oct
Tripterococcus brunonis Endl.	Stackhousiaceae	H(n)	-	-	-	-	Oct
Ursinia anthemoides (L.) Poiret Ursinia	Asteraceae	H(i)	33.3	1.7	0.03	-	Sept-Oct
Vicia sativa L. Common Vetch	Papilionaceae	H(i)	-	-	-	-	Sept-Oct
Vulpia bromoides (L.) Gray Squirrel tail Fescue	Poaceae	H(i)	-	-	-	-	Oct
Vulpia myuros (L.) C. Gmelin Rat's tail Fescue	Poaceae	H(i)	-	-	-	-	Oct
Wahlenbergia gracilenta Loth. Annual Bluebell	Campanulaceae	H(n)	-	-	-	-	Oct
Waitzia acuminata Steetz	Asteraceae	H(n)	10.0	0.6	-	-	Sept-Oct
Waitzia suaveolens (Benth.) Druce Fragrant Waitzia	Asteraceae	H(n)	23.3	1.8	-	-	Sept-Nov
Xanthorrhoea preissii Endl. Blackboy	Xanthorrhoeaceae	W(n)	100.0	-	27.5	ab	Oct-Nov

Appendix 2. Name, family, type of species associated with Lake near Pinnaroo Valley Memorial Park

W = woody perennial; H = herb; n = native; i = introduced.

Lakeside Species	Family	Type
Anagallis arvensis L. var. *arvensis* Scarlet Pimpernel	Primulaceae	H(i)
Centaurium spicatum (L.) Fritsch ex Janchen Spike Centaury	Gentianaceae	H(n)
Cyperus vaginatus R.Br. Stiffleaf Sedge	Cyperaceae	H(n)
Juncus holoschoenus R.Br. Jointed Rush	Juncaceae	H(n)
Juncus aff. *holoschoenus* R.Br.	Juncaceae	H(n)
Juncus planifolius R.Br. Broadleaf Rush	Juncaceae	H(n)
Lotus angustissimus L. Narrowleaf Trefoil	Papilionaceae	H(i)
Melaleuca rhaphiophylla Schauer Swamp Paperbark	Myrtaceae	W(n)
Rumex crispus L. Curled Dock	Polygonaceae	H(i)
Schoenoplectus validus (M. Vahl) A. Love & D. Love River Clubrush	Cyperaceae	H(n)

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Vegetation surveys near Lake MacLeod

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Abstract

Tyler, J. P. Vegetation surveys near Lake MacLeod. Kingia 1(1): 49-74 (1987). The vegetation adjacent to Lake MacLeod was assessed and documented from 1980-1984. A total of 269 flora species were collected from the area and are currently housed in the Dampier Salt Research Laboratory at Dampier.

The dynamics of the vegetation were assessed using permanent quadrats in four vegetatively distinct areas. For convenience of study, the vegetation was classified in three categories, namely herbs, shrubs less than 1 metre high, and shrubs greater than 1 metre high. The herbs exhibited a distinct annual pattern, with peak numbers of individuals and species occurring in early spring. The number of small shrub species fluctuated with rainfall regardless of the season. Large shrubs exhibited very slow growth rates and few recruitments or deaths.

The impact of grazing animals was assessed using exclosed and unexclosed areas. No significant grazing pressure was found. The Lake MacLeod shrublands were found to regenerate very slowly if degraded by fire. This is due to the inherently slow growth rates of the shrub species.

Introduction

Lake MacLeod is a 2000 km^2 natural coastal salina some 40 km north of Carnarvon. It is separated from the Indian Ocean to the south by a thirty metre high ridge of white sand dunes called the Bejaling Dunes. These are around 2 km wide. To the west of Lake MacLeod lies the Quobba Ridge, a barrier separating Lake MacLeod from the Indian Ocean. The red sand dunes of the Quobba Ridge run parallel to the coast and merge with the Bejaling Dunes. The dunes of the Quobba Ridge overlie limestone which is frequently exposed as rocky outcrops.

Lake MacLeod is in an arid region with an average rainfall of around 200 millimetres per year. It occurs in the major soil zone called desert-steppe. These soils show no characteristic profile due to an absence of leaching and high wind action, and are red to reddish-brown in colour (Prescott 1952). The scrub with associated saltbush, typical of these soils, is in evidence near Lake MacLeod.

There are few published accounts on the vegetation near Lake MacLeod and the area has not been extensively surveyed. This study concerns itself with the vegetation of the Quobba Ridge and the Bejaling Dunes. Both of these areas lie within the Quobba Station pastoral lease and are used as grazing land for sheep. The area also contains feral goats, rabbits and kangaroos.

The purpose of the study is to document the vegetation and floristics, and to assess the impact of grazing animals.

Materials and Methods

1. Vegetation classification

The vegetation was classified into three categories for convenience of study.

These were as follows:

(a) Shrubs greater than one metre high

These were well established shrubs and trees.

(b) Shrubs less than one metre high

These were distinctly woody plants less than one metre high. This category included a number of species such as *Stemodia grossa, Solanum lasiophyllum* and *Acanthocarpus preissii* which even when well established did not reach one metre in height. It also included woody annuals such as *Ptilotus* and *Olearia* and the seedlings of all the larger shrubs.

(c) Herbs

This category included all annual species with soft non-woody stems and all the grasses.

2. Permanent Quadrats

Three permanent quadrats were established in visually-assessed distinctive vegetation zones on the Quobba Ridge. A fourth was established in the Bejaling Dunes (Figure 1). The 20 m x 20 m permanent quadrats were pegged in July 1980 using surveyors pegs and marking tape.

Quadrat 1 Environs

Quadrat 1 was located on the Quobba Ridge, adjacent to the old salt haulage road previously used by Dampier Salt (Operations) Pty Ltd. This road was no longer in use and the area was remote from salt field activities. The quadrat was situated in an area of dense *Acacia* scrub. There were no sheep in the area due to a lack of drinking water, although goats and kangaroos had been sighted. The red sandy soils had a pH around 6.9.

Quadrat 2 Environs

Quadrat 2 was located in the Bejaling Dunes. The vegetation was mainly salt bush (*Atriplex* and *Rhagodia* spp.) interspersed with *Acacia* spp., *Banksia ashbyi* and *Thryptomene baeckeacea*. The white sandy soils were alkaline with a mean pH of 8.0. Sheep, feral goats and rabbits were present in the Bejaling Dunes.

Quadrat 3 Environs

Quadrat 3 was situated on the Quobba Ridge, north of the present salt haulage road from the Lake MacLeod mine site to Cape Cuvier. Like quadrat 1, some twenty kilometres to the north, it had neutral soils of pH 7.0. The vegetation was open *Acacia* scrub and *Triodia* grassland. A bore about a kilometre from the quadrat provided water for sheep and feral goats, which were plentiful in the area.

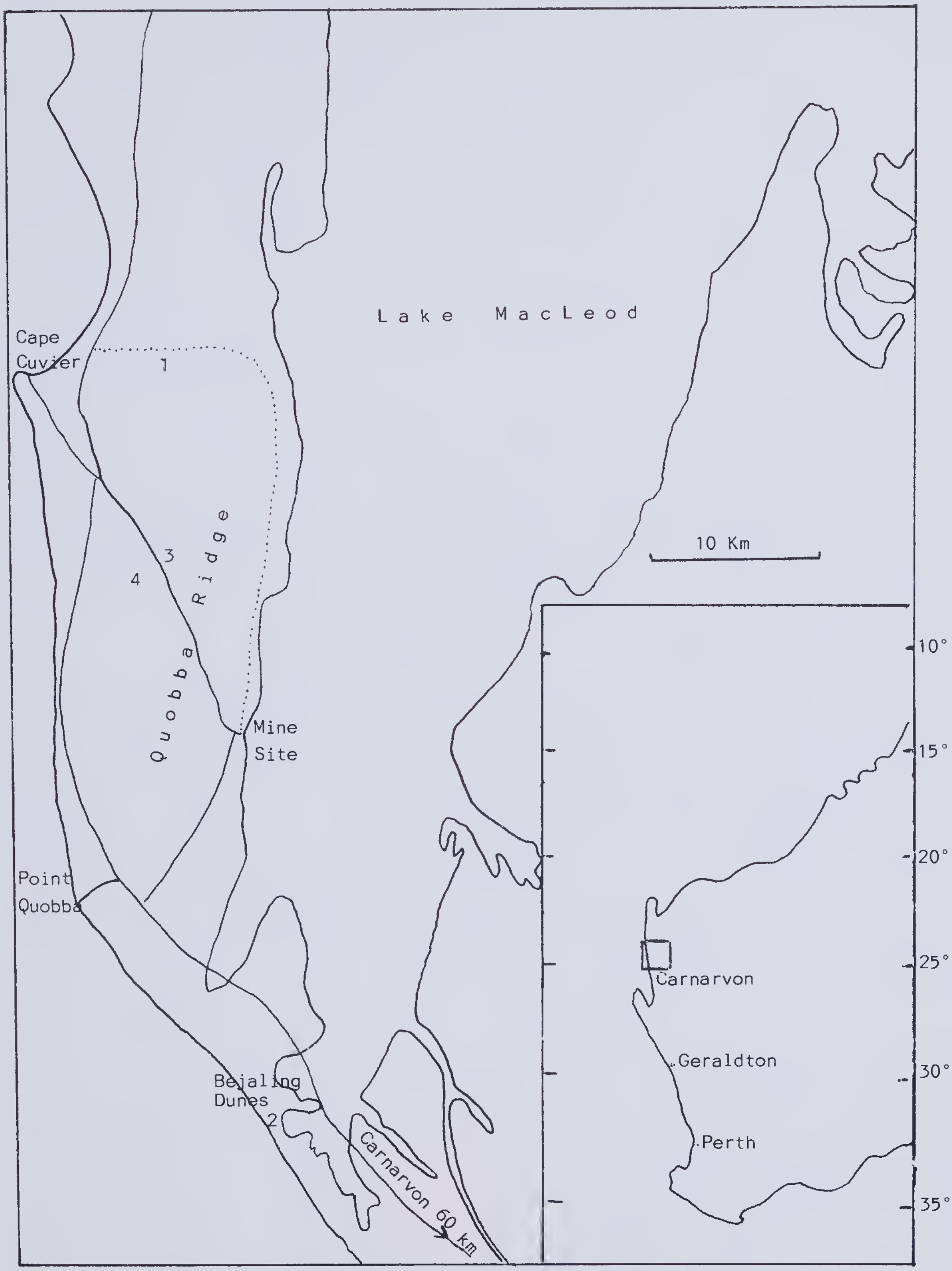


Figure 1. Locality map showing study areas.

Table 1. Rainfall Readings at Lake MacLeod Meteorological Station

(a) Monthly means from 1968-1982 (mm)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
13.0	11.6	21.0	10.1	24.7	43.7	44.7	13.9	5.2	5.1	3.75	0.68

(b) Average yearly rainfall (mm)

1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	Mean
78.1	—	273.3	175.6	147.7	339.8	331.8	198.3	130.4	223.4	67.5	249.8	176.5	181.2	198

(c) Total monthly rainfall (mm) during study period

1980						1981											
July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
14.1	15.0	1.3	9.1	0	0	4.0	14.7	18.4	0	34.5	42.1	24.2	17.2	18.8	0.6	0.4	1.6

1982									
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
93.8	8.1	23.8	0	13.3	23.1	0	10.3	7.3	1.2

Table 2. Number and change in number of shrub species greater than 1 m high recorded in 20 x 20 m permanent quadrats from 1980 to 1982.

	Quadrat 1			Quadrat 2			Quadrat 3			Quadrat 4		
	1980	1982	Changes	1980	1982	Changes	1980	1982	Changes	1980	1982	Changes
Acacia coriacea					2	2	0					
Acacia ligulata				9	7	−2	3	4	+1			
Acacia sclerosperma	1	1	0									
Acacia tetragonophylla	8	9	+1	3	5	+2				1	1	0
Atriplex cinerea				1	2	+1						
Banksia ashbyi				1	1	0						
Corchorus walcottii							2	4	+2			
Dodonaea amblyophylla							3	2	Merged			
Exocarpos aphyllus				1	2	+1	3	3	0			
Grevillea wickhamii	2	4	+2									
Heterodendrum oleaefolium	3	3	0				1	2	+1			
Pimelea microcephala				2	2	+1, −1	1	1	0			
Rhagodia baccata	1	1	0	0	1	+1						
Santalum lanceolatum				1	3	+2						
Scaevola crassifolia				2	2	0						
Scaevola spinescens	16	15	−2, +1	3	3	0						
Scaevola tomentosa	0	1	+1	0	1	+1	5	5	−1, +1			
Stylobasium spathulatum				5	4	−1						
Thryptomene baeckeacea	1	1	0									
Total No. Shrubs	32	35	+3	30	35	+5	18	21	+3	1	1	0
Total No. Species	7	8	+1	11	13	+2	7	7	0	1	1	0

Quadrat 4 Environs

Quadrat 4 was situated less than fifty metres from quadrat 3, but on the southern side of the salt haulage road. A fire in 1979 only burnt the area south of the haul road. The soil and vegetation type were similar to those of quadrat 3, but with far fewer shrubs. A number of plant species common on the north side of the road in a good season, had not been sighted in the previously burnt area. These included *Thysanotus speckii*, *Dichopogon* sp. and *Dianella revoluta.*

The following information was recorded once monthly for 26 months.

(a) The area covered by shrubs greater than one metre in height was mapped onto graph paper. The positioning of the shrubs and their sizes were obtained by pacing. The maps illustrate recruitment and death of shrubs.

(b) A list of all shrubs species less than one metre high in the quadrat was compiled.

(c) All herb species present in the quadrat were listed.

3. Exclosure Experiments

One chicken wire exclosure 3 m x 3 m x 1 m was established in each survey area adjacent to the 20 m x 20 m permanent quadrat. Unexclosed control quadrats were pegged adjacent to the exclosures. A once monthly survey of all quadrats was undertaken. The area covered by shrubs greater than one metre high was mapped. Shrub species less than one metre high and herb species were listed and quantified.

4. Flora List

A list of all flowering plants present on the Quobba Ridge and the Bejaling Dunes was compiled over four years from 1980 to 1984. Plants were mainly collected on the monthly quadrat survey, but extra surveys were undertaken following any period of heavy rain. Occasional specimens were collected on daily journeys to and from the salt field. A habit photograph of most species was taken and pressed specimens of each species are housed in the company herbarium. Specimens were identified using published keys, with doubtful identifications being verified at the Western Australian Herbarium (PERTH). All plant species are listed in Appendix 1. Nomenclature follows Green (1985).

Table 3. Presence of shrubs greater than 1 m high over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat			
	1	2	3	4
Chenopodiaceae				
Atriplex aff. *cinerea*		+		
Rhagodia baccata	+	+	+	
Goodeniaceae				
Scaevola crassifolia		+		
Scaevola spinescens	+	+		
Scaevola tomentosa	+	+	+	
Mimosaceae				
Acacia coriacea		+		
Acacia ligulata		+	+	
Acacia sclerosperma	+			
Acacia tetragonophylla	+	+	+	+
Myrtaceae				
Thryptomene baeckeacea	+			

Table 3 (continued). Presence of shrubs greater than 1 m high over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat 1	2	3	4
Proteaceae				
Banksia ashbyi		+		
Grevillea wickhamii	+			
Santalaceae				
Exocarpos aphyllus		+	+	
Santalum lanceolatum		+		
Sapindaceae				
Dodonaea amblyophylla			+	
Heterodendrum oleaefolium	+		+	
Solanaceae				
Solanum orbiculatum			+	
Surianaceae				
Stylobasium spathulatum		+		
Tiliaceae				
Corchorus walcottii			+	
Thymelaeaceae				
Pimelea microcephala		+	+	
Total Number Per Quadrat:	8	13	10	1

All species with the exception of *Rhagodia baccata* and *Scaevola tomentosa* in Quadrat 2 were present in the quadrats for the whole of the study period.

$$\text{Similarity index} = \frac{\text{Number in common}}{\text{total number in both}} \times 2 \times 100$$

The maximum possible similarity between two samples is 100%
Quadrat 1/Quadrat 2 = 38.1% Quadrat 2/Quadrat 3 = 52.2%
Quadrat 1/Quadrat 3 = 44.4% Quadrat 2/Quadrat 4 = 14.3%
Quadrat 1/Quadrat 4 = 22.2% Quadrat 3/Quadrat 4 = 18.2%

Table 4. Presence of shrubs less than 1 m high over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat 1	2	3	4
Amaranthaceae				
Ptilotus obovatus	+	+	+	+
Ptilotus villosiflorus		+		
Ptilotus sp. 1 (J.P.T. 133 Dampier)	+			
Ptilotus sp. 2 (J.P.T. 134 Dampier)	+			
Asteraceae				
Olearia imbricata				+
Boraginaceae				
Halgania preissiana			+	
Caesalpiniaceae				
Cassia oligophylla		+	+	
Chenopodiaceae				
Chenopodium desertorum		+		+
Einadia nutans		+		
Enchylaena tomentosa	C8m	C9m	C12m	
Maireana tomentosa	+			
Rhagodia baccata	+	+	+	+
Salsola kali		+		

Table 4 (continued). Presence of shrubs less than 1 m high over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat 1	2	3	4
Dasypogonaceae				
Acanthocarpus preissii	C13m	C+	+	
Euphorbiaceae				
Euphorbia atoto	+			
Goodeniaceae				
Dampiera incana	+	+		C
Scaevola crassifolia		+		
Scaevola restiacea				+
Scaevola spinescens	+	+		
Scaevola tomentosa	+	+	+	+
Scaevola sp. (J.P.T. 235 Dampier)			+	
Loranthaceae				
Amyema sp. (J.P.T. 157 Dampier)		+		
Malvaceae				
Abutilon geranioides			+	
Hibiscus drummondii				C
Mimosaceae				
Acacia coriacea		+		
Acacia ligulata		+	+	+
Acacia tetragonophylla	+	+	+	
Myrtaceae				
Thryptomene baeckeacea	+	C	+	+
Phormiaceae				
Dianella revoluta		+	+	
Proteaceae				
Grevillea wickhamii		+		
Hakea stenophylla				+
Santalaceae				
Exocarpos aphyllus		+	+	+
Santalum lanceolatum		+		
Sapindaceae				
Diplopeltis eriocarpa				+
Dodonaea amblyophylla			+	+
Heterodendrum oleaefolium			+	
Scrophulariaceae				
Stemodia grossa	+	C15m		
Solanaceae				
Solanum lasiophyllum			C9m	C9m
Solanum orbiculatum			C6m	+
Surianaceae				
Stylobasium spathulatum		+	+	
Thymelaeaceae				
Pimelea microcephala	+	+	+	+
Tiliaceae				
Corchorus elachocarpus	+	C7m	+	+
Corchorus walcottii	+		C	C
Total Number per Quadrat	19	24	22	21

Species designated C were present in the quadrat continuously since the beginning of the study.

Species designated Cxm were present continuously for the final x months of the study.

$$\text{Similarity index} = \frac{\text{Number in common}}{\text{total number in both}} \times 2 \times 100$$

The maximum possible similarity between two samples is 100%

Quadrat 1/Quadrat 2 = 55.8% Quadrat 2/Quadrat 3 = 56.5%

Quadrat 1/Quadrat 3 = 53.7% Quadrat 2/Quadrat 4 = 48.9%

Quadrat 1/Quadrat 4 = 50.0% Quadrat 3/Quadrat 4 = 69.8%

Table 5. Presence of herbs over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat 1	2	3	4
Aizoaceae				
Disphyma crassifolium		+		
Anthericaceae				
Dichopogon sp. (J.P.T. 98 Dampier)			+	
Apiaceae				
Trachymene pilosa			+	+
Asteraceae				
Angianthus cunninghamii				+
Brachycome iberidifolia	+	+	+	
Brachycome latisquamea	+	+	+	+
Calocephalus brownii		+		
Gnephosis gynotricha			+	+
Helipterum humboldtianum		+		
Podotheca angustifolia		+		
Senecio lautus		+	+	
Sonchus oleraceus			+	
Waitzia acuminata	+			+
Boraginaceae				
Heliotropium paniculatum				+
Brassicaceae				
Sisymbrium irio			+	
Campanulaceae				
Wahlenbergia gracilis		+		
Chenopodiaceae				
Dysphania plantaginella			+	+
Euphorbiaceae				
Euphorbia drummondii		+	+	+
Gentianaceae				
Centaurium tenuiflorum			+	
Geraniaceae				
Erodium cygnorum	+		+	
Goodeniaceae				
Goodenia berardiana	+			
Lauraceae				
Cassytha aurea	+			
Lobeliaceae				
Lobelia heterophylla	+		+	+

Table 5 (continued). Presence of herbs over the whole study period (1980-1982) and similarity of the four permanent quadrats based on species presence.

	Quadrat 1	2	3	4
Papilionaceae				
Glycine clandestina	+			
Glycine tabacina		+		+
Indigofera georgei		+		+
Lotus australis		+		
Swainsona kingii		+		
Poaceae				
Aristida contorta		+	+	+
Cenchrus ciliaris		+	+	+
Eragrostis australasica	+	+		
Eragrostis eriopoda	+		+	+
Eragrostis japonica	+	+	+	+
Eulalia fulva			+	+
Sorghum plumosum	+	+	+	
Triodia basedowii	+		+	+
Triodia pungens	+		+	+
Triodia sp.		+		
Triraphis sp. (J.P.T. 109 Dampier)		+		+
Portulacaceae				
Calandrinia polyandra	+	+	+	
Solanaceae				
Nicotiana simulans		+	+	+
Stackhousiaceae				
Stackhousia sp. 1 (J.P.T. 159 Dampier)		+		
Zygophyllaceae				
Zygophyllum fruticulosum		+	+	+
Total Number per Quadrat	14	24	24	22

$$\text{Similarity index} = \frac{\text{Number in common}}{\text{total number in both}} \times 2 \times 100$$

The maximum possible similarity between two samples is 100%

Quadrat 1/Quadrat 2 = 26.3% Quadrat 2/Quadrat 3 = 45.8%
Quadrat 1/Quadrat 3 = 47.4% Quadrat 2/Quadrat 4 = 47.8%
Quadrat 1/Quadrat 4 = 38.9% Quadrat 3/Quadrat 4 = 69.6%

Table 6. Changes in number of shrubs less than 1 m high in exclosed and unexclosed quadrats from spring, 1983 to summer, 1984.

(a) Site 1

Species	06.09.83 Exclosed	06.09.83 Unexclosed	15.02.84 Exclosed	15.02.84 Unexclosed
Acanthocarpus preissii	1	1	1	1
Corchorus walcottii	1	0	0	0
Ptilotus sp. (J.P.T. 133 Dampier)	23	11	0	0
Unknown sp.	1	1	1 (dying)	1
New emergent	1	0	0	0
Total	27	14	2	2

(b) Site 2

Species	06.09.83 Exclosed	06.09.83 Unexclosed	15.02.84 Exclosed	15.02.84 Unexclosed
Enchylaena tomentosa	1	5	dying	dying (clump
Rhagodia baccata	0	¾ cover of quadrat	0	¾ cover of quadrat
Salsola kali	1	3	0	3
Stemodia grossa	9	4	3	3
Total (excluding *Rhagodia*)	11	12	5	6

(c) Site 3

Species	06.09.83 Exclosed	06.09.83 Unexclosed	15.02.84 Exclosed	15.02.84 Unexclosed
Enchylaena tomentosa	1	0	2	2
Ptilotus obovatus	3	2	0	0
Rhagodia baccata	3	0	1	1
Scaevola tomentosa	1	1	0	0
Stemodia grossa	1 (large clump)	0	1 (large clump)	0
Total	9	3	4	3

(d) Site 4

Species	06.09.83 Exclosed	06.09.83 Unexclosed	15.02.84 Exclosed	15.02.84 Unexclosed
Acacia ligulata	0	1	0	0
Corchorus elachocarpus	0	1	0	1
Dampiera incana	4	9	6	8
Diplopeltis eriocarpa	1	1	1	1
Melaleuca cardiophylla	1	0	2	0
Scaevola restiacea	0	2	0	1
Solanum lasiophyllum	3	0	2	0
Unknowns	3	0	2	0
Total	12	14	11	11

Table 7. Changes in number of herbs in exclosed and unexclosed quadrats from spring, 1983 to summer, 1984.

