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The Australian Flora

Our Floral Emblems

Our floral emblems present a cross-section of Australia's unique flora. Golden Wattle, *Acacia pycnantha*, the floral emblem of Australia is featured on page 332. *Acacia* trees were featured in our last issue.

A "gum" tree, *Eucalyptus globulus*, the floral emblem of Tasmania. See page 301. Our *Eucalyptus* trees are world famous.

The Waratah, *Telopea speciosissima*, the floral emblem of New South Wales. This magnificent plant was featured in our last issue. See also page 299.

Sturt's Desert Pea, *Clianthus formosus*, the floral emblem of South Australia. A unique, spectacular plant of the Australian inland 'desert'.

The Kangaroo Paw, *Anigozanthos manglesii*, the floral emblem of Western Australia, a spectacular plant that has shown great potential for horticulture.

The Pink Heath, *Epacris impressa*, the floral emblem of Victoria. A plant of the heath lands of Victoria, abundant with dainty fringed bells, page 292.

The Cooktown Orchid, *Dendrobium bigibbum*, the floral emblem of Queensland. Australia has many fascinating orchids. To be featured in an issue soon.

Sturt's Desert Rose, *Gossypium sturtianum*, the floral emblem of the Northern Territory. A large flowered desert hibiscus fully described in our No. 103 issue.

Royal Bluebell, *Wahlenbergia gloriosa*, the floral emblem of the Australian Capital Territory. The violet blue, open bell-type flowers are 2-3 cm in diameter on this small perennial herb. It makes a charming potted plant. ■

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COVER PLATE

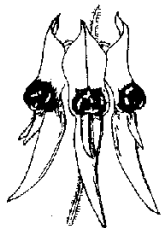
Sturt's Desert Pea – *Clianthus formosus*

Photography by R. J. Hayward

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Sturt's Desert Pea

by Paul Nixon*

Sturt's Desert Pea is the common name of the floral emblem for South Australia. The 'Classic' Desert Pea flower is a deep scarlet or red on the standard keel and wings with a black or dark red boss. In nature many colour variations are known, ranging from red through pinks to yellow and even albino forms. The boss is generally black or shades of dark red to brown.

These spectacular flowers were first collected by a colourful character, William Dampier, pirate and adventurer in what is known as Dampier Archipelago, in August/September 1699. His collection of 23 specimens is housed in the Sherardian Herbarium at Oxford and is of major historical interest in that it represents the first recorded collection of Australian plants. The accepted scientific name is *Clianthus formosus*.

In cultivation the desert pea is regarded as difficult and few people attempt to grow it. It is treated as an annual although it is, to some extent, a perennial. However, if the soil is deep and well drained in a sunny and, in particular, a protected position, it will have few problems.

Germination of Sturt's Desert Pea Seed Is Easy

Seed is widely available. There are about 150 small kidney shaped seeds in one gram but small quantities are available in packets. In early spring, prepare the pot in which you want to grow the plant to maturity. A 10 litre size pot or a hanging basket will be ideal. The potting mixture should be equal parts of sand, loam and peat. Before sowing the seed where it is to grow, it should be nicked in the back of the seed coat with a knife to break nature's long-lasting protective layer. Place several seed, widely placed, close to the surface and drench the pot with a litre of general purpose fungicide such as Benlate. Seedlings should emerge in a few days. The young seedling's root system is growing so fast at this stage that transplanting would be a problem. One centimetre of shoot may have 10 cm of root.

Growing On Sturt's Pea Plants

Place the pot in a raised sunny position. In winter where frost can be expected, the morning sun should be kept off the plant. The western side of a building would be suitable. Desert Pea should be protected from slugs and snails. During summer, Red Spider may be a problem. This is indicated by a mottled brownish look especially on the leaf underside. These should be sprayed with an insecticide such as Kelthane. Fertilize with complete slow-release fertilizer at half recommended rate in spring and autumn. When the tendrils get too long and ungainly they should be pruned back.

*The editor, Australian Plants, has invited me to submit the article on this magnificent plant for the issue featuring the floral emblem of each of the states of Australia. My first reaction was that previous articles in Australian Plants (Vol. 1, Vol. 5, Vol. 6, Vol. 8, and Vol. 11) had very adequately covered the subject. However, the brief summary above may encourage readers to consult the articles in previous volumes. The fact is that while the seed is freely sold and is easy to germinate, it is not easy to nurture the seedlings to maturity and to flower. ■



***Anigozanthos humilis*, The Cat's Paw**

Photograph from The Australian National Botanic Garden

Smallest of the Kangaroo Paw group of plants it has earned the unusual common name of Cat's Paw. These charming little plants look very attractive in a rock garden or as a pot subject. They are available in a range of colours from yellow to red and in various forms as accepted by the botanists and described on page 306.



The Red and Green Kangaroo Paw – Floral Emblem of Western Australia

Anigozanthos manglesii The Red and Green Kangaroo Paw

Photography by Bob Sack

This unusual flower earned the common name of Kangaroo Paw for the group of plants in the genus *Anigozanthos*. There are a number of species, all of exceptional horticultural value, all described and illustrated on colour photographs in previous issues of Australian Plants. Towards the end of this issue is a report of research concerned with nutrition of plants that are extensively cultivated for the export trade.

The Red and Green Kangaroo Paw

By Bob Dixon, Horticultural Advisor
Kings Park and Botanic Garden

The Red and Green Kangaroo Paw, also occasionally known as the Common Kangaroo Paw or Mangles Kangaroo Paw was officially declared the State Floral Emblem of Western Australia on November 9, 1960. This was an appropriate choice as it is so well known and like all the other Kangaroo paws is endemic to the south of Western Australia.

Although the genus *Anigozanthos* was first described by Labillardiere in 1800 from a specimen of *A. rufus* collected in 1792, the Red and Green Kangaroo Paw was not named until 1834. The type specimen from which it was described and commemorates, was raised by the well known English gardener Robert Mangles from seed sent to England in 1833 by Sir James Stirling, Western Australia's first Governor.

The Red and Green Kangaroo Paw is a short lived (although we have no data on the exact life span) rhizomatous, herbaceous perennial, which in its natural habitat, is dormant during the dry summer period. Plants occur naturally in heathland, low woodland and open forest on sand, sandy lateritic or loamy, free-draining soils from Shark Bay and Kalbarri in the north, to the Scott River and close to Mt Barker in the south.

The best time to see plants flowering in their natural environment is after a bush fire when the surrounding vegetation has been cleared away enabling surviving plants to produce flowers in the late winter and spring. During this time, stored seed in the soil germinates freely producing hundreds of seedlings with a surprisingly low mortality rate. A few years after the fire the Kangaroo Paws decline in vigour and the surrounding vegetation takes over, crowding out the plants until the next fire when the cycle repeats itself.

Flowers which are produced from August (sometimes earlier in cultivation) to October are carried on long clear stems up to almost 1 m high but usually much smaller and are pollinated by nectar feeding birds. As the common name suggests, flowers are normally red and green; however, there are several colour variants which occur naturally e.g. orange base with greenish-yellow perianth tube, red base with metallic blue perianth tube, reddish-mauve base and tube, yellow base with greenish-yellow perianth tube. Other colour forms do exist in cultivation and several years ago a pure white form was photographed in Northam, Western Australia. Of course many of these colour variants are popular with florists and several are being grown in row crop situations for the local and overseas cut flower market.

In his recent revision of the genus Dr Stephen Hopper¹ lists two subspecies; *A. manglesii* subspecies *manglesii*, a yellow form and *A. manglesii* subspecies *quadrans* the branching form which is found from Jurien Bay north to Shark Bay. The latter is rarely grown in cultivation as people prefer single stemmed flowers.

¹Hopper, S. D., 1987. *Anigozanthos*. Flora of Australia Vol. 45. Hydatellaceae to Liliaceae (Ed. A. S. George). pp. 112-26. Aust. Gov. Pub. Service. ISBN 0644052147.

Previous issues of Australian Plants describe the species of *Anigozanthos*.

Seed Collection and Propagation of Kangaroo Paw

Anigozanthos manglesii produces copious amounts of seed in its natural habitat. However, in cultivation cross pollination is required to produce good quality seed. Many of the colour variants can be bred true to type by careful crossing using similar-coloured plants.

In Western Australia seed is usually ready for collection in early December. The old flower head hangs on until the seed is ripe, when the receptacle holding it splits, releasing the seed (shaking it out) as the wind blows. An easy way to collect the seed is to bag the flower heads after all the flowers have faded (being pollinated); the ripe seed will then fall into the bag.

Seed is best sown in the early autumn. No seed treatment is required although some people have had better results by placing the seed in a hot water bath (Hopper²) prior to sowing. Sow the seed in a free draining mix such as six parts of grey bush sand and one part cladium peat (parts by bulk). Seed should be covered with a thin layer of blue metal dust (crushed granite) 2-3 mm grist. Alternatively use a commercial seed mix for native plants. Germination usually takes about three weeks given ideal conditions.

Seedlings are susceptible to damping off; this can be controlled by drenching the seed pot or spraying with a suitable fungicide. A good biological control is to prick out (transplant) the seedlings when only one or two days old; this isolates the individual seedlings and reduces your losses. Seedlings can also be pricked out when much bigger without damage. Use a free draining mix with a slow-release fertilizer.

Other methods of propagation include division of the rhizomes in autumn leaving three or four shoots on each division (heavy losses often occur using this method) or tissue culture of selected clones.

Cultivation of Kangaroo Paw

Seedlings may be planted out when about 10 cm high or grown on in pots until the following autumn. They require a free draining, preferably, sandy soil and a full sun position, although they will grow in light broken sunlight.

In the home garden plants are generally short lived, and are best treated as an annual or biennial and raised from seed each year. Plants respond well to a light dressing of a general slow-release fertilizer or weak liquid fertilizer.

The number of flowers produced by each plant usually varies from 6 to 20 flowering stems, however, vigorous plants can produce over 50 stems. This is dependant on how much water/fertilizer the plant receives as well as clonal variation.

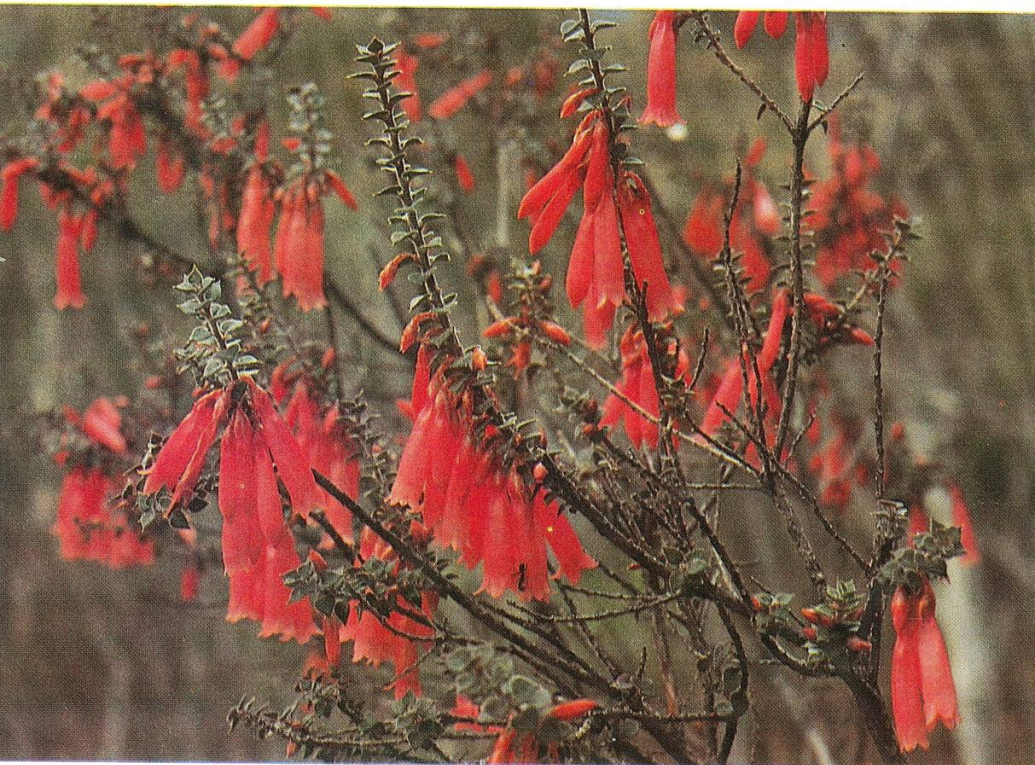
I have had Kangaroo Paw survive in my garden for eight years. If you wish to keep the plants more than one flowering season, cut off the old flowers after the seed has ripened, collecting the seed if you wish. In late March/early April, cut off the remaining dead flower stems almost to ground level and remove all the dead leaves. Commercial growers burn off other species of Kangaroo Paws and this is worth trying. The plants must be gradually weaned off water from January onwards. Burning an actively growing plant will kill it. After burning, watering can commence again. For Pests and Diseases of Kangaroo Paws, see page 320.

²Hopper, Stephen and Dixon, Bob, 1979. Growing Kangaroo Paws and Related Species. Aust. Plants. Vol. 10:81, 199-211.



Epacris impressa △

▽ *Epacris reclinata*



Common Heath – The Floral Emblem of Victoria

Epacris impressa

"Common Heath"
by Neil R. Marriott
"White Gums Nursery"

Epacris impressa is a widespread species in coastal and mountainous regions of south-east Australia from South Australia, throughout Victoria, Tasmania, and New South Wales. It is a variable and most attractive species, ranging from a low sub-shrub on exposed coastal headlands to a tall, usually lanky shrub often over 2 m high in rocky sites or fertile shady areas.

Flower colour varies from white through a multitude of shades of pink, red, and orange-red. A curious feature of plants in the wild is the irregular distribution of the various colours; some areas have only one colour, while other areas have the full range all in the one area.

