Systematic Studies in *Gastrolobium* (Fabaceae: Mirbelieae)

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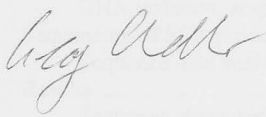
I, Gregory Thomas Chandler, certify that the following thesis, except for the acknowledged sections below, is my own work, and has not been submitted in a previous application for a higher degree.

Chapters 1, 2 and 4 are entirely my own work. In Chapter 3, Dr Michael Crisp, Australian National University, provided raw ITS and trnL-trnF sequences, though the alignment and subsequent analysis was my own work. In Chapter 5, Dr Lindy Cayzer, The Australian National University, provided much of the data used to describe the species that were formerly in the genus *Nemcia* (40 species), to which I then added significant information, and Dr Michael Crisp provided detailed notes on many species, including typification of many taxa, which I consulted, and all other work in this chapter is entirely my own.



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Abstract.

Gastrolobium (Fabaceae: Mirbelieae) is an endemic Australian genus that produces toxic sodium monofluoroacetate. A phylogenetic reconstruction of *Gastrolobium* and the related genera *Brachysema*, *Callistachys*, *Jansonia*, *Nemcia*, *Oxylobium* and *Podolobium* is presented, using two molecular data sets. The first data set uses sequence data from 94 taxa and three regions – the *psb*A-*trn*H intergenic spacer and the *trn*K 5' intron from cpDNA, and the 3' end of the external transcribed spacer (ETS) from nrDNA. The second data set uses sequence data from 48 taxa and five regions, the three previously mentioned plus the *trn*L/*trn*F intergenic spacer from cpDNA and the internal transcribed spacer (ITS) from nrDNA. In both cases, *Gastrolobium* is shown to be paraphyletic, with *Brachysema*, *Jansonia*, *Nemcia* and *Oxylobium lineare* nesting within it, and *Nemcia* is shown to be polyphyletic within *Gastrolobium*. Past key morphological characters, such as fluoroacetate content, ovule number, subtending floral bract type and characters associated with pollination syndrome, are shown to be homoplastic, with fluoroacetate possibly a plesiomorphic condition lost in more derived species. *Podolobium* is also shown to be polyphyletic, with the *P. ilicifolium* group putatively sister to *Gastrolobium*, and the *P. alpestre* group sister to *Callistachys*, a member of the *Oxylobium* group. A monograph is presented in which *Gastrolobium* is expanded to include *Brachysema*, *Jansonia*, *Nemcia* and *Oxylobium lineare*. In total, 109 species are presented, of which 29 are described as new.

Chapter 1 – Introduction

Gastrolobium

The tribe Mirbelieae (Fabaceae) is endemic to Australia, and comprises a major component of the flora in many temperate ecosystems. The c. 60 species of *Gastrolobium* R.Br. belong to this tribe, and most of the c. 60 species currently assigned to this genus are endemic to the south-west of Western Australia, except for two species that occur in northern Australia, *G. brevipes* and *G. grandiflorum* (Figure 1.1). Furthermore, it is one of the largest legume genera in the south west of Western Australia, where it forms a major component of the understorey in many areas, such as sandplains with their accompanying vegetation, which is usually heath (kwongan) or mallee (shrubby eucalypt woodland).

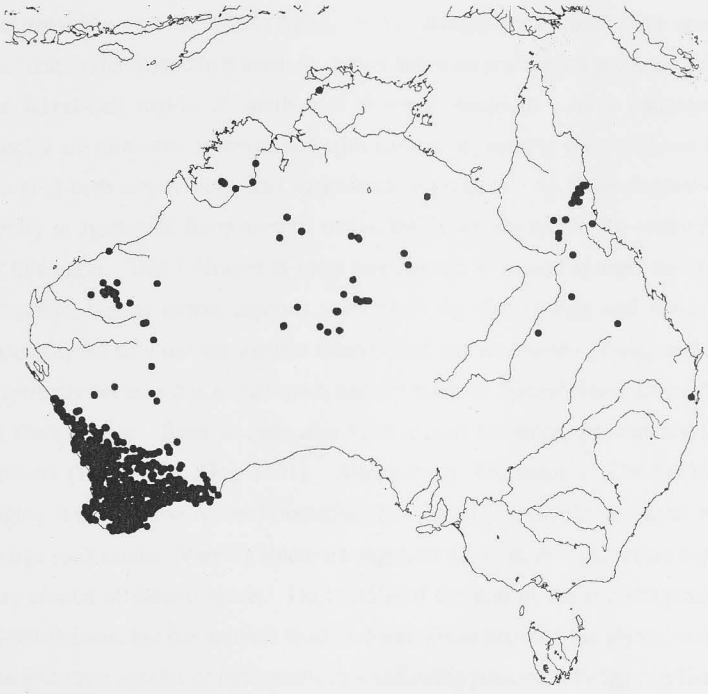

Fig. 1.1. Distribution of *Gastrolobium*.

Gastrolobium, as currently circumscribed, comprises simple-leaved shrubs that have terminal, racemose inflorescences with yellow, orange and red petalled flowers. The coloration of the flower is typical of the tribe Mirbelieae, with the standard petal

generally orange or yellow, and a central red ring surrounding the yellow centre. These orange and yellow standard petals are assumed to indicate insect pollination, whilst a red standard (present in only one species, *G. grandiflorum*) is considered indicative of bird pollination (see review in Crisp, 1994).

Gastrolobium accumulates sodium monofluoroacetate (Compound 1080™), making it highly toxic. Plants in the genus were first discovered to be poisonous by trials carried out in what was then the Swan River Colony (now Western Australia) by Preiss and Drummond in the late 1830's and early 1840's, at the request of colonists suffering disastrous stock losses, and several species were identified as toxic, notably *G. calycinum* and *G. oxylobioides* (Erickson, 1969). Gardner and Bennetts (1956) provided a review of the toxic plants of Western Australia, though they were unable to isolate the toxic compound. It was not until the 1960's that the toxin present in *Gastrolobium* was identified (Aplin, 1971). Severe stock losses have occurred in the past due to fluoroacetate poisoning, which led to an eradication program, particularly in the wheat-belt region of south-west Western Australia. As a consequence, many species are now rare or threatened with extinction, making *Gastrolobium* important in terms of both conservation and agricultural ecomonics. As *Gastrolobium* evolved this ability to synthesise fluoroacetate, native herbivores apparently co-evolved a tolerance to this toxin. This tolerance is most pronounced in animal species native to Western Australia, but its extent depends very much on diet (Twigg and King 1991). For example, the emu has the highest tolerance of any bird tested (Twigg and King 1991), apparently because it is a seed eater, and the seeds of *Gastrolobium* are particularly high in fluoroacetate. Seed weevils also have a high tolerance, presumably for the same reasons (Twigg and King 1991). Alternatively, the seeds of Gastrolobium may be highly toxic because of seed predation, leading to an evolutionary arms race with the native seed eaters. Varying tolerance regulates how much a particular organism's diet can consist of *Gastrolobium*. Up to 25% of the diet of the red kangaroo consists of *Gastrolobium*, but the animals tend to discriminate between the plants, and eat more of the less toxic species or individuals to avoid being poisoned (Twigg and King 1991).

Modern agricultural approaches, such as pest control and fertilizers, have added to the problems of *Gastrolobium*. In particular, fertilizers are toxic to these plants, which are adapted to low-nutrient soils. Also, herbicides such as pre-emergents, which stop the germination of weeds, also prevent the germination of seeds of native plants. A possible example of this, *G. tenue*, occurs along a narrow roadside strip surrounded by

wheat fields. Personal observations by myself showed no recruitment for this species over several years of monitoring the same population, and the adult plants appeared to be in severe decline.

Despite these problems, *Gastrolobium* still flourishes in some areas that are currently free from the land degradation seen in many other areas of Western Australia, particularly in National Parks (for example, the Stirling Range, Fitzgerald River Biosphere Reserve, Cape Arid, and the Ravensthorpe Ranges).

Fluoroacetate (Compound 1080) toxicity

Sodium monofluoroacetate is one of the most toxic substances known. It acts on the tricarboxylic acid (TCA) cycle (Liebecq and Peters 1949; Morrison and Peters 1954; Hall 1972; Twigg and King 1991), through its conversion to fluorocitrate, where it actively competes with aconitate hydratase, blocking the TCA cycle at the citrate stage.

It is widely used as a vertebrate pest control, it was introduced to Australia in the early 1950's to control rabbits, but poses problems for the management of native wildlife (for example, Twigg, 1990). Most unadapted animals are fatally poisoned by doses of less than 2 $\mu g.g^{-1}$ (Atzert 1971), with birds generally being the least sensitive of endothermic vertebrates, and ectothermes are also moderately insensitive to this toxin (Chenoweth 1949; Atzert 1971; McIlroy *et al.* 1985)

Sodium fluoroacetate is readily absorbable across the gut wall, but only to a limited extent across the skin (Morgan 1989). It does appear to have an effect, however, through extended skin contact. I spoke with a local farmer in the Cunderdin, Western Australia, area found that when they were pulling out Box Poison (*G. parviflorum*) when he was young, after a few hours vision started faltering, and they had to cease contact with the plants.

Known levels of of fluoroacetate in *Gastrolobium* are given in Table 1. These levels vary from 73 µg/g to 3875 $\mu g.g^{-1}$ for ephemeral tissue (eg. flowers, seeds, young leaves) and 0-175 $\mu g.g^{-1}$ for older plant tissues (Twigg *et al.* 1996b).

Research problems within Gastrolobium

Gastrolobium needs revision at the species level, something that has not been accomplished for nearly 150 years (Bentham, 1864). To date, alpha taxonomy alone has been used in major revisions of *Gastrolobium*, which often only repeated previous

Table 1.1: The range of fluoroacetate concentration previously tested for various species of *Gastrolobium*, and *Nemcia*. All measurements in $\mu g.g^{-1}$ (which is the same as parts per million). Data are adapted from McEwan (1964), Aplin (1971), Twigg and King (1991), Twigg *et al.* (1996a), Twigg *et al.* (1996b), and Twigg *et al.* (1999), plus miscellaneous information supplied on herbarium specimens, coming originally from the Western Australian Department of Agriculture.

Taxon	Fluoroacetate concentration ($\mu g.g^{-1}$)
Gastrolobium bennettsianum	1300
G. bilobum	730-2650 (seeds up to 6200)
G. brevipes	56-301
G. brownii	80-260
G. callistachys	100-1000
G. calycinum	400-1400
G. crassifolium	150
G. crispatum ms.	< 20
G. cuneatum	1200
G. densifolium	not detected
G. floribundum	1350
G. glaucum	200
G. grandiflorum	to 185
G. graniticum	1240
G. hamulosum	100
G. laytonii	500
G. microcarpum	0-600
G. oxylobioides	0-1050
G. parviflorum	150-2500
G. parvifolium	300
G. polystachyum	0-10
G. pycnostachyum	175
G. racemosum	1500
G. rigidum	10
G. rotundifolium	150
G. spectabile	400
G. spinosum	0-400
G. stenophyllum	90
G. tetragonophyllum	750
G. trilobum	not detected
G. velutinum	300
G. villosum	10-50
Nemcia spathulata	40-80

works. The only review to include this group in any form of experimental systematic studies is Sands (1975), who carried out a thorough cytological study and suggested informal groups within the tribe Mirbelieae, but did nothing to actually revise any of the

genera within this tribe. Crisp and Weston (1987, 1995), undertook a cladistic analysis of the tribes Mirbelieae, Bossiaeeae, and Brongniartieae, using exemplars from many genera, but again, no actual revision of the genera in these tribes was undertaken. We have no convincing idea of the generic affinities of *Gastrolobium*, or even if it is a monophyletic group, which preliminary data show that it may not be as currently circumscribed. In a group which is so important, both ecologically and economically, it is important to get a clear idea of the relationships within the genus itself and between more closely related genera, in order to understand the full impact that the group has on its environment. Added to this, a number of new species have been found in Western Australia, particularly in the more remote areas in the eastern portion of the south-west region, which need study and formal description.

A well-supported phylogeny is required, to (i) resolve the generic limits of the genus, particularly in relation to the genera *Brachysema*, *Jansonia* and *Nemcia*; (ii) elucidate the internal relationships within *Gastrolobium*, which are currently unclear; and (iii) examine the evolutionary history of biologically interesting traits, such as fluoroacetate content and pollination syndromes, to better understand the evolution of natural systems and plant responses to predation.

Outline of the present study

This thesis sets out to resolve long standing phylogenetic problems in *Gastrolobium* and related genera. The major approach will be a molecular one, using DNA sequencing to reconstruct the phylogeny of *Gastrolobium* and related genera. Following this, morphology will be used to produce a traditional monographic treatment of the genus.

The thesis is divided into three major sections. Chapter 2 presents a 94-taxon phylogeny of *Gastrolobium* and related genera using three DNA sequences – two from the chloroplast, and one nuclear region. Chapter 3 presents another phylogeny of *Gastrolobium* and related genera, using a 48-taxon subset of the 94-taxon analysis, but using five DNA sequences – the three presented in Chapter 2, and adding another cpDNA and nrDNA region. Following this, in Chapter 4, is a general discussion of the results of the two phylogenies, and options for the future circumscription of *Gastrolobium*. The monograph of *Gastrolobium* is presented in Chapter 5, and a full reference list follows this. The monograph describes all new taxa, and gives any new combinations or names required for all taxonomic rearrangements or novelties that were proposed. As well, lectotypification of a number of species of unlectotypified taxa was accomplished.

Chapter 2 – A molecular phylogeny of the genus Gastrolobium and allied genera using chloroplast and nuclear markers

The results of this chapter have been accepted for publication in the American Journal of Botany.

Introduction

As morphological data alone have been insufficient in resolving the relationships of the *Gastrolobium* group, molecular data was the obvious choice for attempting to find a robust phylogeny on which to base future taxonomic classifications. This study has utilised the *psbA/trnH* intergenic spacer, the *trn*K 5' intron (both from chloroplast DNA), and the 3' end of the external transcribed spacer (ETS, from nuclear ribosomal DNA).

Molecular versus morphological methods in phylogenetics

There has been controversy in the past (which still exists) whether molecular or morphological data are better sources of phylogenetic information (Patterson *et al.* 1993). For species sharing a common evolutionary history, congruence between the data sets will probably be high. However, congruence between molecular data sets can be quite low, as can the congruence between molecular and morphological data (Patterson *et al.* 1993). Also, it is easy to mistake a gene phylogeny for a species phylogeny, even though the two may be quite different (Patterson 1987; Patterson *et al.* 1993).

Reasons for incongruence are many and varied. Sytsma (1990) identified two types of problems: procedural problems and biological problems. Procedural problems concern data analysis, where the data may provide an accurate measure of the phylogeny if correctly analysed. The second group concerns inherent biological or evolutionary features, where the discrepancies in the data (from DNA or morphological evidence), for example, incorrect homology assessments, are such that an accurate phylogeny is not possible without the collection of more independent data. Of course, many phylogenetic problems are a combination of both these types of problems (Sytsma 1990).

Results vary through the literature as to the congruence of morphological and molecular data. Some studies (e.g. Bremer and Struwe 1992; Bayer *et al.* 1996; Soltis *et al.* 1996b) find congruence between the morphological and molecular data, though they also found some incongruencies. Compiling both types of data would be useful where there are a limited number of characters in any one data set. For example, there are too few reliable morphological characters to give a well supported phylogeny of *Gastrolobium* and related genera, so molecular characters could become invaluable in this group. Morphological characters are by no means useless in resolving this group; however, they are few relative to the large number of taxa in the genus, and that many of the characters are continuous rather than discreet.

Molecular phylogenetics

Molecular phylogenetics is a field that has rapidly expanded over the last decade or so. There are a number of tools available for systematics from the field of molecular biology. These include DNA fingerprinting (e.g. microsatellites), randomly amplified polymorphic DNAs (RAPD) analysis, restriction fragment length polymorphism (RFLP) analysis and nucleotide sequencing. Nucleotide sequencing is currently being used widely for phylogenetic reconstruction, using mainly chloroplast DNA (cpDNA) and nuclear DNA (nDNA) regions.

The polymerase chain reaction (PCR) is a major advance in molecular technology, which has allowed closer examination of molecular evolution, and has been adopted by many evolutionary biologists to assist in phylogenetic reconstruction. Major advantages of using PCR for the examination of sequence variation is the ability to select specific areas of the genome for analysis (Jordan *et al.* 1996), and also allows the production of large amounts of template DNA, negating the need, in most cases, for cloning. For example, in the chloroplast genome, where different regions are evolving at different rates (Wolfe *et al.* 1987; Shimada and Sugiura 1991; Morton and Clegg 1993), a particular region(s) can be selected for the taxonomic level being studied. Regions with relatively low variation (e.g. *rbc*L) are more useful at a higher taxonomic level (e.g. family, order) than would a more rapidly evolving regions (e.g. the *trn*L-*trn*F spacer), which are more applicable to the generic level.

The chloroplast genome

The chloroplast has a central role in energy metabolism within the plant cell, containing within it all the machinery for photosynthesis, and also participates in the

synthesis of amino acids, nucleotides, lipids and starch. The molecular biology of this organelle has had intensive research over the past three decades or so (Clegg *et al.* 1991), resulting in a new field, 'chloroplast molecular biology'.

The chloroplast genome is a circular molecule ranging from c. 71 kb (kilo-bases) to c. 220 kb in size in higher plants (Palmer 1987), and there are a number of different regions within it, including a large region that is duplicated and inverted, thus dividing the genome into a large single copy (LSC) region, a small single copy (SSC) region, and the inverted repeat region (IR) (See Fig. 1 in both Clegg *et al.* 1991 and Sugiura 1992).

The smallest known chloroplast genome is 71 kb in size, and belongs to the non-photosynthetic root parasite *Epifagus virginiana* Barl (Orobanchaceae) (dePamphilis and Palmer 1990). The smallest photosynthetic chloroplast genome is 85 kb in size, and belongs to the siphonous green alga *Codium fragile* (Suringar) Hariot, whilst the largest is 292 kb, belonging to the green alga *Chlamydomonas moewusii* Gerloff (Sugiura 1992). Much of this size variation is the result of variation in the length of the IR region (Clegg *et al.* 1991; Sugiura 1992). This region is typically 20-25 kb long, but is absent in some conifers (Strauss *et al.* 1988) and some legumes (Palmer 1987), and has expanded to 78 kb in *Pelargonium* L'Herit. (Geraniaceae), incorporating a number of genes otherwise found in the LSC region of most plant species (Palmer 1987).

Papers have been published with complete chloroplast genomes from a number of plants, including tobacco (*Nicotiana tabacum* L.; Sugiura 1992; Shinozaki *et al.* 1986), rice (*Oryza sativa* L.; Hiratsuka *et al.* 1989), *Epifagus virginiana* (dePamphilis and Palmer 1990), *Pinus thunbergii* Franco (Wakasugi *et al.* 1994), *Zea mays* L. (Maier *et al.* 1995) and a liverwort (*Marchantia polymorpha* L.; Ohyama *et al.* 1986). The availability of these has made it easier to design primers to target specific regions of the chloroplast genome, with a number of published cpDNA sequences now found in the literature, including *atp*B (e.g. Hoot 1995; Hoot and Douglas 1998), *mat*K (e.g. Hilu and Alice 1999; Hilu and Liang 1997; Johnson and Soltis 1994a & b; Johnson, *et al.* 1996; Les *et al.* 1999; Liang and Hilu 1996; Plunkett et al. 1996, 1997; Soltis *et al.* 1996a & b; Kajita *et al.* 1998; Wang *et al.* 1999), *rbc*L (e.g. Chase *et al.* 1993; Doyle *et al.* 1997; Käss and Wink, 1995 and 1997; Soltis *et al.* 1996b), *rpl*16 (e.g. Kelchner and Clark 1997), *rpo*C1and *rpo*C2 introns (e.g. Asmussen and Liston 1998; Liston and Wheeler 1994; Downie *et al.* 1996; Downie *et al.* 1998 a & b), *ndh*F (e.g. Neyland and Urbatsch 1996; Bohs and Olmstead 1997; Smith *et al.* 1998), the *trn*L intron (e.g. Bayer and Starr 1998; Bayer *et al.* 2000; Kajita *et al.* 1998), and the *trn*L-*trn*F (e.g. Bayer and

Starr 1998; Bayer *et al.* 2000; Cros *et al.* 1998; Kajita *et al.* 1998; Taberlet *et al.* 1991; Sang *et al.* 1997) and *psb*A-*trn*H (e.g. Aldrich *et al.* 1988; Asmussen and Liston 1998; Kim *et al.* 1999; Sang *et al.* 1997) intergenic spacers.

Chloroplast DNA has been reported to be more conservative than nuclear DNA (Wolfe *et al.* 1987; Wolfe *et al.* 1989; Small *et al.* 1998; Kim *et al.* 1999), though the evolutionary rates within the chloroplast genome itself differ. For example, Gielly *et al.* (1996) found that the *trn*L intron in cpDNA evolves 2-3 times slower than ITS region of nuclear ribosomal DNA in *Gentiana* Tourn. ex Linn. (Gentianaceae), and Kim *et al.* (1999) found that the *psb*A-*trn*H intergenic spacer in cpDNA evolves about 4 times slower than the ITS region in the subtribe Sonchinae (Asteraceae), while Wolfe *et al.* (1987) reported that on average, cpDNA evolves at half the rate of nDNA. Within the chloroplast genome, the more conservative regions are genes associated with photosynthesis, e.g. *rbc*L, *psb*A, *psb*F and *psb*D (Wolfe *et al.* 1989). This indicates that cpDNA, being on average more conservative than nDNA, should be more suited to higher level (e.g. intergeneric) studies, though Kim *et al.* (1999) did find it partly useful (using the *psb*A-*trn*H intergenic spacer) at the infrageneric level. This would obviously depend on the study group in question, and the divergence of cpDNA in that group. See also Small *et al.* (1998), where a comparison is presented between selected nDNA and cpDNA regions for one set of taxa. This study found that non-coding cpDNA regions do not have a particularly high number of characters for studying closely related taxa (in fact, some regions showed no variation at all).

A prime example of a cpDNA nucleotide sequence data set is that for angiosperms (Chase *et al.* 1993), using the *rbc*L gene, which is crucial to the transcription of the large subunit of RUBISCO. This is a particularly conserved region, and therefore should be useful at a higher level (for example, orders) for phylogenetics. However, according to Doyle *et al.* (1998, submitted), a cpDNA phylogeny may not be congruent with taxic relationships, as it appears that chloroplast haplotypes are younger than are nDNA haplotypes (e.g. Histone alleles), implicating hybridisation rather than lineage sorting, as the source of incongruence. This does, however, contrast with views of other authors (for example, Sang *et al.* 1997). It must be remembered, though, that cpDNA is usually inherited from the maternal parent, and as such, perhaps should be treated as just a chloroplast phylogeny, as opposed to a complete species phylogeny.

Nuclear DNA

There are relatively few nDNA regions currently available for DNA sequencing and subsequent phylogenetic analysis. Multiple copy regions such as ITS and ETS are currently favoured for phylogenetic studies of plants, as the original template is available in multiple copies. Examples of regions used are the internal transcribed spacers of ribosomal DNA, or ITS (e.g. Ainouche and Bayer, 1999; Molvray *et al.*, 1999; Baldwin, 1992; Bena *et al.*, 1998; Käss and Wink, 1997), the external transcribed spacer of ribosomal DNA, or ETS (e.g. Bena *et al.*, 1998; Baldwin and Markos, 1998, Linder *et al.*, 2000), an alcohol-dehydrogenase gene, *Adh*C (e.g. Denda *et al.*, 1995; Small *et al.*, 1998), the Histone H3-D introns (Doyle *et al.*, 1996), and G3*pdh* (Olsen and Schaal, 1999).

The ITS region of nuclear ribosomal DNA has been commonly used for phylogenetic analysis to date. This region has been useful in elucidating relationships in a number of plant lineages, but has not been shown to be particularly useful at lower levels in legumes (e.g. Nickrent and Doyle, 1995; Kollipara *et al.*, 1997; Ainouche and Bayer, 1999; M.D. Crisp, unpublished data), though it does appear to be highly informative at the intertribal level (see Kass and Wink 1997). The external transcribed spacer (ETS) has recently been shown to be more informative than the ITS region, and much larger, providing a large number of characters for use in phylogenetic analyses (Baldwin and Markos, 1998; Bena *et al.*, 1998; Clevinger and Panero, 2000; Linder *et al.*, 2000, in press, Volkov *et al.*, 1996). This region could be particularly useful for phylogenetic reconstruction in the Mirbelieae, given that ITS data to date has failed to achieve low-level phylogenetic resolution in some groups, such as the *Callistachys* group.

Chloroplast versus nuclear DNA for phylogenetic reconstruction

Non-coding chloroplast DNA is popular for phylogenetic reconstruction for a variety of reasons, which include the fact that it is a relatively small genome, it is abundant within plants, and much of it evolves conservatively (see review in Riesburg and Soltis 1991). This enables the same primers to be used in taxa that are not closely related, because the primers can be anchored in the conserved region of neighbouring genes. Nuclear DNA, on the other hand, is a large genome, is not as abundant, and there are far fewer genes currently available for analysis, making it harder to use for phylogenetic reconstruction than its cpDNA counterpart. To illustrate the difference in

gene conservatism, the different DNA types are often used at different levels, depending on how variable a particular region is. For example, *rbc*L is used at the family level or higher, whereas ITS tends to be used at the tribal level in legumes, though at species or genus level in other groups.

There are a number of chloroplast regions available, but chloroplast DNA appears to be effectively non-recombining in flowering plants, so all of its genes and numerous spacer regions may represent a singe 'gene' for the purposes of phylogenetic analysis (Doyle *et al.* 1996). Hence, the majority of sequences for phylogenetic reconstruction should come from the nuclear genome which does recombine (Doyle *et al.* 1996).

Chloroplast and nuclear regions evolve separately from each other, so any phylogenetic information obtained from each of these regions is independent of the other. Therefore, if the two regions show congruence, this can increase the confidence in the results obtained. Alternatively, if they do not show congruence, it requires that more work be done to increase confidence in a particular phylogeny.

Another potentially major problem is that of hybridization or introgression in cpDNA. Chloroplast DNA is prone to reticulation, and this can include such factors as chloroplast 'capture', or introgression (Riesburg and Soltis 1991). This refers to a species or population that has a cpDNA haplotype that is different from its closest relatives. The most common explanation for this pattern is that after a past hybridization event, there was introgression of the hybrids back to one parental species, so that the cpDNA of one parent is combined with the nuclear genome of the other. This implies that crossing is asymmetric, such that only one of two species has been the maternal parent in a cross. This is also highly speculative, as rare past events are being reconstructed.

Chloroplast gene flow can occur at various levels, including among closely related species (e.g. *Zea* [Doebley 1989] and *Helianthus* [Riesburg et al. 1991]), among more distantly related species, for example at the intersectional level in *Gossypium* (Wendel and Albert 1991), and at the intergeneric level, for example, in *Heuchera* (Soltis et al. 1991). It was suggested by Riesburg and Soltis (1991) that one way of detecting phylogenetic problems using cpDNA was to compare it with nDNA, and they advocate using both types of data where possible.

In order to get the best phylogenetic estimate, it is wise to pursue a number of regions, utilizing both cpDNA and nDNA. So it is not really a matter of choosing

between cpDNA and nDNA, it is combing cpDNA and nDNA data sets, so that the conclusions drawn from the analyses are as robust as possible.

Intergenic spacers

Intergenic spacers are non-coding regions of DNA that are situated between two genes. They are more variable than their protein-encoding counterparts, because protein structure is generally unaffected by random mutations to the spacer, so these mutations tend to occur more frequently. This makes them particularly useful for phylogenetic analyses at lower taxonomic levels (for example, the genus, species or subspecies level). Although they are non-coding regions, they may still have a role in gene transcription. Monde *et al.* (2000) found that adding a piece of DNA into the *pet*B/*pet*D spacer affected the production of *pet*D mRNAs. So, while these regions are non-coding, there may be a selection pressure on the structure of the spacer.

Introns

Introns are non-coding pieces of DNA that occur within a gene, splitting it into different regions. Some introns can be divided into different types: group I and group II introns (Michel *et al.*, 1982), and group III introns (Sugita *et al.*, 1985), though not all authors agree on the inclusion of the third group (e.g. Michel *et al.*, 1989). This discussion will focus on group I and group II introns only, this seeming to be the consensus classification among many workers (e.g. Michel *et al.*, 1989; Saldanha *et al.*, 1993; Michel and Ferat, 1995).

Group I and group II introns are types of RNA enzymes (ribozymes), catalyzing their own splicing by different mechanisms, and are also mobile genetic elements (Jurica and Stoddard 1999; Lambowitz and Belfort 1993; Michel *et al.* 1982; Saldanha *et al.* 1993). The two intron groups differ in their splicing mechanisms, and have different mobility mechanisms. These are briefly discussed below.

Group I introns. These introns are present in rRNA, tRNA and protein-coding genes (Saldanha *et al.*, 1993). Group I introns have highly conserved secondary and tertiary structures, which enable them to catalyze their own splicing through two Guanosine-initiated transesterification reactions (Cech, 1990; reviewed in Lambowitz and Belfort, 1993; Saldanha *et al.*, 1993). The folding of the intron creates an active site, bringing together segments of sequence that are otherwise widely separated (Saldanha *et al.*, 1993). Group I introns also catalyze other reactions, including endonucleolytic cleavage of RNA and DNA, RNA polymerization, nucleotide transfer,

RNA ligation, and aminoacyl-ester cleavage (Cech, 1990; reviewed in Saldanha *et al.*, 1993).

Group II introns. Group II introns have been shown to occur in fungal and plant mitochondria, and in chloroplasts (Saldanha *et al.*, 1993). They occur mostly in protein-coding genes, and some in tRNA dn rRNA genes (Michel *et al.*, 1989). These introns are of particular interest because of their possible evolutionary relationship to nuclear mRNA introns, which was initially suggested because of similarities in splicing mechanisms (Cech, 1986; Jacquier, 1990; Michel *et al.*, 1989). Splicing proceeds under a two-step transesterification mechanisms, almost identical to that of mRNA introns (reviewed in Lambowitz and Belfort, 1993 and Saldanha *et al.*, 1993). The first phase involves the formation of an intron lariat, where the 5' end of the intron is linked to a nucleotide residue near the 3' end, by a 2'-5' phosphodiester bond (Michel *et al.*, 1989). This is followed by exon ligation coupled to cleavage at the 3' splice site and release of the intron lariat (Michel *et al.*, 1989). Only a few group II introns have been shown to self-splice (and then under artificial, experimental conditions – see Saldanha *et al.*, 1993), indicating a reliance on external (or *trans*) acting proteins for efficient splicing.

Regions used in this study

The psbA/trnH intergenic spacer

The *psbA/trnH* intergenic spacer region lies in the Inverted Repeat region of the chloroplast genome, near the boundary with the Large Single Copy region, adjacent to the *trn*K gene (Sugiura, 1992). The *psb*A chloroplast gene belongs to the Photosystem II (PSII) protein complex, and codes for the PSII D1-protein; the *trn*H^{His} (GUG) gene belongs to the transfer RNA gene system, and transfers for the amino acid histidine. Phylogenetic studies reported this spacer to be of more use at higher taxonomic levels, particularly intergeneric levels (for example, Aldrich *et al.*, 1988; Asmussen and Liston, 1998; Sang, *et al.*, 1997; Kim *et al.*, 1999), though Kim *et al.* (1999) did find it somewhat useful at the infrageneric level.

The trnK intron and the matK coding region

The *trn*K intron is a group II intron, is about 2500 bp long, and encodes the *mat*K gene, which is about 1500 bp long (Ems *et al.* 1995; Hilu and Liang 1997). It is located on the large single-copy region in the chloroplast, adjacent to the inverted repeat. It appears to be structurally related to portions of a maturase-like polypeptide at the carboxyl terminus (3' end), and may be involved in splicing group II introns (Neuhaus

and Link 1987; Sugita *et al.* 1985). Whatever the function of the *mat*K gene, it appears to be significant, because *Epifagus virginiana*, a root parasite that has lost ~65% of its chloroplast genome, still contains the *mat*K gene, except for a 204 bp deletion at the 5' end.

The maturase produced by class II introns is generally involved in splicing the introns of its own precursor (Weis-Brummer *et al.* 1983). However, *Epifagus* has lost the *trn*K group II intron flanking the gene (Ems *et al.* 1995; Hilu and Liang 1997; Mohr *et al.* 1993), and Ems *et al.* (1995) used this to theorize that the gene acts 'in *trans*' to assist the splicing of group II introns other than the one where it is hosted, possibly *rpl*2 or *rps*12.

Some studies on the rate and pattern of variation in *mat*K sequences shows that it may not be as functionally constrained as *rbc*L sequences (Steele and Vilgalys, 1994; Hilu and Liang, 1997), an idea that is reinforced by data showing that *mat*K evolves 2-3 times faster than *rbc*L (Johnson and Soltis, 1994; Soltis *et al.* 1996; Plunkett *et al.* 1997; Xiang *et al.* 1998).

Hilu and Liang (1997) found that the 5' end of the *mat*K gene is less conserved than the 3' end, and contains a number of indels, whereas the 3' end has a large section (448 bp) with no indels at all. In fact, the 448 bp region lacking indels corresponds to "domain X", which is the section that corresponds to that shared with group II intron maturases, reflecting an essential function in the binding of the intron RNA during reverse transcription and RNA splicing (Mohr *et al.* 1993; Ems *et al.* 1995).

The *trn*K intron, which includes the *mat*K coding region, has been used to reconstruct phylogenies in a number of different families, such as the Apiaceae (Plunkett, *et al.*, 1996, 1997), Cornaceae (Xiang, *et al.*, 1998), Cupressaceae (Gadek *et al.*, 2000), Fabaceae (Hu *et al.*, 2000; Lavin *et al.*, 2000), Juglandaceae (Stanford, Harden, and Parks, 2000), Nymphaeaceae (Les *et al.*, 1999), Orchidaceae (Jarrell and Clegg, 1995), Pinaceae (Wang *et al.*, 1999), Poaceae (Liang and Hilu, 1996; Hilu and Alice, 1999; Hilu and Liang, 1997), Polemoniaceae (Steele and Vilgalys, 1994; Johnson *et al.*, 1996; Johnson and Soltis, 1995), and Saxifragaceae (Johnson and Soltis, 1994, 1995).

Hilu and Liang (1997) evaluate the rate, patterns and types of nucleotide substitutions in the *mat*K gene, functional constraints, and phylogenetic utility of the gene, using data from a number of different plant families, and report that the 5' end of

the *trn*K intron is larger and contains more informative characters than the 3' end. This means that the different parts of the *mat*K gene and *trn*K intron can be used at different taxonomic ranks, and where it is not feasible to sequence the complete *trn*K intron. The 5' intron would be more useful at lower taxonomic ranks, such as the species level, as the number of informative characters is larger, but still alignable at this level. Accordingly, the 5' section of the *trn*K intron was selected for use in this study.

External trascribed spacer (ETS)

The external transcribed spacer, which lies at the 3' end of the intergenic spacer between the 18S and 26S genes, has recently been shown to be much larger and contains more phylogenetically informative characters than the internal transcribed spacer (ITS), providing a large number of characters for use in phylogenetic analyses (Baldwin and Markson, 1998; Bena *et al.* 1998). To date, the ETS has been used mainly to study phylogeny within the Asteraceae (Baldwin and Markos, 1998; Linder *et al.*, 2000), and the Fabaceae (Bena *et al.*, 1998). However, sequences have been generated from the ETS region in a number of families, sometimes covering the entire intergenic spacer (IGS) of ribosomal DNA, including the Asteraceae (Baldwin and Markos, 1998; Linder *et al.*, 2000), Brassicaceae (Rathgeber and Capesius, 1990), Cucurbitaceae (King *et al.* 1993), Fabaceae (Rogers and Bendich, 1987 a & b; Schiebel *et al.*, 1989; Bena *et al.*, 1998), and Solanaceae (Borisjuk *et al.*, 1994; Schmidt-Puchta, *et al.*, 1989; Volkov *et al.*, 1996).

Materials and Methods

Fieldwork

Extensive fieldwork was undertaken throughout the south west of Western Australia, involving several trips made during different times of the year, in summer and early, mid and late spring. This allowed the collection of material in the best condition for both DNA extraction and for subsequent morphological analysis (not presented here). Leaves for DNA extraction were preserved in liquid CTAB/NaCl solution at ambient temperature and stored later at –20°C (Rogstad, 1992). Table 2.1 shows the 94 taxa used in this analysis including their authorities, along with GenBank accession numbers for the sequences obtained. Vouchers of all specimens used in the analysis are deposited at the Australian National Herbarium (CANB), and the collector name and number for each accession are provided in Table 2.1, along with a brief locality description.

Outgroup selection

Outgroups were selected using the phylogenetic analysis of the genistoid legume tribes by Crisp, *et al.* (in press), and following the work of Crisp and Weston (1995), and sampled throughout the 5-nucleate embryo sac clade. *Isotropis cuneifolia* was used to root the tree, as this genus occurs at the base of the 5-nucleate embryo sac group. Other outgroups used were *Jacksonia horrida*, *Latrobea hirtella*, *Mirbelia depressa*, *M. dilatata*, *Phyllota phylicoides*, *Pultenaea dentata* and *P. reticulata*. Outgroup genera that appeared closely related to *Gastrolobium* were sampled more extensively, including *Callistachys* (1/1 species), *Oxylobium* (5/6 species) and *Podolobium* (6/6 species).

Ingroup sampling

A pilot study suggested that *Brachysema*, *Jansonia* and *Nemcia* were nesting within *Gastrolobium*, so these genera were sampled more extensively than originally planned, and include 9/10 species of *Brachysema*, 1/1 species of *Jansonia*, and 16/39 species of *Nemcia*, including one undescribed species (all undescribed taxa are marked in Table 2.1 with 'ms.'). Species of *Nemcia* were added to the sample as it became clear that this genus is polyphyletic, and were chosen to represent the diversity of this group. Within *Gastrolobium* sensu Crisp and Weston (1987), 48/60 species were sampled, including 13 undescribed species. Of the 12 species of *Gastrolobium* not sampled, six were unavailable recent discoveries. For the other six, fresh or CTAB-preserved material was unavailable and herbarium material of these failed to amplify. It was felt that the final sample size was sufficient to test the monophyly (or non-monophyly) of each group, and to largely resolve relationships within them.

DNA isolation, amplification and sequencing

Total DNA was isolated as outlined in Bayer *et al.* (1996). Methods outlined in Gilmore *et al.* (1993) were used to isolate DNA from herbarium tissue and to purify recalcitrant DNAs. When this methods failed, DNAs were run through a QIAquick™ PCR Purification Kit (QIAGEN, Hilden, Germany).

All three regions were amplified by the polymerase chain reaction (PCR) using *Taq* DNA polymerase, using the following conditions. The PCR samples were heated to 94°C for 3 min prior to the addition of DNA polymerase to denature unwanted proteases and nucleases. The double-stranded PCR products were produced via 30 cycles of denaturation (94°C for 1 min), primer annealing (48°C for 1 min), and extension (72°C for 1 min). A seven minute final extension cycle at 72°C followed the

30th cycle to ensure the completion of all novel strands. See Table 2.2 for all primer sequences and references. Double-stranded PCR products were cleaned using QIAquick™ PCR Purification Kits (QIAGEN, Hilden, Germany) prior to sequencing.

psbA/trnH intergenic spacer sequences—The PCR reaction mixture consisted of 70 µL of sterile water, 10µL of 10x reaction buffer, 6µL of 25 mmol/L magnesium chloride solution, 4µL of 40 mmol dNTP solution in equimolar ratio, 20pmol of each primer (*psb*Af and *trn*Hr), 10-50 ng of template DNA and 0.5 µL of *Taq* polymerase in a total volume of 100µL.

trnK 5' intron sequences—The PCR reaction mixture consisted of 35 µL of sterile water, 5µL of 10x reaction buffer, 3µL of 25 mmol/L magnesium chloride solution, 2µL of 40 mmol dNTP solution in equimolar ratio, 10 pmol of each primer (3914f and 1110R[5]), 5-25 ng of template DNA and 0.25 µL of *Taq* polymerase in a total volume of 50µL. Some taxa required the use of four primers (3914f & Gast12; Gast11 & 1110r) to amplify this region, particularly when herbarium material was used. Gast11 and Gast12 were designed in a conserved part of the *trn*K intron, and provide overlapping sequences (Table 2.2).

External transcribed spacer sequences—Specific primers were developed by initially utilising a long-range PCR amplification of the entire intergenic spacer region (IGS) between the 18S and 26S subunits of rDNA, using the universal primers of Baldwin and Markos (1998). The 18S-IGS primer was then used to sequence the 3' end of the ETS region. The 5' end of this region yielded a conservative site suitable for the design of another primer, Gast1 (Table 2.2), which allowed the amplification of approximately 350 bp of sequence. The PCR reaction mixture consisted of 70 µL of sterile water, 10µL of 10x reaction buffer, 6µL of 25 mmol/L magnesium chloride solution, 4µL of 40 mmol dNTP solution in equimolar ratio, 20pmol of each primer (18SIGS and Gast1), 10-50 ng of template DNA and 0.5 µL of *Taq* polymerase in a total volume of 100µL.

Table 2.1. Taxa used in the analysis, with the nearest named place given in the locality, and with Genbank accession numbers for each sequence. All voucher specimens are housed at the Australian National Herbarium (CANB). Taxa appear in alphabetical order, and the nearest named place is followed by the state of collection. WA = Western Australia, NSW = New South Wales (eastern Australia).

Taxon	Collector	No.	Locality	*trn*K 5' intron accession	*psbA/trnH* accession	ETS accession
Brachysema bracteolosum F.Muell.	G.T. Chandler	426	Bremer Bay, WA.	GBAN-AF298424	GBAN-AF298330	GBAN-AF298236
Brachysema celsianum Lem.	M.D. Crisp	9009	Mogumber, WA.	GBAN-AF298425	GBAN-AF298331	GBAN-AF298237
Brachysema latifolium R.Br.	G.T. Chandler	365	Lort River, WA.	GBAN-AF298426	GBAN-AF298332	GBAN-AF298238
Brachysema melanopetalum F.Muell.	M.D. Crisp	8470	Manjimup, WA.	GBAN-AF298427	GBAN-AF298333	GBAN-AF298239
Brachysema minor Crisp	M.D. Crisp	8922	Mt Barker, WA.	GBAN-AF298428	GBAN-AF298334	GBAN-AF298240
Brachysema modestum Crisp	M.D. Crisp	8465	Busselton, WA.	GBAN-AF298429	GBAN-AF298335	GBAN-AF298241
Brachysema praemorsum Meisn.	G.T. Chandler	729	Mt Barker area, WA.	GBAN-AF298430	GBAN-AF298336	GBAN-AF298242
Brachysema sericeum Domin	J.M. Taylor	1959	Hay River, WA.	GBAN-AF298431	GBAN-AF298337	GBAN-AF298243
Brachysema subcordatum Benth.	M.D. Crisp	8511	Porongorup Range	GBAN-AF298432	GBAN-AF298338	GBAN-AF298244
Callistachys lanceolata Vent.	G.T. Chandler	474	Albany area, WA.	GBAN-AF298433	GBAN-AF298339	GBAN-AF298245
Gastrolobium acrocaroli ms.	G.T. Chandler	778	Peak Charles, WA.	GBAN-AF298434	GBAN-AF298340	GBAN-AF298246
Gastrolobium appressum C.A.Gardner	G.T. Chandler	208	Gunyidi area, WA.	GBAN-AF298435	GBAN-AF298341	GBAN-AF298247
Gastrolobium bennettsianum C.A.Gardner	G.T. Chandler	556	Bodallin area, WA.	GBAN-AF298436	GBAN-AF298342	GBAN-AF298248
Gastrolobium bilobum R.Br.	G.T. Chandler	724	Two People Bay, WA.	GBAN-AF298437	GBAN-AF298343	GBAN-AF298249
Gastrolobium brownii Meisn.	G.T. Chandler	726	Denmark area, WA.	GBAN-AF298438	GBAN-AF298344	GBAN-AF298250
Gastrolobium callistachys Meisn.	G.T. Chandler	678	Dingo Rock, WA.	GBAN-AF298439	GBAN-AF298345	GBAN-AF298251
Gastrolobium calycinum Benth.	G.T. Chandler	544	Wongan Hills, WA.	GBAN-AF298440	GBAN-AF298346	GBAN-AF298252
Gastrolobium carinatum ms	G.T. Chandler	427	Bremer Bay, WA.	GBAN-AF298480	GBAN-AF298386	GBAN-AF298292
Gastrolobium congestum ms.	G.T. Chandler	404	Fitzgerald River National Park, WA.	GBAN-AF298441	GBAN-AF298347	GBAN-AF298253
Gastrolobium crassifolium Benth.	G.T. Chandler	419	Jerramungup area, WA.	GBAN-AF298442	GBAN-AF298348	GBAN-AF298254
Gastrolobium cuneatum Henfr.	M.D. Crisp	8937	Blackwood River, WA.	GBAN-AF298443	GBAN-AF298349	GBAN-AF298255
Gastrolobium densifolium C.A.Gardner	G.T. Chandler	532	Tarin Rock, WA.	GBAN-AF298444	GBAN-AF298350	GBAN-AF298256

Taxon	Collector	No.	Locality	*trn*K 5' intron accession	*psbA/trnH* accession	ETS accession
Gastrolobium diabolophyllum ms.	G.T. Chandler	559	Bodallin area, WA.	GBAN-AF298445	GBAN-AF298351	GBAN-AF298257
Gastrolobium floribundum S.Moore	G.T. Chandler	553	Carrabin, WA.	GBAN-AF298446	GBAN-AF298352	GBAN-AF298258
Gastrolobium glaucum C.A.Gardner	G.T. Chandler	543	Wongan Hills, WA.	GBAN-AF298447	GBAN-AF298353	GBAN-AF298259
Gastrolobium grandiflorum F.Muell.	G.T. Chandler	598	Aust Nat Botanic Gardens	GBAN-AF298448	GBAN-AF298354	GBAN-AF298260
Gastrolobium graniticum (S.Moore) Crisp	G.T. Chandler	567	Bullabulling, WA.	GBAN-AF298449	GBAN-AF298355	GBAN-AF298261
Gastrolobium hamulosum Meisn.	G.T. Chandler	845	Wongan Hills, WA.	GBAN-AF298450	GBAN-AF298356	GBAN-AF298262
Gastrolobium heterophyllum (Turcz.) Crisp	G.T. Chandler	918	Fitzgerald River National Park, WA.	GBAN-AF298451	GBAN-AF298357	GBAN-AF298263
Gastrolobium hians ms.	G.T. Chandler	868	Norseman area, WA.	GBAN-AF298452	GBAN-AF298358	GBAN-AF298264
Gastrolobium involutum ms.	G.T. Chandler	805	Mt Buraminya, WA.	GBAN-AF298453	GBAN-AF298359	GBAN-AF298265
Gastrolobium laytonii J.White	G.T. Chandler	664	Mt Gibson area, WA.	GBAN-AF298454	GBAN-AF298360	GBAN-AF298266
Gastrolobium revolutum ms.	G.T. Chandler	524	Lake King, WA.	GBAN-AF298464	GBAN-AF298370	GBAN-AF298276
Gastrolobium microcarpum Meisn.	G.T. Chandler	686	Clackline, WA.	GBAN-AF298455	GBAN-AF298361	GBAN-AF298267
Gastrolobium stenocarpum ms.	G.T. Chandler	406	Mt Desmond, WA.	GBAN-AF298470	GBAN-AF298376	GBAN-AF298282
Gastrolobium nutans ms.	G.T. Chandler	817	Lake King area, WA.	GBAN-AF298456	GBAN-AF298362	GBAN-AF298268
Gastrolobium oxylobioides Benth.	G.T. Chandler	654	Geraldton area, WA.	GBAN-AF298457	GBAN-AF298363	GBAN-AF298269
Gastrolobium parviflorum (Benth.) Crisp	G.T. Chandler	760	Narrogin, WA.	GBAN-AF298458	GBAN-AF298364	GBAN-AF298270
Gastrolobium polystachyum Meisn.	G.T. Chandler	627	Badgingarra area, WA.	GBAN-AF298459	GBAN-AF298365	GBAN-AF298271
Gastrolobium propinquum C.A.Gardner	G.T. Chandler	652	Port Gregory, WA.	GBAN-AF298460	GBAN-AF298366	GBAN-AF298272
Gastrolobium pusillum Crisp & P.H.Weston	M.D. Crisp	8921	Mt Barker, WA.	GBAN-AF298461	GBAN-AF298367	GBAN-AF298273
Gastrolobium pycnostachyum Benth.	G.T. Chandler	337	Mt Ragged, WA.	GBAN-AF298462	GBAN-AF298368	GBAN-AF298274
Gastrolobium reflexum ms.	G.T. Chandler	645	Arrino area, WA.	GBAN-AF298463	GBAN-AF298369	GBAN-AF298275
Gastrolobium rigidum (C.A.Gardner) Crisp	G.T. Chandler	531	Tarin Rock, WA.	GBAN-AF298465	GBAN-AF298371	GBAN-AF298277
Gastrolobium rotundifolium Meisn.	G.T. Chandler	658	Watheroo, WA.	GBAN-AF298466	GBAN-AF298372	GBAN-AF298278

Taxon	Collector	No.	Locality	*trn*K 5' intron accession	*psbA/trnH* accession	ETS accession
Gastrolobium semiteres ms.	G.T. Chandler	694	Boorabbin Rock, WA.	GBAN-AF298467	GBAN-AF298373	GBAN-AF298279
Gastrolobium spectabile (Endl.) Crisp	G.T. Chandler	821	Kunanoppin, WA.	GBAN-AF298468	GBAN-AF298374	GBAN-AF298280
Gastrolobium spinosum Benth.	G.T. Chandler	548	Mt O'Brien, WA.	GBAN-AF298469	GBAN-AF298375	GBAN-AF298281
Gastrolobium stenophyllum Turcz.	G.T. Chandler	735	Marningarup area, WA.	GBAN-AF298471	GBAN-AF298377	GBAN-AF298283
Gastrolobium stowardii S.Moore	G.T. Chandler	950	Lake Grace, WA.	GBAN-AF298503	GBAN-AF298409	GBAN-AF298315
Gastrolobium tenue ms.	G.T. Chandler	688	Belka area, WA.	GBAN-AF298472	GBAN-AF298378	GBAN-AF298284
Gastrolobium tergiversum ms.	G.T. Chandler	344	Mt Ragged, WA.	GBAN-AF298473	GBAN-AF298379	GBAN-AF298285
Gastrolobium tetragonophyllum (E.Pritzel) Crisp	G.T. Chandler	706	Mt Short, WA.	GBAN-AF298474	GBAN-AF298380	GBAN-AF298286
Gastrolobium tomentosum C.A.Gardner	G.T. Chandler	756	Williams area, WA.	GBAN-AF298475	GBAN-AF298381	GBAN-AF298287
Gastrolobium triangulare Domin	G.T. Chandler	655	Geraldton area, WA.	GBAN-AF298476	GBAN-AF298382	GBAN-AF298288
Gastrolobium trilobum Benth.	G.T. Chandler	536	Bindi Bindi area, WA.	GBAN-AF298477	GBAN-AF298383	GBAN-AF298289
Gastrolobium truncatum Benth.	M.D. Crisp	8919	Bokal, WA.	GBAN-AF298478	GBAN-AF298384	GBAN-AF298290
Gastrolobium villosum Benth.	G.T. Chandler	542	Callingiri area, WA.	GBAN-AF298479	GBAN-AF298385	GBAN-AF298291
Isotropis cuneifolia Heynh.	M.D. Crisp	8459	Mogumber, WA.	GBAN-AF298481	GBAN-AF298387	GBAN-AF298293
Jacksonia horrida DC.	M.D. Crisp	8934	Scott River, WA.	GBAN-AF298482	GBAN-AF298388	GBAN-AF298294
Jansonia formosa Kipp.	M.D. Crisp	8933	Scott River, WA.	GBAN-AF298483	GBAN-AF298389	GBAN-AF298295
Latrobea hirtella Benth.	M.D. Crisp	8478	Stirling Range, WA.	GBAN-AF298484	GBAN-AF298390	GBAN-AF298296
Mirbelia depressa E.Pritzel	M.D. Crisp	9020	Perenjori, WA.	GBAN-AF298485	GBAN-AF298391	GBAN-AF298297
Mirbelia dilatata R.Br.	M.D. Crisp	8491	Stirling Range, WA.	GBAN-AF298486	GBAN-AF298392	GBAN-AF298298
Nemcia alternifolia ms.	M.D. Crisp	8512	York area, WA.	GBAN-AF298487	GBAN-AF298393	GBAN-AF298299
Nemcia coriacea Domin	G.T. Chandler	723	Nanarup area, WA.	GBAN-AF298488	GBAN-AF298394	GBAN-AF298300
Nemcia crenulata (Turcz.) Crisp	G.T. Chandler	490	Stirling Range, WA.	GBAN-AF298489	GBAN-AF298395	GBAN-AF298301
Nemcia emarginata (S.Moore) Crisp	M.D. Crisp	8963	Stirling Range, WA.	GBAN-AF298490	GBAN-AF298396	GBAN-AF298302
Nemcia hookeri (Meisn.) Crisp	M.D. Crisp	8907	York area, WA.	GBAN-AF298491	GBAN-AF298397	GBAN-AF298303
Nemcia leakeana (Drumm.) Crisp	M.D. Crisp	8481	Stirling Range, WA.	GBAN-AF298492	GBAN-AF298398	GBAN-AF298304
Nemcia luteifolia Domin	M.D. Crisp	9407	Stirling Range, WA.	GBAN-AF298493	GBAN-AF298399	GBAN-AF298305
Nemcia obovata (Benth.) Crisp	G.T. Chandler	657	Watheroo, WA.	GBAN-AF298494	GBAN-AF298400	GBAN-AF298306

Taxon	Collector	No.	Locality	*trn*K 5' intron accession	*psbA/trnH* accession	ETS accession
Nemcia plicata (Turcz.) Crisp	G.T. Chandler	623	Badgingarra area, WA.	GBAN-AF298495	GBAN-AF298401	GBAN-AF298307
Nemcia pulchella (Turcz.) Crisp	M.D. Crisp	8480	Stirling Range, WA.	GBAN-AF298496	GBAN-AF298402	GBAN-AF298308
Nemcia pyramidalis (T.Moore) Crisp	G.T. Chandler	488	Stirling Range, WA.	GBAN-AF298497	GBAN-AF298403	GBAN-AF298309
Nemcia reticulata Domin	G.T. Chandler	540	Seabird, WA.	GBAN-AF298498	GBAN-AF298404	GBAN-AF298310
Nemcia retusa Domin	G.T. Chandler	595	South Stirling, WA.	GBAN-AF298499	GBAN-AF298405	GBAN-AF298311
Nemcia rubra Crisp	G.T. Chandler	489	Stirling Range, WA.	GBAN-AF298500	GBAN-AF298406	GBAN-AF298312
Nemcia spathulata (Benth.) Crisp	M.D. Crisp	8448	Bindoon, WA.	GBAN-AF298501	GBAN-AF298407	GBAN-AF298313
Nemcia vestita Domin	M.D. Crisp	8489	Stirling Range, WA.	GBAN-AF298502	GBAN-AF298408	GBAN-AF298314
Oxylobium arborescens R.Br.	G.T. Chandler	616	Gibraltar Range, NSW.	GBAN-AF298504	GBAN-AF298410	GBAN-AF298316
Oxylobium ellipticum R.Br.	G.T. Chandler	603	Aust Nat Botanic Gardens	GBAN-AF298505	GBAN-AF298411	GBAN-AF298317
Oxylobium lineare (Benth.) Benth.	M.D. Crisp	8471	Tonebridge, WA.	GBAN-AF298506	GBAN-AF298412	GBAN-AF298318
Oxylobium pulteneae DC.	M.D. Crisp	9046	Howes Valley, NSW.	GBAN-AF298507	GBAN-AF298413	GBAN-AF298319
Oxylobium robustum Joy Thomps.	I.R. Telford	4294	Lake Cootharaba, QLD.	GBAN-AF298508	GBAN-AF298414	GBAN-AF298320
Phyllota phylicoides Benth.	M.D. Crisp	9048	Morgans Gully, NSW.	GBAN-AF298509	GBAN-AF298415	GBAN-AF298321
Podolobium aciculiferum F.Muell.	G.T. Chandler	606	Wyong State Forest, NSW.	GBAN-AF298510	GBAN-AF298416	GBAN-AF298322
Podolobium aestivum Crisp & P.H.Weston	G.T. Chandler	612	Gibraltar Range, NSW.	GBAN-AF298511	GBAN-AF298417	GBAN-AF298323
Podolobium alpestre (F.Muell.) Crisp & P.H.Weston	G.T. Chandler	1039	Brindabella Range, ACT.	GBAN-AF298512	GBAN-AF298418	GBAN-AF298324
Podolobium ilicifolium (Andrews) Crisp & P.H.Weston	G.T. Chandler	308	Nelligen, NSW.	GBAN-AF298513	GBAN-AF298419	GBAN-AF298325
Podolobium procumbens (F.Muell.) Crisp & P.H.Weston	B. Hadlow	461	Verneys Range, NSW.	GBAN-AF298514	GBAN-AF298420	GBAN-AF298326
Podolobium scandens DC.	G.T. Chandler	309	Nelligen, NSW.	GBAN-AF298515	GBAN-AF298421	GBAN-AF298327
Pultenaea dentata Labill.	M.D. Crisp	9053	Boonoo Boonoo Falls, NSW.	GBAN-AF298516	GBAN-AF298422	GBAN-AF298328
Pultenaea reticulata Benth.	G.T. Chandler	953	Mt Barker area, WA.	GBAN-AF298517	GBAN-AF298423	GBAN-AF298329

Sequencing of PCR products

The double-stranded PCR products were used as templates in cycle sequencing reactions, which employed the same primers that were used for PCR amplification to sequence both strands. The double-stranded PCR products were sequenced using the dideoxy chain termination method (Sanger *et al.*, 1977) with the use of the Big Dye Terminator RR Kit® (Perkin Elmer Applied Biosystems, Norwalk, Connecticut, USA) at CSIRO, Division of Plant Industry. An annealing temperature of 60°C was used for both primers. The cycle sequencing protocol followed manufacturer's instructions.

Sequences were assembled using Sequencher™ 3.0 (Gene Codes Corporation, Ann Arbor, Michigan, USA), then manually adjusted following the principles of noncoding sequence alignment using secondary structure (Kelchner, in press; Kelchner and Clark, 1997). Indels were placed where they minimized the number of inferred length mutations, unless clear evidence was seen for non-homologous length mutation events.

Table 2.2. List of primer sequences and references used in this study.

Primer	Primer sequence	Reference (if applicable)
psbA f	GTT ATG CAT GAA CGT AAT GCT C	Sang, Crawford, & Stuessy (1997)
trnH r	CGC GCA TGG TGG ATT CAC AAA TC	Sang, Crawford, & Stuessy (1997)
3914 f	GGG GTT GCT AAC TCA ACG G	Johnson & Soltis (1994)
1110 r	TAT TCT GTT GAT ACA TTC G	Previously unpublished
Gast11	GTG CTT GGT GTG GTA AAG GC	Previously unpublished
Gast12	CAA CGG ATT CTC TCA CCT CGC	Previously unpublished
18SIGS	CAC ATG CAT GGC TTA ATC TTT G	Baldwin & Markos (1998)
26S	CTG CCA CGA TCC ACT GAG STC C	Baldwin & Markos (1998)
Gast1	CGG TTG CGG CTC TGG TGT TC	Previously unpublished

Sequence data analysis

Sequence data were analysed using parsimony as implemented in PAUP 4.0b3a (Swofford, 1997) on a Macintosh G3 computer. The data matrix contained 75 ingroup taxa, taken from the 'Callistachys' group of Crisp and Weston (1987), which includes *Gastrolobium* and allied genera, and 19 outgroup taxa. Phylogenetic reconstruction was performed on unweighted characters by heuristic searches with simple addition of taxa. An island search was employed to search for additional most parsimonious trees, with a random addition sequence of 100 replicates using a heuristic search (Maddison, 1991). The three sets of sequences were analysed individually and together. A partition homogeneity test was conducted to test the compatibility of the three data sets.

The robustness of clades was tested using two methods - bootstrapping (Felsenstein, 1985) and decay analysis (Bremer, 1988). 1000 replicates were used for the bootstrap. The decay analysis was facilitated by the program AutoDecay (Eriksson, 1998), and the decay values were then extracted using AutoDecay and visualised using the tree-drawing package, TreeView (Page, 1996).