(a) Site 1

Species	06.09.83 Exclosed	06.09.83 Unexclosed	15.02.84 Exclosed	15.02.84 Unexclosed
Calandrinia polyandra	43	32	0	0
Goodenia berardiana	1	0	0	0
Gnephosis gynotricha	2	11	0	0
Lobelia heterophylla	11	4	0	0
Sonchus oleraceus	0	1	0	0
Triodia pungens	8	6	9	5
Total	65	54	9	5

(b) Site 2

Species	06.09.83 Exclosed	Unexclosed	15.02.84 Exclosed	Unexclosed
Calandrinia polyandra	17	7	0	0
Calocephalus brownii	90	60	0	0
Eragrostis japonica	Sparse covering	Sparse covering	0	0
Ptilotus villosiflorus	15	4	0	0
Total (excluding *Eragrostis*)	122	71	0	0

(c) Site 3

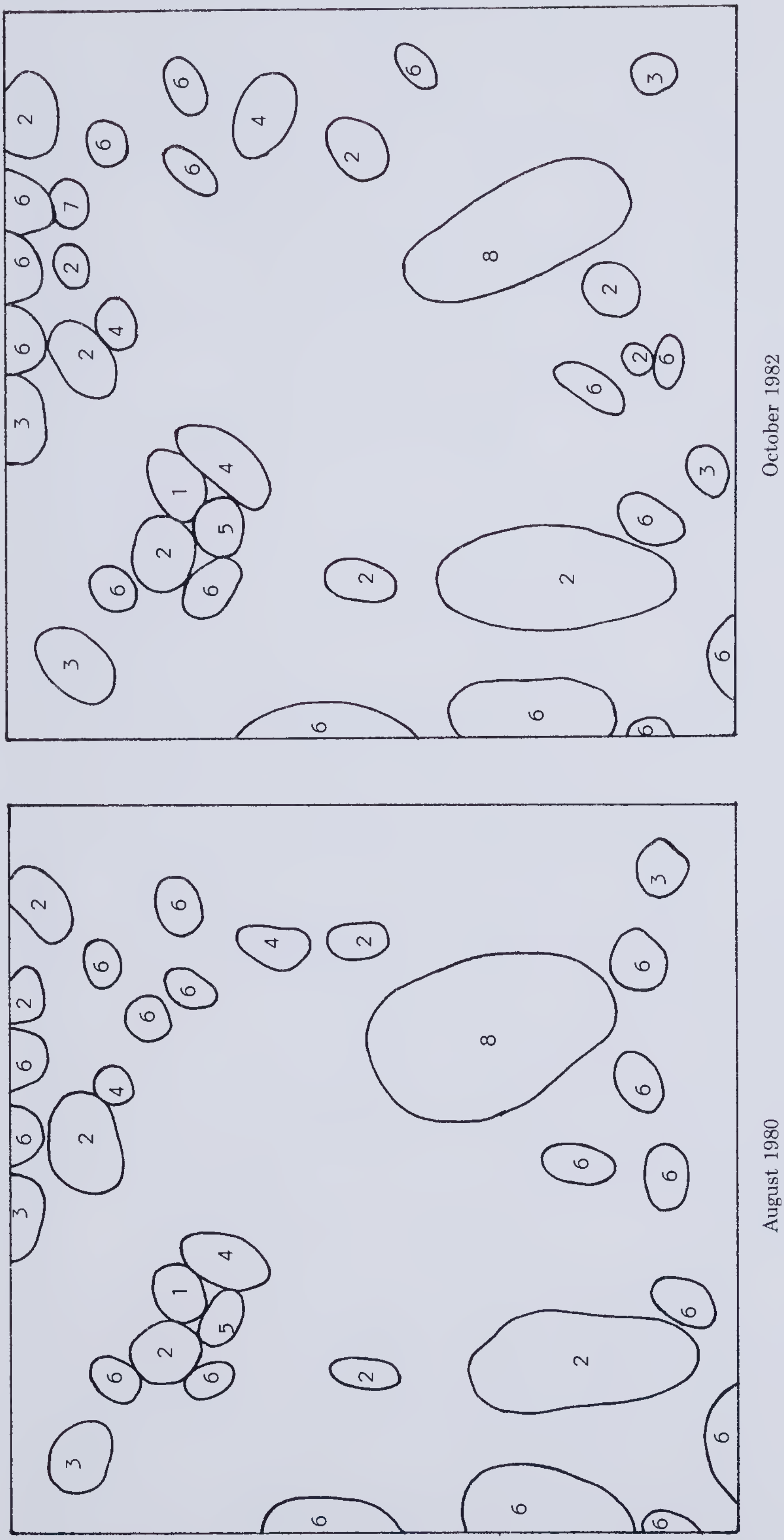
Species	06.09.83 Exclosed	Unexclosed	15.02.84 Exclosed	Unexclosed
Brachycome latisquamea	9	4	0	0
Cenchrus ciliaris	80% cover	20% cover	dying	absent
Gnephosis gynotricha	5	0	0	0
Nicotiana simulans	3	0	0	0
Sonchus oleraceus	0	1	0	0
Sorghum plumosum	0	7	0	0
Triodia pungens	4	4	0	0
Triodia wiseana	0	0	8	10
Zygophyllum fruticulosum	0	3	0	0
Total (excepting *Cenchrus*)	12	19	8	10

(d) Site 4

Species	06.09.83 Exclosed	Unexclosed	15.02.84 Exclosed	Unexclosed
Eragrostis eriopoda	0	4	0	0
Euphorbia drummondii	0	4	0	0
Gnephosis gynotricha	11	3	0	0
Indigofera georgei	4	1	0	0
Lobelia heterophylla	1	1	0	0
Triodia pungens	3	0	5	0
Triodia wiseana	23	25	35	30
Zygophyllum fruticulosum	1	1	0	0
Total	43	39	40	30

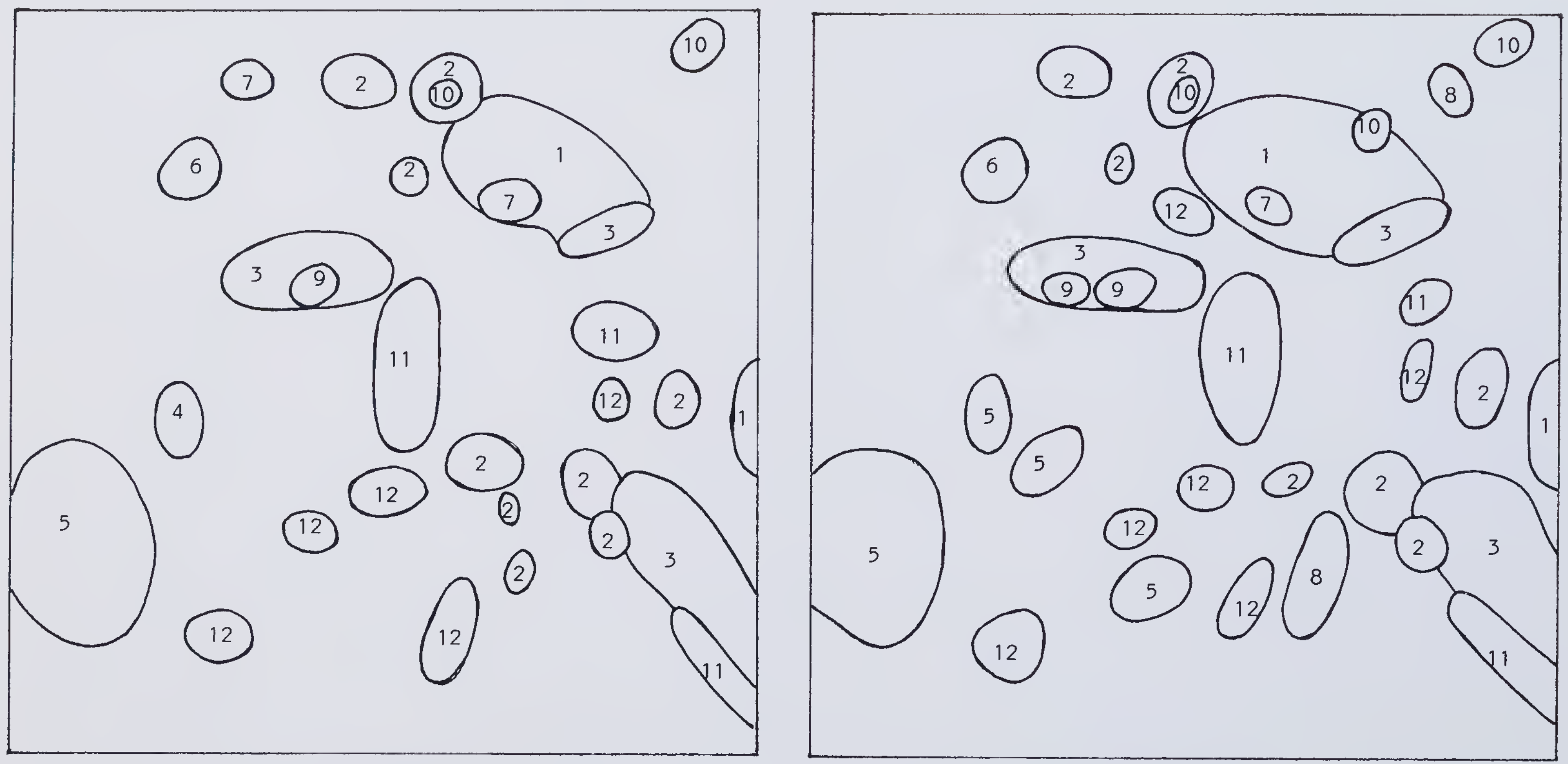
Results and Discussion

Quadrat 1 was situated in an area of dense *Acacia* scrub. Grazing pressure in this area was very low due to a lack of nearby drinking water. Low grazing pressure was confirmed by the exclosure experiment which showed no obvious changes in the vegetation of the unexclosed plot without corresponding changes within the exclosure (Tables 6 and 7). The species diversity of the large shrubs within Quadrat 1 increased by 1 during the study period, and the number of individual shrubs increased by 3 (Table 2). There was no appreciable change in the area covered by any of the large shrubs, illustrating very slow growth rates (Figure 2).



1 *Acacia sclerosperma*
2 *Acacia tetragonophylla*
3 *Grevillea wickhamii*
4 *Heterodendrum oleaefolium*
5 *Rhagodia baccata*
6 *Scaevola spinescens*
7 *Scaevola tomentosa*
8 *Thryptomene baeckeacea*

Figure 2. Location and size of shrubs greater than 1m high in permanent quadrat 1 during August, 1980 and October, 1982.

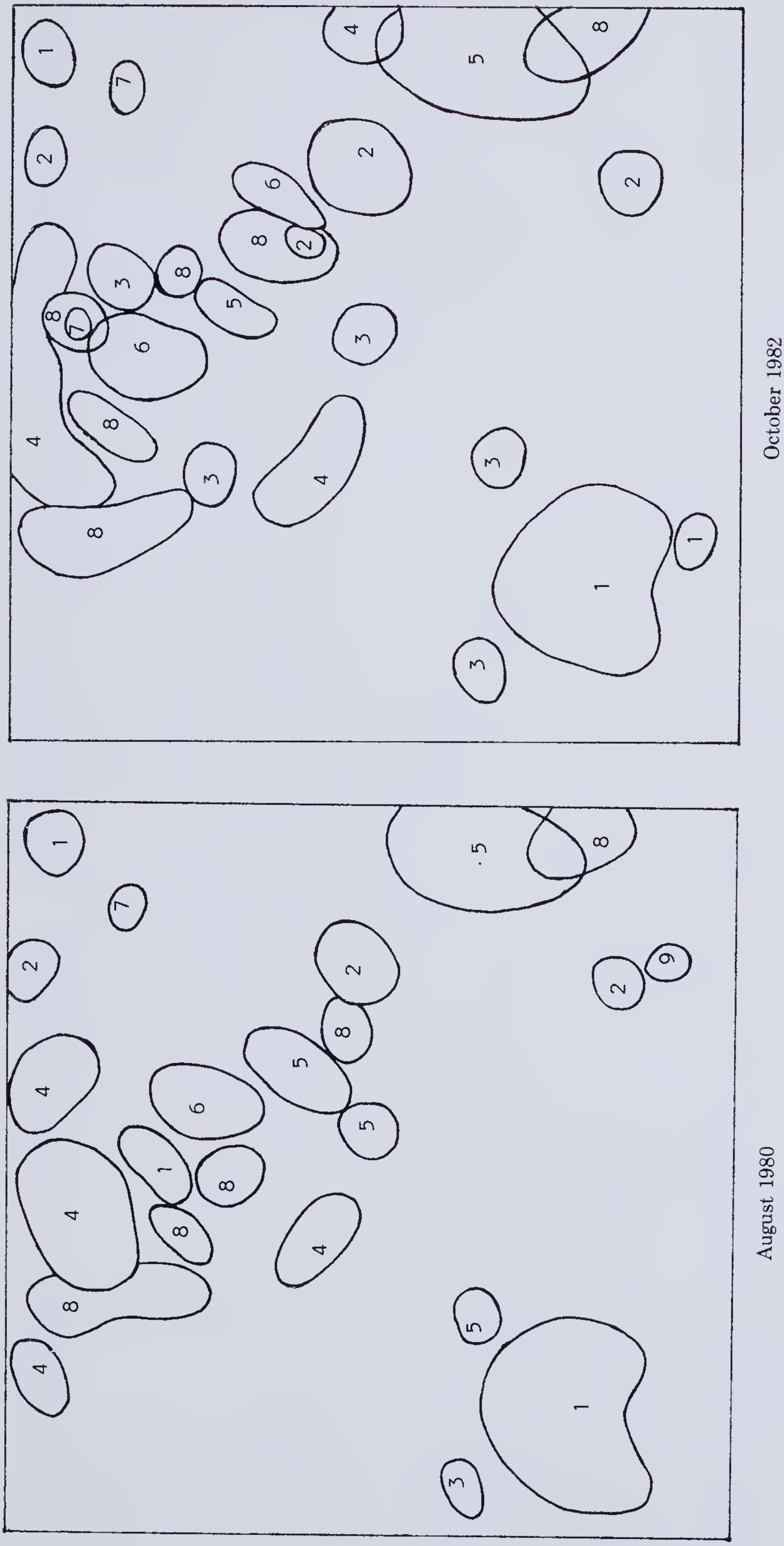


August 1980

October 1982

1 *Acacia coriacea*
2 *Acacia ligulata*
3 *Acacia tetragonophylla*
4 *Atriplex cinerea*
5 *Banksia ashbyi*
6 *Exocarpos aphyllus*
7 *Pimelea microcephala*
8 *Rhagodia baccata*
9 *Santalum lanceolatum*
10 *Scaevola crassifolia*
11 *Scaevola spinescens*
12 *Stylobasium spathulatum*

Figure 3. Location and size of shrubs greater than 1m high in permanent quadrat 2 during August, 1980 and October, 1982.



1 *Acacia ligulata*
2 *Acacia tetragonophylla*
3 *Corchorus walcottii*
4 *Dodonaea amblyophylla*
5 *Exocarpos aphyllus*
6 *Heterodendrum oleaefolium*
7 *Pimelea microcephala*
8 *Scaevola tomentosa*
9 *Solanum orbiculatum*

Figure 4. Location and size of shrubs greater than 1m high in permanent quadrat 3 during August, 1980 and October, 1982.

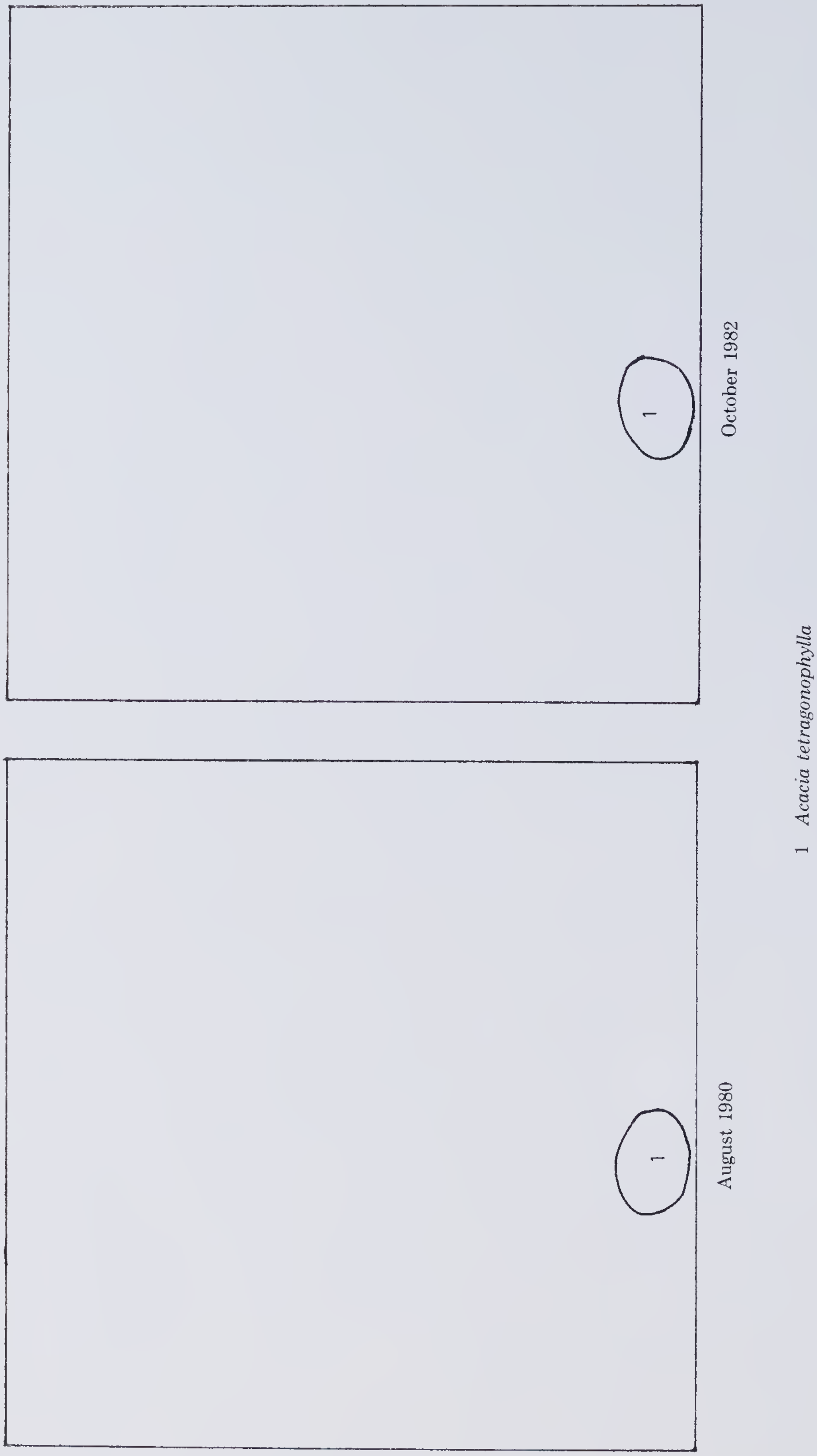


Figure 5. Location and size of shrubs greater than 1m high in permanent quadrat 4 during August, 1980 and October, 1982.

Quadrat 2 was situated in the Bejaling Dunes. Sheep, goats and kangaroos were all seen near the quadrat during the study, but grazing pressure remained low. With the exception of a sheep trail through the unexclosed plot near Quadrat 2, there was no obvious influence of grazing animals on the vegetation. Changes within the unexclosed plot paralleled those within the exclosure (Tables 6 and 7). Five individual shrubs were recruited into the large shrub category in Quadrat 2 over the study period (Table 2). These included *Scaevola tomentosa* and *Rhagodia baccata,* species which were not previously present in the large shrub category. The growth rates of large shrubs in the Bejaling Dunes were slow (Figure 3).

Quadrat 3 was subjected to intermittent grazing pressure due to the proximity of water. This grazing pressure affected the herbaceous plants, such as *Cenchrus ciliaris* but not the shrubs (Tables 6 and 7). All the *Cenchrus ciliaris* within the unexclosed plot disappeared within three months, while the floor of the exclosure had an 80% covering of this species. There was no evidence of grazing pressure on shrubs over the study period, and an additional three individual large shrubs became established within Quadrat 3 (Table 2). Quadrant 3 also demonstrated very slow growth rates for large shrubs (Figure 4).

Quadrat 4 was situated less than 50 metres from Quadrat 3, but on the other side of the road. A fire in 1979 had destroyed all but one of the large shrubs in this area. There was no recruitment of large shrubs within this quadrat during the study period despite the presence of seedlings of many of the larger shrub species, e.g. *Acacia ligulata, Pimelea microcephala, Dodonaea amblyophylla* and *Exocarpos aphyllus* (Tables 2 and 4). The area was 70% similar to Quadrat 3 in the category of shrubs less than 1 metre high. The slow rate of recovery can be considered a function of the slow growth rates of the shrubs (Figure 5). The only evidence of grazing in this area was on soft spinifex (*Triodia pungens*) (Table 7). This was completely absent from the unexclosed plot but there were five plants within the exclosure.

The number of shrub species less than 1 metre high fluctuated broadly with rainfall regardless of the seasons (Table 1, Figures 6 and 7). Some of the plants were woody annuals such as *Olearia* and *Ptilotus* which would germinate, flower and set seed very quickly following rain, and then die off in the drier weather. The majority of the perennial small shrub species that were present continuously in the quadrats were represented by individuals that were well established from the start. These included *Acanthocarpus preissii* and *Thryptomene baeckeacea* in Quadrat 2; *Corchorus walcottii* in Quadrat 3; and *Acanthocarpus preissii, Corchorus walcottii, Dampiera incana* and *Hibiscus drummondii* in Quadrat 4. As only the presence and absence of species was noted, it is not possible to ascertain whether any new individuals of these species became established during the study period. A number of other perennial shrubs species were present continuously for six months or more at the end of the study. These included *Acanthocarpus preissii* in Quadrat 1; *Enchylaena tomentosa* in Quadrats 1, 2 and 3; *Corchorus elachocarpus* in Quadrat 2; *Solanum lasiophyllum* in Quadrats 3 and 4; *Solanum orbiculatum* in Quadrat 3; and *Stemodia grossa* in Quadrat 2.

The number of herb species in the permanent quadrats fluctuated seasonally with maximum numbers occurring around September (Figures 6 and 7). About 25% of the herb species were composites and most of these, presumably for similar reasons to those found by Mott (1972), would only germinate and flower during winter. About 25% of the herb species were grasses. These would germinate at any time of the year following rain. They were the major component of the summer herb population following rain and, with the composites, formed the major component of the winter population of herbs. Unlike the Murchison area examined by Mott (1972), there was no obvious winter dormancy exhibited by the grasses. One possible reason was the higher winter temperatures of the area around Lake MacLeod. Most of the remaining species were also winter annuals.

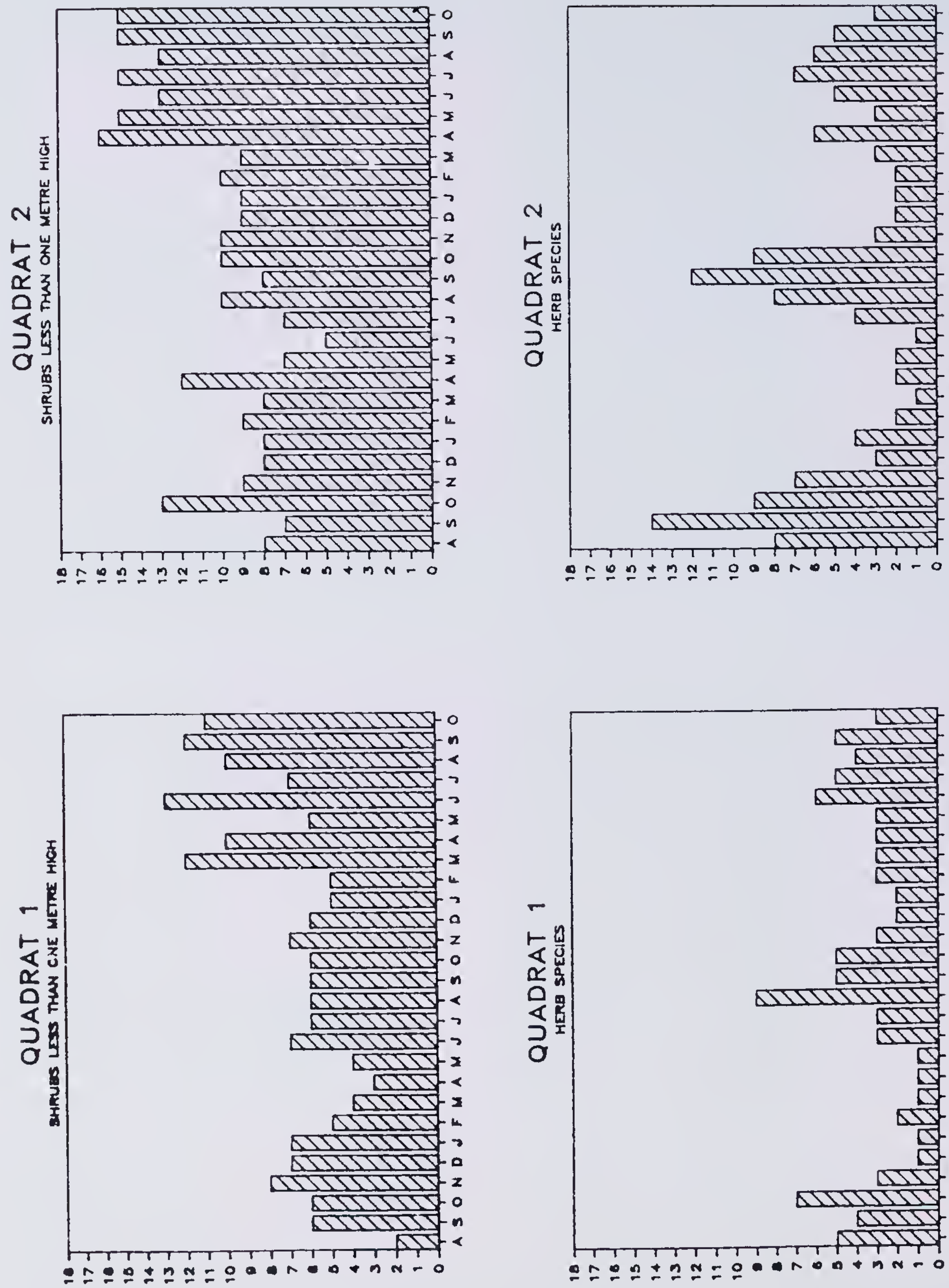


Figure 6. Number of shrub species less than 1m high and herb species recorded in permanent quadrats 1 and 2 from August, 1980 to October, 1982.

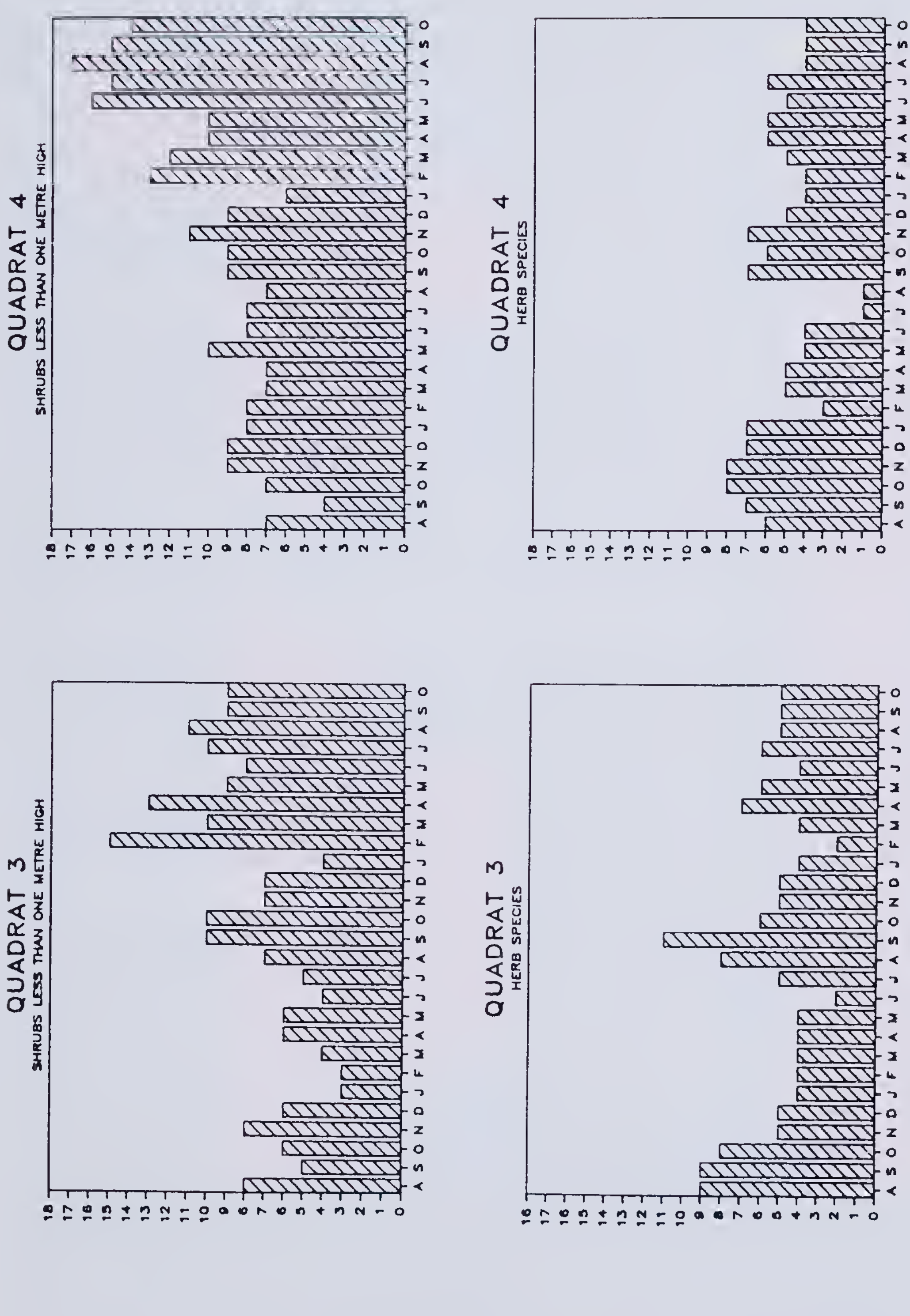


Figure 7. Number of shrub species less than 1m high and herb species recorded in permanent quadrats 3 and 4 from August, 1980 to October, 1982.

One exception was *Lobelia heterophylla* which would germinate and flower between September and December each year. Another exception was *Zygophyllum fruticulosum* which would quickly appear following uniform light rain, and was often the only herb species present in the quadrats during dry summer periods.

The lower than normal number of herb species in the 1982 winter period was probably due to the exceptionally dry weather. July had no rain at all and all other months had rainfall below the monthly average (Table 1). The minimum water requirement for the germination of many of the winter annuals did not seem to have been reached.