Flowering is normally at its peak throughout the winter months but plants can often be found flowering at any time of the year. Some areas are noted for their early or late flowering forms, while other areas are noted for their distinct flower colours or variations in habit.

In the Victorian Grampians a superb form with larger pink flowers and broader grey-green leaves can be found; this has been given varietal status as var. *grandiflora* Benth. Another attractive form occurs in the Bega district of southern NSW; this form has distinctly orange-red flowers and has proven to be a far more hardy and adaptable plant in cultivation than most other forms.

All forms grow best in well drained but moist, acid peaty sand or sandy to gravelly loam. Most soils, especially sands or heavy clays, benefit from the addition of liberal applications of compost prior to planting. Plants will succeed in full sun situations if well mulched to provide a cool root run, but generally they do better in a situation protected from hot afternoon sun. They are hardy to fairly heavy frosts. See page 296 for details of the flower.

After several years plants tend to become rather lanky and unshapely; at this stage they should be watered, fertilized and heavily pruned. This will result in the formation of a dense, leafy, compact plant that will flower profusely in the following season.

Epacris impressa propagates quite readily from semi-firm tip cuttings taken in spring or autumn. Their roots however are very brittle, and struck cuttings must be handled carefully and hardened off after potting up.

Although the Victorian Floral emblem is the pink-flowered form, all colours and forms of *Epacris impressa* make highly desirable, showy and pleasing garden plants. Imagine what a bed of various colours would look like in your garden! Not only would it make a delightful show throughout the cold winter months, but it would also be a great attraction for our honey-eating birds. ■

Epacris impressa, (opp., above). Photograph supplied by the Australian National Botanic Garden.

A dainty little plant of the heathland of Victoria, Southern New South Wales, Tasmania and South Australia. The dainty bell-like flowers to 25 mm long are carried in abundance. An excellent plant for the rockery or for pot culture.

Epacris reclinata (opp., bottom).

Photography by Brian Walters, see page 294.

EAST COASTAL – 7, *EPACRIS*

A Series by
Brian Walters

In an earlier article I rambled on at some length about my lack of enthusiasm for winter and how *Grevillea* provided a rare redeeming feature. There are, of course, other genera which make life tolerable (barely) during the cold months. As I look out of the window this morning, the deep pink racemes of *Hakea francisiana* compete with the deep orange spikes of *Banksia ericifolia* for the attention of the honeyeaters. The white cluster of flowers on *Phebalium elatus* have also caused much comment from the neighbours. And then there is *Epacris* (and its relatives) . . .

The epacrids don't seem to be grown as much as they deserve, possibly because *Epacris impressa*, the best known species, has often been very short lived in cultivation. There are many other species, however, which are adaptable to garden conditions and there are even hardy forms of *Epacris impressa*.

Probably the best way to grow the smaller epacrids is as container plants. However, they can't be expected to perform well in "any old mix" and it is necessary to give a bit of attention to their needs. I described potting mixes in the last issue. *Epacris impressa* is a magnificent plant and there is little wonder that it is Victoria's floral emblem. In the Grampians, in particular, it can be found in numerous colour forms from white through various shades of pink to deep red. There are double forms, one exceptional one being deep rose coloured. But *E. impressa* is not restricted to Victoria and it occurs in South Australia, Tasmania and in southern NSW. It is these latter forms which seem most adaptable in cultivation, particularly in areas with humid summers.

The best known of the NSW forms of *E. impressa* is the "Bega" form which produces its red flowers from autumn through to spring. It looks absolutely stunning in a large pot and deserves to be widely grown . . . a good one to wipe the smug look off the faces of the *Erica* enthusiasts!! Also in southern NSW are white and pink forms which have not been widely grown to date but seem to have a lot of potential. See colour photograph on page 292.

Epacris longiflora is one which needs little introduction. This one seems to do well in well drained, moist soils preferably in semi-shade. The long, red tubular flowers with their white tips never fail to attract attention. *E. longiflora* has a host of inappropriate common names . . . I've even heard a few people call it "Cigarette flower" (which makes one wonder just what they are used to smoking!). Apart from the flowers the other feature of *E. longiflora* that appeals to me is its sprawling, arching habit of growth. However, those who find this offensive will find the plant responds well to secateurs.

Epacris obtusifolia is a white flowered species not grown all that often, but good forms put on a great display. I haven't been growing it long enough to speculate on its adaptability but so far there are no problems.

Epacris reclinata is a species that I've had a lot of trouble with. Native to the upper Blue Mountains, NSW, this species has long tubular flowers of variable colour from pale mauve to a bright red. The rosy pink form in general cultivation has proved difficult at Sydney's low altitude but seems successful in cooler areas, such as parts of Victoria. Nonetheless I will persist (trying different potting mixes) as it is such a beautiful plant . . . from such pursuits do mental disorders follow? See the colour photograph on page 292.

The Flower – Part 3

by Peter Bailey and W. H. Payne

Flowers are extremely variable in appearance. The genus *Leptospermum* (ti-tree) is typical of a simple flower with the most obvious part being the envelope of petals which surround the reproductive organs.

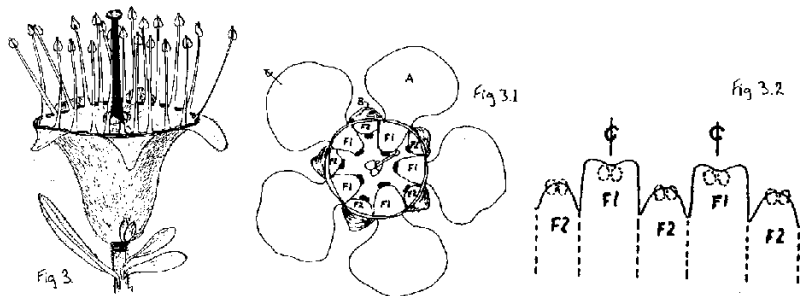


Fig 3. Shows the flower of the ti-tree with the five petals removed showing the female part of the plant (the gynoecium) which accepts pollen, surrounded by a ring (a whorl) of stamens (the androecium). Fig. 3.1. Plan view of the flower *Rinzia*, a genus closely related to *Leptospermum* (ti-tree), with its five petals (A) alternating with the much smaller five sepals (B). There are 10 stamens the five (F1) opposite the petals being larger than the five (F2) opposite the sepals. Fig. 3.2. Shows details of stamens of *Rinzia* as if they were all opened out 'flat' showing the centre line of the petals. This is the way botanists group plants into genera.

Fig. 4a *Hibiscus* also has a symmetrical flower. The sketch below appeared in Part 1 of this series to show the regular whorls of flower parts. From the outside the whorl of bracts, five small and leaf-like, the whorl of five sepals known as the calyx, the whorl of five overlapping petals collectively known as the corolla, the whorl of stamens, known as the androecium* and the central female seed producing part of the flower, the gynoecium. This is not clear in the original sketch and a stylised sketch Fig. 4b, is shown below also. The stamens are united to form a tube which surrounds the central female column known as the style.

THE ANDROECIUM

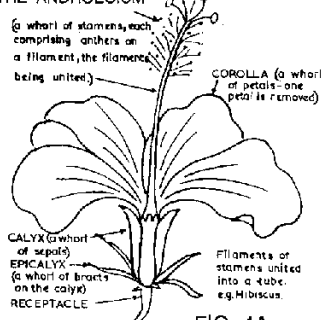


FIG. 4A

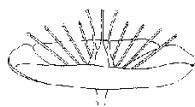


FIG. 4B

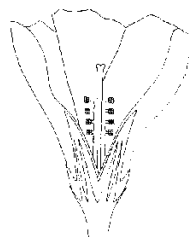


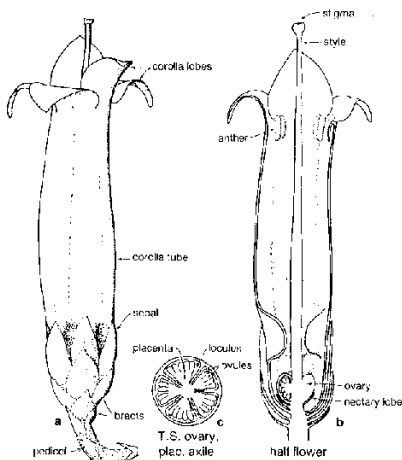
FIG. 5

Fig. 5 *Eucryphia*, the Tasmanian Leatherwood, also has an open symmetrical flower comprising four petals attached to the base of the flower, enclosing a whorl of numerous stamens. The female part of the flower in the centre (the gynoecium) has, in this case, five to twelve tiny ovary chambers each having its own style sitting up in the centre of the flower waiting to be fertilized. Only three of these are shown in the sketch below, for clarity. Reference to the colour plate on page 305 will show these dainty, cherry-blossom-type flowers. The four petals surround a large number of stamens with the group of styles in the centre.

*Correction. Part 1 of this series had two errors, the spelling of "androecium" and the first sentence of page 219, corrected as above.

Epacris, the floral emblem of Victoria, shown in colour on page 292, also has a regular or symmetrical flower as shown below. The outer layer is several whorls of bracts cupping the flower, a whorl of five sepals, a whorl of five petals, which in this case have united to form a tube except for the ends or five lobes on the top of the tube. The stamens are attached near the base of each corolla lobe, their filaments having fused to the corolla tube as shown dotted in the sketch. The central, female part of the flower, the gynoecium, comprises a style with the stigma on top, the surface that receives pollen for fertilization of the ovary at the base of the style.

Fig. 6. *Epacris* — Each flower is composed of a corolla tube with five lobes (five petals fused to form a tube, the petals being joined at the upper end to form the five lobes) and an outer whorl of five sepals. Outside the sepals are several whorls of bracts. The stamens are attached near the base of each corolla lobe. The female part of the flower comprising the style with the stigma on top and the ovary at the bottom, is in the centre of the flower. The other detail shows some of the ovules (each of which may form a seed on fertilization) in the five compartments of the ovary. There is more than one level of five ovules.



Name that Flower

by Ian Clarke and Helen Lee

"The system of classification and naming plants now in use was established in 1753 by Swedish naturalist Carolus Linnaeus. Linnaeus based his system of classification on the characteristics of the sexual reproductive organs and these are found in the flower. Thus, the flower is most important in the life-cycle of a plant, as the end-product of flowering is usually the production of seeds. In addition, the structure of the flower remains fairly constant, even if a species grows in a range of habitats which may result in considerable variation in the general appearance of the whole plant.

"An appreciation of the structure of flowers and familiarity with the language will help the reader to see that plants are not isolated organisms, but form natural groups that are related to each other. Some groups are easy to spot: the orchids, wattles, gum trees and bottlebrushes, for example. However, the close relationships of genera in a family are not always immediately obvious, for example, the grouping of gum trees and ti-trees, or of proteas and grevilleas. "One way of finding out about floral structure and coming to grips with the terminology is to work through the book . . ."

This is from the introductory section of a book of the above name by the authors credited. Our series "The Flower" presents the same subject in serial form but not as completely as is possible in a 260-page book. The book gives full page detailed sketches of selected species from a wide range of genera found throughout Australia to encourage you to go out yourself and identify plants. In the family Epacridaceae, eight species from four genera are illustrated, the sketches for *Epacris impressa*, illustrated in colour in this issue, being reproduced to a smaller size as above. The introductory section on flower structure and the illustrated guide to the botanical terms used is of exceptional value to anyone wishing to know more about botany. — Editor.

"Name that Flower" by Ian Clarke and Helen Lee is available from SGAP Book Service, P.O. Box 167, North Ryde 2113 for \$24.00 plus \$2.50 postage to anywhere in Australia. ■

The position of flower parts appears infinite. Each arrangement that is unique for a small group of plants has been called a genus by botanists. In the last issue we saw how genera in the family Proteaceae, *Grevillea*, *Banksia*, *Telopea*, etc. differ from one another in the way the pollen is presented.

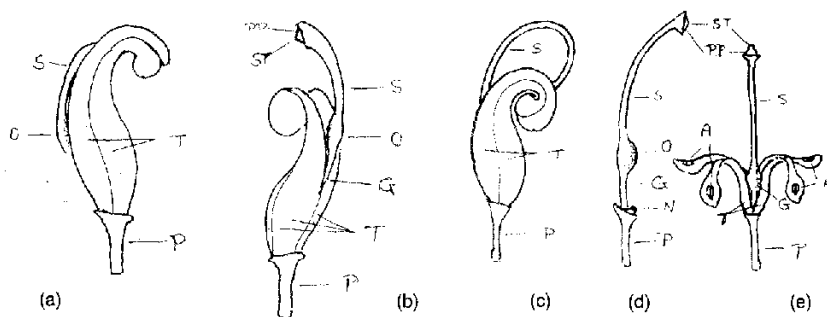


Fig. 7. The individual flower of the Waratah (*Telopea*) – The sketch (a) shows a flower that has matured to the stage where the style (s) has emerged as a loop between the tepals (petals), out the back of the flower. In sketch (b) the flower has matured further to the stage where the end of the style carrying the stigma (ST) with the pollen presenter (PP) has 'popped' out.

Fig. 8. The individual flower of the *Grevillea* – The sketch (c) shows a flower that has matured to the stage where the style (s) has emerged in a loop between the tepals (petals), out the back of the flower. Sketch (e) shows the flower fully matured with the tepals (petals) folded back revealing the anthers and the style upright. The various parts are indicated in sketch (d).

KEY – Tepals or Petals (T), Pedicel (P), Style (S), Stigma (ST), Pollen-presenter (PP), Anther (A), Ovary (O), Gynophore (G).

CORRECTION: These sketches are reproduced from page 263 of our issue on Proteaceae (*Telopea*, *Grevillea*, *Banksia*, etc.) where the caption to these sketches was incorrect.

Before we look at how each of the individual components of a flower may differ, plant by plant, we will study a few more unique arrangements of flower parts. In this issue we have *Anigozanthos*, the Kangaroo Paw with its unusual flowers and *Clianthus*, the Sturt's Desert Pea, of the large pea-flower family.