Results

Sequence characteristics

Table 2.3 presents statistics for the sequences, including length variation, proportion of nucleotide differences, G/C content, sequence divergence, informative characters, and indel information, while a summary is provided here. Combined sequence lengths vary from 1392 bp in *Isotropis cuneifolia* to 1731 bp in *Nemcia alternifolia* ms.; the *psbA/trnH* spacer ranges from 180 bp in *Isotropis cuneifolia* to 414 bp in *Gastrolobium tenue* ms. and *G. oxylobioides*; the trnK 5' intron ranges from 816 bp in *G. villosum* to 1016 bp in *Nemcia alternifolia* ms.; and the ETS ranges from 315 bp in *Pultenaea reticulata* to 345 bp in *Mirbelia depressa*.

G/C content in the combined analysis ranges from 35.84% in *Mirbelia dilatata* to 38.74% in *Podolobium procumbens*; that in the *psbA/trnH* spacer ranges from 25.68% in *Gastrolobium laytonii* to 32.12% in *G. appressum*; that in the trnK 5' intron varies from 31.63% in *Nemcia rubra* to 35.47% in *Isotropis cuneifolia*; and that in the ETS ranges from 51.45% in *Mirbelia depressa* to 64.13% in *Pultenaea reticulata*.

In the combined matrix, sequence divergence varies from 0.435% between *Nemcia hookeri* and *N. obovata* to 21.451% between *Pultenaea reticulata* and *Isotropis cuneifolia*; in the *psbA/trnH* spacer it varies from 0% between *Podolobium alpestre* and *P. procumbens* to 21.364% between *Gastrolobium parviflorum* and *Isotropis cuneifolia*; in the trnK 5' intron it ranges from 0% between *Gastrolobium heterophyllum* and *G. nutans* to 20.2% between *Isotropis cuneifolia* and *Gastrolobium stowardii*; and in the ETS it ranges from 0% between several sets of taxa (*N. leakeana*/*N. luteifolia*/*N. rubra*; *N. coriacea*/*N. hookeri*/*N. obovata*/*N. plicata*; *Gastrolobium stowardii*/G. carinatum ms; *G. revolutum*/*G. tetragonophyllum*/*G. parviflorum*; *G. floribundum*/*G. propinquum*; and *G. appressum*/*G. oxylobioides*) to 28.444% between *Callistachys lanceolata* and *Isotropis cuneifolia*.

TABLE 2.3. Sequence characteristics of the *psbA/trnH* spacer, the *trn*K 5' intron and the external transcribed spacer (ETS) sequenced in this study. NA = not applicable.

Sequence characteristic	*psbA/trnH* Spacer	*trn*K 5' Intron	ETS	Combined (all 3 sequences)
Length range (bp)	180-414	816-1016	315-345	1592-1931
Length mean (bp)	356	897	339	1781
Aligned length (bp)	603	1352	355	2310
G + C content mean	29.5%	33%	58%	37%
Sequence divergence (%)	0.00-21.36%	0.00-20.20%	0.00-28.44%	0.44-21.45%
Number of variable sites	328/603 (54 %)	466/1352 (34 %)	233/355 (65 %)	1027/2310 (45%)
Number of potentially informative sites	192/603 (32 %)	237/1352 (18 %)	142/355 (40 %)	571/2310 (25%)
Number of constant sites	275/603 (46 %)	887/1352 (66 %)	123/355 (35 %)	1285/2310 (55%)
Number of autapomorphic sites	136/603 (22 %)	229/1352 (16 %)	91/355 (25 %)	456/2310 (20%)
Number of unambiguously coded indels	5	11	0	16
Coded indel size range (bp)	2-241	5-20	0	2-241
Ratio of coded indels to potentially informative sites	1:38	1:22	0	1:36

The number of unambiguous indels in each region varies considerably, with numerous indels present in the *psbA/trnH* spacer (ranging in size from 2 to 241 bp) to very few in the ETS (all of which were autapomorphic, and therefore phylogenetically uninformative). Only the number of unambiguously coded indels are given in Table 2.3, which range in size from 2 to 241 bp in the *psbA/trnH* spacer, 5 to 20 bp in the *trn*K intron, and none in the ETS.

Phylogenetic reconstruction

A heuristic search of all potentially phylogenetically informative nucleotide characters, including indels, revealed 360 trees of 2327 steps, with CI = 0.404, RI = 0.631, RC = 0.255. A 50% majority rule tree, which also shows the decay and bootstrap values calculated for each clade, is shown in Fig. 2.1. Only five branches in the majority rule tree collapse in the strict consensus, and are shown with dashed lines (Fig. 2.1). A phylogram is presented in Fig. 2.2, showing the number of synapomorphies supporting each branch in one of the equally most parsimonious trees. The partition homogeneity test indicated the data sets are not significantly different (p = 0.08), and can therefore be combined into one analysis.

Topology of major clades

This analysis shows *Gastrolobium* (Clade C, Fig. 2.1) to be paraphyletic, with *Brachysema*, *Jansonia*, *Nemcia* and *Oxylobium lineare* nesting within it. *Nemcia* is shown to be polyphyletic (Clades I, J, K and L, Fig. 2.1), as is *Podolobium* (Clades A and B). The *Podolobium ilicifolium* group (Clade B) is sister to *Gastrolobium*.

The major clades, as indicated in Fig. 2.1, are described below. The subtending floral bract type and ovule number for the *Gastrolobium* sensu Crisp and Weston (1987) species are presented in Table 2.4, and summarised in each clade below. The letters NA mean not applicable.

Clade A (decay [D] = 3, synapomorphies [SYN] = 16, bootstrap [BS] = 28). The 'Oxylobium' group, which contains *Oxylobium* (excluding *O. lineare*), *Mirbelia*, *Callistachys* and three species of *Podolobium* (*P. alpestre*, *P. procumbens* and *P. scandens*). *Oxylobium* and *Podolobium* both occur in eastern Australia (see Fig. 5.2), *Mirbelia* occurs in both eastern and western Australia, and *Callistachys* is endemic to the south-west of Western Australia.

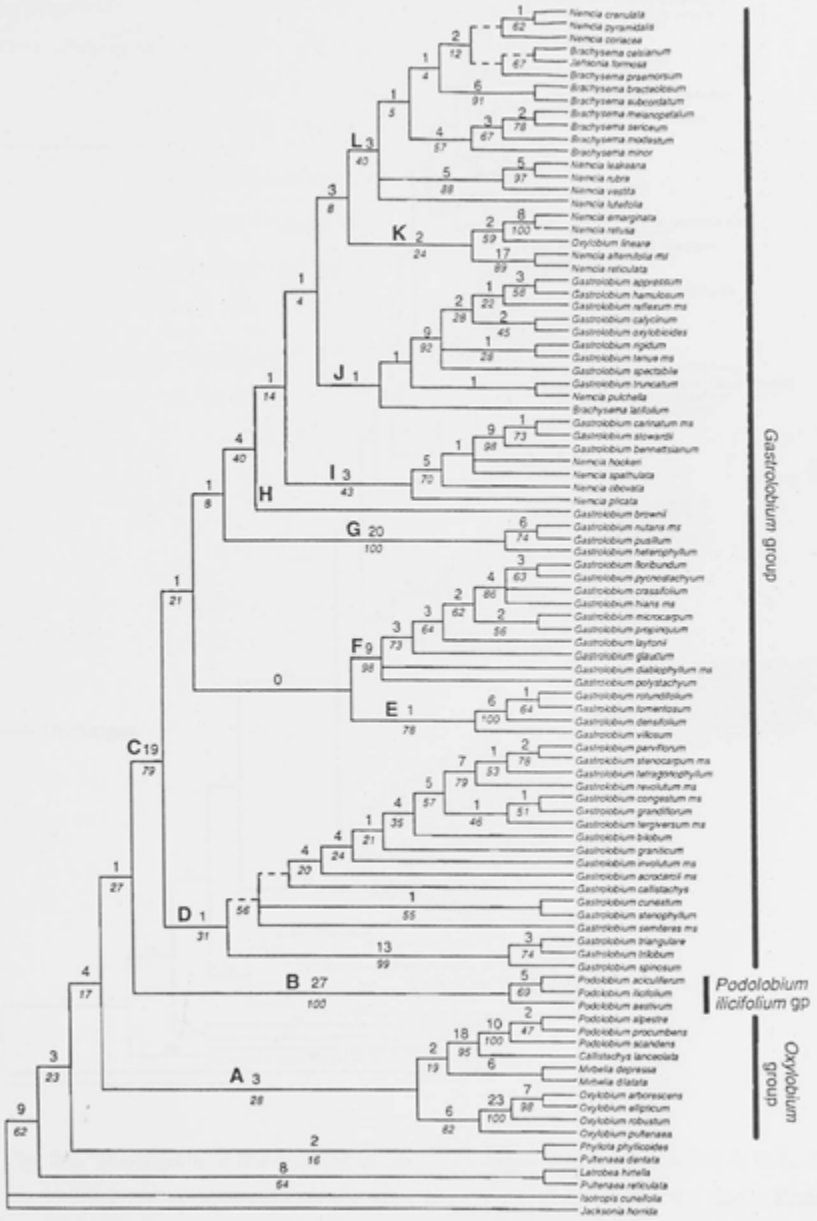

Fig. 2.1. 50% majority rule consensus tree of 360 trees. Tree length is 2327 steps. CI = 0.404, RI – 0.631. The major clades are marked A to L. Decay values are given above the line, and bootstrap values below.

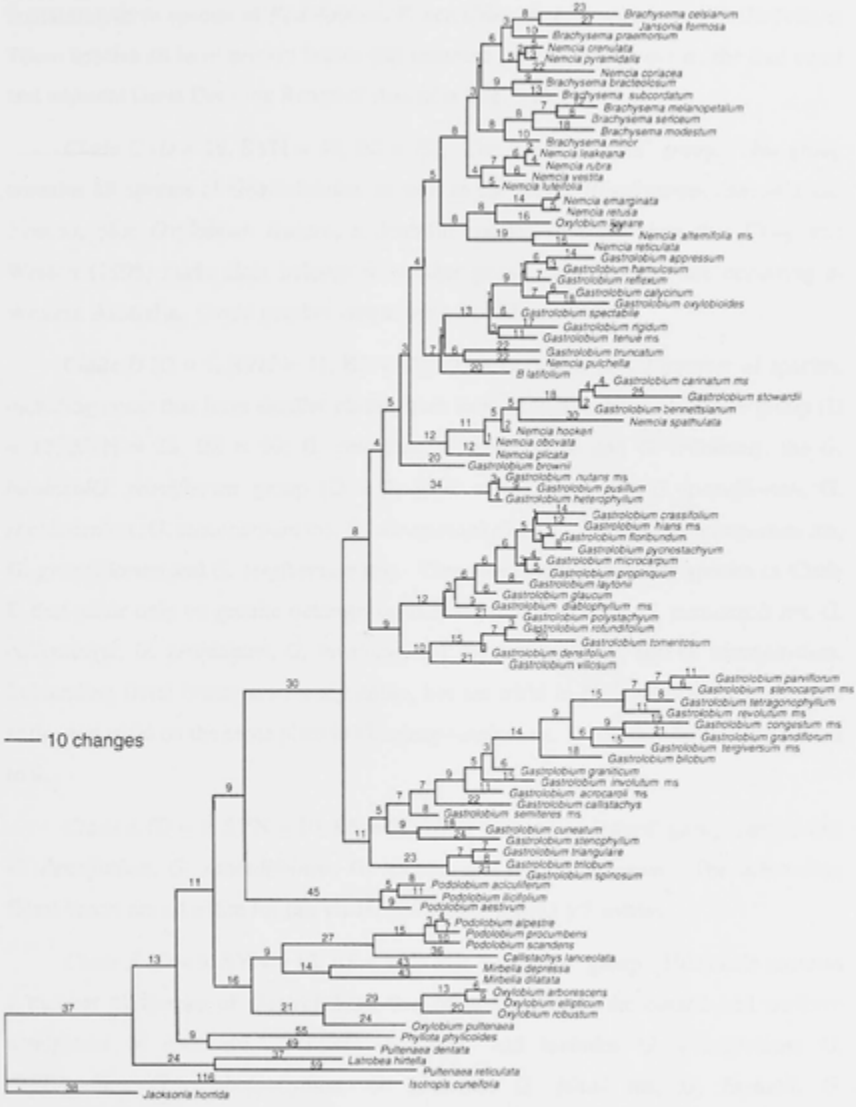

Fig. 2.2. Phylogram of one tree out of 360. The major clades are marked A to L, and the number of synapomorphies for each branch are given above the line. Branch lengths are proportional to the amount of change, with a scale provided.

Clade B (D = 27, SYN = 45, BS = 100). The *Podolobium ilicifolium* group, containing three species of *Podolobium*, *P. aciculiferum*, *P. aestivum* and *P. ilicifolium*. These species all have prickly leaves and recurved calyces, and occur on the east coast and adjacent Great Dividing Range of Australia (Fig. 5.2).

Clade C (D = 19, SYN = 30, BS = 79). The 'Gastrolobium' group. This group contains all species of *Gastrolobium*, as well as the genera *Brachysema*, *Jansonia* and *Nemcia*, plus *Oxylobium lineare*, a doubtful species of *Oxylobium* that Crisp and Weston (1995) made clear belongs in another genus, and the only one occurring in Western Australia. Ovule number ranges from 2 to 21.

Clade D (D = 1, SYN = 11, BS = 31). This clade contains a number of species, including some that form smaller clades, such as the *Gastrolobium spinosum* group (D = 13, SYN = 23, BS = 99; *G. spinosum*, *G. triangulare* and *G. trilobum*); the *G. bilobum*/*G. parviflorum* group (D = 4, SYN = 14, BS = 79; *G. parviflorum*, G. *revolutum* ms, G. *stenocarpum* ms, *G. tetragonophyllum*, *G. bilobum*, *G. congestum* ms, *G. grandiflorum* and *G. tergiversum* ms). There are also a number of species in Clade D that occur only on granite outcrops or their margins, including *G. acrocaroli* ms, *G. callistachys*, *G. graniticum*, *G. involutum* ms, *G. semiteres* ms, and *G. stenophyllum*. Subtending floral bracts are mostly entire, but are trifid in *G. involutum*, and are both entire and trifid on the same plant in *G. tetragonophyllum*. Ovule number ranges from 2 to 9.

Clade E (D = 1, SYN = 10, BS = 78). The 'tomentose-leaved' group, comprising *G. densifolium*, *G. rotundifolium*, *G. tomentosum* and *G. villosum*. The subtending floral bracts are all entire for this clade, and there are strictly 2 ovules.

Clade F (D = 9, SYN = 12, BS = 98). The 'sandplain' group. This clade contains a number of species of *Gastrolobium* that occur throughout the central and northern sandplains of south-west Western Australia, and includes *G. crassifolium*, *G. floribundum*, *G. diabolophyllum*, *G. glaucum*, *G. hians* ms, *G. laytonii*, *G. microcarpum*, *G. polystachyum*, *G. propinquum*, and *G. pycnostachyum*. The subtending floral bracts in this group are mostly entire, with two species (*G. laytonii* and *G. diabolophyllum*) possessing both entire and somewhat trifid bracts. This group also contains species with only 2 ovules.

Clade G (D = 20, SYN = 34, BS = 100). Three morphologically disparate species make up this clade, *G. heterophyllum*, *G. nutans* and *G. pusillum*. *Gastrolobium*

heterophyllum has both entire and trifid subtending floral bracts, *G. nutans* has entire bracts, and *G. pusillum* has trifid bracts only. Ovule number ranges from 2 in *G. nutans* to 4-10 in *G. heterophyllum* and *G. pusillum*.

Clade H (D = NA, autapomorphies = 20, BS = NA). A single species only, *G. brownii*, situated directly between Clade G and Clade I. *Gastrolobium brownii* has both entire and trifid subtending floral bracts and 2 ovules.

Clade I (D = 3, SYN = 12, BS = 43). This group contains a number of species of *Nemcia* which appear to be intermediate in morphology between *Gastrolobium* and *Nemcia* (*N. hookeri*, *N. obovata*, *N. plicata* and *N. spathulata*), a theory expanded further in the discussion, plus *Gastrolobium bennettsianum*, *G. stowardii* and *G. carinatum* ms (aff. *bennettsianum*). These species have shortly racemose inflorescences, generally in the axils of the leaves, all species have trifid subtending floral bracts, except for *G. bennettsianum*, which has entire bracts, and they all have strictly 2 ovules.

Clade J (D = 1, SYN = 7, BS = 6). Contained in this clade are *Brachysema latifolium* (the type species of *Brachysema*), *Nemcia pulchella* and *Gastrolobium truncatum*, as well as a group of *Gastrolobium* sensu Crisp and Weston (1987) species (D = 9, SYN = 13, BS = 92), including *G. appressum*, *G. calycinum*, *G. hamulosum*, *G. oxylobioides*, *G. reflexum* ms., *G. rigidum*, *G. spectabile* and *G. tenue*, that share glaucous leaves with strongly reticulate venation and an intramarginal vein. The numbers of subtending floral bracts and ovules range broadly in this clade. *Gastrolobium truncatum* has both entire and trifid bracts, *N. pulchella*, *G. rigidum* and *G. tenue* have trifid bracts, while the rest of the *Gastrolobium* sensu Crisp and Weston (1987) species all have entire bracts. Ovule number ranges commonly from 2 to 9, but goes as high as 18-21 in *B. latifolium*.

Clade K (D = 2, SYN = 8, BS = 24). This clade includes a number of *Nemcia* species, *N. alternifolia*, *N. emarginata*, *N. reticulata* and *N. retusa*, and *Oxylobium lineare*. These species all have strongly tomentose calyces which may be bicoloured, and generally have inflorescences reduced to a few flowers in the leaf axils. All species in this clade have trifid bracts, while ovule number in this group ranges mostly from 2 to 9, but goes up to 18 in *O. lineare*.

Clade L (D = 3, SYN = 8, BS = 40). This group contains all bird-pollinated species within the greater *Gastrolobium* group except two (*Brachysema latifolium* and

Gastrolobium grandiflorum), as well as three bee-pollinated species. This includes all but one species of *Brachysema* (*B. bracteolosum*, *B. celsianum*, *B. melanopetalum*, *B. minor*, *B. modestum*, *B. praemorsum*, *B. sericeum*, and *B. subcordatum*), *Jansonia formosa*, and the red-flowered *Nemcia* group, *N. leakeana* (the type species of *Nemcia*), *N. luteifolia*, *N. rubra* and *N. vestita*. The bee-pollinated species of *Nemcia* included within this clade are *N. coriacea*, *N. crenulata* and *N. pyramidalis*. All species in this clade have trifid bracts, though ovule number varies widely throughout this group, with the orange-flowered *Nemcia* species have 2-4 ovules, *Jansonia* has 2 ovules, the red-flowered *Nemcia* species vary from 4 to 6 ovules, and *Brachysema* contains 2-18 ovules (mostly more than 6).

Discussion

Resolution of the dilemma in circumscribing Gastrolobium

Whereas morphological analyses of *Gastrolobium* and its close relatives have provided unsatisfactory resolution within this group (e.g. Crisp and Weston, 1987, 1995; Crisp, 1994), molecular data have clarified relationships. It is clear from this analysis that *Gastrolobium* sensu Crisp and Weston (1987) is paraphyletic, with strong support for the inclusion of *Brachysema*, *Jansonia*, *Nemcia* and *O. lineare* within *Gastrolobium*. *Nemcia* itself is polyphyletic within this clade.

Past classifications have circumscribed these genera primarily using floral characters which appear to be related to pollination syndrome (bird pollination versus bee pollination), as well as inflorescence structure and fluoroacetate content (Crisp and Weston, 1987). Thoughts on the homology of such characters need to be reconsidered, because this analysis shows all of these to be homoplastic. More care needs to be taken when choosing morphological characters for cladistics, with many characters in the past being more relevant to phenetic analyses. This is not to say that morphology does not provide important phylogenetic information in the *Gastrolobium* group, simply that it does not provide enough resolution exclusive of other data.

Table 2.4. List of *Gastrolobium* sensu Crisp and Weston (1987) species, with the number of ovules and the subtending floral bract type.

Taxon	Ovule Number	Subtending floral bract type
Brachysema bracteolosum	6-8	trifid
Brachysema celsianum	14-18	trifid
Brachysema latifolium	18-21	trifid
Brachysema melanopetalum	17	trifid
Brachysema minor	12-13	trifid
Brachysema modestum	13	trifid
Brachysema praemorsum	19	trifid
Brachysema sericeum	12-14	trifid
Brachysema subcordatum	2-6	trifid
Gastrolobium acrocaroli	5-6	entire
Gastrolobium appressum	2-3	entire
Gastrolobium bennettsianum	2	entire
Gastrolobium bilobum	2	entire
Gastrolobium brownii	2	entire and trifid
Gastrolobium callistachys	2	entire
Gastrolobium calycinum	2	entire
Gastrolobium carinatum	2	entire
Gastrolobium congestum	3-5	entire
Gastrolobium crassifolium	2	entire
Gastrolobium cuneatum	2	entire
Gastrolobium densifolium	2	entire
Gastrolobium diabolophyllum	2	entire and trifid
Gastrolobium floribundum	2	entire
Gastrolobium glaucum	2	entire
Gastrolobium grandiflorum	2	entire
Gastrolobium graniticum	6-7	entire
Gastrolobium hamulosum	2	entire
Gastrolobium heterophyllum	8	entire and trifid
Gastrolobium hians	2	entire
Gastrolobium involutum	4-6	trifid
Gastrolobium laytonii	2	entire and trifid
Gastrolobium revolutum	4	entire
Gastrolobium microcarpum	2	entire
Gastrolobium stenocarpum	4-9	entire
Gastrolobium nutans	2	entire
Gastrolobium oxylobioides	2	entire
Gastrolobium parviflorum	3-4	entire
Gastrolobium polystachyum	2	entire
Gastrolobium propinquum	2	entire
Gastrolobium pusillum	4-10	trifid
Gastrolobium pycnostachyum	2	entire
Gastrolobium reflexum	2	entire
Gastrolobium rigidum	4-5	trifid
Gastrolobium rotundifolium	2	entire

Table 2.4 (con't).

Taxon	Ovule Number	Subtending floral bract type
Gastrolobium semiteres	4-5	entire
Gastrolobium spectabile	10-12	entire
Gastrolobium spinosum	2	entire
Gastrolobium stenophyllum	2	entire
Gastrolobium stowardii	2	entire
Gastrolobium tenue	2	trifid
Gastrolobium tergiversum	2	entire
Gastrolobium tetragonophyllum	4	entire and trifid
Gastrolobium tomentosum	2	entire
Gastrolobium triangulare	2	entire
Gastrolobium trilobum	2	entire
Gastrolobium truncatum	2	entire and trifid
Gastrolobium villosum	2	entire
Jansonia formosa	2	trifid
Nemcia alternifolia	2-3	trifid
Nemcia coriacea	4	trifid
Nemcia crenulata	2	trifid
Nemcia emarginata	2	trifid
Nemcia hookeri	2	trifid
Nemcia leakeana	4	trifid
Nemcia luteifolia	6	trifid
Nemcia obovata	2	trifid
Nemcia plicata	2	trifid
Nemcia pulchella	2	trifid
Nemcia pyramidalis	2	trifid
Nemcia reticulata	8-9	trifid
Nemcia retusa	4	trifid
Nemcia rubra	6	trifid
Nemcia spathulata	2	trifid
Nemcia vestita	4-6	trifid
Oxylobium lineare	18	trifid

To illustrate this point, this analysis gives weak support for a large, mostly bird-pollinated lineage within *Gastrolobium* (Clade L), showing that the floral characters that appear related to bird pollination are indeed phylogenetically informative (also, see below). However, morphological characters were unable to satisfactorily work out the broader relationships of this lineage, which the molecular data more satisfactorily resolves.

The red-flowered, apparently bird-pollinated, species (Clade L, including *Brachysema*, *Jansonia*, and some species of *Nemcia*) form a well-supported clade (D = 3, SYN = 8), although three other species of *Nemcia* which have short, dense, many-flowered racemes with large, orange flowers are also within this clade (*N. coriacea*, *N. crenulata* and *N. pyramidalis*). This conflicts with previous morphological work (Crisp, 1994), which suggested that bird-pollination in the genera *Brachysema*, *Jansonia* and *Nemcia* was due to convergence, and had arisen twice. This study suggests that there is one main lineage within the greater *Gastrolobium* that appears to be bird-pollinated, whilst only two other species (*Brachysema latifolium* and *Gastrolobium grandiflorum*) occur singly outside this group, so that bird pollination appears to have originated three times within *Gastrolobium*.

It is recognised that morphology can be selected to change rapidly for a new pollinator (see review in Crisp, 1994), so convergence among a number of different lineages is possible. In fact, only one or two genes may be responsible for flower colour and shape (Gottleib, 1984; Coen, 1991; Coen and Meyerowitz, 1991), such that minimal genetic change may dramatically alter floral morphology. In the *Brachysema* and red-flowered *Nemcia* clade (Clade L), a variety of floral shapes and colours are found. For example, the red-flowered *Nemcia* species do not have a reduced standard petal or enlarged keel petals, whereas the *Brachysema* species do. The colours range from white (e.g. *B. modestum*) through green (*B. bracteolosum*), red (e.g. *B. subcordatum*, *Jansonia formosa* and *Nemcia rubra*) to black or very dark purple (*B. melanopetalum*). It is possible that these species shared a common ancestor that evolved towards bird pollination, and then underwent an adaptive radiation, expanding into many shapes and colours. This may have been facilitated by the release of developmental constraints on the ancestral, yellow and red, bee-pollinated flowers in the rest of the *Gastrolobium* clade. This may also be true for other genera within the Mirbelieae and Bossieeae, because red flowers with elongated keels are found in species of *Bossiaea* Vent.,

Chorizema Labill., *Daviesia* Sm., *Gompholobium* Sm., *Leptosema*, *Mirbelia* Sm. and *Sphaerolobium* Sm.

Fluoroacetate is found in a number of clades within the *Gastrolobium* clade (Clades D to J), but not in Clades K or L. It is possible that production of fluoroacetate is the plesiomorphic condition in this group (acquired in the ancestor of Clade C), and was then lost from some lineages, most notably in the common ancestor of the red-flowered group (Clade L) and a group of yellow-flowered *Nemcia* species (Clade K). Toxin strength does not otherwise appear to decline in derived clades in the tree (except in the species of *Nemcia* intermediate with *Gastrolobium* in Clade I, where trace levels have been recorded). Usually, fluoroacetate is either present or absent in these groups, implying that a mutation in the fluoroacetate metabolic pathway to interrupt production could have occurred, which could have led to a drastic reduction in fluoroacetate production, as found in *N. spathulata* by Twigg *et al.* (1996), or even a complete absence of fluoroacetate in some of the more derived clades.

The subtending floral bracts have been used in the past as evidence for segregating *Gastrolobium* and *Nemcia*. At a glance, it would seem that this is a useful diagnostic character (Table 2.4). However, there are a few species of *Gastrolobium* sensu Crisp and Weston (1987) that have trifid bracts, and some that contain both entire and trifid bracts. For example, in *G. tetragonophyllum*, the bracts are mostly entire on inflorescences towards the base of the branchlets, but become mostly trifid on inflorescences towards the apex. Also, a number of 'entire' bracts are in fact lacerate or fimbriate, and if examined closely, appear to have slight bulges to either side of the apex, as if indicating an intermediate state. Therefore this character is difficult to divide into clear-cut states, and is of doubtful use in the overall separation of *Gastrolobium* and *Nemcia*.

Ovule number has been shown to be homoplastic throughout the tribe Mirbelieae (Crisp and Weston, 1987, 1995). This study has shown this character to be homoplastic also throughout *Gastrolobium* and related taxa, and no support can be found for its use in past classifications to distinguish between the genera in this group, especially *Gastrolobium*, *Nemcia* and *Oxylobium*. In fact, when Crisp and Weston (1987) placed a number of species of *Oxylobium* into *Gastrolobium*, they placed species with more than two ovules into a group that had formerly had strictly two ovules. Moreover, the present analysis has found many clades that contain species with two ovules and species with more than two ovules. Only four clades (E, F, H and I) contain species with

exclusively two ovules, while three species (*G. appressum*: Clade J, *N. alternifolia*: Clade K and *B. celsianum*: Clade L) are polymorphic with both two and more than two ovules present. Therefore these supposedly separate character states in fact overlap.

Characteristics of the major clades

Most major clades in Figs. 2.1 & 2.2 show consistency in morphology and ecology among their included species as described in detail below.

Groups contained within Clade D, which consists entirely of species from *Gastrolobium* sensu Crisp and Weston (1987) and is sister to the rest of *Gastrolobium* sens. lat. (Clade C), include the *G. parviflorum* group of species, and members of the *G. bilobum* group (the type of the genus). These all share condensed, many-flowered racemes and have cuneate, emarginate leaves. Additionally, Clade D contains the strongly supported *G. spinosum* clade (D = 13, SYN = 23, BS = 99), which has spinose leaves, short, few-flowered racemes and strictly two ovules. Clade D also contains a number of species occurring solely on granite outcrops and their immediate margins, though these do not form a clade (*G. acrocaroli*, *G. callistachys*, *G. graniticum*, *G. involutum*, *G. semiteres*, and *G. stenophyllum*). (In fact, the only species occurring in the same habitat that is not within Clade D is *G. spectabile*, which occurs within Clade J.) These granite-inhabiting species all share a similar inflorescence and floral structure (long, open racemes with long internodes, relatively large flowers and strongly recurved calyx lobes), though the ovule number varies quite widely (see Table 2.4).

Clade E contains the tomentose-leaved *Gastrolobium* species. These four species all share details of the inflorescence structure (strongly hairy, with short floral internodes and with large, lanceolate bracts that persist longer than in most species of *Gastrolobium*, which are caducous), and all except *G. densifolium* have leaves that are tomentose on the abaxial surface. These species are the sister group to the 'sandplain' group (Clade F), though this is only weakly supported (D = 1, SYN = 10, BS = 63). These sandplain species are open, spreading shrubs which have tough, often glaucous leaves and long, open racemes, and generally have widespread distributions, occurring throughout the sandplains of south-west Western Australia. Both of these groups contain species with strictly two ovules.

There is very strong support for Clade G (D = 20, SYN = 31, BS = 100), though the composition of this group is somewhat puzzling. Two of these three species (*G. heterophyllum* and *G. nutans* ms.) share similar leaves and inflorescences, but the third

(*G. pusillum*) is very different in morphology, although this species does not strongly resemble any other species of *Gastrolobium* sens. lat. These species are well differentiated, having a number of morphological autapomorphies, including three different states for subtending floral bracts (entire, trifid, and entire and trifid).

The position of *Gastrolobium brownii* is interesting, as it was one of three species out of 22 transferred to *Nemcia* by Crisp and Weston (1987), (together with *G. pusillum* and *G. truncatum*), that were transferred back to *Gastrolobium* by Crisp and Weston (1995) because of uncertainties in relationships based on morphology. Like most of *Gastrolobium* sensu Crisp and Weston (1987), *G. brownii* is known to accumulate fluoroacetate. *Gastrolobium brownii* and *G. truncatum* both have inflorescences similar to many of those in the *Nemcia* group (short, few-flowered axillary racemes), and both sit with or near this group in the phylogeny presented here. Further evidence for their intermediate position between *Nemcia* and *Gastrolobium* sensu Crisp and Weston (1987) can be seen in the subtending floral bracts, as they have some bracts that are entire and some that are trifid. The group of species that are seemingly intermediate in morphology between *Gastrolobium* sensu Crisp and Weston (1987) and *Nemcia* (Clade I), which includes *N. hookeri*, *N. obovata*, *N. spathulata* and *N. plicata*, have more in common with *Gastrolobium*, such as short racemes, recurved calyx lobes, stipitate ovaries and ovoid fruits, than with the circumscription of *Nemcia* provided by Crisp and Weston (1987), despite possessing trifid bracts. *Gastrolobium truncatum* is weakly sister to *Nemcia pulchella* (with which it shares details of inflorescence structure such as short racemes, and petal coloration). Thus the molecular data agree with the morphology in placing this group of species intermediate between *Gastrolobium* sensu Crisp and Weston (1987) and *Nemcia*.

Within the rest of Clade J, a group of *Gastrolobium* sensu Crisp and Weston (1987) species form a strongly supported group (D = 9, SYN = 13, BS = 92). These species have similar morphology, including glaucous leaves with strongly reticulate venation and an intramarginal vein, inflorescences with long floral internodes, very pubescent calyces, and richly orange standard petals.

Clade K contains a group of *Nemcia* species and *Oxylobium lineare*. Within this clade, *Nemcia alternifolia* and *N. reticulata* are sister species sharing standard petals that are almost entirely maroon on the back, an identical inflorescence type (solitary or paired flowers in the axils) and strongly tomentose calyces. Similarly tomentose calyces are shared with *N. emarginata* and *N. retusa*, however the latter two species

have cuneate and emarginate leaves, two-toned hairs on the calyces (silver at the base, and golden brown at the top), and inflorescences clustered at the branchlet terminus with numerous flowers. *Oxylobium lineare* has similar leaves to those of *Nemcia reticulata*, but has a long raceme with many flowers that have uniformly coloured hairs on the calyces, and may be a reversion to a more typical, long *Gastrolobium*-type raceme as seen in the *Gastrolobium* groups towards the base of the tree. Many species of *Nemcia*, and a few in *Gastrolobium* (such as *G. heterophyllum*) have short axillary shoots with a short, terminal raceme, so not many developmental changes may be required to further reduce this to a solitary flower.

The red-flowered group (Clade L) includes *Brachysema*, *Jansonia*, and species of *Nemcia* with red flowers, plus some *Nemcia* species with orange flowers in condensed, dense racemes. There is some support for a sister relationship between *Brachysema celsianum* and *Jansonia formosa*, though this is not found in all trees, and they share riverine habitats and straggly habits. The other *Brachysema* species have similar floral architecture. Three out of four red-flowered *Nemcia* species group together strongly and consistently (D = 5, SYN = 7, BS = 88), and all four group together in some of the most parsimonious trees. The three presumably bee-pollinated *Nemcia* species share a condensed terminal raceme with many, large flowers that are strongly orange in colour, and have large, crenulate leaves.

Phylogenetic utility of the loci

Together, the three sequence regions used in this analysis provide a moderately well supported phylogeny. In a data set this large (94 taxa), numerous characters are required to obtain much resolution, and any DNA region alone is unlikely to yield a sufficient number of informative characters. For example, Table 2.2 shows that the *trn*K 5' intron, which has the greatest number of informative characters, only has 2.5 informative characters on average per taxon. In contrast, the combined analysis has 587 informative characters (including coded indels), or 6.3 characters on average per taxon.

Some regions appear more phylogenetically useful than others, however. The trees produced from only the *trn*K 5' intron and ETS data sets (not presented) more closely resemble the tree from the combined analysis than does that from the *psb*A/*trn*H

spacer data set. This may be due to the large number of indels (particularly deletions which can be large) present in the *psb*A/*trn*H spacer, most of which are not phylogenetically informative. These large deletions leave a large number of potential characters unavailable for many taxa. The analyses performed with and without coded indels produced trees with identical topologies, but when they were included support for individual clades increased slightly.

Different combinations of data sets also appear more phylogenetically informative than others, with the tree from the combined chloroplast data set most closely resembling the tree from the total combined data. The combined cpDNA set also has the largest number of informative characters. The tree from the combined *trn*K-ETS data set is next most similar to the tree from the total combined data, whilst the topology from the *psb*A/*trn*H-ETS data set is the most different from that from the total combined analysis. There is no strong disagreement between nuclear and chloroplast sequences, however, with all topologies being similar. However, it is felt that the best phylogeny is one estimated from all data, under the assumption the more characters added, the more robust the phylogeny becomes. The result of the partition homogeneity test, which showed no significant difference between the data sets, justifies the combining of the data into one analysis.

Implications for taxonomy

This study has important implications for the taxonomy of the *Gastrolobium* group. It provides strong support for the inclusion of *Brachysema*, *Jansonia* and *Nemcia* within *Gastrolobium* sensu Crisp and Weston (1987), and the continued recognition of all these genera as currently circumscribed is undesirable. There are two options for the taxonomy of this group. One would be to lump all species into *Gastrolobium*, and the other would be to split the *Gastrolobium* clade (Clade C) into different genera. The internal support of many branches within *Gastrolobium* (Figs. 2.1 & 2.2) is low (decay = 1 for many of them), with many of these branches forming a "ladder". In light of this low support and the overall shape of the tree, even though some individual groups have very strong support, the further splitting of *Gastrolobium* would not be the optimal nor stable solution. In addition, some of the genera would be difficult to distinguish morphologically, such as *Brachysema* and *Jansonia*, and

Gastrolobium and *Nemcia*, due to the similar combinations of characters present in these genera. Therefore, the lumping of *Brachysema*, *Jansonia*, *Nemcia* and *Oxylobium lineare* appears to have the strongest support from this analysis.

Chapter 3 – Molecular phylogeny of Gastrolobium and related genera using five molecular regions.

Disclaimer – The ITS and *trn*L/F sequences were provided by the laboratory of Dr M.D. Crisp, Division of Botany & Zoology, Australian National University, Canberra, Australia. The alignment and analysis of these sequences, however, is all my own work.

The results of this chapter have been submitted to Systematic Botany for publication.

Introduction

The taxonomy of *Gastrolobium* has been unstable throughout its history. The analysis presented in Chapter 2, using 94 taxa and three molecular regions, showed that *Gastrolobium* is paraphyletic, containing three other genera within it. Due to the history of taxonomic instability in this group, this result should be tested, before any more changes are made to its classification. This study uses five molecular regions, three of which (*psbA*/*trnH* intergenic spacer, the 5' *trn*K intron, and the 3' end of the ETS) were used in the 94-taxon analysis presented in Chapter 2, while two are new (the internal transcribed spacer from nrDNA and the *trn*L/*trn*F intergenic spacer from cpDNA), giving a total of 3 cpDNA and 2 nrDNA regions. Only 48 taxa had all five sequence regions available for analysis (Table 3.1), so this data set is significantly reduced with respect to the number of taxa sampled. In particular, many species of *Gastrolobium* sensu Crisp are missing, so that much internal resolution may be lost. However, this analysis can be used to test the overall robustness of the previous, larger analysis, and provide further information on which to base taxonomic decisions at genus level, rather than attempting to firmly establish internal relationships within *Gastrolobium* sens. lat.

The internal transcribed spacer (ITS)

The ITS region of nuclear ribosomal DNA has been widely used in the molecular systematics of plants, and has been useful in resolving phylogenies in a number of different lineages, including the legumes. Examples of work in the legumes include *Astragalus* L. (Wojciechowski *et al.* 1999), *Glycine* Willd. (Nickrent and Doyle, 1995; Kollipara *et al.* 1997), *Lotus* L. (Allan and Porter, 2000), *Lupinus* L. (Ainouche and Bayer 1999), and *Phaseolus* L. (Delgado-Salinas et al. 1999), the Carmichaelinae (Wagstaff *et al.* 1999), and molecular biogeography of the Dalbergieae (Lavin *et al.* 2000). However, resolution has been shown to be poor at the species level in the

legumes (for example, Nickrent and Doyle, 1995; Kollipara *et al.* 1997), and the region appears to be more informative at the intertribal level, at least among closely related tribes (see Kass and Wink, 1997; Crisp *et al.* in press).

The trnL-trnF intergenic spacer and the trnL intron

Many studies have now evaluated the use of the *trn*L/*trn*F intergenic spacer and the trnL intron of chloroplast DNA (e.g. Taberlet *et al.* 1991; Sang *et al.* 1997; Bayer and Starr 1998; Bayer *et al.* 2000), and have found also to be particularly useful at the intergeneric level, with some usefulness at the infrageneric level. Studies using the trnL/trnF spacer and the *trn*L intron in the Fabaceae include *Astragalus* (Wojciechowski *et al.* 1999), *Pultenaea* Sm. (Crisp *et al.* 1999), and *Vicia* L. (Fennell *et al.* 1998).

Materials and Methods

Taxon selection

The taxa used in this analysis were all present in the 94-taxon analysis presented in Chapter 2, but of these only 48 sequences were available for the ITS and *trn*L/*trn*F regions. These sequences are part of a larger, higher level phylogeny being prepared by M.D. Crisp and co-workers, so the detail of individual genera has been sacrificed in order to obtain higher level relationships. However, 10/60 species of *Gastrolobium*, 12/40 species of *Nemcia*, 9/10 species of *Brachysema*, plus *Jansonia formosa* and *Oxylobium lineare* are present in the ingroup. This provided enough taxa to test the robustness of the 94-taxon phylogeny, and thus the monophyly of *Gastrolobium* and allied genera. The outgroups are the same as the previous analysis, but with four omissions – *Latrobea hirtella*, *Podolobium aciculiferum*, *Phyllota phylicoides* and *Pultenaea dentata*.

DNA isolation, amplification and sequencing

Total DNA extraction and clean-up used the methods presented in Chapter 2. Chapter 2 contains details of PCR amplification for the *psbA/trnH* spacer, the *trn*K 5' intron, and the ETS.

Table 3.1. List of taxa presented in the analysis, with their GenBank accession numbers. See Table 2.1 for GenBank accession numbers for the *psbA/trnH* spacer, the *trn*K 5' intron and the ETS.

Taxon	Collector	No.	Locality	*Trn*K 5' intron accession	*psb*A-*trn*H accession	3' ETS accession	ITS accession	*trn*L/*trn*F accession
Brachysema bracteolosum F.Muell.	G.T. Chandler	426	Bremer Bay, WA.	AF298424	AF298330	AF298236	AY015063	AY015180
Brachysema celsianum Lem.	M.D. Crisp	9009	Mogumber, WA.	AF298425	AF298331	AF298237	AY015064	AY015181
Brachysema latifolium R.Br.	G.T. Chandler	365	Lort River, WA.	AF298426	AF298332	AF298238	AY015065	AY015182
Brachysema melanopetalum F.Muell.	M.D. Crisp	8470	Manjimup, WA.	AF298427	AF298333	AF298239	AY015066	AY015183
Brachysema minor Crisp	M.D. Crisp	8922	Mt Barker, WA.	AF298428	AF298334	AF298240	AY015067	AY015184
Brachysema modestum Crisp	M.D. Crisp	8465	Busselton, WA.	AF298429	AF298335	AF298241	AY015068	AY015185
Brachysema praemorsum Meisn.	G.T. Chandler	729	Mt Barker area, WA.	AF298430	AF298336	AF298242	AY015069	AY015186
Brachysema sericeum Domin	J.M. Taylor	1959	Hay River, WA.	AF298431	AF298337	AF298243	AY015070	AY015187
Brachysema subcordatum Benth.	M.D. Crisp	8511	Porongorup Range	AF298432	AF298338	AF298244	AY015071	AY015188
Callistachys lanceolata Vent.	G.T. Chandler	474	Albany area, WA.	AF298433	AF298339	AF298245	AY015072	AY015189
Gastrolobium bilobum R.Br.	G.T. Chandler	724	Two People Bay, WA.	AF298437	AF298343	AF298249	AY015073	AY015190
Gastrolobium brownii Meisn.	G.T. Chandler	726	Denmark area, WA.	AF298438	AF298344	AF298250	AY015074	AY015191
Gastrolobium calycinum Benth.	G.T. Chandler	544	Wongan Hills, WA.	AF298440	AF298346	AF298252	AY015075	AY015192
Gastrolobium congestum ms.	G.T. Chandler	404	Fitzgerald River National Park, WA.	AF298441	AF298347	AF298253	AY015076	AY015193
Gastrolobium cuneatum Henfr.	M.D. Crisp	8937	Blackwood River, WA.	AF298443	AF298349	AF298255	AY015077	AY015194
Gastrolobium grandiflorum F.Muell.	G.T. Chandler	598	Aust Nat Botanic Gardens	AF298448	AF298354	AF298260	AY015078	AY015195
Gastrolobium parviflorum (Benth.) Crisp	G.T. Chandler	760	Narrogin, WA.	AF298458	AF298364	AF298270	AY015079	AY015196
Gastrolobium pusillum Crisp & P.H.Weston	M.D. Crisp	8921	Mt Barker, WA.	AF298461	AF298367	AF298273	AY015080	AY015197
Gastrolobium spinosum Benth.	G.T. Chandler	548	Mt O'Brien, WA.	AF298469	AF298375	AF298281	AY015081	AY015198
Gastrolobium truncatum Benth.	M.D. Crisp	8919	Bokal, WA.	AF298478	AF298384	AF298290	AY015082	AY015199
Isotropis cuneifolia Heynh.	M.D. Crisp	8459	Mogumber, WA.	AF298481	AF298387	AF298293	AY015083	AY015200
Jacksonia horrida DC.	M.D. Crisp	8934	Scott River, WA.	AF298482	AF298388	AF298294	AY015084	AY015201
Jansonia formosa Kipp.	M.D. Crisp	8933	Scott River, WA.	AF298483	AF298389	AF298295	AY015085	AY015202
Mirbelia depressa E.Pritzel	M.D. Crisp	9020	Perenjori, WA.	AF298485	AF298391	AF298297	AY015086	AY015203
Mirbelia dilatata R.Br.	M.D. Crisp	8491	Stirling Range, WA.	AF298486	AF298392	AF298298	AY015087	AY015204
Nemcia alternifolia ms.	M.D. Crisp	8512	York area, WA.	AF298487	AF298393	AF298299	AY015088	AY015205

Nemcia coriacea Domin	G.T. Chandler	723	Nanarup area, WA.	AF298488	AF298394	AF298300	AY015089	AY015206
Taxon	Collector	No.	Locality	*Trn*K 5' intron accession	*psb*A-*trn*H accession	3' ETS accession	ITS accession	*trn*L/*trn*F accession
Nemcia hookeri (Meisn.) Crisp	M.D. Crisp	8907	York area, WA.	AF298491	AF298397	AF298303	AY015090	AY015207
Nemcia leakeana (Drumm.) Crisp	M.D. Crisp	8481	Stirling Range, WA.	AF298492	AF298398	AF298304	AY015091	AY015208
Nemcia luteifolia Domin	M.D. Crisp	9407	Stirling Range, WA.	AF298493	AF298399	AF298305	AY015092	AY015209
Nemcia obovata (Benth.) Crisp	G.T. Chandler	657	Watheroo, WA.	AF298494	AF298400	AF298306	AY015093	AY015210
Nemcia plicata (Turcz.) Crisp	G.T. Chandler	623	Badgingarra area, WA.	AF298495	AF298401	AF298307	AY015094	AY015211
Nemcia pulchella (Turcz.) Crisp	M.D. Crisp	8480	Stirling Range, WA.	AF298496	AF298402	AF298308	AY015095	AY015212
Nemcia pyramidalis (T.Moore) Crisp	G.T. Chandler	488	Stirling Range, WA.	AF298497	AF298403	AF298309	AY015096	AY015213
Nemcia reticulata Domin	G.T. Chandler	540	Seabird, WA.	AF298498	AF298404	AF298310	AY015097	AY015214
Nemcia spathulata (Benth.) Crisp	M.D. Crisp	8448	Bindoon, WA.	AF298501	AF298407	AF298313	AY015098	AY015215
Nemcia vestita Domin	M.D. Crisp	8489	Stirling Range, WA.	AF298502	AF298408	AF298314	AY015099	AY015216
Oxylobium arborescens R.Br.	G.T. Chandler	616	Gibraltar Range, NSW.	AF298504	AF298410	AF298316	AY015100	AY015217
Oxylobium ellipticum R.Br.	G.T. Chandler	603	Aust Nat Botanic Gardens	AF298505	AF298411	AF298317	AY015101	AY015218
Oxylobium lineare (Benth.) Benth.	M.D. Crisp	8471	Tonebridge, WA.	AF298506	AF298412	AF298318	AY015102	AY015219
Oxylobium pulteneae DC.	M.D. Crisp	9046	Howes Valley, NSW.	AF298507	AF298413	AF298319	AY015103	AY015220
Oxylobium robustum Joy Thomps.	I.R. Telford	4294	Lake Cootharaba, QLD.	AF298508	AF298414	AF298320	AY015104	AY015221
Podolobium aestivum Crisp & P.H.Weston	G.T. Chandler	612	Gibraltar Range, NSW.	AF298511	AF298417	AF298323	AY015105	AY015222
Podolobium alpestre (F.Muell.) Crisp & P.H.Weston	G.T. Chandler	1039	Brindabella Range, ACT.	AF298512	AF298418	AF298324	AY015106	AY015223
Podolobium ilicifolium (Andrews) Crisp & P.H.Weston	G.T. Chandler	308	Nelligen, NSW.	AF298513	AF298419	AF298325	AY015107	AY015224
Podolobium procumbens (F.Muell.) Crisp & P.H.Weston	B. Hadlow	461	Verneys Range, NSW.	AF298514	AF298420	AF298326	AY015108	AY015225
Podolobium scandens DC.	G.T. Chandler	309	Nelligen, NSW.	AF298515	AF298421	AF298327	AY015109	AY015226
Pultenaea dentata Labill.	M.D. Crisp	9053	Boonoo Boonoo Falls, NSW.	AF298516	AF298422	AF298328	AY015110	AY015227

trnL/F intergenic spacer and the internal transcribed spacer sequence data

These sequences were provided by M. D. Crisp, and the protocols and primers used follow those of Crisp *et al.* (1999).

Sequencing of PCR products

Chapter 2 provides details of the sequencing of the psbA/trnH spacer, the trnK 5' intron and the ETS. Those for the trnL/trnF spacer and the ITS follow those of Crisp *et al.* (1999).

Sequence data analysis

Sequence data were analysed using the methods presented in Chapter 2.

Results

Sequence characteristics

Table 3.2 presents statistics for the sequences used, including length variation, proportion of nucleotide differences, G/C content, sequence divergence, informative characters, and indel information, while a summary is provided here. Combined sequence lengths vary from 2750 bp in *Callistachys lanceolata* to 3109 bp in *Gastrolobium congestum* ms.; the *psbA/trnH* spacer ranges from 180 bp in *Isotropis cuneifolia* to 413 bp in *Oxylobium lineare*; the *trn*K 5' intron varies from 878 bp in *Oxylobium arborescens* to 1016 bp in *Nemcia alternifolia* ms.; the ETS is from 321 bp in *Pultenaea dentata* to 328 bp in *O. robustum* in length; the ITS ranged from 560 bp in *P. dentata* and 573 bp in *G. congestum* ms.; and in the trnL/trnF spacer, length varies from 622 bp in *C. lanceolata* and 906 bp in *Podolobium ilicifolium* (Table 3.2).

G/C content across all sequences ranges from 38.82% in *Isotropis cuneifolia* to 41.85% in *Callistachys lanceolata*; that of the *psbA/trnH* spacer ranges from 25.64% in *N. leakeana* to 31.97% in *B. celsianum*; that of the *trn*K 5' intron varies from 32.81% in *N. alternifolia* to 35.47% in *Isotropis cuneifolia*; in the ETS it ranges from 51.45% in *Mirbelia depressa* to 64.19% in *Callistachys lanceolata*; the ITS G/C content ranges from 51.50 % in *I. cuneifolia* and 60.62 % in *Brachysema sericeum*; and in the trnL/trnF spacer it varies from 31.31% in *N. plicata* and 35.64 % in *C. lanceolata*.

In the combined matrix, sequence divergence varies from 3.27% between *Nemcia hookeri* and *N. obovata* to 19.17% between *Gastrolobium brownii* and *Isotropis cuneifolia*; in the *psbA/trn*H spacer it varies from 0% between *Podolobium alpestre* and *P. procumbens* to 21.36% between *Gastrolobium parviflorum* and *Isotropis cuneifolia*;

in the *trn*K 5' intron it ranges from 0.10% between *Nemcia hookeri and N. obovata* to 20.2% between *Isotropis cuneifolia* and *Brachysema subcordatum*; in the ETS it ranges from 0% between two sets of taxa (*N. leakeana*/*N. luteifolia*, and *N. coriacea*/*N. hookeri*/*N. obovata*/*N. plicata*) to 28.44% between *Callistachys lanceolata* and *Isotropis cuneifolia*; that in the ITS ranges from 0.35 % between *N. luteifolia* and *N. pyramidalis* and 19.10 % between *Isotropis cuneifolia* and *N. leakeana*; and in the trnL/trnF spacer it varies from 0.12 % between *N. hookeri* and *N. obovata* and 19.15 % between *I. cuneifolia* and *G. brownii*.

The number of unambiguous indels in each sequence varies considerably, with numerous indels present in the *psbA/trnH* spacer (ranging in size from 2 to 241 bp) to very few in the ETS, ITS and *trn*L/*trn*F (all of which were autapomorphic, and therefore phylogenetically uninformative). Only the number of unambiguously coded indels are given in Table 3.3, which range from 2 to 241 bp in the *psbA/trnH* spacer, 5 to 20 bp in the *trn*K intron, and none in the ETS, ITS and *trn*L/*trn*F spacer.

Phylogenetic reconstruction

A heuristic search of all nucleotide characters, including indels, revealed four trees of 3022 steps, with CI = 0.64, RI = 0.64, RC = 0.41. The strict consensus tree is presented in Fig. 3.1, which also shows the decay and bootstrap values calculated for each clade. One tree out of four is presented in Fig. 3.2, showing the number of synapomorphies supporting each branch. The partition homogeneity test indicated the data sets are not significantly different (p = 0.06), and can therefore be combined into one analysis.

Topology of major clades

The topologies of the major clades are described below. All of these clades have letters delimiting them on the majority rule tree (Fig. 3.1). NA following a particular statistic means not applicable.

TABLE 3.2. Sequence characteristics of the *psbA/trnH* spacer, the *trn*K 5' intron and the external transcribed spacer (ETS) sequenced in this study. NA = not applicable.

Sequence characteristic	*psb*A/*trn*H Spacer	*trn*K 5' Intron	3' ETS	ITS	trnL/F Spacer	Combined (all 5 sequences)
Length range (bp)	180-414	816-1016	315-345	560-573	622-906	2750-3109
Length mean (bp)	356	897	339	568	811	2960
Aligned length (bp)	603	1352	355	593	1036	3954
G + C content mean	29.5%	33%	58%	59%	33%	40%
Sequence divergence (%)	0.00-21.36%	0.00-20.20%	0.00-28.44%	0.35-19.10%	0.10-19.10%	3.27-19.17%
Number of variable sites	328/603 (54%)	466/1352 (34%)	233/355 (65%)	229/593 (38%)	369/1036 (35%)	1469/3954 (37%)
Number of potentially informative sites	192/603 (32%)	237/1352 (18%)	142/355 (40%)	125/593 (21%)	137/1036 (12%)	674/3954 (17%)
Number of constant sites	275/603 (46%)	887/1352 (66%)	123/355 (35%)	365/593 (62%)	682/1036 (65%)	2485/3954 (63%)
Number of autapomorphic sites	136/603 (22%)	229/1352 (16%)	91/355 (25%)	104/593 (17%)	232/1036 (23%)	795/3954 (20%)
Number of unambiguously coded indels	5	11	0	0	0	16
Coded indel size range (bp)	2-241	5-20	0	0	0	2-241
Ratio of coded indels to potentially informative sites	1:38	1:22	NA	NA	NA	1:42

The first labeled clades appear to be the most closely related clades to *Gastrolobium*. *Clade A* [Decay (D) = 4, synapomorphies (SYN) = 24, Bootstrap (BS) = 64] contains the "Oxylobium" group (*Callistachys*, *Mirbelia*, *Oxylobium* and the *Podolobium alpestre* group). Within this clade, *Clade B* (D = 28, SYN = 51, BS = 100) contains the *Podolobium alpestre* and *Callistachys* clade, and *Clade C* (D = 17, SYN = 29, BS = 100) contains the *Oxylobium* sensu Crisp (1987) clade.

Clade D (D = 44, SYN = 65, BS = 100) is comprised of the *Podolobium ilicifolium* group.

Clade E (D = 27, SYN = 46, BS = 100) contains the *Gastrolobium* sensu Crisp group, including *Brachysema*, *Jansonia*, *Nemcia* and *O. lineare*. Ovule number ranges from 2 to 21.

The first clade of the *Gastrolobium* group is a single species lineage, Clade F (D = NA, SYN = 61, BS = NA), and contains *G. pusillum*, with 4-10 ovules, while Clade G (D = 3, SYN = 20, BS = 60) is made up of a group of core *Gastrolobium* species, including *G. spinosum*, *G. cuneatum*, *G. bilobum*, *G. congestum*, *G. grandiflorum* and *G. parviflorum*, and the ovule number ranges from 2 to 5, while the subtending floral bracts are all entire.

Clade H (D = 2, SYN = 4, BS = 25) contains *Brachysema latifolium*, as well as four *Nemcia* species with morphological traits intermediate between *Gastrolobium* and *Nemcia*, including *N. hookeri*, *N. obovata*, *N. plicata* and *N. spathulata*, with the ovule number ranging from 2 in the *Nemcia* species to 21 in *Brachysema latifolium*, and the subtending floral bracts are all trifid.

Clade I (D = NA, SYN = 42, BS = NA) is a single species lineage containing *G. calycinum*, which is the only representative of this subgroup found in the 94-taxon analysis in Chapter 2, and it has two ovules and entire subtending floral bracts.

The next few clades contain only single species lineages. Clade J (D = 5, SYN = 16, BS = 67) includes *G. brownii* and *G. truncatum*, which have two ovules and both entire and trifid subtending floral bracts; Clade K (D = NA, SYN = 41, BS = NA) contains only *N. pulchella*, which has two ovules and trifid bracts; whilst Clade L (D = 2, SYN = 9, BS = 29) is made up of *N. alternifolia*, *N. reticulata* and *Oxylobium lineare*, which vary in ovule number from two to 18, but all have trifid bracts.

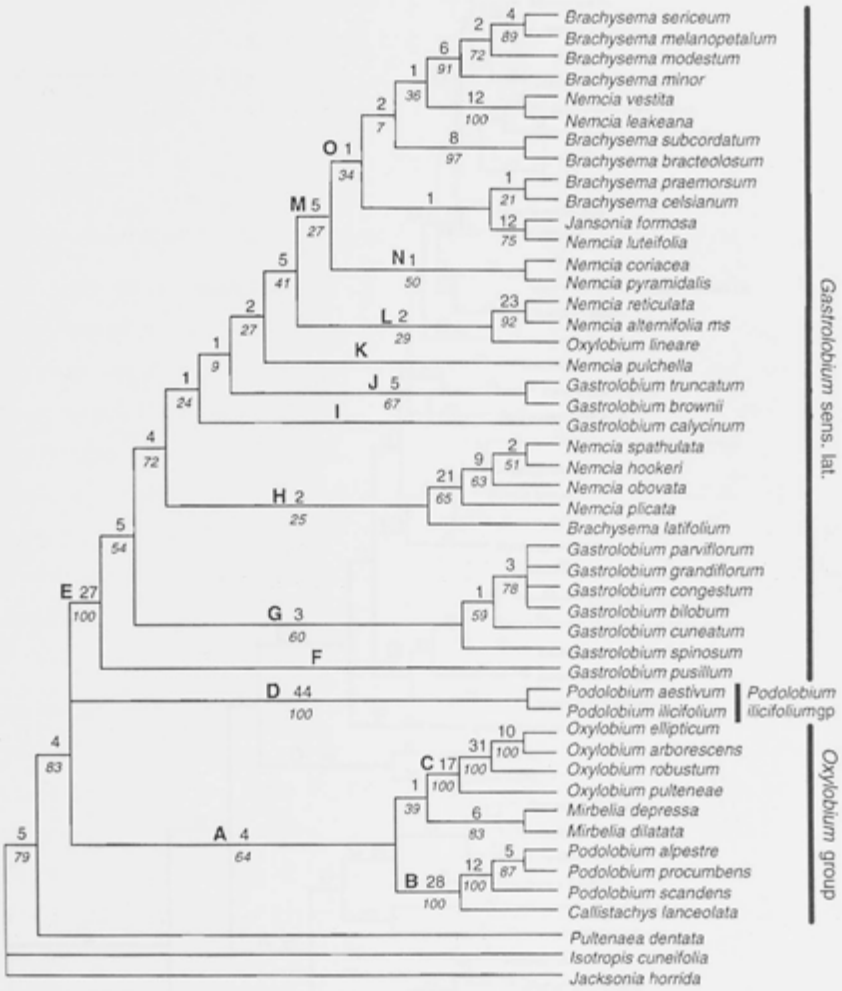

Fig. 3.1. Strict consensus tree of 4 trees, of length 3022 steps. CI = 0.64, RI = 0.64. The major clades are marked A to O. Decay values are given above the line, bootstrap values below.