A comparison of species similarity between quadrats is included in Tables 3, 4 and 5. The highest similarity in both the small shrub and herb categories occurred between Quadrats 3 and 4 which had about 70% similarity in both these categories. This is to be expected as the quadrats were very close to one another geographically and shared similar soils. These quadrats, however, show a low similarity with respect to large shrubs because of a recent fire at the site of Quadrat 4.

Over one third of all small shrub species (8) occurred in all four quadrats at some stage during the study, although very few of these became established (Table 4). These shrubs largely accounted for the 50% similarity obtained between all quadrats in this vegetation category with the exception of Quadrats 3 and 4. The similarity indices for the large shrub category, with the exception of Quadrats 2 and 3 which also had around 50% similar, tended to be lower than for the small shrub category.

The herb category exhibited the greatest variation in similarity indices, with geographical separation apparently playing a major role. Quadrats 3 and 4 were adjacent and had a similarity index of 69.6% whilst the widely separated Quadrats 1 and 2 were only 26.3% similar.

A large number of species in all vegetation categories were present in Quadrat 2 but were not found in any other quadrat. This is possibly a function of the alkaline, white sandy soils in Quadrat 2 which were of more recent origin than the reddish neutral soils of Quadrats 1, 3 and 4 on the Quobba Ridge.

In general undisturbed *Acacia* shrublands are stable areas and only slightly susceptible to erosion. Once this type of vegetation is degraded it is slow to recover, and serious erosion can occur (Condon 1972). Very little regeneration has occurred in western New South Wales where large areas of mulga (*Acacia aneura*) have died due to overgrazing, coupled with tree lopping during drought.

This study demonstrated that the Lake MacLeod shrublands regenerate very slowly if degraded by fire. This is due to the inherently slow growth rates of the shrub species. There was no evidence of overgrazing in the study areas but recovery rates are likely to be slow if this should occur.

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Appendix 1. Tentative list of plant species

* denotes introduced species

Aizoaceae
* *Carpobrotus aequilaterus* (Haw.) N.E.Br.
* *Mesembryanthemum crystallinum* L.

Amaranthaceae
Alternanthera sp.
Amaranthus pallidiflorus F. Muell.
Ptilotus alexandri Benl
Ptilotus exaltatus Nees
Ptilotus obovatus (Gaudich.) F. Muell.
Ptilotus spathulatus (R.Br.) Poiret
Ptilotus villosiflorus F. Muell.
Ptilotus sp. 1 (J.P.T. 133 Dampier)
Ptilotus sp. 2 (J.P.T. 134 Dampier)

Anthericaceae
Dichopogon tyleri N.H. Brittan
Murchisonia volubilus N.H. Brittan
Thysanotus speckii N.H. Brittan

Apiaceae
Daucus glochidiatus (Labill.) Fisher, C. Meyer & Ave-Lall.
Trachymene pilosa Smith

Asclepiadacae
Sarcostemma australe R.Br.

Asphodelaceae
Asphodelus fistulosus L.

Asteraceae
Angianthus cunninghamii (DC.) Benth.
Aster subulatus Michaux
Asteridea aff. *athrixioides* (Sonder & F. Muell.) G. Kroner
Brachycome iberidifolia Benth.
Brachycome latisquamea F. Muell.
Brachycome sp. (J.P.T. 240, 245 Dampier)
Calocephalus angianthoides (Steetz) Benth.
Calocephalus brownii (Cass.) F. Muell.
Calotis aff. *multicaulis* (Turcz.) Druce
Cephalipterum drummondii A. Gray
Chthonocephalus pseudevax Steetz
Craspedia sp. (J.P.T. 277 Dampier)
Gnephosis brevifolia (A. Gray) Benth.
Gnephosis gynotricha Diels
Helipterum corymbosum (A. Gray) Benth.
Helipterum humboldtianum (Gaudich.) DC.
Helipterum hyalospermum F. Muell. ex Benth.
Helipterum involucratum (F. Muell.) Benth.
Helipterum strictum (Lindley) Benth.
Helipterum splendidum Hemsley
Helipterum sp. (J.P.T. 263 Dampier)
Lagenifera huegelii Benth.
Millotia myosotidifolia (Benth.) Steetz
Olearia axillaris (DC.) F. Muell. ex Benth.
Olearia imbricata (Turcz.) Benth.
Olearia sp. (J.P.T. 219 Dampier)
Pluchea squarrosa Benth.
Podolepis auriculata DC.
Podolepis canescens Cunn. ex DC.
Podolepis gardneri G. Davis
Podolepis lessonii (Cass.) Benth.
Podolepis sp. (J.P.T. 87 Dampier)
Podotheca angustifolia (Labill.) Less.
Podotheca pygmaea A. Gray
Schoenia cassiniana (Gaudich) Steetz
Senecio glossanthus (Sonder) Belcher
Senecio lautus G. Forster ex Willd. subsp. *maritimus* Ali
Senecio lautus G. Forster ex Willd. subsp. *dissectifolius* Ali

Sonchus oleraceus L.
Streptoglossa liatroides (Turcz.) C.R. Dunlop
Waitzia acuminata Steetz
Waitzia sp. 1 (J.P.T. 130 Dampier)
Waitzia sp. 2 (J.P.T. 297 Dampier)

Avicenniaceae
Avicennia marina (Forsskal) Vierh.

Boraginaceae
Halgania preissiana Lehm.
Heliotropium paniculatum R.Br.
Heliotropium undulatum M. Vahl
Trichodesma zeylanicum (Burm. f.) R.Br.

Brassicaceae
* *Diplotaxis tenuifolia* (L.) DC.
Lepidium aff. *rotundum* (Desv.) DC.
* *Sisymbrium irio* L.
Sisymbrium sp. (J.P.T. 54, 55 Dampier)

Caesalpiniaceae
Cassia oligophylla F. Muell.
Cassia sturtii R.Br.
Labichea eremaea C. Gardner

Campanulaceae
Wahlenbergia gracilis A.DC.

Capparaceae
Capparis spinosa L.

Caryophyllaceae
* *Spergularia rubra* (L.) J.S. Presl & C. Presl

Chenopodiaceae
Atriplex aff. *cinerea* Poiret
Atriplex nummularia Lindley
Atriplex paludosa R.Br.
Atriplex spongiosa F. Muell.
* *Chenopodium ambrosioides* L.
Chenopodium desertorum (J. Black) J. Black
Didymanthus roei Endl.
Dysphania plantaginella F. Muell.
Einadia nutans (R.Br.) A.J. Scott
Enchylaena tomentosa R.Br.
Eriochiton sclerolaenoides (F. Muell.) F. Muell. ex A.J. Scott
Halosarcia halocnemoides (Nees) Paul G. Wilson
Halosarcia indica subsp. *bidens* (Nees) Paul G. Wilson
Halosarcia pruinosa (Paulsen) Paul G. Wilson
Maireana appressa (J. Black) Paul G. Wilson
Maireana planifolia (F. Muell.) Paul G. Wilson
Maireana polypterygia (Diels) Paul G. Wilson
Maireana scleroptera (J. Black) Paul G. Wilson
Maireana tomentosa Moq.
Rhagodia baccata (Labill.) Moq.
Rhagodia crassifolia R.Br.
Rhagodia latifolia (Benth.) Paul G. Wilson
Salsola kali L.
Sarcocornia quinqueflora (Bunge ex Ung.-Sternb.) A.J. Scott
Sclerolaena eurotioides (F. Muell.) A.J. Scott
Sclerolaena aff. forrestiana (F. Muell.) Domin
Sclerolaena tridens (F. Muell.) Domin
Sclerolaena uniflora R.Br.
Sclerolaena sp. (J.P.T. 334 Dampier)
Sclerostegia disarticulata Paul G. Wilson
Suaeda australis (R.Br.) Moq.

Chloanthaceae
Pityrodia loxocarpa (F. Muell.) Druce

Colchicaceae
Wurmbea odorata T.D. Macfarlane

Convolvulaceae
Porana sericea (Gaudich.) F. Muell.

Crassulaceae
Crassula colorata (Nees) Ostenf.

Cucurbitaceae
Mukia maderaspatana (L.) M. Roemer

Cyperaceae
Cyperus sp. 1 (J.P.T. 21 Dampier)
Cyperus sp. 2 (J.P.T. 22 Dampier)
Cyperus sp. 3 (J.P.T. 123 Dampier)
Cyperus sp. 4 (J.P.T. 106 Dampier)

Dasypogonaceae
Acanthocarpus preissii Lehm.

Euphorbiaceae
Adriana tomentosa Gaudich
Euphorbia atoto G. Forster
Euphorbia drummondii Boiss.
Phyllanthus sp. 1 (J.P.T. 199 Dampier)
Phyllanthus sp. 2 (J.P.T. 317 Dampier)

Frankeniaceae
Frankenia ambita Ostenf.
Frankenia pauciflora DC.

Gentianaceae
* *Centaurium spicatum* (L.) Fritsch ex Janchen
* *Centaurium tenuiflorum* (Hoffsgg. & Link) Fritsch ex Janchen

Geraniaceae
Erodium cygnorum Nees

Goodeniaceae
Dampiera incana R.Br.
Goodenia berardiana (Gaudich.) Carolin
Scaevola aff. *collaris* F. Muell.
Scaevola crassifolia Labill.
Scaevola glandulifera DC.
Scaevola restiacea Benth.
Scaevola spinescens R.Br.
Scaevola tomentosa Gaudich.
Scaevola sp. (J.P.T. 235 Dampier)

Gyrostemonaceae
Codonocarpus cotinifolius (Desf.) F. Muell.
Gyrostemon sp. (J.P.T. 222 Dampier)

Juncaginaceae
Triglochin calcitrapa Hook.

Lauraceae
Cassytha aurea J.Z. Weber

Lobeliaceae
Lobelia heterophylla Labill.

Loranthaceae
Amyema sp. (J.P.T. 157 Dampier)
Lysiana exocarpi (Behr) Tieghem

Malvaceae
Abutilon geranioides (DC.) Benth.
Abutilon leucopetalum (F. Muell.) F. Muell. ex Benth.
Gossypium australe F. Muell.
Hibiscus drummondii Turcz.
Hibiscus sturtii Hook.
Lawrencia densiflora (E.G. Baker) Melville
Lawrencia glomerata Hook.
Sida intricata F. Muell.
Sida sp. (J.P.T. 268 Dampier)

Mimosaceae
Acacia bivenosa DC.
Acacia coriacea DC.
Acacia farnesiana (L.) Willd.
Acacia gregorii F. Muell.
Acacia idiomorpha Cunn. ex Benth.
Acacia ligulata Cunn. ex. Benth.
Acacia linophylla W. Fitzg.
+*Acacia morrisonii* Domin
Acacia murrayana F. Muell. ex Benth.
Acacia pyrifolia DC.
Acacia ramulosa W. Fitzg.
Acacia sclerosperma F. Muell.
Acacia spathulifolia Maslin
Acacia tetragonophylla F. Muell.
Acacia victoriae Benth.
Acacia xiphophylla E. Pritzel
Acacia sp. (J.P.T. 340 Dampier)

+ may be conspecific with *A. pyrifolia* DC.

Moraceae
Ficus platypoda (Miq.) Cunn. ex Miq.

Myoporaceae
Eremophila glabra (R.Br.) Ostenf.
Eremophila mackinlayi F. Muell.
Eremophila oppositifolia R.Br.
Eremophila subfloccosa Benth.
Myoporum apiculatum A.DC.

Myrtaceae
Calothamnus chrysantherus F. Muell.
Calytrix brevifolia (Meissner) Benth.
Eucalyptus camaldulensis Dehnh.
Eucalyptus coolabah Blakely & Jacobs
Eucalyptus foecunda Schauer
Melaleuca cardiophylla F. Muell.
Melaleuca leucadendra (L.) L.
Pileanthus limacis Labill.
Thryptomene baeckeacea F. Muell.

Najadaceae
Najas marina L.

Nyctaginaceae
Boerhavia sp. (J.P.T. 33 Dampier)
Commicarpus australis Meikle

Papaveraceae
* *Argemone ochroleuca* Sweet

Papilionaceae
Brachysema aphyllum Hook.
Clianthus formosus (G. Don) Ford & Vick.
Crotalaria cunninghamii R.Br.
Daviesia divaricata Benth.
Glycine clandestina Willd.
Glycine tabacina (Labill.) Benth.
Glycyrrhiza acanthocarpa (Lindley) J. Black
Indigofera brevidens Benth.
Indigofera georgei E. Prtizel
Lotus australis Andrews
Swainsona kingii F. Muell.

Phormiaceae
Dianella revoluta R.Br.

Plumbaginaceae
Muellerolimon salicorniaceum (F. Muell.) Lincz.

Poaceae
Aristida browniana Henrard
Aristida contorta F. Muell.

* *Avellinia michelii* (Savi) Parl.
* *Axonopus* sp. (J.P.T. 20 Dampier)
* *Cenchrus ciliaris* L.
* *Ehrharta longiflora* Smith
Enteropogon acicularis (Lindley) Lazarides
Eragrostis australasica (Steudel) C.E. Hubb.
Eragrostis brownii (Kunth) Nees ex Steudel
* *Eragrostis curvula* (Schrader) Nees
Eragrostis eriopoda Benth.
Eragrostis japonica (Thunb.) Trin.
Eriachne aff. *aristidea* F. Muell.
Eulalia fulva (R.Br.) Kuntze
* *Lolium perenne* L.
Sorghum plumosum P. Beauv. ex Roemer & Schultes
Stipa elegantissima Labill.
Themeda australis (R.Br.) Stapf
* *Trachynia* sp. (J.P.T. 122 Dampier)
Triodia basedowii E. Pritzel
Triodia pungens R.Br.
Triraphis sp. (J.P.T. 109 Dampier)

Polygonaceae
* *Emex australis* Steinh.
Muehlenbeckia sp.
Polygonum sp. (J.P.T. 13 Dampier)

Portulacaceae
Calandrinia granulifera Benth.
Calandrinia polyandra Benth.
Portulaca oleracea L.

Potamogetonaceae
Ruppia sp.

Primulaceae
Samolus junceus R.Br.

Proteaceae
Banksia ashbyi E.G. Baker
Grevillea eriostachya Lindley
Grevillea stenobotrya F. Muell.
Grevillea wickhamii Meissner.
Grevillea sp.
Hakea stenophylla Cunn. ex R.Br.

Santalaceae
Exocarpos aphyllus R.Br.
Santalum acuminatum (R.Br.) A.DC.
Santalum lanceolatum R.Br.
Santalum spicatum (R.Br.) A.DC.

Sapindaceae
Diplopeltis eriocarpa (Benth.) Hemsley
Dodonaea amblyophylla Diels
Dodonaea ptarmicaefolia Turcz.
Heterodendrum oleaefolium Desf.

Scrophulariaceae
Stemodia grossa Benth.
Stemodia viscosa Roxb.

Solanaceae
Anthocercis gracilis Benth.
Anthocercis littorea Labill.
Lycium australe F. Muell.
* *Nicotiana glauca* Graham
Nicotiana occidentalis Wheeler subsp. *occidentalis*
Nicotiana simulans N. Burb.
Solanum esuriale Lindley
Solanum lasiophyllum Dunal ex Poiret
* *Solanum nigrum* L.
Solanum orbiculatum Dunal ex Poiret

Stackhousiaceae
Stackhousia sp. 1 (J.P.T. 159 Dampier)
Stackhousia sp. 2 (J.P.T. 203 Dampier)

Surianaceae
Stylobasium spathulatum Desf.

Thymelaeaceae
Pimelea ammocharis F. Muell.
Pimelea microcephala R.Br.

Tiliaceae
Corchorus elachocarpus F. Muell.
Corchorus walcottii F. Muell.

Tremandraceae
Tetratheca hirsuta Lindley

Zygophyllaceae
Tribulus terrestris L.
Zygophyllum fruticulosum DC.
Zygophyllum glaucum F. Muell.

Time between germination and first flowering of some perennial plants

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Abstract

Muir, B. G. Time between germination and first flowering of some perennial plants. Kingia 1(1); 75-83 (1987). Time elapsed between germination and first flowering is presented for 198 plant species from the south-west of Western Australia. About 12% of the species examined required six or more years after germination before they first flowered. This has significance for the long term survival of such species in areas where the bushland is burnt in regular cycles of five years or less.

Introduction

The opinion is held by some land management agencies and a section of the public, that vegetation in the south-west of Western Australia should be burned as often as it will support fire. The reasoning behind this philosophy is generally that frequent burning is necessary to reduce fuel loads to levels which will not allow fierce wildfires to develop during the hot, dry, summer months.

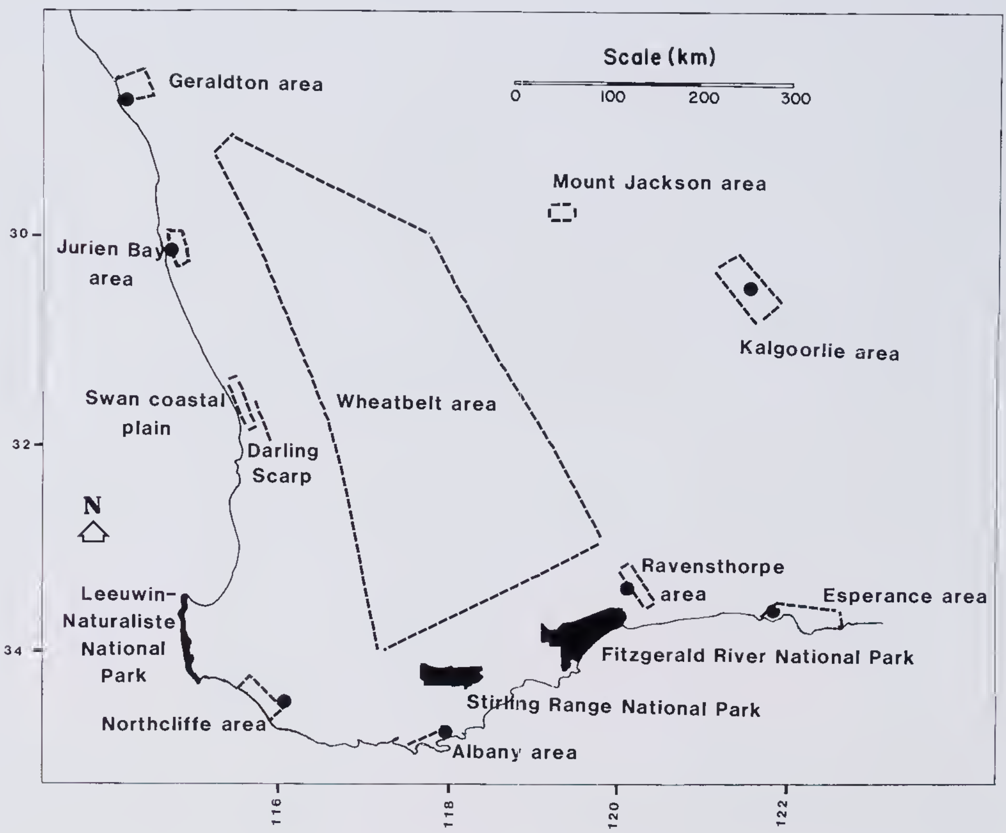
The apparent fire tolerance of the vegetation is reflected in its rapid post-fire regeneration, increased flowering in some species following fire, and the lush look of new growth compared to the straggly appearance of older bushland. These factors give the layman the impression that recently burned bush "looks better", therefore frequent burning must be better for both flora and fauna. My own observations indicate that although many plants are fire tolerant they are not necessarily fire dependent. Evidence exists which indicates that burning too frequently can permanently alter floristic richness (Connell 1978, Westman 1975, Baird 1958). Similarly, physiognomy may be altered (Muir 1977, Cochrane 1966, Gill 1975), weed invasion may be exacerbated (Road Verge Committee Report 1970, Muir 1977) or fire-sensitive species may be removed (Wallace 1966).

In order for native plant species to persist and to maintain the full potential of their gene pool, adequate seed set and plant regeneration must occur between fires. Frequent burning may destroy plants before flowering and seed set have occurred. Thus species which are obligate seed regenerators and flower within a year or two of being burned may be disadvantaged compared, for example, to species growing from rootstocks. Even seedstocks stored in the soil may be progressively depleted if seedlings are continually being burned before having the opportunity to flower and set further seed. Ultimately therefore, species may be lost from certain vegetation types as a consequence of too frequent burning.

Studies on vegetation and flora in the Western Australian wheatbelt (Kitchener 1976, Muir 1978-79) by the author, and at other localities, generated numerous observations on the time between germination and first flowering. It was considered that information on the period of time between germination and first flowering would be of assistance in estimating the minimum period necessary to allow successful propagation of some plant species. It is also possible that first flowering may be poor, that the seed set in the first one or two years of flowering may be sterile, e.g. *Dryandra sessilis*; or such small numbers of seeds may be set that all succumb to predators. If so, many fire-free years may be necessary to ensure the survival of even a single new plant. It should be borne in mind that the intervals between germination and first flowering listed in this paper may be atypically long or short depending on particular soils and climatic conditions during the study period (1975-84). Nonetheless, field observations are considered a fairly reliable guide to the time taken from germination to first flowering, at least of some plants. Data from cultivation, by contrast, are probably less reliable than field observations, but as all records reported here are from one site, the data provide a valid comparison.

Methods

Data on the time between germination and first flowering were collected during field studies in the Western Australian wheatbelt (Kitchener 1976, Muir 1978-79), and elsewhere in south-western Australia. Other studies and casual observations have been made during preparation of publications including Morris and Muir (1975), Muir (1979) and Muir (1983). Most field observations were based on studies of vegetation of various ages since fire. The presence of flowers or recent fruits on a plant was considered as indicating potential seed set although, as mentioned above in the case of *Dryandra sessilis*, this may not always be true. The age of the plant since fire was then noted. Care was



Map 1. Location and areas referred to in Appendix 1.

taken to ensure that all observations were made on plants arising from seed and not suckers or rootstocks. Fire age was determined from Local Authority records, information from farmers and from interpretation of aerial photographs.

Because of the wide range of distribution of some species the approximate geographic location of the field observations is presented in Appendix 1 and shown on Map 1. Data on time to first flowering in cultivation were recorded from plants grown in the author's garden. All cultivated specimens were grown from freshly collected seed planted at a single location at Boya, about 18 km east of Perth on the edge of the Darling Scarp. All were planted in sandy loam, loam, clay loam or sandy clay soils in May or June following initial germination in sand in pots. Hard seeds of *Acacia* were abraded with sand paper, but all other seeds were untreated. After planting, all were watered twice per week in their first summer and once per week in the second. During following years all plants were unwatered unless they showed signs of stress. No fertilizers were applied.

For the purpose of this paper "light" soils are those classed as sand (0-10% clay) to sandy clay loam (20-30% clay) and "heavy" soils range from clay loam (30-40% clay) to heavy clay (greater than 50% clay) (Northcote 1971).

Each species record presented in Appendix 1 is based on at least three separate field and/or cultivation observations, except those recorded as "wheatbelt" which are based on a minimum of five observations. The presence of at least two flowering individuals was taken as evidence of possible seed set within any stand of young plants.

Results and Discussion

Data collected on 198 species of plants are presented in Appendix 1. Minimum recorded number of years to first flowering and percentage of species which flowered for the first time in that year are presented in Table 1.

Table 1. Minimum recorded number of years to first flowering and percentage of species which flowered for the first time in that year.

Minimum recorded years to first flowering	% of total number of species
1	1.5
2	12.1
3	20.7
4	34.3
5	17.7
6	10.6
7 or more	2.0

Although many species flowered within five years of germination, over 12% required six or more years before flowering. The presence of even one or two species of this type in a stand of vegetation points to a corresponding minimum frequency at which deliberate control burning can be carried out if species are not to be lost. Any additional constraints such as poor first flowering, sterile seed or excessive seed predation would necessitate even longer between-fire intervals to permit the build up of a sufficient seed store to permit survival of the species.

The difference in time to first flowering was compared between those species where data were available from both the field and cultivation. These results are presented in Table 2.

Table 2. Source of data, mean time to first flowering in years, the standard deviation (SD) within the groups and number (n) of observations.

Source	Mean time to first flowering (yrs)	SD	n
Field	4.35	3.51	152
Cultivation	3.46	1.15	178

Although the means are not significantly different there is a suggestion that most plants flower slightly earlier in cultivation. With water supplements over summer, a higher rainfall than inland areas of Western Australia, less competition and some predator control this is not unexpected, but further research is required.

Observations on species which were recorded on both light and heavy soil types were compared. Where a species was recorded in each soil type in the field, preference was given to this data rather than to cultivation data (if it was available).

Twenty-seven species provided data for flowering in both light and heavy soils. Of these 10 species showed no difference in time to first flowering. A further 14 species showed that flowering occurred earlier in light soils, while 4 species showed earlier flowering on heavy soils. Although no results were statistically different there was some suggestion of a trend to earlier flowering in some species on lighter soils, perhaps because of easier establishment of root systems.

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Appendix 1. List of species with time to first flowering (in years) as determined from observations in the field and under cultivation.

Soil types are shown as L (light: sand to sandy clay loam) or H (heavy: clay loam to heavy clay). The location of the seed source refers to the areas shown on Map 1.