The Kangaroo Paw, *Anigozanthos*, is shown in colour on page 289. The paws consist of individual flowers at various stages of development. The more mature flower is at the top of the inflorescence and eventually, all the flowers will resemble the top one. Each flower is composed of a perianth tube with six lobes and is shortly or deeply divided at one intersection of the lobes. The term perianth is more commonly used when one whorl has ceased to exist. The remaining whorl has often taken on a modified form adapted to assist nature's creature that normally pollinates the flower. For clarity a stylised sketch is also shown and you will see that at one time the six perianth lobes may have been united to form a tube as in *Epacris* but that one of these joins has been incomplete showing in a split or division some way down the flower. As with *Epacris*, the six stamens are attached near the base of each lobe and on maturity these lobes fold back exposing the six stamens in a row. The female part of the flower, in the centre, has the stigma on top of the style in proximity to the stamens, awaiting fertilization. ■

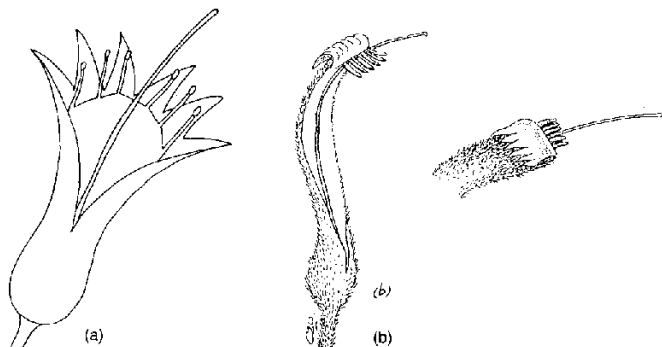


Fig. 9. (b) is the individual flower of the kangaroo paw which is redrawn in detail (a) in a more stylized form. Each flower is composed of a perianth tube with six lobes and is shortly divided in some species, or deeply as in this case, at the intersection of two lobes. The six stamens are inserted near the base of each lobe. The style arises from the centre of the flower.

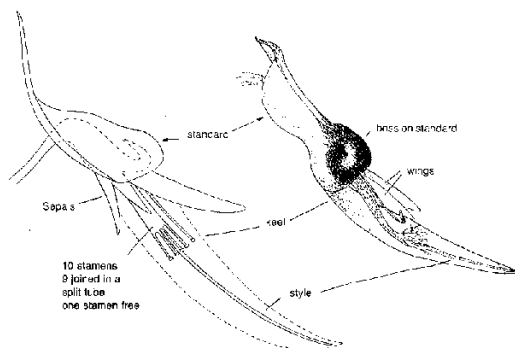


Fig. 10. The Sturt's Pea, *Clianthus*, drawn as you see it and in a more stylized form for clarity. Each flower is pendulous and comprises five petals and an outer whorl of five sepals. The largest petal is known as the standard and is folded back and hence upwards. The two smallest petals are called the wings. They are inserted inside the standard on each side of its broad base. The two remaining petals form the keel which almost completely encloses the reproductive parts. Nine of the ten stamens are joined in a tube, the remaining one being free.

THE BANKSIA ATLAS

Anne Taylor and Stephen Hopper

The 'Atlas' is a book of 258 large pages and is a record of a bold venture to record the incidence of all *Banksia* species throughout Australia, in their native habitat. Populations were counted and their geographical locations accurately recorded; size of plants, new shoot growth, flowering times and habitat (altitude, soil type, vegetation in the vicinity and landform) were recorded together with interesting pertinent facts. The whole of Australia? All populations? The organization, the paper work, the collating of information would be staggering! Those concerned about accuracy and adequate coverage may well ask this and some will be additionally sceptical when advised how the information was collected.

Following the success of the project 'Atlas of Australian Birds', a project guided by scientists but carried out by enthusiastic amateur bird observers, The Australian Biological Resources Study (ABRS) took a refreshingly bold step in engaging Dr Stephen Hopper to undertake 'The Banksia Atlas'. With Anne Taylor as national co-ordinator over 1 000 enthusiastic volunteers were sent out into the field with adequate support in instruction, direction (written and verbal) and computer compatible recording sheets. The 13 000 completed record sheets were professionally checked and pertinent data fed into a computer. The result in published form is 'The Banksia Atlas'.

The first 58 pages of the book describe how the project was organized and how professional competence transformed the enthusiasm of large numbers of amateurs blundering through the bush in all parts of Australia, into a creditable scientific report. It also shows how the scientific record was extended and new species discovered. While 'The Banksia Atlas' is acknowledged as a significant contribution to scientific knowledge, the 'Atlas' as a book, is so well presented that the information collected may be easily read and appreciated by all.

The bulk of the book devotes two pages to each species of *Banksia* and its varieties in easily read form. For the amateur seeking information on *Banksia*, 'The Banksia Book' by A. S. George is most suitable. To supplement this book for those wishing to know still more, 'The Banksia Atlas' is valuable. Both books are available from the SGAP NSW Book Service, P.O. Box 167, North Ryde, 2213. 'The Banksia Book' is \$30.00, post free and 'The Banksia Atlas' is \$32.00 plus \$2.50 postage. This represents a saving on normal retail price of over \$30.00. ■

Wildflowers from Seed

W. H. Payne

Readers are urged to purchase their plants from a specialist native plant nursery, especially those who advertise with us in this issue – see third last page. The very best forms can only be grown by vegetative means often requiring great skill. The specialist nursery goes to a great deal of trouble to propagate from the very best forms of plants. However, there are many that can be grown successfully from seed by those who wish to go to the trouble.

Waratah – *Telopea* from Seed

Our last issue featured Waratah and the well presented step-by-step procedure will allow even the most inexperienced to grow a Waratah to flowering, even in a pot. The method recommended for germination by seed for those who want to bother, suggested that the seed should be sown in early August and the container kept at 25°C. As mentioned on page 258 of that issue I tried his method with some success and I now have many strong, well grown Waratah plants in pots nearly a year old. However, I did mention the problems I found in trying to get the germinating seed to 25°C in Sydney but starting late in September did help. By the time they germinated and grew on, the hotter moister climate was on us and I did have numerous losses. This year I sowed the seed in ice cream containers using a medium of peat and perlite, in March. The temperature was just right and I got 95% germination. Four months later I now have healthy seedlings to 6 cm high with no losses.

Sturt's Desert Pea – *Clianthus* from Seed

Widely available are small packets of Sturt's Desert Pea seed and many people are tempted to purchase a packet. The plants in flower are a fantastic sight and some people have startling success. As Paul Nixon presented Waratah in such a simple, any-mug-can-do-it manner, I asked him to prepare the article on page 287 of this issue. He has made it appear so easy. It is easy. Nick a small hole in the seed coat. I use a pair of fingernail cutters. The seed will all germinate but keeping them vigorous is the trick. They must be sown in their permanent positions, kept warm and away from snails. Unless you have a very warm winter spot out of the rain, I feel that you will need to wait until October, at least in Sydney or plant in early March. At least, planting in a

hanging basket will enable you to move it around for the sun, out of the wind and especially out of rain, and be sure the snails do not eat them.

***Epacris* – The Heath Bells from Seed**

Who has grown the many species of *Epacris* from seed? How? When do you collect it? Please contact the Editor as I intend to try and I am sure many others wish to do so as well.

STUDY GROUPS

by Barbara Daly, Study Group Co-ordinator

The study of plants under cultivation. This is a practical way of applying knowledge gained from "Australian Plants" to gain further data to assist in the conservation of the magnificent Australian flora and its development for horticulture.

Study Groups consist of a Leader, active members who participate in any studies undertaken, and passive members who receive newsletters but take no active part in the Group's activities. To join a Study Group write to the Leader (addresses below) stating whether you wish to become an active or a passive member (some of the smaller Groups are only interested in taking on active members at the moment). Their annual subscription fees are listed below. Please send a stamped envelope with correspondence as Study Groups operate on slim budgets.

Study Group Leaders

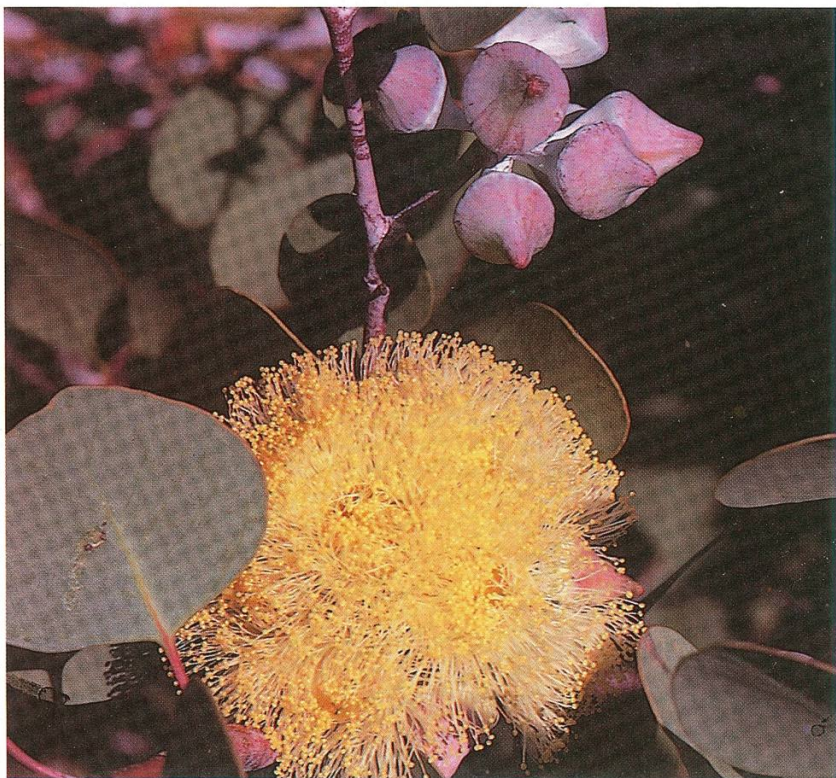
Fee \$

ACACIA — Mrs Marion Simmons, P.O. Box 1148, Legana, Tas. 7251.	3.00
BANKSIA — Mr Trevor Blake, 22 Vista Avenue, Ringwood East, Vic. 3135.	
BEAUFORTIA & ALLIED GENERA — Mr David Jones, 22 Brinsmead Road, Mount Nelson, Tas. 7007.	Cost of reports 4.00
BIRDS AND NATIVE PLANTS — Mrs Judy Smith, 44 Hawkins Parade, Blaxland, NSW 2774.	4.00
BRACHYCHITON & ALLIED GENERA — Mr Peter Vaughan, 66 Ridgeway Road, New Lambton Heights, NSW 2305.	3.00
CALOTHAMNUS — Mrs Barbara Graham, Nundle Road, Woolomin, NSW 2340.	2.00
CALYTRIX — Mrs Gwynne Clarke, 26 Henry Street, Cook, A.C.T. 2614.	2.00
CYCAD AND ZAMIAD AND PALM — Mr Len Butt, 25 Olive Street, Yeronga, Qld 4104.	4.50
DAISY, The AUSTRALIAN — Mrs Esma Salkin, 38 Pinewood Drive, Mt. Waverley, Vic. 3149.	5.00
DODONAEA — Mrs Jeanette Closs, 7 Vyella Court, Austins Ferry, Tas. 7011.	4.00
DRYANDRA — Mrs Margaret Pieroni, 16 Calpin Crescent, Attadale, WA 6150.	3.00
EREMOPHILA — Mr Geoff Needham, 2 Stuckey Avenue, Underdale, SA 5032.	2.00
EUCALYPTUS — Mr Tony Bean, P.O. Box 397, Nambour, Qld 4560.	4.00
FERN — Mr Peter Hind, 41 Miller Street, Mt. Druitt, NSW 2770.	3.00
FOOD PLANTS, AUSTRALIAN — Mr Rodney Barker, P.O. Box 62, Kangaroo Gd. 3097	3.00
GOODENIACEAE — Mr Dennis Margan, 583 Norman Avenue, Thornleigh, NSW 2120.	3.00
GRASSES, AUSTRALIAN — Mr Dermott Kelly, 6 Wilcox Avenue, Prospect, SA 5082	5.00
GREVILLEA — Mr Peter Olde, 138 Fowler Road, Illawong, NSW 2234.	5.00
HAKEA — Mrs Hazel Blackney, 23 Devon Street, Eaglemont, Vic. 3084.	3.00
HIBBERTIA — Mr Bernard Dixon, 82 Gilbertson Road, Kardinia, WA 6163.	2.00
HIBISCUS AND RELATED GENERA — Mr Doug Phillips, P.O. Box 467, Toowong, Qld 4066.	2.00
MELALEUCA AND RELATED GENERA — Mr Allan Foster, 40 Fairfax Road, Warners Bay, NSW 2282.	5.00
PLANTS IN CONTAINERS — Mrs Margaret Barbour, P.O. Box 818, Wagga Wagga, NSW 2650.	3.00
PROSTANTHERA & WESTRINGIA — Mr Brian Timmis, 7 Cranberry Street, Loftus, NSW 2232.	4.00
RAINFORREST — Mr Ian Innes, P.O. Box E327, St. James, NSW 2000.	2.00
THYSANOTUS AND REL. GENERA — Mr Andrew Gaering, Waite Ag. Res. Glen Osmond, S.A. 5064.	5.00
VERTICORDIA — Mr Maxwell Hewett, 11 Harvey Place, Cherrybrook, NSW 2120.	3.00

AUSTRALIAN PLANTS – The Periodical

There are many books on wildflowers available. Most are of interest to beginners but to obtain a continually updated reference to the Australian flora and its application to horticulture, serious readers will eventually need to obtain the available copies of Australian Plants. Past issues are marketed as bound volumes as advised on the inside of the rear cover of this issue. ■

The Blue Gum, The Floral Emblem of Tasmania



Photography by Neil Marriott

Eucalyptus globulus becomes a very tall tree. The flowers are not a significantly attractive feature, the above colour plate being of a very good form. The most noteworthy feature of this tree is its blue-green rounded foliage when a sapling. Travellers in Tasmania cannot fail to note the many small trees along the roadside. Trees may be coppiced a number of times.