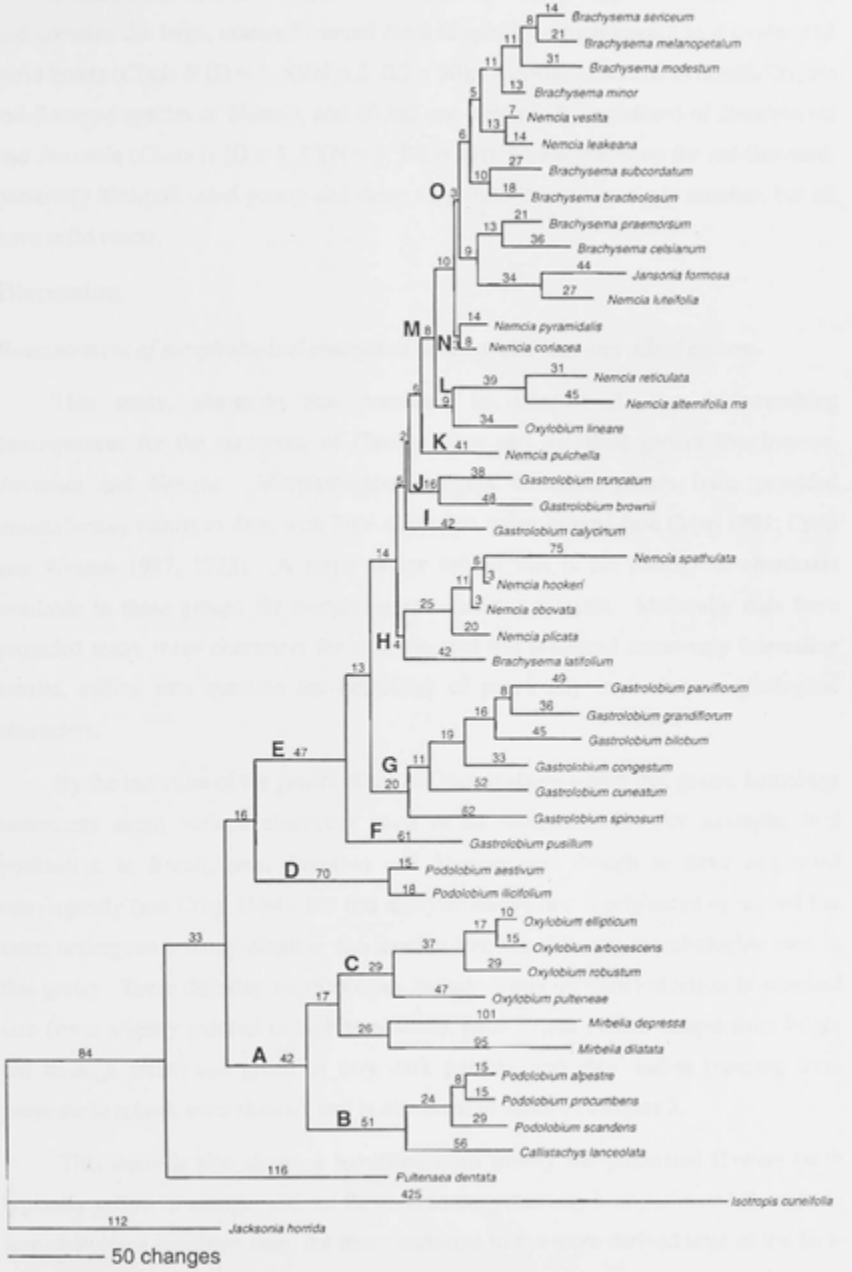

Fig. 3.2. Phylogram of one tree of four. Synaopmorphies for each branch are given, and the major clades are marked A to O. Branch lengths are proportional to the amount of change, and a scale is provided.

Clade M (D= 5, SYN = 10, BS = 27) has two weakly supported clades within it, and contains the large, orange-flowered *Nemcia* species, which have 2 to 4 ovules and trifid bracts (*Clade N* [D = 1, SYN = 3, BS = 50]; *N. coriacea* and *N. pyramidalis*), the red-flowered species of *Nemcia*, and all but one species (*B. latifolium*) of *Brachysema* and *Jansonia* (*Clade O* [D = 1, SYN = 3, BS = 34]), which makes up the red-flowered, putatively bird-pollinated group, and these vary from 2 to 21 in ovule number, but all have trifid bracts.

Discussion

Reassessment of morphological characters in Gastrolobium and allied genera.

This study, alongside that presented in Chapter 2, has wide-reaching consequences for the taxonomy of *Gastrolobium* and its allied genera *Brachysema*, *Jansonia* and *Nemcia*. Morphological analyses of these genera have provided unsatisfactory results to date, with little resolution being offered (see Crisp 1994; Crisp and Weston 1987, 1995). A major factor behind this is the paucity of characters available in these groups for morphological cladistic analysis. Molecular data have provided many more characters for analysis, and has produced some very interesting results, calling into question the homology of previously important morphological characters.

By the inclusion of the genera allied to *Gastrolobium* within that genus, homology statements about various characters need to be reconsidered. For example, bird pollination in *Brachysema*, *Jansonia* and *Nemcia* was though to have originated convergently (see Crisp 1994), but this analysis shows that it originated once, and has since undergone a morphological acceleration into the different morphologies seen in this group. These differing morphologies include a non-uniform reduction in standard size (from slightly reduced to highly reduced), petal colour (which ranges from bright red through cream and green to very dark purple), and plant habits (ranging from prostrate to robust, erect shrubs), and is discussed in detail in Chapter 2.

This analysis also shows a transition from mostly bee-pollinated flowers (with typically yellow or orange, and red flowers) to the putatively bird-pollinated flowers, in turn showing a transition from the more primitive to the more derived state in the bird-pollinated clade. If such a transition exists in the *Gastrolobium* group, it may also exist within other genera of the Mirbelieae/Bossieeae, as red flowers with elongated keels are

found in species of *Bossiaea*, *Chorizema*, *Daviesia*, *Gompholobium*, *Leptosema*, *Mirbelia* and *Sphaerolobium*.

In the past, subtending floral bract type and ovule number were used as characters to distinguish *Gastrolobium* from other genera, notably *Oxylobium*, which has more than two ovules, and *Nemcia*, which has two ovules and trifid bracts. Table 2.4 shows the inadequacy of both of these characters. Generally, it is true that *Nemcia* has trifid bracts, but a number of species of *Gastrolobium* have both trifid and entire bracts, generally within one plant, but sometimes on one inflorescence (for example, *G. heterophyllum*). Ovule number varies throughout the genus, and indeed, throughout the analysis presented here and in Chapter 2. Many species have strictly two ovules, including many but not all species of *Nemcia*, but these often occur in clades where there are species with more than two ovules present. In fact, *G. congestum* ms. has 2-3 ovules (as does *G. appressum*, which is not included in this analysis, but is included in the 94-taxon analysis in Chapter 2), showing an overlap between these supposedly separate character states.

Comparisons with the 94-taxon analysis and topology of the major clades

This analysis shows that *Gastrolobium* is paraphyletic, containing within it the genera *Brachysema*, *Jansonia*, *Nemcia*, and *Oxylobium lineare*, the same result that the 94-taxon analysis gave (Chapter 2), with the two analyses sharing similar topologies. The sister group affinity of the *Podolobium ilicifolium* group, however, is much weaker in this reduced data set, because the *P. ilicifolium* group, the *Oxylobium* group and the *Gastrolobium* sens. lat. group form a basal polytomy (Fig. 3.1). Ongoing work in the tribes Mirbelieae and Bossieeae (Crisp *et al.* in press) shows that this is not an unusual result. Strongly supported genera are often found, yet the relationships between these genera is often tenuous, possibly indicating a "starburst" radiation in this group. In this analysis, five molecular regions were used, netting 674 parsimony informative characters for 48 taxa (leaving on average 14 characters per taxon), yet the sister group relationships to *Gastrolobium* are not clearly resolved.

Gastrolobium pusillum has moved to the base of *Gastrolobium* in the current analysis, though the two apparent sister species (*G. heterophyllum* and *G. nutans*) are missing from this analysis. The topology of Clade E, however, is almost identical to that of Clade D in the 94-taxon analysis (Fig. 2.1), with the *G. spinosum* group, the granite group (which includes *G. bilobum*) and the *G. parviflorum* group forming a moderately well supported clade (D = 3, SYN = 20, BS = 60).

Within Clade F of the current analysis, four species of *Nemcia* with intermediate morphology between *Gastrolobium* and *Nemcia* are present (which will be termed the *N. obovata* group for ease of discussion), again with the same topology and position as was the case in the 94-taxon analysis (Fig. 2.1). The topology of this tree, however, is somewhat different to that in Chapter 2. This is not surprising, in the light of a weak backbone in the 94-taxon analysis, which does not improve much in the 48-taxon analysis. The changes to the topology are detailed below.

In the current analysis, *Brachysema latifolium* has changed positions, and is now allied with this group of *Nemcia* species, away from *G. truncatum* and *N. pulchella*. *Gastrolobium brownii* has moved away from the *N. obovata* group to become the sister taxon to *G. truncatum*. These taxa share similar morphological features, such as short, few-flowered axillary racemes, the subtending floral bracts are both entire and trifid within one plant, and both have strictly two ovules.

Gastrolobium calycinum, the only representative of the group of core *Gastrolobium* species from Clade J in the 94-taxon (Fig. 2.1), is present on its own, as sister to the clade containing *G. brownii* and *G. truncatum*. In turn, these are sister to *N. pulchella*. In the 94-taxon analysis, three of these species (*G. calycinum*, *G. truncatum* and *N. pulchella*) occurred in the same clade (Clade J, Fig. 2.1). In this analysis, they do not form a clade, instead they form a ladder along the backbone of the tree that has little or no support. *Gastrolobium brownii* and *G. truncatum* both have inflorescences similar to many of those in the *Nemcia* group (short, few-flowered axillary racemes), and both sit in a more or less intermediate position in the present analysis. Further evidence for their intermediate position can be seen in the subtending floral bracts, as they have some bracts that are entire and some that are trifid.

Clade J contains three taxa, all of which occurred in the one clade in the 94-taxon analysis (Clade K, Fig. 2.1), including *Oxylobium lineare*, *N. alternifolia* ms. and *N. reticulata*. The two *Nemcia* species are sisters, and share standard petals that are almost entirely maroon on the back, an identical inflorescence type (solitary or paired flowers in the axils) and strongly tomentose calyces. *Oxylobium lineare* has similar leaves to those of *Nemcia reticulata*, but has a long raceme with many flowers that have uniformly coloured hairs on the calyces, and may be a reversion to a more typical, long *Gastrolobium*-type raceme as seen in the more basal *Gastrolobium* groups. Many species of *Nemcia*, and a few in *Gastrolobium* (such as *G. heterophyllum* and *G.*

truncatum) have short axillary shoots with a short, terminal raceme, so only a few developmental steps may be required to reduce this to a solitary flower.

The last major clade in the reduced analysis (Clade K, Fig. 3.1) contains two subgroups, the first including the large, orange-flowered *Nemcia* species (Clade L), and the other containing the red-flowered *Nemcia* species, *Brachysema* and *Jansonia* (Clade M). Interestingly, in this analysis, the large, orange-flowered *Nemcia* species occur at the base of the red-flowered clade, whereas in the 94-taxon analysis, the large, orange-flowered *Nemcia* species occurred well within the red-flowered species (see Fig. 2.1), and although this result is not strongly supported, it is very interesting, because it suggests that the orange-flowered species could be transitional from bee pollinated flowers to bird pollinated flowers.

Providing answers to the Gastrolobium generic dilemma

The taxonomy of *Gastrolobium* has been unstable since its description by Brown (1811). Factors such as toxicity, ovule number and pollination syndrome have at times heavily influenced taxonomic decision making in these genera. However, the great wealth of morphological divergence, particularly in vegetative morphology, within this group has led to confusion about homology statements, particularly in regard to pollination syndrome and ovule number. On the strength of the two analyses presented, one using three molecular regions with 94 taxa, and one using five molecular regions with 48 taxa, an expanded *Gastrolobium* is strongly supported (Clade C, Fig. 2.1: D = 19, SYN = 30, BS = 79; Clade C, Fig. 3.1: D = 27, SYN = 46, BS = 100). There is also a strong intermediate node within *Gastrolobium* sens. lat., midway along the backbone of the cladogram (Fig. 3.1). This strengthens the evidence in favour of the lumping of *Brachysema*, *Jansonia* and *Nemcia* into *Gastrolobium*.

In conclusion, *Gastrolobium* will be expanded to include *Brachysema*, *Jansonia* and *Nemcia*. The taxonomy will be presented in Chapter 5, including descriptions of new species, and any new combinations that are required.

Chapter 4 – General Discussion

The Mirbelieae is a tribe of legumes that are endemic to Australia and comprise some 24 genera and about 650 species, and there is a wealth of morphological diversity within the tribe. For example, *Daviesia* has phyllodes rather than true leaves, *Gompholobium* has palmately or pinnately compound leaves (all other genera in the tribe have simple leaves or phyllodes), *Mirbelia* has a septum that divides the fruits into two locules, whereas species of *Gastrolobium* often contain toxic fluoroacetate, *Sphaerolobium* and *Viminaria* are basically leafless, and a number of genera contain putatively bird-pollinated species (e.g. *Bossiaea*, *Chorizema*, *Daviesia*, *Gastrolobium*, *Gompholobium*, *Leptosema*, *Mirbelia* and *Sphaerolobium*).

The taxonomy and classification of *Gastrolobium* sens. lat. has been unstable, and species transfers have been frequent between *Gastrolobium*, *Oxylobium* and *Nemcia*, as previously discussed. As well, a number of species of *Gastrolobium* described in the early 1800's were transferred to and from genera such as *Chorizema* and *Mirbelia*. For example, *Gastrolobium racemosum* was originally described as a *Mirbelia*, then placed into *Chorizema*, and finally being transferred to *Gastrolobium*, and conversely *Gastrolobium seorsifolium* F.Muell. was transferred to *Mirbelia*. Misleading homoplastic morphological characters abound, for example, inflorescence structure in particular is variable within *Gastrolobium* sens. lat., many 'core' species of *Gastrolobium*, have long, many-flowered racemes, and many species that were transferred to *Nemcia* had reduced racemes, often to only one flower in the axils of the leaves.

Brachysema and *Jansonia*, together with the red-flowered species of *Nemcia*, appear to share a common ancestor. This group may then have undergone a rapid morphological radiation, giving rise to the present diversity. This large, putatively bird-pollinated group is part of *Gastrolobium*, rather than a separate lineage within the tribe. While there are large morphological differences between these species and *Gastrolobium* sensu Crisp, the basic architecture of the plants is quite similar. Given the variation shown within some genera in this tribe, it is not particularly surprising that *Gastrolobium* contains such a wealth of diversity.

Evidence for an expanded Gastrolobium

The two analyses presented here, one using three molecular regions and 94 taxa, and the other using five molecular regions and a 48-taxon subset of the previous data

set, show that the previous circumscription of *Gastrolobium* is paraphyletic, and contains within it *Brachysema*, *Jansonia*, and *Nemcia*. Also within this greater *Gastrolobium*, *Nemcia* is polyphyletic. Support for the clade including *Gastrolobium* and allied genera is very strong (Clade C in both Figs. 2.1 and 3.1). In the 94-taxon analysis it has a decay value of 19, 30 synapomorphies, and a bootstrap of 79. In the 48-taxon analysis, the support for a greater *Gastrolobium* is a decay value of 27, 47 synapomorphies and a bootstrap of 100. While much of the support along the backbone of the tree in both analyses is low, there are some intermediate nodes in each analysis that have strong support (e.g. the node below clade F on Fig. 3.1, D = 4, SYN = 14, BS = 72), lending further support to the lumping of *Brachysema*, *Jansonia*, and *Nemcia* into *Gastrolobium*. The morphological similarities and evolutionary progressions previously discussed, such as ovule number, subtending floral bract type, fluoroacetate content, and stipitate ovaries, as well as the basic architecture of the leaves, inflorescence and flowers, all favor the circumscription of a larger *Gastrolobium*.

Implications for the taxonomy of the Mirbelieae/Bossiaeeae

Gastrolobium is not the only genus in the Mirbelieae/Bossiaeeae to have a complicated morphology and complex interspecies relationships. For example, *Pultenaea* has had some small genera split from it (including *Almalaea* and *Stonesiella*, the latter being segregated on the basis of molecular evidence Crisp *et al.* 1999). There are a number species of *Pultenaea* from Western Australia that are morphologically dissimilar to the eastern Australian species (where the main centre of diversity lies), and their placement in *Pultenaea* is questionable. This problem needs further investigation using molecular data.

Molecular data has already helped to clarify relationships at much higher levels in the tribes Mirbelieae and Bossiaeeae. Crisp *et al.* (in press) show the Bossiaeeae nested within the Mirbelieae, and that this greater Mirbelieae has two distinct groups. In the past, the two tribes were separated on the basis of staminal fusion, with the Mirbelieae having free or cohering filaments, and the Bossiaeeae having a staminal tube. Two possible taxonomic solutions are to subsume one tribe into the other, or to recircumscribe the two tribes separately based on new evidence. There is morphological evidence to support the recircumscription of the two tribes into a 5-nucleate embryo sac tribe and a giant antipodals tribe, rather than lumping the two (Cameron and Prakash, 1990, 1994). Again, this shows that morphological homology statements need to be reexamined, but also indicates that new morphological characters

can be found to resolve relationships in these tribes. In any case, the relationships in this group have bee clarified by the use of molecular data.

Conclusions

This aims of this study were to resolve long standing phylogenetic problems in *Gastrolobium* and the allied genera *Brachysema*, *Jansonia* and *Nemcia*, and to provide a taxonomic treatment of *Gastrolobium*. Two molecular phylogenies were produced, one using 94 taxa and three molecular regions, and the other using a 48 taxon subset and five regions. Both analyses produced well-supported phylogenies with similar topologies, and both support the lumping of *Brachysema*, *Jansonia* and *Nemcia* into *Gastrolobium*. Morphology was used to create a monograph of the expanded *Gastrolobium*, including 109 species, and 29 of which were previously undescribed. New combinations were made for the species transferred from *Brachysema* and *Jansonia*, plus some species of *Nemcia* that were not previously included in *Gastrolobium*.

Future directions

While a large phylogeny was produced by this study, further work could be done. Some groups of species (e.g. the exstipulate species, including *Gastrolobium punctatum*, as well as a number of new species) were not included in the analysis. A future study could add these taxa in an attempt to place them phylogenetically within *Gastrolobium*. Also, an examination of fluoroacetate levels and the evolution of fluoroacetate were not attempted in this study, but would be interesting. Many species of *Gastrolobium* sens. lat. are assumed to be non-toxic (including species from *Brachysema*, *Jansonia* and *Nemcia*), but may contain trace levels of the toxin. Many species of *Gastrolobium* sensu Crisp have also not been tested for fluoroacetate levels. Examination of the levels of toxin in species of *Gastrolobium* may lead to a better understanding of the evolution of the fluoroacetate in this group.

Chapter 5 – Taxonomy of *Gastrolobium*

Disclaimer – Dr Lindy Cayzer provided much of the data used in approximately 40 descriptions of species that were previously in *Nemcia*, to which I added significant information. I also consulted the notes of Dr M. D. Crisp, collated over many years, on type specimens for all genera, as well as those on *Nemcia*. All other work is entirely my own.

This chapter has been submitted to Australian Systematic Botany for publication.

Introduction

Taxonomic history and problems

Throughout its taxonomic history, the circumscriptions of *Gastrolobium* and its allied genera, particularly *Oxylobium* Jackson, have changed considerably. As a result, species have been transferred from one genus to another on several occasions. A major component of the problem of the circumscription of *Gastrolobium* is due to the fact that morphological data has, to date, failed to fully resolve the relationships within the tribes Mirbelieae and Bossiaeeae (see Crisp and Weston, 1987, 1995), especially the *Gastrolobium/Oxylobium* generic group.

Gastrolobium was described by Brown (1811) as a monotypic genus, diagnosed by a stipitate ovary with two ovules, which distinguished it from *Oxylobium* (below), though Brown (1811) did not mention this fact explicitly. Lindley (1834) described one species, and Bentham (1837a & b) provided generic desciptions as part of a revision of legumes of the world. However, it was not until 1839, when Bentham (in Lindley, 1839) published a number of new species of *Gastrolobium*, that the genus began to grow in numbers significantly. Subsequently, a number of authors published species of *Gastrolobium*, most notably Turczaninow (1853), who published a major work on the Australian Flora describing many new species in many genera, including *Gastrolobium*. Bentham (1864), in *Flora Australiensis*, provided the first major treatment of *Gastrolobium*, including a number of new species. Once again, it was primarily ovule number that separated *Gastrolobium* from *Oxylobium*, with *Gastrolobium* having two ovules, and *Oxylobium* four or more ovules (Bentham, 1864). Both genera contained species that produced fluoroacetate, and *Oxylobium* contained species from both eastern and western Australia.

Kuntze (1891) subsumed *Oxylobium* into the earlier genus *Callistachys* Vent., though *Oxylobium* was later conserved against *Callistachys*. *Nemcia* was described by Domin (1923), including 12 species characterised by four to six ovules, trifid bracts and condensed racemose inflorescences. This work was largely ignored, and the concepts of *Gastrolobium* and *Oxylobium* remained as they had been since Bentham (1864).

Gardner and Bennetts (1956) published a guide to the toxic plants of Western Australia, which included a number of species of *Gastrolobium* and *Oxylobium*. However, this was not a revision of the group, since it did not include the non-toxic species of either genus and did not make formal taxonomic changes. Furthermore, the toxic species of both genera were interleaved in the key provided in this guide, the authors apparently being unable to distinguish easily between the genera. Again, the concept of Bentham (1864) was used as the division between *Gastrolobium* and *Oxylobium*, relying on ovule number as the main character.

Introduction to morphology in Gastrolobium sens. lat.

As *Gastrolobium sens. lat.* contains three other genera (*Brachysema*, *Jansonia* and *Nemcia*), a brief introduction to morphology is provided to highlight similarities and differences taxa in these genera. Many of the characters below have been shown to be homoplastic by the analyses presented here, but are still important for identification. Groups described in the taxonomy are given as *Gastrolobium*, though many were previously in other genera.

Habit. Nearly all species of *Gastrolobium* and *Nemcia* are erect, bushy shrubs, with only a few species prostrate or scrambling shrubs. Most species of *Brachysema* are scrambling to tangled shrubs, and *Jansonia* (monotypic) is a twining to tangled shrub. Many of these are adventitious colonisers of disturbed sites, particularly road verges and roadside gravel pits.

Chromosome numbers. Sands (1975) counted 28/109 species of *Gastrolobium sens. lat.*, and all have $2n = 16$.

Seedling stages. Seedling leaves nearly always resemble the adult leaves, but tend to be larger and somewhat broader in size, grading into the adult foliage.

Adult stages. *Gastrolobium sens. lat.* have simple, unifoliate leaves, in common with all but one genus in the tribe Mirbelieae. Stipules are mostly present. Leaf arrangement is generally opposite or whorled, rarely alternate or scattered.

Inflorescence structure. This is perhaps the most diverse character, distinguishing the four genera in traditional morphological analyses. *Gastrolobium sens. str.* nearly always has a long, open raceme with prominent floral internodes, and flowers in 2's, 3's, or rarely 4's. Only in several species(the *G. bilobum* group) is floral internode suppression evident. However, inflorescence structure in *Nemcia* is variable. Some species have short racemes with minor internode suppression (the *G. obovatum* group, apparently intermediate in morphology between *Gastrolobium* and *Nemcia*). Others have major internode suppression coupled with many large flowers (the *G. pyramidale* group) The majority of species in *Nemcia* have racemes reduced to one or two flowers in the axils. *Brachysema* has inflorescences ranging from racemes to solitary flowers in the axils (Crisp, 1994), while *Jansonia* has a 4-flowered capitulum.

Within the inflorescence, the subtending floral bract shape is an important distinguishing character, particularly between *Gastrolobium* and *Nemcia*, although this study has shown this character to be also homoplastic. In nearly all species of *Gastrolobium sens. lat.*, the bracts are caducous at early bud stage. Most species of *Gastrolobium sens. str.* have entire bracts, some of which are quite prominent, but these are generally lost before the flower opens (particularly in the *G. floribundum* group). All species of *Nemcia* have bracts with trifid apices, but several species of *Gastrolobium sens. str.* have entire bracts grading into trifid bracts on one inflorescence. *Brachysema* has large, trifid bracts, while *Jansonia* has a sheath of four entire bracts.

Floral structure. Species of *Gastrolobium sens. lat.* have a typical papilionoid flower. Some species, notably *Brachysema*, *Jansonia* and the red-flowered species of *Nemcia*, and *Gastrolobium grandiflorum*, have flowers apparently modified for bird pollination (see review in Crisp, 1994), with large red flowers, often with a reduced standard, and the keel often enlarged. The *G. pyramidale* group (formerly in *Nemcia*) has numerous, large, deep orange flowers, possibly indicative of an intermediate morphology between bee and bird pollination. The majority of species are bee-pollinated, typically with yellow, yellow-orange or orange flowers, with a central, red ring around a yellow centre. In the putatively bird-pollinated species (Crisp, 1994), this central red ring on the standard petal (typical in the tribe Mirbelieae) is still present.

Ovary structure. All species in *Gastrolobium sens. lat.* are unilocular. The ovary is typically covered in long, antrorse, simple hairs, which often go partway up the style. The style mostly tapers from the base to the apex, though occasionally it is uniform in

width to the apex. *Gastrolobium sens. lat.* belongs to a sub-section of the tribe Mirbelieae that has a 5-nucleate embryo sac (Crisp *et al.* in press).

Ovule number has often been used to separate genera in the *Oxylobium*/ *Gastrolobium* complex, but has been shown to be homoplastic in this analysis. Many species of *Gastrolobium* sens. str., *Jansonia* and *Nemcia* have strictly two ovules (Table 2.4). However, many species of these genera have more than two, as do all species of *Brachysema* except for *B. subcordatum* (two to six). Importantly, some species have two to three (one species has two to six) ovules, showing these states may overlap, and hence are uninformative.

Fruit. All species *Gastrolobium sens. lat.* produce dry, dehiscent legumes, mostly with two or more seeds. Some species have numerous seeds, which are arranged in two rows. The fruits are generally ovoid to ellipsoid, and often stipitate, particularly in *Gastrolobium sens. str.* and a number of species of *Nemcia*. The seeds are generally free, rarely enclosed in pith.

Phylogenetic analysis

Crisp and Weston (1987) published the first major review of generic delimitation in *Gastrolobium* since Bentham (1864). They presented a phylogeny of the tribe Mirbelieae based on morphology, and reinstated and expanded both *Nemcia* and *Podolobium* F.Muell., the latter being an eastern Australian genus closely aligned with *Oxylobium*. *Gastrolobium* fell into the 'Callistachys' group, which consisted of *Brachysema* R.Br., *Callistachys*, *Jansonia* Kipp., *Gastrolobium*, *Nemcia*, *Podolobium* and *Oxylobium lineare*. The analysis of Crisp and Weston (1987), however, was done at a higher level to resolve tribal relationships within the Mirbelieae, using mostly genera and species groups as terminal taxa. Crisp and Weston (1987) changed the circumscription of *Gastrolobium* to include all toxic species of *Gastrolobium* and *Oxylobium* (see Aplin, 1971), so that for the first time, species with more than two ovules were included within *Gastrolobium*. This left only one species of *Oxylobium* occurring in Western Australia (*O. lineare*), which required further work to determine its generic affinities. Their reduced concept of *Oxylobium* comprises five species endemic to eastern Australia, mostly along the central and southern coast plain and the adjacent Great Dividing Range, as well as Tasmania (Fig. 5.1). The non-toxic species of *Gastrolobium* and *Oxylobium* were mostly removed into *Nemcia*.

Nemcia, as defined by Crisp and Weston (1987), contained species with axillary racemes often reduced to one or two flowers (though some had condensed, terminal racemes with many flowers), and included the non-toxic species transferred from *Gastrolobium* and *Oxylobium*, thereby using secondary metabolites as an aid in the resolution of this taxonomically difficult group (but see Twigg, *et al.*, 1996). Other characters which were used include trifid bracts, although Crisp and Weston (1987) acknowleged that some species of *Gastrolobium* also possess these, and non-stipitate fruits.

Fig. 5.1. Distribution of *Oxylobium*, as defined by Crisp & Weston (1987), without *O. lineare*.

Genera such as *Brachysema*, *Jansonia* and *Leptosema* Benth. were distinguished by floral characteristics which have been interpreted by later authors as indicative of bird pollination (e.g. Keighery, 1982). These characters include red petals, a reduced standard petal and enlarged keel petals, and copious nectar. *Gastrolobium* and *Oxylobium* are primarily bee-pollinated, except *G. grandiflorum*, which has large, red flowers, but lacks the "bird-flower" modifications of genera like *Brachysema*, such as a

reduced standard petal. However, most of the assumptions of bee- or bird-pollination are largely inference based on floral structure, which often came from empirical data, such as sightings of birds visiting flowers (e.g. Keighery, 1980, 1982, 1984).

The evolution of bird-pollination in this group was discussed by Crisp (1994, 1996), using a phylogeny of *Brachysema*, *Jansonia* and *Nemcia* and *Oxylobium lineare* derived from morphology. This analysis tested the monophyly of these genera, but did not include *Gastrolobium*. *Nemcia* was shown to be paraphyletic, while *Brachysema* was demonstrated to be monophyletic.

Phylogenetic basis of classification

Crisp, Gilmore, and Van Wyk (in press) provide a molecular phylogeny of the genistoid legume tribes, though only two species of the 'Callistachys' group are used in this tribal phylogeny, so nothing can be deduced about the relationships within this group. A sound, well-resolved phylogeny of *Gastrolobium* and its close relatives was therefore required in order to resolve the taxonomic dilemmas surrounding this group and bring stability to these genera. That study, involving two data sets and utilising a total of five molecular regions (see Chapters 2 and 3), shows that *Gastrolobium* is paraphyletic, including within it *Brachysema*, *Nemcia*, *Jansonia* and *Oxylobium lineare*.

Gastrolobium is hereby expanded to include within it all of these genera, expanding the number of species to 109, including 29 new species, making *Gastrolobium* among the most diverse genera of pea-flowered legumes in Australia, and the third largest in the tribe Mirbelieae, behind *Daviesia* (126 species) and *Pultenaea* (110-120 species).

The taxonomy is presented here in phylogenetic order (where possible), and follows the 94-taxa phylogeny presented in Chapter 2. As this phylogeny does not include all species, only informal groups are presented here. Species not included in the analysis are placed into their most likely groups, or if relationships are unclear, they are presented at the end in an artificial group. A complete key to species is provided, along with complete descriptions for all species. This treatment should enable the correct identification and nomenclature of any species of *Gastrolobium*, and is the first complete, descriptive account of the genus since Bentham (1864).

Materials and Methods

Specimens from the Australian National Herbarium (CANB), the State Herbarium of Western Australia (PERTH), together with a small number from the Royal Botanic

Gardens, Melbourne (MEL) were measured and scored for the descriptions. All length by breadth measurements are given with the length from base to apex (not necessarily the longest axis) first, followed by the breadth at the widest point. Vernacular names are given immediately following the description where available. Floral measurements were taken from fully opened flowers preserved in an ethanol: water: glycerol mix (70: 20: 10) where available, otherwise from reconstituted flowers (about 20 species). Branchlet descriptions refer to young,. terminal branchlets, and all leaf measurements and features are taken from mature leaves only, unless otherwise stated. The inflorescence peduncle and rachis measurements were taken only from mature inflorescences.

Conservation status has only been provided where relevant, and up to three conservation measures are given, depending on availability. One follows the IUCN criteria, an international convention of the World Conservation Monitoring Centre. The second follows the Rare or Threatened Australian Plants (ROTAP) listings of Briggs and Leigh (1995), which provides a comprehensive listing of all rare and endangered plants in Australia. The third and final measure follows the Department of Conservation and Land Management (CALM), Western Australia, and lists taxa currently on their Declared Rare Flora list. The codes for the IUCN criteria can be found on their website: http://www.wcmc.org.uk/species/plants/categories.htm, and both the ROTAP and CALM codes are listed in Briggs & Leigh (1995).

Taxonomy

Gastrolobium R.Br. (1811). *Type*: *G. bilobum* R.Br.

> *Brachysema* R.Br. (1811). *Type*: *B. latifolium* R.Br. (= *G. latifolium* (R.Br.) G.Chandler & Crisp).
>
> *Jansonia* Kippist ex Lindl. (1847). *Type*: *Jansonia formosa* Kippist ex Lindl. (= *G. formosum* (Kippist ex Lindl.) G.Chandler & Crisp).
>
> *Nemcia* Domin (1923a). *Type*: *Oxylobium atropurpureum* Turcz. (= *G. leakeanum* Drumm.).

Slender, erect to prostrate, bushy to open *shrubs*. *Leaves* simple, erect, ascending, spreading to retorse, opposite, alternate, scattered, or in whorls of 3 or 4, venation generally prominently reticulate. *Stipules* usually present (except *G. cruciatum*, *G. epacridoides*, *G. ferrugineum* and *G. punctatum*). *Inflorescences* terminal or axillary

racemes or more rarely umbels, rarely branched or 1-2 flowers in the axils or a capitulum, 1 to more than 30-flowered; *subtending bracts* generally caducous, occasionally somewhat persistent, nearly always scale-like, rarely leaf-like, entire, bilobed or prominently trilobed; margins may be lacerate. *Flowers*: generally upright, occasionally resupinate or nutant; papilionaceous, sometimes with the standard reduced; usually pedicellate, sometimes shortly so, rarely sessile; *bracteoles* absent. *Calyx* nearly always campanulate, upper two lobes usually united higher than the lower three, occasionally ± equal to the lower three lobes, rarely united lower; upper two lobes valvate in bud, lower three lobes imbricate, with the upper two often folded across the apices of the lower three, rarely all imbricate. *Corolla*: clawed, mostly yellow or orange, sometimes red, cream, pale green or almost black, usually with a red central ring surrounding a yellow centre; *standard* lamina usually broader than long, apex usually emarginate, occasionally entire or acute; *wings* auriculate on the upper margin, sometimes also auriculate (if slightly so) on the lower margin, rarely auriculate on the lower margin only, often slightly saccate; *keel* petals lightly to strongly united, base auriculate, saccate. *Stamens* 10, free to base; *filaments* subequal to strongly different in length; *anthers* generally uniform, sometimes differing in size and shape, versatile. *Style* filiform to compressed, terete to compressed in the vertical plane, usually incurved to slightly hooked, rarely ± straight, often with some hairs present in the lower third; *ovary* stipitate to sessile, densely pubescent; *ovules* 2-20, rarely more. *Fruit* a legume, usually not enclosed in the calyx, sometimes almost wholly enclosed in the calyx, stipitate to ± sessile, dry and fully dehiscent, ± ovoid to ellipsoid, generally pubescent. *Seed* reniform to ellipsoid, arillate. Fig. 5.2.

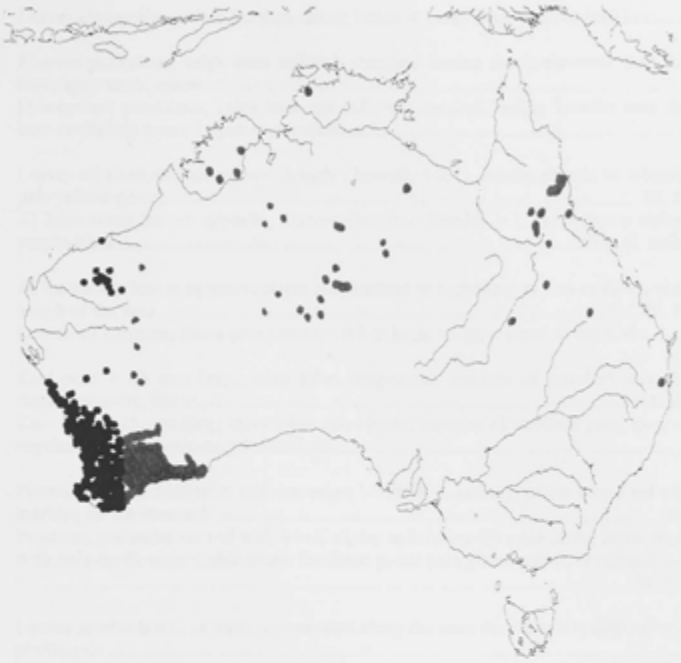

Fig. 5.2. Distribution of *Gastrolobium*.

Key to species of *Gastrolobium*

1 Standard petal reduced to less than 1/3 the length of the keel petal 2
Standard petal at least as long as the keel petal, or rarely slightly shorter 13

2(1) Flowers sessile in a 4-flowered head sheathed by an involucre of large bracts; petals obscured by the lower calyx lobes ..... 98. *G. formosum*
Flowers in racemes, umbels or solitary, pedicellate; petals not obscured by the calyx lobes ... 3

3(2) Leaves strictly opposite and decussate 4
Leaves all alternate, or some opposite and some alternate 7

4(3) Leaf base always cordate; keel petal < 14 mm long; petals burgundy ..... 96. *G. subcordatum*
Leaf base not or slightly cordate; keel petal > 18 mm long; petals red or pale greenish 5

5(4) Leaves ovate to linear; lower three calyx lobes ± equal to the tube ..... 97. *G. celsianum*
Leaves obcordate, obtriangular, obovate or obcrescentic; lower three calyx lobes 2-4 times longer than the tube 6

6(5) Leaves obcordate, obtriangular or obovate, herbaceous, not pungent-pointed; flowers resupinate or erect; keel petal c. 30 mm long ..... 100. *G. praemorsum*
Leaves consistently obcrescentic, coriaceous, semi-pungent with mucro; flowers pendulous; keel petal c. 20 mm long ..... 99. *G. papilio*

7(3) Leaves linear-elliptic, except at base of stem; bracts 5-7 mm long, with 2 round lobes, cupped around calyx base ..... 95. *G. bracteolosum*

Leaves almost always broader than linear; bracts < 1 mm long, trifid or leaf-like 8

8(7) Flowers pendulous; calyx base inflated; standard lamina much narrower than the auricular base, apex acute, entire 9
Flowers not pendulous; calyx base not inflated; standard lamina broader than the auricular base or slightly tapered, apex emarginate 10

9(8) Leaves all alternate, not narrow (length : breadth < 2:1), mostly elliptic to orbicular; flowers pale yellow-green ..... 92. *G. sericeum*
At least some leaves opposite, narrow (length : breadth > 3:1), ovate to oblong; flowers purple-black ..... 91. *G. melanopetalum*

10(8) At least some leaves opposite; stems procumbent or ascending to 1 m or more; wings half the length of the keel ..... 92. *G. sericeum*
Leaves all alternate; stems prostrate or < 0.5 m high; wings ± equal to the keel 11

11(10) Keel petal > 35 mm long; calyx lobes long-acute; margins of standard incurved at apex; stipules ± terete, entire ..... 54. *G. latifolium*
Keel petal < 25 mm long; calyx lobes sub-obtuse; margins of standard petal recurved at apex; stipules ± angular, minutely denticulate 12

12(11) Prostrate, not stoloniferous; inflorescences 1-flowered, axillary; petals bright red with a yellow marking on the standard ..... 93. *G. minus*
Prostrate, stoloniferous and with aerial stems; inflorescences paniculate, borne on the stolons, with only the flowers visible above the litter; petals pale green with pink infusion ..... 94. *G. modestum*

13(1) Leaves in whorls of 3 or more, or crowded along the stem such that it is difficult to distinguish phyllotaxis 14
Leaves opposite, alternate or scattered along the stem, not crowded along the stem 66

14(13) Inflorescence strictly axillary 15
Inflorescences terminal, or with both terminal and axillary inflorescences present 36

15(14) Flowers solitary or in pairs in the axils 16
Flowers aggregated into condensed racemes or umbels 21

16(15) Stipules entirely absent 17
Stipules present (may be minute) 19

17(16) Leaves patent to retrorse ..... 80. *G. epacridioides*
Leaves erect and appressed to the branchlet 18

18(17) Leaves ovate, 8-10 mm long; petioles present (c. 1 mm long) ..... 81. *G. punctatum*
Leaves elliptic, 4-6(-8) mm long; petioles absent ..... 82. *G. reticulatum*

19(16) Leaves pungent-pointed 20
Leaves unarmed ..... 71. *G. linearifolium*

20(19) Leaves recurved, 12-22 x 4-6 mm; standard 8-9 mm long; ovules 2 ..... 68. *G. acutum*
Leaves straight or incurved, 20-50 x 8-20 mm; standard 10-12 mm long; ovules 4 ..... 107 *G. dilatatum*

21(15) Leaves pungent-pointed 22
Leaves unarmed (may be mucronate, but not pungent) 27

22(21) Leaves with 3 or more pungent points (at least some leaves per specimen) 23
Leaves with 1 pungent-point 24

23(22) Leaf margins recurved; lamina tending to undulate between depressed main veins ..... 76. *G. ilicifolium*
Leaf margins not recurved; lamina somewhat folded up lengthwise but otherwise flat .....

78. *G. tricuspidatum*

24(22) Inflorescence rachis elongate (30-160 mm long) ..... 31. *G. propinquum*
Inflorescence rachis not elongate (0-18 mm long) 25

25(24) Leaves crowded along stem, linear, 1-3 mm broad ..... 75. *G. stipulare*
Leaves not crowded, oblong, cuneate, rhombic or strongly obovate, 4-24 mm broad 26

26(25) Young branchlets angular; leaf apex acute; stipules 3-5 mm long ..... 47. *G. obovatum*
Young branchlets terete; leaf apex rounded, obtuse or truncate; stipules < 1.5 mm long ..... 45. *G. brownii*

27(21) Flowers large (calyx > 8 mm long); petals red ..... 89. *G. rubrum*
Flowers smaller (calyx < 8 mm long); petals yellow to orange with red markings 28

28(27) Calyx indumentum 2-toned, with silver hairs at the base and golden or rust-coloured hairs towards the apex 29
Calyx indumentum uniform in colour, usually silvery but sometimes buff-coloured 31

29(28) Leaves cuneate, obovate or obtriangular to narrowly so ..... 64. *G. dorrienii*
Leaves orbicular, ovate, elliptic, oblong or narrowly so 30

30(29) Inflorescences, young stems and sometimes young leaves densely hirsute with rust-coloured hairs ..... 85. *G. pyramidale*
Inflorescences and young stems sericeous to villous with silvery hairs ..... 84. *G. crenulatum*

31(28) Leaf margins longitudinally folded up (plicate) 32
Leaf margins flat, incurved or recurved but not longitudinally folded up 34

32(31) Leaves recurved 33
Leaves straight ..... 71. *G. linearifolium*

33(32) Leaves generally opposite (rarely whorled or alternate), obtrullate or rhombic; standard 8-11 x 8-12 mm ..... 47. *G. obovatum*
Leaves in whorls of 3, spathulate; standard 7.5-10 x 7-7.5 mm ..... 49. *G. spathulatum*

34(31) Venation on lower leaf surface very thick, with areoles reduced to pin-pricks; flowers mostly in summer ..... 74. *G. effusum*
Venation on lower leaf surface openly reticulate; flowers in spring 35

35(34) Mature leaves sericeous beneath ..... 109. *G. lehmannii*
Mature leaves glabrate ..... 52. *G. pulchellum*

36(14) Calyx indumentum 2-toned (silver hairs at the base, with golden or rust-coloured hairs towards the apex) 37
Calyx indumentum uniform in colour 44

37(36) Leaves cuneate or obtrullate, or narrowly so 38
Leaves orbicular, ovate, elliptic, oblong, or narrowly so 42

38(37) Leaves with margins recurved, especially towards the bilobed apex; upper leaf surface rugose with obscure venation; lower leaf surface sericeous and scarcely glabrescent ..... 64. *G. dorrienii*
Leaves with margins not recurved, sometimes undulate or crisped, apex not bilobed (may be slightly emarginate) ; upper surface venation conspicuously, finely reticulate; lower surface glabrous or soon glabrescent 39

39(38) Leaves obtrullate, trilobed, with the middle lobe equal to or longer than the lateral lobes; leaves pungent-pointed ..... 77. *G. rhombifolium*
Leaves obovate or cuneate, usually narrow, never obtrullate; apex rounded to bilobed; leaves may be mucronate, but are never pungent-pointed 40

40(39) Leaf margins crisped ..... 73. *G. crispatum*
Leaf margins not crisped 41

41(40) Leaves ± spathulate; stipules lacking a thickened, grey-tomentose base; peduncle 2-10 mm long ..... 65. *G. retusum*
Leaves ± oblong, but may be slightly ovate or slightly obovate; stipules with a thickened, grey-tomentose base; peduncle 10-25 mm long ..... 66. *G. whicherensis*

42(37) Inflorescences, young stems and sometimes young leaves densely hirsute with rust-coloured hairs ..... 85. *G. pyramidale*
Inflorescences and young stems sericeous to villous, hairs silvery 43

43(42) Leaves silvery sericeous below, very tardily glabrescent; peduncle 10-40 mm long; subtending bracts entire ..... 83. *G. coriaceum*
Leaves glabrate below; peduncle 2-10 mm long; subtending bracts trifid ..... 65. *G. retusum*

44(36) Leaf apex emarginate, sometimes bilobed 45
Leaf apex entire 51

45(44) Base of peduncle with an involucre of scale-like bracts ..... 103. *G. venulosum*
Base of peduncle lacking an involucre of bracts, though some apparently aborted buds may be scattered along the peduncle 46

46(45) Inflorescence rachis < 10 mm long; floral internodes < 3 mm long 47
Inflorescence rachis > 15 mm long; floral internodes generally > 4 mm long 48

47(46) Keel petal scarcely auriculate, not saccate, c. 9-10 x 1.5 mm; style barely incurved; leaves light green and concolorous; flowers orange ..... 15. *G. tergiversum*
Keel petal strongly auriculate and saccate, c. 6.5-8.5 x 2 mm; style strongly incurved to hooked; leaves dark green above and often below; flowers typically yellow with red markings, almost never orange ..... 14. *G. bilobum*

48(46) Leaves > 15 mm broad, not recurved; flowers predominantly red; occurs in the northern parts of WA, plus NT, QLD, ?SA ..... 16. *G. grandiflorum*
Leaves < 10 mm broad, rarely flat, usually recurved to revolute; flowers yellow to orange with red markings; occurs in the SW corner of WA 49

49(48) Inflorescence rachis > 70 mm long; leaves > 20 mm long ..... 9. *G. cuneatum*
Inflorescence rachis < 50 mm long; leaves < 20 mm long 50

50(49) Leaves widely spreading to deflexed, often incurved longitudinally, oblong to linear or almost square; margins strongly recurved to revolute; ovules 4; stipules 1.5-3 mm long ..... 23. *G. tetragonophyllum*
Leaves spreading to ascending, not incurved longitudinally, cuneiform to oblong; margins flat to recurved, never revolute; ovules strictly 2; stipules 0.5-1.5 mm long ..... 41. *G. velutinum*

51(44) Leaves erect and ± appressed to the branchlet, crowded along the stem 52
Leaves spreading to erect, but never appressed to the branchlet, not crowded 53

52(51) Leaves ovate; leaf apex acute; leaves 4-7.5 x 1.5-2.5 mm ..... 55. *G. appressum*
Leaves obovate to narrowly so; leaf apex ± truncate; leaves 4-15 x 2-5 mm ..... 40. *G. parvifolium*

53(51) Leaves strongly incurved to involute 54
Leaves flat, recurved, revolute, slightly incurved (appearing concave) or longitudinally folded up 55

54(53) Leaves canaliculate, not crowded along the stems, upper surface visible; calyx 7-9 mm long; standard c. 12 mm broad; ovules 4-5 ..... 7. *G. semiteres*
Leaves involute, crowded along the stems, upper surface not visible; calyx 4.5-5.5 mm long; standard 8-9 mm broad; ovules 2 ..... 8. *G. stenophyllum*

55(53) Leaves longitudinally folded up (conduplicate) 56
Leaves flat, recurved or revolute, or rarely concave 59

56(55) Leaves obovate ..... 51. *G. bennettsianum*
Leaves ovate to elliptic 57

57(56) Calyx 6-7.5 mm long; inflorescence 5-10-flowered ..... 58. *G. oxylobioides*
Calyx < 5 mm long; inflorescence > 15-flowered 58

58(57) Petiole decurrent with the branchlet; stipules 3-5 mm long; peduncle 5-10 mm long; standard 5-6 mm long; occurs north of Geraldton, around Northampton, WA ..... 31. *G. propinquum*
Petioles continuous but not decurrent with the branchlet; stipules 1-2.5 mm long; peduncle 2-4 mm long; standard c. 8 mm long; occurs in the Darling escarpment around Perth, WA ..... 36. *G. microcarpum*

59(55) Leaves linear; standard > 11 mm long ..... 10. *G. callistachys*
Leaves not linear; standard < 10 mm long (or if longer, leaves are not linear) 60

60(59) Leaf apex recurved 61
Leaf apex not recurved 62

61(60) Leaves < 5 mm broad; petiole articulate with the branchlet; young branchlets angular and somewhat pubescent; pedicels very short (0.5-1 mm long) ..... 57. *G. hamulosum*
Leaves > 6 mm broad; petiole continuous with the branchlet; young branchlets ± terete and glabrous; pedicels 2-2.5 mm long ..... 34. *G. glaucum*

62(60) Leaves strongly recurved to revolute, often longitudinally incurved ..... 43. *G. nutans*
Leaves flat to slightly incurved 63

63(62) Leaves concave, unarmed ..... 37. *G. crassifolium*
Leaves flat, usually pungent-pointed 64

64(63) Inflorescences < 12-flowered; standard c. 14 mm broad ..... 58. *G. oxylobioides*
Inflorescences > 15-flowered; standard 7-8 mm broad 65

65(64) Leaf margins not recurved, often crenulate or undulate; lower leaf surface glabrous; leaves > 7 mm broad ..... 36. *G. microcarpum*
Leaf margins recurved, not crenulate or undulate; lower leaf surface moderately pubescent; leaves < 7 mm broad ..... 103. *G. venulosum*

66(13) Leaves pungent-pointed 67
Leaves unarmed but may be mucronate to stiffly mucronate 96

67(66) Leaves with 3 or more pungent angles 68
Leaves with only 1 pungent angle 76

68(67) Inflorescences in terminal, 2-3-flowered umbels ..... 6. *G. aculeatum*
Inflorescences in terminal or axillary racemes 69

69(68) Leaves obtriangular, margins recurved to revolute, apex strongly recurved ..... 32. *G. diabolophyllum*
Leaves ovate to triangular or obtrullate, margins flat, never recurved, apex not recurved 70

70(69) Leaves with 4 or more spines 71
Leaves with 3 spines 73

71(70) Spines per leaf 7-10; inflorescence rachis 35-50 mm long and moderately to densely pubescent; calyx 4.5-5.5 mm long; standard 5.5-6.5 mm broad ..... 3. *G. wonganensis*
Spines per leaf 4-7 (rarely up to 9), inflorescence rachis 5-25 mm long and glabrous; calyx 6-9 mm long; standard 9-13 mm broad 72

72(71) Flower-subtending bracts about twice as long as the bud, c. 6 mm long; inflorescences strictly terminal ..... 2. *G. euryphyllum*
Flower-subtending bracts shorter than the bud, 2-4.5 mm long; inflorescences terminal and/or axillary ..... 1. *G. spinosum*

73(70) Leaves obtrullate ..... 35. *G. laytonii*
Leaves ovate to triangular 74

74(73) Leaves very broadly to depressed triangular, not trilobed, all 3 pungent angles pointing in different directions ..... 4. *G. triangulare*
Leaves ovate (rarely appearing slightly triangular), trilobed, all 3 pungent angles pointing upwards 75

75(74) Inflorescence 2-7-flowered, generally axillary (rarely terminal); calyx 4-5 mm long; standard 6.5-8.5 mm broad; pod c. 5 mm long ..... 5. *G. trilobum*
Inflorescence 6- to more than 30-flowered, axillary and/or terminal; calyx 6-7 mm long; standard 9.5-13 mm broad; pod 6-10 mm long ..... 1. *G. spinosum*

76(67) At least some leaves becoming trilobed (which is often indicated by a slight bulge to either side of the apex) ..... 5. *G. trilobum*
No leaves becoming trilobed 77

77(76) Inflorescences in terminal, 2-3-flowered umbels ..... 6. *G. aculeatum*
Inflorescences in terminal or axillary racemes 78

78(77) Leaves upwardly canaliculate or involute 79
Leaves flat, recurved or longitudinally folded up, never canaliculate 80

79(78) Leaves strongly involute, appearing almost terete; never glaucous; flowers quite small (calyx c. 6 mm long, standard 11 mm broad) ..... 63. *G. tenue*
Leaves canaliculate, never appearing terete; usually glaucous; flowers quite large (calyx 8-14 mm long, standard 14-21 mm broad) ..... 56. *G. calycinum*

80(78) Inflorescences strictly terminal 87
Inflorescences axillary or both axillary and terminal 81

81(80) Leaves strictly alternate; flowers solitary or paired in the axils ..... 70. *G. alternifolium*
Leaves opposite (rarely appearing alternate); inflorescences with more than 2 flowers 82

82(81) Leaves longitudinally recurved, conduplicate (folded up longitudinally) 83
Leaves straight, not conduplicate 84

83(82) Leaves not glaucous, obovate to rhombic, apex acute ..... 47. *G. obovatum*
Leaves glaucous, obtrullate to obtriangular, apex truncate ..... 106. *G. cyanophyllum*

84(82) Young branchlets terete; leaf shape obovate to rarely oblong ..... 45. *G. brownii*
Young branchlets angular; leaf shape ovate, triangular, elliptic or orbicular 85

85(84) Leaf shape elliptic to orbicular; leaf margins somewhat undulate ..... 104. *G. axillare*
Leaf shape ovate to triangular; leaf margins flat 86

86(85) Stipules absent or minute (< 0.3 mm long); leaf shape triangular; inflorescence rachis pubescent with rust-coloured hairs ..... 101. *G. ferrugineum*
Stipules prominent (1-3.5 mm long); leaf shape ovate; inflorescence rachis glabrous ..... 1. *G. spinosum*

87(80) Stipules strongly recurved to reflexed 88
Stipules ascending to erect 89

88(87) Leaves glaucous, fiercely pungent-pointed; ovules 2 ..... 60. *G. reflexum*
Leaves not glaucous, semi-pungent; ovules 10-12 ..... 62. *G. spectabile*

89(87) Leaves canaliculate ..... 33. *G. floribundum*
Leaves flat or conduplicate, never canaliculate 90

90(89) Leaf shape trullate, obtrullate or rhombic ..... 35. *G. laytonii*
Leaf shape ovate, elliptic, obovate or linear 91

91(90) Stipules scarious, very long (> 6 mm), sometimes fused at the base 92
Stipules rigid to hyaline, < 5 mm long, never fused 93

92(91) Stipules somewhat fused behind the leaf; leaves 10-16 x 3-4 mm; leaf base cuneate; leaves longitudinally recurved ..... 25. *G. densifolium*
Stipules free; leaves 18-32 x 8-18 mm; leaf base rounded; leaves straight . 29. *G. rotundifolium*

93(91) Leaf apex recurved; leaves < 17 mm long ..... 34. *G. glaucum*
Leaf apex straight; leaves > 20 mm long 94

94(93) Ovules 4-5; peduncle > 15 mm long; rachis < 20 mm long; inflorescence axes glabrous; stipules rigid ..... 61. *G. rigidum*
Ovules 2; peduncle < 10 mm long; rachis > 25 mm long; inflorescence axes pubescent; stipules hyaline 95

95(94) Petiole decurrent with the branchlet; leaves not crenulate; stipules > 2.5 mm long; wing petals equal in length to the keel petals ..... 35. *G. laytonii*
Petiole not decurrent with the branchlet; leaves crenulate; stipules < 2.5 mm long; wing petals longer than the keel petals ..... 36. *G. microcarpum*

96(66) Inflorescences axillary, or both axillary and terminal 97
Inflorescences strictly terminal 121

97(96) Calyx > 8 mm long; petals all predominantly red 98
Calyx < 8 mm long (or if > 8 mm, then petals predominantly yellow to orange); standard yellow to orange with red markings 103

98(97) Leaf margins recurved ..... 89. *G. vestitum*
Leaf margins not or very scarcely recurved 99

99(98) Calyx prominently zygomorphic; calyx hairs unicoloured; petiole not decurrent with the branchlet; wing petals auriculate on both margins; occurs in northern WA, NT, Qld, and ?SA ..... 16. *G. grandiflorum*
Calyx apparently actinomorphic; calyx hairs bicoloured (rarely unicoloured); petiole decurrent with the branchlet; wing petals auriculate only on the upper margin; occurs in south-west WA, specifically in the Stirling Range 100

100(99) Flowers not resupinate, nutant; leaves narrowly oblong ..... 90. *G. rubrum*
Flowers resupinate, spreading to erect; leaves elliptic, rarely obovate or somewhat oblong . 101

101(100) Stipules < 4 mm long; leaf apex truncate, rarely very slightly emarginate; subtending bracts > 12 mm long ..... 88. *G. luteifolium*
Stipules > 7 mm long; leaf apex prominently emarginate; subtending bracts < 7 mm long ... 102

102(101) Wing petals < 16 mm long; inflorescence umbellate; leaves 50-65 x 20-40 mm; standard petal fully reflexed ..... 86. *G. leakeanum*
Wing petals > 20 mm long; inflorescence usually racemose, rarely umbellate; leaves 25-58 x 11-24 mm; standard petal not fully reflexed ..... 87. *G. mondurup*

103(97) Leaves canaliculate 104
Leaves flat, recurved or longitudinally folded up, never canaliculate 105

104(103) Calyx moderately pubescent; standard petal c. 9 x 11 mm ..... 33. *G. floribundum*
Calyx glabrous; standard petal c. 7 x 10 mm ..... 38. *G. hians*

105(103) Leaf margins recurved to revolute 106

Leaf margins flat to incurved or longitudinally folded up 111

106(105) Leaf apex strongly emarginate to bilobed, or ± tricuspidate, generally strongly recurved 107
Leaf apex entire, without any lateral axes, not recurved 109

107(106) Rachis > 15 mm long; petiole not decurrent with the branchlet ..... 30. *G. polystachyum*
Rachis < 4 mm long; petiole decurrent with the branchlet 108

108(107) Leaves recurved, not undulate, oblong to cuneiform ..... 50. *G. stowardii*
Leaves flat, undulate, elliptic ..... 52. *G. pulchellum*

109(106) Leaves > 10 mm broad; ovules 2 ..... 109. *G. lehmannii*
Leaves < 7 mm broad; ovules 4-8 110

110(109) Leaves < 5 mm broad; petiole not decurrent with the branchlet; rachis > 8 mm long (generally > 20 mm long); usually with leaves of different sizes present along one branchlet ..... 42. *G. heterophyllum*
Leaves > 5 mm broad; petiole decurrent with the branchlet; rachis < 5 mm long; leaves uniform in size along one branchlet ..... 108. *G. elegans*

111(105) Stipules absent or rarely minute (< 0.3 mm long) 112
Stipules prominent 113

112(111) Leaves erect and appressed to the branchlet; leaf shape elliptic ..... 79. *G. cruciatum*
Leaves patent to broadly spreading; leaf shape triangular or ovate ..... 101. *G. ferrugineum*

113(111) Leaves glaucous; leaf shape ovate to orbicular ..... 105. *G. nudum*
Leaves not glaucous; leaf shape elliptic, oblong or obovate 114

114(113) Rachis > 5 mm long 115
Rachis < 1 mm long 117

115(114) Leaves oblong; leaf margins undulate; standard petal c. 7 mm broad ..... 53. *G. truncatum*
Leaves elliptic to obovate; leaf margins flat; standard petal > 9 mm broad 116

116(115) Leaf apex acute; ovules 4-8; floral bracts trifid; petiole decurrent with the branchlet; occurs in the south-west of WA only ..... 69. *G. capitatum*
Leaf apex rounded to emarginate; ovules 2; floral bracts entire; petiole not decurrent with the branchlet; occurs in central Australia (WA, NT, rarely Qld) ..... 17. *G. brevipes*

117(114) Leaves strictly alternate ..... 70. *G. alternifolium*
Leaves opposite 118

118(117) Leaf shape oblong, apex recurved; young branchlets terete ..... 46. *G. hookeri*
Leaf shape obovate, apex straight; young branchlets angular 119

119(118) Leaves longitudinally folded up, apex acute; ovules 2 ..... 48. *G. plicatum*
Leaves flat, apex rounded to tricuspidate; ovules 4-10 120

120(119) Leaves < 13 mm long, apex tricuspidate; plants prostrate and mat-forming ..... 44. *G. pusillum*
Leaves > 20 mm long, apex emarginate; plants small, bushy shrubs ..... 72. *G. nervosum*

121(96) Leaves orbicular 122
Leaves otherwise 126

122(121) Mature leaves densely tomentose or sericeous beneath 123
Mature leaves glabrous beneath 124

123(122) Mature leaves tomentose beneath; inflorescence rachis elongate, with floral internodes > 5 mm long; plants prostrate or forming bushy clumps ..... 26. *G. tomentosum*
Mature leaves sericeous beneath; inflorescence rachis condensed, with floral internodes < 2 mm long; plants erect, bushy shrubs ..... 18. *G. congestum*

124(122) Inflorescence rachis condensed, with floral internodes < 2 mm long; erect, bushy shrubs ..... 18. *G. congestum*
Inflorescence rachis elongate, with floral internodes > 5 mm long; prostrate, rarely forming bushy clumps 125

125(124) Leaves flat; venation very thick and dense, so that the areoles on the lower surface are reduced to pin pricks (punctate) ..... 28. *G. ovalifolium*
Leaves undulate; venation openly reticulate and not at all punctate on the lower surface ..... 27. *G. glabratum*

126(121) Inflorescence rachis condensed, with floral internodes < 2 mm long 127
Inflorescence rachis elongate, with floral internodes > 5 mm long 128

127(126) Calyx hairs uniform in colour; leaf margins not recurved; standard petal > 12 mm broad ..... 18. *G. congestum*
Calyx hairs bicoloured (silvery and golden brown); leaf margins recurved; standard petal < 10 mm broad ..... 64. *G. dorrienii*

128(126) Leaves canaliculate or involute 129
Leaves recurved, flat or slightly incurved 132

129(128) Leaves strongly involute, with the upper surface ± not visible ..... 12. *G. involutum*
Leaves canaliculate, upper surface visible 130

130(129) Standard petal 14-21 mm broad; calyx lobes not recurved ..... 56. *G. calycinum*
Standard petal 10-11 mm broad; upper calyx lobes not recurved, lower calyx lobes recurved 131

131(130) Calyx moderately pubescent; standard petal c. 9 x 11 mm ..... 33. *G. floribundum*
Calyx glabrous; standard petal c. 7 x 10 mm ..... 38. *G. hians*

132(128) Leaf margins not recurved leaves flat to undulate 133
Leaf margins recurved; leaves not undulate 143

133(132) Leaf margins undulate to strongly so; prostrate to weakly ascending shrubs ..... 24. *G. villosum*
Leaf margins flat; bushy, erect shrubs 134

134(133) Leaves linear to linear-obovate; leaves < 3 mm broad ..... 10. *G. callistachys*
Leaves not linear; leaves > 5 mm broad 135

135(134) Standard petal > 17 mm long; standard petals red ..... 16. *G. grandiflorum*
Standard petal < 15 mm long; standard petals yellow to orange with red markings 136

136(135) Ovules 2 137
Ovules 3 or more 140

137(136) Calyx > 5 mm long; standard petal > 10 mm broad; occurs in central-eastern WA, NT, QLD ..... 17. *G. brevipes*
Calyx < 5 mm long; standard petal < 7 mm broad; occurs only in south-west WA 138

138(137) Leaf base obtuse, rounded or slightly cordate; leaves < 22 mm long; rachis < 15 mm long; leaf length: breadth ratio 1-1.6 ..... 39. *G. pycnostachyum*
Leaf base narrowly cuneate; leaves > 29 mm long; rachis > 25 mm long; leaf length:breadth ratio 2-3 ..... 35. *G. laytonii*

139(136) Stipules recurved to reflexed; leaf base cordate ..... 62. *G. spectabile*
Stipules ascending to erect; leaf base truncate to cuneate 140

140(139) Rachis < 20 mm long; plants glaucous ..... 61. *G. rigidum*
Rachis > 25 mm long; plants not glaucous 141

141(140) Standard petal < 10 mm broad ..... 19. *G. parviflorum*
Standard petal > 15 mm broad 142

142(141) Leaf base cuneate; wing petals > 13 mm long ..... 13. *G. graniticum*
Leaf base rounded to truncate; wing petals < 10 mm long ..... 59. *G. racemosum*

143(132) Mature leaves glabrous beneath 144
Mature leaves at least partly pubescent beneath 147

144(143) Subtending floral bracts entire 145
Subtending floral bracts trifid ..... 67. *G. ebracteolosum*

145(144) Standard petal < 8 mm long ..... 19. *G. parviflorum*
Standard petal > 10 mm long 146

146(145) Leaves linear (length: breadth ratio > 15) ..... 11. *G. acrocaroli*
Leaves not linear (length: breadth ratio < 4) ..... 59. *G. racemosum*

147(143) Leaves cuneiform and not linear; plants prostrate ..... 102. *G. humile*
Leaves not cuneiform (or if so, then they are linear); plants not prostrate (except *G. heterophyllum*, which has ovate to elliptic leaves) 148

148(147) Leaf apex tricuspidate, or rarely truncate ..... 30. *G. polystachyum*
Leaf apex entire, emargiate or bilobed 149

149(148) Young branchlets terete; leaves broadly spreading to deflexed; floral internodes <3 mm long; leaves strictly oblong to linear ..... 23. *G. tetragonophyllum*
Young branchlets angular; leaves spreading to ascending; floral internodes > 5 mm long; leaves oblong, elliptic, ovate, obovate or linear 150

150(149) Leaves linear-obovate; ovules 2 ..... 10. *G. callistachys*
Leaves either not linear, or linear-oblong to -elliptic 151

151(150) Wing petals auriculate on the upper margin only 152
Wing petals auriculate on both margins 154

152(151) Standard petal > 11 mm broad; wing petals > 10 mm long ..... 20. *G. musaceum*
Standard petal < 10 mm broad; wing petals < 8 mm long 153

153(152) Wing petals shorter than the keel petals; leaves ovate to elliptic; leaf margins not strongly recurved; < 20 flowers per inflorescence ..... 42. *G. heterophyllum*
Wing petals longer than the keel petals; leaves oblong; leaf margins strongly recurved; generally > 20 flowers per inflorescence (rarely fewer) ..... 19. *G. parviflorum*

154(151) Leaf margins strongly revolute, such that only the midrib on the lower surface is visible; leaves strictly linear-oblong ..... 22. *G. melanocarpum*
Leaf margins recurved to revolute, but at least part of the lower surface is visible; leaves ovate, elliptic, oblong or linear-oblong 155

155(154) Leaves linear-elliptic to -ovate; subtending floral bracts trifid; ovules > 15 ..... 67. *G. ebracteolosum*
Leaves ovate, elliptic, oblong or linear-oblong; subtending floral bracts entire; ovules < 8 156

156(155) Leaves linear-oblong, paler above to ± concolorous; lower surface glabrous to sparsely pubescent; standard petal > 13 mm broad ..... 11. *G. acrocaroli*
Leaves ovate, elliptic or oblong, but not linear, strongly discolorous; lower surface densely sericeous with white hairs; standard petal < 11 mm broad ..... 21. *G. discolor*

The *G. spinosum* group

This group of *Gastrolobium* species all have spinose, often dentate leaves with 3 or more pungent points per leaf, and have terminal and/or axillary racemes, often with relatively large flowers.