Species	Age at flowering and substrates		Source area
	Field	Cultivated	
Acacia			
acuminata	5L5H	5H	wheatbelt
aneura	4H	3H	Mt. Jackson
assimilis	6H		wheatbelt
blakelyi		2L	wheatbelt
brachyclada	6L		wheatbelt
celastrifolia		3L	wheatbelt
daviesioides	4L	5L	wheatbelt
drummondii	2L	2L	Leeuwin-Naturaliste
ericifolia	3L	3L	wheatbelt, Jurien Bay
filifolia	3H	2L	wheatbelt
glaucoptera	3H	2L	Ravensthorpe
gonophylla		4L	wheatbelt
hemiteles	3H	2L	wheatbelt
lasiocalyx	3L	3H	wheatbelt
ligustrina	3L3H	2L	wheatbelt
mackeyana	5H		wheatbelt
merinthophora	6L		wheatbelt
microbotrya	4H	2H	wheatbelt
multispicata	5H	5L	wheatbelt
myrtifolia	2L	5L	wheatbelt
pentadenia		5L	Northcliffe
pulchella	2H	2L	wheatbelt, Northcliffe
rostellifera		3L	Swan Coastal Plain
saligna	3L	3L	Swan Coastal Plain, wheatbelt, Northcliffe
signata	6L		wheatbelt
stenoptera		3L	wheatbelt
tetragonophylla	5H	4L	wheatbelt, Kalgoorlie
truncata		5L	wheatbelt
willdenowiana		3L	wheatbelt
Actinodium			
cunninghamii		2H	Stirling Range
Adenanthos			
meisneri	3L	2L	Darling Scarp
Agonis			
flexuosa	5L	4H	Leeuwin-Naturaliste
juniperina	4L	2L	Northcliffe
marginata		4L	Darling Scarp
Allocasuarina			
acutivalvis	5L	4L	wheatbelt
campestris	3H	4H	wheatbelt
corniculata	4L		wheatbelt
drummondiana	4L	5L5H	Jurien Bay
fraseriana	3L	2L	Swan Coastal Plain
huegeliana	4H	4H	wheatbelt, Darling Scarp
humilis	2L3H	2L	Darling Scarp, wheatbelt
microstachya	4L	3L	wheatbelt
pinaster	5L		wheatbelt
Alyogyne			
hakeifolia	2L	2H	Fitzgerald River National Park
Anigozanthos			
bicolor	3H	2L	Darling Scarp
flavidus		3L	Albany
humilis	2L	2L	wheatbelt, Darling Scarp
manglesii	2L	2L	Swan Coastal Plain
pulcherrimus		3L	wheatbelt, Jurien Bay
rufus		3L	Stirling Range
viridis	3L	2L	Swan Coastal Plain

Species	Age at flowering and substrates: Field	Age at flowering and substrates: Cultivated	Source area
Astartea			
ambigua		3L	Stirling Range
fascicularis	4L6H	4L	Darling Scarp, Northcliffe
heteranthera	3H	2L	wheatbelt
Baeckea			
camphorosmae		4L	Darling Scarp
muricata	4H	4L	wheatbelt
Banksia			
ashbyi		3L	Fitzgerald River National Park
attenuata	4L	3L	Jurien Bay, Swan Coastal Plain
baueri	4L	3L	wheatbelt, Stirling Range
baxteri		4L	Fitzgerald River National Park
caleyi		5L	Stirling Range
grandis	5L	4L	Darling Scarp
media	5L4H	3L	Esperance
menziesii	3L		Swan Coastal Plain
prionotes	4L	4L	Jurien Bay, wheatbelt
sceptrum	4L	4L	Geraldton
sphaerocarpa	4H	3H4L	Jurien Bay, wheatbelt
Beaufortia			
decussata		4L	Stirling Range
elegans		4L	Swan Coastal Plain, Esperance
heterophylla		4L	Kalgoorlie, Ravensthorpe, Stirling Range
micrantha	6H		wheatbelt
sparsa	4L	4L	Stirling Range, Northcliffe
Boronia			
alata		4L	Stirling Range, Northcliffe
crenulata		1L	Northcliffe, Darling Scarp, Stirling Range
heterophylla	4L	4L	Northcliffe
megastigma	2L	2L	Northcliffe
Bossiaea			
eriocarpa		4L	wheatbelt
Brachychiton			
gregorii	8H	6H	Mt. Jackson
Brachysema			
aphyllum	5H	4L	wheatbelt
celsiana		4L	wheatbelt
daviesioides	4H		wheatbelt, Kalgoorlie
Bursaria			
spinosa		4L	wheatbelt
Callistemon			
phoeniceus	4H	4H4L	wheatbelt
speciosus	5L	5L5H	Albany
Calothamnus			
blepharospermus		4L	wheatbelt, Geraldton
chrysantherus	4H	3L4H	wheatbelt
gilesii		4L	wheatbelt, Kalgoorlie, Mt. Jackson
gracilis		4L	Fitzgerald River National Park
lateralis	2L	2L	Northcliffe
longissimus		5L	Jurien Bay
oldfieldii		4L	Geraldton
planifolius	5L	3L	Stirling Range
quadrifidus	3L	4L	wheatbelt, Darling Scarp
sanguineus	3L	2H3L	Darling Scarp, Stirling Range
villosus		2L	Swan Coastal Plain, Darling Scarp

Species	Age at flowering and substrates Field	Cultivated	Source area
Calytrix			
angulata		5L	Darling Scarp
fraseri	3L	3L	Swan Coastal Plain
stipulosa		5L	wheatbelt
Cassia			
nemophila	5H	4L	wheatbelt
pleurocarpa		3L	Mt. Jackson, Kalgoorlie
Casuarina			
obesa	5H	4H	Swan Coastal Plain
Chamelaucium			
axillare		3L	Esperance
ciliatum	5H	5L	wheatbelt, Stirling Range
megalopetalum	4L	3L	Fitzgerald River National Park
uncinatum	2L	2H	Geraldton
Darwinia			
citriodora	2H	3L2H	Darling Scarp
Dianella			
revoluta	3L5H	4L	Swan Coastal Plain, Darling Scarp, wheatbelt
Dodonaea			
attenuata	4H	2L4H	wheatbelt
inaequifolia	3H	3L	wheatbelt
Dryandra			
carduacea	4H	4H	wheatbelt
cirsioides	6L		wheatbelt
fraseri		3L	wheatbelt
nobilis	5H	5H	wheatbelt
polycephala	4H	3L	wheatbelt
proteoides	6H	5H	wheatbelt
sessilis	3L2H	2H	wheatbelt, Darling Scarp, Swan Coastal Plain, Jurien Bay
Eremaea			
beaufortioides	3L	3L	Swan Coastal Plain, Jurien Bay
fimbriata		4L	Swan Coastal Plain
pauciflora	4L	4L	wheatbelt, Jurien Bay
violacea	4L	4L	Jurien Bay
Eremophila			
clarkei		2L	Mt. Jackson, wheatbelt
decipiens	2L3H	1H	wheatbelt
glabra	4H	3H	wheatbelt
Eriostemon			
deserti	6H		wheatbelt, Kalgoorlie
Eucalyptus			
burdettiana		4L	Fitzgerald River National Park
caesia		5H	wheatbelt
calophylla	2H	2H	Darling Scarp
cylindriflora	4H	3H	wheatbelt
erythrocorys	5H	7H	Jurien Bay
gardneri	5H	5H	wheatbelt
loxophleba	4H	4H	wheatbelt
macrocarpa	3L	3L	wheatbelt
platypus	4H	3H	Stirling Range
salmonophloia	5H	4H	wheatbelt, Kalgoorlie
tetragona	3L	3L	Fitzgerald River National Park, Esperance
torquata	2H	2H	wheatbelt

Species	Age at flowering and substrates Field	Cultivated	Source area
Grevillea			
bipinnatifida	2H	2H	wheatbelt
didymobotrya	6H		wheatbelt
"excelsior"	4L	3L	wheatbelt
nematophylla	4L	3L	wheatbelt
paniculata	4H	4L	wheatbelt
Hakea			
adnata	5H	6H	wheatbelt
bucculenta		3L	Geraldton
coriacea	6L		wheatbelt
cucullata		4L	Albany, Stirling Range
falcata	6H	3L	wheatbelt
incrassata		3L4H	wheatbelt
laurina	3H	3H	wheatbelt, Fitzgerald River National Park
multilineata	5L	4L4H	wheatbelt
petiolaris	4L	3H	wheatbelt
platysperma	5H	4H	wheatbelt
scoparia	3L	3L	wheatbelt
subsulcata	6L6H	4L5H	wheatbelt
victoria	4L	4L	Fitzgerald River National Park
Hypocalymma			
angustifolium	4L	5L	Swan Coastal Plain, Jurien Bay, wheatbelt
robustum	4L	4L	Jurien Bay, Swan Coastal Plain
Kunzea			
baxteri	4H	4L	Esperance
pulchella	3L	2L3H	wheatbelt
recurva		4L	Northcliffe
vestita	4L	4L	Swan Coastal Plain
Lechenaultia			
biloba	2L	2L	Darling Scarp
formosa	1H	1L	wheatbelt
Lepidosperma			
drummondii	6L6H		wheatbelt
pubisquameum	6H		wheatbelt
Leptospermum			
erubescens	4L	4L	wheatbelt, Darling Scarp
Melaleuca			
acuminata	4H	4L	wheatbelt
conothamnoides		2L	wheatbelt
cordata	6L		wheatbelt
cymbifolia	4H	4H	wheatbelt, Kalgoorlie
diosmifolia	7L	6L	Northcliffe
elliptica	5H	4H	Fitzgerald River National Park, wheatbelt
fulgens	4H	4H	wheatbelt
lanceolata	3L	3L	Leeuwin-Naturaliste
lateritia	5H	4L5H	Swan Coastal Plain, Leeuwin-Naturaliste
laxiflora	6L	3L	wheatbelt
oldfieldii	4L4H	3L	wheatbelt, Geraldton
pungens	6L	4L	wheatbelt
radula	3H	4L2H	Jurien Bay, Geraldton, wheatbelt
scabra	6L	5L	wheatbelt, Fitzgerald River National Park
subtrigona	6H	5L	wheatbelt, Fitzgerald River National Park
uncinata	6L	4L	wheatbelt
Olearia			
axillaris	4L	4L	Leeuwin-Naturaliste, Northcliffe

Species	Age at flowering and substrates Field	Cultivated	Source area
Paraserianthes			
lophantha	2H	2L	Darling Scarp
Pelargonium			
australe	1L2H	1L1H	Swan Coastal Plain, Jurien Bay
Petrophile			
ericifolia	5L	3L	wheatbelt
serruriae	4H	3H	Darling Scarp, wheatbelt
Phyllanthus			
calycinus	2H	2H	Darling Scarp
Pimelea			
physodes	4H	2L	Fitzgerald River National Park
Pittosporum			
phylliraeoides	7H	7H	wheatbelt
Regelia			
ciliata	5L	5L	Swan Coastal Plain
megacephala	3L	3L	Jurien Bay
velutina	5H	5L	Fitzgerald River National Park
Santalum			
acuminatum	8H		wheatbelt
Templetonia			
retusa	4L	3L	Swan Coastal Plain, Leeuwin-Naturaliste, Northcliffe
Verticordia			
chrysantha	6H	4L	wheatbelt
multiflora	3L	3L	Stirling Range, Fitzgerald River National Park
roei	5L	5L	Darling Scarp, wheatbelt
Xanthorrhoea			
nana	5L6H		wheatbelt

The phytogeography, ecology and conservation status of *Lechenaultia* R.Br. (Goodeniaceae)

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Abstract

Morrison, D.A. The phytogeography, ecology and conservation status of *Lechenaultia* R.Br. (Goodeniaceae). Kingia 1(1): 85-133 (1987). Distribution maps for each of the 25 known species of *Lechenaultia* are presented for 0.5° lat. x 0.5° long. grid cells, along with discussions of the habitat, flowering period, morphology, and conservation status. Nineteen of the species are endemic (or nearly endemic) to south-western Western Australia. An isoflor map of this region indicates a high node of species-richness on the northern sandplains, with a band of moderate species-richness running south-eastwards to the southern sandplains. This species-richness band follows the 400 mm annual rainfall isohyet, and corresponds with the kwongan heathlands and the wheatbelt.

Ordination, cluster and discriminant function analyses of the distribution of these 19 *Lechenaultia* species suggests that there are five biogeographic regions:- one area on the far northern sandplains, one on the northern sandplains and northern part of the wheatbelt, one in the jarrah woodlands and karri forests, one on the southern sandplains and southern part of the wheatbelt, and one in the inland mallee area. Discriminant function analyses of the distribution of these 19 *Lechenaultia* species among the phytogeographic regions of Beard and Barlow indicate that they are both accurate reflections of the *Lechenaultia* distributions.

Similarity coefficients of species presence among the phytogeographic regions of Beard indicate that the Irwin, Darling and Avon Botanical Districts are more similar to each other than they are to the Eyre and Roe Botanical Districts; while cladistic analysis of endemic species indicates that the Irwin, Roe and Eyre Districts have a more similar history. This suggests that there has been fairly widespread dispersal of some species in recent times.

Lechenaultia laricina is considered to be an endangered species, with *L. juncea*, *L. longiloba* and *L. pulvinaris* vulnerable, and *L. acutiloba* and *L. superba* rare; *L. chlorantha* and *L. ovata* are too poorly known for the conservation status to be known. Only three of these species are confidently known to be represented in conservation reserves, with two of the others thought to be present.

Introduction

The Goodeniaceae are well-represented in the flora of Western Australia (Marchant 1973), and they are one of the commonly encountered families in the heathlands of the south-west (George et al. 1979, Lamont et al. 1984). Within this family, *Lechenaultia* R.Br. is one of the most interesting genera. It is restricted to Australia and New Guinea, with all of the 25 recognised species occurring in Australia (Morrison 1986). Nineteen of the species are endemic (or nearly endemic) to south-western Western Australia, with one species on North-West Cape, two species in arid western Central Australia, one in arid eastern Central Australia, one restricted to a small area of the Northern Territory, and one species widespread across tropical northern Australia and extending to the southern coast and off-shore islands of New Guinea.

Most of the species are small perennial sub-shrubs or herbs, with only *Lechenaultia acutiloba*, *L. divaricata* and *L. linarioides* becoming shrubs over 1 m high. The plants are widespread but never dominant components of the flora of south-western Western Australia, occurring in woodland, forest, and especially heath (George et al. 1979, Specht 1981, Lamont et al. 1984).

This paper provides previously unpublished notes on the ecology, morphology, and conservation status of all of the species, as well as presenting the distribution data. The phytogeography of the South-West Botanical Province of Western Australia is also analysed in relation to the distribution and phylogeny of *Lechenaultia*.

Methods

The data presented were obtained from the herbarium collections housed at AD, BRI, CANB, CBG, LD, MEL, NT, PERTH and SYD, plus the type collections of CGE and S (codes as in Holmgren et al. 1981), supplemented by field observations of some 70% of the species (all from south-western Western Australia). The taxonomic scheme used was that of Morrison (1986).

The distribution of each species was recorded on a map of Australia subdivided into a 0.5° latitude by 0.5° longitude grid, corresponding to the 1:100,000 topographic survey maps of the Division of National Mapping, Commonwealth Department of Natural Resources.

Within the *Lechenaultia* distribution, only the South-West Botanical Province of Western Australia contains enough species for the analysis of phytogeographic patterns in detail. Consequently, the phytogeographic analyses concentrated on this area.

Two species-richness (isoflor) maps of the South-West Botanical province were derived from the distribution data. The first presented the species distribution based solely on validated herbarium records. However, as this is presumably an incomplete record, due to sparse collecting in some areas and land clearance in others, a second map presented the distributions as they could be conservatively inferred from the recorded distribution. For most species, this second map differed from the first only in one or two grid cells; and this second map was assumed to be superior to the first as a true representation of the species' distributions. It was therefore these inferred distributions that were used in the phytogeographic analyses.

The pattern of variation among the distributions of the 19 *Lechenaultia* species present in the South-West Botanical Province was analysed simultaneously using an ordination technique, detrended correspondence analysis (Hill 1979a), on the presence or absence of the species in each of those 130 grid cells that occur in the South-West Botanical Province. This non-linear technique is reported to be superior to the traditional linear ordinations (Gauch et al. 1977, Hill and Gauch 1980, Gauch et al. 1981), and this appears to be true for the data sets for which I have made comparisons. The pattern of variation among the 130 grid cells was analysed by ordinating the presence or absence of each of the 19 *Lechenaultia* species in each cell.

The clustering pattern of the 130 grid cells was investigated using a clustering strategy, two-way indicator species analysis (Hill 1979b), on the presence or absence of the 19 *Lechenaultia* species in each grid cell. This polythetic divisive technique is reported to be superior to traditional agglomerative techniques (Gauch and Whittaker 1981), and this appears to be also true for the data sets that I have used.

The predictability of the phytogeographic clusters formed by this analysis was tested using discriminant function analysis (Klecka 1975). This technique derives a small number of linear functions that weight the original discriminating variables (in this case, presence or absence of each of the 19 *Lechenaultia* species) so as to maximise the separation of the total scores of a set of reference samples summed over all of the variables. In this case, the reference samples consisted of each of the 0.5° x 0.5° grid cells that make up a particular phytogeographic cluster. Each of the grid cells was then individually re-classified using the discriminant functions derived from the original analysis, to see if the they were correctly classified into the particular phytogeographic region to which they were originally assigned. This technique effectively weights the species by constancy within groups (ie. minimal within-group variance and maximal between-group variance), and this approach to assessing classifications has been suggested by several people (Farris 1966, Johnson 1982).

The relationships between the *Lechenaultia* species distributions and the phytogeographic regions of Beard (1980d) and Barlow (1985) that cover the South-West Botanical Province (see Figures 6a and 6b) were also analysed using discriminant function analysis. For the Barlow (1985) regions, assigning each of the 131 grid cells to a particular region was straightforward, as this system is based on a 1° x 1° grid; while for the Beard (1980d) regions, which are based on vegetation physiognomy, those grid cells near the boundaries of the regions were assigned to the region that occupied the greatest portion of the cell. Once again, each of the grid cells was then individually re-classified using the discriminant functions to see if the they were correctly classified into the particular phytogeographic region to which they were originally assigned. A comparison was also made between the original Barlow (1984) regions and the modified regions of Barlow (1985), to see if there was any significant improvement in the predictivity of the modified regions compared to the original.

The relationships among the five south-western phytogeographic regions of Beard (1980d), as related to *Lechenaultia*, were analysed in two ways. Firstly, the overall superficial similarity was assessed using two similarity indices:- the Jaccard Coefficient and the Simple Matching Coefficient (Hubalek 1982).

Secondly, the historical relationships among the regions were analysed by converting the *Lechenaultia* morphological cladogram of Morrison (1987) into an area cladogram. This was done by simply superimposing the phytogeographic regions of Beard (1980d) onto the cladogram (cf. Nelson and Platnick 1981). Unfortunately, the cladogram as it stands (Figure 7a) is uninformative (or falsely informative; Platnick 1981) as far as the phytogeographic regions are concerned, because too many of the species occur in several of the regions. Therefore, the area cladogram was reduced to only those 11 species that are endemic to one of the phytogeographic regions plus those 3 species that are more characteristic of only one region (Figure 7b). While this potentially results in the loss of information (Platnick 1981), it does allow the cladogram to be resolved to a simple informative five-area cladogram. Those species excluded from the analysis were *L. biloba*, *L. floribunda*, *L. formosa*, *L. macrantha* and *L. tubiflora*, which are all widespread generalist species, while *L. acutiloba* was considered typical of the Eyre region and *L. linarioides* and *L. stenosepala* typical of the Irwin region.

The predominant geographical modes of speciation shown by *Lechenaultia* in Australia were investigated by studying the distributions of pairs or groups of closely related species, as defined by the taxonomic system of Morrison (1986).

Results and Discussion

The distribution maps, and the notes on morphology, ecology, and conservation status are presented in Appendix 1. The species present or presumed to be present in each of the 0.5° x 0.5° grid cells of south-western Western Australia are listed in Appendix 2.

Most of the south-western species occur in shrubland of some sort, although several species also occur in woodland or mallee. Only *L. biloba* is known from forests. The inland species usually occur in open grassland or woodland. All of the species occur in freely-draining sand or lateritic gravelly soils, except for *L. expansa*, which occurs in permanently wet areas. All of the species apparently have woody rootstocks, some of which can spread laterally. This may allow them to regenerate vegetatively after a fire or a dry spell.

The main flowering period for the genus is October and November, as shown in Figure 1. However, many of the species flower sporadically throughout the year, perhaps only after rain or a fire.

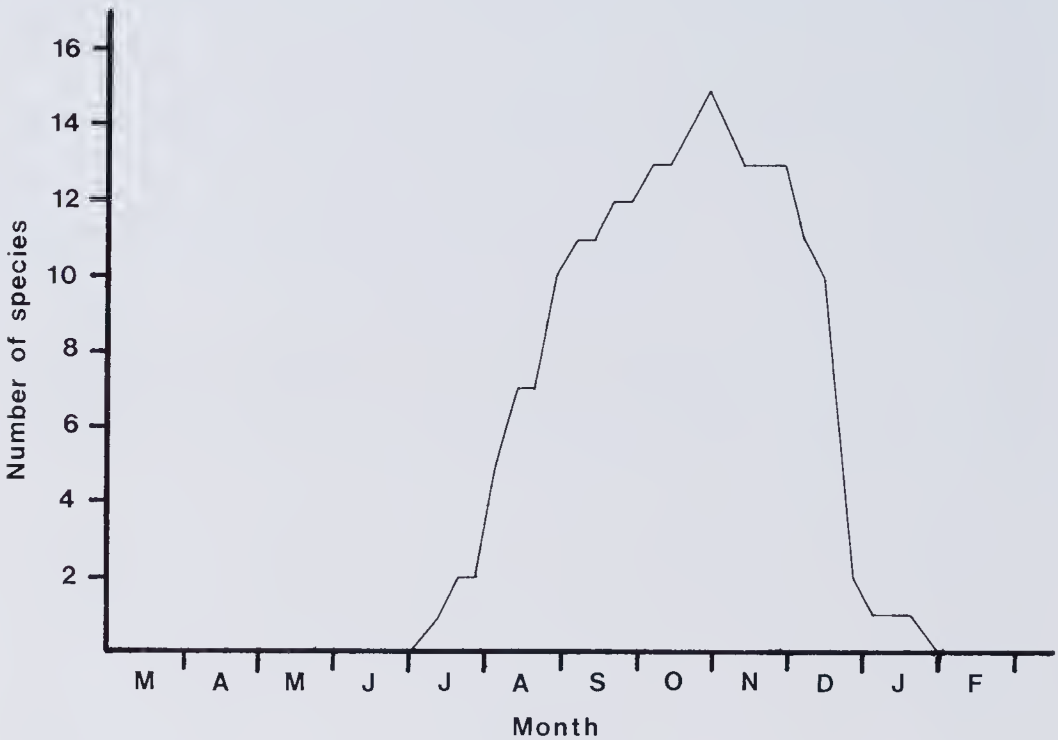


Figure 1. Number of *Lechenaultia* species flowering per week in south- western Western Australia. Data from Appendix 1.

Table 1 summarises the conservation status for those species considered to be at risk. Six of the species (24%) are thought to be under threat, all of them from the South-West Botanical Province of Western Australia. A further two species are too poorly known for their conservation status to be accurately determined. Three of the species are thought not to occur in conservation reserves, while two others have not been recently confirmed as present in them. Rye et al. (1980) and Burgman and Hopper (1982) report only two of these species to be exploited in the wild by the wildflower industry, although 32% of the total number of *Lechenaultia* species are exploited. Nearly all of this exploitation is for the nursery trade.

Table 1. Summary of the conservation data for the *Lechenaultia* species considered to be at risk.

Conservation Category *	Leigh et al. (1981) +	This study +
Extinct (X)	—	—
Endangered (E)	*L. longiloba* (C)	—
	L. pulvinaris	—
	—	*L. laricina*
Vulnerable (V)	*L. juncea*	*L. juncea*
	—	*L. longiloba* (C?)
	—	*L. pulvinaris* (C)
Rare (R)	*L. acutiloba* (C)	*L. acutiloba* (C)
	L. superba (C)	*L. superba* (C)
	L. chlorantha (C)	—
Poorly Known (K)	—	*L. chlorantha* (C?)
	—	*L. ovata*

* See Leigh et al. (1981) for a detailed explanation
\+ C - species known from conservation reserves. ? - not recently confirmed to be present

The two maps of the species-richness isopleths are shown in Figures 2a and 2b. The isoflor map of Figure 2b indicates a high node of species richness on the northern sandplains, with over 44% of the species occurring in a grid cell south-east of Eneabba. This is in accord with the comments of George et al. (1979), who consider *Lechenaultia* to be characteristic species of the floristically rich heathland between the Moore River and Dongara. A band of moderate species-richness then runs south-east through the wheatbelt, and then extends eastward along the southern sandplains past Esperance. The kwongan heathlands predominate on both the northern and southern sandplains of this species-rich area, with eucalypt and banksia woodlands occupying the intermediate wheatbelt. The Jarrah, Marri and Karri forests of the extreme south-west are relatively species-poor, as are the woodlands and shrublands of the inland area.

This band of species richness roughly follows the 400 mm annual rainfall isohyet, with the 800 mm isohyet defining the transition to the species-poor area of the south-western forests and the 300 mm isohyet defining the eastern limit of *Lechenaultia* distribution. This distribution appears to be a recurrent pattern at the generic level in the flora of south-western Australia, with many examples appearing in a wide range of families (eg. Haemodoraceae, Proteaceae, Rutaceae, Mimosaceae, Myrtaceae; see Hopper 1979, Lamont et al. 1984). This has resulted in the recognition of three species-richness zones in south-western Australia:- one in the Eneabba-Mt Lesueur area, one in the Stirling Ranges, and one near the Fitzgerald River (George et al. 1979). It is therefore interesting to note that *Lechenaultia* does not appear to have the expected node in the Stirling Ranges.

One of the apparent reasons for the high species richness in the kwongan heathlands is the high number of localised endemics compared to the wheatbelt and the species-poor areas. There are three extremely localised endemics (*L. chlorantha, L. juncea* and *L. longiloba*) in the northern kwongan and another three in the southern kwongan (*L. acutiloba, L. heteromera* and *L. superba*), while the wheatbelt only has two localised endemics (*L. laricina* and *L. pulvinaris*) and the other areas none.

A comparison of Figures 2a and 2b highlights several apparently sparsely collected areas in the South-West Botanical Province. The only species with any large remaining disjunctions in its distribution is *L. formosa* (Morrison 1986); the other gaps in the species distributions are therefore presumably the result of under-collection or the destruction of populations due to agricultural clearance. The most obvious under-collected area is the eastern half of the Roe Botanical District. This is an area of mallee that has only recently become easily accessible to botanical collectors, and it

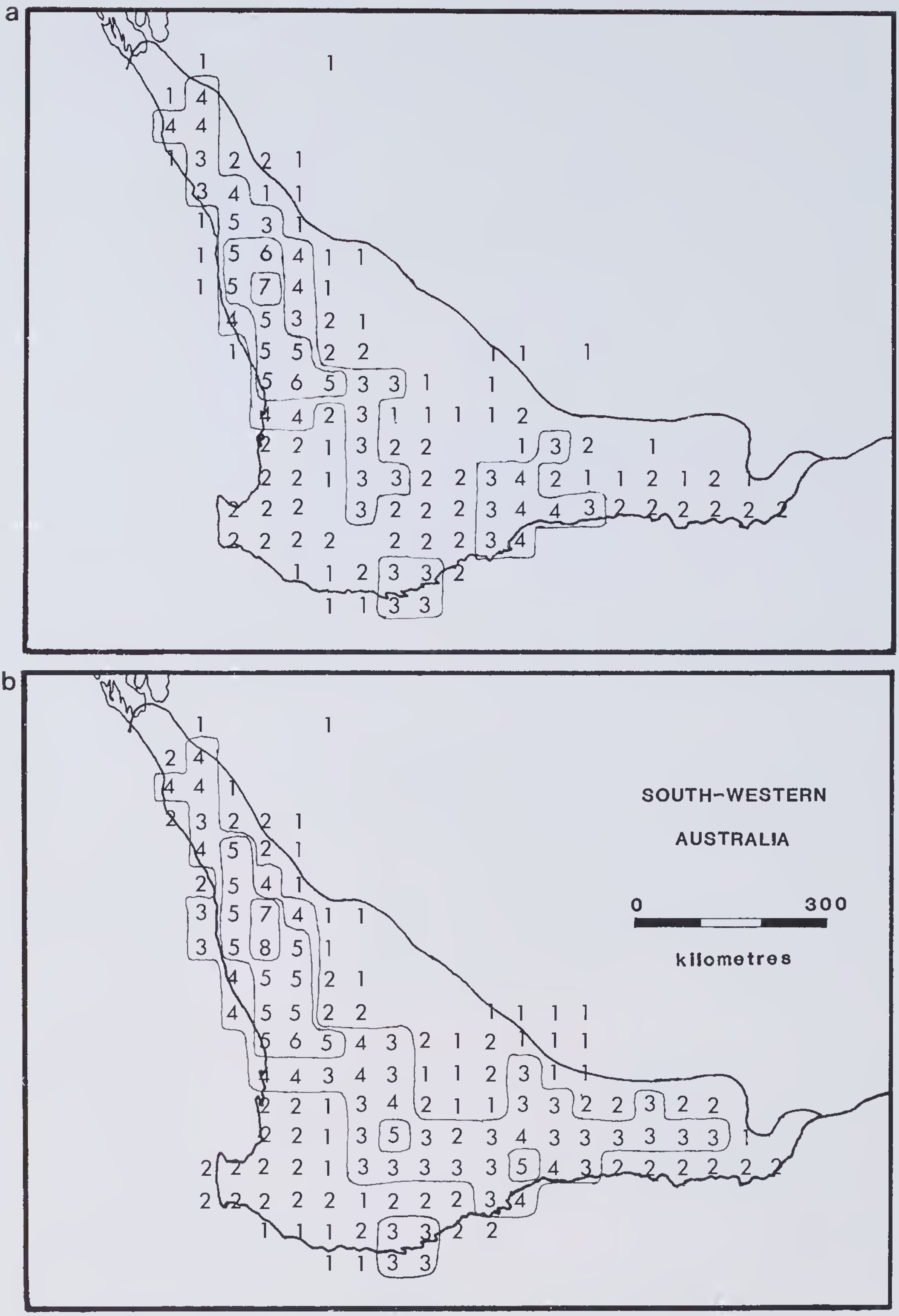


Figure 2. Isoflor maps of *Lechenaultia* species in 0.5° x 0.5° grid cells, based on validated herbarium records (Figure 2a) and on inferred species distributions (Figure 2b). Contour interval is 2 species. Data from Appendix 2.