Tasmania's Floral Emblem

by Alan Gray

The large Australian genus of trees — *Eucalyptus* — is an integral and characteristic feature of the natural landscape. The chiefly Tasmanian *Eucalyptus globulus* or 'Tasmanian blue gum' is a fine tree, some specimens often attaining a height of 20 m or more.

Young plants of *Eucalyptus globulus* are often quite attractive with their large bluish-white or grey oblong leaves, nearly stalkless and borne on square stems. At this stage and during its transition to the gracefully curved dark green adult leaves it makes an attractive specimen plant. As a landscaping or horticultural specimen this is where its charm finishes as it quite rapidly develops into a large tree. Older trees are potential "limb-shedders" and this vice as well as their invasive root system have led them to be counted on the list of trees banned for suburban planting by local councils.

I have a deep admiration for our Australian *Eucalyptus*, magnificent and fascinating trees that Australia has every right to be proud of and although it is "nice" that one state has adopted a species for its floral emblem, it is clear that this plant is hardly suitable and surely not for Tasmania! I suspect that this poor choice was probably the only native with which the politicians were familiar so that was "it". It may well be that this bi-centennial year may be an opportune time to rethink this matter and find the courage to make a change!

There are many fine plants much more characteristic of the Tasmanian floral scene and one that has been suggested in the past and appears to enjoy approval is the lovely *Eucryphia lucida* our famous "leatherwood tree".

Confined as it is to Tasmania it is none-the-less very common in wet forests of sub-alpine and lowland areas especially in the west of the state. In late spring and summer, the trees, which may reach 10-15 metres or so, are covered with masses of large white flowers, 2-3.5 cm in diameter, resembling small, single roses. The nectar is copious and provides bees which work the trees with the raw material for the strong but distinctive leatherwood honey which is appreciated by many and, indeed, is exported world-wide!

The leatherwood tree is easily grown from cuttings and will grow in any good, moist garden soil; the plant is easily contained by pruning after flowering. This distinctive tree would be a far more convenient, amenable and unique floral emblem for this state and what is more it can be easily controlled and grown as a container plant — try that with the blue gum! A pink flowering form is commercially grown, as is a variegated form.

Tasmanians — what about a change — are you with me?

Restoring Nature's Balance — The Potential for Major Reafforestation

Economic Significance of the Tasmanian Bluegum

The following notes are taken from an article under the above heading by Syd Shea and John Bartle in the Autumn Edition, April, 1988 of the periodical 'Landscape'. This is published by Western Australia's Department of Conservation and Land Management and is available from them (50 Hayman Road, Como, Western Australia 6152) for \$2.50 post free. The article follows years of study into the salination of half the fresh water streams and pollution of most coastal wetlands and estuaries.

Clearing of vast tracts of native eucalypt woodlands and forest for agriculture has been the major cause of salination of half the fresh water streams and pollution of most coastal wetlands of south-eastern Western Australia. Once fertile farmland has become salt damaged and about half of the total water resource of the south-western region has been degraded.

The study has found that the planting of woodlots of Tasmanian Bluegum in selected areas in the manner recommended can restore nature's balance and return large areas of farmland back to healthy production. For the areas planted by the farmer with Tasmanian Bluegum the yield will be in excess of his income from a similar area under his usual crop. The recommended programme would yield \$400 million in export income in 10 years. The farmer will receive an annual payment of between \$50 and \$250 per hectare depending on the site, from the time of initial planting. Most importantly the farmer will then be able to restore his remaining land, the major part, to full production. Incredible! By restoring a balance to the environment other benefits such as providing a refuge for wildlife, beautifying the landscape, etc., may be, of even greater value.

Incredibly, the time to maturity/harvesting of Tasmanian Bluegum is ten years whereas for *Pinus radiata* it is between 25 and 30 years. Regeneration after fire is also a significant factor. Two further croppings can be obtained as bluegum, like many other eucalypt species, resprouts from the cut stumps.

Tasmanian Bluegum, *Eucalyptus globulus*, has wood quality characteristics which are ideal for high quality paper production. It has the capacity to grow on a wide variety of soils although its growth rate varies according to soil type and rainfall. Its low level of frost tolerance restricts its distribution to low altitudes and near coastal locations. The species has proved very adaptive and productive, and it has become one of the most important temperate zone eucalypt in world forestry. It is also widely planted at high altitudes in tropical latitudes. International plantings now exceed two million hectares, principally in Brazil, Spain, South Africa and Portugal. ■

Eucryphia

By Ken Gillanders

Woodbank Nursery, Kingston, Tasmania

The genus *Eucryphia* has quite a remarkable distribution with one species – *Eucryphia moorei* in Victoria and New South Wales, two species in Tasmania – *Eucryphia milligani* and *E. lucida* and two in Chile – *E. cordifolia* and *E. glutinosa*. Although separated by thousands of miles of ocean, the South American species show their very close relationship to our species by hybridizing freely when grown together in England.

Eucryphia milligani occurs at higher altitudes than *E. lucida* and is a smaller tree with smaller leaves and flowers. Its range extends beyond the tree line in the mountains and it can be found at 1 300 m growing as a gnarled prostrate shrub with tiny leaves 4 mm long. Where the two species overlap, variations can be found which are possibly hybrids. *E. milligani* grows quite well in the garden if given similar conditions as mentioned for *E. lucida*. One hybrid between *E. moorei* and *E. lucida*, occurred as a spontaneous seedling in Hilliers nursery in England and is known as *Eucryphia* 'Hilliers'.

Eucryphia moorei forms a small light tree with pinnate leaves. The white flowers are about 2.5 cm in diameter and occur on our plant much later than the other two species mentioned. Although coming from a rather temperate habitat, *E. moorei* is surprisingly hardy in southern Tasmania, tolerating quite strong frosts.

The most common species in Tasmania is *Eucryphia lucida*, which is widespread in the south and west of the state, frequently growing in association with *Nothofagus cunninghamii* and *Atherosperma moschatum*. In ideal situations, it will grow to 30 m with a trunk girth of 60-90 cm. *Eucryphia* has not been exploited for its timber but apiarists make full use of its flowering season, which is from January until March. Leatherwood is the common name for *Eucryphia* in Tasmania and the leatherwood honey produced from the *Eucryphia* flowers is quite delicious with a slightly waxy flavour.

The flowers are four petalled and pure white, about 4 cm in diameter with a central boss of pink tipped stamens. *Eucryphia lucida* produces conspicuous beads of wax on its growth buds. These used to be gathered by early bushmen and used as an ointment. I cannot, however, find out what results were obtained by its use. Although discovered in 1792 by Labillardiere, the French botanist in the D'entrecasteaux expedition, it does not seem to have found its way into many Australian gardens, although grown quite extensively in the south of England. It prefers a cool moist climate and acid soil. If provided with these conditions it grows very well. In cultivation, it does not grow to the size it would in its natural habitat. It generally forms a narrow upright plant to about 5-6 m. See the tree opposite. Propagation is easy from cuttings placed in a peat and sand mix. Rooting will take about 2-3 months with gentle bottom heat.

Two forms of *Eucryphia lucida* have occurred and have been named and propagated. One named *Eucryphia lucida* 'Leatherwood Cream' has attractive foliage margined with a narrow line of cream variegation.

The other *Eucryphia lucida* 'Pink Cloud' is the first coloured *Eucryphia* to be discovered. It is soft pink with a crimson stain in the base of each flower. The buds, before they open, are a deep rose. ■



Eucryphia lucida 'Pink Cloud'

Photography by Ken Gillanders

Eucryphia lucida 'Pink Cloud' was selected from a wild population near Smithton in north-west Tasmania in 1984. The collection was made in a forestry working area. The plant from which the material was selected was about 16 m tall. However, as with other forms of *Eucryphia lucida* when grown in cultivation, it will most likely only attain a height of 5 to 7 m. The flowers, which occur in the summer months, are a soft pink deepening to rose in the centre of the flower. They are 4 cm in diameter. In cultivation extra moisture will be required in drier parts of Australia during the summer months. The cultivar is frost hardy. Plants are available from Woodbank Nursery, RMB 303, Kingston, 7150.



***Eucryphia lucida*, The Tasmanian Leatherwood Tree**

Photography by A. M. Gray

A tree that may reach 10-15 metres in height but usually much less when grown as a specimen. As above, it covers itself with masses of large white flowers, 2-3.5 cm in diameter. The flowers are usually white, like small single roses, but selected species have a soft pink or crimson stain as shown opposite.

Kangaroo Paw Varieties

by Dr Stephen Hopper*

All the presently accepted species of *Anigozanthos* were treated in detail in Volume 10, issue 81 of Australian Plants. As foreshadowed, several races have been recognized in "Flora of Australia", Vol. 45, and to update our record these are presented below.

Anigozanthos bicolor

Anigozanthos bicolor subsp. *decrescens* is distinguished from the type subspecies in having perianth strongly constricted above the middle (not slightly constricted) and from subsp. *minor* in having leaves 10-25 cm long (not 5-10 cm long), perianth 45-65 mm long (not 30-45 mm long) and ovary hairs red-purple (not red).

Anigozanthos bicolor subsp. *exstans* is distinguished from the type subspecies in having scape 10-25 cm tall (not 20-60 cm tall), perianth 55-75 mm long and 4-10 mm wide at narrowest point above the middle (not 45-65 mm long and 5.5-12 mm wide at narrowest point above the middle).

Anigozanthos bicolor subsp. *minor* is distinguished from the type subspecies in having perianth strongly constricted above the middle (not slightly constricted above the middle) and from subsp. *decrescens* in having leaves 5-10 cm long (not 10-25 mm long), scape 5-20 cm tall (not 10-45 cm tall), perianth 30-45 mm long (not 45-65 mm long) and ovary hairs red (not red-purple).

***Anigozanthos humilis* – The Cat's Paw**

Anigozanthos humilis subsp. *chrysanthus* is distinguished from the type subspecies in having scape 20-40 cm tall (not 10-30 cm tall, rarely to 100 cm) and perianth uniformly yellow and 20-35 mm long (not usually yellow with varying suffusions of red or orange and 25-50 mm long).

***Anigozanthos manglesii* – The Red and Green Kangaroo Paw**

Anigozanthos manglesii subsp. *quadrans* is distinguished from the type subspecies in having perianth hairs orange-red over most of the tube (not with red only at the base of the tube) and perianth slightly constricted near the filaments (not parallel-sided near the filaments).

***Anigozanthos viridis* – The Green Kangaroo Paw**

Anigozanthos viridis subsp. *terraspectans* is distinguished from the type subspecies in having scape 10-15 cm tall (not 10-85 cm tall), perianth 45-60 mm long and 4-5 mm wide at its narrowest point above the middle (not 55-75 mm long and 5.5-12 mm wide at its narrowest point above the middle).

Wildflowers of the Dry Country

Reprinted from the 1987 Annual Report of the Australian Flora Foundation, the project opposite is one of a number of recommendations by the Foundation of areas of research to be especially promoted and sponsored. Applications are invited for support of research projects that may lead to the use of our dry arid areas to cultivate the spectacular flora (see page 309) for the lucrative export trade. You could sponsor Australia by making your contribution of \$100.00 as outlined.

WILDFLOWERS OF THE DRY COUNTRY

Floriculture in Arid and Semi-Arid Regions

by The Australian Flora Foundation

The Australian Flora is very rich in species which are suitable for cut flower and cut foliage production. A number of species are cultivated but most of these originate from regions which have a damp, temperate climate. To date, species from the arid and semi-arid regions, areas of high temperatures and low rainfall, have been neglected for floricultural purposes.

It would be practicable to cultivate Australian species for flower, foliage and ornamental fruit production in many places in the arid and semi-arid regions of Australia. To a limited extent Israel is having success in cultivating Australian plants on a commercial scale and, in some cases, experimentation with watering from the Dead Sea has proved successful. Australia is missing an excellent opportunity to use the native flora and the difficult arid zones in a manner which could provide monetary return through the export of flowers, foliage and fruits in a fresh or dried state.

Many species from the arid and semi-arid regions which could be useful for floriculture are difficult to propagate, e.g., *Conospermum*, *Eremophila*, *Lachnostachys*, *Newcastelia*, *Physopsis* and *Pityrodia*. Research is needed into these problems of propagation. We can no longer afford to collect these materials from virtually unmanaged natural sites. Many species are now becoming rare in nature due to harvesting which severely restricts the production and dispersal of seed in order for regeneration to occur.

Dry zone cultivation of native plants is relatively unexplored and cultivation techniques need to be researched. The Australian Flora Foundation has decided that this is a priority objective and invites scientists throughout Australia to submit research proposals in this area for funding. ■

The Australian Flora Foundation

The Australian Flora is a magnificent collection of plant life. The activities of man have placed its very existence under threat. We desperately need competent scientific research to assure its survival. Our interest also is to be able to grow those plants with horticultural merit where we can admire them and add beauty to our surroundings. To achieve this The Australian Flora Foundation was created. Thanks to your support, the Foundation has:

- A. Become established with recognition and support from the scientific world.
- B. Initiated feasibility studies into areas of research.
- C. Compiled a reference catalogue of current research projects.
- D. Held seminars in Melbourne, Adelaide, Canberra and Sydney.

What is needed now is:

1. Direct government support: The people of Australia have spontaneously arisen and formed this foundation dedicated to "foster research into the biology and cultivation of the Australian Flora". There are no political or pressure group ties. Clearly a well organized, well supported large group of citizens is dedicated to the preservation of a significant sector of our Australian heritage, the unique flora of Australia. The time is opportune for the government of our land to give direct support.
2. From the Community! The community, a large number of individuals, has made personal sacrifice to ensure the creation of The Australian Flora Foundation. It is largely individuals who have contributed the finance to establish the foundation to this stage. Once again we appeal to these far-sighted Australians to send in their \$100.00 (tax free) donations to the research fund. Donations should be sent to The Secretary, The Australian Flora Foundation, 28 Buderim Avenue, Kareela, NSW 2232.
3. From the Commercial/Industrial Sector of Australia. At a time when the competitive economic climate has become critical, the good name and prestige of a public undertaking has never been more important. Support will also be an investment in Australia's natural wealth.