1. Gastrolobium spinosum Benth., in Lindley (1839, p. 13). *Type citation*: none cited. *Type specimens*: *Lectotype* (here chosen): "Swan River, Drummond 1st coll. 1839." (CGE); *isolecto*: BM.

Gastrolobium preissii Meisn. (1844, p. 68). *Type citation*: "In solo sublimoso district Hay, d. 8 Nov. 1840. Herb. Preiss. No. 1131. Et in region interior. Australiae merid-occid. No. 1133". *Type specimens*: *Lectotype* (here chosen): LD (Preiss 1131); *isolecto*: NY.

Gastrolobium spinosum Benth. var. *angustum* E.Pritz., in Diels & Pritzel (1904, p. 254). *Gastrolobium spinosum* Benth. forma *angustum* (E.Pritz.) D.A.Herb (1922, p. 39). *Type citation*: "ex distr. Eyre occidentali pr. West River flor. m. Oct. (D. 4904)". *Type specimens*: *Lectotype* (here chosen): the plate (Fig. 32-F & G, p. 255).

Gastrolobium spinosum Benth. forma *crassifolium* D.A.Herb. (1922, p. 40). *Type citation*: "Pingelly, Geo. Walton, 1899; Lomos, Dyer, 1916; Yoting, Herbert & Wilson, 1920." *Type specimens*: *Lectotype* (here chosen): PERTH; *isolecto*: CBG, K.

Gastrolobium spinosum Benth. forma *parvifolium* D.A.Herb. (1922, p. 39). *Base name*: *Gastrolobium spinosum* Benth. var. *microphyllum* S.Moore (1920, p. 170). *Type citation*: "Kauring; G.W. Brown (Hb. Stoward, 554)." *Type specimens*: *holo*: BM.

Gastrolobium spinosum Benth. var. *inerme* S.Moore (1920, p. 170). *Type citation*: "Woodanilling; Stoward 721." *Type specimens*: *holo*: BM.

Gastrolobium spinosum Benth. var. *subinerme* Domin 1923b, p. 36). *Type citation*: "Bridgetown to Kojonup and Slab Hut Gully, A.A. Dorrien-Smith." *Type specimens*: *holo*: K.

Gastrolobium spinosum Benth. forma *oliganthum* Domin 1923b, p. 36). *Type citation*: "Victoria Desert, Elder Exploring Expedition, R. Helms IX. 1891." *Type specimens*: *Lectotype* (here chosen): K; *isolecto*: MEL.

Gastrolobium spinosum Benth. forma *typicum* D.A.Herb. (1922, p. 39). *Nom. illeg.*

Low and bushy to erect and open *shrubs*, 0.3-3.5 m high. *Branchlets* spreading to ascending, angular, glabrous, often glaucous. *Petioles* very short, somewhat swollen, continuous and slightly decurrent with the branchlet, < 1 mm long. *Leaves* patent to spreading, very robust, opposite, narrowly to very broadly ovate, 6-40 x 7-32(-45) mm, glabrous, often glaucous, venation prominently reticulate; apex usually acute, rarely obtuse, often long and tapering, fiercely pungent-pointed; margins not recurved, dentate, with numerous spines particularly towards the base (commonly 4-9); base truncate to cordate. *Stipules* erect, triangular, hyaline, 1-3.5 mm long. *Inflorescences* terminal or axillary racemes, often with both on one plant, 1-3 per terminus or axil, 6 to more than 30 flowered; *peduncle* (0-)8-15 mm long; *rachis* 5-25 mm long; *subtending bracts* caducous, scale-like, ovate, lacerate, shorter than bud, 2-4.5 mm long. *Pedicels* terete, 1-1.5 mm long. *Calyx* campanulate, 6-7 mm long including the 1-1.5 mm receptacle, glabrous, lobes all recurved; upper two lobes united higher than the lower three, rounded, 2-3.5 mm long; lower three lobes triangular, acute, 2-3 mm long. *Corolla*: *standard* transversely elliptic, 9-13 x 9.5-13 mm including the 2-5.5 mm claw, yellow to orange with a red ring surrounding the yellow centre, apex emarginate, base truncate; *wings* ovate to obovate, 8-12 x 2.5-3.5 mm including the 2-4.5 mm claws, yellow to orange and red, apex rounded, not incurved to somewhat incurved, not enclosing keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, margins not incurved, 8.5-11 x 3.5 mm including the 2.5-4 mm claws, pink and maroon, apex broadly rounded to sub-acute, base auriculate, saccate. *Style* long, incurved to slightly hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 6-10 x 4-6 mm, glabrous. *Seed* reniform to ellipsoid, c. 3 mm long, arillate.

Notes on variation. *Gastrolobium spinosum* is an extremely variable species, in both leaf shape and size, and flower size, and has had several forms and varieties named in the past. However, these all intergrade at all stages, such that it is very difficult to identify any specimen falling into the middle of this morphological range. Also, some of these 'forms' were found to exist on one specimen (e.g. a specimen from Tarin Rock,

west of Lake Grace, *G.T. Chandler 281*, contained *G. spinosum* forma *inerme*, forma *angustum* as well as forma *spinosum*). None of these sub-specific taxa are being recognised in this treatment.

Vernacular name. Prickly Poison.

Flowering period. September to December. *Fruiting period.* From October in the north to January in the south.

Distribution (Map 1). South-west Western Australia. Occurs throughout the south west region.

Map 1. Distribution of *G. spinosum*.

Habitat. Grows in a wide range of habitats, from sandplains to mountain escarpment, on sandy soils to clay-loam soils in forest, woodland, mallee and heathland.

Selected specimens (330 examined). WESTERN AUSTRALIA: Avon District: Wongan Hills Experimental Farm, 6.5 km N of Wongan Hills, 30°51'S, 116°43'E, *K.J. Knight 323*, 23 Oct. 1984 (MEL, PERTH); 2 miles [3 km] E of Tammin, 31°38'S, 117°31'E, *T.E.H. Aplin 1984*, 13 Sep. 1962 (PERTH). Coolgardie District: 52 km

along Hyden-Norseman Track, towards Norseman from Southern Cross Road, 32°16'06"S, 120°16'19"E, *G.T. Chandler 897 et al.*, 16 Sep. 1999 (BRI, CANB). Darling District: 12.5 km toward Collie from intersection with Williams to Pinjarra Road, 33°10'16"S, 116°36'43"E, *G.T. Chandler 759 & S. Donaldson*, 3 Nov. 1998 (CANB, MEL), Roleystone, 32°06'S, 116°05'E, *R.A. Saffrey 152*, 11 Nov. 1964 (PERTH); Gin Gin Cemetery, 31°21'S, 115°54'E, *G.J. Keighery 714*, 8 July 1975 (PERTH). Irwin District: 12 km N of Green Head Road along Eneabba South Road, 13 km NW of Warradarge Hill, 29°58'S, 115°13'E, *M.D. Crisp 5439*, 24 Jan. 1979 (CANB, NSW, PERTH); 15 km from Three Springs towards Eneabba, 29°45'26"S, 115°24'02"E, *G.T. Chandler 219 & W. Keys*, 11 Sep. 1997 (CANB). Eyre District: 500 m E of the Oldfield River crossing on the South Coast Highway, 33°40'22"S, 120°40'20"E, *G.T. Chandler 263 & W. Keys*, 17 Sep. 1997 (CANB, NSW). Roe District: Dragon Rocks Nature Reserve, ca 37 km N of Newdegate, 32°49'S, 119°01'E, *T.F. Houston 921-6*, 24 Nov. 1996 (PERTH); 20 km from Newdegate towards Hyden, 35°54'42"S, 119°02'44"E, *G.T. Chandler 949 et al.*, 19 Sep. 1999 (CANB); Tarin Rock siding, 33°06'34"S, 118°13'56"E, *G.T. Chandler 281 & W. Keys*, 18 Sep. 1997 (CANB, UNE).

Toxicity. The fluoroacetate levels of this species have been tested, and found to be 0-400 $\mu g.g^{-1}$ (Aplin, 1964; Twigg, *et al.*, 1996b).

Affinity. This species resembles *G. aculeatum*, *G. euryphyllum*, *G. triangulare*, *G. trilobum* and *G. wonganensis*. *Gastrolobium aculeaum* differs by having light green leaves with 1 or 3 spines and umbellate inflorescences with 2-3 flowers. *Gastrolobium euryphyllum* can be distinguished by the large, glaucous leaves (though this character is shared by some specimens of *G. spinosum*) but mostly by the subtending bracts, which are longer than the bud that they subtend. *Gastrolobium triangulare* can be distinguished by the leaves, which have a strict triangular shape with 3 angles which point at about 120° from each other, and by the generally smaller flowers and fruits (e.g. calyx 4-6 mm long, standard 8.5-10 x 9-11.5, pod 5-6 mm long). *Gastrolobium trilobum* differs by having 1 or 3 spines only (though some specimens of *G. spinosum* also have this feature), but the inflorescence can then distinguish these variants, as they are fewer flowered (2-7-flowered), and have smaller flowers and fruits (e.g. calyx 4.5-5 mm long, standard 7-10 x 6.5-8.5 mm, pod c. 5 mm long). *Gastrolobium wonganensis*

differs by having long, open, pubescent racemes with smaller flowers (rachis 35-50 mm long, calyx 4.5-5.5 mm long, standard 6.5-7.5 x 5.5-6.5 mm).

2. Gastrolobium euryphyllum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Avon District: 20 km N of Newdegate towards Hyden, 32°54'42"S, 119°02'44"E, *G.T. Chandler 948, A. Monro & S. Donaldson*, 19 Sep. 1999 (*holo*: CANB; *iso*: PERTH).

Slender, erect, glaucous shrubs. The subtending floral bracts distinguish *G. euryphyllum* from all other spinose species of *Gastrolobium*, as they are about twice as long as the buds that they subtend, where in other spinose species they are usually shorter than the buds.

Frutices tenui erecti glauci, bracteis flores subtenentibus quam alabastris duplo longioribus; species ceterae spinosae *Gastrolobii* bracteis alabastris brevioribus.

Etymology. The specific epithet comes from the Greek (eurys = broad, and phyllon = leaf), referring to the particularly broad leaves of this species.

Slender, erect, glaucous *shrubs*, to 2.5 m high. *Branchlets* ascending to erect, angular, glabrous, glaucous. *Petioles* terete, continuous and scarcely decurrent with the branchlet, c. 0.5 mm long. *Leaves* spreading, very robust, opposite, very broadly to transversely ovate, 14-28 x 19-41 mm, glabrous, glaucous, venation somewhat obscured, pinnate; apex acute, fiercely pungent-pointed; margins not recurved, dentate, with 5-6 fiercely spinescent angles; base cordate. *Stipules* erect, rigid, triangular, 2-2.5 mm long. *Inflorescences* terminal racemes, 6-20-flowered; *peduncle* 4-6 mm long, glabrous; *rachis* 2-15 mm long; *subtending bracts* caducous, scale-like, entire, linear-lanceolate, longer than bud, c. 6 mm long, glabrous to sparsely pubescent. *Pedicels* terete, c. 1.5 mm long. *Calyx* campanulate, 8-9 mm long including the 1-1.5 mm receptacle, glabrous, lobes all recurved; upper two lobes united higher than the lower three, rounded, 3-4 mm long; lower three lobes triangular, acute, 2.5-3.5 mm long. *Corolla*: *standard* transversely elliptic, 8.5-9 x 9-9.5 mm including the c. 2 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex slightly emarginate, base truncate; *wings* oblong, 8.5-9 x 2.5-3 mm including the 2-2.5 mm claws, orange-yellow, red towards the base, apex rounded, not incurved, not enclosing keel, base auriculate on both margins, saccate; *keel* half very broadly obovate, very robust, margins not incurved, c. 9 x 3.5 mm including the 2.5 mm claws, deep maroon, apex rounded, base auriculate saccate. *Style* long, slightly hooked, lower third slightly

pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 7-8 x 4-5 mm, glabrous. *Seed* ellipsoid, c. 4 mm long, arillate.

Flowering period. September to January. *Fruiting period.* November to January.

Distribution (Map 2). South-west Western Australia. Occurs around the Newdegate area.

Map 2. Distribution of *G. euryphyllum*.

Habitat. Grows on rolling sand dunes in sand over laterite, in mallee or *Allocasuarina* shrubland.

Specimens examined. WESTERN AUSTRALIA: Roe District: near Lake Biddy, between Lake Grace and Newdegate, c. 33°00'S, 118°56'E, *W.E. Blackall 1388*, 19 Nov. 1931 (PERTH); 46 km E of Pingaring along road to Varley, 32°44'S, 119°05'E, *B. Barnsley 982*, 29 Jan. 1979 (CANB, PERTH).

Toxicity. Unknown, but as it is related to *G. spinosum*, it is probably toxic.

Affinity. Similar to the broader-leaved forms of *G. spinosum*, but *G. spinosum* is not always glaucous, has much smaller bracts, and most specimens have some axillary

inflorescences, where *G. euryphyllum* is always terminal. It is also somewhat similar to *G. wonganensis*, but this is a much smaller and bushier shrub (< 1 m high), has smaller leaves (7-16(-20) x 13-21(-28) mm) with more spines (c. 10), the stipules are hyaline, the subtending bracts are trifid and smaller (3-4 mm long), the flowers are smaller (calyx 4.5-5.5 mm long, standard 6.5-7.5 x 5.5-6.5 mm), and the inflorescence is longer (rachis 35-50 mm long) and pubescent.

3. Gastrolobium wonganensis G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Avon District: Wongan Hills Nature Reserve, near carpark, c. 11 km NW of Wongan Hills township, 30°49'21"S, 116°38'11"E, *G.T. Chandler 844, A. Monro & S. Donaldson*, 10 Sep. 1999 (*holo*: CANB; *iso*: BRI, HO).

The greater number of spines (7-10), the pubescent inflorescence axes and the smaller flowers (e.g. standard 6.5-7.5 x 5.5-6.5 mm) distinguish *G. wonganensis* from the specimens of *G. spinosum* with small, round leaves.

A speciminibus *G. spinosi* foliis parvis rotundis distincta foliorum spinis plus (7-10), inflorescentiae rachidibus pubescentibus et floribus parvioribus (e.g. vexillum 6.5-7.5-5.5-6.5 mm).

Etymology. This species is named after the area where it occurs, Wongan Hills.

Low, dense, spreading *shrubs*, to 0.7 m high. *Branchlets* spreading to ascending, somewhat angular, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, < 0.5 mm long. *Leaves* spreading, opposite, with bases overlapping, transversely ovate, almost appearing semi-circular, 7-16(-20) x 13-21(-28) mm, glabrous, venation prominently reticulate; apex broadly rounded, fiercely pungent-pointed; margins not recurved, dentate, with 7-10 angles, each fiercely pungent-pointed; base slightly cordate. *Stipules* erect, hyaline, 1.5-2.5 mm long. *Inflorescences* terminal racemes, 14-21-flowered, peduncle and rachis moderately to densely pubescent; *peduncle* 9-15 mm long; *rachis* 35-50 mm long; *subtending bracts* caducous, scale-like, trifid, narrowly rhombic, 3-4 mm long, pubescent. *Pedicels* terete, 1-2.5 mm long. *Calyx* campanulate, 4.5-5.5 mm long including the 1 mm receptacle, moderately to densely pubescent, lobes all recurved to reflexed; upper two lobes united higher than the lower three, acute, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* very broadly ovate, 6.5-7.5 x 5.5-6.5 mm including the 1.5-2 mm claw, yellow to yellow-orange with a red ring surrounding the yellow centre, apex emarginate, base truncate; *wings* obliquely elliptic, c. 7 x 2 mm including the 2 mm

claws, yellow, apex rounded, not incurved, not enclosing keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, margins not incurved, c. 7 x 3 mm including the 2 mm claws, maroon, apex rounded, base auriculate, saccate. *Style* long, incurved, lower third slightly pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 5.5-7.5 x 3-4 mm, glabrous. *Seed* not seen.

Flowering period. September and October. *Fruiting period.* Unknown.

Distribution (Map 3). Occurs only around the Wongan Hills area.

Map 3. Distribution of *G. wonganensis*.

Habitat. Grows on lateritic rises on clay loam over laterite in open mallee woodland.

Specimens examined. WESTERN AUSTRALIA: Avon District: 0.5 km from the summit of Mt O'Brien, NW of Wongan Hills on Piawaning road, 30°51'S, 116°33'E, *J.H. Ross 3589*, 7 Oct. 1992 (MEL); summit of Mt O'Brien, W of Wongan Hills, 30°50'16"S, 116°38'16"E, *G.T. Chandler 548 et al.*, 21 Feb. 1998 (CANB); Wongan Hills, c. 1.5 km N of Wongan Hills (township) to Piawaning Road and c. 13 km (by road) NW of the former town, 30°49'S, 116°37'E, *B.J. Conn 2247*, 19 Sep. 1985 (B,

CHR, MEL, MO, NSW, PERTH); Wongan Hills, 30°49'S, 116°38'E, *K.F. Kenneally 2355*, 6 Oct. 1974 (PERTH).

Toxicity. Unknown, but given its relationship to *G. spinosum*, it is likely to be toxic.

Affinity. Very similar to the more typical forms of *G. spinosum*, which can be distinguished from *G. wonganensis* by the fewer spines on the leaf (1-9), the glabrous inflorescence and the larger flowers (calyx 6-7 mm long, standard 9-13 x 9.5-13 mm). It is also similar to *G. euryphyllum*, but that is a much larger and more spindly shrub (up to 2.5 m high), has much larger leaves (14-28 x 19-41 mm) with fewer spines (5-6), the stipules are triangular and rigid, the subtending bracts are entire and larger (c. 6 mm long), the flowers are larger (calyx 8-9 mm long, standard 8.5-9 x 9-9.5 mm), and the inflorescence is shorter (rachis 2-15 mm long) and glabrous.

4. Gastrolobium triangulare (Benth.) Domin (1923b, p. 35). *G. spinosum* var. *triangulare* Benth. (1864, p. 103). *Type citation*: "Stony places, Port Gregory, Oldfield". *Type specimens*: *Lectotype* (here chosen): K (Port Gregory, Oldfield); *iso*: MEL, P.

Low, spreading, dense, glabrous *shrubs*, 0.3-1.5 m high. *Branchlets* spreading to ascending, mostly terete, sometimes slightly angular, glabrous. *Petiole* very short, somewhat swollen at the base of the leaf, continuous but not decurrent with the branchlet, c. 0.5 mm long. *Leaves* broadly spreading, opposite, very broadly to depressed-triangular, 8-25 x 12-28 mm, older leaves sometimes glaucous, otherwise a light green colour, venation prominently reticulate, raised, intramarginal vein usually present; apex obtuse, all 3 angles with pungent points; margins entire or minutely crenulate; base cordate. *Stipules* erect, linear-triangular, 2-lobed, inner margins slightly fimbriate, c. 1.25 mm long. *Inflorescences* mostly terminal racemes, occasionally on short lateral shoots, 6-12-flowered; *peduncle* 8-22 mm long; *rachis* 5-17 mm long; *subtending bracts* caducous, scale-like, entire, triangular, 1.5-2 mm long. *Pedicels* terete, 1 mm long; sometimes abruptly curved at 90° to the rachis (more commonly as flower ages), causing a number of flowers to appear nodding. *Calyx* campanulate, 4-6 mm long including the 0.75-1 mm receptacle, glabrous; upper two lobes united higher than the lower three, broadly triangular, spreading to slightly recurved, 1.5-2.5 mm long; lower three lobes triangular, strongly spreading to reflexed, 1.5-2.25 mm long. *Corolla*: *standard* elliptical to slightly ovate, 8.5-10 x 9-11.5 mm including the c. 3 mm claw, orange-yellow with a red ring around the pale yellow centre, apex emarginate,

base cordate, occasionally slightly auriculate; *wings* obovate to oblong-obovate, 9-9.5 x 2.5-3 mm including the c. 2.5 mm claw, orange-yellow, red towards the base, apex obtuse, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half obliquely broadly elliptic, turgid, margins not incurved, 8-8.5 x 2.5-3 mm including the c. 3 mm claw, maroon, apex obtuse, base auriculate. *Style* long, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, obliquely ellipsoid to ellipsoid, nutant, 5-6 x 3-4 mm. *Seed* ellipsoid or rhomboid, 2.75 long, arillate.

Flowering period. July to November. *Fruiting period.* Some fruit in August, but mostly September to December.

Distribution (Map 4). This species occurs in an area north of Geraldton, from White Peak to around Northampton and Port Gregory, and inland to Howatharra Hill.

Map 4. Distribution of *G. triangulare*.

Habitat. Grows in sandy or sandy clay soils on rocky slopes and ridges, in low shrubland or heathland.

Selected specimens (19 examined). WESTERN AUSTRALIA: Irwin District: 36 km along the North West Coastal Highway from Geraldton towards Northampton, 28°28'58"S, 114°38'04"E, *G. T. Chandler 222 & W. Keys*, 11 Sep 1997 (CANB, MEL, PERTH); Howatharra Nature Reserve, 3.5 km towards Nanson from the turnoff on the North West Coastal Highway (c. 30 km N of Geraldton), 28°32'52"S, 114°39'45"E, *G. T. Chandler 224 & W. Keys*, 11 Sep 1997 (CANB, K); 36 km along the North West Coastal Highway from Geraldton towards Northampton, 28°28'58"S, 114°38'04"E, *G. T. Chandler 222 & S. Donaldson*, 24 Oct. 1998 (CANB, MEL); Woggrakine, *H. W. Hawthorne s.n.*, 19 Nov. 1953 (PERTH); low sandstone hill close to North West Coastal Highway, 10 mls. [16 km] S. of Northampton & 21 mls. [33.5 km] N. of Geraldton, 28°28'S, 114°38'E, *R. V. Smith 66/391*, 9 Sep. 1966 (CANB, MEL, PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium triangulare* is similar to both *G. spinosum* and *G. trilobum*. *Gastrolobium spinosum* differs by having ovate leaves generally with numerous spines, and the flowers and fruits are generally larger (e.g. calyx 6-7 mm long, standard 9-13 x 9.5-13 mm, pod 6-10 mm long). *Gastrolobium trilobum* differs in having ovate to triangular leaves, and although it has 3 spines, they all generally point upwards, rather than having the lower 2 spines pointing either downwards or straight out.

5. Gastrolobium trilobum Benth., in Lindley (1839, p. 13). Type: none cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River, Drummond, 1839); *isolecto*: CGE (2 sheets).

> *Gastrolobium spinosum* Benth. var. *trilobum* S. Moore (1920, p. 170). *Type citation*: "Kauring, *G. W. Brown* (Hb. Stoward, 551, 632)." *Type specimens*: *Lectotype* (here chosen): BM (Stoward 551); *isolecto*: PERTH.

Rigid, bushy, spreading *shrubs*, occasionally more slender and erect, 0.6-1.8 m high, glabrous, occasionally glaucous. *Branchlets* spreading to ascending, terete, sometimes with a decurrent rib from the petiole, glabrous. *Petiole* terete, continuous but not decurrent with the branchlet, 1-2 mm long. *Leaves* patent to spreading, opposite, ovate to sub-triangular, rarely trullate, trilobed (rarely not, and if not, at least some leaves becoming trilobed on the plant), 11-36 x 10-20 mm, glabrous, often glaucous, venation reticulate, with a major vein going from the prominent midrib to the lateral lobes, light to olive green; apex broadly triangular to quite long and lanceolate, pungent-pointed,

lateral lobes broad and short or lanceolate, pungent-pointed; margins often somewhat conduplicate; base obtusely rounded to cuneate, rarely cordate (mostly in the Wongan Hills-Wyalkatchem area). *Stipules* erect, linear-triangular, c. 3 mm long. *Inflorescences* axillary, occasionally terminal, racemes (terminal particularly in the Wongan Hills-Wyalkatchem area), 2-7-flowered; *peduncle* 3-12 mm long; *rachis* 1-13 mm long; *subtending bracts* caducous, scale-like, trifid with somewhat fimbriate margins, triangular, c. 1.5 mm long, pubescent to glabrous. *Flower*: *pedicels* terete, straight to curved to 90°, 2-3 mm long. *Calyx* tapered to the base, c. 4.5-5 mm long including the. 0.75-1.5 mm receptacle, pubescent to glabrous; lobes slightly recurved to reflexed; upper 2 lobes more or less united into an emarginate, truncate lip, c. 2 mm long; lower 3 lobes triangular, sometimes rounded, c. 1.5 mm long. *Corolla: standard* very broadly ovate to transversely broadly elliptic, 7-10 x 6.5-8.5 including the 2-3 mm claw, orange or yellow, with a central red ring surrounding the orange or yellow centre, apex emarginate, base cordate; *wings* obovate to nearly oblong, 6.5-10 x 2-2.5 mm including the 2-3 mm claw, orange or yellow, red towards the base, apex rounded, not incurved, not enclosing the keel, auriculate on both margins, slightly saccate; *keel* half obliquely elliptical, 7-10 x 2.5-3.5 mm including the 3-4 claw, deep maroon, apex almost black or rarely yellow, apex obtuse, base auriculate, saccate. *Style* long, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, c. 5 x 3 mm. *Seed* ellipsoid, c. 2 mm long, arillate.

Vernacular name. Bullock Poison.

Chromosome number. 2n = 16 (Sands 1975).

Flowering period. July to November. *Fruiting period*. From October.

Distribution (Map 5). Occurs in the central to mid-western wheatbelt of Western Australia, from Brookton and Narrogin in the west, to Marvel Loch in the east, and from Bindi Bindi in the north to Katanning in the south.

Habitat. Grows on sandy soils in open woodland and mallee woodland.

Selected specimens (53 examined). WESTERN AUSTRALIA: Avon district: 1.5 km N along the Great Southern Highway, from the Narrogin turnoff at Wagin, 33°17'56"S, 117°19'26"E, *G.T. Chandler 283-285 & W. Keys*, 19 Sep. 1997 (CANB, PERTH); 14 km from Bindi Bindi towards Ballidu, 30°35'17"S, 116°29'09"E, *G.T. Chandler 680 & S. Donaldson*, 26 Oct. 1998 (CANB); 2 km E of Woodanilling, 33°34'S, 117°57'E, *R.J.*

Cranfield 275, 3 Nov. 1978 (CANB, PERTH); Entrance to Fowlers Gully, Wongan Hills, 30°49'S, 116°38'E, *K.F. Keneally 1383*, 20 July 1974 (PERTH); 74 mls [135 km] from Perth to Brookton, c. 32°23'S, 116°55'E, *J.R. Knox 65x001*, Oct. 1965 (PERTH); 31 km ESE of Highbury, 33°06'S, 117°35'E, *R.J. Cranfield 4599*, 22 Oct. 1983 (PERTH); 12 km NW of Quairading, 3 km NW of Woolaring Well, 31°57'S, 117°18'E, *M.D. Crisp 6187, et al.*, 27 Sep. 1979 (CANB, PERTH); Coolgardie district; Along State Vermin Fence No. 7, 1.5 km SE of Southern Cross, 80 km S of Great Eastern Highway, 31°51'S, 120°01"E, *J. Dodd 207*, 4 Nov. 1985 (CANB, K, PERTH); 29.4 miles [48 km] from Marvel Loch on Mt Day road, 31°44'S, 119°51'E, *B.H. Smith 1011*, 3 Nov. 1987 (CANB, MEL, PERTH).

Map 5. Distribution of *G. trilobum*.

Toxicity. Purported to be toxic, but does not appear to have been tested. According to Gardner and Bennetts (1956), it has only rarely been implicated in stock loss.

Notes on variation. *Gastrolobium trilobum* generally has 3 pungent points per leaf, but occasionally has only one. These leaves are often found on plants that have mostly 3 spines, but for some reason a particular branchlet produces leaves with only one spine,

so it is important to examine the whole plant for the purposes of collection. Also, the leaves of *G. trilobum* with only one spine often show signs of bulging out to either side of the apex, indicating showing an affinity to becoming trilobed.

Affinity. *Gastrolobium trilobum* is similar in appearance to *G. triangulare* and *G. spinosum*. *Gastrolobium triangulare* is easily distinguished by the strictly triangular leaves with the lower 2 spines pointing downwards or straight out, where *G. trilobum* has a more ovate leaf with the lower 2 spines pointing upwards. *Gastrolobium spinosum* can be distinguished by usually having a greater number of spines (typically 4-9) per leaf, though some specimens have 1 or 3 spines, however, *G. spinosum* also has a greater number of flowers per inflorescence (6 to more than 30 flowered), and larger flowers and fruits (e.g. calyx 6-7 mm long, standard 9-13 x 9.5-13 mm, pod 6-10 mm long).

6. Gastrolobium aculeatum G.Chandler, Crisp & R.J. Bayer, *sp. nov.* *Type*: WESTERN AUSTRALIA: Coolgardie District: 61 km on Mt Day – Marvel Loch road from Hyden –Norseman track, towards Marvel Loch, near Barrier Fence, 31°50'45"S, 119°59'44"E, *G.T. Chandler 903, A. Monro & S. Donaldson*, 16 Sep. 1999 (*holo*: CANB; *iso*: AD, BRI, K, MEL, NSW, NY, PERTH).

The glaucous leaves and particularly sharp pungent apices of this species, together with the terminal, 2-3-flowered umbels, distinguish this species from the other spinose-leaved species of *Gastrolobium* that have 1-3 pungent apices.

A speciebis *Gastrolobii* foliis apicibus 1-3 pungentibus distincta foliis glaucis, foliorum apicibus maxime pungentibus, umbellis terminalibus 2-3-floribus.

Etymology. This specific epithet comes from Latin (aculeus = a prickle or very sharp point), and is named after the particularly needle-like apices of the leaves.

Erect, bushy *shrubs*, 1-2.5 m high. *Branchlets* ascending, terete to slightly angular, glabrous. *Petioles* terete, continuous but not decurrent with the branchlet, 1-1.5 mm long. *Leaves* spreading, opposite, ovate, 10-20 x 6-13 mm, somewhat glaucous, venation prominently reticulate; apex acute, fiercely pungent-pointed, all three angles pungent-pointed when trilobed; margins slightly conduplicate, entire or trilobed (often both present on one specimen); base cordate to rarely truncate. *Stipules* erect, hyaline, 0.5-1 mm long. *Inflorescences* terminal umbels, 2-flowered (rarely 3-flowered); *peduncle* angular, 5-9 mm long; *rachis* absent; *subtending bracts* caducous, entire, obovate, c. 1 mm long. *Pedicels* tapering to the base, 3-4 mm long. *Calyx* campanulate,

6-7 mm long including the c. 0.5 mm receptacle, glabrous to sparsely pubescent, lobes all recurved; upper two lobes united higher than the lower three, rounded, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, c. 11 x 11 mm including the 3 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex entire, base truncate; *wings* significantly smaller than the keel, oblong, c. 11 x 3 mm including the 2 mm claw, orange-yellow, apex rounded, not enclosing the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, 12-13 x 4 mm including the 3 mm claw, light yellow, apex obtuse, slightly spout-like, base auriculate, saccate. *Style* long, hooked, pubescent towards the base; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* prominently stipitate, ellipsoid, 8 x 4.5 mm, glabrous. *Seed* not seen.

Flowering period. September to November. *Fruiting period*. Unknown.

Distribution (Map 6). South-west Western Australia. Occurs SE of Southern Cross, near Marvel Loch, and Moorine Rock, and east to Steich Mound, which is on the western edge of the Great Victoria Desert.

Map 6. Distribution of *G. aculeatum*.

Habitat. Grows on deep white or grey sand dunes, in mallee woodland or shrubland.

Specimens examined. WESTERN AUSTRALIA: Coolgardie District: along State Vermin Fence No. 7, 105 km SE of Southern Cross, 80 km S of Great Eastern Highway, 31°51'S, 120°01'E, *J. Dodd 207*, 4 Nov. 1985 (CANB, PERTH); 29.4 miles [47 km] from Marvel Loch on Mt Day road, 31°44'S, 119°51'E, *B.H. Smith 1011*, 3 Nov. 1987 (CANB, MEL, PERTH); 46 km on Mt Day – Marvel Loch road from Hyden – Norseman track, towards Marvel Loch, 31°58'29"S, 120°09'07"E, *G.T. Chandler 901 et al.*, 16 Sep. 1999 (CANB, PERTH); ibid, *G.T. Chandler 902 et al.*, 16 Sep. 1999 (CANB, PERTH); 6 km W of Moorine Rock Railway Bridge on Great Eastern Highway, 31°20'S, 119°02'E, *R.A. McKenzie 93/17*, 7 Sep. 1993 (PERTH); 13 km SE PNC Officer Basin camp, 53 km NNE Streich Mound, 30°01'S, 123°52'E, *D.J. Pearson 570*, 23 Jan. 1989 (PERTH).

Toxicity. Unknown.

Affinity. This species resembles *G. spinosum* and *G. trilobum*. It can be told apart from these two species quite easily, however, as *G. trilobum* has mostly axillary racemes that are 2-7-flowered and generally has a darker leaf, compared to the 2(-3)-flowered umbels and the light green leaves of *G. aculeatum*. *Gastrolobium spinosum* is easily distinguished, having generally darker leaves with more spines per leaf (typically 4-9) and racemose inflorescences greater numbers of flowers (6 to more than 30 flowered).

The *G. bilobum* group

This group of *Gastrolobium* species are often found on or around granite outcrops, or on sandy soils over granite. This group includes the type of the genus *Gastrolobium*, *G. bilobum*, and also contains the *G. parviflorum* group, a common suite of species found throughout the central and southern wheatbelt of south-west Western Australia.

7. Gastrolobium semiteres G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Coolgardie District: Boorabbin Rock, 300 m to the NE (Boorabbin Rock is between Southern Cross and Coolgardie), 31°11'48"S, 120°17'16"E, *G.T. Chandler 694 & S. Donaldson*, 27 Oct. 1998 (*holo*: CANB; *iso* K, MEL, NSW, PERTH).

Bushy, glaucous shrubs with semi-terete leaves and large, densely pubescent flowers. *Gastrolobium involutum* differs by the non- glaucous leaves, the upper leaf surface is completely obscured, the flowers are smaller (e.g. calyx 7 mm long, standard c. 11 mm

long), the wings overlap the keel and are auriculate on the upper margin only, and the inflorescence is much less pubescent.

Frutices glaucis foliis semi-teretibus et floribus magnis dense pubescentibus. *G. involutum* a hac species foliis non glaucis, folii pagina omnino occulta, floribus parvioribus (e.g. calyx 7 mm longus, vexillum c. 11 mm longum), aliis carinam excedentibus lobo solum in margine adaxiali et inflorescentia multo minus pubescenti superna differt.

Etymology. Named after the semi-terete leaf shape of this species.

Open, multi-stemmed *shrubs*, 0.5-1.5 m high. *Branchlets* ascending, angular to almost terete, moderately pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1.5-2.5 mm long. *Leaves* ascending, in whorls of 3, linear-oblong, 20-40 x 1-2 mm, sparsely pubescent along mid-vein, glabrous, often glaucous, venation prominently reticulate; apex obtuse to rounded, slightly mucronate; margins thickened and canaliculate, forming a groove along the leaf such that the upper margin is barely visible; base tapering to the petiole. *Stipules* erect, vestigial, c. 0.2 mm long. *Inflorescences* terminal racemes, 7-20-flowered; *peduncle* angular, with or without apparently aborted buds at the base, 10-20 mm long; *rachis* angular, 25-50 mm long; *subtending bracts* caducous, scale-like, entire, narrowly triangular, 4-5 mm long, densely pubescent, especially at the base. *Pedicels* terete, 3-4.5 mm long. *Calyx* campanulate, 7-9 mm long including the c. 1 mm receptacle, densely pubescent, lobes may be slightly recurved; upper two lobes united higher than the lower three, obtuse, sometimes united into an emarginate truncate lip, 2.5-3 mm long; lower three lobes triangular, acute, 2-2.5 mm long. *Corolla*: *standard* transversely elliptic, c. 13 x 12 mm including the 4 mm claw, yellow-orange with a red ring surrounding the yellow centre, apex emarginate, base truncate, slightly auriculate; *wings* oblong, c. 12 x 3.5 mm including the 4 mm claw, orange to orange-red, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, not saccate; *keel* half transversely broadly obovate, margins not incurved, c. 12 x 4 mm including the 4 mm claws, maroon, apex rounded, base auriculate, saccate. *Style* long, incurved to slightly hooked, lower half pubescent along inner margin; *ovary* shortly stipitate, densely pubescent; *ovules* 4-5. *Pod* stipitate, obliquely elliptic, 7-9 x 3-4.5 mm, densely villous. *Seed* not seen.

Flowering period. August to October. *Fruiting period*. November and December.

Distribution (Map 7). Has a narrow distribution in the sandplains around Boorabbin Rock (E of Southern Cross), and south to Disappointment Rock (SE of Southern Cross).

Map 7. Distribution of *G. semiteres*.

Habitat. Grows on broad sand dunes or deep yellow sand over granite in open mallee and *Acacia* heath.

Specimens examined. WESTERN AUSTRALIA: Coolgardie District: Koorarawalyee, 0.5 km along Yilgarn Barrier Fence, c. 35 km E of Yellowdine, 31°16'44"S, 120°00'08"E, *G.T. Chandler 880 et al.*, 15 Sep. 1999 (CANB, MEL, PERTH); Boorabbin, 31°12'39"S, 120°15'36"E, *G.T. Chandler 878 et al.*, 15 Sep. 1999 (CANB, PERTH); Disappointment Rock, 32°07'53"S, 120°53'37"E, *R. Davis 8969*, 22 Sep. 1999 (CANB, PERTH); 300 m NE of Boorabbin Rock, 31°11'48"S, 120°17'16"E, *G.T. Chandler 695 & S. Donaldson*, 27 Oct. 1998 (CANB); ibid, *G.T. Chandler 696 & S. Donaldson*, 27 Oct. 1998 (CANB, MEL); Boorabbin, 31°11'S, 120°17'E, *C.A. Gardner 13870*, 15 Dec. 1961 (CANB, PERTH); Boorabbin Rock and near vicinity, 31°12'S, 120°17'E, *T. Houston 408-32*, 4-9 Oct. 1981 (PERTH); 67 miles [109 km] east of

Southern Cross, 31°11'S, 120°17'E, *J.R. Knox 65x087*, Aug. 1965 (PERTH); 24 km W of Boorabbin, 31°17'S, 120°00'E, *K. Newbey 8385*, 28 July 1981 (PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium semiteres* is similar in appearance to *G. involutum*, but *G. involutum* does not have glaucous leaves, the upper leaf surface is completely obscured, the flowers are smaller (e.g. calyx 7 mm long, standard c. 11 mm long), the wings overlap the keel and are auriculate on the upper margin only, and the not very hairy inflorescence.

8. Gastrolobium stenophyllum Turcz. (1853, p. 275). *Type citation*: "Drum. V. n. 52". *Type specimens*: *holo*: KW; *iso*: BM, K (3 sheets), W.

Bushy, erect *shrubs*, to 3 m high. *Branchlets* ascending, angular to almost terete, moderately pubescent. *Petioles* terete, continuous and partly decurrent with the branchlet, 1.5-3 mm long. *Leaves* broadly spreading, crowded along stem, internodes very short, generally opposite, but may be scattered, whorled or alternate, linear or linear-obovate, 14-45 x 2-4 mm, glabrous, venation prominently reticulate; apex sub-acute to broadly rounded, unarmed, slightly recurved, may have a tiny, blunt mucro; margins conduplicate so that upper surface is often not visible; base cuneate. *Stipules* inconspicuous, erect, hyaline, < 1 mm long. *Inflorescences* terminal racemes, 10 to more than 30 flowered, flowers very crowded along rachis; *peduncle* 1-4 mm long; *rachis* 10-50 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, keeled, c. 2 mm long, moderately pubescent. *Pedicels* 2-3 mm long. *Calyx* campanulate, 4.5-5.5 mm long including the c. 1 mm receptacle, moderately to densely sericeous, lobes not or scarcely recurved; upper two lobes united higher into an almost truncate lip, rounded, c. 2 mm long; lower three lobes triangular, acute, 1.5-2 mm long. *Corolla*: *standard* transversely ovate, c. 8.5 x 8.5 mm including the 3 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, slightly auriculate; *wings* obovate, c. 9 x 3 mm including the 3 mm claws, orange, apex rounded, incurved and slightly overlapping to partly enclose the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, margins incurved, c. 8.5 x 2.5 mm including the 3 mm claw, pink and maroon, apex rounded, slightly spout-like, base auriculate, saccate. *Style* long, incurved to slightly hooked, lower third pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, ovoid, 6-7 x 2.5-3 mm, moderately pubescent. *Seed* ellipsoid, c. 2.5 mm long, arillate.

Vernacular names. Phillips River Poison; Narrow-leaved Poison.

Flowering period. September to February. *Fruiting period*. Mid-December to February.

Distribution (Map 8). South-west Western Australia. Occurs along the rivers of Fitzgerald River National Park, extending north to near Ravensthorpe, and west to near Jerramungup, where it grows around granite outcrops where away from rivers.

Map 8. Distribution of *G. stenophyllum*.

Habitat. This species prefers sandy soils over granite, often found at the base of granite outcrops or along rivers with granite rocks, in woodland, shrubland or heath.

Conservation status. ROTAP: 3KC-. CALM: P3. This species is poorly known, and may in fact occur quite widely throughout the south coast of SW Western Australia on small granite outcrops on farm properties. Further survey work is needed to determine its conservation status.

Selected specimens (25 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Eyre District: Between

Jerramungup and Ravensthorpe, *J.M. Fox 86/235*, 1 Feb. 1986 (CANB); Phillips River, Fitzgerald River National Park, *B.J. Lepschi 3779 & B.A. Fuhrer*, 28 Oct. 1997 (AD, BRI, CANB, MEL, NSW, PERTH); SSW of Jerramungup, private property, 34°07'S, 118°53'E, *G.T. Chandler 735 & S. Donaldson*, 31 Oct. 1998 (CANB, MEL, MO, PERTH); Fitzgerald River, *C.A. Gardner 9235*, 22 Sep. 1948 (CANB, PERTH).

Toxicity. Fluoroacetate 90 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The crowded leaves make this species difficult to confuse with any other *Gastrolobium*, especially when combined with the crowded racemes. The inflorescence and fruits are somewhat similar to those of *G. bilobum*, but the leaves of *G. bilobum* are not linear, and do not have recurved margins and the rachis is much shorter (2-10 mm long). The foliage of *G. stenophyllum* is similar to that of *G. tenue*, but *G. tenue* is finely pungent-pointed, the inflorescence is not crowded and has fewer flowers (4-10-flowered), and the subtending bracts are persistent and trifid.

9. Gastrolobium cuneatum Henfry (1852b, p. 49). *Type citation*: "... exhibited by the Messrs. Henderson of Pine Apple Place ... It was raised from seeds sent by Mr. Drummond, collected in Australia". *Type*: the plate.

> *Gastrolobium forrestii* Ewart in Ewart, White & Tovey (1908, p. 188). *Type citation*: "Blackwood River, W.A., Sir John Forrest; W. Aust. 1889; Gordon River in forest Ian 1877". *Type specimens*: *Lectotype* (here chosen): MEL (624683); *isolecto*: BM, K (2 sheets), MEL (624682), PERTH.

Erect *shrubs*, 1-2 m high. *Branchlets* ascending, angular, sparsely to moderately pubescent. *Petioles* terete, continuous and sometimes decurrent with the branchlet, 1.5-3 mm long. *Leaves* spreading to ascending, whorled or rarely opposite, elliptic or linear-so to cuneate (juvenile leaves in particular are often cuneate), 20-33(-61) x (2.5-)5-10 mm, upper surface glabrous, lower surface sparsely to densely pubescent, venation prominently reticulate, raised on the upper surface ; apex usually retuse, rarely truncate, mucronate, recurved or straight; margins entire, recurved, revolute or occasionally flat; base rounded. *Stipules* erect, hyaline, 2-3.5 mm long. *Inflorescences* terminal racemes, 20-40-flowered; *peduncle* (5-)11-58 mm long; *rachis* 75-116 mm long; *subtending bracts* caducous, scale-like, entire, subulate, 2-4 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 4-6 mm long including the c. 1 mm receptacle, sparsely to moderately pubescent, lobes not recurved; upper two lobes united higher than the lower three, triangular, acute, c. 2.5 mm long; lower three lobes

triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely obovate, c. 9 x 10 mm including the c. 4 mm claw, yellow to yellow-orange, apex emarginate, base cordate, auriculate; *wings* obovate, lower margin reflexed to expose the keel, c. 8.5 x 2.5 mm including the c. 2 mm claw, yellow to orange, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only; *keel* half transversely elliptic, turgid, margins not incurved, c. 4 x 2 mm including the c. 2 mm claws, orange-red, red or pink, apex with an acicular beak, base auriculate, saccate, with a circular opening near the claws to expose the stamens from below. *Style* short, straight but at 45 degrees to the ovary, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 6.5-8 x 3.5-4 mm, moderately pubescent. *Seed* reniform, c. 2.5 mm long, arillate.

Vernacular name. River Poison.

Flowering period. September to February. *Fruiting period*. November to February.

Distribution (Map 9). South-west Western Australia. Distributed throughout the Darling escarpment, from Pinjarra south to Margaret River, east to Albany and the Porongurup Range.

Map 9. Distribution of *G. cuneatum*.

Habitat. Grows in fairly moist areas usually on loam or clay soils in eucalypt forest or woodland, or swampy areas.

Selected specimens (37 examined). WESTERN AUSTRALIA: Darling District: Wilson Inlet near Hay River mouth, 10 km E of Denmark, 34°58'33'S, 118°27'33'E, *A.R. Annels 1073*, 16 Dec. 1991 (PERTH); Margaret River, 33°57'S, 115°04'E, *A. Lea s.n.*, Oct. 1898 (PERTH); Picton, along Preston River, 33°21'S, 115°41'E, *F.G. Davies s.n.*, Oct. 1966 (CANB, PERTH); Sappers Bridge, Gully Road, Walpole Nornalup National Park, Frankland River, 34°57'40"S, 116°49'20"E, *A.R. Annels 5075 & R.W. Hearn*, 30 Nov. 1994 (CANB, K, MEL, PERTH); Blackwood River Bridge, Warner Glen Road, 34°05'33"S, 115°12'57"E, *M.D. Crisp 8937 & W. Keys*, 12 Oct. 1996 (CANB, PERTH); Kent River, c. 34°45'S, 117°05'E, *C.A. Gardner s.n.*, 22 Jan. 1936 (CANB, PERTH). Eyre District: East of Porongurups, *G.I. Gauntlett 3*, Sep. 1963 (PERTH).

Notes on nomenclature. The name commonly used for this species is *Gastrolobium forrestii*. However, a search of the literature uncovered an earlier name that matches the description of *G. forrestii*. The type is a plate, which is unambiguously the same as *G. forrestii*.

Toxicity. Highly toxic; fluoroacetate 1200 $\mu g.g^{-1}$ (Aplin, 1964, as *G. forrestii*).

Affinity. Some specimens seen have foliage superficially similar to *G. bilobum*, but the inflorescence structure of *G. bilobum* is different, having quite a short rachis (2-10 mm long) with the flowers crowded along its length (internodes 1-2 mm long) compared with *G. cuneatum* (> 5, often > 10 mm long).

10. Gastrolobium callistachys Meisn. (1848, p. 216). *Type citation*: "Swan River, Drummond coll. III. no. 90". *Type specimens*: *holo*: BM; *iso*: CGE, G, K (2 sheets), NY, W.

> *Gastrolobium lineare* Meisn. (1855b, p. 30). *Type citation*: "Drumm. Coll. VI. n. 25". *Type specimens*: *holo*: NY; *iso*: CGE (2 sheets), E, BM, K (2 sheets), LD.

Open, often weeping *shrubs*, 1-3 m high. *Branchlets* ascending, angular, moderately sericeous. *Petioles* terete, continuous and sometimes decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, opposite or whorled, linear-elliptic or linear-obovate, (30-)38-56 x 2-2.5 mm, upper surface glabrous but with raised venation, lower

surface sparsely to moderately sericeous, venation prominently reticulate; apex rounded, unarmed; margins entire, usually recurved; base cuneate. *Stipules* erect, hyaline, 0.5-1.5 mm long. *Inflorescences* terminal racemes, 6-24(-32)-flowered; *peduncle* (5-)17-35 mm long; *rachis* 33-80(-200) mm long; *subtending bracts* caducous, scale-like, entire, linear-lanceolate, 3-4 mm long. *Pedicels* terete, 2.5-4 mm long. *Calyx* campanulate, 6-8 mm long including the 1-1.5 mm receptacle, moderately sericeous, lower three lobes sometimes recurved; upper two lobes united higher than the lower three, broadly triangular, apex rounded, 3-3.5 mm long; lower three lobes triangular, acute, 2-3 mm long. *Corolla*: *standard* transversely elliptic, 11-12.5 x 11-12 mm including the 3.5-4 mm claw, yellow or orange, with a red ring surrounding the yellow centre, apex emarginate, base obtuse; *wings* obovate, c. 11 x 3-3.5 mm including the c. 3 mm claw, yellow or orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half circular, margins slightly incurved, c. 11 x 3.5-4 mm including the 3-3.5 mm claw, pink or maroon, sometimes appearing brown when olde, apex rounded, base auriculate, saccater. *Style* long, incurved or hooked, glabrous or with hairs in the lower third; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 8-9 x 4-6 mm, sparsely to moderately pubescent. *Seed* reniform, c. 2.5 mm long, arillate.

Vernacular name. Rock Poison.

Flowering period. September to November. *Fruiting period*. From late October to December.

Distribution (Map 10). South-west Western Australia. Occurs on the northern sandplains and mallee regions, from Jurien Bay and Moora in the north to Wongan Hills and Goomalling in the south.

Habitat. Usually found on the margins of granite outcrops, more rarely on siltstone, on sandy soils, in woodland dominated by *Eucalyptus* or *Allocasuarina*.

Conservation status. IUCN: R (rare). ROTAP: 3RCi. CALM: P4. This species is rare, though it is well surveyed and not considered to be at risk.

Selected specimens (36 examined). Due to the conservaton status of this species, detailed localities are not given. WESTERN AUSTRALIA: Avon District: Dingo Rock, *B.H. Smith 991*, 2 Oct. 1987 (CANB, DAV, HO, LEN, MEL, NSM); Mount Caroline Granite area, *F.H. & M.P. Mollemans 3523*, 3 Oct. 1990 (PERTH); Wongan Hills area, *M.J. Fitzgerald 11*, 12 Sep. 1993 (PERTH); Mount Stirling, *K. Newbey 1568*,

22 Oct. 1964 (PERTH); Irwin District: North of Watheroo, *M.G. Corrick 10689*, 24 Sep. 1991 (MEL, PERTH); Dandaragan, *R.D. Royce 5126*, 20 Sep. 1955 (PERTH); Carnamah, *A. Morrison 16347*, 7 Nov. 1906 (CANB, K); SE of Jurien Bay, *F.C. Vasek 681008-83*, 8 Oct. 1968 (CANB).

Map 10. Distribution of *G. callistachys*.

Toxicity. Very toxic; fluoroacetate 100-1000 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The weeping habit and flat leaves of *G. callistachys*, combined with the long racemes, make this species difficult to confuse with any other species of *Gastrolobium*. The irregularly grouped leaves, which are evident upon close inspection, distinguish it from *G. bilobum* and *G. stenophyllum*, which also differ by having a raceme with very short internodes (< 1.5 mm long), whereas *G. callistachys* has long, open racemes (up to 10 mm long).

11. Gastrolobium acrocaroli G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: Peak Charles, 32°53'S, 121°09'E, *G.T. Chandler 778 & S. Donaldson*, 9 Nov. 1998 (*holo*: CANB; *iso*: K, MEL, NSW, PERTH).

The size and shape of the leaves, and the large flowers of this narrowly endemic granite outcrop species make it difficult to confuse with any other. The only species that has been confused with it in the past is *G. parviflorum*, which has smaller leaves, the calyx lobes are not strongly recurved and it has much smaller flowers.

Haec species non nisi in collibus duo graniticis habitat, speciei ulla altra difficili confundere, foliis magnis oblongis (45-80[-110] x [2-]3-6[-8] mm) et floribus magnis (e.g. vexillum 10-12.5 x 13.5-14 mm) distinguenda.

Etymology. This specific epithet comes from the Greek (*acro* = hill or peak, and *Carolus* = Charles) is named after Peak Charles, where it is endemic.

Erect, open *shrubs*, 1-2.7 m high. *Branchlets* ascending, angular, glabrous to sparsely pubescent. *Petiole* terete, slightly swollen at base, continuous and sometimes slightly decurrent with the branchlet, 5-7 mm long. *Leaves* ascending, opposite, linear-oblong to linear-elliptic, 45-80(-110) x (2-)3-6(-8) mm, glabrous or very slightly pubescent on the abaxial surface, venation prominently reticulate; apex rounded to truncate, usually mucronate, occasionally emarginate; margins entire, recurved to slightly so; base cuneate or slightly rounded. *Stipules* erect, narrowly triangular, 0.5-1.5 mm long. *Inflorescences* terminal racemes, (5-)7-16-flowered; *peduncle* (5-)8-15(-23) mm long; *rachis* 17-30(-45) mm long; *subtending bracts* caducous, scale-like, minutely trilobed (often appearing entire), c. 2 mm long, slightly pubescent. *Pedicels* terete, 3-5 mm long. *Calyx* campanulate, 7-9 mm long including the 1-1.25 mm receptacle, glabrous to sparsely pubescent, lobes not recurved; upper two lobes united higher than the lower three, triangular, obtuse, 3-3.5 mm long; lower three lobes triangular, acute or slightly obtuse, 2.5-2.75 mm long. *Corolla*: *standard* transversely elliptic, 10-12.5 x 13.5-14 mm including the 3-4 mm claw, orange, rarely yellow, with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* oblong, 10.5-12 x 3.5-4 mm including the 3-3.5 mm claw, orange, rarely yellow, apex rounded, incurved and touching, not overlapping, mostly enclosing the keel, base auriculate on both, slightly saccate; *keel* half very broadly elliptic, margins rolled inwards, 10-12 x c. 4 mm including the 3-4 mm claw, white with a pink apex, very rarely yellow, apex obtuse, base auriculate, saccate. *Style* long, incurved, lower half pubescent; *ovary* stipitate,

densely pubescent; *ovules* 5-6. *Pod* stipitate, fusiform or ellipsoid, 12-15 x 22-30(-35) mm, glabrous. *Seed* not seen.