Figure 3. Projection of the *Lechenaultia* species onto axes representing the first two components from the detrended correspondence analysis of the distribution data. The eigenvalues associated with these two components were 0.786 and 0.360 respectively.

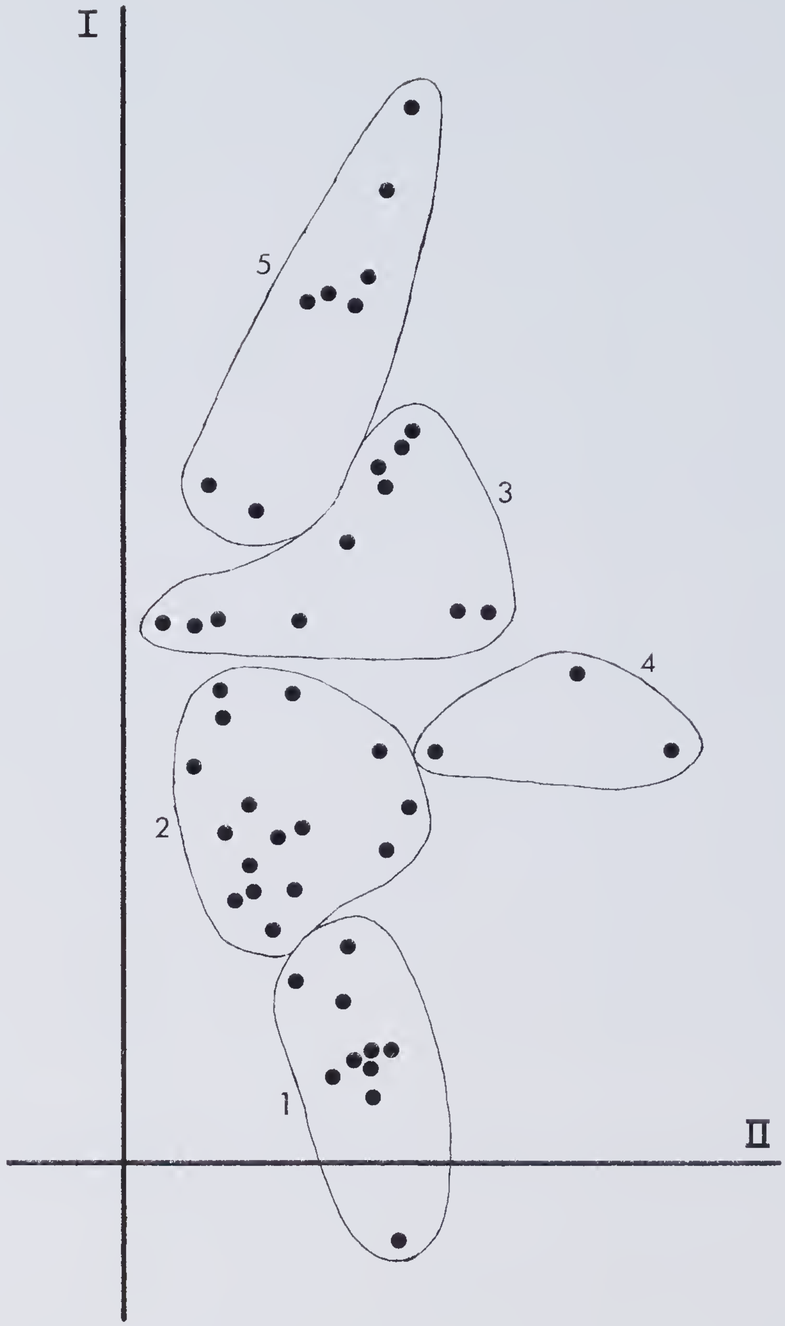


Figure 4. Projection of the 0.5° x 0.5° grid cells onto axes representing the first two components from the detrended correspondence analysis of the distribution data. The eigenvalues associated with these two components were 0.786 and 0.360 respectively. The five phytogeographic groups from the cluster analysis are also shown.

appears to be an area relatively rich in uncollected species. For example, the two newly described *Lechenaultia* species from south-western Australia are from this area (Morrison 1986). The other apparently poorly collected area is the northern tip of the Irwin Botanical District and the Shark Bay area, another area that has received only relatively recent botanical inspection. The area between Collie and Mt Barker in the south-west also shows gaps in many of the species distributions, but this is more likely to be a result of clearing for agriculture.

The ordination of the species distributions (Figure 3) indicates three main groupings of species. Those species that are restricted to the Roe and Eyre Botanical Districts (*L. acutiloba, L. brevifolia, L. heteromera, L. papillata,* and *L. superba*) ordinate together, as do most of those species common in the northern kwongan (*L. biloba, L. chlorantha, L. floribunda, L. hirsuta, L. juncea, L. linarioides, L. longiloba. L. macrantha* and *L. stenosepala*). The two endemics of the Avon District (*L. laricina* and *L. pulvinaris*) form the third group. The sole endemic of the south-western forests (*L. expansa*) and the two widespread species (*L. formosa* and *L. tubiflora*) do not fit into any of the groups.

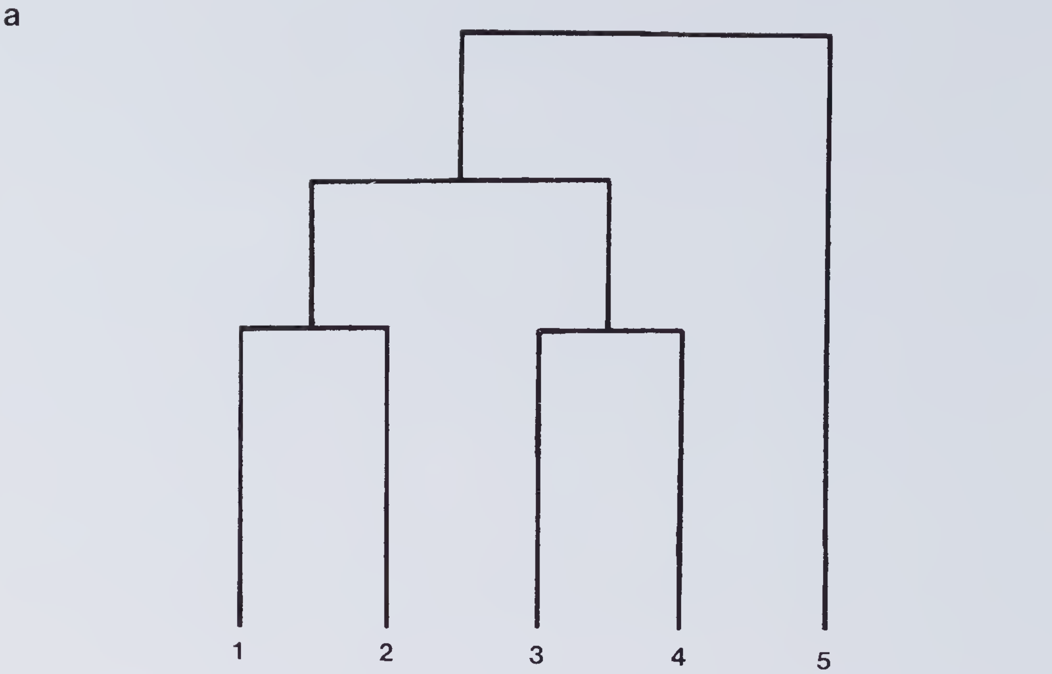
The first axis of this ordination accurately separates the north-western species from the south-eastern ones, while the second axis appears to reflect the rainfall gradient away from the coast. The distribution of the individual species thus also appears to be strongly influenced by rainfall, as well as the generic distribution.

The ordination of the grid cells (Figure 4) does not reveal any obvious clusters, indicating that there are no clear-cut groupings of regions within the South-West Botanical Province as far as *Lechenaultia* is concerned. Once again, the first axis separates those grid cells in the north-west from those in the south-east, while the second axis separates the coastal grid cells from the inland ones.

The clustering analysis reveals five main groupings of the grid cells (Figures 5a and 5b); and the re-classification of the grid cells in the discriminant function analysis of the clusters indicates that only 3.1% of the grid cells were incorrectly classified. This suggests that the cluster pattern has a high level of predictability. However, while the projection of these clusters onto the ordination (Figure 4) shows that they are non- overlapping, they are nonetheless somewhat arbitrary clusters in a continuum of variation.

These grid cell clusters correspond fairly closely to the biogeographic areas traditionally recognised in south-western Western Australia:- Groups 1 and 2 occur in the kwongan of the northern sandplains, with Group 2 extending into the northern part of the wheatbelt, Group 3 occurs in the kwongan of the southern sandplains and extends into the southern part of the wheatbelt, Group 4 occurs in the jarrah and marri woodlands and karri forests of the south-west, and Group 5 occurs in the inland mallee area. However, the cluster analysis fails to unite the wheatbelt as a single unit, and the northern sandplains are clearly divided into two areas. This latter pattern seems to be the result of a large number of localised endemics that are restricted to only one of these two areas. Finally, the analysis also suggests that the southern areas are more similar to each other than they are to the northern areas (Figure 5a).

The results of the re-classification of the grid cells in the discriminant function analyses (Tables 2 and 3) indicate that the phytogeographic regions of both Beard (1980d) and Barlow (1985) are reasonably accurate reflections of the distribution of the *Lechenaultia* species. The discriminant functions correctly re-classified approximately 85% of the grid cells in both cases (87.0% for the Beard regions and 83.2% for the Barlow regions), and those grid cells incorrectly re-classified were usually around the boundaries of the regions (Figures 6a and 6b).



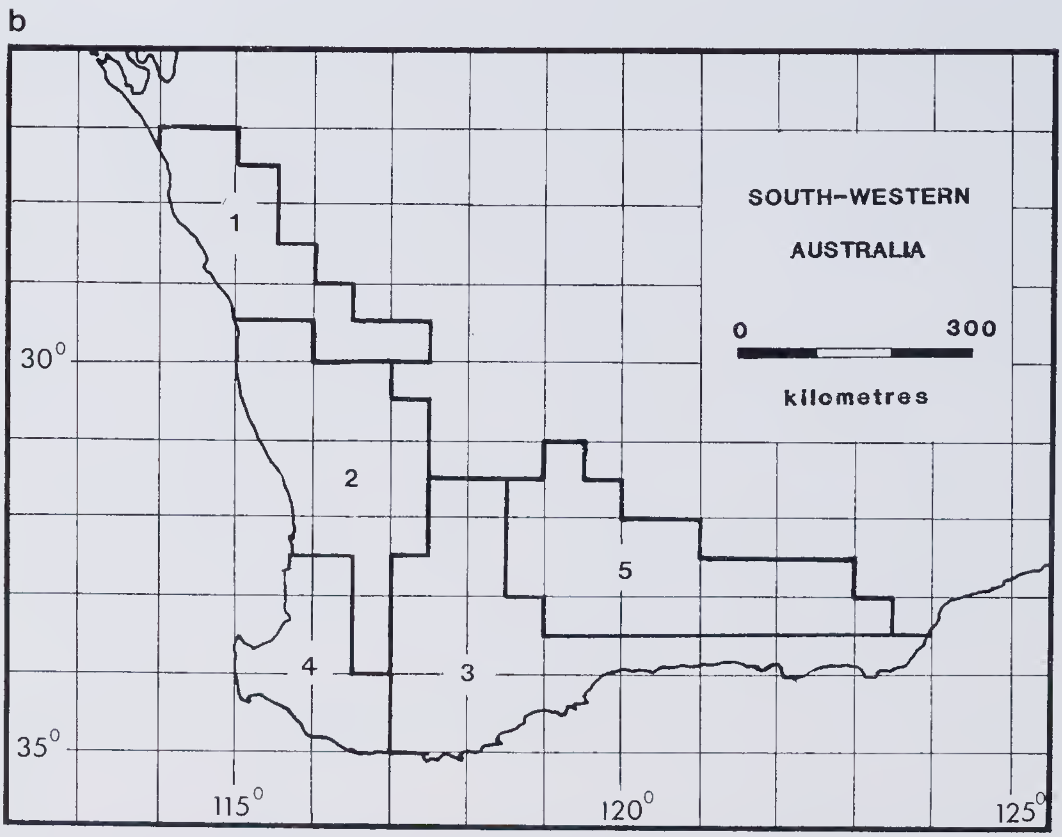


Figure 5. Dendrogram (Figure 5a) and map (Figure 5b) of the five phytogeographic groups resulting from the clustering analyses of the distribution data.

Table 2. Results of the re-classification of the grid cells of the Beard (1980d) phytogeographic regions using discriminant function analysis.

Phytogeographic region predicted from the discriminant function	Phytogeographic region of Beard					Total no. of grid cells
	Irwin	Avon	Darling	Roe	Eyre	
Irwin	18	1	0	0	0	19
Avon	1	24	5	7	0	37
Darling	0	1	32	0	0	33
Roe	0	0	0	22	0	22
Eyre	0	1	1	0	15	17

Table 3. Results of the re-classification of the grid cells of the Barlow (1984) and (1985) phytogeographic regions using discriminant function analysis.

Phytogeographic region predicted from the discriminant function	Phytogeographic region of Barlow			Total no. of grid cells
	Bencubbin	Leeuwin	Esperance	
Barlow (1984)				
Bencubbin	28	7	3	38
Leeuwin	2	32	2	36
Esperance	5	2	50	57
Barlow (1985)				
Bencubbin	38	7	6	51
Leeuwin	3	32	2	37
Esperance	2	2	39	43

For the Beard (1980d) regions, most of the incorrectly re-classified grid cells were in the complex boundary area of the Avon, Darling, Eyre and Roe Botanical Districts to the north of the Stirling Ranges (Figure 6a). In particular, the analysis indicates that most of this area should be correctly classified as part of the Avon Botanical District. However, such a result is not unexpected, as the regions were originally based on vegetation physiognomy rather than floristics (Beard 1980d), and there is thus no *a priori* reason to assume that they should accurately reflect the distribution of any one particular genus.

On the other hand. the incorrectly re-classified grid cells for the analysis of the Barlow (1985) regions are around the boundaries of most of the regions (Figure 6b). In particular, the analysis indicates that most of the boundaries are displaced by 0.5° of latitude or longitude. This is in fact a very suggestive result, as the regions were originally based on a 1° grid, and the analysis thus indicates that the regional boundaries are actually correctly placed at this scale. The Barlow (1985) regions appear to be slightly less predictive than the original Barlow (1984) regions, as the original regions were 84.4% correctly re-classified by the discriminant function analysis (Table 3).

The similarity coefficients among the phytogeographic regions of Beard (1980d) (Table 4) indicate that the Irwin, Avon and Darling Botanical Districts are superficially very similar, as are the Roe and Eyre Botanical Districts. On the other hand, the reduced area cladogram (Figure 7c) indicates that the Irwin Botanical District has a more similar history to that of the Roe and Eyre Botanical Districts. The history thus unites the northern and southern kwongan areas, even though they are now spacially separated.

Such a relationship has been noted for other genera as well, based on the distribution of vicarious species pairs and disjunctions in the distributions of species (see Nelson 1981, Lamont et al. 1984). The current disjunction between the kwongan vegetation areas has been postulated to be the result of disruption of a previously continuous range,

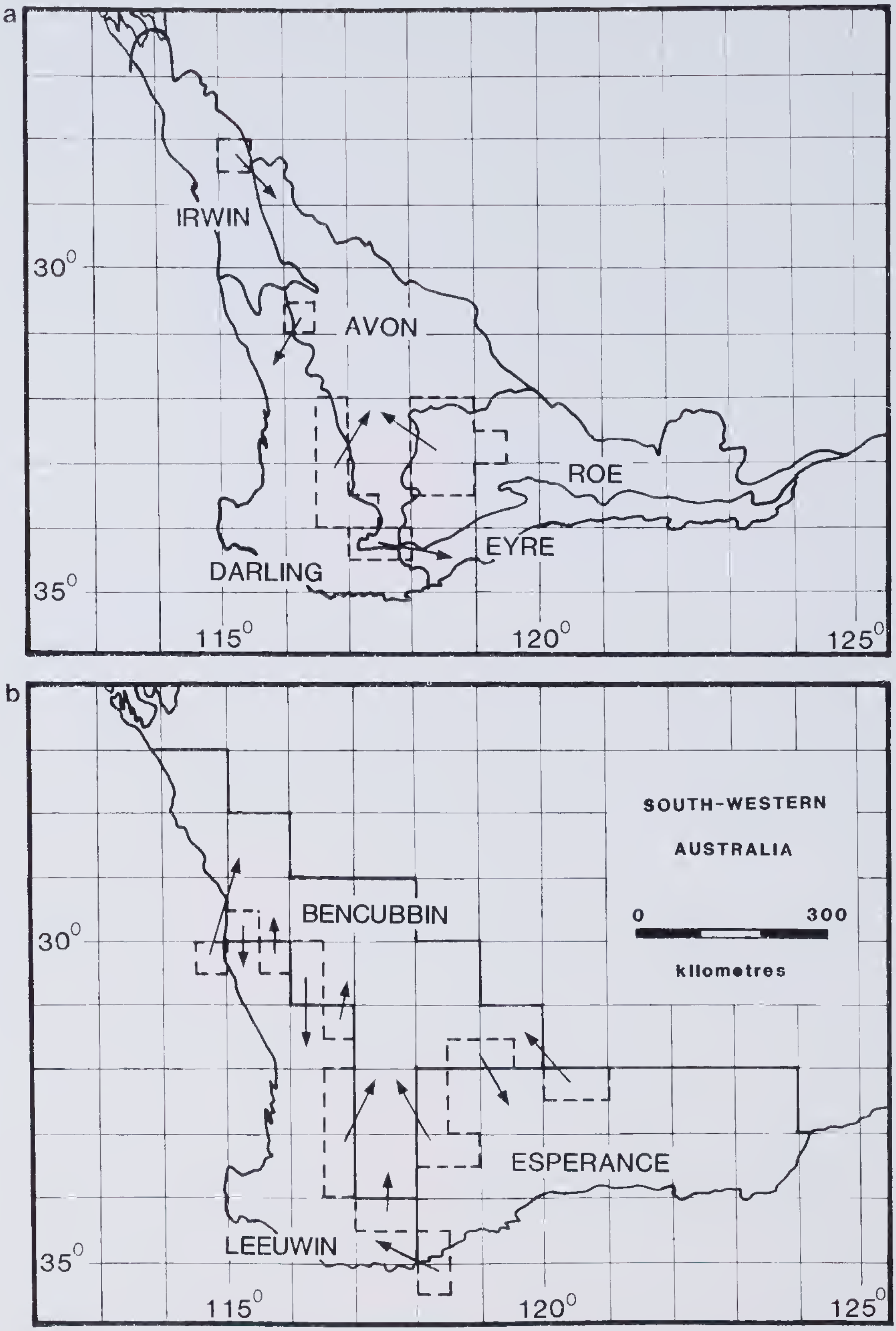


Figure 6. The South-West Botanical Province phytogeographic regions of Beard (1980d) (Figure 6a) and Barlow (1985) (Figure 6b), showing those grid cells incorrectly re-classified by the discriminant functions.

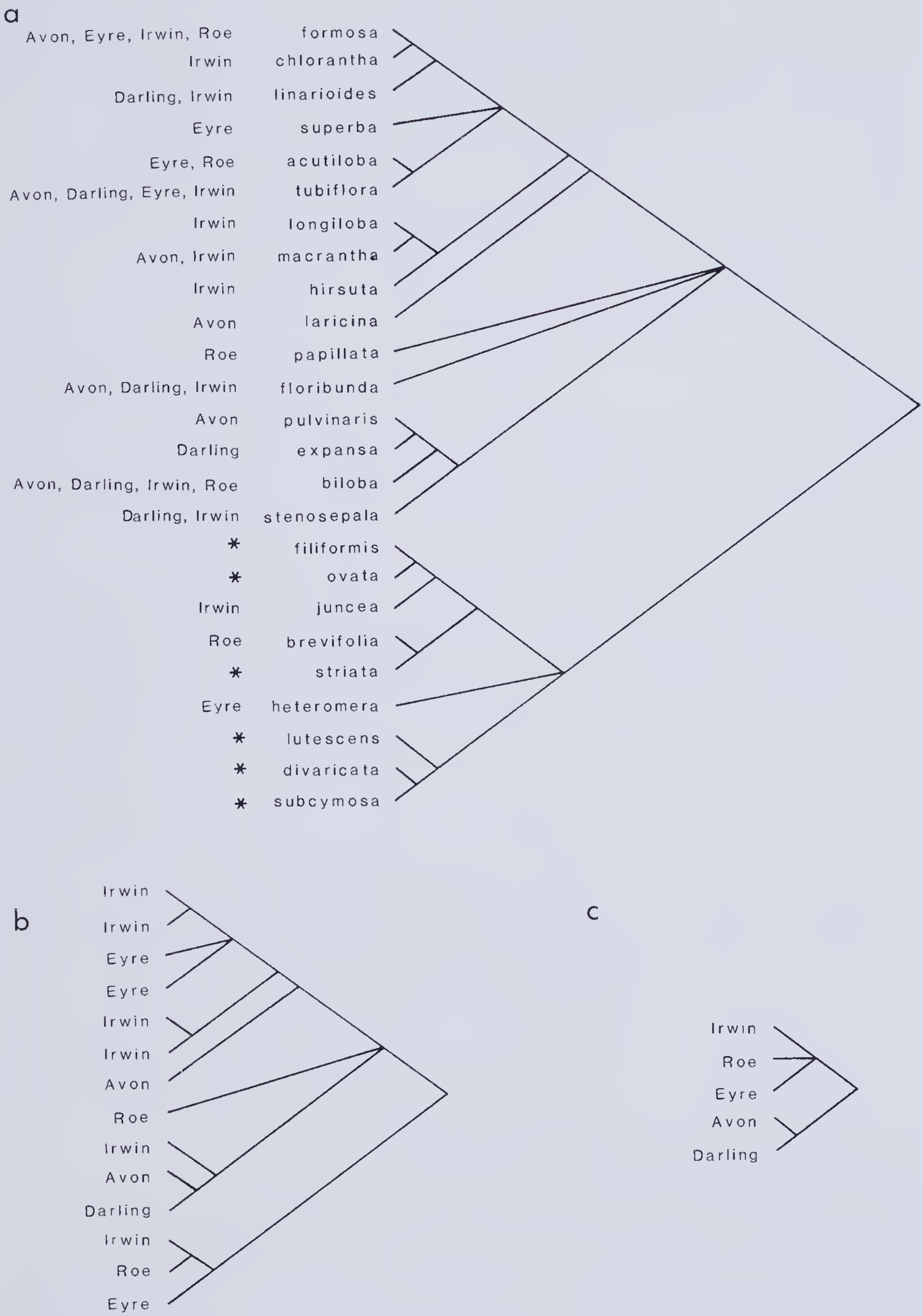


Figure 7. Area cladogram of all of the *Lechenaultia* species (Figure 7a), those *Lechenaultia* species that are endemic to only one Botanical District of the South-West Botanical Province (Figure 7b) and the reduced area cladogram from Figure 7b (Figure 7c), showing the Botanical Districts of the South-West Botanical Province, in which they occur. * Not in South-West Botanical Province.

Table 4. Percentage similarity of the phytogeographic regions of Beard (1980d). The upper half of the similarity matrix contains the Simple Matching Coefficient while the lower half contains the Jaccard Coefficient.

Phytogeographic Region	Phytogeographic region Irwin	Avon	Darling	Roe	Eyre
Irwin	—	57.9	63.2	36.8	36.8
Avon	38.5	—	63.2	57.9	57.9
Darling	50.0	27.3	—	52.6	52.6
Roe	14.3	20.0	20.0	—	68.4
Eyre	14.3	20.0	20.0	25.0	—

this continuous range itself being the result of colonisation of the whole area by laterite-tolerant species after the area was subjected to lateritisation during the Miocene (Marchant 1973, Lamont et al. 1984). The cause of the disjunction is postulated to be the onset of more arid conditions during the Holocene (Nelson 1981, Hopkins et al. 1983, Lamont et al. 1984). The expansion of the drier regimes would have resulted in the extinction of the kwongan species, leaving the upland areas as refugia and subsequent centres of speciation. The current superficial floristic similarity of the northern kwongan with the forests of the south-west and the woodlands of the wheatbelt could thus be the result of very recent dispersal of species into these regions, particularly from the north.

Figure 7a indicates that *L. subcymosa*, which occurs on North West Cape and the Shark Bay islands, is closely related to the arid zone species (particularly *L. divaricata*), and is only more distantly related to the south-western species. Thus, this does not support Burbidge and George's (1978) use of this species as an example of the close taxonomic affinity of the Shark Bay area with that of the South-West Botanical Province rather than with that of the Eremaean Province. This area should indeed, as they suggest, be part of a "transitional zone".

The analysis of the geographical distributions of the groups of closely related species reveals that within the South-West Botanical Province the congeners are frequently allopatric, sometimes sympatric, and rarely parapatric (Table 5). This suggests that, in this area, geographical isolation has probably played a major role in speciation within *Lechenaultia*; and a similar pattern has been found for *Acacia* (Hopper and Maslin 1978). Outside this region, most of the congeners are allopatric, which is in contrast to the finding of Maslin and Hopper (1982) that sympatry and allopatry are about equally common in central Australia.

Table 5. Geographical relationships of the closely related species groups of *Lechenaultia*.

Species group	Geographic distribution Allopatric	Parapatric	Sympatric
Sect. Patentes			
L. biloba and *L. stenosepala*			+
L. expansa and *L. pulvinaris*	+		
L. floribunda and *L. papillata*	+		
Sect. Latouria			
L. heteromera and *L. lutescens*	+		
L. divaricata and *L. subcymosa*	+		
L. brevifolia, *L. juncea* and *L. striata*	+		
L. filiformis and *L. ovata*			+
Sect. Lechenaultia			
L. hirsuta, *L. laricina* and *L. superba*	+		
L. longiloba and *L. macrantha*			+
L. acutiloba and *L. tubiflora*		+	
L. chlorantha and *L. formosa*	+		

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Appendix 1. Notes on the distribution, ecology, morphology and conservation status of *Lechenaultia* species

The morphological notes are based on personal observation of the herbarium collections, supplemented by field observations of the species. Distributional and ecological data are from details on the herbarium labels, also supplemented by personal field observations. References which contain more details of some of these aspects (eg. more detailed descriptions of specific habitats) are also cited. Distributional data were derived from the point distributions of the specimens examined, and are mapped for grids of 0.5° lat. x 0.5° long. The distributions are also recorded for the standard botanical regions currently used by each of the state herbaria, and also for the more recent Australian phytogeographic regions of Barlow (1985). The conservation status of each species is expressed using the scheme of Leigh et al. (1981), supplemented where necessary by more detailed observations; and the number of specimens examined is given, to provide some measure of species abundance. The most widely-used common name is also recorded, where known; and a list of checked illustrations is provided, to aid with the identification of the species.

Lechenaultia acutiloba Benth., Fl. Austral. 4:41 (1868)

Distribution (Figure 8)
Western Australia: Roe and Eyre Districts, between Ravensthorpe and Ongerup.

Esperance Region.