Those who so generously supported the current vital research programmes on the application to the Australian flora to horticulture have recently received the current publication of the foundation, "The Annual Report, 1986-1987", and substantial reports/books entitled, "Waratahs - Their Biology, Cultivation and Conservation" and "Index of Current Horticultural and Biological Research on the Australian Flora". Those who send a donation in 1988 will receive these publication while stocks last, if they have not already received them, together with publications in the 1988-89 period. As well you will be supporting vital research. How about it John and Jane Citizen, this is your opportunity to make a significant contribution to the conservation of the Australian flora. Please do not leave it to someone else, we need your support.





Pityrodia axillaris (above and opposite top)

Photography by F. W. Humphreys

A magnificent flowering plant of arid areas of Australia. Do not look in issues of Australian plants (or any other publication) for advice on how to grow this plant. We do not know. See "Floriculture in Arid and Semi-arid Regions" on page 307. Here we are advised that the Australian Flora Foundation has recognized the enormous horticultural potential of a plant with significant market prospects for commercial cultivation in our vast arid areas and they propose to do something about it.

Lachnostachys eribotrya (opposite bottom)

Photography by John Symmons

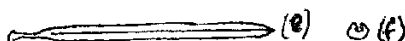
A novel plant of the arid areas of Australia. The concern by the Australian Flora Foundation that such unique plants cannot be widely grown is echoed by us all.

Bush Peas

The Genus *Pultenaea* —

Part 8 by C. E. & D. T. Woolcock

a — the calyx cupping the flower
b — large petal — the standard
c — two petals — covering keels
d — two petals — boat shaped keel
e — the leaves in this group are terete
f — with edges curved upwards



Previous issues have introduced the pea-flowered plants starting with No. 86 issue. The group of plants known as *Pultenaea* have been presented in parts. The flower of a *Pultenaea* is shown above, a four petalled flower, the petals being a characteristic shape, a large one "b" called the standard, two side petals "c" covering the keel, and two lower petals clasping one another to resemble the keel of a boat.

This group of plants have terete leaves (leaves curved to almost form a tube) and in this case the channel is on the upper side formed by the leaf edges turning up. The leaves alternate along the stem. The flowers are solitary or twin and not in clusters. The following sketches will allow you to identify these plants.

Pultenaea fasciculata Benth.

Alpine Bush-pea

- Habit:** Low undershrub, stems prostrate, with silvery pubescence. (A).
Leaves: Terete, channelled above, mucronate (tip not recurved), 4-8 mm long, appressed hairs or glabrescent, sometimes slightly tuberculate. Stipules 1-2 mm long. (B₁ B₂ B₃).
Flowers: Axillary near ends of branchlets, on pedicels 1-2 mm long. Calyx short, hairy, lobes as long as the tube and acuminate. (C).
Bracteoles: Linear, hairy, about as long as the tube, attached at base of the tube. (D).
Flowering: Summer — January/February.
Distribution: Alpine around bogs and wet areas. Occurs in Vic., Tas., A.C.T., NSW (northern and southern tablelands).

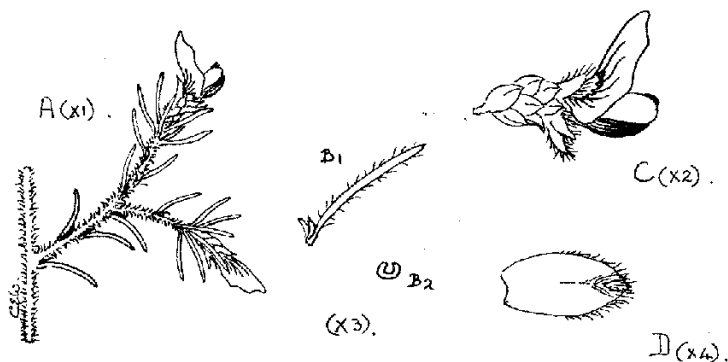


Pultenaea prolifera* Williamson*Otway Bush-pea**

- Habit:** Graceful bushy shrub to about 1 m high. Branches pubescent. (A).
Leaves: Linear-terete, strongly incurved, hispid, obtuse, 4-8 mm long, shortly petiolate with subulate stipules c. 2 mm long. (B_1 B_2).
Flowers: 1 or 2 together, usually terminal. Branchlets proliferous, giving heavy flowering. Calyx heavily enclosed in hispid bracts, ends of lobes only visible and these are short and ciliate. Short peduncle 1-2 mm long. (C).
Bracteoles: Ovate-lanceolate, ciliate, slightly longer than calyx tube and attached at its base. (D).
Flowering: October-November.
Distribution: Near coastal areas in Southern Victoria and Tasmania.

***Pultenaea prostrata* Benth. ex Hook.****Silky Bush-pea**

- Habit:** Small shrub to 60 cm high, erect or spreading branches. (A). Stems pubescent.
Leaves: Terete, 1-furrowed above, 3-7 mm long, pubescent becoming glabrous with age. Stipules small and inconspicuous (1 mm long). (B_1 B_2).
Flowers: Always solitary, terminal on short branchlets. Calyx tube glabrous but lobes silky hairy, enclosed by Involucre of brown bracts, which are glabrous except for minute marginal cilia. Keel dark red. (C).
Bracteoles: Ovate-oblong, brown, slightly ciliate on margins and near apex. (D).
Flowering: September-October.
Distribution: Sth. Aust., Vic., Tas. — inland and Mallee.





***Pultenaea canaliculata* F. Muell.**

Coast Bush-pea

Habit: Rigid, often spreading shrub 1-2 m high, with soft silky appearance (A).

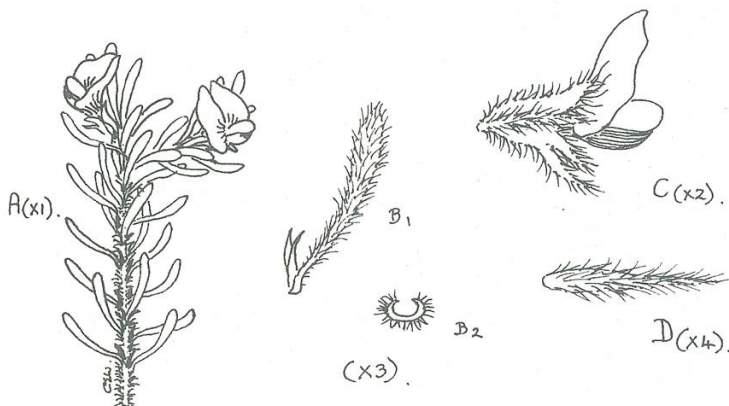
Leaves: Linear, inrolled, crowded, slightly club-shaped and curled towards the stem, 7-10 mm long, silky-pubescent, often blue-grey. Stipules 3-4 mm long, prominent. (B₁, B₂).

Flowers: Few, in leafy clusters towards the ends of short branchlets. Calyx villous with acuminate lobes. Keel yellow or dark red. (C).

Bracteoles: Linear-lanceolate, longer than calyx-tube, villous, attached at base of calyx. (D).

Flowering: August-December.

Distribution: Sth Aust. (Southern Mt. Lofty Range, Eyre Peninsula); Vic. Mainly coastal.

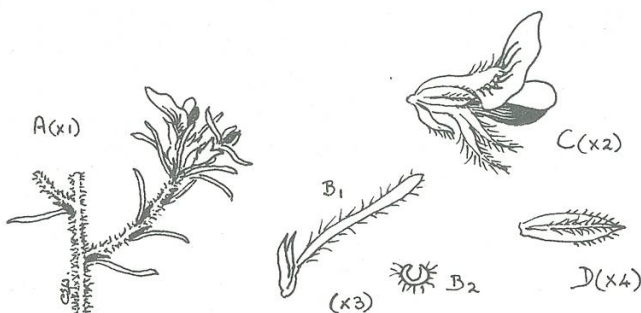




***Pultenaea tenuifolia* R. Br.**

Slender Bush-pea

- Habit:** Slender procumbent shrub to about 50 cm high. (A) Branches pubescent. *P. tenuifolia* var. *glabra* in Vic. Mallee more robust and almost glabrous.
- Leaves:** Terete, 1-channelled above, crowded, 4-8 mm long, usually pubescent or villous. Stipules moderately prominent and up to 3 mm long. (B₁ B₂).
- Flowers:** Sessile, solitary or twin at ends of short branchlets, surrounded by broad stipular bracts, which are light brown, pubescent, and with a prominent mid-rib. Calyx lobes acuminate, longer than the tube, villous. Calyx tube often glabrous. Keel dark red. (C).
- Bracteoles:** Lanceolate, as long as or slightly longer than calyx tube. Pubescent on mid-rib, ciliate on margins. (D).
- Flowering:** September-October.
- Distribution:** Sth Aust., W.A., Vic., Tas. Usually coastal but var. *glabra* in Mallee.



Tricoryne¹

by A. Thongpukdee and H. T. Clifford.
Botany Department, University of Queensland,
St. Lucia, Australia 4067

Yellow Rush Lilies, Yellow Autumn Lilies, Star Lilies.

The bushy compact habit of most species of *Tricoryne* and the ease with which they may be propagated from seed or rhizomes makes them ideal garden or pot plants. Their flowers are bright yellow, up to 2 cm across with bearded staminal filaments forming a delicate sheath about the pistil. Several species have wide ecological tolerances as reflected in their extensive geographical distributions and most flower for several months during the spring and summer. One taxon, *T. anceps* subsp. *pteroaulon*, flowers throughout the year.

Hence it is surprising that members of the genus are not more widely cultivated. The reason may be that the flowers are relatively short-lived, not opening until early afternoon and closing a few hours later. That each flower is so short lived is a disadvantage but there is compensation in that the umbels in which they are borne may produce a new flower on successive days for as long as two or three weeks. Furthermore, individual plants may flower continuously for several months. Accordingly, the genus is worthy of further recognition as a horticultural plant.

The first specimens of *Tricoryne* were collected at the Endeavour River by Banks and Solander in 1770 while Cook was careening his ship. The plants were named as *Anthericum* spp. in manuscript until Brown (1810) placed them in *Tricoryne* which he created in his *Prodromus Florae Novae Hollandiae*. The most recent revision of the genus is by Thongpukdee (1987). Except for *T. anceps* subspecies *pteroaulon* the genus is restricted to Australia.

Morphology

All seven species of *Tricoryne* are perennials with aerial stems that may persist for several years, occasionally bearing new shoots from axillary buds.

Root system: Fibrous throughout with roots often swollen and fleshy.

Rhizome: Short, developing erect flowering branches.

Leaves: Linear or grass-like in seedlings and at the lower nodes but becoming scale-like distally in some species. Hence, on the basis of leaf form two groups of species may be recognized: one in which linear leaves persist on mature plants; (*T. humilis*, *T. simplex*, *T. elatior*) and one in which linear leaves do not persist; (*T. anceps*, *T. corynothecoides*, *T. muricata*, *T. tenella*).

Aerial shoots and branches: Either flattened (*T. anceps*) or terete (*T. corynothecoides*, *T. elatior*, *T. humilis*, *T. muricata*, *T. simplex*, *T. tenella*).

Inflorescence: Flowers clustered in umbels, from 2-20 in number per umbel.

Flowers: Perianth of six free segments arranged in two alternating trimerous whorls, the sepals narrower than the petals, both bright yellow. All segments become twisted after anthesis (Fig. 11).

Stamens: Six with hairy filaments, those opposite the sepals shorter than those opposite the petals. Filaments attach to the connective inside a pit (Fig. 2G).

¹ The name is derived from two Greek words *treis*, (three) and *koryne*, (club) and refers to the club-shaped mericarps. (single-seeded fruit segments).

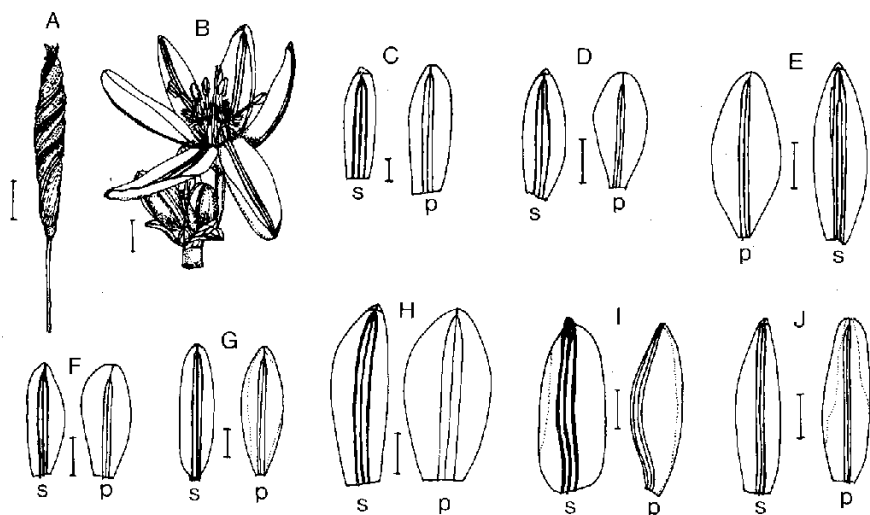


Fig. 1. Flowers and floral envelopes of *Tricoryne* species. A, the twisted flower at postanthesis of *T. muricata*; B, the inflorescence of *T. elatior*; the floral envelopes of C, *T. anceps* ssp. *anceps* where s=sepal and p=petal. The scale marked in each case is 2 mm; D, *T. anceps* ssp. *pterochaulon*; E, *T. corynothecoides*; F, *T. tenella*; G, *T. elatic*; H, *T. simplex*; I, *T. humilis*; J, *T. muricata*. (s=sepal, p=petal; scale=2 mm).