Flowering period. September to November, with some flowers present on one collection made in April. *Fruiting period.* From November.

Distribution (Map 11). South-west Western Australia. This species has a very narrow distribution, being endemic to Peak Charles and a nearby granite outcrop.

Map 11. Distribution of *G. acrocaroli*.

Habitat. Grows on granite outcrops in well-drained areas with skeletal soils, in open shrubland or dense heath with *Acacia*, *Calothamnus* and *Labichea*.

Selected specimens (10 examined). WESTERN AUSTRALIA: Roe District: Peak Charles, 32°53'S, 121°10'E, *A.S. Weston 8992*, 28 Nov. 1975 (PERTH); Peak Charles, 32°53'05"S, 121°09'44'E, *S. Barrett 395*, 19 Apr. 1995 (PERTH); Peak Charles, Peak Charles National Park, ca 45 km W of Salmon Gums, 32°52'54"S, 121°09'29"E, *K.R. Newbey 6438*, 10 Nov. 1979 (CANB, PERTH); Peak Charles, 32°53'12"S, 121°09'53"E, *G.T. Chandler 779 & S. Donaldson*, 9 Nov. 1998 (CANB); large granite

outcrop, c. 1 km NW of Peak Charles, 32°52'28"S, 121°08'21"E, *G.T. Chandler 784 & S. Donaldson*, 9 Nov. 1998 (CANB, PERTH).

Toxicity. Unknown.

Affinity. It is difficult to confuse *G. acrocaroli* with any other species of *Gastrolobium*, due to the size and shape of the leaves, and the large flowers, though some specimens have been misidentified as *G. parviflorum* in the past. It is easy to tell the difference between these species, as *G. parviflorum* has shorter leaves (10-35 x 3-11 mm), and much smaller flowers (e.g. calyx 4-6 mm long, standard 6.5-8 x 8-10 mm).

12. Gastrolobium involutum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: NW slope of Mt Buraminya, right at the base of the outcrop, 33°13'31"S, 123°07'16"E, *G.T. Chandler 805 & S. Donaldson*, 11 Nov. 1998 (*holo*: CANB; *iso*: AD, BRI, K, MEL, NSW, NY, PERTH).

This species is distinctive by its strongly involute, linear leaves and its occurrence around granite outcrops in the far east of south-west Western Australia. It is similar in appearance to *G. semiteres*, which differs in having glaucous leaves, with the upper leaf surface wholly or partially visible, larger flowers (calyx to 9 mm long, standard c. 13 mm broad), the wings not overlapping the keel and auriculate on both margins, and the inflorescence strongly villous.

Ob folia linearia valde involuta et habitationem circa colles graniticos facile distinguenda. *G. semitereti* similis, quae foliis glaucis, folii superficie superna omnino vel partim visibile, floribus majoribus (calyx ad 9 mm longus, vexillum c. 13 mm latum), aliis carinam non excedentibus et lobis in ambo marginibus, inflorescentia valde villosa differt.

Etymology. This species is named after the involute leaves.

Erect, spreading *shrubs*, 1.2-3 m high. *Branchlets* ascending, angular, sparsely pubescent. *Petioles* terete, continuous and decurrent with the branchlet, c. 1 mm long. *Leaves* ascending, opposite to scattered, linear, 18-40 x 0.5-1 mm, ± glabrous, venation reticulate; apex truncate, slightly mucronate, slightly recurved; margins involute, with upper surface completely obscured making the leaves appear terete; base tapering into the petiole. *Stipules* erect, minute, < 0.5 mm long. *Inflorescences* terminal racemes, 6-14-flowered; *peduncle* angular, 10-20 mm long; *rachis* angular, 13-45 mm long; *subtending bracts* caducous, somewhat trifid, narrowly triangular, < 1 mm long.

Pedicels terete, 1-1.5 mm long. *Calyx* campanulate, 6-7 mm long, ± glabrous, lobes not recurved; upper two lobes united into an almost truncate lip, rounded, c. 2 mm long; lower three lobes triangular, obtuse, c. 1.5 mm long. *Corolla*: *standard* transversely ovate, c. 12 x 11 mm including the 4 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, c. 8 x 3 mm including the 3 mm claw, orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on upper margin only, saccate; *keel* half transversely elliptic, turgid, margins not incurved, c. 6 x 2 mm including the 3 mm claw, pink to maroon, apex rounded, base auriculate, saccate. *Style* long, straight, only the apex is incurved to hooked, scarcely sericeous at base; *ovary* shortly stipitate, shortly sericeous; *ovules* 4-6. *Pod and seed* not seen.

Flowering period. June to November. *Fruiting period.* Unknown.

Distribution (Map 12). South-west Western Australia. Grows in a restricted region on granite outcrops in the area around Mt Buraminya, SE of Norseman.

Map 12. Distribution of *G.involutum*.

Habitat. Grows at the base of granite outcrops on sandy soils, in woodland or tall shrubland.

Specimens examined. WESTERN AUSTRALIA: Roe District: Mt Andrew, ca 118 km SE of Norseman, 32°40'S, 122°56'E, *K. Newbey 7784*, 23 Sep. 1980 (CANB, PERTH); 33.5 km N of Mt Buraminya, c. 28 km WNW of Mt Coobaninya, 32°55'S, 123°06'E, *W. Archer 22099014*, 22 Sep. 1990 (CANB, NSW, PERTH); c. 40 km NW of Mt Ragged, lower slopes of Mt Buraminya, 33°14'S, 123°07'E, *W. Archer 809908*, 8 Sep. 1990 (CANB, MEL, NSW); ibid, *W. Archer 1606906*, 16 June 1990 (CANB, HO, PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium involutum* is similar in appearance to *G. semiteres*, which differs in having glaucous leaves, the upper leaf surface wholly or partially visible, larger flowers (e.g. calyx to 9 mm long, standard c. 13 mm broad), the wings not overlapping the keel and auriculate on both margins, and the plant is generally more pubescent, particularly the villous inflorescence.

13. Gastrolobium graniticum (S.Moore) Crisp in Crisp & Weston (1987, p. 130). *Oxylobium graniticum* S.Moore (1899, p. 185). *Type citation*: "Viget apud petras graniticas ad Bullabulling, mens. Sept. florescens". *Type specimens*: *holo*: BM; *iso*: K, NY (part).

> *Oxylobium kelsoi* W.Fitzg. (1904, p. 4). *Type citation*: "The new plant is named after the original discoverer, Mr. E. Kelso, forest officer, stationed at Coolgardie". *Type specimens*: *Lectotype* (here chosen): PERTH (E. Kelso 1902).

Erect, open, *shrubs*, 1-2.5 m high. *Branchlets* ascending, angular, sparsely to moderately pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 5-7 mm long. *Leaves* spreading, opposite, elliptic to rarely obovate, 48-62 x 19-32 mm, glabrous to sparsely pubescent, venation prominently reticulate, raised; apex rounded, unarmed or slightly mucronate; margins slightly undulate, not recurved; base cuneate. *Stipules* erect, narrowly triangular to hyaline, 2-3 mm long. *Inflorescences* terminal racemes, more than 30-flowered; *peduncle* 5-12 mm long; *rachis* 30-75 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, 2-3 mm long. *Pedicels* terete, 2.5-4 mm long. *Calyx* campanulate, 6-8 mm long, lobes usually recurved, upper lobes sometimes straight, sparsely to densely pubescent; upper two lobes united higher than the lower three, acute to rounded, 2-4 mm long; lower three lobes triangular, acute, c. 3

mm long. *Corolla*: *standard* transversely ovate, reflexed, 13-15 x 15.5-16.5 mm including the 4-5 mm claw, yellow-orange with a red ring surrounding the yellow centre, apex shallowly emarginate, base slightly cordate, auriculate; *wings* ovate to obovate, 13-14 x 3.5-5 mm including the 4-5 mm claw, yellow-orange to red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half circular or very broadly elliptic, margins not incurved, 12-13.5 x 4-4.5 mm including the 4-5 mm claw, pink or red, apex obtuse, base auriculate, saccate. *Style* long, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 6-7. *Pod* stipitate, ovate to elliptic, 9-14 x 4.5-7 mm, glabrous. *Seed* reniform, 4-4.5 mm long, arillate.

Vernacular name. Granite Poison.

Flowering period. August and September. *Fruiting period.* From October.

Distribution (Map 13). South-west Western Australia. Restricted in distribution, occurring only around the Coolgardie area, with an outlier in a little-explored region south of Merredin.

Map 13. Distribution of *G. graniticum*.

Habitat. Grows around the margins of granite outcrops, particularly along the drainage lines, on sandy soils in open woodland.

Conservation status. IUCN: E. ROTAP: 2ECi. CALM: R. This species is quite rare, though fairly widespread, and is considered to be endangered. Two populations were observed during this study that were in reserves, of which one was recovering after what appeared to be a disease affected the population.

Selected specimens (18 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Coolgardie District: Queen Victoria Rocks, S of Coolgardie, *G.T. Chandler 874 et al.*, 14 Sep. 1999 (CANB, NSW, UWA); Bullabulling, *C.A. Gardner s.n.*, Nov. 1948 (CANB, PERTH); Gnamma Hill, *S.D. Hopper 4582*, 14 Sep. 1985 (PERTH).

Toxicity. Highly toxic; fluoroacetate 1240 $\mu g.g^{-1}$ (Aplin, 1964). Gardner & Bennetts (1956) report that *G. graniticum* is highly toxic at all growth stages.

Affinity. Similar to *G. racemosum*, which differs in having a relatively narrower leaf and shorter petiole (leaf size [(20-)25-46(-60) x (5-)8-13(-35) mm], petiole 4-6 mm long), a shorter inflorescence with fewer flowers (rachis 25-50 mm long, which is 15-30-flowered), a glabrous inflorescence, standard petal with a distinctive apricot colour, and the style equal in length to the ovary, whereas in *G. graniticum* it is longer than the ovary.

14. Gastrolobium bilobum R.Br. (1811, p. 16). *Type citation* "Nat. of the South-west coast of New Holland. Robert Brown, Esq. Introd. 1803, by Mr. Peter Good." *Type specimens*: *Lectotype* (here chosen): BM (R. Brown, King Georges Sound, 1801).

> *Gastrolobium corymbosum* Turcz. (1853, p. 272). *Gastrolobium bilobum* R.Br. var. *angustifolium* Benth. (1864, p. 107). *Type citation*: "Drumm. V. n. 58". *Type specimens*: *holo*: KW; *iso*: BM, K (3 sheets), W.

Bushy, erect shrubs or rarely a small tree, to 4 m high. *Branchlets* ascending, angular with decurrent ribs, moderately to densely sericeous. *Petioles* terete, continuous and decurrent with the branchlet, 1-5 mm long. *Leaves* spreading to ascending, in whorls of 3 or 4, rarely opposite, cuneiform, obovate or elliptic, sometimes narrowly so (particularly the Stirling Range form) , 10-40(-50) x 5-15(-20) mm, upper surface glabrous, lower surface glabrous to sparsely sericeous, venation prominently reticulate; apex emarginate, often appearing bilobed, occasionally almost truncate, unarmed or

with a tiny mucro; margins not or scarcely recurved; base cuneate, obtuse or slightly rounded. *Stipules* erect or slightly recurved, hyaline, 2-6 mm long. *Inflorescences* terminal racemes, sometimes terminal on short axillary shoots, flowers very crowded with floral internodes very short (< 1.5 mm long), >20-flowered; *peduncle* angular, 1-15 mm long; *rachis* angular, crowded with pedicels, 2-10 mm long; *subtending bracts* caducous, scale-like, linear-lanceolate, 2-3.5 mm long, margins lacerate. *Pedicels* longer than calyx, terete, 5-7 mm long. *Calyx* campanulate, 4-5 mm long including the 0.75-1 mm receptacle, glabrous to sparsely pubescent, upper two lobes straight or recurved, lower three lobes recurved; upper two lobes united higher than the lower three, triangular, acute, 2-3 mm long; lower three lobes triangular, acute, 1.5-2.5 mm long. *Corolla*: *standard* transversely elliptic to transversely ovate, 6-7 x 7-9.5 mm including the 2-2.5 mm claw, yellow or yellow-orange with a red ring surrounding the yellow centre, apex emarginate, base truncate to slightly cordate; *wings* obovate, 6.5-9 x 2-3 mm including the c. 2 mm claws, yellow and orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on upper margin only, rarely auriculate on both, saccate; *keel* half elliptic to transversely elliptic, boat-shaped, margins not incurved, 6.5-8.5 x c. 2 mm including the 2-3 mm claw, maroon, apex rounded, base auriculate, saccate. *Style* long, strongly incurved to slightly hooked, pubescent in the lower third; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ovoid, often obliquely so, apex beaked, 7-8 x 3-4 mm, glabrous to moderately pubescent. *Seed* ellipsoid, c. 3-3.5 mm long, arillate.

Vernacular name. Heart-leaved Poison.

Flowering period. August (in the north) to December in the far south. *Fruiting period*. October to January.

Distribution (Map 14). South-west Western Australia. This species is found in the Darling Escarpment, east of Perth, south to the Bunbury and Margaret River districts, and east through the Albany region and Cape Riche; then there is a curious disjunction to the east, where no collections have been made, until the Esperance area, where it then extends to Cape Arid and inland as far as Mt Beaumont, Mt Heywood and Mt Ridley (all granite outcrops).

Habitat. Grows around granite peaks and outcrops, and along rivers. Occurs on a variety of soils, but mostly over granite. Vegetation types include karri and marri forest, mallee, and heath.

Selected specimens (144 examined). WESTERN AUSTRALIA: Avon District: 4 miles [6.5 km] W of Wagin, 33°19'S, 117°17'E, *T.E.H. Aplin 2831*, 8 Nov. 1964 (PERTH). Darling District: Upper Helena Valley, 31°56'S, 116°04'E, *J. Seabrook 419*, 23 Oct. 1977 (PERTH); 2 km west of Waterloo to Bunbury, 33°20'S, 115°48'E, *G.J. Keighery 13388*, 24 Oct. 1993 (PERTH); Walpole-Nornalup National Park, Pt 235, 35°01'50"S, 116°35'30"E, *A.R. Annels 564*, 14 Dec. 1988 (PERTH); 13km W of Kojonup towards Boyup Brook, 33°50'26"S, 117°01'12"E, *G.T. Chandler 738 & S. Donaldson*, 2 Nov. 1998 (CANB, MO). Eyre District: SE base of Mt Arid, 33°58'53"S, 123°13'40"E, *G.T. Chandler 815 & S. Donaldson*, 13 Nov. 1998 (CANB, K, MEL, NY, PERTH); High Island, Duke of Orleans Bay, 33°54'S, 122°36'E, *P.G. Wilson 8178*, 2 Oct. 1968 (PERTH); Bald Island, off Albany, 34°55'S, 118°28'E, *A.R. Main s.n.*, Dec. 1963 (PERTH) ; Bakers Spring, eastern Stirling Range, 34°26'S, 118°20'E, *G.J. Keighery 5453*, 19 Oct. 1982 (CANB, PERTH); 3.2 km N of Ellen Peak, Stirling Range, 34°20'S, 118°20'E, *M.D. Crisp 5295*, 19 Jan. 1979 (CANB, PERTH). Roe District: Mt Ridley, 33°18'S, 122°07'E, *H. Demarz D7970*, 13 Dec. 1979 (PERTH); Mt Beaumont, 33°22'S, 122°41'E, *M.A. Burgman 2401 & S. McNee*, 29 Sep. 1983 (PERTH).

Map 14. Distribution of *G. bilobum*.

Toxicity. Highly toxic; fluoroacetate 730-2650 (seeds up to 6200) $\mu g.g^{-1}$ (Aplin, 1964; Twigg, *et al.* 1996b), probably making *G. bilobum* the most toxic of all species of *Gastrolobium*, though seeds for many species have not been tested.

Affinity. This species bears a close resemblance to *G. tergiversum*, and the narrow-leaved Stirling Range form is vegetatively similar to *G. cuneatum*, though the long, open racemes of *G. cuneatum* (75-116 mm long) immediately identify this species, as do the narrower leaves (2.5-10 mm broad) and relatively shorter pedicels (which are shorter than the calyx). *Gastrolobium tergiversum* has light green leaves and orange flowers, as opposed to the dark green leaves and yellow flowers of *G. bilobum*. The most striking differences, however, occur in the floral structures. *Gastrolobium tergiversum* has an unusual keel, which is barely auriculate and not at all saccate at the base, and is long and tapering (c. 9.5 x 1.5 mm), the wings do not enclose the keel, and the style is not or barely incurved.

15. Gastrolobium tergiversum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: Base of Mt Ragged, NW side, along track to summit, 33°26'45"S, 123°27'56"E, *G.T. Chandler 812 &S. Donaldson*, 12 Nov. 1998 (*holo*: CANB; *iso*: AD, BRI, K, MEL, NSW, PERTH).

Similar to *G. bilobum*, but differing in the light green foliage, orange flowers, the keel petal, scarcely auriculate and not saccate, and the almost straight style, whereas *G. bilobum* has dark green foliage, typically yellow flowers, the keel petal relatively broader and strongly auriculate and saccate, and the style strongly recurved to hooked.

G. bilobi similis sed foliis dilutis viridibus, floribus aurantiacis, carina vix auriculata nec saccata et stylo fere recto differt.

Etymology. The specific epithet comes from the Latin (*tergi* = back, and *versum* = turned about), and refers to the fact that the leaf is concave and paler above, the reverse to most leaves, especially by comparison with the closely related *G. bilobum*, which is paler below and flat to slightly convex.

Slender to open, erect *shrubs*, 1.5-2 m high. *Branchlets* ascending, angular, moderately to densely pubescent. *Petioles* terete, continuous and decurrent with the branchlet, 2-3 mm long. *Leaves* ascending, generally in whorls of 3, occasionally appearing opposite with the third leaf slightly further along the stem and appearing as a separate node, obovate or rarely elliptic, 15-24 x 5-7 mm, glabrous, venation thick on the upper surface

and difficult to see, prominently reticulate on the lower surface; apex deeply emarginate, often almost bilobed, unarmed; margins slightly conduplicate or almost flat; base cuneate. *Stipules* inconspicuous, erect, < 0.5 mm long. *Inflorescences* terminal racemes, 10-25-flowered, flowers crowded along rachis; *peduncle* angular, 1-3 mm long; *rachis* angular, 5-8 mm long; *subtending bracts* caducous, scale-like, entire, ± ovate, keeled, < 1 mm long, moderately pubescent. *Pedicels* terete, 2-3 mm long. *Calyx* tapering to the base, 7-8 mm long including the c. 1.5 mm receptacle, moderately sericeous, lobes not recurved; upper two lobes united higher than the lower three, rounded, 2.5-3 mm long; lower three lobes triangular, acute, 2-2.5 mm long. *Corolla*: *standard* transversely ovate, c. 11 x 9.5 mm including the 3 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obliquely obovate, 11 x 3 mm including the 2.5 mm claws, orange-yellow, red towards the base, apex rounded, not incurved, keel exposed, base barely auriculate on upper surface only, not saccate; *keel* half elliptic, boat-shaped, margins not incurved, 9.5 x 1.5 mm including the 2 mm claws, pink and red, apex acute, base barely auriculate, not saccate. *Style* long, barely incurved, base slightly pubescent; *ovary* stipitate, moderately pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. October to February. *Fruiting period*. Unknown.

Distribution (Map 15). South-west Western Australia. This species is restricted to Mt Ragged and and nearby Gora Hill, in Cape Arid National Park.

Habitat. Grows towards the base of outcrops, on sandy soils over granite and quartzite, in mallee heath.

Specimens examined. WESTERN AUSTRALIA: Roe District: Mt Ragged, Cape Arid National Park, 33°27'S, 123°28'E, *R.D. Royce 10106*, 5 Dec. 1971 (PERTH); Mt Ragged, 33°27'S, 123°28'E, *R.A. Kilgour 490*, 31 Dec. 1984 (MEL, PERTH); ibid, *M. Hislop 1955*, 15 Dec. 1999 (CANB, PERTH); ibid., *S. Barrett 463*, 26 Sep. 1995 (PERTH); ibid., *L. Sweedman 3093*, 20 Nov. 1993 (PERTH); ibid, *A.S. George 2108*, 7 Dec. 1960 (PERTH); ibid., *L. Cayzer 437 et al.*, 10 Feb. 1998 (CANB); ibid, *G.T. Chandler 344 et al.*, 10 Feb. 1998 (CANB, UWA); 10 miles [16 km] SW of Mt Ragged, 33°33'S, 123°22'E, *A.S. George 2051*, 6 Dec. 1960 (PERTH).

Toxicity. Unknown, but as it is related to *G. bilobum*, it is likely to be toxic.

Map 15. Distribution of *G. tergiversum*.

Affinity. *Gastrolobium tergiversum* is similar to *G. bilobum*, but *G. bilobum* has dark green foliage and yellow flowers, as opposed to the light green leaves and orange flowers of *G. tergiversum*. The most obvious differences are in the flower, however, particularly the keel petal, which is relatively much broader in *G. bilobum* (6.5-8.5 x 2-3 mm), and is strongly auriculate and saccate at the base, the wings do not enclose the keel, and the style is strongly incurved to slightly hooked, whereas in *G. tergiversum* it is ± straight.

16. Gastrolobium grandiflorum F.Muell. (1862, p. 17). *Type citation*: "In tractu montano Whithrington Range Australiae borealis. J Macd. Stuart". *Type specimens*: *holo*: MEL 88464.

> *Gastrolobium grandiflorum* F.Muell. var. *luteum* L.R.Kerr, in Ewart, Kerr & Derrick (1926, p. 81). *Type citation*: "Bonny Well, N.T., 30 m. N. of Wycliffe Well, June, 1924. Not common, F.A.C. Bishop". *Type specimens*: unknown.

Erect *shrubs*, 0.5-3 m high. *Branchlets* ascending, angular, moderately to densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 3-8 mm

long. *Leaves* spreading to ascending, usually opposite, sometimes alternate or whorled, ovate, elliptic or obovate, occasionally narrowly so, (34-)49-74 x (15-)23-32 mm, glabrous to moderately sericeous on both surfaces, venation prominently reticulate, raised; apex retuse, rounded or truncate; margins entire, not recurved; base cuneate. *Stipules* erect, hyaline, somewhat rigid, 2-4 mm long. *Inflorescences* terminal racemes, occasionally axillary or on short axillary shoots, 8-20-flowered; *peduncle* (1-)7-10 mm long; *rachis* 14-30 mm long; *subtending bracts* caducous, scale-like, entire, narrowly triangular, c. 5 mm long. *Pedicels* terete, 6-8 mm long. *Calyx* tapering gradually to the base, (5-)8-12 mm long, moderately to densely pubescent, lobes not recurved; upper two lobes united higher than the lower three, triangular, obtuse to rounded, 3-4 mm long; lower three lobes triangular, acute, 2-3 mm long. *Corolla*: *standard* transversely broadly elliptic, may be longitudinally folded up, 18-19.5 x 17-18 mm including the c. 4.5 mm claw, red, rarely orange, apex emarginate, base cordate; *wings* obliquely narrowly elliptic, 18.5-19.5 x 4.5-5 mm including the 4-5 mm claw, red, rarely orange, apex rounded, incurved and overlapping to enclose keel, base auriculate on both margins, not saccate; *keel* half broadly elliptic, 17-19 x c. 5 mm including the 4.5-5 mm claw, red, apex obtuse, base auriculate, slightly saccate. *Style* long, slightly incurved, bent at 45° to the ovary, hairs present sparsely at the base, tapering to the apex; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, c. 10 x 5.5-6 mm, sparsely to densely pubescent. *Seed* ellipsoid, 4-5 mm long, arillate.

Vernacular name. Wallflower Poison.

Flowering period. February to August. *Fruiting period*. April to September.

Distribution (Map 16). Occurs throughout northern and central Australia, in Western Australia, Northern Territory and Queensland.

Habitat. Sandy or gravelly soils, sometimes loamy, in open eucalypt or *Acacia* woodland. Often found along drainage lines in the drier parts of its range.

Selected specimens (80 examined). WESTERN AUSTRALIA: Fortescue District: Pilbarra Region, 5 km NW of Munjina Claypan, on Munjina Gorge Creek, 22°34'20"S, 118°45'15"E, *F.H. Mollemans 2332*, 16 Feb. 1987 (CANB); 20 km S of Mt Brockman Homestead, 22°30'S, 117°15'E, *A.A. Mitchell 365*, 7 June 1977 (CANB, PERTH). Fitzgerald District: Mt Bell, King Leopold Range, 17°09'S, 125°18'E, *A.S. George 15150*, 18 June 1978 (CANB, PERTH); Upper plateau on Mt Leake, Kimberely Region, 17°34'S, 126°02'E, *T. Willing 467*, 10 Aug. 1991 (CANB, PERTH). Keartland District:

Little Sandy Desert, 15.5 km ESE of Moffettah Well, 24.5 km S of Cooma Well, 20 km NW of Yanneri Lake, 24°18'25"S, 120°21'22"E, *S. van Leeuwen 1261*, 25 May 1992 (CANB, PERTH). Mueller District: 30 miles [48 km] east of Balgo Mission, Eremean Province, 20°17'S, 128°24'E, *A.R. Peile 19*, 25 Apr. 1975 (CANB); Gardner Range, 190 km SE of Halls Creek, SE Kimberley, 19°13'24"S, 128°51'10"E, *K. Coate 377*, 6 July 1995 (BRI, CANB, DNA, PERTH).

Map 16. Distribution of *G. grandiflorum*.

NORTHERN TERRITORY: Barkly Tableland: Stuart Highway, c. 2 km from Newcastle Waters turnoff, *G.W. Carr 2654 & A.C. Beauglehole*, 1 July 1974 (CANB, MEL). Central Australia North: Tanami Gorge, c. 5 km W of Tanami, 19°59'S, 129°40'E, *B.C. Crisp 604*, 8 May 1983 (CANB, MEL); 50 km NE of Curlew Waterhole, 20°16'S, 132°29'E, *P.K. Latz 11516*, 20 July 1989 (CANB, DNA, MEL, MO, NSW, NT). Victoria Rivers: Beside Stuart Highway, 70 km N of Tennant Creek, c. 18°45'S, 134°10'E, *N.G. Walsh 1723*, 21 June 1987 (CANB, MEL, NT).

QUEENSLAND: Burke District: 111 miles [177 km] N of Hughenden towards Lynd, c. 19°40'S, 144°15'E, *J. Birbeck 187*, May 1972 (CANB). Cook District: c. 5 km N of Spencer Creek crossing on road to Windsor Tableland, 27°26'S, 153°02'E, *D.L. Jones 4424 & M.A. Clements*, 27 May 1989 (BRI, CANB, MEL); Watsonville, 17°23'S, 145°19'E, *P.I. Forster 6255*, 24 Feb. 1990 (BRI, CANB, MEL, MEXU); Davies Creek, 750 m E of falls, 17°00'06"S, 145°35'03"E, *BSW 721*, 12 Apr. 1998 (BSW, BRI, CANB, NSW). North Kennedy District: about 5 miles [8 km] S of Mt Garnet, 17°55'S, 145°15'E, *S.L. Everist 5483*, 9 May 1954 (BRI, CANB). Mitchell District: Corinda, 27°32'S, 152°59'E, *S.L. Everist 3865*, 4 June 1949 (BRI, CANB).

Toxicity. Fluoroacetate 0-185 $\mu g.g^{-1}$ (McEwan, 1964).

Affinity. *Gastrolobium grandiflorum* is similar in appearance to *G. brevipes*. There is a clear difference between the two, as *G. brevipes* has smaller flowers (standard c. 9-14 x 10-15 mm) and deep orange flowers versus the larger, red flowers of *G. grandiflorum*. The gynophore of *G. brevipes* is shorter than the ovary and enclosed within the calyx tube (2-2.5 mm long), whereas *G. grandiflorum* has a gynophore that is longer than the ovary (7-10 mm long) and is exserted from the calyx tube.

17. Gastrolobium brevipes Crisp (1983, p. 11). *Type citation*: "Western Australia, Entrance to Glen Cumming, Rawlinson Range, 25°00'S, 128°24'E, *A.S. George 12150*, 24 July 1974." *Type specimens*: *holo*: K; *iso*: CANB, NSW, PERTH.

Erect *shrubs* to 2.5 m high. *Branchlets* ascending, angular, moderately to densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-5 mm long. *Leaves* alternate, opposite or rarely subternate, obovate to elliptic, usually narrowly so, 20-60 x 6-20 mm, sericeous to glabrous, venation prominently reticulate; apex obtuse to retuse, unarmed; margins flat; base obtuse. *Stipules* erect, hyaline, 2-5 mm long. *Inflorescences* usually terminal racemes, occasionally axillary or on short axillary shoots, 2 to more than 30 flowered; *peduncle* (0-)10-34 mm long; *rachis* (10-)30-70(-210) mm long; *subtending bracts* caducous, mostly scale-like, rarely herbaceous, entire, ovate, c. 5 mm long unless herbaceous, in which case they resemble small leaves. *Pedicels* terete, 3-6 mm long. *Calyx* campanulate, 5-7 mm long including the c. 1.5 mm receptacle, moderately to densely pubescent; upper two lobes united higher than the lower three, triangular, sub-acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* very broadly obovate, 9-14 x 10-15 mm, deep orange face with a red ring surrounding the yellow centre, deep red on the

back, apex emarginate, base truncate; *wings* narrowly obovate, 10-12 x 2-3 mm including the 3-4 mm claw, dark red, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin, rarely auriculate on both, not saccate; *keel* half transversely elliptic, 10-12 x 2-3 mm including the 3-4 mm claw, dark red, apex acute, base auriculate, saccate. *Style* long, incurved, lower half sparsely pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, slightly obliquely ovoid, 7-10 x 4-6 mm, densely pubescent, base enclosed by calyx tube. *Seed* ellipsoid, 3-4 mm long, arillate.

Flowering period. April to August, occasionally into September. *Fruiting period.* August to November.

Distribution (Map 17). Occurs in Western Australia and the Northern Territory, in central Australia, in the George Gill and MacDonnell Ranges. There is also one old record from Port Hedland, Western Australia, which is quite out of the range of the rest of the specimens.

Habitat. Dunefields, dry watercourses and mountain slopes, in sandy gravelly or rocky soils.

Selected specimens (23 examined). WESTERN AUSTRALIA: Giles District: Giles Creek, south of Rawlinson Range, c. 25°00'S, 128°25'E, *J.B. Cleland s.n.*, 22 June 1960 (PERTH); 7 miles [11 km] NE Giles (? Glen Cummins), 24°58'S, 128°25'E. NORTHERN TERRITORY: Central Australia South: +/- 1 mile [1.5 km] NE of Reedy Rockhole, George Gill Range, 24°18'S, 131°36'E, *A.C. Beauglehole 26535*, 11 July 1968 (CANB, MEL); Kings Canyon, George Gill Range, 24°16'S, 131°39'E, *J.R. Maconochie 2484*, 27 Aug. 1980 (AD, B, BRI, CANB, K, M, MEL, MO, NSW, NT, PAUH, PERTH); Standley Chasm, MacDonnell Range, 23°43'S, 133°28'E, *N.T. Burbidge 4161 & M. Gray*, 18 Nov. 1955 (CANB); Uluru National Park, Kata Tjuta (The Olgas), 46.6 km WNW of Range Station, 25°17'S, 131°43'E, *M. Lazarides & J. Palmer 454*, 14 Aug. 1988 (CANB).

Toxicity. Fluoroacetate 17-99 $\mu g.g^{-1}$ in the leaves and 56-301 $\mu g.g^{-1}$ in the pods (Twigg *et al.* 1999).

Map 17. Distribution of *G. brevipes*.

Affinity. *Gastrolobium brevipes* is similar in appearance to *G. grandiflorum*. There is a clear difference between the two by the larger (standard c. 20 x 18 mm), bright red flowers of *G. grandiflorum* versus the smaller, deep orange of *G. brevipes*. The gynophore in *G. brevipes* is shorter than the ovary and enclosed within the calyx tube, whereas *G. grandiflorum* has a gynophore that is longer than the ovary (7-10 mm long) and is exserted from the calyx tube.

18. Gastrolobium congestum G.Chandler & Crisp, *sp. nov*. *Type*: WESTERN AUSTRALIA: Eyre District: SW slope of East Mount Barren, Hammersley Drive, Fitzgerald River National Park, 33°53'58"S, 119°56'46"E, *G.T. Chandler 765 & S. Donaldson*, 5 Nov. 1998 (*holo*: CANB; *iso*: AD, B, BRI, K, MEL, MO, NSW, NY, PERTH).

> *Oxylobium retusum* R.Br. var. *minus* Benth. (1864, p. 22). *Type citation*: "Drummond, n. 95, and 4th Coll. n. 20." *Type specimens*: *Lectotype* (here chosen): K (Drummond, 4th Coll. n. 20); *isolecto*: BM, K (2 sheets), W.

The foliage of *G. congestum* is similar to that of *G. pyramidale*, but has villous white hairs, where *G. pyramidale* has villous, rust-coloured hairs on the stems, underside of the leaves and inflorescence axes. *Gastrolobium coriaceum* is also vegetatively similar to *G. congestum*, but differs in having a shorter rachis (up to 10 mm long) and only 10-20 flowers per inflorescence, whereas *G. congestum* has a rachis 5-80 mm long, and 30- to more than 50 flowers per inflorescence.

A *G. pyramidali* indumento villoso albo differt. *G. coriaceum* vegetative similis est sed rhachide breviore (usque ad 10 mm longa) et inflorescentia floribus tantum 10-20 differt.

Etymology. This species is named after the densely clustered inflorescence.

Erect *shrubs*, 0.5-2.5 m high. *Branchlets* ascending, angular, moderately to densely villous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-4 mm long. *Leaves* spreading to ascending, opposite, ovate to elliptic or transversely so to orbicular, (14-)18-41 x 20-48 mm, upper surface glabrous or sparsely pubescent, lower surface glabrous to densely sericeous, venation prominently reticulate; apex retuse or rounded, unarmed; margins entire, not recurved; base cordate to rounded. *Stipules* erect, very narrowly triangular to hyaline, 4-7 mm long. *Inflorescences* terminal racemes, somewhat condensed with the flowers crowded to give a head-like appearance, 30- to more than 50-flowered; *peduncle* 4-11(-23) mm long; *rachis* (5-)13-80 mm long; *subtending bracts* caducous, entire, linear-lanceolate, 4-5 mm long. *Pedicels* angular, 4-5 mm long. *Calyx* campanulate, 6-8 mm long including the 1-1.5 mm receptacle, moderately to densely villous, lobes not recurved; upper two lobes united higher than the lower three, triangular, acute to rounded, 2.5-3 mm long; lower three lobes triangular, acute, 2-2.5 mm long. *Corolla*: *standard* transversely elliptic, 10-12 x 12-14 mm including the c. 4 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cuneate to truncate; *wings* obovate, 9-10 x 2.5-3.5 mm including the c. 3 mm claw, orange to orange-red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins or on the upper margin only, not saccate; *keel* half transversely broadly elliptic, margins incurved, 8-9.5 x c. 3 mm including the 3-3.5 mm claw, orange-red to red, apex rounded, base auriculate, saccate. *Style* long, incurved, hairs present in the lower third, tapering to the apex; *ovary* shortly stipitate, densely pubescent; *ovules* 3-5. *Pod* stipitate, ellipsoid to ovoid, 8-11 x 5-9 mm, moderately to densely pubescent. *Seed* reniform to ellipsoid, c. 4 mm long, arillate.

Flowering period. September to February. *Fruiting period.* October to March.

Distribution (Map 18). South-west Western Australia. Occurs along the south coast from Cape Riche to Hopetoun.

Habitat. Undulating plains, hillsides or mountain slopes in gravelly sand or sandy loam over laterite, quartz or limestone. Shrubland or heath, with the associated species including *Allocasuarina* spp., *Eucalyptus lehmannii*, *E. preissiana*, *E. tetragona*, *Daviesia*, *Dryandra*, *Hakea*, *Lambertia*, *Lomatia*.

Conservation status. CALM: P2. This taxon is regarded as being poorly known, with further surveys required. It is doubtful that this species is rare, and is probably to be found throughout the south coast of SW Western Australia.

Map 18. Distribution of *G. congestum*.

Selected specimens (32 examined). WESTERN AUSTRALIA: Eyre District: Cape Riche, 34°37'S, 118°47'E, *D.J. Moir s.n.*, 2 Nov. 1967 (CANB, PERTH); 1.7 km from Cape Riche towards Wellstead, on Sandalwood Road, 34°35'29"S, 118°43'46"E, *G.T. Chandler 463 et al.*, 16 Feb. 1998 (CANB, NSW); Fitzgerald River National Park, Northern slope of No Tree Hill, c. 23.5 km due S of Ravensthorpe, 33°48'S, 120°01'E,

J.M. Fox 86/150 & K. Bradby, 1 Feb. 1986 (CANB, PERTH); 4 km N of Hopetoun, 33°55'S, 120°07'E, *M. Blewitt s.n.*, Jan. 1988 (PERTH); Road into Cape Riche, 2.6 km from Cape Riche, 34°34'51"S, 118°43'00"E, *R. Davis 2890*, 18 Mar. 1997 (PERTH); Fitzgerald River National Park, Hammersley Drive, 5 km N of track to Hammersley Beach, 33°56'S, 119°56'E, *J. Taylor 1732 & P. Ollerenshaw*, 12 Sep. 1983 (AD, CANB, MEL, PERTH); Ravine leading from East into Fitzgerald Inlet, just south of widest part, Fitzgerald River National Park, 34°05'S, 119°36'E, *A.S. Weston 6397*, 22 July 1971 (CANB, PERTH).

Toxicity. Unknown.

Affinity. The inflorescence structure of *G. congestum* is very similar to *G. bilobum*, but *G. bilobum* has much smaller leaves, which even when long, are narrow (10-50 x 5-20 mm), and smaller flowers (calyx 4-5 mm long, standard 6-7 x 7-9.5 mm), and strictly 2 ovules. *Gastrolobium pyramidale* and *G. coriaceum* also look superficially like *G. congestum*, particularly in the vegetative stage. However, *G. pyramidale* has long, rust-coloured hairs on the stems, underside of the leaves and inflorescence axes, whereas *G. congestum* has shorter, white hairs. *Gastrolobium coriaceum* differs in having a shorter rachis (up to 10 mm long) and fewer flowers per inflorescence (10-20).

The G. parviflorum sub-group

This group of *Gastrolobium* species belongs with the 'granite group', but forms quite a strong clade within this group, and is worthy of recognition, as it is a very common and distinctive group. This group is characterised by the opposite, usually oblong leaves with recurved to revolute margins, and long, terminal racemes with many flowers.

19. Gastrolobium parviflorum (Benth.) Crisp, in Crisp & Weston (1987, p. 130). *Oxylobium parviflorum* Benth., in Lindley (1839, p. 12), *Callistachys parviflora* (Benth.) Kuntze (1891). *Type citation*: none cited. *Type specimens*: *Lecto* (here chosen): CGE (Swan River. Drummond, 1839); *isolecto*: K (3 sheets).

Erect, bushy *shrubs*, 0.5-2.5 m high. *Branchlets* ascending, angular, moderately sericeous. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-3 mm long. *Leaves* opposite to sub-opposite, spreading to ascending, oblong, elliptic or obovate to narrowly or linear, 10-35 x 3-11 mm, upper surface glabrous, lower surface glabrous to densely sericeous, venation openly to thickly reticulate; apex rounded to truncate, emarginate, may be recurved; margins ± flat to slightly undulate, often

recurved; base cuneate to rounded. *Stipules* erect, narrowly triangular, 1.5-3 mm long. *Inflorescences* terminal racemes, (13-) generally more than 25-flowered; *peduncle* (4-)8-22 mm long; *rachis* 30-65 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, 2-3 mm long, densely pubescent. *Pedicels* terete, 1.5-2.5 mm long. *Calyx* campanulate, 4-6 mm long including the 1-1.5 mm receptacle, glabrous to moderately pubescent, lobes not or slightly recurved; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely ovate, 6.5-8 x 8-10 mm including the 2-2.5 mm claws, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, 6-7.5 x 2-2.5 mm including the 2-2.5 mm claws, orange and red, apex rounded, incurved and overlapping the keel, base auriculate on the upper margin only, saccate; *keel* half transversely elliptic, margins not incurved, 5.5-6.5 x 2-2.5 mm including the 2-2.5 mm claws, maroon, apex rounded to slightly spout-like, base auriculate, saccate. *Style* about as long as the ovary, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 3-4. *Pod* stipitate, obliquely ellipsoid, 7-10 x 3-4.5 mm, glabrous to sparsely pubescent. *Seed* reniform, 2-3 mm long, arillate.

Vernacular name. Box Poison.

Flowering period. August to October. *Fruiting period*. October to December.

Distribution (Map 19). South-west Western Australia. Occurs very commonly throughout the central wheatbelt districts of this region, from around Kalannie in the north to near Hopetoun in the south, with an outlier near Mt Ragged, Cape Arid.

Habitat. Grows in a variety of habitats, generally on sandy soils, in heathland, shrubland, mallee woodland or woodland.

Selected specimens (300 examined). WESTERN AUSTRALIA: Avon District: 11 km W of Narrogin towards Williams, 32°58'36"S, 117°04'25"E, *G.T. Chandler 301 & W. Keys*, 22 Sep. 1997 (CANB, MEL, M); NE corner of Narrogin Agricultural College, 32°58'S, 117°07'E, *T. Higgs s.n.*, 30 Nov. 1987 (CANB, PERTH); 0.5 km S of Broomehill on Great Southern Highway, 33°51'00"S, 117°38'37"E, *G.T. Chandler 289 & W. Keys*, 19 Sep. 1997 (CANB, PERTH); 6.5 km W of Kellerberrin P.O. on Great Eastern Highway, 31°37'38"S, 117°39'06"E, *G.T. Chandler 245 & W. Keys*, 15 Sep. 1997 (AD, CANB, PERTH). Coolgardie District: 0.9 km N on track 18.5 km E of Yellowdine on Great Eastern Highway, 31°16'40"S, 119°50'28"E, *G.T. Chandler 255 & W. Keys*, 16 Sep. 1997 (CANB, US). Darling District: Toodyay Road, 5 km towards

Toodyay from intersection with Fernie Road, 31°38'26"S, 116°23'41"E, *G.T. Chandler 823 & S. Donaldson*, 16 Nov. 1998 (CANB, NSW, PERTH). Eyre District: 300m W of Elverdton Road turnoff on the South Coast Highway, 33°35'59"S, 120°10'38"E, *G.T. Chandler 269 & W. Keys*, 17 Sep. 1997 (CANB, PERTH); Near Mt Short, c. 15 km N of Ravensthorpe, 33°30'57"S, 120°02'17"E, *G.T. Chandler 921 et al.*, 18 Sep. 1999 (CANB, NSW, PERTH).

Map 19. Distribution of *G. parviflorum*.

Toxicity. Highly toxic; fluoroacetate 150-2500 $\mu g.g^{-1}$ (Aplin, 1964; Twigg, *et al.* 1996b; herb specimen *T. Higgs s.n.*, 30 Nov. 1987, CANB 495609 & PERTH). *Gastrolobium parviflorum* one of the most toxic species of *Gastrolobium*.

Affinity. Similar to *G. discolor*, *G. melanocarpum* and *G. musaceum*. *Gastrolobium discolor* differs by the generally larger leaves (25-50 x 5-10 mm), the longer inflorescence (peduncle 15-45 mm long, rachis 70-110 mm long) and the larger flowers (e.g. standard 10-11 mm broad), as well as the highly discolorous leaves that often have the margins recurved at different levels along the leaf, often causing the basal half to be much broader than the apical half. *Gastrolobium melanocarpum* differs in the highly

revolute leaf margins that leave only the mid-rib visible on the lower surface, the strictly linear leaves (only 1-2 mm broad) and the ovoid pods which are often black in colour. *Gastrolobium musaceum* differs by the generally fewer number of flowers (10-25-flowered), and the much larger flowers (e.g. calyx 6-7 mm long, standard 10-13.5 x 11-13 mm).

20. Gastrolobium musaceum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Eyre District: Cascades Road, 23 km towards Lake King from West Point Road, 33°13'03"S, 120°41'28"E, *G.T. Chandler 937, A. Monro & S. Donaldson*, 19 Sep. 1999 (*holo*: CANB; *iso*: AD, NSW, PERTH).

> *Oxylobium parviflorum* Benth. var. *stenocarpum* C.A. Gardner in Gardner & Bennetts (1956, p. 54), *nom. nud.*

Bushy shrubs related to *G. parviflorum*, but differing by having fewer flowers per inflorescence (10-25) and much larger flowers (calyx 6-7 mm long, standard 10-13.5 x 11-13 mm).

G. parvifloro affinis sed inflorescentia floribus paucioribus (10-25), floribus multo majoribus (calyx 6-7 mm longus, vexillum 10-13.5 x 11-13 mm) differt.

Etymology. From the Latin, *Musa*, which is banana. This species is named after the distinctive fruits, which are banana-shaped.

Erect, bushy *shrubs*, 0.5-2 m high. *Branchlets* ascending, ± angular, moderately sericeous. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-3 mm long. *Leaves* opposite or sub-opposite, spreading to ascending, linear-oblong to ± narrowly elliptic, 20-45 x 2-4.5 mm, upper surface glabrous, lower surface moderately to densely sericeous, venation openly reticulate; apex unarmed or slightly mucronate, recurved, rounded, ± emarginate; margins recurved; base rounded to truncate. *Stipules* erect, narrowly triangular, c. 2 mm long. *Inflorescences* terminal racemes, 10-25-flowered; *peduncle* 7-20 mm long; *rachis* 25-60 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, 1-2 mm long, densely pubescent. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 6-7 mm long including the 1-1.5 mm receptacle, lobes not or scarcely recurved, sparsely to moderately pubescent; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely ovate, 10-13.5 x 11-13 mm including the 3-4.5 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, 10-12.5 x 3-4 mm including the 2.5-4 mm claws,

orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half transversely elliptic, margins not incurved, 9-12 x 3-3.5 mm including the 3-4 mm claws, maroon, apex rounded, base auriculate, saccate. *Style* about as long as the ovary, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 4-9. *Pod* stipitate, obliquely ellipsoid, 7-11 x 3-4 mm, moderately pubescent. *Seed* reniform, c. 3 mm long, arillate.

Flowering period. August to October. *Fruiting period*. October to December.

Distribution (Map 20). South-west Western Australia. Occurs along the south coast of this region, from Jerramungup east to Cape Arid, with a few collections inland around Peak Charles and Moorine Rock.

Habitat. Grows on the southern sandplains on undulating dunes and around rivers on sandy soils in shrubland or mallee woodland.

Map 20. Distribution of *G. musaceum*.

Selected specimens (47 examined). WESTERN AUSTRALIA: Roe District: 4 km along Kumarl Road from Lake King-Norseman Road, c. 80 km from Norseman to Lake

King, 32°45'09"S, 121°21'54"E, *G.T. Chandler 913 et al.*, 17 Sep. 1999 (CANB, PERTH). Eyre District: 0.5 km on Elverdton Road from Hopetoun Road, 33°37'20"S, 120°08'47"E, *G.T. Chandler 772 & S. Donaldson*, 6 Nov. 1998 (CANB, MEL); 12 km E of Jerramungup, 33°54'29"S, 119°02'54"E, *M. Hislop 1139*, 27 Sep. 1998 (CANB, PERTH); 29 km N of Hopetoun towards Ravensthorpe, at intersection with Jerdacuttup Road, 33°42'09"S, 120°11'18"E, *G.T. Chandler 273 & W. Keys*, 18 Sep. 1997 (CANB, NSW); ca. 5-10 km inland from Point Malcolm, 33°47'S, 123°45'E, *R.J. Hnatiuk 761135*, 20 Sep. 1976 (PERTH).

Toxicity. Unknown, but given its affinity to *G. parviflorum*, it is presumed to be toxic.

Affinity. Similar to *G. discolor*, *G. melanocarpum* and *G. parviflorum*. *Gastrolobium discolor* differs in the highly discolorous leaves which are much broader (5-10 mm broad), the greater number of flowers per inflorescence (> 25-flowered), the longer racemes (peduncle 15-45 mm long, rachis 70-110 mm long) and the smaller flowers (e.g. calyx 4.5-5.5 mm long, standard 7-9 x 10-11 mm). *Gastrolobium melanocarpum* is easily distinguished, as it has highly revolute, linear leaves (1-2 mm broad), and much smaller flowers (e.g. calyx 4.5-5.5 mm long, standard 7-8 x 9.5-10.5 mm). *Gastrolobium parviflorum* generally has broader leaves (3-11 mm broad), more flowers per inflorescence (generally > 25-flowered), and much smaller flowers (e.g. calyx 4-6 mm long, standard 6.5-8 x 8-10 mm).

21. Gastrolobium discolor G.Chandler, Crisp & R.J. Bayer, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: 16.5 km S of Grass Patch on Coolgardie-Esperance Highway, 33°22'21"S, 121°41'20"E, *G.T. Chandler 258 & W. Keys*, 17 Sep. 1997 (*holo:* CANB; *iso*: MEL, PERTH).

Bushy shrubs with highly discolorous leaves that are often constricted midway along the lamina by the margins suddenly becoming more recurved than the basal half and very long terminal racemes of flowers (peduncle 15-45 mm long, rachis 70-110 mm long) which has prominent bright white villous hairs, which serves to distinguish it from its close relatives *G. musaceum* and *G. parviflorum*.

Frutices *G. musaceo* et *G. parvifloro* arte affinis, sed foliis valde discoloribus saepe super medium angustatis marginibus abrupte recurvis plus quam in dimidio inferno folii et racemis terminalibus longissimis (pedunculus 15-45 mm longus, rhachis 70-110 longa) dense albi-villosis distinguendi.

Etymology. This species is named after the discolorous leaves, with the glabrous upper surface olive green and the densely sericeous lower surface white.

Low, bushy *shrubs*, 0.4-1.5 m high. *Branchlets* ascending, terete to somewhat angular, densely sericeous. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, opposite to sub-opposite, narrowly oblong, elliptic to narrowly so, or somewhat ovate (when the upper margins are more revolute than the lower margins) , 25-50 x 5-10 mm, upper surface glabrous, lower surface densely sericeous, venation prominently reticulate; apex emarginate, occasionally almost bilobed, unarmed or slightly mucronate, recurved to revolute; margins recurved to strongly revolute; base rounded to truncate. *Stipules* ± erect to strongly recurved, linear-triangular, 2-3 mm long. *Inflorescences* terminal racemes, more than 25-flowered; *peduncle* 15-45 mm long; *rachis* 70-110 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, 2-3 mm long, densely pubescent. *Pedicels* terete, 1-3 mm long, densely pubescent. *Calyx* campanulate, 4.5-5.5 mm long including the 0.75-1.25 mm receptacle, moderately to densely pubescent, lobes not or scarcely recurved; upper two lobes united higher than the lower three, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely ovate, 7-9 x 10-11 mm including the c. 2.5 mm claw, deep orange, sometimes with a pinkish tinge, with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, 7-7.5 x 2.5-3.5 mm including the c. 2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, margins incurved, 5.5-6 x 2.5-3 mm including the c. 2.5 mm claws, pink and maroon, apex acute, base auriculate, saccate. *Style* long, strongly incurved, base pubescent; *ovary* stipitate, densely pubescent; *ovules* 4. *Pod* stipitate, obliquely ovoid to obliquely ellipsoid, rarely broadly so, 5-8 x 3-3.5 mm, moderately pubescent. *Seed* barely reniform, 2.5-3 mm long, arillate.

Flowering period. August to October. *Fruiting period*. November and December.

Distribution (Map 21). South-west Western Australia. Occurs mainly in the far east of this region, from the Oldfield River, W of Esperance, east to Mt Buraminya, and north to near Norseman, with one outlier near Two People Bay, in the Albany region. This is an old collection, and the reliability of the data is unknown.

Map 21. Distribution of *G. discolor*.

Habitat. Grows near rivers, on undulating dunes or around granite outcrops on sandy or sandy-loam soils, in mallee woodland or mallee heathland.

Selected specimens (27 examined). WESTERN AUSTRALIA: Roe District: near NW base of Mt Buraminya, 33°13'25"S, 123°07'19"E, *G.T. Chandler 806 & S. Donaldson*, 11 Nov. 1998 (CANB, PERTH); Wittenoom Hills, ca. 3 km west of Mt Burdett, 33°27'S, 122°06'E, *A.E. Orchard 1360*, 4 Oct. 1968 (AD, CANB); Base of Mt Heywood, 82 km NE of Esperance, 33°19'54"S, 122°32'01"E, *W.R. Archer 210953*, 2 Oct. 1995 (MEL, PERTH). Eyre District: between Two People Bay & Nannarup, 34°57'S, 118°05'E, *W. Dennis 864/64*, Aug. 1964 (PERTH); Lort River area, c. 33°40'S, 121°15'E, *O.I.C. Esperance (R.A. Rose) s.n.*, May 1963 (PERTH); 27 km E of the Oldfield River crossing on the South Coast Highway, towards Esperance, *G.T. Chandler 265 & W Keys*, 17 Sep. 1997 (CANB, MO, PERTH).

Toxicity. Unknown, but given the relationship to *G. parviflorum*, presumed to be toxic.

Affinity. Very similar to *G. musaceum* and *G. parviflorum*. *Gastrolobium musaceum* has narrower leaves (2-4.5 mm broad) that are not strongly discolorous, shorter

inflorescence axes (peduncle 7-20 mm long, rachis 25-60 mm long) and larger flowers (e.g. calyx 6-7 mm long, standard 10-13.5 x 11-13 mm). *Gastrolobium parviflorum* generally does not have strongly discolorous leaves (though occasionally there are collections that are strongly discolorous, but these lack other features common to *G. discolor*), shorter inflorescence axes (peduncle 4-22 mm long, rachis 30-65 mm long), a slightly smaller flower (e.g. standard 6.5-8 x 10-11 mm), and lacks the prominent bright white villous hairs on the inflorescence axis that *G. discolor* possesses.

22. Gastrolobium melanocarpum G.Chandler & Crisp, *sp. nov. Type*: WESTERN AUSTRALIA: Roe District: Peak Charles, first saddle on main track, 32°53'15"S, 121°10'05"E, *G.T. Chandler 911, S. Donaldson & A. Monro*, 17 Sep. 1999 (*holo*: CANB; *iso*: BRI, MEL, PERTH).

> *Oxylobium parviflorum* Benth. var. *revolutum* C.A.Gardner, in Gardner and Bennetts (1956, p. 54), *nom. nud.*

Bushy shrubs with strongly revolute linear leaves with only the midrib visible on the abaxial surface, with long, many-flowered racemes (> 20-flowered, rachis 40-100 mm long) and quite small flowers (e.g. calyx 4-5.5 mm long, standard 7-8 x 9.5-10.5 mm), which serves to distinguish it from its close relatives *G. discolor*, *G. musaceum* and *G. parviflorum*.

Frutices foliis valde revolutis linearibus, solum costa in superficie adaxiali visibili, racemis longis multifloris (> 20 floribus, rhachidi 40-100 mm longa). G. discolori, G. musaceo et G. parvifloro arte affinis sed floribus minoribus (calyx 4-5.5 mm longus, vexillum 7-8 x 9.5-10.5 mm longum) differt.

Etymology. From the Greek, *melano* = black, and *carpos* = fruit. This species is named after the fruits, which are often black.

Bushy, erect *shrubs*, 0.4-1.8 m high. *Branchlets* ascending, angular, densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, opposite, linear-oblong, 15-60 x 1-2 mm, upper surface glabrous, lower surface densely sericeous, venation openly reticulate; apex truncate, slightly emarginate, strongly recurved, unarmed or slightly mucronate; margins revolute so that only the midrib is visible on the lower surface; base tapering to petiole. *Stipules* erect, triangular, 1-2 mm long. *Inflorescences* terminal racemes, more than 20-flowered; *peduncle* 11-25 mm long; *rachis* 40-100 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, c. 2 mm long, densely sericeous. *Pedicels*

terete, 1-4 mm long. *Calyx* campanulate, 4-5.5 mm long including the c. 1 mm receptacle, moderately to densely pubescent, lobes not to slightly recurved; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely ovate, 7-8 x 9.5-10.5 mm including the 2.5-3 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, 6-7.5 x 2-3 mm including the c. 2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half elliptic, margins not incurved, c. 5.5 x 2.5 mm including the 2-2.5 mm claws, pink and maroon, apex somewhat rounded, base auriculate, saccate. *Style* about the same length as the ovary, strongly incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 4. *Pod* stipitate, ovoid, 6-7 x 3-4 mm, moderately pubescent. *Seed* slightly reniform, c. 2 mm long, arillate.

Flowering period. August to October. *Fruiting period*. October to December.

Distribution (Map 22). South-west Western Australia. Occurs in the eastern portion of the southern sandplains, from around Newdegate east to the Norseman area. There are also populations at Moorine Rock and around Bodallin, slightly north of the main range.

Habitat. Grows on undulating dunes or around granite outcrops on sand over laterite or granite in open shrubland, dense heathland or mallee woodland.

Selected specimens (40 examined). WESTERN AUSTRALIA: Avon District: 3.8 km S along Stephen Road from the intersection of a track paralleling the Great Eastern Highway 5.5 km W of Bodallin, 31°25'04"S, 118°48'08"E, *G.T. Chandler 254 & W. Keys*, 16 Sep. 1997 (CANB, DNA); 3 km along Ivey Road from Dulyabin Road, S of Bodallin, 31°36'01"S, 118°51'11"E, *G.T. Chandler 859 et al.*, 12 Sep. 1999 (AD, CANB, MEL, NSW, PERTH). Roe District: 6 km NW of Annie Peak, Eyre Range, 33°49'50"S, 119°55'37"E, *K.R. Newbey 11350*, 2 Nov. 1986 (PERTH); 25 km from Newdegate towards Hyden, 32°50'55"S, 119°03'10"E, *G.T. Chandler 947 et al.*, 19 Sep. 1999 (CANB, PERTH); 31 km W of main crossroads at Lake King towards Newdegate, 33°05'40"S, 119°21'04"E, *G.T. Chandler 279 & W. Keys*, 18 Sep. 1997 (CANB, MEL, PERTH); Lake King area, 63 km towards Norseman, 32°58'46"S, 120°16'35"E, *G.T. Chandler 908 et al.*, 17 Sep. 1999 (AD, CANB, PERTH); Salmon Gums, 32°59'S, 121°39'E, *C.A. Gardner s.n.*, 15 Sep. 1934 (AD, BRI, CANB, MEL, NSW, PERTH).

Map 22. Distribution of *G. melanocarpum*.

Toxicity. Unknown, but given its affinity to *G. parviflorum*, it is presumed to be quite toxic.

Affinity. Similar to *G. musaceum* and *G. parviflorum*. *Gastrolobium musaceum* has broader leaves (2.5-4 mm broad) that are not highly revolute, with at least half of the lower surface visible at all times, shorter inflorescence axes (peduncle 7-20 mm long, rachis 25-60 mm long) with fewer flowers (10-25-flowered), and much larger flowers (e.g. calyx 6-7 mm long, standard 10-13.5 x 11-13 mm). *Gastrolobium parviflorum* has broader leaves (3-11 mm broad) that are generally only slightly recurved rather than revolute, the rachis is often shorter (30-65 mm long), and the pod is relatively narrower (7-10 x 3-4.5 mm).

23. Gastrolobium tetragonophyllum (E. Pritzel) Crisp, in Crisp & Weston (1987, p. 130). *Oxylobium tetragonophyllum* E. Pritz. in Diels & Pritzel (1904, p. 226). *Type citation*: "In distr. Eyre inter West - et Phillips River in fruticetis praecipue Melaleucis compositis in solo lutoso-arenoso flor. et fruct. m. Oct. (D. 4828)". *Type specimens*: *holo*: unknown. The type may have been destroyed when Berlin herbarium was bombed.