Ecology
A small shrub with a woody rootstock that may sucker. It occurs in sand or sandy gravel, usually in damp soil near river banks or occasionally swamps. It is found in open floodplains or heath, where it is never very common. Flowering is from mid September to late December.

Notes
Closely related to *L. tubiflora*, from which it can be readily distinguished by the shrubby habit, larger green flowers, and wingless corolla lobes.

Specimens Examined
18.

Conservation Status
2RC, as it is geographically localised (Marchant and Keighery 1979, Rye 1981) and restricted to a specific habitat. The river banks along which it usually occurs are, in many cases, parts of water conservation reserves; but these reserves are all extremely small, and are thus of only limited use as flora conservation areas. The species may also occur in Fitzgerald River National Park, but this has not been confirmed. It is exploited for the nursery trade (Rye et al. 1980), and is known to be in cultivation (Rye 1981). Newbey (1968) and Fairall (1970) discuss its cultivation requirements.

Common Name
Wingless lechenaultia.

Lechenaultia biloba Lindley, Sketch Veg. Swan R. 27 (1839)

Distribution (Figure 9)

Western Australia: Irwin, Avon, Darling, and Roe Districts.

Bencubbin, Leeuwin, and Esperance Regions.

Ecology

A sub-shrub or small shrub with a woody rootstock (cf. Majer 1981). It has been recorded from white, grey, yellow, orange and light brown sand, or sandy loam (Muir 1976, 1977), often over laterite (Griffin and Hopkins 1985), as well as from gravel. It occurs in a wide range of heaths (Beard 1976d, 1979a, 1980b, 1980c, Muir 1979, Beadle 1981, Hopkins and Hnatiuk 1981, Brown and Hopkins 1983, Griffin et al. 1983, Griffin and Hopkins 1985), scrubs (Beard 1976e, 1980b), mallee (Muir 1976, 1977, Beard 1980b), woodlands (Beard 1979a, 1979b), and (mainly Jarrah and Marri) forests (Williams 1932, Majer 1981), usually occurring in open patches or even disturbed areas (Muir 1977). It is often locally common in the western part of its range, but it usually occurs as scattered plants in the inland areas. Flowering is usually from early August to mid November (cf. Majer 1981, Milewski and Davidge 1981); and it has been recorded to flower in the first season after a March fire (Majer 1981). In the Jarrah forests, the roots show a high level of infection by vesicular-arbuscular mycorrhizae (Lamont 1984).

Variability

Flower and leaf size as well as flower colour vary greatly (see Morrison 1986), but these characters do not appear to be correlated.

Notes

Closely related to *L. expansa* and *L. stenosepala*, from which it can be readily distinguished by the (usually) darker blue flowers with much broader wings and a more hairy floral tube. In inland areas it can look similar to *L. brevifolia*, which has a distinctly scapigerous flowering habit and much reduced wings on the superior lobes of the flowers.

Specimens Examined

343.

Conservation Status

Not at risk, as it is widespread and common throughout South Western Australia. It is exploited for the nursery and seed trades (Rye et al. 1980, Burgman and Hopper 1982).

Common Name

Blue lechenaultia.

Illustrations

Anon. (1965) *Aust. Pl.* 3:141; Morcombe (1968) p.12; Newbey (1968) pp.112-3,125; Baglin and Mullins (1969) p.89; Beard (1970) pl.xxxi; Fairall (1970) p.181; Morcombe and Morcombe (1970) p.80; Baker (1971) p.19; Hodgson and Paine (1971) p.89; Anon. (1973) *Aust. Pl.* 7:115; Blombery (1973) p.190; Holliday (1973) p.16; Grieve and Blackall (1975) pl.v; Green & Wittwer (1976) *Aust. Pl.* 8:329; Gardner (1978) pp.5,130; Mullins and Baglin (1978) pl.75; Erickson et al. (1979) p.46; A.P.S.G. (1980) between pp. 176-7.

Lechenaultia brevifolia D.A. Morrison, Brunonia 9:18 (1987)

Distribution (Figure 10)
Western Australia: Coolgardie and Roe Districts.

Leonora, Bencubbin, and Esperance Regions.

Ecology
A sub-shrub with a woody rootstock that may sucker. It has been found on deep yellow or shallow red sand, usually in low scrub or heath (Beard 1969, as *L.* sp. inedit.). Plants are usually scattered, but are sometimes common in patches. Flowering is from late October to early December.

Variability
There is some variablity in flower and ovary size between populations, but this does not seem to be significant.

Notes
Closely related to *L. heteromera*, from which it can be readily distinguished by the distinctly scapigerous flowering stems and much darker flowers, and to *L. juncea* and *L. striata*, which have much longer leaves and paler flowers.

Specimens Examined
27.

Conservation Status
Not at risk, as it is widespread and relatively common throughout the south-eastern mallee of South Western Australia.

Lechenaultia chlorantha F. Muell., Fragm. 2:20 (1860)

Distribution (Figure 11)
Western Australia: Irwin District, near the mouth of the Murchison River.

Bencubbin Region.

Ecology
A sub-shrub with a woody rootstock that may sucker. Little data exist on the habitat of this species, but it has been recorded from exposed red sandstone breakaways, where it is apparently uncommon. Flowering specimens have been collected in August and September.

Notes
Closely related to *L. formosa* and to *L. linarioides*, from which it can be readily distinguished by the green corolla.

Specimens Examined
7.

Conservation Status
2KC, as it is very geographically localised (Rye 1981) and not locally common, and it is currently known from only one small population. It has also been recorded from Kalbarri National Park (Beard 1976c); but it is not known how extensive these

populations are, and the species has not been recently confirmed to be present. This species is very poorly collected (Marchant and Keighery 1979), and much more needs to be known before the conservation status can be accurately assessed. If a viable representation in a conservation area is demonstrated then it would be more accurately classified as 2RC. It is not known to be in wide cultivation (cf. Rye 1981), but see also A.P.S.G. (1980).

Lechenaultia divaricata F. Muell., Fragm. 3:33 (1862)

Distribution (Figure 12)
Northern Territory: Central Australia North and Central Australia South Regions; Queensland: Gregory North and Gregory South Districts; South Australia: Lake Eyre Basin Region; New South Wales: North Far Western Plains Sub-division.

MacDonnell, Thomson, Simpson, Cooper, and Torrens Regions.

Ecology
A small shrub with a woody rootstock that may sucker (Maconochie 1982). The fruit is woody and often persistent for several years. It has been recorded from deep red sand dunes (where it occurs on the upper slopes and crests; Buckley 1981b), sandplains, alluvial soils, or sometimes in flood-plains (Boyland 1970), swales, or other periodically wet depressions. It occurs in open grassland, low open woodland (Boyland 1970), or open mulga (Cunningham et al. 1981). It usually occurs as scattered bushes, but is sometimes locally common. The plants appear to have high drought tolerance (Buckley 1982). It apparently flowers sporadically throughout the year.

Variability
Throughout its range, there is considerable variability in flower colour and size, but the species nevertheless remains distinctive. However, specimens are often mis-identified (eg. Buckley 1983, who records this species off the Western Australian coast), often in confusion with, for example, *Scaevola depauperata* or *S. spinescens*. Within any one individual plant the number of articles per pseudocapsule (and hence pseudocapsule size) varies greatly, unlike any other species except *L. filiformis*.

Notes
Closely related to *L. subcymosa* and *L. lutescens*, from which it can be readily distinguished by the divaricate almost leafless habit.

Specimens Examined
125.

Conservation Status
Not at risk, as it is apparently common and widespread throughout arid eastern Central Australia. Specht et al. (1974) report it to be rare in South Australia, but this does not appear to be the case. However, Melville (1973) and Specht et al. (1974) list it as a relict species that has retained primitive morphological features, and that is therefore worthy of particular attention.

Common Name
Tangled lechenaultia.

Illustrations
Cunningham et al. (1981) p.636; Jessop (1981) p.360; Jessop & Toelken (1986) p.1407.

Lechenaultia expansa R.Br., Prodr. 1:581 (1810)

Distribution (Figure 14)
Western Australia: Darling District.

Leeuwin Region.

Ecology
A sub-shrub with a woody rootstock. It has been recorded from sand or peaty sand, where it usually occurs in swamp heath, around the edge of paperbark swamps, or in other permanently damp or seasonally waterlogged areas (Speck and Baird 1984). It is sometimes locally common. Flowering is from late October to mid January.

Variability
Flower and pseudocapsule size are very constant, but leaf size can vary considerably between populations.

Notes
Closely related to *L. floribunda* and often confused with it, particularly in the area around Perth where the two distributions overlap. However, *L. expansa* has larger and often minutely pitted leaves, a more densely hairy floral tube, smaller and almost equal corolla wings, a more thickly hairy indusium, and smaller pseudocapsules with fewer and ovoidal articles.

Specimens Examined
96.

Conservation Status
Not at risk, as it is widespread and apparently common throughout the Jarrah and Marri forests of South Western Australia. It is exploited for the nursery trade (Rye et al. 1980).

Lechenaultia filiformis R.Br., Prodr. 1:581 (1810)

Distribution (Figure 13)
Western Australia: Gardner, Fitzgerald, and Hall Districts; Northern Territory: Victoria River, Darwin and Gulf, and Barkly Tableland Regions; Queensland: Burke, Cook, and North Kennedy Districts. Also Papua-New Guinea, along the south-eastern coast.

Kimberley, Arnhem, Barkly, Carpentaria, Tanami, and Cape York.

Ecology
A herb or sub-shrub that probably grows annually from a woody rootstock. It is usually found in sand or sandy loam near water-courses or other low-lying areas, but it sometimes occurs on sandstone plateaux or granitic pebble hillsides. It is usually found in *Triodia* grassland under *Eucalyptus* or *Melaleuca* woodland, where it usually occurs as scattered plants. The plants apparently flower sporadically throughout the year, perhaps only after rain.

Variability
Flower size and colour is very variable, and this apparently correlates with longitude, as plants with the larger flowers predominate in the western part of the distribution and plants with the smallest ones predominate in Queensland and New Guinea (see Morrison 1986).

Notes

This species and *L. ovata* can be readily distinguished from all of the other members of the genus by the fruits, which do not develop articles at the ends, and by the distinctive prolongation of the superior calyx lobe compared to the inferior ones. *L. filiformis* has longer and thinner leaves than *L. ovata*.

Specimens Examined

85.

Conservation Status

Not at risk, as it is widespread and common throughout tropical Northern Australia.

Lechenaultia floribunda Benth., in Endl., Enum. Pl. 70 (1837)

Distribution (Figure 15)

Western Australia: Irwin, Avon, and Darling Districts.

Bencubbin and Leeuwin Regions.

Ecology

A sub-shrub or small shrub with a woody rootstock (Baird 1977, Dodd et al. 1984). It has been recorded from white or grey sand or loamy sand, where it occurs in heath (Beard 1976d, 1979a, Beadle 1981), thicket (Beard 1979a), or *Banksia/Eucalyptus* woodland with a heath understorey (Baird 1977, Milewski and Davidge 1981). It is often locally common. Flowering is from late August to mid December.

Variability

Leaf length, flower size, and flowering habit are all very variable, apparently with a morphocline running from north to south, with many of the northern populations having plants with smaller flowers, larger leaves, and a more densely-branched flowering habit than the southern plants (see Morrison 1986).

Notes

Closely related to *L. expansa*, from which it can be distinguished as above, and to *L. papillata*, which has papillate leaves, sepals, ovaries, and pseudocapsules.

Specimens Examined

108.

Conservation Status

Not at risk, as it is widespread and common throughout the northern sandplains of South Western Australia. It is exploited for the nursery and seed trades (Rye et al. 1980, Burgman and Hopper 1982).

Common Name

Free-flowering lechenaultia.

Lechenaultia formosa R.Br., Prodr. 1:581 (1810)

Distribution (Figure 16)

Western Australia: Irwin, Avon, Roe, Eyre, and Eucla Districts.

Nullarbor, Bencubbin, Leeuwin, and Esperance Regions.

Ecology

A sub-shrub with a woody rootstock that may sucker (Gardner 1944). It has been recorded from sand and sandy soils, often over laterite or granite, as well as from clay and gravelly clay. It occurs in a variety of heaths (Beard 1972, 1973b, 1980c, Beadle 1981), scrubs, mallee (Beard 1973a, 1973b, 1976a, 1979c), and woodlands (Beard 1979c, 1980c), where it is often locally common. Flowering apparently occurs sporadically throughout the year, but it is most prolific from early August to late October.

Variability

Flower and leaf size as well as flower colour and habit vary greatly. Large-flowered prostrate plants occur throughout the geographical range, but the smaller-flowered more erect forms are confined to the coastal strip between Albany and Cape Le Grande (see Morrison 1986).

Notes

Closely related to *L. chlorantha*, from which it can be readily distinguished by the red and orange flowers, and to *L. linarioides*, which is a much larger more tangled plant.

Specimens Examined

302.

Conservation Status

Not at risk, as it is widespread and common throughout South Western Australia. However, Specht et al. (1974) recognise the conservation importance of the disjunct relict populations on the coastal sand sheets of the Great Australian Bight.

It is exploited for the nursery and seed trades (Rye et al. 1980, Burgman and Hopper 1982).

Common Name

Red lechenaultia.

Illustrations

Baglin and Mullins (1969) p.91; Fairall (1970) p.182; Hodgson and Paine (1971) p.89; Blombery (1973) p.190; Holliday (1973) p.17; Grieve and Blackall (1975) pl.v; Gardner (1978) p.5.

Lechenaultia heteromera Benth., Fl. Austral. 4:43 (1868)

Distribution (Figure 17)

Western Australia: Eyre District, between Starvation Boat Harbour and West Mt Barren.

Esperance Region.

Ecology

A sub-shrub with a woody rootstock. It is usually found in deep white sand, where it occurs in heath (Beard 1973a, Beadle 1981, as *L. stenosepala*, Beard 1976a, as *L. stenomera*), open scrub, or *Banksia* woodland. It is usually infrequent. Flowering is from late August to Late November.

Variability

This is a relatively constant species, varying only moderately in flower colour, leaf density, and the degree to which the leaves are reflexed.

Notes
Closely related to *L. brevifolia*, *L. juncea*, and *L. striata*, from which it can be readily distinguished by the non-scapigerous flowering habit and scattered, thicker, recurved leaves. It is also sometimes confused with *L. biloba*, which has subequal wings on all of the petal lobes.

Specimens Examined
45.

Conservation Status
Although it has a restricted distribution it is common throughout its range, and is therefore probably not at risk. It is represented in Fitzgerald River National Park.

Common Names
Claw lechenaultia (Erickson et al. 1979); Hook-leaf lechenaultia (Grieve and Blackall 1975).

Lechenaultia hirsuta F. Muell., Fragm. 6:9 (1867)

Distribution (Figure 18)
Western Australia: Irwin District. Bencubbin and Leeuwin Regions.

Ecology
A herb or sub-shrub with a woody rootstock. It occurs in white or light brown sand or lateritic sand, where it is commonly found in low open heath (Beard 1976c, 1976d, Hopkins and Hnatiuk 1981). It is often frequent, especially when regenerating after fire. Flowering is from early September to mid December.

Variability
This is a very distinctive and relatively constant species, but it does vary somewhat within populations in leaf size and density.

Notes
Closely related to *L. superba* and to *L. laricina*, from which it can be readily distinguished by the extreme hirsuteness.

Specimens Examined
56.

Conservation Status
Not at risk, as it is widespread and common on the northern sandplains of South Western Australia. It is exploited for the nursery trade (Rye et al. 1980, Burgman and Hopper 1982).

Common Name
Hairy lechenaultia.

Illustrations
Morcombe (1968) p.110; Morcombe (1970) p.98; Morcombe and Morcombe (1970) p.81; Baker (1971) p.19; Blombery (1973) p.191; Grieve and Blackall (1975) pl.vi; Gardner (1978) p.5; Erickson et al. (1979) p.98; Crafter (1983) *Aust. Pl.* 12:56.

Lechenaultia juncea E. Pritzel, Bot. Jahrb. Syst. 35:553 (1905)

Distribution (Figure 19)

Western Australia: Irwin District, between Three Springs and Gunyidi. Bencubbin Region.

Ecology

A herb or sub-shrub with a woody rootstock. It occurs in sand or sandy gravel, in heath (Beard 1976d, Beadle 1981, as *L. juncoides*). It is usually infrequent, and usually growing amongst the branches of other plants. It is now only recorded in fields, and along road margins. Flowering is usually from late November (sometimes earlier) to mid December.

Notes

Closely related to *L. brevifolia*, which has much darker-blue flowers and shorter leaves, *L. striata*, which has much thinner more crowded leaves and larger flowers and pseudocapsules, and *L. heteromera*, which does not have the scapigerous flowering habit. This species has also been confused with *L. subcymosa*, from which it can be distinguished by the more upright junciform habit and the much longer sepals.

Specimens Examined

8.

Conservation Status

2V, as it is geographically localised (Rye 1981), and currently known only from a few roadside verges and relatively undisturbed fields in farmland. This species is very poorly collected (Marchant and Keighery 1979), and it is not known from any conservation reserves or known to be in cultivation (cf. Rye 1981). This species would be classified as 2E, except that there are a couple of good populations in protected areas in farmland that will hopefully become conservation reserves in the near future (cf. Beard 1976d).

Common Name

Reedy lechenaultia.

Lechenaultia laricina Lindley, Sketch Veg. Swan R. 27 (1839)

Distribution (Figure 20)

Western Australia: Avon District, between Meckering and Clackline, and between Kukerin and Moulyinning. Bencubbin and Leeuwin Regions.

Ecology

A small shrub with a woody rootstock that may sucker. In the past, this species has been recorded from sand or occasionally gravelly loam, usually in woodland. It is now known only from disturbed areas in farmland. Flowering is from late October to late December.

Variability

This species is relatively constant morphologically, but it does vary somewhat in flower colour, with some populations being less scarlet than others. As well, some variation exists between the two disjunct groups of populations of this species, the southern group being much more prostrate plants, with greyish bark and somewhat smaller flowers.

Notes

Closely related to *L. hirsuta*, from which it can be readily distinguished by the glabrous habit, and to *L. superba*, which has a more upright habit, longer leaves, and yellowish flowers with a broader tube. However, this species is apparently persistently and frequently confused with other species (see Morrison 1986), usually resulting in the identification of other species (often *L. formosa*) as *L. laricina*. This has, in the past, suggested that *L. laricina* occurs over a much larger area than it really does (cf. the map in Rye et al. 1980) and that it has been collected much more frequently. It was apparently this confusion that caused Marchant and Keighery (1979) and subsequent workers to overlook this species as an endangered taxon.

Specimens Examined
17.

Conservation Status
2E. This species was once apparently common in the area between Meenaar, Meckering, and Northam (Gardner 1978), but in this area it is now known from only two populations in farmland. Both of these populations are currently being protected, but this relies entirely on the goodwill of the people concerned, and one of the populations appears to have contracted recently. The only other reliable collection localities are near Kukerin, where it has not been found recently. It thus seems that this species is under immediate threat, especially as no populations have been reported in conservation areas. Gazettal as protected flora is therefore essential. The species is reported to be exploited for the nursery trade (Rye et al. 1980, Burgman and Hopper 1982), but the collection locality given by Burgman and Hopper (1982) suggests that many of these reports may be mis-identifications (see above). Fortunately, it is apparently in wide cultivation, as this would seem to be critical for the continued survival of the species. Fairall (1970) discusses its cultivation requirements.

Common Name
Scarlet lechenaultia.

Illustrations
Fairall (1970) p.183; Grieve and Blackall (1975) pl.v; Gardner (1978) p.5.

Lechenaultia linarioides DC., Prodr. 7:519 (1839)

Distribution(Figure 21)
Western Australia: Irwin and Darling Districts, and Carnarvon District on the Shark Bay peninsulas. Murchison, Bencubbin, and Leeuwin Regions.

Ecology
A small shrub with a woody rootstock that may sucker. It occurs in deep white or yellow sand, where it is found in open-heath (Beard 1976c, 1976d, 1979a, 1979b, Burbidge and George 1978, Bell et al. 1979, Bridgewater and Zammit 1979, George et al. 1979, Beadle 1981), scrub (Beard 1976c, 1976d, Beard and Burns, 1976), or occasionally woodland (Bell et al. 1979). It is often locally common. Plants apparently flower sporadically throughout the year, but flowering is mainly from early August to early December.

Variability
Stature, leaf and flower size, and flower colour are all very variable. The isolated group of plants near Shark Bay are taller and more densely shrubby with thicker branches than the southern ones, which tend to be more sprawling. Flower size and colour varies considerably between populations, and the flowers themselves also apparently become redder with age.

Notes
Similar to *L. formosa* and *L. chlorantha*, from which it can be readily distinguished by the thicker stems with downcurved branchtips and more scattered leaves, as well as by the larger flowers.

Specimens Examined
135.

Conservation Status
Not at risk, as it is widespread and common throughout the northern sandplains of South Western Australia. It is exploited for the nursery and seed trades (Rye et al. 1980, Burgman and Hopper 1982).

Common Name
Yellow lechenaultia.

Illustrations
Morcombe and Morcombe (1970) p.80 (as *L. linaroides*); Hodgson and Paine (1971) p.91; Blombery (1973) p.191; Grieve and Blackall (1975) pl.v; Gardner (1978) p.131.

Lechenaultia longiloba F. Muell., Fragm. 6:10 (1867)

Distribution (Figure 22)
Western Australia: Irwin District, between Mullewa and Dongara. Bencubbin Region.

Ecology
A sub-shrub with a woody rootstock that may sucker. It has been recorded in deep white or grey earthy sand, in open heath (Beard 1976d). It was apparently once common in *Banksia* heath (especially if regenerating after fire), but it is now more commonly found along disturbed roadsides. Flowering is usually from late July to early October, but it sometimes continues sporadically until early December.

Variability
This is a relatively constant species, but there is some variability between populations in flower colour (varying from red to yellowish) and flower size.

Notes
Closely related to *L. hirsuta*, from which it can be easily distinguished by the glabrous habit, and to *L. macrantha*, which has longer leaves (which are characteristically held to one side of the branch), larger wings, and a shorter broader corolla tube.

Specimens Examined
30.

Conservation Status
2VC, as it is geographically localised (Rye 1981), and is now known from only a few populations along roadsides in farmland (see Leigh et al. 1984 for a more detailed discussion), and from one population in an "A Class" conservation reserve (Beard and Burns 1976). Gazettal as protected flora would seem to be appropriate, and it may be necessary to manage the roadside verges specifically to maintain this species (cf. Scott 1981). Hartley and Leigh (1979) report it to have been subject to heavy commercial exploitation in the wild, but this has not been confirmed (cf. Rye et al. 1980). It is not known to be in wide cultivation (Leigh et al. 1984), and horticultural propagation would seem to be essential to ensure the continued survival of this species.

Common Name
Irwin lechenaultia.

Illustrations
Baglin and Mullins (1969) p.91; Grieve and Blackall (1975) pl.v; Erickson et al. (1979) p.107; Crafter (1983) *Aust. Pl.* 12:57; Leigh et al. (1984) between pp.192-3.

Lechenaultia lutescens D.A. Morrison & R.C. Carolin, *Brunonia* 9:15 (1987)

Distribution (Figure 26)
Northern Territory: Central Australia North, and Central Australia South Regions; Western Australia: Mueller, Giles, Carnegie, and Helms Districts. Gibson, Tanami, MacDonnell, and Victoria Desert Regions.

Ecology
A herb or sub-shrub with a woody rootstock. It has been recorded from deep red sand dunes, sandy loam plains, or around the gravelly edges of lateritic breakaways. It occurs among mallees, desert oak, open *Triodia* grassland, or *Spinifex* open scrub, where it is often locally common. Flowering apparently occurs sporadically throughout the year, perhaps only after recent rain.

Variability
This species varies somewhat between populations in leaf size, and flower size and colour, but this does not seem to be significant.

Notes
Closely related to *L. heteromera*, from which it can be readily distinguished by the yellow flowers and shorter calyx lobes. It has also been confused with *L. striata*, which has a distinctly scapigerous flowering habit and ridged rather than grooved articles.

Specimens Examined
21.

Conservation Status
Not at risk, as it is widespread and common throughout arid western Central Australia.

Lechenaultia macrantha K. Krause, Pflanzenr., IV. 54:100 (1912)

Distribution (Figure 23)
Western Australia: Irwin and Avon Districts; and one isolated collection in Irwin District, near Nerren Nerren station, and one in Austin District, near Boolardy station.

Murchison and Bencubbin Regions.

Ecology
A herb or sub-shrub that grows annually from a woody rootstock (Erickson et al. 1979). It occurs in yellow sand or, more usually, red gravelly soil, in open areas near heathland (Beard 1976e), or along road margins or other disturbed areas. It is usually locally common. Flowering is from mid August to late October.

Variability
Leaf size, and flower colour and size vary considerably between plants. Much of this variability appears to be latitudinal, with the more northern inland plants having the larger organs.

Notes

Closely related to *L. longiloba,* from which it can be readily distinguished by the wreath-like flowering habit, longer leaves and sepals, and larger petals with broader wings.

Specimens Examined

40.

Conservation Status

Not at risk, as it is relatively widespread and common on the inland red gravels of northern South Western Australia. Both Specht et al. (1974) and Hartley and Leigh (1979) consider the species to have suffered marked depletions in distribution, but as it apparently responds well to disturbance this is probably not as big a problem as was first thought. Hartley and Leigh (1979) record the species as occurring in conservation reserves. They also report it to have been subject to heavy commercial exploitation in the wild, but this has not been confirmed (cf. Rye et al. 1980).

Common Name

Wreath lechenaultia.

Illustrations

Morcombe (1968) p.31; Newbey (1968) p.125; Baker (1971) p.19; Blombery (1973) p.191; Grieve and Blackall (1975) pl.v; Gardner (1978) pp.131-2; Erickson et al. (1979) p.118; Crafter (1983) *Aust. Pl.* 12:56.

Lechenaultia ovata D.A. Morrison, Telopea 3: in press

Distribution (Figure 26)

Northern Territory: Darwin and Gulf Region. Arnhem Region.

Ecology

A herb that probably grows annually from a woody rootstock. It has been collected from short sedgeland in a sandy depression on a sandstone plateau. The specimen was flowering in February.

Notes

This species can be readily distinguished from all of the other members of this genus by the ovate leaves.

Specimens Examined

1.

Conservation Status

1K, as it is known only from the type collecion (see Morrison 1987). The population is apparently fairly large, but the locality is just outside Kakadu National Park. Intensive searches need to be made in the area to correctly ascertain the status of this species.

Lechenaultia papillata D.A. Morrison, Brunonia 9:12 (1987)

Distribution (Figure 24)

Western Australia: Roe District. Esperance Region.

Ecology

A sub-shrub or small shrub with a woody rootstock. It has been recorded from yellow or white sand, loamy sand, and gravelly loam. It usually occurs in heath (Beard 1969, Beadle 1981, as *L. expansa*), low open scrub, or eucalypt scrub mallee, where it may be locally common. Flowering is usually from late October to late November.

Variability

Flower size is somewhat variable, but the species nevertheless remains distinctive.

Notes

Closely related to *L. floribunda*, from which it can be readily distinguished by the shorter more crowded leaves, the papillate leaves, sepals, ovaries and pseudocapsules, and the much more hairy floral tube.

Specimens Examined

14.

Conservation Status

Although poorly collected, this species occurs in an area that is sparsely collected in general. Given the large area over which collections have been made, the species is probably not at risk. It is represented in Frank Hann National Park.

Lechenaultia pulvinaris C. Gardner, J. Roy. Soc. W. Austral. 47:63 (1964)

Distribution (Figure 25)

Western Australia: Avon District, between Corrigin and Wagin, and near Beverley. Bencubbin and Leeuwin Regions.