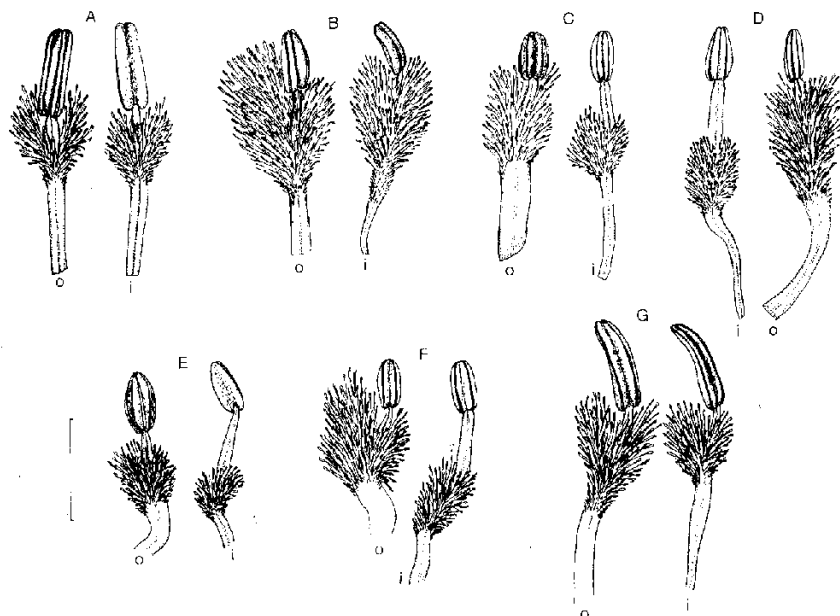


Fig. 2. The stamens of *Tricoryne* species. A, *T. anceps* subsp. *pterochaulon*; B, *T. corynothecoides*; C, *T. elatior*; D, *T. humilis*; E, *T. tenella*; F, *T. muricata*; G, *T. simplex*; (o = stamen opposite sepal, i = stamen opposite petal; scale = 2 mm).



Tricoryne elatior ▲ (Photography by F. W. Humphreys)

▼ *Tricoryne humilis*



Anther: Oblong, 1 mm or more long (*T. anceps*, *T. simplex*) or ovoid and less than 1 mm long (*T. elatior*, *T. corynothecoides*, *T. humilis*, *T. muricata*, *T. tenella*). (Fig. 2). Dehiscence is by longitudinal slits.

Ovary: Ovoid to sphaeroid, trilobulate with two ovules per locule of which only one develops into mature seed.

Style: Straight, erect with papillate stigma.

Fruit: Schizocarpic with 1-3 mericarps enclosed by brown pericarp when mature. The sculpture of the pericarp and the presence or absence of apical appendage (umbo) enable the genus to be divided into three groups (Fig. 3) — pericarp smooth, umbo absent: (*T. anceps* ssp. *anceps*), pericarp ribbed or reticulate, umbo absent: (*T. anceps* ssp. *pteroaulon*, *T. elatior*, *T. muricata*, *T. simplex*), and pericarp smooth or slightly reticulated, umbo present: (*T. corynothecoides*, *T. humilis*, *T. tenella*).

Seed: Varies in shape from obovoid to ellipsoid; testa black, shiny, reticulated and crustaceous.

Species members of the genus

1. *Tricoryne anceps* R.Br.

To 70 cm high with branches cylindric toward base but flattened above (> 2 mm wide in *T. anceps* subsp. *pteroaulon* and < 2 mm wide in *T. anceps* subsp. *anceps* (Fig. 5). Leaves 5-10, grass-like glabrous 5-7 cm long present only in seedlings and juvenile state. Umbels 3-15-flowered, subtended by scarious subulate bracts 3 mm long. Perianth members 3-7-nerved. Mericarps ellipsoidal 5-7 mm long. Pericarp smooth or ribbed. Two subspecies are recognized, *T. anceps* subsp. *anceps* and *T. anceps* subsp. *pteroaulon* which may be distinguished as follows:

Branches flattened, equal or less than 2 mm wide; pericarp smooth; sepals 3-5-nerved *T. anceps* subsp. *anceps*.

Branches flattened, wider than 2 mm; pericarp ribbed; sepals 3-7-nerved *T. anceps* subsp. *pteroaulon*.

The subspecies *anceps* occurs in eucalypt open forest in eastern Australia from Rockingham Bay to around Endeavour River and the subspecies *pteroaulon* occurs northwards of southern Queensland through Cape York and extending into Papua New Guinea in savannah forests of Western district. Flowers throughout year.

2. *Tricoryne corynothecoides* Keighery

To 30 cm high with 3-5-divaricated or recurved fork-like branches. Umbels 2-11-flowered, subtended by scarious subulate or narrow deltoid bracts 1.5-2 mm long. Perianth members 3-5-nerved. Mericarp obovoid with apical umbo. Pericarp mostly smooth. Occurs in north-western coastal W.A. from Exmouth Gulf to Kennedy Range and in south-western W.A. north of Dillon Bay. Grows in red sandy loam limestone soil, flowering June-February.

3. *Tricoryne elatior* R.Br.

To one metre high, weakly erect with terete or wiry branches. Leaves scale-like except on seedlings. Umbels 2-10-flowered subtended by a narrow, acuminate, deltoid or subulate scarious bracts, 3-8 mm long. Perianth members 3-nerved. Mericarps ellipsoidal 4-6 mm long without an apical umbo. Pericarp smooth or occasionally with a single vertical rib. The species occurs throughout eastern Australia from Sydney to Kuranda and rather sparsely in Northern Territory, Western Australia and Tasmania. It grows in heathlands, open forests, woodlands, and occasionally swamps, with flowers throughout the year. See colour photograph on page 316.

4. *Tricoryne humilis* Endl.

Usually 6-20 cm high but sometimes to half a metre, sparsely branched or reduced to a single shoot. Leaves well developed, lanceolate or linear grass-like 6-10 cm long with finely toothed margins. Umbels 8-12-flowered subtended by 3-4 leaf-like lanceolate or linear bracts 12-40 mm long. Perianth members 3-nerved. Fruit ellipsoid or obovoid 3-6 mm long, 1.5-3 mm diameter with apical umbo. Pericarp smooth or slightly reticulate. The species is endemic in south-western W.A. from Perth to the Stirling Range growing in jarrah forests. It flowers from September to January. See the colour photograph on page 316.

5. *Tricoryne muricata* Baker

To 30 cm high with terete, hairy branches (Fig. 4). Basal leaves linear 1.2-7.5 cm long, hairy along the mature veins. Umbels 3-12-flowered subtended by scarious deltoid bract, 1-2 mm long. Perianth members 3-nerved. Mericarp obovoid 3-4 mm long, without an apical umbo. Pericarp reticulate. The species occurs in south-eastern and central Queensland growing in wallum communities and eucalypt forest. It flowers from May to November.

6. *Tricoryne simplex* R.Br.

To 20 cm high, rarely branched. Basal leaves grass-like 6.15 cm long, 3-5 mm wide, mostly glabrous, hairy at margin. Umbels 6-20 or more flowered, subtended by scarious subulate bracts, the outer few leafy linear, 4-5 mm long. Perianth members 3-4-nerved. Mericarps obovoid 3.5-4 mm long, without apical umbo. Pericarp reticulate. The species occurs in New South Wales from Cobar to the Shoalhaven River, growing in heathland and wet sclerophyll forest. It flowers from September to December.

7. *Tricoryne tenella* R.Br.

To 25 cm high with terete, clustered branches. Leaves grass-like appear only in early developing young shoots but reduced to scales on mature branches. Umbels 2-15-flowered subtended by scarious deltoid bracts to 1.5 mm long. Perianth members 3-nerved. Mericarps ellipsoid 2.5-4 mm long with apical umbo. Pericarp slightly reticulate. The species is restricted to the south coast of South Australia, Kangaroo Island and inland in southern Western Australia. It grows in heathland, flowering from November to January. This species is very similar to *T. elatior* and was at one time included under that name, but is distinguished by its umbonate fruit.

Propagation and Cultivation

The percentage seed germination is rather low in the two south-east Queensland species (*T. anceps* subspecies *pteroaulon*, *T. elatior*) cultivated and the seedlings showed a lower rate of growth compared with plants propagated from rhizomes. It is generally more convenient to grow *Tricoryne* from rhizomes. To propagate the plants, rhizomes can be cut into sections about 1-2 cm long then transplanted into well-drained pots or directly to a well-watered garden bed in full sun.

References

- Brown, R. (1810). 'Prodromus Florae Novae Hollandiae et Insulae Van Diemen'. Vol. 1. (J. Johnson: London).
Thongpukdee, A. (1987). '*Tricoryne*'. In 'Flora of Australia'. 45. (Ed. A. S. George). (Australian Government Publishing Service: Canberra).

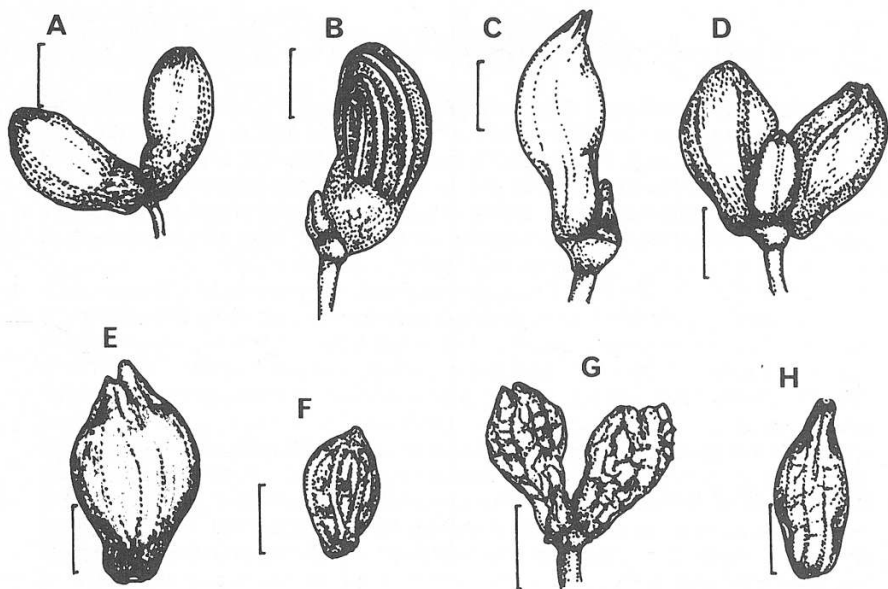


Fig. 3 The fruit of *Tricoryne*. A, *T. anceps* subsp. *anceps*; B, *T. anceps* subsp. *pterochaulon*; C, *T. corynothecoides*; D, *T. elatior*; E, *T. humilis*; F, *T. muricata*; G, *T. simplex*; H, *T. tenella*. (scale = 2 mm). (Fig. 3. G. redrawn from Thongpukdee in "Flora of Australia", George (1987)).

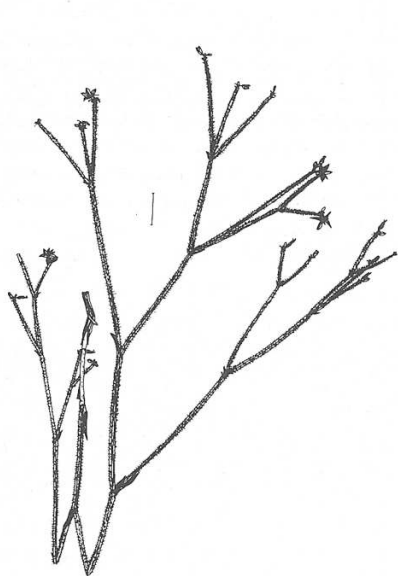


Fig. 4. *Tricoryne muricata* plant (scale = 2 cm)



Fig. 5. *Tricoryne anceps* subsp. *anceps*.

Kangaroo Paw

Action to Study Kangaroo Paws
by Keith Oliver, Chairman, The Kangaroo
Paw Society of Western Australia

The eleven species of *Anigosanthos* and the single species of *Macropidia* which comprise the Kangaroo Paws are only found in the south of Western Australia. All species produce bizarre and beautiful flowers, which are covered with a velvet-like fur which can come in many different colours, and in some cases, in striking combinations of colours. The unique beauty of these flowers has aroused attention in many parts of the world and they are now grown in, and exported to, many countries worldwide.

A limiting factor to further exploitation of their enormous horticultural potential has been the incidence of disease limiting the long term production of blooms of the more striking species. There has been a trend to produce hardy, disease-resistant forms by hybridizing, using selected species, and this is reflected in the many Kangaroo Paw hybrids offered for sale. There is still much to learn.

How do we raise Kangaroo Paw from seed? When is the best time to divide the clumps and how is the best way to do this? What about diseases and their control? How long do different species live? What pigments form the flower colours and can these be controlled? What fertilizers can be used? What is the best method of watering? The questions are numerous and the answers are coming slowly.

The Kangaroo Paw Society of Western Australia was formed recently, a society dedicated to the study, cultivation and conservation of these plants. The primary objective is to tackle the above problems. Activities of the society for those resident in Perth include formal meetings with a competent speaker, field trips to see Kangaroo Paws in the wild, inspections of members' gardens, visits to Kangaroo Paw Farms, where the plants are grown for the cut flower export trade, visits to tissue culture laboratories, etc.