Bushy, often rounded *shrubs*, 0.3-1.5 m high. *Branchlets* ascending, terete, moderately to densely pubescent. *Petioles* very short, continuous but not decurrent with the branchlet, < 0.5 mm long. *Leaves* broadly spreading to strongly deflexed, opposite or in whorls of 3, narrowly oblong to almost square, sometimes slightly incurved, 8-15(-20) x 2-9 mm, upper surface glabrous, lower surface densely pubescent, venation prominently reticulate; apex emarginate, unarmed; margins strongly recurved to reflexed; base truncate to slightly cordate. *Stipules* erect, hyaline, 1.5-3 mm long. *Inflorescences* terminal racemes, 18 to more than 30 flowered, floral internodes 1-2.5 mm; *peduncle* 0.5-8(-25) mm long; *rachis* 15-40 mm long; *subtending bracts* caducous, scale-like, entire to slightly trilobed, lanceolate, 1.5-2 mm long, densely pubescent. *Pedicels* terete, 1.5-2.5 mm long. *Calyx* campanulate, 4.5-5.5 mm long including the 0.5-1 mm receptacle, densely pubescent, lobes all slightly recurved, all lobes with a small, globose tubercle at the apex; upper two lobes united higher than the lower three, obtuse, 1.5-2 mm long; lower three lobes triangular, acute, 1.5-2 mm long. *Corolla*: *standard* transversely elliptic, 7-9 x 7-10 mm including the 2-2.5 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base truncate, may be slightly auriculate; *wings* obovate, 5-7 x 2-3 mm including the 2-2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, 5-5.5 x 2-2.5 mm including the c. 2 mm claws, red or pink, and maroon, apex sub-acute, base auriculate, saccate. *Style* about as long as the ovary, slightly hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 4. *Pod* stipitate, ellipsoid to almost spheroid, 5-6 x 3.5-5 mm, moderately pubescent. *Seed* not seen.

Vernacular name. Brother-brother.

Flowering period. August to October. *Fruiting period*. October and November.

Distribution (Map 23). South-west Western Australia. Occurs mainly from the Lake King area south to the Ravensthorpe Ranges, with one old collection from Esperance.

Map 23. Distribution of *G. tetragonophyllum*.

Habitat. Grows on sandplains or hillslopes, in sand or gravelly laterite in heathland or mallee shrubland.

Selected specimens (28 examined). WESTERN AUSTRALIA: Eyre District: Esperance, 33°50'S, 121°53'E, *O.I.C. Esperance s.n.*, Mar. 1963 (PERTH); N slopes of Mt Short, c. 20 km N of Ravensthorpe, 32°27'32"S, 120°00'04'E, *G.T. Chandler 919 et al.*, 18 Sep. 1999 (AD, CANB, NSW, PERTH); Young River crossing on West Point Road, 8 km SW of intersection with Cascades Road, 33°09'S, 120°13'23"E, *G.T. Chandler 943 et al.*, 19 Sep. 1999 (AD, CANB, MEL, PERTH). Roe District: Lake King area, corner of Norseman Road and Hogans Road, 14 km E of Lake King, 33°05'09"S, 119°50'15"E, *G.T. Chandler 904 et al.*, 17 Sep. 1999 (CANB, MEL, NSW, PERTH); Just E of Lake King caravan park, 33°04'59"S, 119°41'24"E, *G.T. Chandler 700 & S. Donaldson*, 28 Oct. 1998 (CANB, MEL).

Toxicity. Highly toxic; fluoroacetate 750 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species is similar to *G. parviflorum* and *G. nutans*. *Gastrolobium parviflorum* differs by not having deflexed leaves, the overall leaf shape is generally

narrower (10-35 x 3-11 mm), and the racemes have a longer internode between flowers (up to 15 mm). *Gastrolobium nutans* differs in having recurved leaves and strictly 2 ovules.

The *G. villosum* group

Most species within this group have more or less round leaves (except *G. densifolium*, which shares other features with this group), a more or less tomentose inflorescence, and large, often membranous stipules (up to 15 mm long).

24. Gastrolobium villosum Benth. in Lindley (1839, p. 13). *Type*: none cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River, Drummond, 1839); *iso*: BM, CGE, E.

Low, spreading, rarely trailing *shrubs*, to 0.3-0.6(-1) m high. *Branchlets* ascending, terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 3-6 mm long, densely pubescent. *Leaves* spreading, opposite, broadly ovate, ovate or ± oblong, 20-45(-60) x 7-25(-35) mm, mature leaf upper surface glabrous, lower surface moderately to densely pubescent, venation openly reticulate; apex broadly rounded, slightly emarginate, often with a small, blunt mucro; margins strongly undulate; base truncate or slightly cordate. *Stipules* erect, entire, narrowly triangular, membranous, 8-15 mm long, glabrous to sparsely pubescent. *Inflorescences* terminal racemes, more than 30 flowered, sparsely to densely pubescent; *peduncle* usually with a sheath of persistent barren bracts at the base, 15-90 mm long; *rachis* 80-150 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, keeled, 8-10 mm long, moderately pubescent. *Pedicels* terete, 1-2 mm long, pubescent. *Calyx* campanulate, 6-7 mm long including the c. 1.5 mm receptacle, moderately pubescent, lobes all reflexed; upper two lobes united higher than the lower three, triangular, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, 11-12 x 13-14 mm including the 3-4 mm claw, deep orange to pale red with a red to pink ring around the yellow centre, apex emarginate, base cordate; *wings* obovate, c. 8 x 3 mm including the 2 mm claws, deep orange to pale red, apex rounded, incurved and overlapping to ± enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 5 x 2 mm including the 2 mm claw, pink, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, incurved, lower third pubescent; *ovary* stipitate, densely

pubescent; *ovules* 2. *Pod* shortly stipitate, obliquely ellipsoid, 8-9 x 6-6.5 mm, sparsely to moderately pubescent. *Seed* reniform, 4-5 mm long, arillate.

Vernacular name. Crinkle-leaved Poison.

Flowering period. August to October. *Fruiting period*. October to early December.

Distribution (Map 24). South-west Western Australia. Occurs in the Darling escarpment around Perth, north as far as the New Norcia area, and inland as far as the area near Dandaragan.

Map 24. Distribution of *G. villosum*.

Habitat. Grows in the Darling escarpment on gravelly clay, soils, sometimes with a loam component, in woodland or forest.

Selected specimens (80 examined). WESTERN AUSTRALIA: Darling District: 4.8 km NW of Mount Yetar, 31°56'S, 116°27'E, *M.G. Allen 42*, 5 Nov. 1996 (PERTH); 13 km S of New Norcia, Great Northern Highway, 31°04'29"S, 116°12'09"E, *G.T. Chandler 681 & S. Donaldson*, 25 Oct. 1998 (CANB); 3.8 km towards Calingiri from turnoff on the Great Northern Highway, 31°10'10"S, 116°11'37"E, *G.T. Chandler 190 & W. Keys*, 9 Sep. 1997 (CANB, MEL, NSW); Jane Brook, Swan View, 31°53'S, 116°03'E, *C.A.*

Gardner s.n., 27 Sep. 1933 (PERTH); vicinity of Red Hill, near Toodyay, *R. Spjut 7169 et al.*, 23 Sep. 1981 (PERTH); Darling Range, Gleneagle Forest, Kinsella Road, near Canning Road, 32°17'S, 116°13'E, *M.D. Corrick 7848*, 21 Oct. 1981 (CANB, MEL, PERTH); 41.8 miles [67 km] NE along Geraldton Highway, 31°30'S, 116°11'E, *R.J. Garraty 145*, 26 Aug. 1973 (CANB, PERTH); 8 m. [13 km] E of Karragullen, 32°05'S, 116°15'E, *R.D. Royce 3853*, 6 Oct. 1952 (CANB, PERTH).

Toxicity. Fluoroacetate 10-50 $\mu g.g^{-1}$ (Aplin, 1964; Twigg, *et al.* 1996b).

Affinity. This species is most closely related to *G. tomentosum*, which shares with it an undulate leaf with a densely tomentose lower surface when mature, but *G. tomentosum* can easily be distinguished by the short racemes (peduncle up to 10 mm long; rachis 25-45 mm long) which have smaller flowers (e.g. standard 7.5 x 8 mm) lacking the distinctive keel of *G. villosum* (shared with the *G. floribundum* group). Additionally the leaf shape of *G. tomentosum* is circular or nearly so, whereas *G. villosum* has leaves which are prominently longer than broad.

25. Gastrolobium densifolium C.A.Gardner (1926, p. 69). *Type citation*: "In the DUDININ district, flowering m. October, 1925 (Gottsch Bros.). Gravelly rises in the KUKERIN district, in thickets of *Eucalyptus redunca* var. *elata*, fl. m. Sept. – October (W.E. Blackall and C.A. Gardner, No. 1910). The Type". *Type specimens*: *holo*: PERTH; *iso*: PERTH x 2

Low, dense *shrubs* to 0.7 m high. *Branchlets* ascending to erect, angular, glabrous. *Petiole* extremely short, continuous and decurrent with the branchlet, c. 0.5 mm long. *Leaves* ascending, opposite, recurved towards the apex, ovate, elliptic or rarely obovate, 10-16 x 3-4 mm, glabrous, venation prominent or slightly obscured with only the secondary venation showing; apex acute, recurved to hooked, pungent-pointed; margins usually recurved, sometimes flat; base cuneate. *Stipules* erect, prominent, very narrowly triangular to hyaline, partly fused behind the axillary bud, 6-10 mm long, red or sometimes black in colour. *Inflorescences* terminal racemes, 10-15 flowered; *peduncle* 4-7 mm long,; *rachis* 12-20 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, margins strongly recurved to reflexed, moderately pubescent, 7-9 mm long. *Flower*: *pedicels* terete, 1.5-2.5 mm long. *Calyx* campanulate, 6-7 mm long including the 1-1.5 mm receptacle, densely villous, lobes not recurved; upper two lobes united scarcely higher than the lower three, 2-3 mm long, triangular, acute; lower three lobes triangular, acute, 2.5-3 mm long. *Corolla*: *standard* transversely elliptic, 8-9 x

10-11 mm including the 3-3.5 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate or oblong, 8-9 x c. 3 mm including the c. 3 mm claw, orange, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, not saccate; *keel* half transversely broadly elliptic, c. 8 x 3 mm including the c. 3 mm claw, maroon, apex obtuse, base auriculate, saccate. *Style* long, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, broadly ellipsoid to almost spherical, 4-5.5 x 3-3.5 mm, moderately to densely pubescent. *Seed* ellipsoid, 2-2.5 mm long, arillate.

Vernacular name. Mallet Poison.

Flowering period. September and October. *Fruiting period.* November and December.

Distribution (Map 25). South-west Western Australia. A rare species, occurring around the Kukerin, Dudinin, Tarin Rock and Dragon Rocks areas.

Map 25. Distribution of *G. densifolium*.

Habitat. Grows on undulating dune areas or sandy soils in mallee heath or mixed shrubland.

Conservation status. ROTAP: 2KC-. CALM: P4. This species is rare, and poorly known in its distribution, but is not considered to be at risk.

Specimens examined. WESTERN AUSTRALIA: Roe District: Dudinin, 32°52'S, 117°54'E, *C.A. Gardner s.n.*, 4 Nov. 1934 (CANB, PERTH); ibid, *Gottsch Brothers s.n.*, Oct. 1925 (PERTH); Dragon Rocks Nature Reserve, 2 km S of Mouritz Road on Buettners Road, 32°39'S, 118°59'E, *R.M. Buehrig 93.12.9(9A)*, 9 Dec. 1993 (PERTH); Kukerin, 33°11'S, 118°05'E, *A.K. Joyce s.n.*, 3 Sep. 1952 (PERTH); E from Kukerin, *C.A. Gardner s.n.*, 3 Oct. 1959 (PERTH); Dragon Rocks Nature Reserve, south of Mouritz Road, 32°38'S, 119°02'E, *A.M. Coates 3366*, 26 Oct. 1991 (CANB, PERTH); opposite Tarin Rock siding, 33°06'27"S, 118°13'53"E, *G.T. Chandler 532 et al.*, 19 Feb. 1998 (CANB, NSW); Tarin Rock, 33°06'29"S, 118°13'56"E, *G.T. Chandler 716 & S. Donaldson*, 29 Oct. 1998 (CANB).

Toxicity. Fluoroacetate not detected (Aplin, 1964).

Affinity. This species is very difficult to confuse with any other *Gastrolobium*, due to the distinctive recurved leaves with a ± triangular apex and large stipules, which leave a persistent base when the hyaline apex is worn away. The only other species sharing this stipule character is *G. rotundifolium*, which has broader (8-18 mm), undulate leaves.

26. Gastrolobium tomentosum C.A.Gardner (1955, p. 186). *Type citation*: "In distr. Darling ad Dardadine prope Williams, in collibus glareosis, fl. m. Oct. M.W.H. Moore (Typus)". *Type specimens*: *Lecto* (here chosen): "Dardadine, M.W.H. Moore, 23 Sept. 1953" (PERTH); *isolecto*: PERTH.

Weak, decumbent, often clumped *shrubs*, up to 1 m high. *Branchlets* trailing, angular, densely villous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-4 mm long, densely villous. *Leaves* spreading, opposite, circular to elliptic, 13-30 x 8–20 mm, mature upper surface glabrous, lower surface densely tomentose, venation reticulate; apex broadly rounded, rarely slightly emarginate, unarmed or with a small, blunt mucro; margins undulate; base obtuse to broadly rounded. *Stipules* erect, membranous, entire, narrowly triangular, 5-8 mm long, more prominent on younger leaves. *Inflorescences* terminal racemes, 10-18-flowered, densely tomentose; *peduncle* often with a sheath of persistent barren bracts at the base, up to 10 mm long; *rachis* 25-45 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, densely pubescent, 7-8 mm long. *Flowers*: *pedicel* terete, densely pubescent, 1-2 mm long. *Calyx* campanulate, c. 5 mm long including the c. 0.75 mm receptacle, densely

tomentose, lobes all reflexed; lobes sub-equal, upper two lobes united scarcely higher than the lower three, all triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, c. 7.5 x 8 mm including the 2 mm claw, deep orange-maroon on the back, orange-yellow on the front with a red ring surrounding the yellow centre, apex emarginate, base auriculate; *wings* oblong, c. 7.5 x 2.5 mm including the 2 mm claws, orange-yellow and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely broadly elliptic, margins not incurved, c. 7 x 3 mm including the 2.5 mm claws, deep maroon to almost black, apex rounded, base auriculate, saccate. *Style* long, strongly incurved, lower half densely pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 6-7 x 4-5 mm, moderately to densely villous. *Seed* reniform, c. 2.5-3 mm long, arillate.

Vernacular name. Woolly Poison.

Flowering period. August to November. *Fruiting period*. October to December.

Distribution (Map 26). South-west Western Australia. Occurs in the areas around Williams and Narrogin, between Perth and Albany.

Map 26. Distribution of *G. tomentosum*.

Habitat. Grows in woodland or forest, preferring the heavier clay and loam soils of this region, though it sometimes occurs on sandier substrates.

Conservation status. IUCN: V. ROTAP: 2V. CALM: P4. This species is rare, and considered to be vulnerable. Much of the region that *G. tomentosum* occurs in has been cleared for logging and farming, leaving little of the native habitat undisturbed. All populations observed in this study were along roadsides, with the populations in some danger of becoming extinct.

Selected specimens (15 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Darling District: between Williams and the Albany Highway, *G.T. Chandler 756 & S. Donaldson*, 2 Nov. 1998 (CANB, MEL, NSW, PERTH); Williams towards Culbin, *T.D. Macfarlane 1235*, 27 Sep. 1983 (PERTH); Dardadine towards Williams, *G.T. Chandler 755 & S. Donaldson*, 2 Nov. 1998 (CANB, PERTH); NW of Kojonup, *C. Lewis s.n.*, Aug. 1993 (PERTH);

Toxicity. Unknown, but according to Gardner and Bennetts (1956), *G. tomentosum* has been reported to cause some stock losses.

Affinity. This species is similar to *G. villosum*, but the stipules are much larger in the latter (8-15 mm long), as is the raceme (peduncle 15-90 mm long and rachis 80-150 mm long). *Gastrolobium ovalifolium* and *G. glabratum* also resemble *G. tomentosum*, but the mature leaves of both species are glabrous, and those of *G. ovalifolium* are not undulate, and have thick venation, such that the aereoles are reduced to pin pricks.

27. Gastrolobium glabratum G.Chandler & Crisp, *sp. nov*. *Type*: Western Australia: Qualen Road, West York, 1.52 km E of Catchment Road at Ref Tree BA 93/1, 32°05'39"S, 116°36'08"E, *F. Hort 235*, 16 Sep. 1998 (*holo*: PERTH; *iso*: CANB).

Very similar to *G. tomentosum*, but *G. tomentosum* has mature leaves that are densely tomentose on the lower surface, and a slightly shorter rachis (25-45 mm long), where *G. glabratum* has glabrous mature leaves, and a slightly longer rachis (35-70 mm long). There is also some resemblance to *G. ovalifolium*, but this species has thick, flat leaves with dense venation, such that the aereoles are reduced to pin-pricks, where *G. glabratum* has much thinner leaves with openly reticulate venation.

G. tomentoso similissima sed foliis maturis glabris, rhachis paulo longiori differt. *G. ovalifolio* nonnihil similis sed foliis multo tenuioribus venatione aperte reticulata differt.

Etymology. Named after the nearly glabrous mature leaves.

Weak, decumbent, often clumped *shrubs*, up to 0.8 m high. *Branchlets* trailing, angular, densely villous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-4 mm long, densely villous. *Leaves* spreading, opposite, circular to elliptic, 10-27(-42) x 12–24(-28) mm, mature leaf glabrous, venation openly reticulate; apex broadly rounded, rarely slightly emarginate, unarmed or with a small, blunt mucro; margins undulate or sometimes almost flat, not recurved; base obtuse to broadly rounded. *Stipules* erect, membranous, triangular, 5-8(-11) mm long, more prevalent on younger leaves. *Inflorescences* terminal racemes, 10-18-flowered, densely tomentose; *peduncle* often with a sheath of persistent barren bracts at the base, up to 5-25 mm long; *rachis* 35-70 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, 7-9 mm long, glabrous. *Flowers*: *pedicel* terete, densely pubescent, 1-2 mm long. *Calyx* campanulate, 5-6 mm long including the 0.75-1 mm receptacle, densely tomentose; lobes all reflexed, subequal, upper two united scarcely higher than the lower three, all triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, c. 7-9 x 8-10 mm including the 2 mm claw, deep orange-maroon on the back, orange-yellow on the front with a red ring surrounding the yellow centre, apex emarginate, base auriculate; *wings* oblong, c. 7.5-8 x 2.5 mm including the 2 mm claws, orange-yellow and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely broadly elliptic, margins not incurved, 7-8 x 3-4 mm including the 2.5 mm claws, deep maroon to almost black, apex rounded, base auriculate, saccate. *Style* very long, strongly incurved, lower half pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 6-7 x 4-5 mm, moderately to densely villous. *Seed* reniform, c. 2.5-3 mm long, arillate.

Flowering period. August to October. *Fruiting period*. From October.

Distribution (Map 27). South-west Western Australia. Occurs south of Perth, from West York south to the Williams district, and down to Bridgetown and Manjimup.

Habitat. Prefers the heavier clay and loam soils of this region. Occurs in woodland or forest.

Conservation status. IUCN: R. ROTAP: 3R. This species is rare, though it is not considered to be at risk.

Map 27. Distribution of *G. glabratum*.

Selected specimens (28 examined). WESTERN AUSTRALIA: Darling District: Near Quindaning, 33°02'S, 116°34'E, *M.E. Phillips s.n.*, 16 Oct. 1962 (CANB); 39.4 miles [63 km] from Collie towards Williams, *E.M. Canning w.n.*, 1 Oct. 1968 (CANB); Manjimup, 34°15'S, 116°09'E, *R.D. Royce 2730*, 28 Sep. 1948 (PERTH); 30 km SW of Williams towards Collie, 33°12'S, 116°36'E, *K.J. Atkins 89010*, 25 Oct. 1989 (PERTH); 12 miles [19 km] from Williams towards Perth, *J.W. Wrigley s.n.*, 8 Oct. 1968 (CANB); North Muradup Road, 30 km W of Kojonup, 33°49'S, 116°57'E, *C. Lewis CML 128*, 8 Sep. 1995 (PERTH); Qualen Road, West York, 32°05'39"S, 116°36'08"E, *F. Hort 235*, 16 Sep. 1998 (CANB, PERTH); 88.5 mile peg, Albany Highway, *T.E.H. Aplin 2822*, 16 Oct. 1964 (PERTH).

Toxicity. Unknown.

Affinity. This species is very similar to *G. tomentosum*, but *G. tomentosum* has mature leaves that are densely tomentose on the lower surface, and a slightly shorter rachis (25-45 mm long). There is also some resemblance to *G. ovalifolium*, but this species has thick, flat leaves with dense venation, such that the areoles are reduced to pin-pricks.

28. Gastrolobium ovalifolium Henfry (1852a, p. 41). *Type citation*: "New Holland shrub was bloomed ... by Messrs. Henderson, of the Pine Apple Nursery,". *Type*: the plate.

Prostrate, spreading shrubs, 0.1 m high. *Branchlets* spreading, terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 2-4 mm long, densely pubescent. *Leaves* spreading, opposite, obovate to ± circular, rarely transversely elliptic, 12-32 x 13-20 mm, mature leaves glabrous, venation reticulate, punctate, much paler on the lower surface; apex usually emarginate, sometimes strongly so, occasionally broadly rounded with a short, blunt mucro; margins entire, not recurved; base obtuse to broadly rounded. *Stipules* erect, triangular, membranous, keeled, 5-8 mm long, moderately villous, more prevalent on younger leaves. *Inflorescences* terminal racemes, 6-18-flowered, densely pubescent; *peduncle* often with a sheath of persistent barren bracts at the base, 10-20 mm long; *rachis* 40-70 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, densely pubescent, 7-8 mm long. *Flowers*: *pedicel* terete, densely pubescent, 1-2 mm long. *Calyx* campanulate, 5-6 mm long including the c. 1 mm receptacle, densely pubescent, lobes all reflexed; upper two lobes united slightly higher than the lower three, triangular, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, c. 7.5 x 8 mm including the 2 mm claw, deep orange-purple on the back, orange-yellow on the front with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* oblong, c. 7.5 x 2.5 mm including the 2 mm claws, orange-yellow and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely broadly elliptic, margins not incurved, c. 7 x 3 mm including the 2.5 mm claws, deep maroon to almost black, apex rounded, base auriculate, saccate. *Style* very long, strongly incurved, lower half densely pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, broadly ellipsoid, 6-7 x 4-5 mm, moderately to densely villous. *Seed* reniform, c. 3 mm long, arillate.

Vernacular name. Runner Poison.

Flowering period. August, and probably September. *Fruiting period*. October.

Distribution (Map 28). South-west Western Australia. Occurs mainly in the Narrogin and Williams districts, but there is one record from Kojonup, further to the south.

Map 28. Distribution of *G. ovalifolium*.

Habitat. Grows on sandy clay soils in wandoo woodland.

Conservation status. IUCN: R. ROTAP: 2RCa. CALM: P4. This species is rare, but is not considered to be at risk.

Specimens examined. Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Darling District: E of Williams, *R.D. Royce s.n.*, Oct. 1958 (PERTH); Narrogin, *C.A. Gardner s.n.*, 31 Aug. 1934 (CANB, PERTH); Dryandra National Park, *T.R. Lally 938 & B.J. Lepschi*, 15 Jan. 1996 (PERTH); Narrogin area, *P. Batt PRB 5-8-93/2*, 4 Aug. 1993 (PERTH); Kojonup, *J.M. Flanagan s.n.* (PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium ovalifolium* is similar to *G. glabratum* and *G. tomentosum*. *Gastrolobium glabratum* differs in having generally undulate leaves with open reticulate venation on the lower surface, while *G. tomentosum* has densely tomentose mature leaves on the lower surface, and has ± glabrous stipules.

29. Gastrolobium rotundifolium Meisn. (1848, p. 216). *Type citation*: "Swan River, Drummond coll: II. No. 99". *Type specimens*: *Holotype* (here chosen): BM; *iso*: G, K x 2, LD.

> *Gastrolobium rotundifolium* var. *angustifolium* C.A.Gardner in Gardner & Bennetts (1956, p. 57). *Nom. nud. & inval.*

Erect, bushy *shrubs*, to 0.8 m high. *Branchlets* ascending, angular to almost terete, moderately to densely pubescent. *Petiole* terete, continuous and may be slightly decurrent with the branchlet, 1-3 mm long. *Leaves* spreading to ascending, opposite, broadly elliptic, rarely elliptic or linear, 18-26(-32) x 8-18 mm, moderately to densely pubescent when young, moderately pubescent to ± glabrous when older, much paler on the lower surface, venation prominently reticulate; apex obtuse to acute, with a very long and needle-like pungent point; margins crinkled, rarely recurved or reflexed; base obtuse, rarely acute. *Stipules* erect, fused for at least part of their length, membranous, somewhat lacerate, narrowly triangular, 10-15 mm long. *Inflorescences* axillary or terminal racemes, 10-20-flowered, inflorescence axis densely pubescent; *peduncle* 3-7 mm long; *rachis* 10-25 mm long; *subtending bracts* caducous, but persisting until after anthesis, scale-like, lanceolate, 7-8 mm long, moderately pubescent. *Flowers*: *pedicel* terete, 1-2 mm long, densely pubescent. *Calyx* campanulate, c. 5 mm long including the 0.75 mm receptacle, densely villous, lobes not or slightly recurved; upper two lobes united higher than the lower three, triangular, acute, c. 2 mm long; lower three lobes narrowly triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, c. 9 x 8 mm including the 3 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base slightly cordate, slightly auriculate; *wings* obovate to oblong, c. 8 x 3 mm including the 3 mm claws, orange-yellow to orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely broadly elliptic, c. 8 x 3 mm including the 3 mm claw, deep maroon, apex obtuse, base auriculate, saccate. *Style* long, hooked, lower half slightly pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, obliquely ellipsoid, 6-7 x 3-4 mm, moderately to densely villous. *Seed* reniform, c. 3 mm long, arillate.

Vernacular name. Gilbernine Poison.

Flowering period. August and September. *Fruiting period*. From October.

Distribution (Map 29). South-west Western Australia. Occurs around Mingenew in the north, south through Watheroo and Calingiri to the areas around Wagin and Narrogin.

Map 29. Distribution of *G. rotundifolium*.

Habitat. Grows in more open positions on heavier clay or loam soils in wandoo woodland.

Conservation status. ROTAP: 3K. CALM: P1. This species is rare, and considered to be at some risk. The population examined in this study was along a local farm access track, in somewhat disturbed woodland surrounded by farms, and is probably at some risk in the future.

Selected specimens (16 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Irwin District: E of Watheroo towards Miling, *G.T. Chandler 830 et al.*, 8 Sep. 1999 (CANB, PERTH, UWA); ibid, *G.T. Chandler 658 & S. Donaldson*, 25 Oct. 1998 (CANB, PERTH); E of Carani, *T.E.H. Aplin 2801*, 16 Sep. 1964 (PERTH); NE of Watheroo, *J.F. Sampson 425*, 14 Aug. 1989 (PERTH); Tootra, *Agric. Adviser Moora*, 1 Oct. 1945. Avon District: Highbury, near Wagin, *C.A. Gardner s.n.*, 29 Aug. 1934 (PERTH).

Notes on variation. There is a form of this species, which Gardner, in Gardner & Bennetts (1956), called *G. rotundifolium* var. *angustifolium* (although this is an invalid name), which has very narrow leaves with revolute margins, so that only the midrib and a very small portion of the abaxial surface is visible (e.g. the cited collection above, from Tootra, near Moora). There is an intermediate specimen (Aplin, 2801, cited above) which has somewhat narrow leaves with a slightly recurved margin that is not as undulate as the more typical form. Further work is required on this species, as it could not be located in the field for this study, to determine whether there are one or two species present.

Toxicity. Fluoroacetate 150 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species is difficult to confuse with any other of *Gastrolobium* due to the particularly large stipules, which only *G. densifolium* shares. These two are easily separated, because *G. densifolium* has narrow, non-undulate, non-recurved leaves that are glabrous, and are recurved along their length, whereas those of *G. rotundifolium* are straight.

The *G. floribundum* group

This is a group of species with generally broad distributions throughout the central sandplains of south-west Western Australia. They share a distinctive keel shape (found in only two other species related to this group), in which the apex is quite acute and slightly beaked, and the lower margin is not entire, having a large hole towards the base through which the stamens are visible and exposed. Also, they have strictly 2 ovules.

30. Gastrolobium polystachyum Meisn. (1848, p. 217). *Type citation*: "Swan River, Drummond coll. II. no. 97". *Type specimens*: *holo*: NY; *iso*: BM, E, K (2 sheets), LD, W.

> *Oxylobium batillum* Hook. (1844). *Type citation*: Swan River settlement. Jas. Drummond (suppl. coll. n. 32)". *Type specimens*: *holo*: K.
>
> *Gastrolobium bidens* Meisn. (1855b, p. 29). *Type citation*: "Drumm. Coll. VI. n. 23". *Type specimens*: *holo*: BM; *iso*: CGE, K, W.
>
> *G. polystachyum* Meisn. var. *revolutum* C.A.Gardner (1956, p. 70). *Nom. nud. & inval.*

Erect, spreading *shrubs*, to 1 m high. *Branchlets* spreading to ascending, angular to almost terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the

branchlet, c. 0.5-1 mm long. *Leaves* spreading, opposite, oblong to linear, cuneiform, elliptic, or obsagittate, 5-35 x 7-25, upper surface glabrous, lower surface moderately to densely pubescent, venation prominently reticulate; apex mucronate, recurved, often bilobed, the other angles usually mucronate; margins recurved to reflexed, may or may not be undulate; base obtuse, rounded or almost truncate. *Stipules* erect, hyaline, 3-5 mm long. *Inflorescences* terminal or axillary racemes, 10-30-flowered, flowers closely spaced along rachis; *peduncle* 2-5(-10) mm long; *rachis* 15-50 mm long; *subtending bracts* caducous, scale-like, entire, ovate, 4-6 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 3-3.5 mm long, lobes all reflexed, moderately pubescent; upper two lobes united slightly higher than the lower three, triangular, acute, c. 1.5 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely elliptic, 5-6 x 7-8.5 mm including the c. 2 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, 5-5.5 x 1.5-2 mm including the c. 1.5 mm claws orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, 3.5-4 x 1.5-2 mm including the c. 1.5 mm claws, pink and maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, incurved to slightly hooked, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid to ovoid, 5-7 x 4-5 mm, moderately pubescent. *Seed* not seen.

Vernacular names. Horned Poison; Hill River Poison.

Flowering period. July to September. *Fruiting period*. October to December.

Distribution (Map 30). South-west Western Australia. Occurs in the northern sandplains to the north of Perth, from Eneabba south through Jurien Bay and Badgingarra to Mogumber, and inland as far as Dandaragan.

Habitat. Grows on undulating white sand dunes over laterite, or on sandy or gravelly clay over granite, in wandoo woodland, shrubland or heath.

Selected specimens (70 examined). WESTERN AUSTRALIA: Irwin District: 12 km from Three Springs along road to Eneabba, 29°35'S, 115°40'E, *M.D. Crisp 6318 et al.*, 2 Oct. 1979 (CANB, PERTH); Moore River, Mogumber, 31°02'S, 116°02'E, *C.A. Gardner s.n.*, July 1936 (CANB, PERTH); 6 miles [9.5 km] from Three Springs towards Arrino, *M.E. Phillips WA/68 942*, 14Sep. 1968 (CANB); 10.7 km along Badgingarra Road from North West Road, towards Dandaragan, 30°29'45"S,

115°36'35"E, *G.T. Chandler 239 & W. Keys*, 13 Sep. 1997 (BRI, CANB, NSW); 14.5 km on Tootbardie Road from Brand Hwy, S of Eneabba, 30°07'14"S, 115°30'04"E, *G.T. Chandler 829 et al.*, 8 Sep. 1999 (CANB); 2.5 km along Tootbardie Road, N of Badgingarra, 30°08'59"S, 115°23'40"E, *G.T. Chandler 629 & S. Donaldson*, 23 Oct. 1998 (CANB, MEL, PERTH); ibid, *G.T. Chandler 635 & S. Donaldson*, 23 Oct. 1998 (CANB). Avon District: 2 km S of New Norcia, 31°00'S, 116°14'E, *M. Fagg 1041*, 26 Aug. 1979 (CANB).

Map 30. Distribution of *G. polystachyum*.

Notes on variation. The leaves of this species vary considerable, and in the past led to the recognition of two varieties (var. *revolutum* and var. *polystachyum*), with notes made on intermediates in Gardner and Bennetts (1956). The two varieties appear distinct in their extremes, with var. *revolutum* being linear-oblong with a bilobed apex, and var. *polystachyum* having more broadly oblong to cuneiform leaves with a somewhat less bilobed apex, often appearing truncate. However, there are a number of intermediates that grade from one form into the other, and in fact may be found in one population, even on one plant (e.g. collections made by the author along Tootbardie Road, S of Eneabba). Hence, these varieties are not being recognised here.

Toxicity. Fluoroacetate 0-10 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species is difficult to confuse with any other of *Gastrolobium*, due to the almost unique shape of the leaf combined with the often prominently bilobed apex. However, a population of a particularly long-leaved form of *G. stowardii* (Chandler 828 et al.) was found to occur sympatrically with a population of *G. polystachyum* along Tootbardie Road, between Eneabba and Badgingarra. This population has plants resembling *G. polystachyum* in leaf shape, but the leaves are small. However, *G. stowardii* is easily told apart from *G. polystachyum*, with inflorescences that are paired in the axils, and the flowers have bracts with enlarged middle lobes.

Some specimens with what appear to be juvenile foliage (broadly cuneiform leaves) vaguely resemble the more juvenile forms of *G. diabolophyllum*. However, *G. diabolophyllum* has robust leaves, where *G. polystachyum* has far less robust leaves, and *G. diabolophyllum* has pungent-pointed apices and angles, whereas these juvenile forms of *G. polystachyum* are unarmed. The foliage of *G. polystachyum* also somewhat resembles that of *G. stowardii*, particularly the more narrowly-leaved form, but *G. stowardii* is easily told apart by the smaller leaves and clustered, axillary inflorescences as opposed to the long racemes of *G. polystachyum*.

31. Gastrolobium propinquum C.A. Gardner (1955, p. 185). *Type citation*: "In distr. Irwin in lutosis glareosis subhumidis, fl. M. Septem. Gardner 12233 (Typus)". *Type specimens*: *holo*: PERTH; *iso*: PERTH.

Low, bushy *shrubs*, 0.5-1(-1.8) m high. *Branchlets* ascending, angular, glabrous. *Petiole* terete, continuous and slightly decurrent with the branchlet, 3-4 mm long. *Leaves* spreading to ascending, in whorls of 3, ovate to elliptic, 17-40(-65) x 6-11(-14) mm, glabrous to slightly glaucous, venation prominently reticulate; apex acute, pungent-pointed or more rarely mucronate; margins conduplicate or rarely ± flat, recurved, margins entire or minutely crenulate; base cuneate. *Stipules* erect, narrowly triangular, 3-5 mm long. *Inflorescences* racemes, terminal or in the upper axils, 1-3 per terminus or axil, 15 to more than 30 flowered; *peduncle* 5-10 mm long; *rachis* 20-120 mm long; *subtending bracts* caducous, scale-like, entire or slightly lacerate, ovate, 4-5 mm long. *Pedicels* terete, 2-3 mm long, becoming nutant at the onset of fruiting. *Calyx* campanulate, 3.5-4.5 mm long including the c. 1 mm receptacle, glabrous to sparsely pubescent, upper two lobes straight, lower three lobes recurved; upper two lobes united into an almost truncate lip, obtuse, c. 1.5 mm long; lower three lobes triangular, acute,

1-1.5 mm long. *Corolla*: *standard* transversely elliptic, c. 5-6 x 6 mm including the 2 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, c. 5-5.5 x 2 mm including the 2 mm claw, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 4.5 x 2 mm including the 1.5 mm claws, maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, incurved, pubescent in the lower half; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, nutant, obliquely ellipsoid, 5-7 x 3-3.5 mm, sparsely to moderately pubescent. *Seed* ellipsoid or somewhat cuboid, c. 3 mm long, arillate.

Vernacular name. Hutt River Poison.

Flowering period. June to September. *Fruiting period.* October and November.

Distribution (Map 31). South-west Western Australia. Grows mainly in the Northampton and Port Gregory districts, with occasional collections around Mullewa and Isseka.

Map 31. Distribution of *G. propinquum*.

Habitat. Grows on clay, clay-loam or sandy clay soils in mixed shrubland.

Conservation status. ROTAP: 3K. CALM: P1. This species is rare, and considered to be in danger. The population examined in this study was found on a highly disturbed roadside.

Selected specimens (24 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Irwin District: between Port Gregory and Northampton, *G.T. Chandler 652 & S. Donaldson*, 24 Oct. 1998 (CANB, PERTH); Mullewa, *R.D. Royce 7511*, 11 Sep. 1962 (CANB, PERTH); Yerina Springs Road, from Port Gregory Road, *S. Patrick 1975*, 9 Aug. 1994 (PERTH); Northampton area, *J. Dodd s.n.*, 12 Aug. 1994 (PERTH); Isseka, *H.W. Jones s.n.*, 20 June 1953 (PERTH); NW of Northampton, *H.P. Dolling 2*, 9 Aug. 1989 (CANB, PERTH); NW of Northampton, *Dr Bellairs DRB1*, 29 July 1989 (PERTH).

Toxicity. Unknown.

Affinity. This species has been confused with *G. oxylobioides* in the past, but *G. oxylobioides* has many fewer flowers per inflorescence (5-10), the flowers are much larger (e.g. standard c. 10 x 14 mm), the keel shape is different, most noticeably lacking a spout-like apex and the lower margin is entire, lacking the hole where the stamens are visible, and the calyx is generally more pubescent.

32. Gastrolobium diabolophyllum G.Chandler, Crisp & R.J.Bayer, *sp. nov. Type*: WESTERN AUSTRALIA: Avon District: Bodallin, 21 km along Hocking Road, at corner of Dulyabin Road and road to Bodallin, 31°37'29"S, 118°51'12"E, *G.T. Chandler 856, A. Monro & S. Donaldson*, 12 Sep. 1999 (*holo*: CANB; *iso*: AD, BRI, CANB, K, MEL, NSW, NY, PERTH).

The robust, obtriangular leaves with 3 fiercely pungent points, recurved to revolute margins and a recurved apex distinguishes this species from all others.

A *Gastrolobii* specibus ceteris foliis obtriangularibus robustis, apice recurvo spinis 3 ferocibus, marginibus recurvis vel revolutis, raceme floribus magnitudine moderata (e.g. rhachis 3-7 mm longa, vexillum 7-8 x 10.5-12 mm) distinguenda.

Etymology. From the Greek, *diabolos* = devil and *phyllon* = leaf. Named after the leaves, which have three fiercely pungent-pointed apices.

Erect, open, robust *shrubs*, 0.5-1.5 m high. *Branchlets* ascending, terete, moderately to densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-3

mm long. *Leaves* spreading to ascending, opposite, obtriangular to broadly so, rarely shallowly obtriangular, 12-26 x 10-32 mm, glabrous, occasionally somewhat glaucous; venation prominently reticulate, particularly on the upper surface; apex acute, rarely obtuse, recurved, all three angles with pungent points; margins entire, recurved to revolute; base rounded to cuneate. *Stipules* erect, triangular to hyaline, 1.5-2 mm long. *Inflorescences* terminal racemes, 5-10 flowered; *peduncle* 2-11 mm long; *rachis* 3-7 mm long; *subtending bracts* caducous, scale-like, entire to slightly trilobed, ovate, keeled, 3.5-4 mm long, moderately pubescent. *Flower*: *pedicels* densely pubescent, 1.5-2 mm long. *Calyx* slightly campanulate, c. 5 mm long including the 0.75-1 mm receptacle, moderately to densely pubescent, lobes all reflexed; upper two lobes united higher than the lower three into an almost truncate lip, broadly triangular, 1.5-2 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely ovate, 7-8 x 10.5-12 mm including the 2.5-3 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, 7-7.5 x 2.5-3 mm including the 2.5-3 mm claw, orange, becoming darker towards the base, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely broadly elliptic, turgid, margins incurved, 5.5-6 x 2-2.5 mm including the 2-2.5 mm claw, pink, apex obtuse, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* short, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ovoid, 5-6 x c. 3.5 mm, moderately to densely pubescent. *Seed* ellipsoid, c. 3 mm long, arillate.

Flowering period. September. *Fruiting period*. October.

Distribution (Map 32). South-west Western Australia. Known only from one population near Bodallin, along the Great Eastern Highway.

Habitat. Grows on broadly undulating dunes in yellow-brown sand over laterite in open mallee shrubland.

Conservation status. CALM: P1. This taxon is rare, being known only from the type locality, which is located on a roadside reserve in a farming area, and is considered to be at risk.

Specimens examined. WESTERN AUSTRALIA: Avon District: 26 km due SW of Bodallin, 31°34'S, 118°43'E, *R.J. Cranfield 2363*, 16 Sep. 1982 (PERTH); c. 24 km SSE of Carrabin (NNE of Noombanderry Rock), 31°35'S, 118°50'E, *A. Strid 20334*,

15-17 Sep. 1982 (PERTH); 27 km directly S of Bodallin, at intersection of Dulyabin Road and road to Bodallin, 31°37'30"S, 118°51'13"E, *G.T. Chandler 559-561 et al.*, 23 Feb. 1998 (AD, CANB, MEL, NSW, NY, PERTH); 21 km along Hocking Road, at intersection of Dulyabin Road & road to Bodallin, 31°37'30"S, 118°51'13"E, *G.T. Chandler 691 & S. Donaldson*, 26 Oct. 1998 (CANB); 21 km along Hocking Road, at intersection of Dulyabin Road & road to Bodallin, 31°37'29"S, 118°51'12"E, *G.T. Chandler 858 et al.*, 12 Sep. 1999 (CANB, MEL, PERTH).

Map 32. Distribution of *G. diabolophyllum*.

Toxicity. Unknown.

Affinity. It is almost impossible to confuse this species with any other species of *Gastrolobium*. Superficially, it vegetatively resembles some juvenile forms of *G. polystachyum*, but is easily told apart by the more robust leaves of *G. diabolophyllum* which are strongly recurved and have three pungent points, where the juvenile forms of *G. polystachyum* have weak leaves which are not recurved, and are unarmed.

33. Gastrolobium floribundum S.Moore (1920, p. 170). *Type citation*: "Nungarin; Stoward, 730". *Type specimens*: *holo*: BM.

Erect *shrubs*, 0.5-2 m high. *Branchlets* ascending, terete or angular, sparsely to densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 0.5-1.5 mm long. *Leaves* ascending, opposite, elliptic to obovate, may be straight, incurved or recurved, canaliculate, (20-)28-41(-83) x 5-10 mm, glabrous, sometimes glaucous, venation prominently reticulate; apex rounded to acute, occasionally retuse, slightly mucronate; margins occasionally recurved; base cuneate. *Stipules* erect, hyaline, 3-4 mm long. *Inflorescences* terminal racemes, rarely axillary, 8-20-flowered; *peduncle* may have what appear to be aborted buds towards the base (3-)9-20(-33) mm long; *rachis* (22-)60-82 mm long; *subtending bracts* caducous, scale-like, entire, triangular, 3-4 mm long. *Pedicels* terete, 1.5-2 mm long. *Calyx* campanulate, 3.5-6 mm long including the c. 0.5 mm receptacle, moderately to densely pubescent, lower lobes only recurved; upper two lobes united higher than the lower three, triangular, rounded, c. 2 mm long; lower three lobes triangular, acute, 1.5 mm long. *Corolla*: *standard* transversely obovate, 9-9.5 x 11 mm including the 3 mm claw, yellow to orange with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, 6.5-7.5 x 3-3.5 mm including the 2-2.5 mm claw, orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely obovate, turgid, upper margin may be incurved, 5.5-6 x 2.5 mm including the 2 mm claw, maroon, apex spout-like, base auriculate, saccate, with a circular opening near the claws to expose the stamens from below. *Style* short, strongly incurved, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, elliptic to ovate, 4-4.5 x 3.5-4 mm, moderately to densely pubescent. *Seed* not seen.

Vernacular name. Wodjil Poison.

Flowering period. August to November. *Fruiting period*. From late October.

Distribution (Map 33). South-west Western Australia. Widespread in the central sandplain regions, from Caron in the west to Hyden and Marvel Loch in the east.

Habitat. Grows on undulating dunes on sandy soils in mallee woodland, shrubland or heath.

Selected specimens (90 examined). WESTERN AUSTRALIA: Avon District: near rabbit proof fence, E of Bodallin, *T.E.H. Aplin 5977*, 29 Aug. 1974 (CANB, PERTH);

Koorda, 30°50'S, 117°29'E, *W.E. Blackall s.n.*, Oct. 1924 (PERTH); Caron siding, 29°38'S, 116°19'E, *C.A. Gardner 2692*, 20 Sep. 1931 (CANB, PERTH); 1 mile [1.5 km] N of Bunjil, 29°38'S, 116°22'E, *K. Newbey 2086*, 25 Aug. 1965 (PERTH); 1.7 km E of Caron, 29°38'S, 116°20'E, *H. Demarz 8983*, 16 Sep. 1981 (PERTH). Coolgardie District: east of Southern Cross, *F.G. Smith 1521*, 11 Sep. 1962 (PERTH); 26 km SW of Marvel Loch, *K. Newbey 9272*, 5 Oct. 1981 (PERTH); 45 km N along Southern Cross Road towards Marvel Loch, from Hyden-Norseman Track, 32°02'14"S, 119°39'02"E, *G.T. Chandler 893 et al.*, 16 Sep. 1999 (CANB, NY); 17 km E of Southern Cross on Great Eastern Highway, 31°16'30"S, 119°30'07"E, *G.T. Chandler 882 et al.*, 15 Sep. 1999 (CANB, PERTH). Roe District: Middle Ironcap, SE of Hyden, 32°35'S, 119°40'E, *G.J. Keighery 892*, 12 Oct. 1976 (PERTH); c. 1 km SW on Woodcutty Soak Road, from intersection with Williamson Road, towards Hyden, 32°11'30"S, 119°05'48"E, *G.T. Chandler 698 & S. Donaldson*, 28 Oct. 1998 (CANB).

Map 33. Distribution of *G. floribundum*.

Toxicity. Highly toxic; fluoroacetate 1350 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. *Gastrolobium floribundum* is very similar to *G. hians*. The flowers of *G. hians* are smaller (standard 7 x 10 mm) and have a glabrous calyx, which in *G. floribundum* is pubescent. Overall, *G. hians* is less hairy than *G. floribundum*.

34. Gastrolobium glaucum C.A.Gardner (1942, p. 180). *Type citation*: "In distr. Avon prope Wongan Hills, in arenoso lutosis apertis, flor. m. August – Septem. Gardner Sept. 1924". *Type specimens*: *holo*: PERTH; *iso*: PERTH.

Low *shrubs*, 0.2-1.2 m high. *Branchlets* ascending, terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* ascending, opposite or whorled, elliptic to obovate, (10-)13-17 x (6-)8-11(-13) mm, glaucous, venation prominently reticulate, raised on both surfaces; apex rounded, recurved, with or without a pungent point; margins entire, not recurved; base rounded to broadly cuneate. *Stipules* erect, hyaline, 3-4 mm long. *Inflorescences* terminal racemes, 8-16-flowered; *peduncle* with a number of apparently aborted buds, (5-)8-10 mm long; *rachis* 25-35(-40) mm long; *subtending bracts* caducous, scale-like, entire, ovate 5-7 mm long. *Pedicels* terete, 2-2.5 mm long. *Calyx* campanulate, c. 6 mm long including the 1 mm receptacle, moderately to densely villous, lobes all recurved to reflexed, rarely not recurved; upper two lobes united higher than the lower three, rounded, 2-3 mm long; lower three lobes triangular, acute, 1.5-3 mm long. *Corolla*: *standard* transversely elliptic, 10-11 x 13-14 mm including the c. 3 mm claw, yellow-orange to orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* broadly obovate, 6.5-8 x c. 3.5 mm including the 2-3 mm claw, orange-yellow to red at the base, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, not saccate; *keel* half transversely ovate, 6-6.5 x c. 3 mm including the c. 2 mm claw, red to maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, incurved, hairs present in the lower half; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, very broadly transversely elliptic to circular, 4-4.5 x 4.5 mm, moderately to densely villous. *Seed* not seen.

Vernacular name. Spike Poison.

Flowering period. August and September, possibly into October. *Fruiting period*. October and November.

Distribution (Map 34). South-west Western Australia. Very rare, occurring only in the Wongan Hills area.

Habitat. Grows in sandy, often gravelly soils over laterite in mixed low heath dominated by Proteaceae and *Acacia*.

Conservation status. IUCN: E. ROTAP: 2E. CALM: R. This species is rare, and is considered to be endangered, though at least one population that was surveyed in this study is well reserved.

Map 34. Distribution of *G. glaucum*.

Specimens examined. Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Avon District: near Wongan Hills agricultural farm, *P.H. Brown 10*, 6 Oct. 1989 (PERTH); N of Wongan Hills, *T.E.H. Aplin 2805*, 5 Oct. 1964 (PERTH); Wongan Hills, *C.A. Gardner 12120*, 8 Sep. 1959 (PERTH); N of Wongan Hills towards Ballidu, *R. Davis 2004*, 14 Jan. 1997 (PERTH); Wongan Hills, *P. Roberts 162*, 7 Sep. 1983 (PERTH); Wongan Hills to Manmanning, *B.H. Smith 624*, 23 Aug. 1985 (CANB, HO, MEL, NSW); N of Wongan Hills, near agricultural farm, *J.D. Briggs 635*, 25 Sep. 1980 (CANB, K, MEL, PERTH); Manmanning towards Wongan Hills, *B.H. Smith 1355*, 21 Sep. 1990 (CANB, MEL, PERTH); N of Wongan Hills towards Ballidu, *G.T. Chandler 842 et al.*, 10 Sep. 1999

(CANB, PERTH, UWA); ibid, *G.T. Chandler 543 et al.*, 21 Feb. 1998 (CANB); N of Wongan Hills, near Elphin, *B.H. Smith 1354*, 21 Sep. 1990 (CANB, MEL, S, WAG).

Toxicity. Fluoroacetate 200 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species may be confused with *G. hamulosum* and *G. rotundifolium*, though these are easily told apart, as the leaves of *G. hamulosum* are smaller (6-11.5 x 3-4.5 mm) and have a hooked point, which *G. glaucum* lacks, and *G. rotundifolium* has a very long, needle-like, pungent point on the leaf (c. 5 mm long), and much larger stipules (10-15 mm long).

35. Gastrolobium laytonii J.White, in Ewart, White & Rees (1910, p. 111). *Type citation*: "Watheroo Rabbit-fence, Max Koch, 1905 No. 1337". *Type specimens*: *holo*: MEL 627584; *iso*: AD, E, PERTH x 2, W.

Erect *shrubs*, to 3 m high. *Branchlets* ascending, angular to almost terete, moderately pubescent. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-5 mm long. *Leaves* (note: there is considerable variation in leaf size and shape according to developmental stages. See notes on variation below. Only adult leaves are described here.) spreading to ascending, opposite, trullate to rarely obtrullate or rhombic to broadly so or rarely elliptic or obovate, often conduplicate, 29-50 x 10-22 mm, glabrous, rarely glaucous, venation prominently reticulate; apex obtuse to acute, rarely retuse, rounded or truncate, often trilobed, pungent-pointed, mucronate or unarmed; margins flat; base cuneate. *Stipules* erect to recurved, hyaline, 2-8 mm long. *Inflorescences* terminal racemes, 1-3 per terminus, 10-30-flowered; *peduncle* angular, 3-10 mm long; *rachis* 25-55 mm long; *subtending bracts* caducous, scale-like, entire, lacerate or prominently trilobed, narrowly lanceolate, 1.5-3 mm long. *Pedicels* terete, 1.5-3 mm long. *Calyx* campanulate, 3-4 mm long including the c. 0.5 mm receptacle, moderately pubescent, upper two lobes straight to slightly recurved, united higher than the lower three, rounded, c. 1.25 mm long; lower three lobes recurved to reflexed, acute, c. 1 mm long. *Corolla*: *standard* transversely elliptic, 6-7 x c. 8 mm including the 2.5 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, 5-6 x 2 mm including the 2 mm claw, orange and maroon, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 5.5 x 2 mm including the 2 mm claw, maroon, lighter towards the base, apex acute, spout-like, base auriculate, saccate, with a circular opening at the base to expose the stamens from

below. *Style* short, incurved to slightly hooked, ± glabrous; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid to globose, 4.5-8 x 3-4 mm, moderately sericeous. *Seed* scarcely reniform to ellipsoid, c. 3 mm long, arillate.

Notes on variation. The leaves of *G. laytonii* show considerable variation between different developmental stages. The juvenile leaves are mainly rhombic or obtrullate, with three prominent angles, and are generally quite large, with a dimensional range of 50-75 x 25-30 mm, plus a 5-10 mm petiole. The bracts on adult specimen are also quite variable, with entire and prominently trilobed bracts found on one inflorescence.

Vernacular names. Breelya; Kite-leaved Poison.

Flowering period. June to September. *Fruiting period.* From October.

Distribution (Map 35). South-west Western Australia. Occurs throughout the northern sandplains, and is often associated with ironstone, from the Wubin area east to the goldfield region around Kalgoorlie.

Map 35. Distribution of *G. laytonii*.

Habitat. Occurs on sand over granite or ironstone in mallee woodland or scrub, or shrubland.

Selected specimens (58 examined). WESTERN AUSTRALIA: Avon District: 30 km W of Cue on W side of Big Bill slime dump, *A.A. Mitchell 1458*, 12 Sep. 1985 (PERTH); Mount Gibson, 29°34'38"S, 117°09'32"E, *G.T. Chandler 831 et al.*, 9 Sep. 1999 (CANB, MEL, PERTH, UWA); 8 km W of Great Northern Highway on Paynes Find – Fields Find road, 29°12'S, 117°40'E, *J.W. Green 5248*, 10 Sep. 1987 (CANB, PERTH); 6.4 km ENE of Anniversary Bore, Jingemarra Station, 27°48'S, 116°44'E, *R.J. Cranfield 6079*, 15 Sep. 1987 (PERTH); Latham, 29°45'S, 116°27'E, *D.A. Herbert s.n.*, Oct. 1919, juvenile foliage only (PERTH); 3 m [5 km] N of Latham, 29°42'S, 116°27'E, *J.S. Beard 7372*, 5 Nov. 1974 (PERTH); 3.5 km along Wanarra East Road from Mt Gibson towards Perenjori, *G.T. Chandler 838 et al.*, 9 Sep. 1999, with adult and juvenile foliage (CANB, NSW, PERTH). Coolgardie District: Boulder, 30°47'S, 121°29'E, *W.D. Campbell s.n.*, Aug. 1900 (PERTH); Kathleen Valley, *F. Lullfitz 2379*, 7 Sep. 1963 (PERTH).

Toxicity. Fluoroacetate 500 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The distinctive kite-shaped leaves of *G. laytonii* makes it difficult to confuse with any other of *Gastrolobium*, though some entire-leaved specimens of *G. laytonii* have been misidentified as *G. graniticum*. However, the leaves of *G. graniticum* are much larger (48-62 x 19-32 mm), as are the flowers (e.g. standard 11-13 mm long).

36. Gastrolobium microcarpum (Meisn.) Benth. (1864, p. 104). *Gastrolobium oxylobioides* Benth. var. *microcarpum* Meisn. (1844, p. 70). *Type citation*: "In region interior Australiae meridiona occidentalis, m. Febr. 1841. Herb. Preiss No. 816, 817. (Drummond n. 205.)". *Type specimens*: *Lecto* (here chosen): BM (Drummond 205); *isolecto*: BM, K (2 sheets), W (2 sheets).

Erect, bushy *shrubs*, 1-2.5 m high. *Branchlets* ascending, angular, moderately to densely pubescent. *Petioles* grooved on the upper surface, continuous but not decurrent with the branchlet, 2-4 mm long. *Leaves* spreading to ascending, in whorls of 3 or 4, elliptic, occasionally conduplicate, occasionally recurved, (16-)25-36 x 7-16 mm, glabrous to slightly glaucous, venation prominently reticulate; apex acute, pungent-pointed, rarely mucronate; margins entire, often crenulate, not recurved; base obtuse to cuneate. *Stipules* erect, hyaline, 1-3.5 mm long. *Inflorescences* terminal racemes, rarely branched, 15 to more than 30 flowered; *peduncle* 2-5 mm long; *rachis* 25-60 mm long; *subtending bracts* caducous, scale-like, entire or minutely lacerate, linear-lanceolate, 4-5 mm long, moderately pubescent. *Pedicels* 1-2 mm long. *Calyx*

campanulate, 3.5-4.5 mm long including the c. 1 mm receptacle, sparsely to moderately pubescent, lobes all straight or lower three lobes recurved; upper two lobes united higher than the lower three, acute, c. 1.5 mm long; lower three lobes triangular, acute, c. 1 mm long. *Corolla*: *standard* transversely elliptic, 8 x 7-8 mm including the 3-3.5 mm claw; orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, occasionally auriculate; *wings* obovate, 6-7 x 2-2.5 mm including the c. 2.5 mm claw, red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, 4-5 x 2-2.5 including the 1.5-2.5 mm claws, deep red to almost pale white, apex acute, spout-like, base auriculate, saccate, with a circular opening at the base near the claws to expose the stamens from below. *Style* very short, incurved to hooked, pubescent in the lower half; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, obliquely ellipsoid, 5-7 x 3-4 mm, sparsely to moderately pubescent. *Seed* reniform, c. 3-4 mm long, arillate.

Vernacular name. Sandplain Poison.

Flowering period. August to October. *Fruiting period*. From November.

Distribution (Map 36). South-west Western Australia. Occurs throughout the Darling escarpment, from Bindoon and Clackline south to Dryandra and Narrogin.

Habitat. Often found in moist areas on well-drained sandy loam or on sand over granite or laterite, in eucalypt forest, woodland or mallee.

Selected specimens (40 examined). WESTERN AUSTRALIA: Darling District: 59 km from Collie towards Williams, from Williams turnoff, 33°08'45"S, 116°40'19"E, *G.T. Chandler 300 & W. Keys*, 22 Sep. 1997 (CANB, PERTH); Toodyay, 31°33'S, 116°28'E, *R.D. Royce 4312*, 7 Sep. 1953 (CANB, PERTH); Wanamal, 31°10'S, 116°03'E, *F. Dewar s.n.*, 15 Nov. 1950 (CANB, PERTH); Clackline Nature Reserve, 15 km W of Northam, 31°42'S, 116°29'E, *G.J. Keighery 10920*, 20 Sep. 1988 (PERTH); Dryandra State Forest, NE of Congelin, c. 32°45'S, 117°00'E, *W. Greuter 23189*, 24 Oct. 1991 (PERTH); S of Walebing, c. 30°42'S, 116°13'E, *R.D. Royce 6026*, 14 Sep. 1959 (PERTH); Clackline, property of H.L. Adams, c. 31°42'S, 116°29'E, *M.E. Carslake s.n.*, 12 Sep. 1969 (K, MEL, PERTH).

Toxicity. Fluoroacetate 0-600 $\mu g.g^{-1}$ (Aplin, 1964).

Map 36. Distribution of *G. microcarpum*.

Affinity. This species has been confused with *G. oxylobioides*, but *G. oxylobioides* has fewer flowers per inflorescence (5-10-flowered), larger flowers (calyx 6-7.5 mm long, standard c. 10 x 14 mm) and lacks the distinctive keel-petal of *G. microcarpum*, which has a spout-like apex and a hole towards the base of the lower margin, through which the stamens are visible.

37. Gastrolobium crassifolium Benth. (1864, p. 105). *Type citation*: "W. Australia. Drummond, n. 32". *Type specimens*: *holo*: K; *iso*: K, MEL.

Erect, bushy *shrubs*, 0.3-1.5 m high. *Branchlets* ascending, angular, moderately sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 1-2 mm long. *Leaves* ascending, in whorls of 3, occasionally 4, rarely opposite, elliptic, occasionally narrowly obovate, concave, 12-25 x 4-14 mm, glabrous, often glaucous, venation partially obscured, pinnate; apex acute, usually mucronate; margins entire, not recurved; base cuneate or rounded. *Stipules* erect, hyaline, 1-4 mm long. *Inflorescences* terminal racemes, sometimes on short, axillary shoots, 8-30-flowered; *peduncle* 2-10 mm long; *rachis* 20-50 mm long; *subtending bracts* caducous, scale-like, entire, elliptic, 5-6 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 4-6

mm long including the c. 1 mm receptacle, glabrous to sparsely pubescent, lobes not or scarcely recurved; upper two lobes united into an almost truncate lip, c. 2 mm long; lower three lobes triangular, acute, 1-1.5 mm long. *Corolla*: *standard* transversely ovate, 7-9 x 9-11 mm including the 3-4 mm claw, orange-yellow to yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, 5-8 x 2-3 mm including the 2-3 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, 4.5-7 x 1.5-2.5 mm including the 2-3 mm claws, maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* short, incurved, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ± spherical, 4-5 x 4-5 mm, sparsely to moderately pubescent. *Seed* ellipsoid to reniform, c. 3 mm long, arillate.