Ecology

A sub-shrub with a woody rootstock. It occurs in deep white sand on plains or gentle slopes, sometimes near low-lying seepage areas. It only grows in open patches in low scrub, becoming absent as the vegetation becomes more dense with age. It is often locally common. Flowering is from mid October to early December.

Notes

Closely related to *L. expansa*, from which it can be easily discerned by the dense pulvinate habit, like that of *L. tubiflora*. It can be readily distinguished from *L. tubiflora* by the hispid foliage and calyx lobes.

Specimens Examined

12.

Conservation Status

3VC, as, although it is not geographically localised (but see Rye et al. 1980), it occurs only in open patches in the vegetation. It is known from only a few apparently disjunct areas (see Leigh et al. 1984), and, although only rediscovered and described in the early 1960s, it was in fact collected late last century. It has been recently reported to occur around the edges of a number of small "A Class" conservation reserves, but it appears to become absent from the vegetation as the vegetation becomes more dense with age. Much more needs to be known about its biology before it can be decided how widespread the species is and whether it is adequately conserved (and therefore more appropriately categorised as 3RC). Hartley and Leigh (1979) report it to have been subject to heavy commercial exploitation in the wild, but the species is now protected as gazetted rare flora (Patrick and Hopper 1982). However, it should be introduced into cultivation to ensure the long term survival of the species, and Newbey (1968) discusses its cultivation requirements.

Common Name
Cushion lechenaultia.

Illustrations
Anon. (1981) between pp.12-3; Rye and Hopper (1981) p.145; Leigh et al. (1984) between pp.192-3.

Lechenaultia stenosepala E. Pritzel, Bot. Jahrb. Syst. 35:552 (1905)

Distribution (Figure 28)
Western Australia: Irwin and Darling Districts. Bencubbin and Leeuwin Regions.

Ecology
A herb or sub-shrub with a woody rootstock that may sucker. It is found in yellow or white sand or sandy gravel, where it is usually recorded from low open heath (Beard 1976d, Hopkins and Hnatiuk 1981), often in damp depressions or valley floors. It is often locally common, especially as regrowth after fire. Flowering is from early October to mid December.

Variability
Leaf and flower size vary considerably, and this apparently correlates with latitude, the largest leaves and flowers only occurring on plants in the northern part of the distribution, and the smallest leaves and flowers only occurring in the southern part (see Morrison 1986).

Notes
Closely related to *L. floribunda*, from which it can be readily distinguished by the longer sepals, and to *L. biloba*, which has flowers of a much deeper blue and with much larger corolla wings.

Specimens Examined
51.

Conservation Status
Not at risk, as it is widespread and common on the northern sandplains of South Western Australia.

Common Name
Narrow-sepaled lechenaultia.

Lechenaultia striata F. Muell., Fragm. 8:245 (1874)

Distribution (Figure 27)
Northern Territory: Central Australia South Region; South Australia: North-western Region; Western Australia: Giles, Canegie, Helms, and Austin Districts. Gibson, MacDonnell, Leonora, and Victoria Desert Regions.

Ecology
A herb or sub-shrub with a woody rootstock that may sucker (Maconochie 1982). It is found on deep red sand dunes, where it is characteristic of the mid and upper slopes (Buckley 1981a). It occurs in open *Triodia* grassland or *Spinifex* open scrub, where it is often locally common, especially after recent rain. Plants appear to have only a moderate drought tolerance (Buckley 1982). Flowering apparently occurs sporadically throughout the year (perhaps only after recent rain), but it is usually from late August to mid November.

Variability
This species varies considerably between plants in leaf, flower and pseudocapsule size, and somewhat less in flower colour. None of this variation appears to be correlated.

Notes
Closely related to *L. brevifolia*, from which it can be readily distinguished by the longer leaves, and to *L. lutescens*, which does not have the scape-like flowering stems.

Specimens Examined
34.

Conservation Status
Not at risk, as it is widespread and common throughout arid western Central Australia. Specht et al. (1974) report it to be rare in the Northern Territory, but this does not appear to be the case.

Common Name
Striate-stemmed lechenaultia.

Illustrations
Jessop & Toelken (1986) p.1407.

Lechenaultia subcymosa C. Gardner & A.S. George, J. Roy. Soc. W. Austral. 46: 134 (1963)

Distribution (Figure 29)
Western Australia: Carnarvon District, on North West Cape and on the Shark Bay islands. Murchison Region.

Ecology
A herb or sub-shrub with a woody rootstock. It has been recorded from sand or loam over limestone (Burbidge and George 1978) or in red sand dunes, where it occurs with scattered low shrubs. It is often found in very dense stands regenerating after fire. Flowering apparently occurs sporadically throughout the year (perhaps only after a recent fire), but it is usually from late July to early October.

Notes
Closely related to *L. divaricata*, from which it can be readily discerned by the larger leaves, smaller flowers, and non-moniliform pseudocapsule.

Specimens Examined
15.

Conservation Status
Although poorly collected, this species occurs in an area that is sparsely collected in general. As it is apparently common where it does occur, the species is probably not at risk.

Common Name
Wide-branching lechenaultia.

Lechenaultia superba F. Muell., Fragm. 6:10 (1867)

Distribution (Figure 30)
Western Australia: Eyre District, at the eastern end of the Barrens. Esperance region.

Ecology
A small shrub with a woody rootstock. It only occurs in quartzite soils on rocky hillsides or in open gullies, where it is found in open patches in thick scrub. Plants are sometimes locally common. Flowering is usually from September to October, but flowering plants have been recorded at other times.

Notes
Closely related to *L. hirsuta*, from which it can be readily distinguished by the glabrous habit, and to *L. laricina*, which has a low spreading habit.

Specimens Examined
19.

Conservation Status
2RC, as it is geographically localised (Rye 1981) and restricted to a specific habitat. Almost the entire known distribution is within Fitzgerald River National Park, but the number of known plants is very small (Rye 1981). It is known to be in cultivation (Rye 1981, Rye and Hopper 1981), and Fairall (1970) discusses its cultivation requirements. It is also protected as gazetted rare flora (Patrick and Hopper 1982).

Common Name
Barrens lechenaultia.

Illustrations
Erickson et al. (1979) p.92; Anon. (1981) between pp.12-3; Rye and Hopper (1981) p.147.

Lechenaultia tubiflora R.Br., Prodr. 1:581 (1810)

Distribution (Figure 31)
Western Australia: Irwin, Avon, Darling, and Eyre Districts. Bencubbin, Leeuwin, and Esperance Regions.

Ecology
A sub-shrub with a woody rootstock that may sucker (Gardner 1944). It has been recorded from deep yellow or white sand, where it usually occurs in open patches in mixed heath (Beard 1973a, 1979c, 1980a, Beadle 1981), or *Eucalyptus* or *Banksia* woodland. It is often locally common, especially on bare ground. Flowering appears to occur sporadically throughout spring and summer, but it is mainly from late September to early December.

Variability

Apart from flower colour and leaf size, which can vary considerably within a single population, this species is apparently differentiated into coastal and inland forms (see Morrison 1986).

Notes

Closely related to *L. acutiloba*, from which it can be readily distinguished by the smaller flowers and winged corolla lobes. The prostrate habit is similar to that of *L. pulvinaris*, which has hispid leaves and calyx lobes.

Specimens Examined

153.

Conservation Status

Not at risk, as it is widespread and common throughout South Western Australia.

Common Name

Heath lechenaultia.

Illustrations

Beard (1970) pl.xxxi; Morcombe (1970) p.110; Walton (1970) *Aust. Pl.* 5:248; Wrigley (1970) *Aust.Pl.* 5:241; Blombery (1973) p.191; Holliday (1973) p.16; Grieve and Blackall (1975) pl.iv; Erickson et al. (1979) p.84; Wrigley and Fagg (1979) pp.128-9; Elliot and Jones (1982) p.185.