The Kangaroo Paw Society of Western Australia is affiliated with the Western Australian Wildflower Society (Inc) which is a member society of the Society for Growing Australian Plants. We would like to hear from people in other areas who are interested in these popular and fascinating plants. All enquiries to the Secretary, Neil Arthur, 23 Denmark Way, Warwick, Western Australia 6024. Phone: (09) 448 7497. The membership fee is \$5.00 ■

Pests and Diseases of Kangaroo Paw

by Bob Dixon

Probably the worst pests are slugs and snails which are easily controlled by snail pellets or by spraying, although some sprays are only effective for three days. Other less troublesome pests include aphids which attack small seedlings and flowers and a range of caterpillars which attack the leaves and/or flowering stems. Major leaf diseases include ink disease *Alternaria alternata* (black spots) and rust disease *Puccinia haemodori* (small orange brown spots). Both diseases can eventually kill the plant; however, rust disease can be controlled fairly well by the regular use of Baycor. Researchers (Sivasithampram and Verhoogt) at the University of Western Australia, have found certain strains of the disease affect some clones more than others. Therefore selection of a so-called resistant clone may be only a temporary reprieve until other strains of the diseases are introduced to your locality.

These diseases thrive in moist, warm conditions; therefore, keep the leaves dry by planting in full sun and use trickle irrigation to control them. ■

Nutrient Disorders in Kangaroo Paws

by Brian Hanger* and Austin Brown†

Summary

Kangaroo Paws were grown in sand culture on major nutrient deficient solutions. Deficiency symptoms were produced for nitrogen, phosphorus, potassium and magnesium, but not for calcium. *Anigozanthos pulcherrimus* was sensitive to the phosphorus level in the nutrient solution ($P = 1 \text{ mmol l}^{-1}$) and developed toxicity symptoms. The intensity of magnesium deficiency symptoms varied between species. Chemical analysis of the plant tops is presented.

Introduction

Little is known of the mineral nutrition of many of the Australian plants including the Kangaroo Paws. As a consequence there is a need to understand more about their basic nutritional requirements, particularly with regard to nutrient imbalance (deficiency and excess) and a recognition of the symptoms. This becomes increasingly important as the number of species brought into cultivation as potted plants or cut flowers continues to grow rapidly. Another area which lacks basic information is that of the nutrient content of these plants and how this is influenced by environmental and soil factors. There is a need to determine critical nutrient concentrations in particular plant organs as a guide in the diagnoses of nutrient disorders in Australian plants under cultivation.

In recent times, the Kangaroo Paws have been brought into large scale cultivation in Australia for cut flowers. Many plantings have been on the deep sands around Perth, Western Australia, and plants in general have responded well to soil applications of superphosphate and regular liquid feeding of nitrogen and potassium through trickle lines. However a number of problems have been encountered and attributed to nutrition (S. Newton, personal communication). Examples are excessively thick flower stalks of *Anigozanthos manglesii* (excessive nutrients?), a sensitivity towards chlorosis at high soil pH (lime-induced iron chlorosis?), twisted or crooked flower stalks of *A. pulcherrimus* (potassium/nitrogen imbalance?) and difficulty in bringing *Macropidia fuliginosa* into cultivation and to flower (nutrient imbalance and level?).

The objective of the present study was to produce and describe symptoms of major nutrient disorders in a number of *Anigozanthos* species and interspecific crosses, to monitor differences in plant response, and to determine the mineral content of affected plants.

Experimental Method

A sand culture system was constructed on benches in an environmentally controlled greenhouse, with a capacity of seven individual treatments – a control and six nutrient deficiencies. The nutrient solutions were stored in 200 litre plastic drums, and pumped along black plastic tubing by submersible pumps. Each pump irrigated 36 free draining pots (120 mm diameter) via low-pressure drippers.

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Duration and frequency of irrigation was electronically controlled, and manually adjusted to suit stage of plant growth and seasonal conditions. This system allowed potted plants to be added, removed or relocated at will. The pots were arranged in three rows of 12; the rows being randomly arranged on the benches. The nutrient solution was added in sufficient volume to each pot to induce leaching of about 10% of the solution. The excess solution was not recycled. The seven nutrient solutions [Control, minus nitrogen (N), minus potassium (K), minus phosphorus (P), minus calcium (Ca), minus magnesium (Mg), and minus iron (Fe)] were prepared from pre-mixed nutrient powders formulated by Duralite Pty Ltd, Melbourne. Tap water of low electrical conductance ($30 \mu\text{S cm}^{-1}$) was used throughout the study with satisfactory results.

All plants were initially grown in tissue culture. The rooted plantlets from culture were potted-up into a perlite vermiculite mix (1:1 by volume) in 58 mm square peat-walled pots, fed full nutrients and held under high humidity. Acclimatization to normal environmental conditions was over a 10-day period. When well established the plants were transferred undisturbed in the peat pots to 120 mm pots filled with washed coarse quartz sand of mixed particle size up to 4 mm. The pots were heavily leached with water to remove much of the residual salts before the respective nutrient treatment was applied. This method was adopted so that plants would gradually become deficient and have gradual development of symptoms. A number of seedling apple trees and the indoor plant *Peperomia caperata* were also grown in the system along with the Kangaroo Paws. The introduction of plants with different nutrient requirements and threshold provided a check on the various deficient solutions in case the Kangaroo Paws fail to develop symptoms.

Two plantings of Kangaroo Paws were made. The first, in mid December (early summer), consisted of *Anigozanthos pulcherrimus* and the interspecific cross *A. preissii* $\times$ *A. flavidus*. The second, in late April (mid autumn), consisted of *A. rufus* $\times$ *A. flavidus*, *A. manglesii* (2 plants only), *A. "Dwarf Delight"*, *A. "Regal Claw"*, and more *A. pulcherrimus* and *A. preissii* $\times$ *A. flavidus*. Plants used for chemical analysis came from the second planting. The entire top growth was removed on day 81, dried at 60°C in a forced draught oven and analysed by the State Chemistry Laboratory. Most plants recovered from the severe pruning and grew on.

Kangaroo Paws grow by means of branched rhizomes. Each rhizome produces a fan of leaves (i.e. termed leaf fan in this paper) and ultimately terminates in a flower.

Results and Discussion

1. Nitrogen Deficiency

All plants were equally affected by nitrogen deficiency. Once subjected to the treatment, the plants made little further growth and became highly stunted and a uniform pale green. Older leaves died from the tips downwards. There was no multiplication of leaf fans although some plants did eventually flower (*A. preissii* $\times$ *A. flavidus*) (Figure 1).

The nitrogen content (mg/g dry weight) in the plant tops with severe symptoms harvested on day 81 was as follows. *A. pulcherrimus* also displayed phosphorus toxicity symptoms.

Plant	Complete Nutrition	Minus Nitrogen
<i>A. preissii</i> × <i>A. flavidus</i>	35	18
<i>A. rufus</i> × <i>A. flavidus</i>	34	15
<i>A. pulcherrimus</i>	32	24
<i>A. "Dwarf Delight"</i>	34	18
<i>A. "Regal Claw"</i>	34	22

*To convert to % dry weight basis, divide by 10.

2. Phosphorus Deficiency

Symptoms of phosphorus deficiency developed slowly. The first signs were a slow down in plant growth and a failure to produce new leaf fans from basal nodes. The first foliar symptom was the appearance of an orangy-yellow chlorosis on the tips of the oldest leaves. This progressed basewards followed by a brownish tan necrosis until finally the entire leaf died (Figure 2).

Plants with advanced phosphorus deficiency were small with erect rigid growth and slow to flower. The oldest leaves were dead, and most other leaves except the youngest had chlorotic or necrotic tips. The root system was very well developed (Figure 2 and 5) which gave the plant its rigidity.

The phosphorus (mg/g dry weight) and manganese (μ g/g dry weight) content of plant tops harvested on day 81, just prior to onset of foliar symptoms, were as follows:

Plant	Complete Nutrition		Minus Phosphorus	
	P	Mn	P	Mn
<i>A. preissii</i> × <i>A. flavidus</i>	3.8	509	.6	186
<i>A. rufus</i> × <i>A. flavidus</i>	3.6	461	.7	363
<i>A. pulcherrimus</i>	15.1	437	.8	168
<i>A. "Dwarf Delight"</i>	3.9	356	.6	183
<i>A. "Regal Claw"</i>	4.0	541	.7	164

The phosphorus content of all deficient plants was similar and approximately one sixth that of the control plants with the exception of *A. pulcherrimus* where the fall was to about a twentieth. The deficient plants also had a 50-70% reduction in manganese content except for *A. rufus* × *A. flavidus* which had a fall of around 20%. This suggests the phosphorus has a positive effect on manganese uptake or translocation and is unexpected because most evidence is that an increase in phosphorus concentration in a soil reduces the uptake of zinc, copper, iron and manganese (Bingham and Garber 1960).

3. Phosphorus toxicity

A. pulcherrimus was the only Kangaroo Paw to develop symptoms of indicative phosphorus toxicity. The nutrient solutions used in the sand culture contained 32 mg/l (1 mmol l⁻¹) P, except for the minus P solution. Within 14 days of the treatments being imposed, *A. pulcherrimus* developed purple leaf tips in all treatments except minus phosphorus and the purplish necrosis rapidly progressed basewards. Affected leaves ultimately shrivelled up to a purplish-black colour. These symptoms were characteristic of a phosphorus toxicity (see Nichols, Jones and Beardsell, 1979) and were most severe in the minus magnesium and minus potassium plants (Figure 3). These plants failed to regenerate following removal of the top growth on day 81. At this stage in the study the best growth of *A. pulcherrimus* was in the minus phosphorus treatment, followed by the minus calcium in which only very mild phosphorus toxicity symptoms developed.

The phosphorus content in the tops of *A. pulcherrimus* harvested on day 81 growing in the six treatments was as follows:

	P mg/g dry weight	Phosphorus toxicity symptoms
Control	15.1	moderate
Minus nitrogen	25.1	moderate
Minus phosphorus	0.8	nil
Minus potassium	13.9	severe
Minus magnesium	17.8	severe
Minus calcium	15.9	mild

These concentrations show that *A. pulcherrimus* is an accumulator of phosphorus compared with the other species (see earlier), and may account for the development of toxicity symptoms. The phosphorus levels in the tissue of plants grown in the various deficient solutions do not relate to the severity of symptom expression. This implies that nutrient balance may have an effect on plant response to high phosphorus levels, e.g. a low potassium or magnesium tissue concentration may aggravate symptoms, and a low calcium alleviate them. Low calcium *A. pulcherrimus* plants had the highest potassium (64.7 mg/g) and magnesium (3.7 mg/g) contents because of the reduced competition with calcium at the root surface for uptake. This could be the reason why low calcium plants developed only mild symptoms.

4. Potassium deficiency

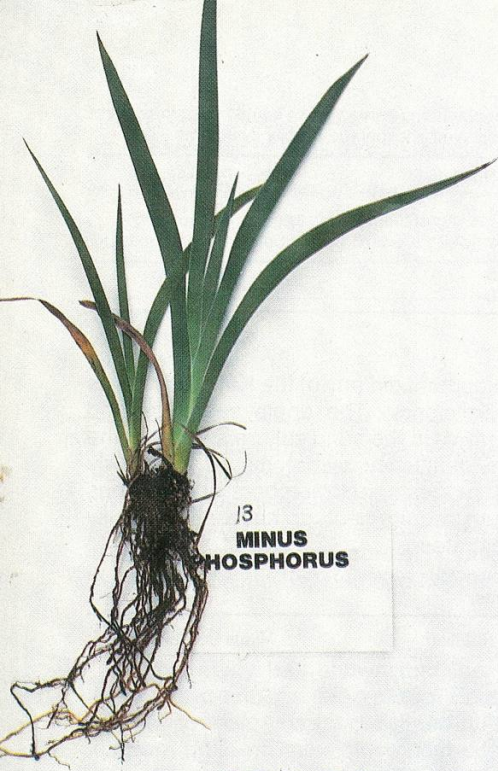
Symptoms were slow to develop. All plants made good vegetative growth and produced new leaf fans before symptoms appeared on the oldest leaves. The most common symptom was the necrotic collapse of the leaf tips which progressed basewards until the entire leaf died. In some leaves, collapse commenced as elliptical shaped necrotic lesions of various sizes with strongly defined margins. The necrotic areas rapidly expanded and coalesced and when these leaves finally died, the outline of the original elliptical lesions were still visible. On a number of occasions, necrotic collapse of the leaf commenced midway along the blade, which caused the unaffected distal half to hang downwards as illustrated by the arrows in Figure 4a. No chlorosis was associated with potassium deficiency. The necrotic tissue ranged from a very pale brown with a greyish tone, to tan in colour.

Potassium deficient plants were generally poorly anchored in the pots, and with the emergence of the flower, the leaf fan tended to topple over. Removal of the plants from the sand showed that very few primary roots had been initiated from the base of the leaf fan, and most of these would have been present at the commencement of the treatment. Compared with those of the control plants the roots were only lightly coloured (Figure 5).

Figure 1 – Nitrogen deficiency symptoms. (opposite, bottom left and right)

- A. preissii* × *A. flavidus* (1st planting) grown for 313 days. The nitrogen deficient plant (left) is stunted and very pale green compared with the plant supplied a complete nutrition.
- Identical nitrogen deficiency symptoms on four different Kangaroo Paws (2nd planting) after 210 days. Total death of oldest leaves and tip necrosis on other leaves except the youngest. From left to right: *A. preissii* × *A. flavidus*, *A. rufus* × *A. flavidus*, *A. "Dwarf Delight"* and *A. "Regal Ciaw"*.

Figure 2 – Phosphorus deficiency symptoms on *A. pulcherrimus*. Yellowing of tips of older leaves which progresses basewards (left). A brownish tan necrosis follows until the entire leaf is dead (right). Top Left: Plant (2nd planting) after 210 days; Top Right: Plant (1st planting) after 256 days.