Vernacular name. Thick-leaved Poison.

Flowering period. July to December. *Fruiting period*. From late October to December.

Distribution (Map 37). South-west Western Australia. Common in the southern-central sandplain and salt-lake areas, from Lake Grace south to Ongerup and Pingrup, and east to Frank Hahn National Park and Cascade.

Habitat. Grows on undulating dunes or flat plains on brown or yellow sand, sandy clay or sandy loam, in *Eucalyptus* or *Allocasuarina* shrubland or heath.

Selected specimens (59 examined). WESTERN AUSTRALIA: Coolgardie District: 17.5 km on Mt Day – Marvel Loch road from Hyden – Norseman Track, towards Marvel Loch, 32°06'58"S, 120°19'30"E, *G.T. Chandler 898 et al.*, 16 Sep. 1999 (CANB, K, NSW, PERTH). Eyre District: Cascades Road, intersection with Lake King – Norseman Road, 33°04'45"S, 120°05'27"E, *G.T. Chandler 944 et al.*, 19 Sep. 1999 (CANB, PERTH); Fitzgerald River National Park, Colletts Road near Fitzgerald River, 34°05'S, 119°31'E, *P.E. Conrick 1680*, 29 Sep. 1983 (AD, PERTH). Roe District: Wishbone Railway siding, 100 metres N of railway line, 33°12'S, 117°51'E, *J.D. Briggs 676*, 28 July 1980 (CANB, MEL, PERTH); 8 km from Lake King towards Norseman, 33°05'13"S, 119°46'12"E, *G.T. Chandler 945 et al.*, 19 Sep. 1999 (CANB, K, NSW, NY, PERTH); 1 ml [1.5 km] W of Ongerup, 33°58'S, 118°28'E, *T.E.H. Aplin 2819*, 16 Oct. 1964 (CANB, PERTH); Tambellup, 34°01'S, 117°38'E, *G.K.B. Hay s.n.*,

19 Sep. (1923 (CANB, PERTH); Tieline Road, between Moore Dam and Parker Roads, Gnowangerup, 33°56'S, 119°59'E, *E.J. Croxford 4830*, 17 Sep. 1986 (PERTH).

Map 37. Distribution of *G. crassifolium*.

Toxicity. Fluoroacetate 150 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species resembles *G. velutinum* and *G. floribundum*. *G. floribundum* can easily be distinguished by the leaf size ((20-)28-41(-83) x 5-10 mm), while *G. velutinum* generally has a notch in the leaf apex, which *G. crassifolium* lacks. Also, *G. floribundum* is distinguished by the open, coarse venation, whereas *G. crassifolium* has fine and obscure venation. *Gastrolobium venulosum* can also be confused with *G. crassifolium*, but *G. venulosum* has a relatively broader leaf (20-27 x 4-7 mm) with prominently open, reticulate venation, whereas *G. crassifolium* has somewhat obscured venation. Also, *G. venulosum* lacks the distinctive keel shape of *G. crassifolium* and the rest of the *G. floribundum* group, because its spout-like apex is not as acute, and the lower margin is entire.

38. Gastrolobium hians G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: 25.5 km along New Norseman – Hyden Road (turn 10 km

N of Norseman), 32°11'06"S, 121°27'57"E, *G.T. Chandler 868, A. Monro & S. Donaldson*, 14 Sep. 1999 (*holo*: CANB; *iso*: AD, B, BRI, K, MEL, NSW, NY, PERTH).

Very similar to *G. floribundum*, but differing in the generally less pubescent appearance, glabrous calyx and smaller flowers (standard 7 x 10 mm), whereas *G. floribundum* is generally more pubescent, has a moderately to densely pubescent calyx, and larger flowers (standard 9 x 11 mm).

G. floribundo similissima sed facie glabrata, calyce glabro et floribus minoribus (vexillum 7 x 10 mm) differt.

Etymology. This specific epithet means open-mounted or gaping, and refers to the fruits of this species, which appear to be gaping when fully open.

Erect, ± glaucous *shrubs*, 0.7-1.7 m high. *Branchlets* ascending, angular, glabrous. *Petioles* terete, continuous and sometimes decurrent with the branchlet, 3-5 mm long. *Leaves* ascending, opposite, linear very narrowly elliptic to obovate, canaliculate, 32-60 x 5-8 mm, glabrous, ± glaucous, venation somewhat obscured; apex rounded, mucronate; margins may be slightly recurved; base cuneate. *Stipules* erect, hyaline, 1.5-4.5 mm long. *Inflorescences* terminal racemes, rarely axillary, with 28 or more flowers; *peduncle* with a series of apparently aborted buds towards the base, 4-10 mm long; *rachis* (20-)35-65 mm long; *subtending bracts* caducous, scale-like, entire, triangular, 3-4 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, 4.5-5 mm long including the c. 1 mm receptacle, glabrous; upper two lobes not recurved, united higher than the lower three, triangular, acute, c. 2 mm long; lower lobes recurved, triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely elliptic, c. 7 x 10 mm including the 3 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, 6.5-7 x c. 3 mm including the 2 mm claw, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half transversely broadly elliptic to circular, upper margins slightly incurved, 6-6.5 x c. 2 mm including the 2 mm claw, maroon, apex rounded, lipped, base auriculate, saccate, with a circular opening at the base to expose the stamens. *Style* short, incurved, glabrous or slightly pubescent in the lower quarter; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, elliptic, 5-7 x 3.4 mm, glabrous. *Seed* not seen.

Flowering period. September. *Fruiting period*. October and November.

Distribution (Map 38). South-west Western Australia. Little is known about this species, and it is only known from just west of Norseman, along the New Norseman – Hyden Track.

Habitat. Grows on sandplains on sandy loam or clay soils in *Acacia* or *Allocasuarina* shrubland.

Specimens examined. WESTERN AUSTRALIA: Coolgardie District: 25.5 km along New Norseman – Hyden Road (turn 10 km N of Norseman), 32°11'06"S, 121°27'57"E, *G.T. Chandler 869-871 et al.*, 14 Sep. 1999 (CANB, MEL, MO, NSW, PERTH, UWA); 31 km W of Norseman, *K. Newbey 6301*, 6 Nov. 1979 (PERTH).

Map 38. Distribution of *G. hians*.

Toxicity. Unknown, but as it is closely related to *G. floribundum*, it is probably toxic.

Affinity. This species is very similar to *G. floribundum*, which has larger flowers (standard 9 x 11 mm) and a pubescent calyx, whereas the calyx of *G. hians* is glabrous. In fact, there is a general lack of hairs on *G. hians* compared to *G. floribundum*, which also helps to distinguish these two species.

39. Gastrolobium pycnostachyum Benth. (1864, p. 103). *Type citation*: "W. Australia. East Mount Barren, Maxwell". *Type specimens*: *holo*: K; *iso*: K, MEL x 2.

Low *shrubs*, to 1 m high. *Branchlets* ascending, angular, moderately sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, opposite to rarely scattered, obovate, elliptic to almost oblong to broadly so, partially conduplicate, 11-22 x 11-14 mm, glabrous, venation prominently reticulate; apex rounded to truncate, emarginate; margins entire, not recurved; base obtuse, truncate, or slightly cordate. *Stipules* erect, narrowly triangular to hyaline, 2-3 mm long. *Inflorescences* terminal racemes, 15-30-flowered; *peduncle* 3-7 mm long; *rachis* 7-12 mm long; *subtending bracts* caducous, scale-like, entire or minutely lacerate, ovate, 5-6 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, 3.5-4 mm long including the c. 1 mm receptacle, moderately pubescent, all lobes recurved; upper two lobes united higher than the lower three, acute, c. 1.5 mm long; lower three lobes triangular, acute, 1-1.5 mm long. *Corolla*: *standard* transversely elliptic, 6 x 7 mm including the 2 mm claw, orange or orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, 6 x 2.5 mm including the 2 mm claw; orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, 6 x 2.5 mm including the 2 mm claws, maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, incurved, pubescent in the lower half; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ovoid to ellipsoid, 6-7 x 3-4 mm, moderately to densely pubescent. *Seed* reniform, 2-3 mm long, arillate.

Vernacular name. Mount Ragged Poison; Round-leaved Poison.

Flowering period. August to October, with a rare, probably opportunistic, flowering event in January. *Fruiting period*. From late October.

Distribution (Map 39). South-west Western Australia. Restricted to the area around Mount Ragged, in Cape Arid National Park, which is east of Esperance.

Habitat. Grows on rocky outcrops or the sandplain immediately around them, on shallow sand over sandstone or red clay in mallee woodland or mixed low heath.

Selected specimens (13 examined). WESTERN AUSTRALIA: Roe District: Base of Mt Ragged, NW side, along track to summit, 33°26'45"S, 123°27'56"E, *G.T. Chandler 811 & S. Donaldson*, 12 Nov. 1998 (CANB); Base of Mt Ragged, *T.E.H. Aplin 4310*, 19

Oct. 1970 (CANB, PERTH); Cape Arid National Park, near Tower Peak, 33°27'S, 123°26'E, *R. Borough 2*, 1 Sep. 1978 (CANB, PERTH); Mt Ragged National Park, 33°27'S, 123°27'E, *J. Taylor 1544 & P. Ollerenshaw*, 8 Sep. 1983 (AD, CANB, MEL, MO, PERTH); Mt Ragged Range, 2.5 km S of Tower Peak, 33°28'S, 123°28'E, *M.D. Crisp 4811*, 6 Jan. 1979 (CANB).

Toxicity. Fluoroacetate 175 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The low habit and restricted distribution of this species makes it difficult to confuse with any other species of *Gastrolobium*. The leaves somewhat resemble those of *G. crassifolium*, as they are somewhat conduplicate, but those of *G. crassifolium* are generally narrower (4-14 mm broad) and glaucous, and the rachis is longer (20-50 mm long).

Map 39. Distribution of *G. pycnostachyum*.

40. Gastrolobium parvifolium Benth., in Lindley (1839, p. 13). *Type citation*: none cited. *Type specimens*: *Lectotype* (here chosen,): K (Swan River, 5th Coll., Drummond, 1839); *isolecto*: BM, CGE.

Low, bushy to spreading *shrubs*, 0.4-0.8 m high. *Branchlets* ascending, ± terete, moderately pubescent. *Petioles* very small, continuous and slightly decurrent with the branchlet, < 0.5 mm long. *Leaves* ascending to erect, in whorls of 3, crowded along stems such that the leaf base is obscured by the apex of the leaf below, obovate to narrowly so, 4-15 x 2-5 mm, glabrous, glaucous, venation reticulate; apex ± truncate, may be slightly recurved, mucronate; margins not recurved, flat or slightly conduplicate; base rounded. *Stipules* erect or slightly recurved, hyaline, 1-2.5 mm long. *Inflorescences* terminal racemes, 21-33-flowered; *peduncle* 2-10 mm long; *rachis* 20-45 mm long; *subtending bracts* caducous, scale-like, entire, boat-shaped, 6-10 mm long, glabrous, except the margin which has curly hairs. *Pedicels* terete, nutant as flower ages, 1-2 mm long. *Calyx* campanulate, 4.5-5.5 mm long including the 0.5-.075 mm receptacle, glabrous; upper two lobes not recurved, united into an emarginate, truncate lip, obtuse, c. 2 mm long; lower three lobes strongly recurved, triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely ovate, c. 8.5 x 10.5 mm including the 3 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, slightly auriculate; *wings* obovate, c. 7 x 3 mm including the 2.5 mm claws, orange to pink, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 5.5 x 2.5 mm including the 2 mm claws, pink or maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* short, incurved, lower half pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, globose, c. 5 x 5 mm, glabrous. *Seed* reniform, c. 4 mm long, arillate.

Vernacular name. Berry Poison.

Flowering period. August to October. *Fruiting period*. October and November.

Distribution (Map 40). South-west Western Australia. Occurs from Tammin and Kellerberrin in the west, to Hyden in the east, and south to the Brookton area.

Habitat. Grows on sand or gravel in mallee shrubland and heathland.

Selected specimens (55 examined). WESTERN AUSTRALIA: Avon District: 19.7 km ENE of East Hyden Bin Road on Hyden-Lake King Road, ca 20 km ENE of Hyden, 32°31'14"S, 119°02'12"E, *T.R. Lally 1143 & B.J. Lepschi*, 11 Aug. 1996 (CANB, PERTH); 1.2 km SW Mount Billy, 31°57'S, 116°26'E, *M.G. Allen 899*, 13 Nov. 1996 (PERTH); W section of Tammin Reserve, 31°40'S, 117°32'E, *R.A. Saffrey 209*, 17 Oct.

1967 (PERTH); 30 km NW of Corrigin, 32°25'S, 118°03'E, *P.E. Conrick 1557*, 19 Sep. 1983 (AD, PERTH); 69 mile peg, Kelmscott-Brookton Road, *T.E.H. Aplin 2812*, 12 Oct. 1964 (PERTH); 21.5 km NNE of Quairading along road to Cunderdin, 31°50'S, 117°19'E, *M.D. Crisp 6616*, 20 Jul. 1980 (CANB, MEL).

Toxicity. Fluoroacetate 300 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species most closely resembles *G. hamulosum*, but can be told apart quite easily, as *G. hamulosum* has a pungent, hooked apex on the leaf, and the leaves are not crowded along the stem.

Map 40. Distribution of *G. parvifolium*.

41. Gastrolobium velutinum Lindl. in Lindley & Paxton (1852, p. 76). *Type citation*: "A handsome Swan River greenhouse shrub ... Introduced by Messrs. I. and A. Henderson". *Type specimens*: *holo*: CGE.

Gastrolobium emarginatum Turcz. (1853, p. 273). *Type citation*: "Drum. V. n. 51". *Type specimens*: *holo*: KW; *iso*: BM, E, K (3 sheets).

Low, bushy *shrubs*, to c. 1 m high. *Branchlets* ascending, angular, moderately pubescent. *Petioles* terete, continuous and somewhat decurrent with the branchlet, 1-2 mm long. *Leaves* spreading to ascending, in whorls of 3, cuneate to oblong, 7-18 x 2.5-8 mm, upper surface ± glabrous, lower surface glabrous to densely pubescent, venation prominently reticulate; apex emarginate, unarmed, may be scarcely recurved; margins scarcely to strongly recurved; base rounded to truncate. *Stipules* erect, hyaline, 0.5-1.5 mm long. *Inflorescences* terminal racemes, 15-30-flowered; *peduncle* with or without apparently aborted buds, 5-20 mm long; *rachis* 15-25 mm long; *subtending bracts* caducous, scale-like, entire, boat-shaped, 6-7 mm long, moderately pubescent. *Pedicels* terete, 1.5-2 mm long. *Calyx* campanulate, 4-4.5 mm long including the c. 0.75 mm receptacle, moderately to densely pubescent; upper two lobes scarcely to strongly recurved, united higher than the lower three, rounded, c. 2.5 mm long; lower three lobes reflexed, triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely ovate, 7.5-9 x 9-11 mm including the 2.5-3 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, may be auriculate; *wings* obliquely elliptic, c. 6 x 2.5 mm including the 2 mm claws, pink, apex rounded, incurved and overlapping to enclose the keel, base strongly auriculate on both margins, saccate; *keel* half very broadly elliptic, 4.5-5 x 2 including the 1.5 mm claws, pink to maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* very short, hooked, lower half pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ovoid, 5.5-6.5 x 3.5-4 mm, moderately pubescent. *Seed* not seen.

Vernacular name. White Gum Poison; Stirling Range Poison.

Flowering period. August to October. *Fruiting period*. October and November.

Distribution (Map 41). South-west Western Australia. Occurs mainly in and around the Stirling Range, extending south and west to the Albany region.

Habitat. Grows on slight mountain slopes, flats or periodically inundated depressions on clay-loam or sandy clay, in marri woodland or mallee woodland.

Selected specimens (50 examined). WESTERN AUSTRALIA: Eyre District: SW edge of Stirling Range, E of Tenterden, 34°22'S, 117°35'E, *T.E.H. Aplin 2825*, 22 Oct. 1964 (CANB, PERTH); 10.5 km from Mt Barker towards Porongurup, 34°38'40"S, 117°46'41"E, *G.T. Chandler 293 & W. Keys*, 20 Sep. 1997 (BRI, CANB); Intersection of Red Gum Pass Road and Salt River Road, Stirling Range, 34°18'53"S, 117°47'30"E,

G.T. Chandler 295 & W. Keys, 21 Sep. 1997 (CANB, NSW); The Pass, 27 km NE of Denmark, 34°17'39"S, 117°34'30"E, *A.R. Annels 1933*, 13 Nov. 1991 (PERTH); 11.2 km along Stirling Range Drive from Red Gum Pass turnoff, 34°24'S, 117°53'E, *M.D. Crisp 8502 & W. Keys*, 25 Sep. 1993 (CANB, GAUBA, PERTH, UWA).

Map 41. Distribution of *G. velutinum*.

Toxicity. Fluoroacetate 300 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species may be confused with *G. cuneatum*, which has a similar leaf shape to the form of *G. velutinum* that has oblong leaves with strongly recurved margins. They are easily told apart, however, as *G. cuneatum* has a longer leaf (20-33(-61) mm long), and the inflorescence is longer (peduncle (5-)11-58 mm long, rachis 75-116 mm long), mainly due to the longer internodes between flowers (>10 mm), where *G. velutinum* has relatively short internodes (3-8 mm). This species has occasionally been confused with *G. parviflorum* in the past, but *G. parviflorum* has elliptic leaves and much longer racemes (rachis > 50 mm long).

The *G. heterophyllum* group

This group of three morphologically disparate species share little in common with each other, but form a strongly supported group. *Gastrolobium heterophyllum* has both entire and trifid subtending floral bracts, *G. nutans* has entire bracts, and *G. pusillum* has trifid bracts only. Ovule number ranges from 2 in *G. nutans* to 4-10 in *G. heterophyllum* and *G. pusillum*. It could be that this small group of species are simply well differentiated from each other, yet quite closely related.

42. Gastrolobium heterophyllum (Turcz.) Crisp, in Crisp & Weston (1987, p. 130). *Chorizema heterophyllum* Turcz. (1853, p. 255). *Oxylobium heterophyllum* (Turcz.) Benth. (1864, p. 25). *Callistachys heterophylla* (Turcz.) Kuntze (1891, p. 168). *Type citation*: "Nova Hollandia, Drummond coll. V. no. 27 (ex parte)". *Type specimens*: *holo*: KW; *iso*: G (2 sheets), K (3 sheets), W.

Weak, almost prostrate *shrubs*, 0.05-0.3(-1.8) m high. *Branchlets* ascending or trailing, angular, moderately pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 0.5-1.5 mm long. *Leaves* spreading, opposite, ovate to elliptic, (8-)16-29 x (1.5-) 3-5 mm, glabrous to moderately pubescent, venation prominently reticulate; apex rounded, recurved, unarmed; margins entire, recurved; base rounded; leaves of different sizes present on each specimen. *Stipules* erect, hyaline, linear-triangular, 2-4 mm long. *Inflorescences* terminal racemes, occasionally terminal on a short axillary shoot, 4-18-flowered; *peduncle* (0-)4-8 mm long; *rachis* (8-)21-58 mm long; *subtending bracts* caducous or persistent, scale-like, entire or trifid, narrowly triangular, 3-5 mm long. *Pedicels* terete, 1.5-2 mm long. *Calyx* campanulate, 4-5 mm long including the 0.5-1 mm receptacle, moderately to densely villous, lobes not recurved or lower lobes only recurved; upper two lobes united higher than the lower three, triangular, acute, 2.5-3 mm long; lower three lobes triangular, acute, 2.5-3 mm long. *Corolla*: *standard* transversely elliptic, c. 7 x 7 mm including the 2.5 mm claw, golden yellow with a red ring surrounding the yellow centre, apex emarginate, base truncate; *wings* oblong, c. 6 x. 1.5-2 mm including the 2 mm claw, golden yellow, apex rounded, incurved but not enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half transversely broadly obovate, c. 7 x 3 mm including the 2 mm claw, black or deep maroon, apex almost truncate, sometimes with a small spout, base auriculate, saccate. *Style* long, incurved to hooked, lower half pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 8. *Pod* stipitate, oblong to elliptic, 6.5-9 x 3-4 mm, moderately to densely pubescent. *Seed* not seen.

Vernacular name. Slender Poison.

Flowering period. August to October. *Fruiting period*. October and November.

Distribution (Map 42). South-west Western Australia. Occurs along the south coast between Hopetoun and Esperance.

Habitat. Generally grows beside or near rivers or drainage lines, on white sand to heavy red clay soils in mixed shrubland to mallee woodland.

Conservation status. ROTAP: 3KC-. This species is rare and poorly known, but this is possibly due to the habit of this species, which is often prostrate or climbing through other plants, making it difficult to see and therefore difficult to collect, and may in fact be quite common throughout the rivers along the south coast of SW Western Australia.

Map 42. Distribution of *G. heterophyllum*.

Selected specimens (11 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Eyre District: Fitzgerald River National Park, *K. Newbey 11300*, 24 Oct. 1986 (CANB, PERTH); Young River,

G.F. Craig 2872, 9 Sep. 1993 (PERTH); Munglinup, *N.S. Lander 1064*, 22 Oct. 1979 (PERTH); Esperance, *E.N. Fitzpatrick s.n.*, 5 Sep. 1969 (PERTH).

Toxicity. Unknown.

Affinity. The unusual growth habit of this plant combined with the ovate leaves of different sizes along the stem make this plant difficult to confuse with other species of *Gastrolobium*. *Gastrolobium parviflorum* most closely resembles *G. heterophyllum* vegetatively, though *G. parviflorum* is an erect, bushy shrub, generally has oblong or elliptic leaves that are broader (3-11 mm broad), the inflorescence axis is generally longer (peduncle 4-22 mm long, rachis 30-65 mm long), and there are fewer ovules per ovary (3-4).

43. Gastrolobium nutans G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe District: Lake King area, 46 km towards Norseman from Lake King, 33°04'37"S, 120°10'08"E, *G.T. Chandler 906, S. Donaldson & A. Monro*, 17 Sep. 1999 (*holo*: CANB; *iso*: AD, B, BRI, CANB, K, MEL, NSW, NY, PERTH).

Gastrolobium nutans has longitudinally recurved leaves and strictly two ovules, which serves to distinguish this species from the vegetatively similar *G. tetragonophyllum*, which does not have longitudinally recurved leaves and has four ovules.

G. tetragonophyllo vegetative simili sed foliis longitudine recurvis et ovulis duobus differt.

Etymology. From Latin, *nuto* = to nod with the head; refers to the nodding flowers and fruits of this species.

Erect, bushy *shrubs*, 0.5-1.5 m high. *Branchlets* ascending, terete, moderately to densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, c. 1-1.5 mm long, densely pubescent. *Leaves* ascending, in whorls of 3, rarely opposite, ± oblong, though juvenile leaves are somewhat elliptic, recurved longitudinally, 12-25 x 2-3.5(-5) mm, upper surface glabrous, lower surface densely pubescent, venation prominently reticulate; apex broadly rounded to almost truncate, slightly mucronate; margins recurved to revolute (less so in juvenile foliage), often only the midrib and a small portion of the abaxial surface is visible; base rounded to truncate. *Stipules* erect, hyaline, 1.5-2 mm long. *Inflorescences* terminal racemes, 15-30-flowered; *peduncle* often with a sheath of persistent barren bracts at the base, 3-6 mm long; *rachis* 15-40 mm long; *subtending bracts* caducous, scale-like, entire, triangular, c. 2 mm long.

Pedicels terete, c. 1-1.5 mm long, pubescent. *Calyx* campanulate, c. 4 mm long including the 1 mm receptacle, moderately pubescent, lobes all strongly recurved; upper two lobes united higher than the lower three, rounded, 1.5 mm long; lower three lobes triangular, acute, 1.5 mm long. *Corolla*: *standard* transversely elliptic, c. 5 x 6 mm including the 2 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, slightly auriculate; *wings* obliquely obovate, c. 6 x 2.5 including the 2 mm claws, orange-yellow, red towards the base, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 4.5 x 1.5 mm including the 1.5 mm claws, pink and maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* long, strongly incurved, pubescent in the lower third; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, nutant, obliquely ellipsoid, 4.5-6 x 2.5-3 mm, moderately pubescent. *Seed* ellipsoid, c. 2 mm long, arillate.

Flowering period. August to October. *Fruiting period.* October and November.

Distribution (Map 43). South-west Western Australia. Occurs in the central-eastern sandplains, from Bullfinch south to Lake King and east to the Peak Charles area.

Habitat. Grows on undulating dunes in deep white or grey sand in mallee shrubland or heathland.

Selected specimens (25 examined). WESTERN AUSTRALIA: Roe District: Mt Hampton, S of Southern Cross, 31°46'S, 119°04'E, *R.D. Royce 9056*, 6 Oct. 1970 (CANB, PERTH); Pallarup, 33°13'S, 119°44'E, *C.A. Gardner 13645*, 20 Oct. 1961 (PERTH); Mt Sturt, *C.A. Gardner 14839*, 17 Oct. 1964 (PERTH); Burkett Rocks, Lake King, 33°04'S, 119°49'E, *Mrs Edwards s.n.*, Sep. 1934 (PERTH); Ca 300 m SE of Hatter Hill trig, 32°49'24"S, 119°59'08"E, *G.F. Craig 2391*, 27 Oct. 1992 (PERTH); Cascades Road, 11.3 km towards Lake King from West Point Road, 33°16'22"S, 120°47'58"E, *G.T. Chandler 930 et al.*, 19 Sep. 1999 (CANB, NSW, PERTH); 11.5 km WSW along track just N of God Rock (from turnoff to Lake Sharpe), 33°00'15"S, 120°56'34"E, *G.T. Chandler 789 & S. Donaldson*, 10 Nov. 1998 (CANB, NSW).

Toxicity. Unknown.

Affinity. Superficially, this species is somewhat similar in leaf shape to the *G. parviflorum* group (*G. parviflorum*, *G. revolutum* and *G. stenocarpum*) and *G.*

tetragonophyllum, but the leaves of the *G. parviflorum* group and *G. tetragonophyllum* are not recurved longitudinally, and these species have more than 2 ovules, where *G. nutans* has strictly 2 ovules.

Map 43. Distribution of *G. nutans*.

44. Gastrolobium pusillum Crisp & P.H. Weston (1995, p. 282). *Oxylobium tricuspidatum* Meisn. (1844, p. 30). *Type citation*: "In sublimoso-glareosis districtus Hay, m. Oct. 1840. specim. florifera. Herb. Preiss. No. 1064. (fructifera. Drummond n. 266)". *Type specimens*: *lecto*: LD 82/70-2150 (*Preiss* 1064); *isolecto*: NY. *Syn*: BM (Drummond 266); *isosyn*: K (2 sheets), W.

Prostrate, mat-forming *shrubs*. *Branchlets* spreading, angular, glabrous. *Petioles* terete, continuous and slightly decurrent with the branchlet, 1-1.5 mm long. *Leaves* spreading, opposite, cuneate to obovate, 7-12 x 5.5-8 mm, glabrous, venation prominently reticulate; apex tricuspidate, each angle with a long, weak mucro; margins not recurved; base rounded to almost truncate. *Stipules* erect, hyaline, c. 2 mm long. *Inflorescences* short axillary racemes, 2-4-flowered; *peduncle* very short, up to 2 mm long; *rachis* almost non-existent, up to 0.25 mm long; *subtending bracts* caducous, scale-like, trifid, c. 1.5 mm long. *Pedicels* terete, c. 2 mm long. *Calyx* campanulate, c. 6 mm long

including the 1 mm receptacle, sparsely pubescent, lobes scarcely recurved; upper two lobes united higher than the lower three, triangular, acute, 2.5-3 mm long; lower three lobes triangular, acuminate, 2.5-3 mm long. *Corolla*: *standard* transversely elliptic, c. 6.5 x 7 mm including the 2.5 mm claw, orange to yellow with a red ring surrounding the yellow centre, apex emarginate, base truncate; *wings* obliquely oblong, c. 7.5 x 2 mm including the 2.5 mm claws, orange to yellow, red towards base, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, saccate; *keel* half transversely obovate, margins not incurved, c. 7 x 3 mm including the 2.5 mm claws, deep maroon, apex rounded, base auriculate, saccate. *Style* long, slightly hooked, lower third pubescent on the inner margin; *ovary* shortly stipitate, densely pubescent; *ovules* 4-10. *Pod* shortly stipitate, ovoid, 5-5.5 x 3-3.5 mm, moderately pubescent. *Seed* not seen.

Flowering period. August to October. *Fruiting period.* From November.

Distribution (Map 44). South-west Western Australia. Occurs south of Perth around Mount Barker, and east as far as Ongerup.

Map 44. Distribution of *G. pusillum*.

Habitat. Grows in wetter areas, including floodplains and swamp margins, in generally loamy soils or in sand along rivers, in shrubland and heathland, often in clearings amongst eucalypt woodland.

Selected specimens (18 examined). WESTERN AUSTRALIA: Darling District: Wambellup Nature Reserve, c. 20 km NW of Mt Barker, 34°31'08"S, 117°27'28"E, *M.D. Crisp 8921 & W. Keys*, 20 Oct. 1996 (CANB, PERTH); Wamballup Nature Reserve, 34°31'11"S, 117°27'27"E, *A.R. Annels 4567*, 11 Oct. 1994 (CANB, PERTH). Eyre District: Fitzgerald River Crossing, main road between Ravensthorpe & Jerramungup, 33°50'S, 119°16'E, *M.D. Tindale 3831*, Aug. 1973 (CANB, NSW, PERTH); Ongerup, 33°57'S, 118°29'E, *H. Wilkins 3529/65*, Oct./Nov. 1965 (PERTH).

Toxicity. Unknown.

Affinity. This species is difficult to confuse with any other species of *Gastrolobium*, due to its diminutive size, the cuneate leaves which bear three slender cusps at the apices, and reduced, axillary racemes of 2-4 flowers.

The *G. obovatum* group

This group of species, which includes Clades H, I and part of J from the 94-taxa analysis and using further evidence from the 48-taxa anlaysis. Many of these species were until recently included in *Nemcia*, share a number of characters intermediate between those of *Gastrolobium* sens. str. and *Nemcia* as defined by Crisp and Weston (1987), such as shortly racemose inflorescences, generally in the axils of the leaves, all species have trifid subtending floral bracts, except for *G. bennettsianum* which has entire bracts and *G. brownii* and *G. truncatum* which have both entire and trifid bracts, and they all have strictly 2 ovules, except for *G. latifolium*, which has 18-21, though the placement of that species in this group requires further work. Most species in this group have not had fluoroacetate levels tested. The ones not tested probably only contain trace levels of fluoroacetate.

45. Gastrolobium brownii Meisn. (1844, p. 71). *Nemcia brownii* (Meisn.) Crisp, in Crisp & Weston (1987, p. 124). *Type citation*: "In rupestribus summitatis montis Wuljenup (Plantaganet) d. 13. Oct. 1840. Herb. Preiss. No. 802". *Type specimens*: *lecto*: LD 82/73-2209; *isolecto*: MO, NY, W (2 sheets).

Tall, bushy *shrubs*, 1.5-3 m high. *Branchlets* ascending, terete, moderately to densely pubescent. *Petioles* terete, continuous and slightly decurrent with the branchlet, 1-2 mm

long. *Leaves* ascending, opposite or rarely whorled, oblong, obovate or cuneate, 8-30 x 4-9 mm, glabrous or very sparsely pubescent on the lower surface around the venation, venation prominently reticulate; apex rounded, obtuse or truncate, generally pungent-pointed; margins entire, flat or recurved; base rounded. *Stipules* free, hyaline, 0.5-1.5 mm long. *Inflorescences* axillary racemes, sometimes on short axillary shoots, (2-)4-9-flowered; *peduncle* (1-)3-6 mm long; *rachis* 2-8(-20) mm long; *subtending bracts* scale-like or herbaceous; if scale-like: caducous, entire, lobed or trifid, generally lanceolate, c. 4 mm long; if herbaceous: 4-7 mm long, obovate, mostly caducous, occasionally persistent. *Flower*: *pedicels* terete, 1-2.5 mm long. *Calyx* campanulate, 3.5-4.5 mm long including the 0.5-1 mm receptacle, two-toned, green at base, very dark brown above, sparsely to moderately sericeous; upper two lobes not recurved, united higher than the lower three, sometimes into a truncate lip, obtuse, 1.5-2 mm long; lower three lobes may be recurved, triangular, acute, 1.5-2 mm long. *Corolla*: *standard* transversely broadly elliptic, 8-8.5 x c. 8.5 mm including the c. 2.5 mm claw, yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, 8-8.5 x c. 2.5 mm including the c. 2 mm claw, yellow, apex rounded, incurved and partially enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half circular to transversely very broadly elliptic, margins not incurved, 7.5-8 x c. 2.5 mm including the c. 2.5 mm claw, red, apex rounded, base auriculate, saccate. *Style* long, incurved to slightly hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid, 5-7 x 2-3.5 mm, sparsely to moderately pubescent. *Seed* reniform, 2-2.5 mm long, arillate.

Flowering period. September to November. *Fruiting period*. From late November onwards.

Distribution (Map 45). South-west Western Australia. Occurs along the western portion of the south coast, from Denmark east to the Albany region, and north to the Porongurup Range.

Habitat. Usually grows in moister areas, unusual for *Gastrolobium*, on loamy, occasionally sandy soils, in forest, open woodland or more rarely shrubland usually dominated by *Eucalyptus calophylla*, *E. diversicolor*, *E. marginata* or *E. megacarpa*.

Map 45. Distribution of *G. brownii*.

Conservation status. ROTAP: 2K. This species is fairly rare and poorly known, with further survey work required to determine its conservation status.

Selected specimens (26 examined). WESTERN AUSTRALIA: Eyre District: Mt Wilyung, 34°57'S, 117°51'E, *T.E.H. Aplin 6038*, 26 Sep. 1974 (CANB, PERTH); 35 km W of Denmark, 0.2 km km along Tindale Road from South Coast Highway, 34°57'15"S, 117°01'02"E, *G.T. Chandler 726& S. Donaldson*, 31 Oct. 1998 (CANB, PERTH); Porongurup Range, Castle Rock, 34°42'S, 117°55'E, *M.D. Crisp 8509 & W. Keys*, 26 Sep. 1993 (CANB, PETH); Albany, c. 35°00'S, 117°53'E, *C.E. Lane-Poole 326*, 21 Jan. 1919 (PERTH); Darling District: Intersection Mountain and Boronia Roads, 34°20'12"S, 115°35'29"E, *A.R. Annels 4618 & R.W. Hearn*, 13 Oct. 1994 (CANB, MJP, PERTH).

Toxicity. Fluoroacetate 80-260 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The distinctive leaf shape and short, axillary racemes of this species make *G. bilobum* difficult to confuse with any other species of *Gastrolobium*.

46. Gastrolobium hookeri Meisn. (1844, p. 71). *Nemcia hookeri* (Meisn.) Crisp, in Crisp & Weston (1987, p. 126). *Type citation*: "Swan River. James Drummond, n. 209." *Type specimens*: *holo*: BM; *iso*: G, K, W (2 sheets).

> *Gastrolobium tricuspidatum* Meisn. var. *subinerme* Meissner in Lehm. (1844, p. 66). *Type citation*: "In planitie arenosa Quangen (Victoria) d. 20. Mart. 1840. Sterile. Herb. Preiss. No. 830." *Type specimens*: *holo*: LD; *iso*: G (2 sheets), NY (rh specimen only).

Bushy *shrubs* to 0.5 m high. *Branchlets* ascending, terete, moderately villous. *Petioles* terete, continuous but not decurrent with the branchlet, 1-2 mm long. *Leaves* spreading, ± opposite, stem clasping, oblong, elliptic or obovate, c. 13-15 x 5-7 mm, sparsely to moderately pubescent, venation prominently reticulate; apex semi-pungent, unevenly recurved; margins slightly crenulate; base rounded. *Stipules* erect, hyaline, 3-4 mm long. *Inflorescences* solitary or paired flowers in the axils; *peduncle* nil; *rachis* nil; *subtending bracts* trifid with the middle lobe elongated. *Pedicels* 2-4 mm long. *Calyx* campanulate, 4-5 mm long including the c. 1 mm receptacle, moderately villous, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acuminate, c. 2 mm long. *Corolla*: *standard* very broadly elliptic, c. 7-8 x 6-7.5 mm including the 3 mm claw, orange and maroon with a small yellow centre, apex emarginate, base ± truncate, slightly auriculate; *wings* obovate, c. 6.5-7 x 2 mm including the 2 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half transversely elliptic, margins slightly incurved, c. 6 x 4 mm including the 2.5 mm claws, maroon, apex rounded, base auriculate, saccate. *Style* slightly longer than the ovary, hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* ovoid, 5-6 x 2-3 mm long. *Seed* not seen.

Flowering period. October. *Fruiting period*. November.

Distribution (Map 46). South-west Western Australia. Occurs on the eastern edge of the Darling escarpment and into the wheatbelt, from Toodyay south to Pingelly.

Habitat. Grows on sand, sandy loam or gravelly clay in open forest and woodland.

Selected specimens (10 examined). WESTERN AUSTRALIA: Darling district: between Toodyay and Bindoon, 31°33'S, 116°27'E, *C.E. & T.D. Woolcock W638*, 24 Aug. 1982 (CANB); 3 km WSW of Quairading, 32°01'S, 117°22'E, *M.D. Crisp 6183et al.*, 27 Sep. 1979 (CANB, PERTH); 0.2 km E along Helena Road from West Talbot

Road towards York, 31°57'45"S, 116°32'14"E, *M.D. Crisp 8907 & W. Keys*, 8 Oct. 1996 (CANB, PERTH); Beverley 32°07'S, 116°56'E, *R.D. Royce 3852*, 6 Oct. 1952 (CANB, PERTH).

Map 46. Distribution of *G. hookeri*.

Toxicity. Unknown.

Affinity. *Gastrolobium hookeri* has been confused with a number of morphologically similar species in the past, but is fairly easily distinguished by the terete branchlets, the non-decurrent petioles, and the distinctive trilobed subtending bracts, with the middle lobe being much longer than the other two.

47. Gastrolobium obovatum Benth. in Lindley (1839, p. 14). *Nemcia obovata* (Benth.) Crisp (1987, p. 127). *Type citation*: None cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond, 1839); *isolecto*: CGE (2 sheets), K, W.

> *Gastrolobium obovatum* Benth. var. *verticillatum* Meisn. (1844, p. 71). *Type citation*: "Swan River. Drummond n. 206." *Type specimens*: G (2 sheets).
>
> *Gastrolobium obovatum* Benth. var. *subverticillatum* Meisn. ex Regel, Gartenflora 6: 156. *Notes*: ?Error for *G. obovatum* var. *verticillatum*.

Bushy, erect *shrubs* 0.3-0.6 m high. *Branchlets* spreading to ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, < 1 mm long. *Leaves* spreading, scattered to ternate, ± rhombic or slightly trullate to narrowly so, 18-30 x 12-24 mm, glabrous, venation prominently reticulate; apex acute, pungent-pointed; margins conduplicate; base truncate. *Stipules* erect, hyaline, 3-5 mm long. *Inflorescences* short axillary racemes or umbels (when 2-flowered), 2-4-flowered; *peduncles* 2-18 mm long; *rachis* 0- 2 mm long; *subtending bracts* trilobed with lobes much longer than trunk, about equal in length, rusty brown tomentose. *Pedicels* terete, 1-3 mm long. *Calyx* 4-6 mm long including the c. 0.5 mm receptacle, moderately to densely pubescent, lobes all recurved; upper two lobes united higher than the lower three, acute, 2-2.5 mm long; lower three lobes triangular, acute, 1.5-2 mm long. *Corolla*: *standard* transversely elliptic, 8-11 x 8-12 mm including the 2.5-4 mm claw, orange yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* ± oblong to obovate, 7.5-10 x 2-3 mm including the 2-3 mm claws, orange becoming red at base, apex rounded, incurved but not overlapping, not enclosing the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, margins not incurved, 7-10.5 x 3-3.5 mm including the 2.54 mm claws, red, apex broadly rounded to obtuse, base auriculate, saccate. *Style* long, incurved to hooked, lower third pubescent; *ovary* prominently stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ovoid to ellipsoid, 6-7 x 2-3 mm, moderately pubescent. *Seed* ellipsoid, 2-3 mm long, covered in blunt ridges, arillate.

Flowering period. August to October. *Fruiting period*. From October.

Distribution (Map 47). South-west Western Australia. This species is widely distributed, occurring from Eneabba south to Wagin, and inland as far as Doodlakine.

Habitat. Grows on undulating hills in sandy soils in heath and open woodland.

Selected specimens (38 examined). WESTERN AUSTRALIA: Avon district: 19 km from Goomalling towards Wongan Hills, 31°08'S, 116°48'E, *J. Taylor 2144 & P. Ollerenshaw*, (CANB, MEL, PERTH); c. 100 m N of the northerly entrance to the Wongan Hills Research Station, 30°50'49"S, 116°44'35"E, *G.T. Chandler 192 & W. Keys*, 9 Sep. 1997 (CANB, PERTH); Mount Hardy, 11 km from York on road to Quairading, 31°54'S, 116°52'E, *J.H. Ross 2775*, 5 Sep. 1982 (AD, CANB, MEL, PERTH); 1 km W of Karrelocking on Wyalkatchem-Merredin Rd., 9 km E of Wyalkatchem, 31°12'S, 117°28'E, *S.J. Forbes 1814*, 25 Oct. 1983 (CANB, MEL,

PERTH); Yilminning, 300 m W of siding, 32°54'10"S, 117°22'00"E, *G.T. Chandler 763 S. Donaldson*, 3 Nov. 1998 (CANB, PERTH); 2.3 km along Belka Road West from Doodlaking-Bruce Rock road, 31°45'00"S, 118°04'55"E, *G.T. Chandler 689 & S. Donaldson*, 26 Oct. 1998 (CANB, PERTH). Darling District, Jurien Bay Road, from Brand Highway, *C.E.& D.T. Woolcock W619*, 19 Aug. 1982 (CANB). Irwin District: 10 km WSW of Eneabba, 29°52'S, 115°11'E, *A. Kanis 1539*, 7 Aug. 1973 (CANB); 2.5 km on Old Geraldton Road, from Merewara Road, E of Watheroo on Miling road, 30°17'59"S, 116°05'55"E, *G.T. Chandler 656 & S. Donaldson*, 25 Oct. 1998 (CANB, MEL).

Map 47. Distribution of *G. obovatum*.

Notes. There is a somewhat narrower-leaved form of *G. obovatum* in the Wongan Hills area that needs further study The leaves of this form tend to be broadest above the middle, and blue-green.

Toxicity. Unknown.

Affinity. *Gastrolobium obovatum* is very similar to *G. spathulatum*, which differs in having leaves that tend to be ± flat with an unarmed apex, prominently spathulate and yellow-green, whereas *G. obovatum* has leaves that are broadest towards the middle.

48. Gastrolobium plicatum Turcz. (1853, p. 274). *Nemcia plicata* (Turcz.) Crisp (1987). *Type citation*: "Drum. V. n. 50." *Type specimens*: *holo*: K; *iso*: BM, K (2 sheets), W.

> *Gastrolobium pauciflorum* C.A.Gardner (1942, p. 179). *Type citation*: "Hab, in distr. Irwin, ca. 9 km. a Three Springs occidentalem versus, in fruticetis apertis arenosis, fl. m. Septem. W.E. Blackall 4895." *Type specimens*: *holo*: PERTH.

Semi-prostrate to erect *shrubs* to 1.5 m high. *Branchlets* ascending, compressed to angular, glabrous. *Petioles* terete, continuous and slightly decurrent with the branchlet, c. 3 mm long. *Leaves* spreading, opposite, obovate to cuneate, 25-40 x 10-12 mm, glabrous, venation prominently reticulate, yellow-green; apex recurved, strongly mucronate; margins often slightly undulate, mostly conduplicate or becoming so; base cuneate. *Stipules* erect, hyaline, 3-4 mm long. *Inflorescences* loose axillary clusters, 2-4-flowered; *peduncle* 0-2 mm long; *rachis* nil; *subtending bracts* trilobed with lobes about the same length as tube, except for the elongated middle lobe. *Pedicels* terete, < 2 mm long. *Calyx* campanulate, c. 6 mm long, densely villous, lobes all recurved to slightly reflexed; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* very broadly elliptic, c. 8-10 x 8 mm including the 2 mm claw, yellow with a red centre apex emarginate, base cordate, not auriculate; *wings* obovate, c. 8-8.5 x 2.5 mm including the 2.5 mm claws, yellow but red at base, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half very broadly ovate, c. 7.5-8 x 2.5 mm including the 3 mm claws, red, apex obtuse, base auriculate, saccate. *Style* long, strongly incurved to hooked, lower third pubescent; *ovary* very shortly stipitate, densely pubescent; *ovules* 2. *Pod* very shortly stipitate, broadly ovoid, c. 6 x 3 mm, densely villous. *Seed* with blunt ridges, c. 2 mm long, arillate.

Flowering period. September and October. *Fruiting period*. November and December.

Distribution (Map 48). South-west Western Australia. Occurs north of Perth, around the Eneabba and Three Springs area, including Tathra National Park.

Map 48. Distribution of *G. plicatum*.

Habitat. Grows on the northern sandplains on sandy soil in heath and open woodland.

Selected specimens (15 examined). WESTERN AUSTRALIA: Irwin district: 10 km N of Three Springs towards Arrino, 29°28'43"S, 115°40'38"E, *G.T. Chandler 209 & W. Keys*, 11 Sep. 1997 (CANB, MEL, PERTH); between Coorow and Arrino, 29°39'S, 115°50'E, *W.E. Blackall 2605*, Sep. 1932 (CANB, PERTH); Tathra National Park, 25.4 km E of Eneabba along road to Carnamah, 29°48'06"S, 115°30'42"E, *M.D. Crisp 9014& W. Keys*, 25 Oct. 1996 (CANB).

Toxicity. Unknown.

Affinity. This species slightly resembles *G. obovatum*, but the latter species is easily distinguished, as the leaves are much somewhat longer and significantly narrower (18-30 x 12-24 mm), the peduncle is longer (2-18 mm long), and there is often a rachis (0-2 mm long).

49. Gastrolobium spathulatum Benth. in Lindley (1839, p. 14). *Nemcia spathulata* (Benth.) Crisp (1987, p. 128). *Type citation*: none cited. *Type specimens*: FI-W, G (2

sheets). *Lectotype* (here chosen,): K (Swan River, Drummond, 1839); *isolecto*: CGE (2 sheets), G, K.

> *Gastrolobium spathulatum* Benth. var. *latifolium* Benth. (1864, p. 100). *Type citation*: "W. Australia, Drummond; Phillips Ranges, Maxwell." *Type specimens*: *holo*: MEL 625087.

Erect, bushy, *shrubs*, to 1.5 m high. *Branchlets* ascending, densely pubescent. *Petioles* terete, continuous and decurrent with the branchlet, < 1 mm long. *Leaves* spreading to ascending, mostly ternate, spathulate, 8-22 x 4-10 mm, glabrous, venation prominently reticulate; apex truncate, emarginate or sometimes almost bilobed, mucronate; margins slightly crenulate, becoming conduplicate; base rounded to cuneate. *Stipules* erect to recurved, triangular to hyaline, 1-2 mm long. *Inflorescences* axillary, solitary or paired to 3-5-flowered, condensed racemes; *peduncle* 0-1.5 mm long; *rachis* 0-4 mm long; *subtending bracts* caducous, scale-like, trilobed with lobes much longer than the tube, c. mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, to 6 mm long including the c. 1 mm receptacle, moderately pubescent, lobes recurved to slightly reflexed; upper two lobes united, much higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* very broadly elliptic, c. 7.5-10 x 7-7.5 mm including the 3 mm claw, orange with a dark red centre, apex emarginate, base cordate; *wings* obovate, c. 7 x 2 mm including the 2.5 mm claws, orange, apex rounded, incurved, may or may not enclose the keel, base auriculate on the upper margin only, slightly saccate; *keel* half very broadly elliptic, c. 7 x 2-2.5 mm including the 3 mm claws, dark red, apex sub-acute, base auriculate, saccate. *Style* long, strongly incurved to hooked, lower third pubescent; *ovary* prominently stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, obliquely ovoid, c. 5-6 x 3 mm, moderately pubescent. *Seed* ellipsoid, c. 3 mm long, arillate.

Flowering period. August to October, but also recorded for March. *Fruiting period*. From October.

Distribution (Map 49). South-west Western Australia. Occurs throughout the Darling escarpment near Perth, from Bindoon south to Dwellingup.

Habitat. Grows on granite outcrops or ridges on clay-loam soils, in open forest and heathland.

Map 49. Distribution of *G. spathulatum*.

Selected specimens (12 examined). WESTERN AUSTRALIA: Darling District: Flat Rocks Road, c. 4 km SE of Bindoon, Red Hill, 31°25'S, 116°08'E, *M.D. Crisp 8448 & W. Keys* (CANB, GAUBA, PERTH, UWA); Toodyay Rd, c. 10 km from Midland, on the Darling scarp, 31°51'S, 116°04'E, *T.R. Lally 57* (AD, BRI, CANB, PERTH); Kalamunda, 19 km E of Perth. 31°58'S, 116°03'E, *R.&M. Hamilton 160* (CANB, CHR, NSW, MEL).

Toxicity. This species is not known to be toxic, but trace levels (40-80 $\mu g.g^{-1}$) have been recorded (Twigg *et al.*, 1996a).

Affinity. This species is often confused with relatives with plicate leaves, but *G. spathulatum* has spathulate leaves with narrow bases that gradually increase in width until the upper third of the leaf, where the breadth increases considerably and often abruptly, the leaf apices are basically obtuse with a small mucro, recurving slightly, and the leaves are noticeably yellow-green, particularly when fresh.

50. Gastrolobium stowardii S. Moore (1920, p. 169). *Type citation*: "Dumbleyung; Stoward, 106." *Type specimens*: *holo*: BM; *iso*: K. *Notes*: specimens have been

previously identified as *Nemcia sp. A* Crisp, ined., and *Gastrolobium* sp. F (aff. hookeri).

Small, twiggy *shrubs*, to 0.5 m high. *Branchlets* spreading to ascending, angular, moderately pubescent. *Petioles* almost nil, continuous and partly decurrent with the branchlet, < 0.5 mm long. *Leaves* often restricted to the upper part of the branchlets, spreading to ascending, opposite, oblong to cuneiform, 10-18 x 5-7 mm, upper surface glabrous with thickened venation, lower surface moderately pubescent with appressed hairs; apex obtuse to almost truncate, often almost horned, strongly recurved, pungent-pointed or strongly mucronate; margins recurved; base rounded. *Stipules* hyaline, 3-4 mm long. *Inflorescences* single or paired flowers in the axils or small axillary racemes with up to 4 flowers; *peduncle* 0-3 mm long; *rachis* 0-3 mm long; *subtending bracts* caducous, scale-like, trilobed, with lobes shorter than tube, the middle lobe longest, to 3 mm long. *Pedicels* 2-3 mm long. *Calyx* campanulate, 4-5 mm long including the < 1 mm receptacle, densely sericeous, lobes recurved to strongly so; upper two lobes united higher than the lower three, rounded to acute, c. 2-2.5 mm long; lower three lobes triangular, acute, c. 2-2.5 mm long. *Corolla*: *standard* transversely to very broadly ovate, 6-9 x 6-8 mm including the 3 mm claw, orange with maroon markings, with a yellow centre, apex emarginate, base obtuse to slightly cordate; *wings* obovate, 5-7 x 2-3 mm including the 2 mm claws, orange and red, apex rounded, incurved and partly overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half broadly elliptic, margins not incurved, c. 6-7 x 2-2.5 mm including the 2 mm claws, maroon, apex obtuse, base auriculate, saccate. *Style* long, strongly incurved, base pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* reddish, 5-6 mm long, softly pubescent.

Flowering period. September and October. *Fruiting period*. November.

Distribution (Map 50). South-west Western Australia. Occurs just south of Eneabba south to Tarin Rock (near Lake Grace), and is particularly common in the Wongan Hills area.

Habitat. Grows mainly on sandy soils in heath and mallee woodland.

Selected specimens (30 examined). WESTERN AUSTRALIA: Avon District: 8-10 miles [13-16 km] East of Calingiri on Wongan Hills Road, 31°00'S, 116°32'E, *T.E.H. Aplin 129*, 10 Sep. 1958 (CANB, PERTH); 8.2 km E of Carani, 31°00'S, 116°30'E, *J.D. Briggs 637*, 25 Sep. 1980 (CANB, MEL, PERTH); Old Ongerup Road east of

Susetta Creek 33°48'S 119°26'E, *M.G. Corrick 8822*, 19 Oct. 1983 (AD, CANB, HO, NSW, MEL, PERTH). Irwin District: 14.5 km on Tootbardi Road from Brand Highway, turnoff S of Eneabba, 30°07'14"S, 115°30'04"E, *G.T. Chandler 828 et al.*, 8 Sep. 1999 (CANB, MEL, PERTH). Roe District: 3 km From Lake Grace towards Newdegate, 33°06'17"S, 118°29'08"E, *G.T. Chandler 950 et al.*, 20 Sep 1999 (CANB, MEL); Tarin Rock, opposite siding, 33°07'S, 118°14'E, *T.E.H. Aplin 6011*, 24 Sep. 1974 (CANB, PERTH).

Map 50. Distribution of *G. stowardii*.

Toxicity. Unknown.

Affinity. Previously in synonymy and causing considerable confusion with *Gastrolobium hookeri*, but in fact *G. stowardii* shows greater morphological similarity to *G. dorrienii*, with which it shares a twiggy habit, and bilobed leaves which tend to recurve both apically and at the margins. *Gastrolobium stowardii*, with opposite leaves, is fairly readily distinguished from *G. dorrienii*, which has thicker, patent leaves in whorls of three. *Gastrolobium stowardii* differs from *G. hookeri* in the flattened or angular stems, the noticeably decurrent petiole bases, the median lobe in the floral

bracts being scarcely longer than the other lobes, rather than noticeably longer, and the general habit differs with most leaves in the upper branches. A population located in Irwin district between Eneabba and Badgingarra (Chandler 828 *et al.*) may extend the known range. This population was growing with *Gastrolobium polystachyum* and these two species may also have been confused in previous collections, because both have a narrow, bilobed leaf. However, the leaves of *G. polystachyum* are much larger (5-35 mm long, and the leaves in this population were all above 25 mm long), and the inflorescence is a long, open raceme.

51. Gastrolobium bennettsianum C.A. Gardner (1942, p. 179). *Type citation*: "In collibus glareosis regionis Eucalypti reducae distr. Avon proprium. Adest ad Yorkrakine prop Tammin meridiem versus ad usque Wagin, fl. m. Septem. Typus est North Bungulla, Gardner Sept. 1936." *Type specimens*: *holo*: PERTH; *iso*: PERTH.

Erect, bushy *shrubs*, to 2 m high. *Branchlets* ascending, angular to almost terete, often a pale yellow in colour, moderately to densely pubescent. *Petioles* terete, swollen at base, continuous and slightly decurrent with the branchlet, 1-3 mm long. *Leaves* spreading to ascending, in whorls of 3, obovate to narrowly so, 6-30 x 4-12 mm, glabrous to rarely glaucous, venation prominently reticulate; apex obtuse to broadly rounded, recurved, usually pungent-pointed, rarely mucronate; margins conduplicate, often strongly so, entire, recurved; base cuneate. *Stipules* erect, bristle-like, 2-3 mm long. *Inflorescences* terminal racemes, very rarely branched, 10-30-flowered; *peduncle* scattered with what appear to be aborted buds, 5-10 mm long; *rachis* 15-45 mm long; *subtending bracts* caducous, scale-like, minutely fimbriate, ovate, keeled, 3-4 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, c. 5 mm long including the 1 mm receptacle, glabrous to sparsely pubescent, upper two lobes straight, united into an almost truncate lip, rounded, c. 2 mm long; lower three lobes recurved to reflexed, triangular acute, c. 1.5 mm long. *Corolla*: *standard* transversely ovate to elliptic, 7.5-8.5 x 8-10 mm including the 3-4 mm claws, orange-yellow to orange with a red ring surrounding the yellow centre, apex emarginate, base strongly cordate; *wings* obovate, 5.5-7 x 2.5-3 mm including the 1.5-2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, usually saccate; *keel* half transversely elliptic, c. 5.5 x 2-2.5 mm including the 2.5 mm claws, maroon, apex acute, spout-like, base auriculate, saccate, with a circular opening near claws to expose the stamens from below. *Style* short, incurved, lower half pubescent;

ovary stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, obliquely ellipsoid, 6-7 x 3-4 mm, moderately pubescent. *Seed* reniform, c. 3 mm long, arillate.

Vernacular name. Cluster Poison.

Flowering period. August to October. *Fruiting period*. October to December.

Distribution (Map 51). South-west Western Australia. Occurs in a band from the Gutha and Wubin areas in the north almost directly south-east through the central wheat-belt area to the Peak Charles area (near Norseman).

Map 51. Distribution of *G. bennettsianum*.

Habitat. Grows on the broader sandplain regions of the central wheatbelt on sand or gravelly sand, sometimes with a clay content, in mallee woodland and *Allocasuarina* heath and shrubland.

Selected specimens (85 examined). WESTERN AUSTRALIA: Avon District: 14 km from Bindi Bindi towards Ballidu, 30°35'17"S, 116°29'09"E, *G.T. Chandler 679 & S. Donaldson*, 25Oct. 1998 (AD, CANB); North Bungulla Bungulla, 31°38'S, 117°35'E, *C.A. Gardner s.n.*, Sep. 1936 (PERTH); 1 mile [1.5 km] SW of Manmanning, 30°52'S, 117°05'E, *B.H. Smith 1315*, 28 Aug. 1990 (CANB, MEL, WAG); SSE of Corrigin,

32°31'S, 117°56'E, *A.S. George 14370*, 7 Sep. 1976 (PERTH); 9 km from Cadoux towards Koorda, 30°48'12"S, 117°11'51"E, *G.T. Chandler 846 et al.*, 11 Sep. 1999 (CANB, UWA); 1 km from Wubin towards Perenjori, on Mullewa to Wubin Road, 30°05'55"S, 116°37'13"E, *G.T. Chandler 839 et al.*, 10 Sep. 1999 (CANB, MEL, NSW, PERTH, NY); Ballidu, 30°36'S, 116°46'E, *C.A. Gardner 12119*, 7 Sep. 1959 (PERTH); 13 miles [21 km] W of Gutha, 29°00'S, 115°45'E, *A. Cox s.n.*, Aug. 1958 (PERTH). Roe District: South Yilgarn, Skeleton Rock area, 31°51'S, 119°28'E, *J.F. Brennard & M.M. Brennard s.n.*, 5 Nov. 1989 (PERTH); Tarin Rock, on Tarin Rock Road North, 33°06'29"S, 118°13'56"E, *G.T. Chandler 714 & S. Donaldson*, 29 Oct. 1998 (BRI, CANB, MEL); 4 km along Kumarl Road from Lake King-Norseman Road, c. 80 km from Norseman to Lake King, 32°45'09"S, 121°21'54"E, *G.T. Chandler 914 et al.*, 17 Sep. 1999 (CANB, NSW, PERTH).

Notes on variation. This species has an extremely variable leaf shape and size, from quite small (around the Corrigin, Tarin Rock and Lake Grace areas), through a long, narrow leaved form around Bungulla, Cadoux and Manmanning, to a long, broad leaved form in the north, from around Wubin, Ballidu and Gutha to the far east around Norseman. However, there are intergrading specimens between all forms. In particular, two specimens (Ballidu, *C.A. Gardner s.n.*, PERTH 2798689 and 13 miles [21 km] west of Gutha, *A. Cox s.n.*, PERTH 2798085) show two of these forms on one specimen. The Cox specimen shows the long, narrow leaved form and the long, broad-leaved form on one specimen, and the Gardner specimen shows the long, broad-leaved form with the short leaved form. Therefore, no taxa will be recognised within this species here, and instead it is considered as a complex species.

Toxicity. Highly toxic; fluoroacetate 1300 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. The smaller-leaved forms of *G. bennettsianum* may resemble the smaller leaved forms of *G. crassifolium*, though the leaves of *G. crassifolium* are not recurved, are glaucous, and lack a pungent-point, having only a very small (if present at all), blunt mucro.