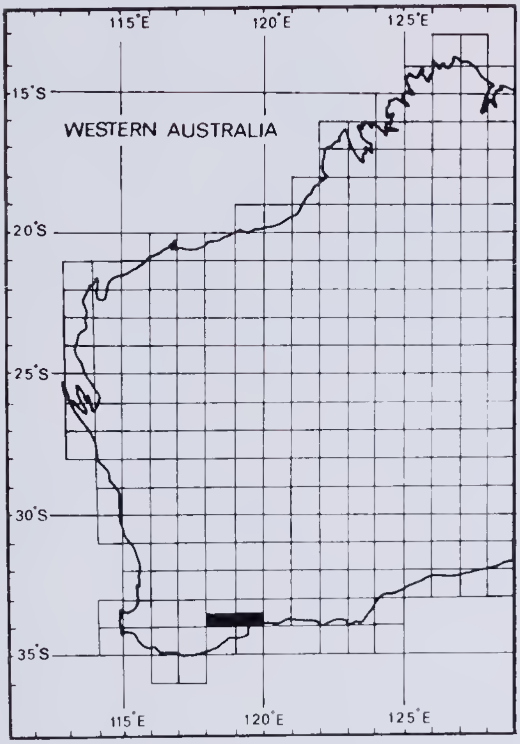

Figure 8. Distribution of L. acutiloba

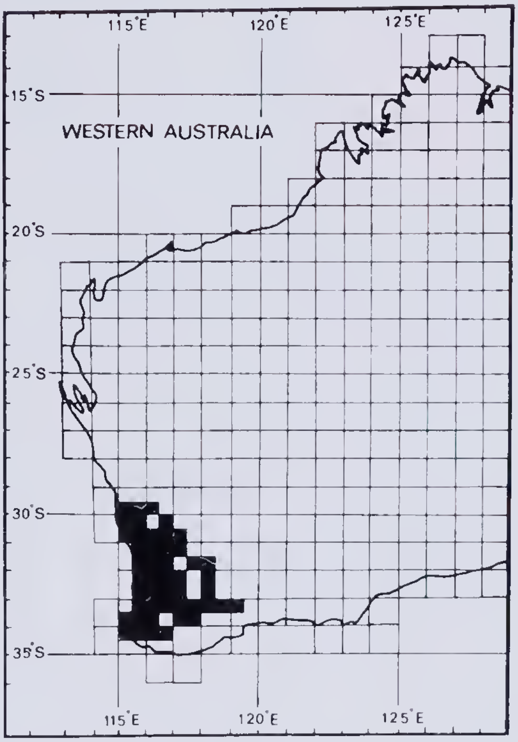

Figure 9. Distribution of L. biloba

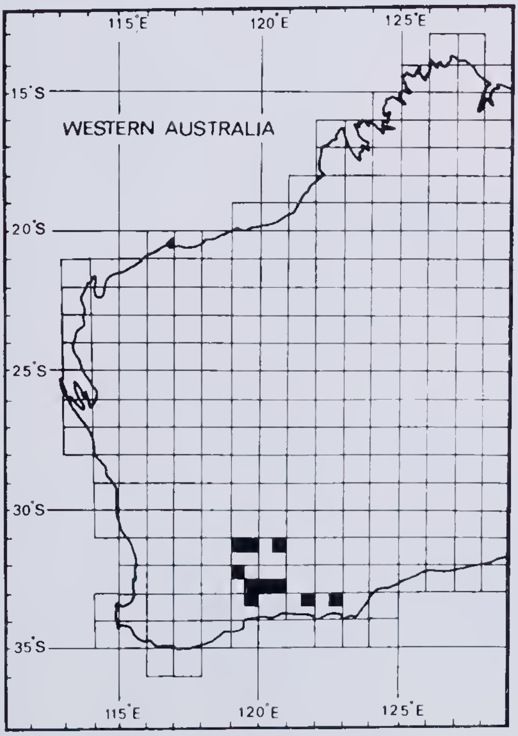

Figure 10. Distribution of L. brevifolia

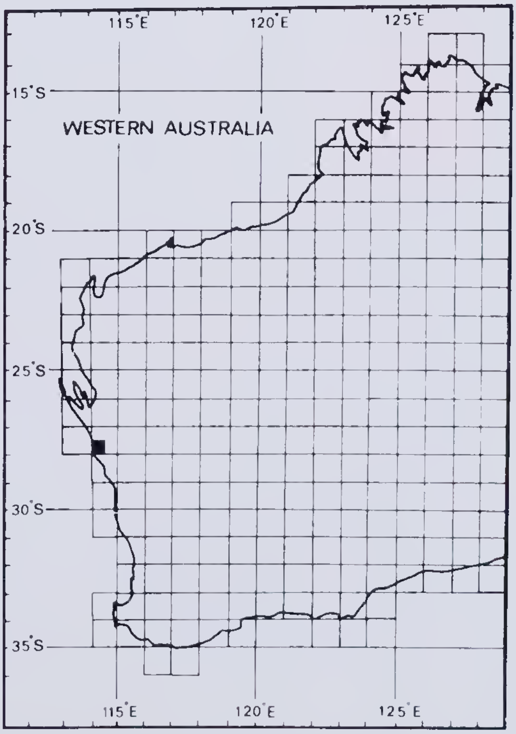

Figure 11. Distribution of L. chlorantha

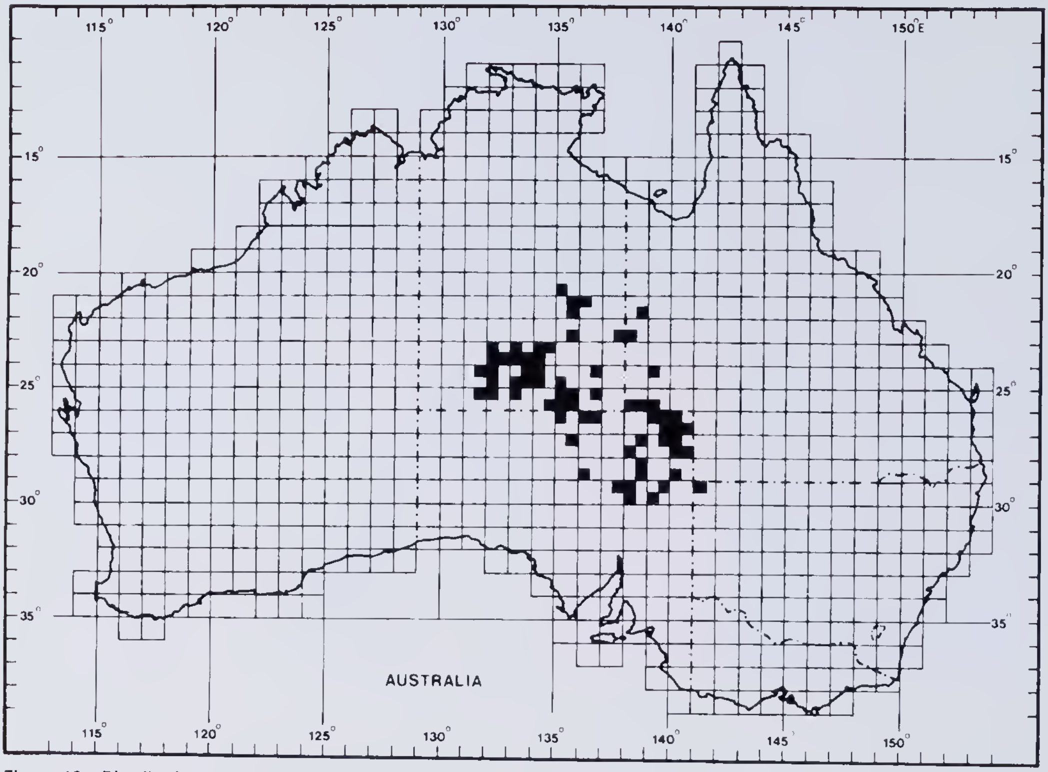

Figure 12. Distribution of L. divericata

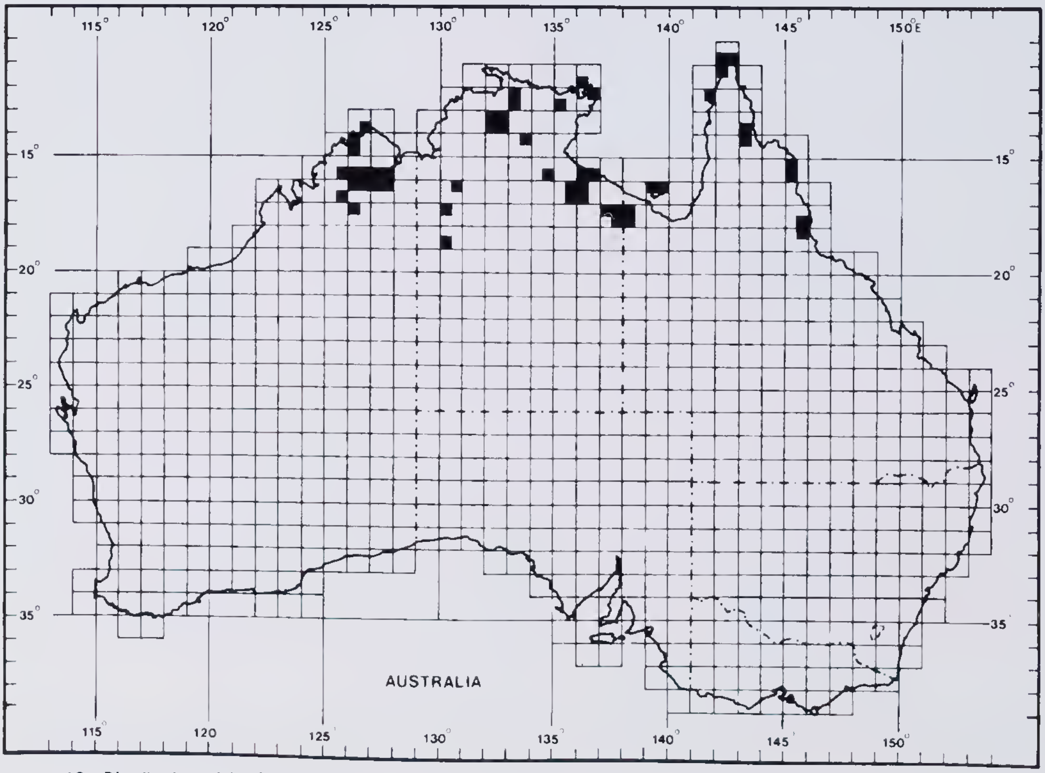

Figure 13. Distribution of L. filiformis

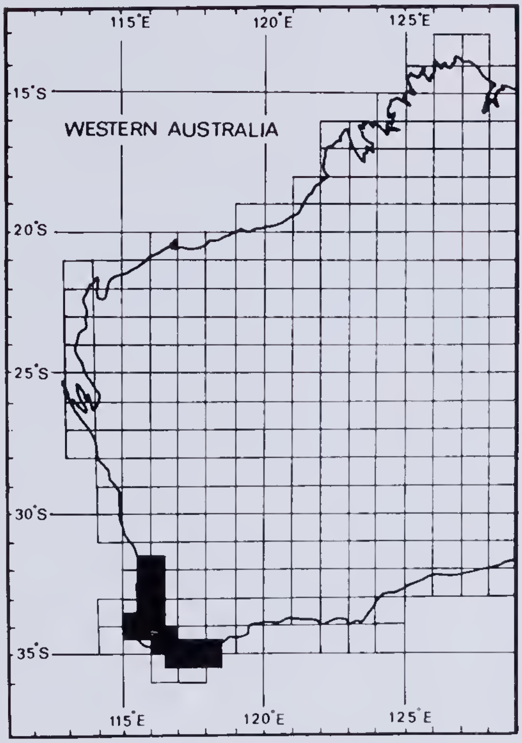

Figure 14. Distribution of L. expansa

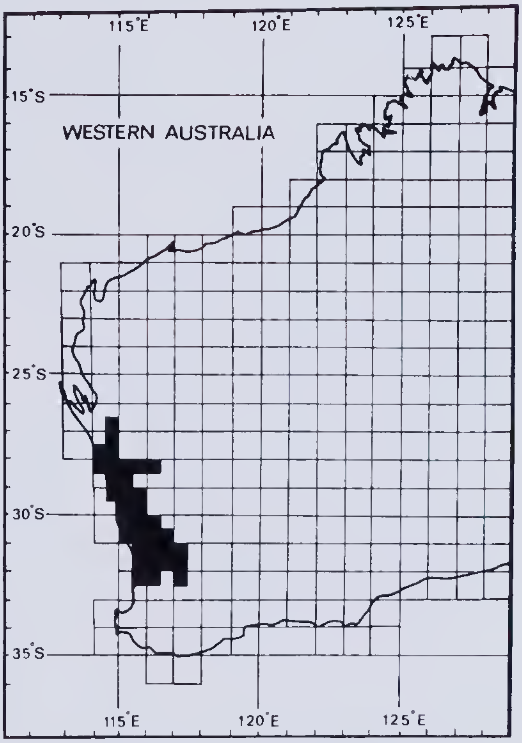

Figure 15. Distribution of L. floribunda

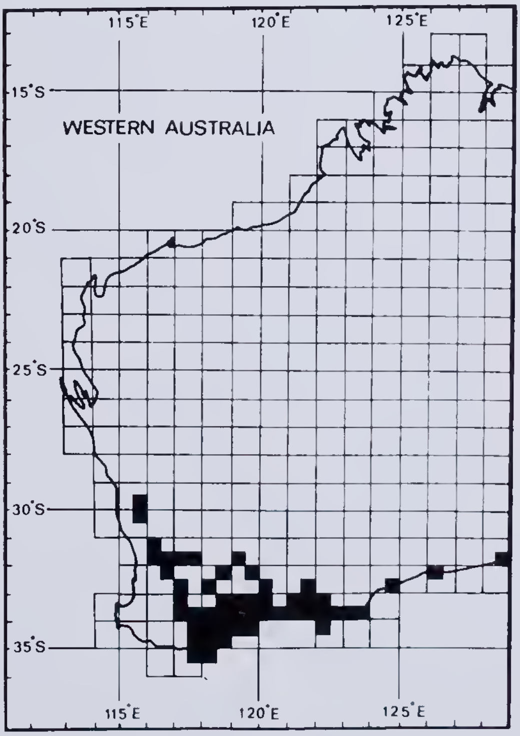

Figure 16. Distribution of L. formosa

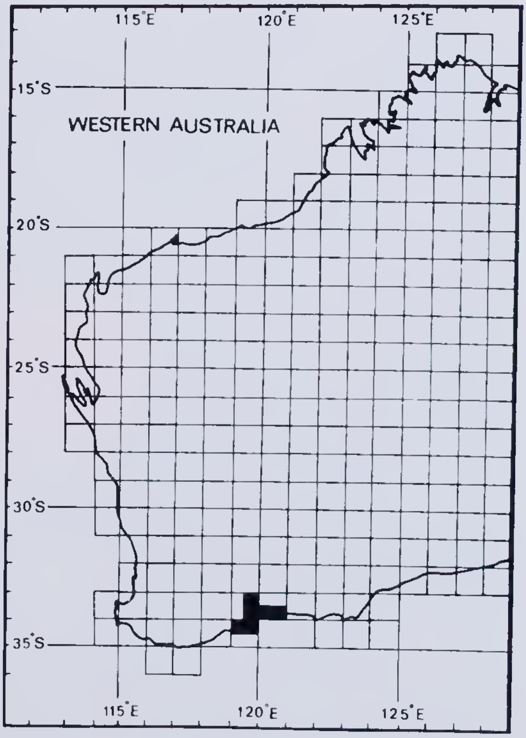

Figure 17. Distribution of L. heteromera

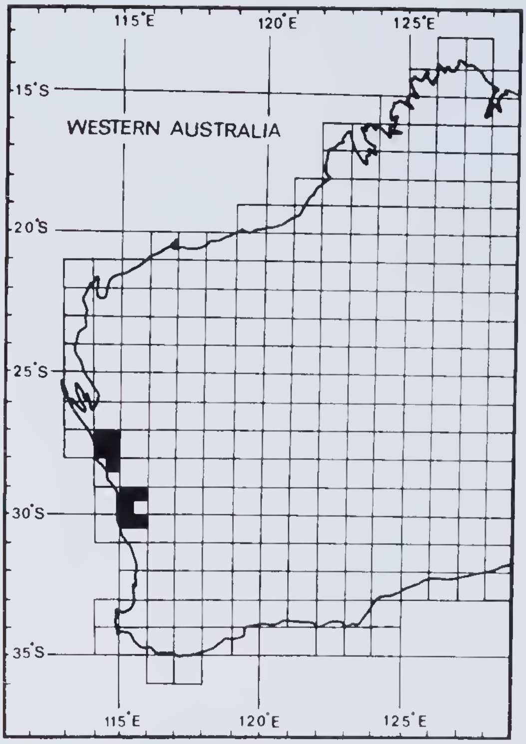

Figure 18. Distribution of L. hirsuta

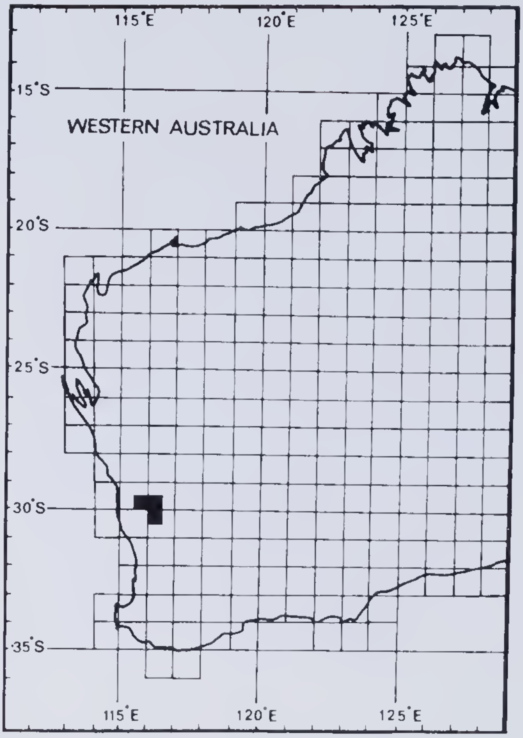

Figure 19. Distribution of L. juncea

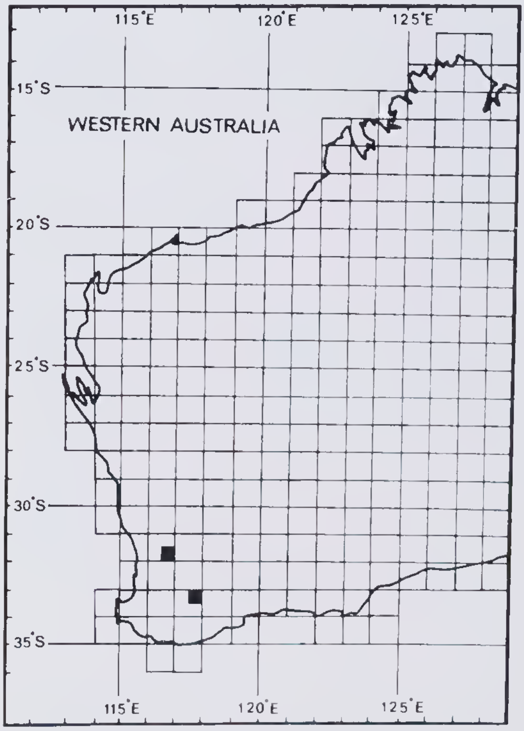

Figure 20. Distribution of L. laricina

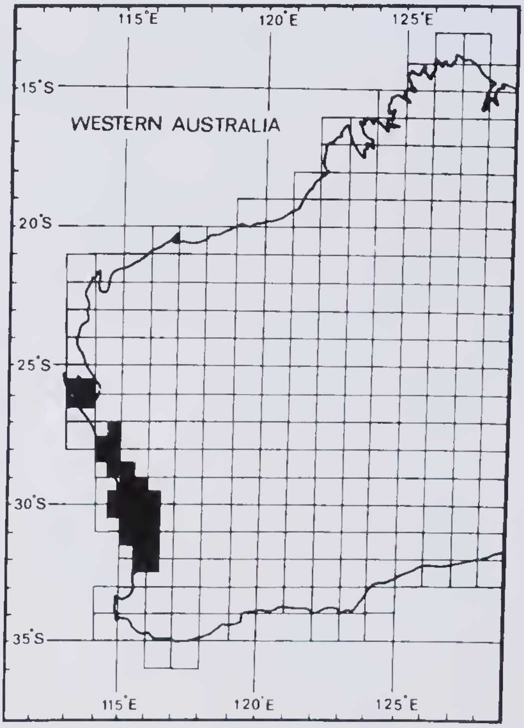

Figure 21. Distribution of L. linarioides

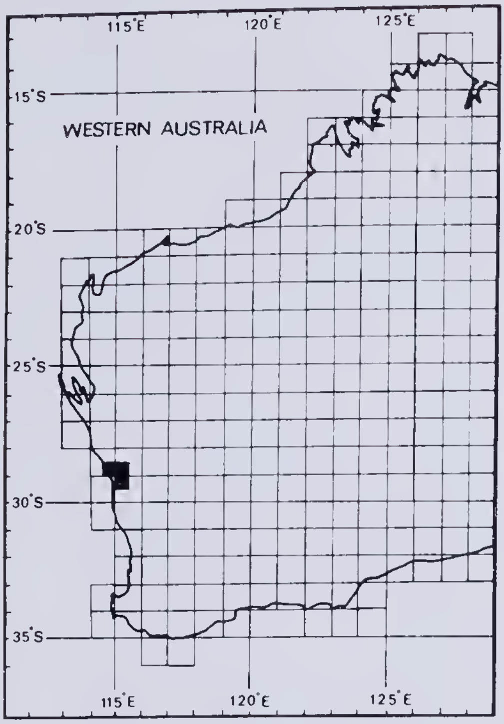

Figure 22. Distribution of L. longiloba

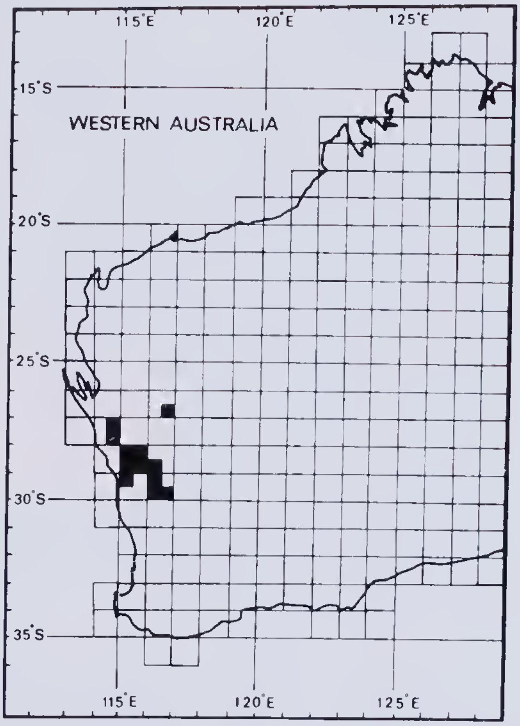

Figure 23. Distribution of L. macrantha

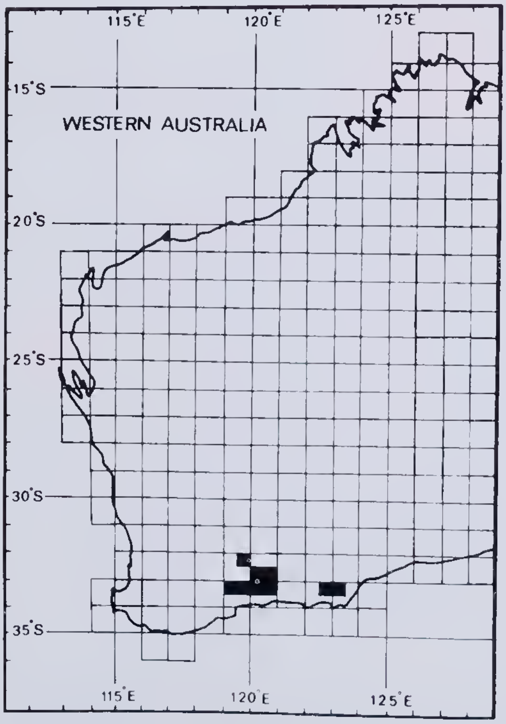

Figure 24. Distribution of L. papillata

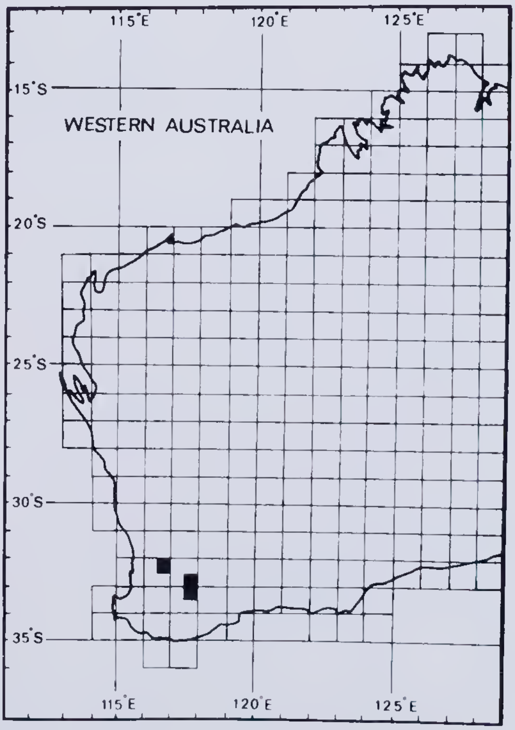

Figure 25. Distribution of L. pulvinaris

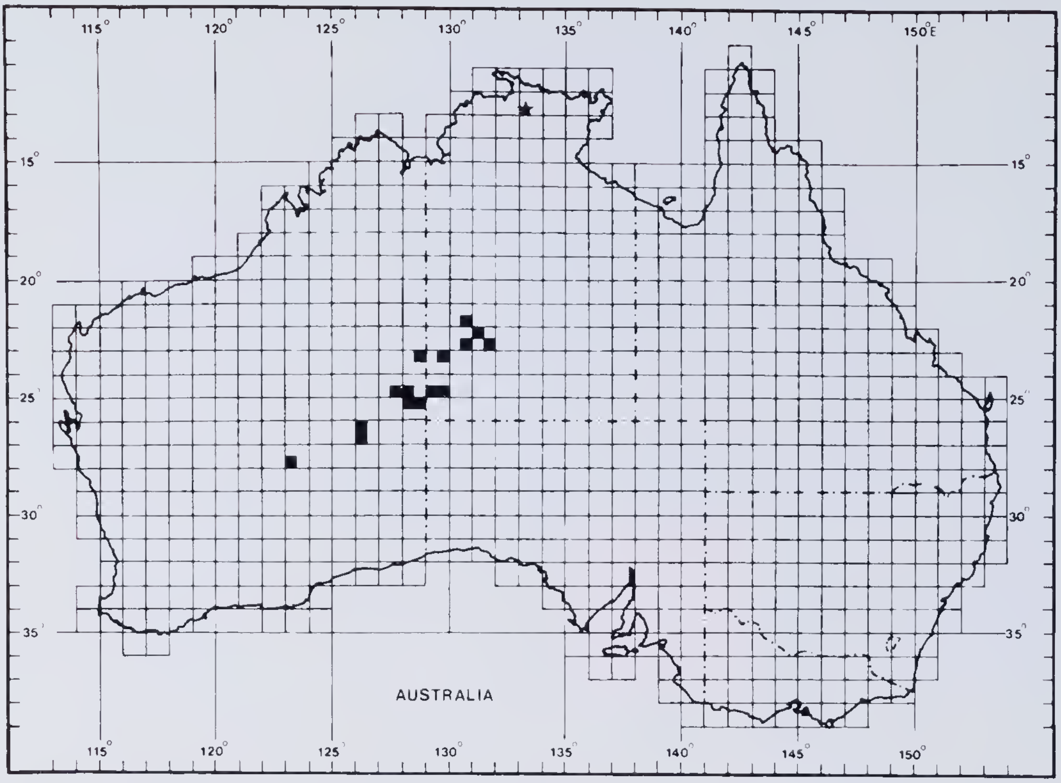

Figure 26. Distribution of L. lutescens and ★ L. ovata

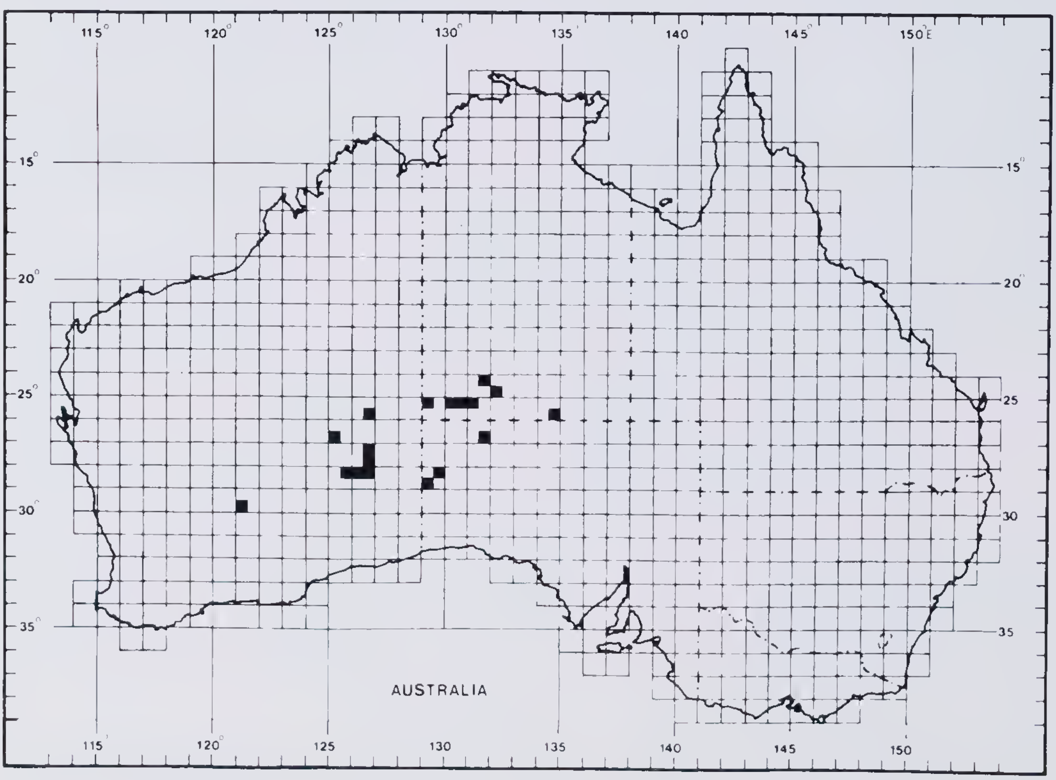

Figure 27. Distribution of L. striata

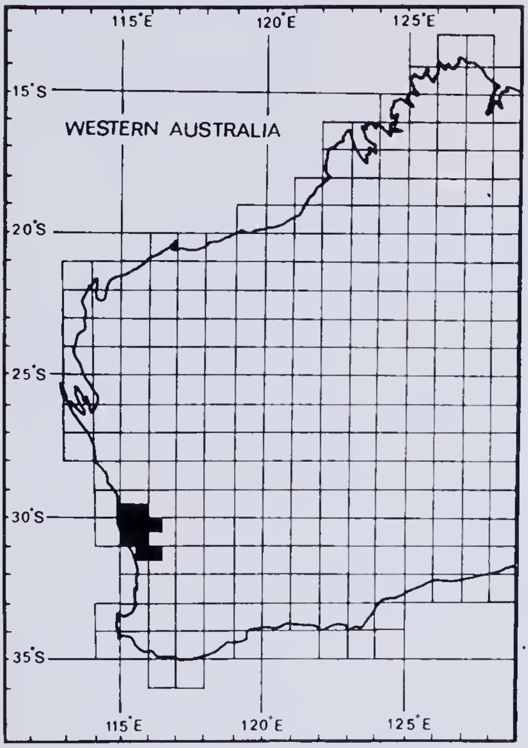

Figure 28. Distribution of L. stenosepala

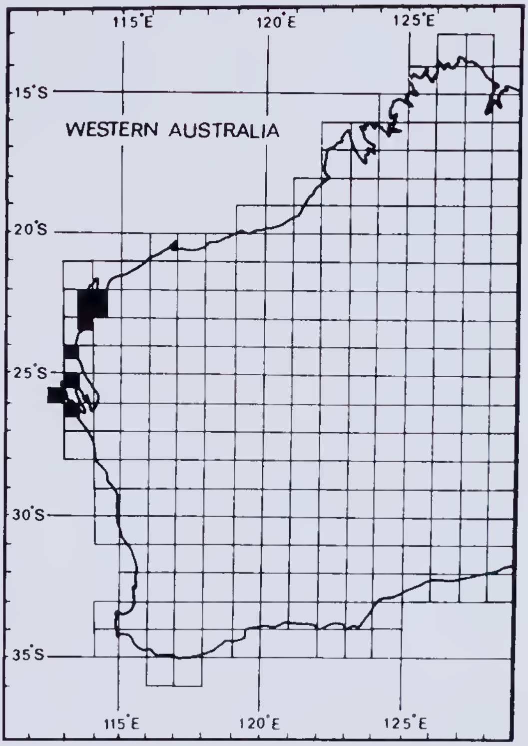

Figure 29. Distribution of L. subcymosa

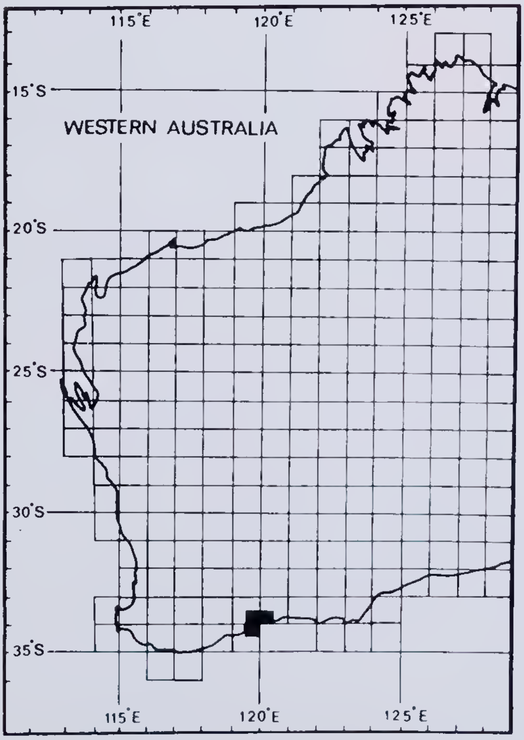

Figure 30. Distribution of L. superba

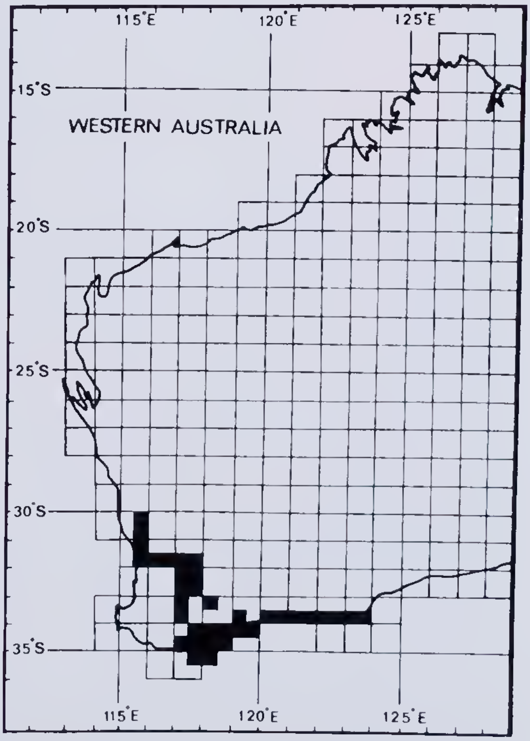

Figure 31. Distribution of L. tubiflora

Appendix 2. ***Lechenaultia*** **species recorded (or considered likely) to occur in 0.5° lat. x 0.5° long. grid cells of South Western Australia and adjacent areas. Occurrences not represented by a herbarium specimen are in brackets. The grid cell numbers and names are those of the Division of National Mapping's coding system for the 1:100,000 topographic maps.**

1446 QUOIN

(*L. linarioides*) *L. subcymosa*

1547 DORRE

L. subcymosa

1546 DENHAM

L. linarioides (*L. subcymosa*)

1545 EDEL

L. linarioides *L. subcymosa*

1646 SHARK BAY

L. linarioides

1645 PERON

L. linarioides

1743 COOLCURDA

L. hirsuta (*L.linarioides*)

1742 KALBARRI

L. chlorantha *L. floribunda* *L. hirsuta* *L. linarioides*

1741 HUTT

L. floribunda *L. linarioides*

1844 WANNOO

L. floribunda

1843 NERREN NERREN

L. floribunda *L. hirsuta* *L. linarioides* *L. macrantha*

1842 AJANA

L. floribunda *L. hirsuta* *L. linarioides* *L. macrantha*

1841 NORTHAMPTON

L. floribunda *L. hirsuta* *L. linarioides*

1840 GERALDTON

L. floribunda (*L. hirsuta*) *L. linarioides* *L. longiloba*

1839 DONGARA

L. floribunda (*L. linarioides*)

1838 BEAGLE ISLANDS

(*L. biloba*) (*L. floribunda*) *L. linarioides*

1837 GREEN HEAD

(*L. biloba*) (*L. floribunda*) *L. linarioides*

1830 CLAIRAULT

(*L. biloba*) (*L. expansa*)

1829 TOOKER

(*L. biloba*) (*L. expansa*)

1942 COOLCALALAYA

(*L. macrantha*)

1941 MUNGO

L. floribunda *L. macrantha*

1940 INDARRA

L. floribunda (*L. hirsuta*) *L. linarioides* *L. longiloba* *L. macrantha*

1939 MINGENEW

L. floribunda *L. hirsuta* *L. linarioides* *L. longiloba* *L. macrantha*

1938 ARROWSMITH

L. biloba *L. floribunda* *L. hirsuta* *L. linarioides* *L. stenosepala*

1937 HILL RIVER

L. biloba *L. floribunda* *L. hirsuta* *L. linarioides* *L. stenosepala*

1936 WEDGE ISLAND
L. biloba *L. floribunda* *L. linarioides* *L. stenosepala*

1935 LEDGE POINT
(*L. biloba*) (*L. floribunda*) *L. linarioides* (*L. stenosepala*)

1930 BUSSELTON
L. biloba *L. expansa*

1929 LEEUWIN
L. biloba *L. expansa*

2041 TALLERING
L. floribunda *L. macrantha*

2040 MULLEWA
(*L. floribunda*) *L. macrantha*

2039 YANDANOOKA
L. floribunda *L. hirsuta* *L. linarioides* (*L. macrantha*)

2038 CARNAMAH
L. biloba *L. floribunda* *L. formosa* (*L. hirsuta*) *L. juncea*
L. linarioides *L. stenosepala*

2037 BADGINGARRA
L. biloba *L. floribunda* *L. formosa* *L. hirsuta* (*L. juncea*)
L. linarioides *L. stenosepala* *L. tubiflora*

2036 DANDARAGAN
L. biloba *L. floribunda* *L. linarioides* *L. stenosepala* *L. tubiflora*

2035 GINGIN
L. biloba *L. floribunda* *L. linarioides* *L. stenosepala* *L. tubiflora*

2034 PERTH
L. biloba *L. expansa* *L. floribunda* *L. linarioides* *L. tubiflora*

2033 FREMANTLE
L. biloba *L. expansa* *L. floribunda* *L. linarioides*

2032 PINJARRA
L. biloba *L. expansa*

2031 BUNBURY
L. biloba *L. expansa*

2030 DONNYBROOK
L. biloba *L. expansa*

2029 DONNELLY
L. biloba *L. expansa*

2028 MEERUP
(*L. expansa*)

2141 WURARGA
L. floribunda

2140 MELLENBYE
L. macrantha

2139 PERENJORI
L. macrantha

2138 CARON
L. biloba *L. juncea* *L. linarioides* *L. macrantha*

2137 WATHEROO
(*L. biloba*) *L. floribunda* *L. juncea* *L. linarioides* *L. stenosepala*

2136 MOORA
L. biloba *L. floribunda* (*L. formosa*) *L. linarioides* (*L. stenosepala*)

2135 CHITTERING
L. biloba *L. floribunda* *L. formosa* *L. linarioides* *L. stenosepala*

2134 WOOROLOO
L. biloba *L. expansa* *L. floribunda* *L. formosa* *L. linarioides*
L. tubiflora

2133 JARRAHDALE
L. biloba *L. expansa* *L. floribunda* *L. linarioides*

2132 DWELLINGUP
L. biloba *L. expansa*

2131 COLLIE
L. biloba *L. expansa*

2130 BRIDGETOWN
L. biloba *L. expansa*

2129 MANJIMUP
L. biloba *L. expansa*

2128 NORTHCLIFFE
L. expansa

2244 BOOLARDY
L. macrantha

2238 MONGERS
L. macrantha

2237 DALWALLINU
L. biloba

2236 WONGAN
L. biloba *L. floribunda*

2235 GOOMALLING
L. biloba *L. floribunda*

2234 NORTHAM
L. biloba *L. floribunda* *L. formosa* *L. laricina* *L. tubiflora*

2233 BEVERLEY
L. biloba (*L. floribunda*) *L. formosa* *L. pulvinaris*

2232 CROSSMAN
L. biloba

2231 DARKAN
L. biloba

2230 DINNINUP
L. biloba

2229 TONEBRIDGE
L. biloba *L. expansa*

2228 DEEP RIVER
L. expansa

2227 RAME HEAD
L. expansa

2338 MOUNT GIBSON
L. macrantha

2336 KOORDA
L. biloba

2335 DOWERIN
L. biloba *L. floribunda*

2334 CUNDERDIN
(*L. biloba*) *L. floribunda* *L. formosa* *L. tubiflora*

2333 BROOKTON
L. biloba *L. floribunda* (*L. formosa*) *L. tubiflora*

2332 NARROGIN
L. biloba *L. formosa* *L. tubiflora*

2331 WAGIN
L. biloba *L. formosa* *L. tubiflora*

2330 KOJONUP
L. biloba *L. formosa* *L.tubiflora*

2329 FRANKLAND
(*L. tubiflora*)

2328 DENMARK
L. expansa *L. tubiflora*

2327 PARRY INLET
L. expansa

2434 KELLERBERRIN
L. biloba *L. formosa* *L. tubiflora*

2433 CORRIGIN				
(*L. biloba*)	(*L. formosa*)	*L. tubiflora*		
2432 YEALERING				
(*L. biloba*)	(*L. formosa*)	*L. pulvinaris*	*L. tubiflora*	
2431 DUMBLEYUNG				
L. biloba	(*L. formosa*)	*L. laricina*	*L. pulvinaris*	(*L. tubiflora*)
2430 KATANNING				
L. biloba	*L. formosa*	(*L. tubiflora*)		
2429 TAMBELLUP				
L. formosa	*L. tubiflora*			
2428 MOUNT BARKER				
L. expansa	*L. formosa*	*L. tubiflora*		
2427 ALBANY				
L. expansa	*L. formosa*	*L. tubiflora*		
2534 BRUCE ROCK				
L. biloba	(*L. formosa*)			
2533 NAREMBEEN				
L. biloba				
2532 KULIN				
L. biloba	*L. formosa*			
2531 KUKERIN				
L. biloba	(*L. formosa*)	*L. tubiflora*		
2530 NYABING				
L. acutiloba	*L. formosa*	(*L. tubiflora*)		
2529 BORDEN				
L. formosa	*L. tubiflora*			
2528 MANYPEAKS				
L. expansa	*L. formosa*	*L. tubiflora*		
2527 BREAKSEA				
L. expansa	*L. formosa*	*L. tubiflora*		
2634 MUNTADGIN				
(*L. formosa*)				
2633 HYDEN				
L. formosa				
2632 PEDERAH				
(*L. formosa*)				
2631 BURNGUP				
L. biloba	*L. formosa*			
2630 JERRAMUNGUP				
L. acutiloba	*L. formosa*	(*L. tubiflora*)		
2629 PALLINUP				
L. formosa	*L. tubiflora*			
2628 CHEYNE				
L. formosa	*L. tubiflora*			
2735 SOUTHERN CROSS				
L. brevifolia				
2734 HOLLETON				
(*L. brevifolia*)	*L. formosa*			
2733 O'CONNOR				
L. brevifolia	(*L. formosa*)			
2732 HURLSTONE				
(*L. formosa*)				
2731 NEWDEGATE				
L. biloba	*L. formosa*	*L. papillata*		
2730 JACUP				
L. acutiloba	*L. formosa*	*L. tubiflora*		
2729 BREMER				
L. formosa	*L. heteromera*	*L. tubiflora*		
2728 CAPE KNOB				
(*L. formosa*)	(*L. tubiflora*)			

2835 YELLOWDINE
L. brevifolia

2834 CHERITONS FIND
(*L. brevifolia*)

2833 HOLLAND
(*L. brevifolia*) *L. formosa* *L. papillata*

2832 IRONCAP
L. brevifolia (*L. formosa*) (*L. papillata*)

2831 KING
L. brevifolia *L. formosa* *L. heteromera* *L. papillata*

2830 COCANARUP
L. acutiloba *L. formosa* *L. heteromera* *L. superba* (*L. tubiflora*)

2829 HOOD POINT
L. formosa *L. heteromera* *L. superba* *L. tubiflora*

2935 BOORABBIN
(*L. brevifolia*)

2934 LAKE PERCY
(*L. brevifolia*)

2933 ROUNDTOP
(*L. brevifolia*)

2932 HOPE
L. brevifolia *L. formosa* *L. papillata*

2931 MOOLYALL
(*L. brevifolia*) *L. formosa* *L. papillata*

2930 RAVENSTHORPE
L. formosa *L. heteromera* *L. superba* *L. tubiflora*

3035 WOOLGANGIE
L. brevifolia

3034 DIAMOND ROCK
(*L. brevifolia*)

3033 JOHNSTON
(*L. brevifolia*)

3032 TAY
L. brevifolia *L. papillata*

3031 NORTHOVER
(*L. brevifolia*) (*L. formosa*) *L. papillata*

3030 OLDFIELD
L. formosa *L. heteromera* *L. tubiflora*

3132 PEAK CHARLES
(*L. brevifolia*) (*L. papillata*)

3131 LORT
(*L. brevifolia*) *L. formosa* (*L. papillata*)

3130 STOKES INLET
L. formosa *L. tubiflora*

3232 DUNDAS
(*L. brevifolia*) *L. formosa* (*L. papillata*)

3231 SCADDAN
L. brevifolia *L. formosa* (*L. papillata*)

3230 ESPERANCE
L. formosa *L. tubiflora*

3332 COWALINYA
(*L. brevifolia*) (*L. papillata*)

3331 BURDETT
(*L. brevifolia*) *L. formosa* (*L. papillata*)

3330 MERIVALE
L. formosa *L. tubiflora*

3432 MOUNT ANDREW
(*L. brevifolia*) (*L. papillata*)

3431 BEAUMONT
L. brevifolia *L. papillata*

3430 HOWICK
L. formosa *L. tubiflora*

3531 BURAMINYA
L. papillata

3530 SANDY BIGHT
L. formosa *L. tubiflora*

3630 MALCOLM
L. formosa *L. tubiflora*

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CONTENTS

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