13
**MINUS
PHOSPHORUS**

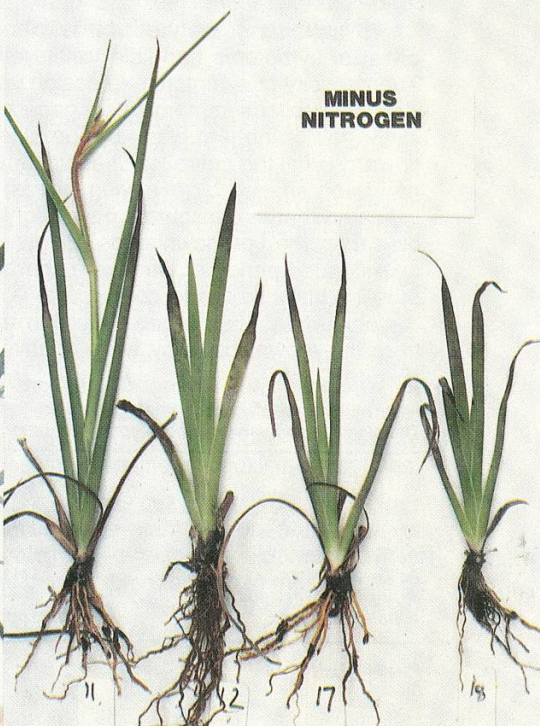


**MINUS
PHOSPHORUS**



**MINUS
NITROGEN**

**COMPLETE
NUTRITION**



**MINUS
NITROGEN**

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The potassium content (mg/g dry weight) in the plant tops harvested on day 81 prior to onset of foliar symptoms was as follows. *A. pulcherrimus* displayed phosphorus toxicity symptoms.

Plant	Complete Nutrition	Minus Potassium
<i>A. preissii</i> × <i>A. flavidus</i>	65.1	7.9
<i>A. rufus</i> × <i>A. flavidus</i>	62.2	5.1
<i>A. pulcherrimus</i>	55.5	9.2
<i>A. "Dwarf Delight"</i>	64.5	8.1
<i>A. "Regal Claw"</i>	69.6	10.1

5. Calcium deficiency

At no stage in their growth and development did any of the Kangaroo Paws develop visual symptoms of calcium deficiency. The apple seedlings and *Peperomia caperata* "Emerald Ripple" grown in the sand culture system at the same time produced classical calcium deficiency symptoms in the newly emerged leaves (Chapman 1966). This suggests that members of the genus *Anigozanthos* either have a low calcium requirement or have successfully adapted for survival on low calcium substrates.

The calcium content (mg/g dry weight) in the plant tops harvested on day 81 was as follows. *A. pulcherrimus* had mild phosphorus toxicity symptoms.

Plant	Complete Nutrition	Minus Calcium
<i>A. preissii</i> × <i>A. flavidus</i>	20.2	5.2
<i>A. rufus</i> × <i>A. flavidus</i>	18.5	5.0
<i>A. pulcherrimus</i>	14.0	3.5
<i>A. "Dwarf Delight"</i>	14.5	5.1
<i>A. "Regal Claw"</i>	17.6	4.4

6. Magnesium deficiency

Symptoms of magnesium deficiency occurred within five weeks, but the onset of symptoms had little visible effect on plant vigour and development. The intensity of symptom expression varied between the species and crosses. The initial foliar symptom was a general purple to blue-black colouration of the lower half of the leaf blade on the oldest leaves. The colouration progressed tipwards until the entire leaf was uniformly affected. Where the base of the leaf had been shaded by overlying leaves, the tissue had remained green which indicated that leaf colouration was light dependent (Figure 6). Affected leaves died from the tips downwards. Plants subjected to magnesium deficiency for an extended period of time were characterized by a mass of dead old leaves, purplish black to tan in colour, with younger leaves in progressive stages of discolouration. Magnesium deficient plants had an abundance of primary roots from the crown, but they were relatively short compared with control plants. (Figure 5).

The magnesium content (mg/g dry weight) in the plant tops harvested on day 81 was as follows. The plants have been grouped according to severity of foliar symptoms.

Plant	Symptoms	Complete nutrition	Minus magnesium
<i>A. rufus</i> × <i>A. flavidus</i>	nil to very mild	2.3	0.9
<i>A. "Regal Claw"</i>	nil to very mild	1.7	1.0
<i>A. "Dwarf Delight"</i>	moderate	1.9	0.8
<i>A. preissii</i> × <i>A. flavidus</i>	severe	1.9	0.8
<i>A. pulcherrimus</i>	phosphorus toxicity	1.8	1.4

This analysis showed that magnesium content of the plants was unrelated to the severity of symptom expression.

7. Minor nutrient content in control plants

The iron, copper and zinc content (mg/g dry weight) in the tops of plants grown on the complete nutrition and harvested on day 81 were as follows:

Plant	Iron	Copper	Zinc
<i>A. preissii</i> × <i>A. flavidus</i>	78	3	33
<i>A. rufus</i> × <i>A. flavidus</i>	75	6	36
<i>A. pulcherrimus</i>	87	12	142
<i>A. "Dwarf Delight"</i>	81	7	41
<i>A. "Regal Claw"</i>	65	5	44

The concentrations of micronutrients were similar in all species except for *A. pulcherrimus* which had triple the zinc and double the copper content. These two nutrients were also high in phosphorus deficient *A. pulcherrimus* (11 ug/g Cu, 100 ug/g Zn) and therefore not an artifact induced by phosphorus toxicity. This suggests that the roots of *A. pulcherrimus* have an increased capacity to remove phosphorus, zinc and copper from the external root environment.

Discussion

This study has shown that the nutrition of Kangaroo Paws for certain elements cannot be generalized. Each species and interspecific cross studied appear to have precisely defined nutrient requirements. All can survive on a calcium deficient solution without development of deficiency symptoms. The traces of calcium arising from natural contamination through the water or sand was sufficient for growth. The intensity of symptom expression of magnesium deficiency varied between the species and crosses, and appeared to be unrelated to the magnesium content of the tissue which suggests that the plants had different sensitivities to magnesium.

The phosphorus concentration in the nutrient solution proved toxic to *A. pulcherrimus* and the intensity of the phosphorus toxicity symptoms was affected by the deficiency treatment to which the plant was subjected. Greatest severity occurred in the minus-potassium and minus-magnesium plants. In an earlier study with *Grevillea shiressii*, the most severe phosphorus toxicity on the rooted cuttings also occurred in the minus-potassium treatment, and these plants died within five weeks of being introduced to this treatment. Other workers (Specht 1963, Grundon 1970, Groves and Keraitis 1976, and Nichols and Beardsell 1981) have reported that symptom expression of phosphorus toxicity in sensitive plant species could change with increase in concentration of other nutrients (e.g. nitrogen, potassium, calcium). Grundon 1970, working with four species of *Proteaceae*, and Nichols and Beardsell 1981 with *Grevillea* cv. "Poorinda Firebird", both found that the application of potassium alleviated symptoms of phosphorus toxicity. This study supports this phosphorus toxicity-potassium relationship, removal of potassium intensifies the toxicity symptoms.

The nutrient content of plants grown in soilless culture may differ considerably from those grown in soil. However because plant response to a nutrient shortage is expressed by changes in growth rate and the development of foliar symptoms, the tissue content of the deficient nutrient should in most cases be totally independent of how the plant was grown. These values can therefore be used as reference levels for diagnostic purposes.

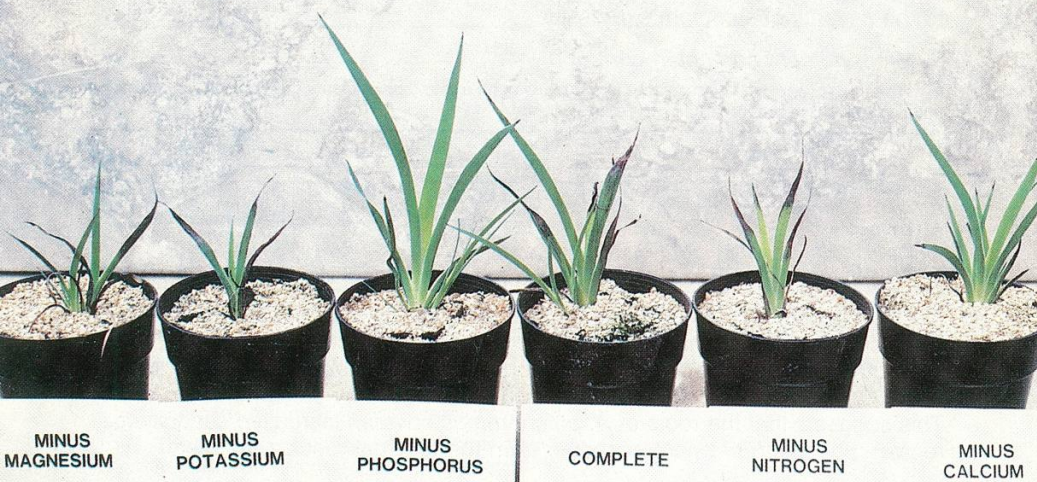


Figure 3 – Phosphorus toxicity symptoms on *A. pulcherrimus* 77 days from commencement of treatment. Phosphorus toxicity occurred in all *A. pulcherrimus* plants except those on the minus phosphorus treatment. Most severe symptoms occurred on plants growing in the minus potassium and minus magnesium treatments.

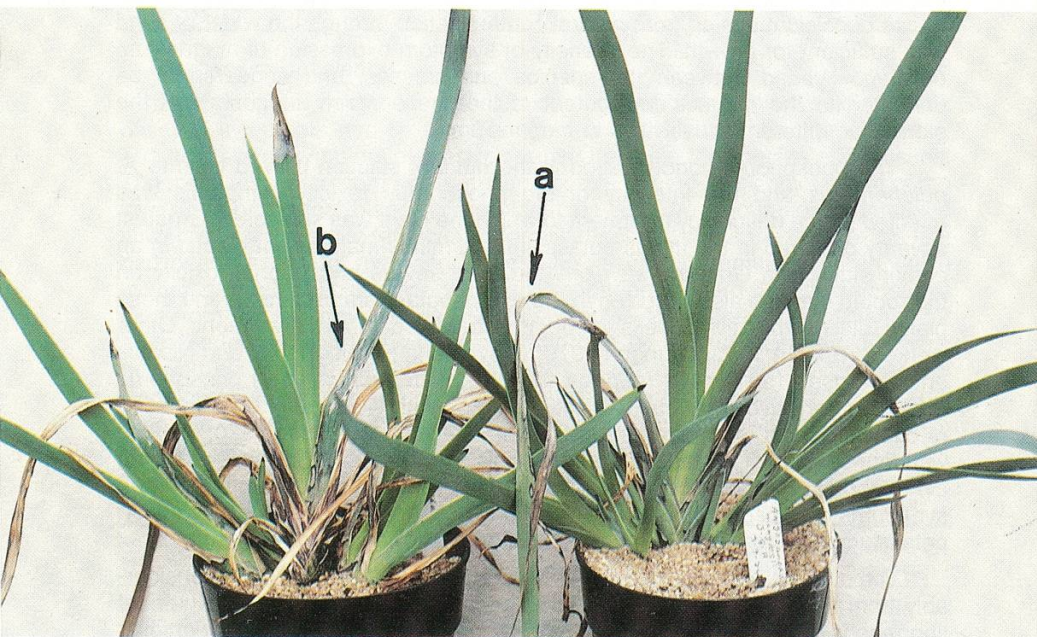


Figure 4 – Potassium deficiency symptoms in *A. manglesii* (a) after 182 days, and *A. rufus* x *A. flavidus* (b) after 125 days. Note mid leaf collapse shown by the arrows (a), and the outline of the original elliptical lesions on dead leaves shown by the arrow (b).

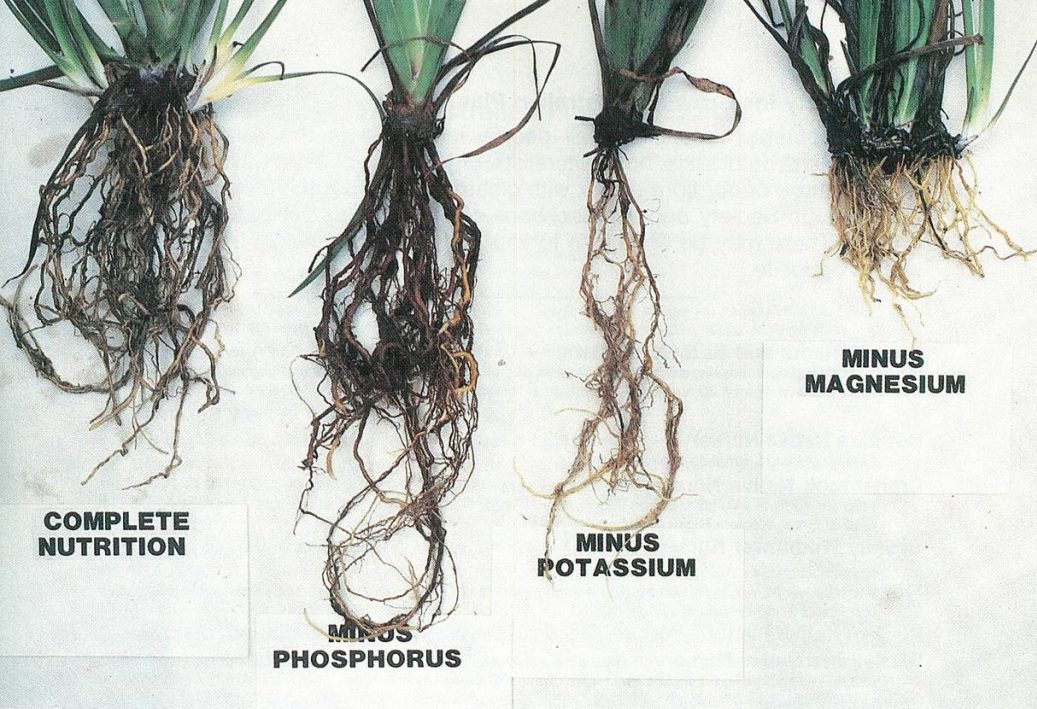


Figure 5 (above) – Representative root systems of Kangaroo Paws grown on various nutrient treatments.



Figure 6 (left) – Severe expression of magnesium deficiency on *A. preissii* × *A. rufus* after 256 days.

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Photography by R. J. Turner

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