52. Gastrolobium pulchellum Turcz. (1853, p. 274). *Nemcia pulchella* (Turcz.) Crisp (1987, p. 127). *Type citation*: "Drum. V. n. 57." *Type specimens*: *holo*: KW; *iso*: BM, K (2 sheets), W.

Bushy *shrubs* to 1.5 m high. *Branchlets* ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, c. 1 mm long. *Leaves*

spreading to ascending, ternate, elliptic, 8-25 x 4-12 mm, glabrous, venation prominently reticulate; apex bilobed to emarginate; margins undulate; base rounded. *Stipules* erect to recurved, hyaline, 4-5 mm long. *Inflorescences* short axillary umbels or paired flowers in the axils; *peduncle* 0-10 mm long; *rachis* nil; *subtending bracts* caducous, scale-like, trilobed, lobes as long as tube, outer lobes hyaline, 3-4 mm long. *Pedicels* 1-2 mm long. *Calyx* campanulate, c. 5 mm long including the c. 0.5 mm receptacle, densely pubescent, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 2.5 mm long; lower three lobes triangular, acuminate, c. c. 2.5 mm long. *Corolla*: *standard* transversely ovate, 9-10 x 8-9 mm including the 3.5 mm claw, yellow apricot, with a red ring surrounding the yellow centre, apex emarginate, base strongly cordate; *wings* obovate, c. 8 x 3 mm including the 3 mm claws, orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on upper margin only or also very slightly auriculate on the lower margin; *keel* half circular, margins slightly incurved in the lower half, c. 7 x 2 mm including the 3 mm claws, reddish, apex acute, slightly incurved, base auriculate, saccate. *Style* long, strongly incurved, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, globose, c. 5 x 5 mm, red. *Seed* ellipsoid, 1-2 mm long, arillate.

Distribution (Map 52). South-west Western Australia. Endemic in the Stirling Range.

Habitat. Grows on mountain slopes on skeletal soils in Proteaceae-dominated heath.

Specimens examined. WESTERN AUSTRALIA: Eyre District: Stirling Range, 1.8 km due N of Ellen Peak, 34°20'14"S, 118°19'49"E, *M.D. Crisp 8945 & W. Keys*, 15 Oct. 1996 (CANB, MEL, PERTH); Stirling Range, Bluff Knoll, 34°22'S, 118°15'E, *N. Ollerenshaw 271 & N. Carriage*, 13 Oct. 1975 (CANB); Stirling Range, base of path to Bluff Knoll, near carpark, 34°22'S, 118°14'E, *M.D. Crisp 8480 & W. Keys*, 24 Sep. 1993 (CANB, GAUBA, PERTH); Stirling Range National Park, Stirling Range Drive, 24 km from Chester Pass Road, 34°25'S, 117°56'E, *J. Taylor 1842 & P. Ollerenshaw*, 15 Sep. 1983 (CANB); Stirling Range National Park, track to Bluff Knoll, 34°22'S, 118°15'E, *J. Taylor 1855 & P. Ollerenshaw*, 16 Sep. 1983 (CANB, PERTH).

Toxicity. Unknown.

Map 52. Distribution of *G. pulchellum*.

Affinity. The leaves of *G. pulchellum* looks similar to the smaller-leaved specimens of *G. crenulatum*, but *G. crenulatum* has a more pronounced peduncle, the inflorescence parts are covered in rust-coloured hairs and the flowers are more orange, whereas the hairs of *G. pulchellum* are a very bright silver in colour, and the flowers are more yellow.

53. Gastrolobium truncatum Benth. (1864, p. 99). *Nemcia truncata* (Benth.) Crisp (1987, p. 128). *Type citation*: "W. Australia, Drummond (5th Coll.?), n. 30". *Type specimens*: *holo*: K; *iso*: MEL 625089.

> *Gastrolobium crispifolium* Domin 1923b, p. 35). *Type citation*: "W.A.: Mallet, leg. Capt. A.A. DORRIEN-SMITH". *Type specimens*: *holo*: K.

Prostrate to weak, bushy *shrubs*, to 0.5 m high. *Branchlets* spreading, angular to almost terete, moderately pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* spreading, opposite, broadly oblong, 5-12 x 5-9 mm, sparsely to moderately villous, venation prominently reticulate; apex truncate to slightly bilobed, unarmed or with a weak mucro; margins undulate, recurved; base truncate,

rarely slightly cordate. *Stipules* erect, narrowly triangular, 4-6 mm long. *Inflorescences* axillary racemes, 4-8-flowered; *peduncle* 0.5-2 mm long; *rachis* 5-15 mm long; *subtending bracts* caducous, scale-like, trifid to entire, 1.5-2 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, c. 4 mm long including the 0.5 mm receptacle, moderately pubescent, upper two lobes slightly recurved, lower three lobes reflexed; upper two lobes united higher than the lower three, triangular, acute, c. 2 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, c. 6 x 7 mm including the 2 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, c. 6.5 x 2 mm including the 2 mm claws, orange-yellow, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half transversely elliptic, upper margins incurved, c. 6.5 x 2.5 mm including the 2 mm claws, maroon, apex rounded, base auriculate, saccate. *Style* long, hooked, lower third pubescent on the inner margin; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, obliquely obovate, c. 4 x 3 mm, moderately pubescent. *Seed* not seen.

Flowering period. May to October. *Fruiting period*. Unknown (only old fruits seen).

Distribution (Map 53). South-west Western Australia. Occurs in narrow range in the Bokal and Wagin areas.

Habitat. Grows in the escarpment region south-east of Perth in the heavy loam and clay soils of this region, in eucalypt woodland.

Selected specimens (8 examined). WESTERN AUSTRALIA: Darling District: Bokal, Beaufort River, 21 km along Boyup Brook Road from Albany Highway at Arthur River, 33°29'38"S, 116°53'50"E, *M.D. Crisp 8918 & W. Keys*, 10 Oct. 1996 (CANB, MEL, PERTH); Bokal District, *P.W. Draper s.n.*, Sep. 1962 (PERTH); Kojonup-Boyup Brook road, *L. Dodd (J) s.n.*, May 1972 (PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium truncatum* is difficult to confuse with any other species of *Gastrolobium* because of its unusual leaf shape. Some juvenile forms of *G. polystachyum* have truncate, horned leaves, though these are much larger and are strongly bilobed, the inflorescences are terminal racemes.

Map 53. Distribution of *G. truncatum*.

54. Gastrolobium latifolium (R.Br.) G.Chandler & Crisp, *comb. nov. Base name*: *Brachysema latifolium* R. Br. (1811: 10). *Type citation*: "Nat. of the South-west coast of New Holland. Robert Brown, Esq. Introd. 1803, by Mr. Peter Good." *Type specimens*: *neo* (Crisp 1990): DBN, cult. at Kew, W.R. McNab s.n.; *isoneo* DBN.

Prostrate, trailing *shrubs*, 0.05 m high. *Branchlets* spreading, trailing, terete, densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-8 mm long. *Leaves* ascending, alternate, ovate, elliptic or orbicular, 15-65 x 10-55 mm, upper surface glabrous, lower surface densely sericeous, venation prominently reticulate; apex obtuse or rounded, mucronate; margins ± undulate, not recurved; base rounded or slightly cordate. *Stipules* erect, filiform, 3-8 mm long. *Inflorescences* reduced axillary or lateral racemes, 1-2-flowered with an aborted, terminal bud, rarely sub-paniculate; *peduncle* mm long; *rachis* mm long; *subtending bracts* caducous, scale-like, trifid, mm long. *Flowers*: not resupinate; *pedicels* terete, 2-4 mm long. *Calyx* campanulate, slightly ventricose, 10-12 mm long including the 2-3 mm receptacle, densely sericeous, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 6 mm long; lower three lobes triangular, acuminate, c. 6 mm long. *Corolla*: *standard* broadly

spathulate, 7-14 x 8-10 mm including the c. 10 mm claw, yellow infused with red towards the margins, with red veins and a rich greenish-yellow marking at the centre, apex emarginate, base rounded, not auriculate; *wings* narrowly oblong, c. 38-42 x 4-5 mm including the c. 8 mm claws, red, apex semi-acute, not incurved, not enclosing the keel, base auriculate, saccate; *keel* half obliquely narrowly elliptic, 41-43 x 8-9 mm including the 7 mm claws, red, apex acute, broadly beaked, base auriculate, saccate. *Style* long, incurved, base pubescent; *ovary* stipitate, with a disc at the base, densely pubescent; *ovules* 18-21. *Pod* exserted from the persistent calyx, obloid, 10-13 x 6-8 mm, moderately villous. *Seed* ellipsoid, c. 2.5 mm long, arillate.

Chromosome number. 2n = 16 (Sands, 1975).

Flowering period. August to October, rarely into November. *Fruiting period.* October and November.

Distribution (Map 54). South-west Western Australia. Occurs mainly near the south coast, from Cape Arid west to Kalgan River, near Albany, with an outlier between Boyup Brook and Kojonup.

Habitat. Often found growing at or near watercourses or wetter areas, on white or grey sand with a clay or gravel component, in mallee or mallee-heath.

Selected specimens (35 examined). WESTERN AUSTRALIA: Eyre District: Highway 1, between Esperance & Ravensthorpe, 1 km W of the Young River, 33°45'S, 121°09'E, *M.G. Corrick 9552*, 26 Sep. 1985 (CANB, MEL); along No. 2 Rabbit Fence, c. 35 km SSE of the Jerramungup-Ravensthorpe road, c. 30 km N of Bremer Bay, *P.G. Wilson 4388*, 2 Oct. 1966 (CANB, PERTH); Jerramungup-Ravensthorpe road, 14 km E of the Gairdner River bridge, 33°53'S, 119°06'E, *M.D. Crisp 6073 et al.*, 22 Sep. 1979 (CANB, NSW, PERTH); 94 km E of Esperance towards Cape Arid, 33°49'S, 122°53'E, *J.M. Taylor 2329 & P. Ollerenshaw*, 27 Sep. 1983 (AD, CANB, MEL, PERTH); E side of the Lort River crossing, South Coast Highway, 62.5 km from Esperance towards Ravensthorpe, 33°44'40"S, 121°16'02"E, *G.T. Chandler 365 et al.*, 12 Feb. 1998 (CANB, MEL); 20 km SW of Chillinup, 34°27'S, 118°28'E, *T.R. Lally 862*, 2 Nov. 1995 (CANB, PERTH).

Map 54. Distribution of *G. latifolium*.

Toxicity. Unknown.

Affinity. This species is not easily confused with any other species of *Gastrolobium*, except for *G. minus*, which is very similar in the vegetative stage. However, *G. minus* has non-terete stipules that are distinctly concave on the lower surface, smaller flowers (c. 15 mm long), the calyx lobes are sub-obtuse and have a broader zone of overlap (0.8-1 mm as opposed to the 0.3 mm overlap in *G. latifolium*), and a sericeous pod.

The *G. calycinum* group

This group of core *Gastrolobium* species share glaucous leaves with strongly reticulate venation and a prominent intramarginal vein, and occur on the central to northern sandplains of south-west Western Australia, with some species being quite widespread (e.g. *G. calycinum* and *G. rigidum*).

55. Gastrolobium appressum C.A.Gardner (1964, p. 59). *Type citation*: "Hab. in distr. Irwin prope Gunyidi, in arenosis glareosis in fruticetis, fl. m. Septem. Gardner 12745 (TYPUS)". *Type specimens*: *holo*: PERTH.

Low *shrubs*, 0.2-0.3 m high. *Branchlets* ascending, terete, moderately to densely pubescent. *Petiole* almost non-existent, continuous and sometimes decurrent with the branchlet, 0.5 mm long. *Leaves* erect and appressed to the branchlet, in whorls of three, ovate, 4-7.5 x 1.5-2.5 mm, glabrous or occasionally with scattered hairs along the veins of the abaxial surface, venation prominently reticulate; apex acute, unarmed; margins entire, not recurved; base obtuse. *Stipules* absent. *Inflorescences* terminal racemes, 5-15-flowered; *peduncle* (4-)8-14 mm long; *rachis* (10-)12-19(-45) mm long; *subtending bracts* caducous, entire, linear-lanceolate, c. 3 mm long. *Flower*: *pedicels* terete, 1-2 mm long. *Calyx* strongly campanulate, 5-6 mm long including the c. 1 mm receptacle, glabrous, lobes not recurved; upper two lobes united higher than the lower three, triangular, acute to obtuse, c. 4 mm long; lower three lobes triangular, acute, c. 4 mm long. *Corolla*: *standard* transversely elliptic, 10-10.5 x c. 10 mm including the c. 3 mm claw, deep orange with a red ring surrounding the orange-yellow centre, apex emarginate, base obtuse, slightly auriculate; *wings* oblong, c. 9.5 x 2.5 mm including the c. 3.5 mm claw, orange-red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both sides, not saccate; *keel* half transversely broadly ovate, margins inrolled, c. 9.5 x 3.5 mm including the c. 3.5 mm claw, maroon, darker at apex, apex barely acute to rounded, base auriculate, saccate. *Style* long, incurved to hooked, lower half pubescent on the inner margin; *ovary* stipitate, densely pubescent; *ovules* 2-3. *Pod* stipitate, very broadly ellipsoid, almost spherical, 4.5-5 x 5-5.5 mm, moderately to densely pubescent. *Seed* ellipsoid, c. 3 mm long.

Flowering period. September to November, sometimes into December. *Fruiting period*. Late October to December.

Distribution (Map 55). South-west Western Australia. This species has a narrow distribution north of Perth in the Gunyidi, Watheroo and Miling areas.

Habitat. Grows on the northern sandplains on deep sand in dense heath or shrubland.

Conservation status. IUCN: V. ROTAP: 2V. CALM: R. This species is very rare, and is considered to be vulnerable, and is at risk of becoming endangered.

Selected specimens (20 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Irwin District: Gunyidi, *B. Carlin s.n.*, Oct. 1957 (PERTH); Miling, *A. Cameron s.n.*, 21 Nov. 1973 (PERTH); Marchagee, *M. Burgman 102*, 12 Nov. 1982 (PERTH); N of Watheroo, *C.A. Gardner s.n.*, Sep. 1957 (PERTH); N of Watheroo, *J.D. Briggs 584*, 21 Sep. 1980 (CANB, K,

MEL, PERTH); near Gunyidi, *G.T. Chandler 208 & W. Keys*, 10 Sep. 1997 (CANB, UWA).

Map 55. Distribution of *G. appressum*.

Toxicity. Unknown.

Affinity. It is difficult to confuse this with any other species of *Gastrolobium* though vegetatively it could be confused with *Pultenaea reticulata*. However, the inflorescence structure is different, with *G. appressum* having many-flowered, terminal racemes and grows on the northern sandplains, where *Pultenaea reticulata* has 1- or 2-flowered, axillary inflorescences and occurs on the southern sandplains.

56. Gastrolobium calycinum Benth., in Lindley (1839, p. 13). *Type citation*: none cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond, 1839); *isolecto*: BM, CGE.

Gastrolobium sagittulatum S.Moore (1920, p. 170). *Type citation*: "Kauring; G.W. Brown (Hb. Stoward, 562)". *Type specimens*: *holo*: BM.

Erect, bushy *shrubs*, 0.5-1.5 m high. *Branchlets* ascending, angular, moderately sericeous. *Petioles* terete, continuous with and sometimes decurrent with the branchlet,

3-4 mm long. *Leaves* spreading to ascending, opposite, ovate to elliptic, conduplicate or rarely flat, straight or recurved, 17-40(-70) x 12-24 mm, glabrous, often glaucous, venation prominently reticulate, sometimes raised on the lower surface; apex acute or rarely rounded, pungent-pointed or rarely unarmed; margins entire, not recurved; base rounded. *Stipules* erect, narrowly triangular to hyaline, 3-6 mm long. *Inflorescences* terminal racemes, 4-14-flowered; *peduncle* 12-50(-78) mm long; *rachis* 25-40 mm long; *subtending bracts* caducous or rarely persistent, scale-like, entire or lacerate, 3-5 mm long. *Pedicels* terete, (1.5-)3-4 mm long. *Calyx* campanulate, 8-14 mm long including the 1-2 mm receptacle, usually glabrous, occasionally sparsely pubescent, lobes not recurved; upper two lobes united higher than the lower three, diverging, broadly triangular, rounded to acuminate, 5-7.5 mm long; lower three lobes triangular, acuminate to acute, 4.5-8 mm long. *Corolla*: *standard* transversely ovate, 11-16 x 14-21 mm including the 3.5-5.5 mm claw, deep orange, apex emarginate, base cordate to truncate; *wings* obovate, 12-15 x 3.5-5 mm including the 3.5-4 mm claw, orange to red, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins; *keel* half circular to transversely broadly elliptic, margins not incurved, 11.5-15 x 4-5 mm including the 3.5-4.5 mm claw, pink to red, apex rounded, base auriculate, saccate. *Style* long, hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, ellipsoid to spherical, 5-8 x 5-6 mm, sparsely to moderately pubescent. *Seed* ellipsoid, 3-5 mm long, arillate.

Vernacular name. York Road Poison.

Flowering period. Late August to November. *Fruiting period*. From December.

Distribution (Map 56). South-west Western Australia. A common species distributed throughout the Darling Range around Perth north to Moora and south as far as the Collie area.

Habitat. This species grows in a wide range of habitats, on low hills, slopes or flats on clay, loam or sand soils over ironstone or laterite in *Eucalyptus* forest, woodland or mallee, or shrubland or heath dominated by *Allocasuarina*, often with a mixed understorey of Fabaceae and Proteaceae.

Selected specimens (127 examined). WESTERN AUSTRALIA: Darling District: 24.5 km from Kojonup to Boyup Brook, 33°51'49"S, 116°54'36"E, *G.T. Chandler 742 & S. Donaldson*, 2 Nov. 1998 (CANB); 54 km from Collie towards Williams, from Williams turnoff, 33°10'09"S, 116°37'44"E, *G.T. Chandler 299 & W. Keys*, 22 Sep. 1997

(CANB, K, NY). Avon District: Moora, 30°38'S, 116°01'E, *L. Chrystal s.n.*, 9 July 1953 (PERTH); 1.2 km W of Wongan Hills – Calgaringi road towards Carani, 31°00'S, 116°31'E, *J.D. Briggs 640*, 25 Sep. 1980 (CANB, PERTH); 4.1 km N on Forestry Road from Yornaning Road, ca 10 km directly SW of Popanyinning, 32°42'50"S, 117°02'39"E, *T.L. Lally 1461 & B. Fuhrer*, 15 Oct. 1997 (CANB, PERTH).

Map 56. Distribution of *G. calycinum*.

Toxicity. Highly toxic; fluoroacetate 400-1400 $\mu g.g^{-1}$ (Aplin, 1964; Twigg, *et al.* 1996b).

Affinity. *Gastrolobium calycinum* somewhat resembles *G. oxylobioides* and *G. propinquum* vegetatively. It can easily be distinguished from *G. propinquum* when in flower, because the flowers of *G. propinquum* are much smaller (standard 5-6 x 6 mm), the rachis is much larger (20-120 mm long) and there are more flowers per inflorescence (15 to more than 30 flowers), and the leaves of *G. propinquum* are narrower (6-11(-14) mm broad), with a cuneate base. The leaves of *G. oxylobioides* are much narrower (5-10 mm broad), and are not usually glaucous, and the flowers are smaller (calyx 6-7.5 mm long, standard c. 10 x 14 mm).

57. Gastrolobium hamulosum Meisn. (1848, p. 218). *Type citation*: "Swan River. James Drummond, n. 209". *Type specimens*: *holo*: BM; *iso*: CGE, K (2 sheets), W.

Very low *shrubs*, 0.2-0.4 m high. *Branchlets* ascending, angular, moderately to densely pubescent. *Petioles* terete, articulate with the branchlet, c. 0.5 mm long. *Leaves* ascending, in whorls of 3, occasionally opposite, obovate to elliptic, 6-11.5 x 3-4.5 mm, sparsely to moderately pubescent, venation prominently reticulate; apex rounded, mucronate; margins entire, may be recurved; base rounded. *Stipules* erect, hyaline, 1.5-3 mm long. *Inflorescences* terminal racemes, (3-)6-15-flowered; *peduncle* 8-16 mm long; *rachis* (0-)8-25(-60) mm long; *subtending bracts* caducous, scale-like, entire, narrowly triangular, 3-4 mm long. *Flower*: *pedicels* terete, 0.5-1 mm long. *Calyx* campanulate, c. 6 mm long including the 0.75 mm receptacle, densely villous, lobes not recurved, not strongly zygomorphic; upper two lobes united slightly higher than the lower three, triangular, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, 9-9.5 x c. 11 mm including the c. 2 mm claw, yellow or orange with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* oblong to obovate, c. 8.5 x 2.5-3 mm including the c. 1.5 mm claw, yellow, orange or red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, slightly saccate; *keel* half transversely broadly elliptic, 7.5-8 x 3-4 mm including the 1.5-2 mm claw, red, apex rounded, base auriculate, saccate. *Style* long, incurved to hooked, lower two thirds pubescent along inner margin; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, ellipsoid to globose, 4-5 x 2.5-4 mm, moderately to densely villous. *Seed* reniform, 1.5-2 mm long, arillate.

Vernacular name. Hook-point Poison.

Flowering period. August to October. *Fruiting period*. From October.

Distribution (Map 57). South-west Western Australia. A rare species, occurring in the Watheroo and Wongan Hills region.

Habitat. Grows in sandy, often gravelly soils in mixed shrubland or wandoo.

Conservation status. IUCN: E. ROTAP: 2E. CALM: R. This species is rare, and is considered to be endangered.

Map 57. Distribution of *G. hamulosum*.

Selected specimens (10 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Avon District: N of Wongan Hills, *J.D. Briggs 636*, 24 Sep. 1980 (CANB, PERTH); E of Carani, *T.E.H. Aplin 5802*, 16 Sep. 1964 (PERTH). Irwin District: N of Watheroo, *J.A. Cochrane 2107*, 20 Nov. 1996 (PERTH).

Toxicity. Fluoroacetate 100 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species most closely resembles *G. parvifolium*, though the latter lacks the pungent, hooked point on the leaf present in *G. hamulosum*, and the leaves are crowded along the stem, so that the apex of one leaf overlaps the base of the next leaf, whereas in *G. hamulosum* they occur at well-spaced intervals.

58. Gastrolobium oxylobioides Benth., in Lindley (1839, p. 13). *Type citation*: none cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond, 1839); *isolecto*: BM, CGE x 3, K

Gastrolobium drummondii Meisn. (1844, p. 69). *Type citation*: "Swan River. Drummond n. 204 et coll. I.". *type specimens*: *holo*: BM; *iso*: K, W (2 sheets).

Low, bushy *shrubs*, to 0.8 m high. *Branchlets* ascending, angular, densely sericeous. *Petioles* terete, continuous and decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, in whorls of 3, elliptic to ovate, recurved or straight, 12-37 x 5-10 mm, glabrous to occasionally glaucous, venation prominently reticulate; apex acute or rounded, pungent-pointed; margins usually slightly conduplicate, occasionally flat, minutely crenulate, not recurved; base cuneate to obtuse. *Stipules* erect, hyaline, 3-7 mm long. *Inflorescences* terminal racemes, 5-10-flowered; *peduncle* angular, 10-25 mm long; *rachis* angular, 10-67 mm long; *subtending bracts* caducous, scale-like, entire (though the abruptly acuminate apex may give the appearance of being slightly trifid), narrowly rhombic, 2-3 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 6-7.5 mm long including the c. 1.5 mm receptacle, moderately pubescent, lobes not or scarcely recurved; upper two lobes united higher than the lower three, rounded, c. 3 mm long; lower three lobes triangular, acute, 2-2.5 mm long. *Corolla*: *standard* transversely ovate, c. 10 x 14 mm including the 3.5 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base truncate or cordate, occasionally auriculate; *wings* obovate, c. 11 x 4.5 including the 4 mm claws, orange and red, apex rounded, incurved and at least partially overlapping to ± enclose the keel, base auriculate on both margins, slightly saccate; *keel* half transversely elliptic, margins not incurved, c. 9 x 3.5 mm including the 4 mm claw, pink and maroon, apex rounded, base auriculate, saccate. *Style* long, incurved to hooked, lower half pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, often shortly so, obliquely ellipsoid, 6-7 x 3-3.5 mm, moderately to densely villous. *Seed* ellipsoid, 2.5-3 mm long, arillate.

Notes on juvenile foliage. The juvenile foliage of *G. oxylobioides* is relatively broader than the adult foliage (28-32 x 18-25 mm), and the leaves are flat. This foliage does not appear to persist longer than the first 8-10 nodes, and may bear flowers from 3-4 nodes.

Vernacular name. Champion Bay Poison.

Flowering period. August to October. *Fruiting period*. October to December.

Distribution (Map 58). South-west Western Australia. Occurs along the west coast from around the Murchison River at Kalbarri National Park south through the Geraldton and Gin Gin areas, to the Darling Range east of Perth.

Habitat. Grows on gravelly or sandy gravelly soils in heath or shrubland.

Map 58. Distribution of *G. oxylobioides*.

Selected specimens (90 examined). WESTERN AUSTRALIA: Irwin District: 36 km from Geraldton towards Northampton, along Great Northern Highway, 28°28'48"S, 114°38'07"E, *G.T. Chandler 654 & S. Donaldson*, 24 Oct. 1998 (BRI, CANB); Western Australia, *C.E. Carter s.n.*, 1 Dec 1935 (CANB); near Howatharra, 28°32'S, 114°38'E, *A. Kanis 1571*, 8 Aug. 1973 (CANB); 6 miles [9.5 km] N from Dandaragan, 30°37'S, 115°45'E, *C.A. Gardner 11873*, 1951 (CANB, PERTH); 17 miles [27 km] E of Murchison River mouth, *M.E. Phillips 1428*, 27 Sep. 1962 (CANB); 2 km N along Eneabba S road from Green Head road, 30°04'S, 115°12'E, *M.D. Crisp 6221 et al.*, 29 Sep. 1979 (CANB, MEL, NSW, PERTH) ; Badgingarra, 30°24'S, 115°33'E, *A. Hayes A*, Oct. 1969, juvenile (PERTH). Darling District: near Pingelly, 32°32'S, 117°05'E, *A. Despassis s.n.*, 2 Oct. 1897, juvenile (PERTH).

Toxicity. Often highly toxic; fluoroacetate 0-1050 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. This species has been confused with *G. propinquum* and *G. calycinum* in the past. *Gastrolobium propinquum* has many more flowers per inflorescence (15 or more), the flowers are much smaller (e.g. standard c. 5 x 6 mm), the keel-petal shape is

different, noticeably with a spout-like apex and the lower margin is not entire, having a hole towards the base where the stamens are visible, and the calyx is generally less pubescent. *Gastrolobium calycinum* has broader leaves (12-24 mm) that are generally more robust, are usually glaucous and are cordate at the base.

59. Gastrolobium racemosum (Turcz.) Crisp (1987, p. 130). *Mirbelia racemosa* Turcz. (1853, p. 282). *Oxylobium racemosum* (Turcz.) C.A. Gardner (1942, p. 178). *Type citation*: "Drum. V. n. 59." *Type specimens*: *holo*: KW; *iso*: BM, CGE, K x 4, W.

Chorozema magnifolium F.Muell. (1863, p. 18). *Type citation*: "Ad sinum Bremer Bay et ad montem Middle Mount Barren in virgultis Eucalyptorum. Maxw." *Type specimens*: *Lectotype* (here chosen): K (Bremer Bay, Maxwell).

Oxylobium bennettsii C.A. Gardner (1936, p. 123). *Type citation*: "Stony clay soil, Ravensthorpe Range, Fl. m. Novem. – Decem. A.J. Milesi and C.A. Gardner, 10th November, 1935. The Type is in the State Herbarium, Western Australia". *Type specimens*: *holo*: PERTH.

Tall, erect *shrubs*, to 2.5 m high. *Branchlets* ascending, angular, glabrous. *Petiole* terete, broader and flatter towards base, continuous and slightly decurrent with the branchlet, 4-6 mm long. *Leaves* spreading to ascending, opposite, ovate to elliptic, (20-)25-46(-60) x (5-) 8-13(-35) mm, glabrous, venation prominently reticulate, with a prominent intramarginal vein, raised; apex rounded to slightly emarginate, unarmed or with a tiny mucro; margins not or scarcely recurved, minutely crenulate; base rounded to truncate. *Stipules* erect, rigid, triangular, 2-4 mm long. *Inflorescences* terminal racemes, 15-30-flowered; *peduncle* 10-20 mm long; *rachis* 25-50 mm long; *subtending bracts* caducous, scale-like, entire, lanceolate, c. 2 mm long, glabrous. *Pedicels* terete, 4-6 mm long. *Calyx* campanulate, 6-7 mm long including the c. 1 mm receptacle, ± glabrous, lobes not or scarcely recurved; upper two lobes united higher than the lower three, rounded, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, c. 12 x 15-16 mm including the 3-4.5 mm claw, orange-apricot with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obliquely obovate, 9-10 x 3-3.5 mm including the 2.5-3 mm claw, red and pink, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only or on both margins, saccate; *keel* half transversely elliptic, margins not incurved, 6.5-7.5 x 3 mm including the 2.5-3 mm claws, pink and maroon, apex acute, almost beaked, base auriculate, saccate. *Style* very short, slightly hooked,

lower half pubescent; *ovary* stipitate, moderately pubescent; *ovules* 4-6. *Pod* stipitate, ellipsoid to ovoid, 10-11 x 5-6.5 mm, glabrous. *Seed* ellipsoid, c. 3-3.5 mm long, arillate.

Vernacular name. Net-leaved Poison.

Flowering period. September to November. *Fruiting period*. October and November.

Distribution (Map 59). South-west Western Australia. Occurs in the south-coast region, chiefly in Fitzgerald River National Park and the Ravensthorpe Ranges, but east as far as the Lort River.

Map 59. Distribution of *G. racemosum*.

Habitat. Grows on sandplains or hillslopes on sand or shaly clay-loam in mallee shrubland.

Selected specimens (51 examined). WESTERN AUSTRALIA: Eyre District: 5 miles [8 km] S of Mount Short, c. 33°30'S, 120°00'E, *K. Newbey 1896*, 31 Oct. 1965 (PERTH); near Naendip, N of Dempster Inlet, 34°03'S, 119°36'E, *A.S. George 10578*, 20 Dec. 1970 (MEL, PERTH); near Quiss Road, E of Jerramungup & S of Highway 1, 33°58'S, 119°13'E, *M.G. Corrick 8823*, 19 Oct. 1983 (CANB, MEL, PERTH); junction of Lake

King to Ravensthorpe Road & Mt Short Road, 33°27'32"S, 119°57'50"E, *G.T. Chandler 705 & S. Donaldson*, 28 Oct. 1998 (CANB, MEL); Lort River Station, Oldfield loc. 909 lot 47, 33°16'S, 121°23'E, *J. Gardner s.n.*, 15 Oct. 1984 (PERTH).

Toxicity. Among the most toxic *Gastrolobium* species; fluoroacetate 1500 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. *Gastrolobium racemosum* is similar to *G. graniticum*, but the latter differs in the relatively broader leaf with a long petiole (leaf range 48-62 x 19-32 mm, petiole 5-7 mm long), a longer inflorescence with more flowers (rachis 30-75 mm long, more than 30 flowers), and a more hairy inflorescence structure. Furthermore, *G. racemosum* has a standard petal which is a distinctive apricot colour, whereas *G. graniticum* has a yellow-orange standard petal.

60. Gastrolobium reflexum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Avon District: 26 km E of Arrino towards Morawa, 29°20'30"S, 115°50'48"E, *G.T. Chandler 644 & S. Donaldson*, 23 Oct. 1998 (*holo*: CANB; *iso*: AD, BRI, K, MEL, NSW, NY, PERTH).

> *Gastrolobium spinosum* Benth. var. *grandiflorum* C.A. Gardner (1955, p. 187). *Type citation*: "Hab. in distr. Irwin interiore prope Latham in arenosis apertis, fl. m. Oct. Gardner sine no. (1934)". *Type specimens*: *Lectotype* (here chosen): PERTH (C.A. Gardner s.n., 11 Oct. 1934); *isolecto*: BM, CANB, CBG, K, MEL, MO, NSW, PERTH x 6.

The reflexed stipules and strongly cordate leaf shape distinguish this species from most other species of *Gastrolobium*. Similar to *G. spectabile*, which differs in the non-glaucous leaves that are not fiercely pungent-pointed, and are generally less robust than the leaves of *G. reflexum*, and has 10-12 ovules, whereas *G. reflexum* has strictly 2 ovules.

A *Gastrolobii* speciebus ceteris stipulis reflexis et foliis valde cordatis plerumque distincta; a *G. spectabili* foliis robustioribus et ovulis duobus differt.

Etymology. This species is named after the reflexed stipules.

Tall and open to spreading and dense, glaucous *shrubs*, 0.6-2.5 m high. *Branchlets* ascending, angular, glabrous. *Petioles* very short, terete, continuous and partly decurrent with the branchlet, <0.5 mm long. *Leaves* broadly spreading to ± divaricate, opposite, transversely to very broadly ovate, 10-23 x 15-30 mm, glabrous, glaucous,

venation sometimes obscured, reticulate; apex obtuse to acute, fiercely pungent-pointed (pungent point up to 6 mm long); margins entire, flat; bases overlapping, strongly cordate. *Stipules* reflexed to almost appressed to the branchlet below the subtended leaves, rigid, 3.5-6 mm long. *Inflorescences* terminal racemes, 6-15-flowered, axis glabrous; *peduncle* angular, 5-13 mm long; *rachis* angular, 15-40 mm long; *subtending bracts* caducous, scale-like, entire, spathiform (constricted at the base, broadly elliptic in the middle and cupping the bud, and acute to acuminate at the apex), 12-13 mm long. *Pedicels* terete, c. 2 mm long. *Calyx* tapering to the base, 11-13 mm long including the c. 1.5 mm receptacle, glabrous, lobes not recurved or upper 2 lobes slightly recurved; upper two lobes united higher than the lower three, strongly diverging, obtuse, 6.5-7.5 mm long; lower three lobes triangular, acute, 5.5-6.5 mm long. *Corolla*: *standard* transversely ovate to transversely elliptic, 12-13 x 13.5-17.5 mm including the 3-3.5 mm claw, deep orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* oblong, 12.5-13 x 4-4.5 mm including the c. 3 mm claws, deep orange, often red towards the base, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, saccate; *keel* half transversely obovate, margins incurved, 12.5-13 x 4.5-5 mm including the c. 4 mm claws, pink, mauve or red, darker towards the apex, apex rounded, base auriculate, saccate. *Style* long, incurved to hooked, pubescent in the lower half on the upper margin; *ovary* strongly stipitate, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. September to December. *Fruiting period*. Not known precisely, but early fruit forming in December.

Distribution (Map 60). South-west Western Australia. Occurs in the central northern part of this region, particularly around the Arrino and Wubin areas, and east to the Kalannie region.

Habitat. Grows on undulating dunes on yellow sand or sandy loam, often gravelly, in mallee shrubland or *Allocasuarina/Melaleuca* shrubland.

Selected specimens (20 examined). WESTERN AUSTRALIA: Avon District: Kalannie, 30°21'S, 117°07'E, *W.E. Blackall s.n.*, 1938 (PERTH); Ballidu, 30°35'S, 116°46'E, *D.C. White 3893/65*, Nov. 1965 (PERTH); c. 20 km W of Dalwallinu, 3.4 km along Sanders Road from Bell Road, 30°13'12"S, 116°28'48"E, *G.T. Chandler 661 & S. Donaldson*, 25 Oct. 1998 (AD, CANB, HO, K, MEL, MO, NSW, PERTH); 29.4 km

NE of Three Springs towards Morawa, 29°20'S, 115°50'E, *J.D. Briggs 629*, 24 Sep. 1980 (CANB, MEL).

Map 60. Distribution of *G. reflexum*.

Toxicity. Fluoroacetate 400 $\mu g.g^{-1}$ (Aplin, 1971). Gardner and Bennetts (1956) report that it was responsible for heavy stock losses in the Latham and Dalwallinu areas.

Affinity. This species is difficult to confuse with many species of *Gastrolobium*, though there are similarities to *G. spectabile*, particularly in leaf shape, stipule orientation and the presence of a prominent intramarginal vein. However, *G. spectabile* has non-glaucous leaves that are not fiercely spinescent and are generally more herbaceous than the robust leaves of *G. reflexum*. The bracts of *G. spectabile* are quite small (up to 4.5 mm long) and ± linear-lanceolate, the pedicels are relatively long (4-5 mm long), the upper margins of the keel are not incurved, and there are 10-12 ovules, whereas *G. reflexum* has large, broad, spathiform bracts, relatively short pedicels (c. 1 mm long), the upper margins of the keel are incurved, and there are strictly 2 ovules.

61. Gastrolobium rigidum (C.A. Gardner) Crisp (1987, p. 130). *Oxylobium rigidum* C.A. Gardner (1964, p. 59). *Type citation*: "Hab. in distr. Eyre montem Madden septentrionalem versus, in glareosis fruticetis, fl. m. Oct. Gardner 13635 (TYPUS)". *Type specimens*: *holo*: PERTH.

Low, bushy *shrubs*, up to 1 m high. *Branchlets* ascending, angular, glabrous. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-3 mm long. *Leaves* ascending, opposite, elliptic to ovate, 20-40 x 10-20 mm, glabrous, glaucous, venation prominently reticulate to slightly obscured; apex obtuse, slightly pungent-pointed or mucronate; margins flat; base truncate to broadly rounded. *Stipules* erect, rigid, 2-3 mm long. *Inflorescences* terminal racemes, 4-6-flowered; *peduncle* angular, 15-20 mm long; *rachis* angular, 12-18 mm long; *subtending bracts* caducous, scale-like, slightly trilobed, ± rhombic, 2-3 mm long. *Pedicels* terete, 3-5 mm long. *Calyx* campanulate, 6-8 mm long including the c. 0.75 mm receptacle, ± glabrous, lobes not recurved; upper two lobes united higher than the lower three, obtuse, c. 3-3.5 mm long; lower three lobes triangular, sub-acute, 3-3.5 mm long. *Corolla*: *standard* transversely ovate, c. 7 x 7.5 mm including the 2 mm claw, orange to orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* oblong, c. 7 x 2 mm including the 2 mm claws, orange and red, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, saccate; *keel* half transversely obovate, margins not incurved, c. 7 x 3 mm including the 2 mm claws, maroon, apex rounded, base auriculate, saccate. *Stamens* identical. *Style* long, strongly incurved to hooked, pubescent in the lower half on the inner margin; *ovary* stipitate, densely pubescent; *ovules* 4-5. *Pod* stipitate, broadly ellipsoid to ± globose, 6-8 x 3.5-7.5 mm, moderately pubescent. *Seed* not seen.

Flowering period. September to October. *Fruiting period*. November and December.

Distribution (Map 61). South-west Western Australia. Occurs mainly in the central eastern part of this region, in the sandplains east of Lake King (Frank Hann National Park), though it does occur east as far as Tarin Rock, and south to the Ravensthorpe Ranges.

Habitat. Grows on undulating sandplains in white, grey or yellow sand over laterite, in mallee-heath, heathland or shrubland.

Conservation status. ROTAP: 3KC-. CALM: P2. This species is considered to be poorly known, but not at risk. This study found numerous, very healthy populations of

this species, many of which were reserved, so this species should not be considered rare in any way.

Map 61. Distribution of *G. rigidum*.

Selected specimens (30 examined). WESTERN AUSTRALIA: Eyre District: 77 km N of Ravensthorpe to Lake King, 33°24'03"S, 119°54'39"E, *G.T. Chandler 703 & S. Donaldson*, 28 Oct. 1998 (CANB, PERTH); ; NW slopes of Mount Short, N of Ravensthorpe, 33°27'53"S, 120°00'51"E, *G.T. Chandler 710 & S. Donaldson*, 28 Oct. 1998 (AD, CANB, HO, K, MEL, NSW, NY, PERTH). Roe District: Frank Hahn National Park, *R.D. Royce 10247*, 10 Dec. 1971 (PERTH); Lake King area, 46 km towards Norseman, 33°04'37"S, 120°10'08"E, *G.T. Chandler 907 et al.*, 17 Sep. 1999 (CANB, UWA); Tarin Rock, 33°06'29"S, 118°13'56"E, *G.T. Chandler 713 & S. Donaldson*, 29 Oct. 1998 (CANB, MEL).

Toxicity. The fluoroacetate levels of this species have been tested, and found to be 10 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. Some specimens of *G. rigidum* have been confused with *G. spectabile* in the past, though *G. spectabile* is easily told apart by its prominently cordate leaves, many-flowered racemes (18-24-flowered) and larger flowers (e.g. standard 10 x 15 mm).

62. Gastrolobium spectabile (Endl.) Crisp (1987, p. 130). *Oxylobium spectabile* Endl., in Endlicher & Fenzl (1839, p. 2). *Callistachys spectabilis* (Endl.) Kuntze (1891). *Type citation*: "Novae-Hollandiae Austro-occidentalis interiora (Roe)". *Type specimens*: *Lectotype* (here chosen): W.

> *Gastrolobium cordatum* Benth. (1839, p. 13). *Type citation*: none cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River, Capt. Mangles, Lindley, 1838); *isolecto*: CGE.

Tall, erect, spreading, tangled *shrubs* to small *trees*, 0.8-4 m high. *Branchlets* ascending, angular, glabrous. *Petioles* very short, terete, continuous and partly decurrent with the branchlet, < 1 mm long. *Leaves* spreading, opposite, ovate to broadly or transversely so, 25-45 x 23-45 mm, glabrous, venation prominently reticulate, intramarginal vein prominent apex obtuse, may be pungent-pointed or mucronate; margins flat or slightly undulate; bases overlapping, prominently cordate;. *Stipules* reflexed, often also slightly curling up, hyaline, rigid, 5-7 mm long. *Inflorescences* terminal racemes, 18-24-flowered; *peduncle* angular, 10-20 mm long; *rachis* angular, 40-60 mm long; *subtending bracts* caducous, scale-like, entire, ± narrowly lanceolate, 2-4.5 mm long. *Pedicels* terete, 3-5 mm long. *Calyx* campanulate, 7-9 mm long including the c. 1.5 mm receptacle, glabrous or rarely slightly pubescent, lobes all recurved; upper two lobes united higher than the lower three, obtuse to rounded, c. 5 mm long; lower three lobes triangular, acute, c. 4 mm long. *Corolla*: *standard* transversely elliptic, c. 10 x 15 mm including the 3 mm claw, rich yellow to light orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* oblong, c. 11.5 x 3 mm including the 2 mm claws, yellow to yellow-orange, apex rounded, not incurved, not enclosing the keel, base auriculate on both margins, saccate; *keel* half transversely obovate, margins not incurved, c. 11.5 x 5 mm including the 3.5 mm claws, creamy green, apex rounded, base auriculate, saccate. *Style* long, incurved to slightly hooked, lower half pubescent on the inner margin; *ovary* strongly stipitate, densely pubescent; *ovules* 10-12. *Pod* stipitate, obliquely ellipsoid, 10-12 x 5-6 mm, glabrous. *Seed* not seen.

Vernacular name. Roe's Poison.

Flowering period. September to November. *Fruiting period.* From November.

Distribution (Map 62). South-west Western Australia. Occurs in a relatively small area, from Kununopping south to Lake Grace (though it is unlikely that this population is extant), and from Trayning east to Muntadgin.

Map 62. Distribution of *G. spectabile.*

Habitat. This species grows around the margins of granite outcrops, in coarse sand, in eucalypt woodland.

Conservation status. CALM: P3. *Gastrolobium spectabile* is rare, possibly due to its restricted habitat. It prefers to grow around the base of granite outcrops, but far enough out from such an outcrop that land clearing for farmland may have vastly reduced the number of populations of this species. This species may in fact be classed as Vulnerable or Rare sometime in the near future.

Selected specimens (19 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Avon District: Cunderdin, *J. Pusenjak 1143/64*, Aug. 1964, probably a juvenile specimen with large leaves (PERTH); Billyacatting Hill, NE of Kununopping, *G.T. Chandler 820 & S. Donaldson,*

15 Nov. 1998 (CANB, MEL, PERTH); near Muntadgin, *C.A. Gardner s.n.*, 10 Nov. 1947 (CANB, PERTH); Lake Grace, *D.R. Taylor s.n.*, Sep. 1945 (CANB, PERTH).

Toxicity. Fluoroacetate 400 $\mu g.g^{-1}$ (Aplin, 1964).

Affinity. It is difficult to confuse *G. spectabile* with any species of *Gastrolobium*, though there are similarities to *G. reflexum*, particularly in leaf shape, stipule orientation and the presence of a prominent intramarginal vein. However, *G. reflexum* has glaucous leaves that are fiercely spinescent and are generally more robust than those of *G. spectabile*. The bracts of *G. reflexum* are large, broadly spathe-like (12-13 mm long and about as broad), the pedicels are very short (c. 1 mm long), the upper margins of the keel are incurved, and there are strictly 2 ovules, whereas *G. spectabile* has small, linear-lanceolate bracts, relatively long pedicels, the upper margins of the keel are not incurved, and there are 10-12 ovules.

63. Gastrolobium tenue G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Avon District: Between Bruce Rock and Doodlakine, c. 31°45'S, 118°05'E, *G.T. Chandler 252 & W. Keys*, 15 Sep. 1997 (*holo*: CANB; *iso*: PERTH).

Low, bushy shrubs, with involute leaves that are finely pungent-pointed and the petals persistent in fruit, completely enclosing the fruit, the subtending floral bracts are persistent and trifid, and there are less than 10 flowers per inflorescence with c. 10 mm floral internodes. Slightly similar vegetatively to *G. stenophyllum*, which differs by being a large, erect shrub with unarmed leaves, the inflorescence is many-flowered (10 to more than 30 flowered), the floral internodes are very short (< 1 mm long), and the subtending bracts are caducous and entire.

Frutices humiles foliis involutis tenue pungentibus; petala persistentia fructum omnino includentia. A *G. stenophyllo* inflorescentia floribus minus quam 10, internodiis inter flores plerumque > 10 mm) et bracteis subtenentibus persistentibus trifidis distinguenda.

Etymology. This specific epithet means slender, and this species is named after the slender leaves.

Bushy, rounded *shrubs*, 0.2-0.6 m high. *Branchlets* ascending, angular, sparsely to moderately pubescent. *Petioles* terete, slightly swollen at base, continuous and slightly decurrent with the branchlet, 1-2 mm long. *Leaves* ascending, opposite, linear, 15-25 x c. 1 mm, glabrous, venation obscurely reticulate; apex slightly rounded, finely pungent-pointed; margins strongly involute, appearing ± terete; base cuneate. *Stipules* erect,

hyaline, 1.5-3 mm long. *Inflorescences* terminal racemes, 4-10-flowered; *peduncle* angular, 13-25 mm long; *rachis* angular, 15-50 mm long; *subtending bracts* persistent, usually scale-like, rarely with the middle lobe elongated and leaf-like, prominently trifid on the lower flowers, almost entire on the upper-most flowers on the rachis, 2-4 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, c. 6 mm long including the c. 0.5 mm receptacle, sparsely to moderately, shortly pubescent, lobes not recurved; upper 2 lobes united higher than the lower three, triangular, obtuse, c. 3 mm long; lower 3 lobes triangular, acute, c. 2.5 mm long. *Corolla*: *standard* transversely ovate, c. 8 x 11 mm including the 1.5 mm claw, orange with a red ring surrounding the yellow centre, apex emarginate, base cordate, auriculate; *wings* obovate, c. 8.5 x 3.5 mm including the 1.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half broadly elliptic, upper margins incurved, c. 8 x 3 mm including the 1.5 mm claws, red and maroon, apex rounded, base auriculate, saccate. *Style* long, slightly hooked, lower third pubescent on the inner margin; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, floral parts persistent, completely obscuring pod, ellipsoid, 5.5-6 x 3-3.5 mm, moderately pubescent. *Seed* ellipsoid, c.2.5 mm long, arillate.

Flowering period. September and October. *Fruiting period*. November and December.

Distribution (Map 63). South-west Western Australia. Occurs in a restricted range on the sandplains around Bruce Rock and Doodlakine.

Habitat. Undulating dunes in yellow sand or sandy clay in *Eucalyptus* or *Allocasuarina* heath.

Conservation status. CALM: P1. This species is known only to be extant at the type locality, which is on a disturbed road verge and very much in danger of becoming extinct. The population has been steadily in decline during the course of this study, with no seedling recruitment and old plants dying, and is in need of urgent measures to ensure its survival. Numerous searches in the area have turned up no new populations of this species.

Selected specimens (12 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Avon District: Shackleton, *I. Salter s.n.*, 18 Nov. 1939 (PERTH); W of Belka, *B.H. Smith 931*, 8 Sep. 1987 (CANB, HO, MEL, PERTH); between Bruce Rock and Doodlakine, *G.T. Chandler 819 & S. Donaldson*, 15 Nov. 1998 (CANB).

Map 63. Distribution of *G. tenue*.

Toxicity. Unknown.

Affinity. The only species of *Gastrolobium* that *G. tenue* may be confused with is *G. stenophyllum*, which has somewhat similar foliage. However, *Gastrolobium stenophyllum* is a large, erect shrub, the leaves are unarmed, the inflorescence is many-flowered (10 to more than 30 flowered), with very short internodes between flowers (< 1 mm), and the subtending bracts are caducous and entire, whereas *G. tenue* has relatively few flowers per inflorescence and relatively long internodes between flowers (generally > 10 mm).

The *G. retusum* group

The species in this group all have strongly tomentose calyces which are often bicoloured, they generally have inflorescences that are reduced to a few flowers in the leaf axils (except *G. ebracteolosum*), and they all have trifid bracts.

64. Gastrolobium dorrienii (Domin) G.Chandler & Crisp, *comb. nov. Base name*: *Nemcia dorrienii* Domin 1923a, p. 29). *Type citation*: "W.A.: Bridgetown to Kojonup

and Slab Hut Gully leg. Capt. A.A. DORRIEN-SMITH (herb Kew)". *Type specimens*: *holo*: K.

Oxylobium emarginatum S. Moore var. *major* S. Moore (1920, p. 167). *Type citation*: "Kojonup; *Stoward*. 806". *Type specimens*: *holo*: BM.

Oxylobium emarginatum S. Moore (1920, p. 167). *Nemcia emarginata* (S.Moore) Crisp (1987, p. 126). *Type citation*: "Kojonup; *Stoward*, 105". *Type specimens*: *holo*: BM.

Typification. As the name *Gastrolobium emarginatum* is already occupied (see *Gastrolobium velutinum*), this new combination requires a different specific name.

Small, twiggy *shrubs*, to 0.5 m high. *Branchlets* ascending, slightly angular, moderately pubescent. *Petioles* terete, continuous and decurrent with the branchlet, 1-2 mm long. *Leaves* patent, ternate, obovate to obtriangular, recurved, 10-17 x 8-12 mm, upper surface glabrous, lower surface moderately pubescent, venation; apex recurved, almost bilobed, mucronate; margins recurved; base rounded. *Stipules* erect, hyaline, 2-3 mm long. *Inflorescences* terminal, sessile clusters of 10 or more flowers; *peduncle* c. 1 mm long; *rachis* c. 1-3 mm long; *subtending bracts* trifid with lobes much shorter than tube. *Pedicels* 1-3 mm long. *Calyx* campanulate, 6-7 mm long including the c. 1 mm receptacle, bicoloured with dense basal white hairs becoming golden brown apically, lobes not recurved; upper two lobes united higher than the lower three, acute to obtuse, c. 2.5 mm long; lower three lobes triangular, acute, c. 2.5 mm long. *Corolla*: *standard* transversely ovate, 9-10 x 9-10 mm including the c. 3 mm claw, rich yellow with a dark red centre, apex emarginate, base truncate; *wings* obovate, 8-9 x 3 mm including the 3 mm claws, base red with yellow tips, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half broadly elliptic, margins incurved, c. 8 x 2 mm including the 2.5 mm claws, dark red, apex obtuse, base auriculate, saccate. *Style* long, strongly incurved to hooked, lower third pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* shortly stipitate, ovoid, enclosed in calyx, c. 6-7 x 2-3 mm, densely pubescent. *Seed* not seen.

Flowering period. October. *Fruiting period*. November.

Distribution (Map 64). South-west Western Australia. Occurs around Kojonup, between Perth and Albany, and further south in the Stirling Range.

Habitat. Grows on sandy loam over laterite in mallee heath.

Selected specimens (7 examined). WESTERN AUSTRALIA: Darling District: White Elephant Road, 33 km W of Kojonup, 33°53'36"S, 116°51'35"E, *C.M. Lewis 279*, 1 Oct. 1997 (CANB, PERTH). Eyre District: Stirling Range, Salt River Road, 11 km W of junction with Formby South Road, 34°19'28"S, 117°57'41"E, *M.D. Crisp 8963 & W. Keys*, 17 Oct. 1996 (CANB, PERTH); Salt River Road, 20 km west of its junction with Chester Pass Road, 34°19"S, 118°00"E, *M.G. Corrick 9683*, 17 Oct. 1985 (CANB, PERTH).

Map 64. Distribution of *G. dorrienii*.

Toxicity. Unknown.

Affinity. Morphologically similar to *Gastrolobium stowardii*, but this latter species has angular stems, opposite leaves with decurrent petioles, and bracts with an elongated middle lobe.

65. Gastrolobium retusum Lindl. (1834, t. 1647). *Oxylobium virgatum* Benth. (1864, p. 22). *Notes*: Bentham changed the epithet because there was an earlier homonym for *Oxylobium retusum*. *Callistachys retusa* (Lindley) Kuntze (1891, p. 168). *Nemcia*

retusa (Lindl.) Domin (1923a, p. 29). *Type citation*: "A native of the south coast of New Holland, whence it was received from Mr. Knight, of the King's Road, in whose Nursery our figure was made in May last." *Type specimens*: *Holo* (here chosen): CGE.

> *Oxylobium drummondii* Meisn. (1844, p. 30). *Oxylobium cuneatum* Benth. var. *emarginatum* Benth. (1864, p. 24). *Type citation*: "Swan River, Drummond n. 210." *Type specimens*: *holo*: BM; *iso*: K (2 sheets), W (2 sheets).
>
> *Oxylobium melinocaule* E. Pritz. in Diels & Pritzel (1904, p. 224 & Fig. 29-D). *Type citation*: "Hab. in distr. Stirling pr. Cranbrook in fruticetis lapidosis fl. m. Sept. (D. 4452)." *Type*: the plate (Fig. 29-D).

Bushy *shrubs*, to 2 m high. *Branchlets* ascending, angular, densely villous. *Petioles* terete, continuous and decurrent with the branchlet, 1-2 mm long. *Leaves* ternate, ± bilobed to spathulate, 11-40 x 6-10 mm, upper surface glabrous, lower surface sparsely to moderately pubescent, glabrescent, venation prominently reticulate; apex often bilobed, mucronate; margins crenulate, becoming plicate; base cuneate. *Stipules* erect, hyaline, 5-6 mm long. *Inflorescences* condensed terminal racemes, 8-12-flowered; *peduncle* 2-10 mm long; *rachis* 2-15 mm long; *subtending bracts* trilobed, the lobes much shorter than the trunk and mostly hyaline, c. mm long. *Pedicels* terete, < 3 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.5 mm receptacle, densely villous, hairs bicoloured, with white hairs at the base becoming golden to dark brown at the lobe apices, lobes not to slightly recurved; upper two lobes united higher than the lower three and much narrower, acute, c. 2.5 mm long; lower three lobes triangular, acute, c. 2.5 mm long. *Corolla*: *standard* transversely elliptic, c. 7.5-10 x 10-11 mm including the 1.5-2 mm claw, orange, dark red at the centre, apex emarginate, base cordate, auriculate; *wings* ± obovate, c. 7-10 x 2.5-3 mm including the 2 mm claws, orange and purple red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, c. 7-10 x 3 mm including the 2 mm claws, maroon, apex ± obtuse, base auriculate, saccate. *Style* long, strongly incurved to hooked, base pubescent; *ovary* very shortly stipitate, densely pubescent; *ovules* 4. *Pod* ± sessile, ovoid, c. 6 x 3 mm, moderately to densely pubescent. *Seed* not seen.

Flowering period. October. *Fruiting period*. October to December.

Distribution (Map 65). South-west Western Australia. This species has a disjunct distribution, occurring around Bindoon, near Perth, and then around the Stirling Range, Bremer Bay and Cape Riche area, but not in between.

Habitat. Occurs on the northern and southern sandplains of south-west Western Australia on sandy soils in heath, woodland or mallee woodland.

Map 65. Distribution of *G. retusum.*

Selected specimens (28 examined). WESTERN AUSTRALIA: Darling District: Red Hill, Toodyay Rd, 31°51'S, 116°04'E, *R.D. Royce 4311*, 7 Sep. 1953 (CANB, PERTH); Nature Reserve, S of Bindoon, 31°28'29"S, 116°02'47"E, *G.T. Chandler 188 & W. Keys*, 9 Sep. 1997 (CANB, NY). Eyre District: 11 km on North Woogerelup Rd, from Woogerelup Road, 34°29'57"S, 117°54'29", *G.T. Chandler 730 & S. Donaldson*, 31 Oct. 1998 (CANB, PERTH); Blackwood River, *Miss Hester s.n.*, (right hand specimen; CANB, MEL, PERTH); Stirling Range, 4.5 km S of Yungermere Peak, 34°26'S, 118°07'E, *M.D. Crisp 6116 et al.*, 24 Sep. 1979 (CANB, MEL, NSW, PERTH, US); 1.9 km along Swamp Road towards Fitzgerald River National Park, from Bremer Bay

Road, 34°23'12"S, 119°17'18"E, *G.T. Chandler 427 et al.*, 15 Feb. 1998 (CANB, PERTH); 22 km on Chillinup Road from Chester Pass Road, intersection with South Stirling Road, 34°32'55"S, 118°13'50"E, *G.T. Chandler 731 & S. Donaldson*, 31 Oct. 1998 (AD, CANB, MEL, NSW, PERTH).

Toxicity. Unknown.

Notes. This is quite a variable species, which requires a detailed study to resolve some complex issues. DNA sequencing of Chandler 427 (Bremer Bay) and Chandler 188 (Bindoon), done as a species replicate, found that these two forms did not fall together on the phylogeny. In fact, they are in quite different groups. However, there was not time to delve into this species to fully resolve this issue.

Affinity. Similar to *Gastrolobium whicherensis*, which differs in the leaves being basically oblong, ranging from slightly ovate to slightly obovate, the stipules have a thickened, grey-tomentose base, there are more flowers per inflorescence (greater than 15), and it has longer peduncles (15-33 mm long).

66. Gastrolobium whicherensis G.Chandler & Crisp, *sp. nov. Type*: Western Australia: Dardanup Forest Block, E of Dardanup, 33°24'00"S, 115°49'00"E, *G.J. Keighery 14932*, (*holo*: PERTH).

Similar to *Gastrolobium retusum* but differing in that the leaves are basically oblong, ranging from slightly ovate to slightly obovate, the stipules have a thickened, grey-tomentose base, there are fewer flowers per inflorescence (8-12), and the peduncles are longer (15-33 mm long).

G. retuso similis sed foliis praecipue oblong (variantibus a vix ovatis ad vix obovatia), stipulis ad basim incrassatis cano-tomentosis et pedunculis longioribus (10-25 mm longis) distincta.

Etymology. Named after the hills in which this species is endemic, the Whicher Range.

Slender, open *shrubs* to 1.6 m high. *Branchlets* ascending, angular to trigonous, moderately to densely sericeous. *Petioles* terete, continuous and may be slightly continuous with the branchlet, 2-4 mm long. *Leaves* ascending, in whorls of three or four, ± oblong, cuneiform or slightly ovate, 20-25 x 3-5 mm, upper surface glabrous, lower surface glabrous to moderately sericeous, venation openly reticulate; apex rounded, often slightly emarginate, slightly mucronate; margins flat slightly recurved; base cuneate to rounded. *Stipules* erect to recurved, narrowly triangular, hyaline, 3-7

mm long, densely pubescent. *Inflorescences* condensed axillary and terminal racemes, more than 15-flowered, peduncle and rachis densely sericeous; *peduncle* 15-33 mm long, angular; *rachis* 3-10 mm long, angular; *subtending bracts* caducous, scale-like, prominently trifid, 4-6 mm long, densely pubescent. *Flowers :pedicels* terete, 2-3 mm long, densely pubescent. *Calyx* campanulate, 5-7 mm long including the c. 0.75 mm receptacle, lobes not recurved, densely pubescent, hairs bicoloured, with white hairs becoming golden towards the lobe apices; upper two lobes united into a truncate, emarginate lip, c. 2.5-3 mm long; lower three lobes triangular, acute, c. 2.5-3 mm long. *Corolla*: *standard* transversely elliptic, c. 9 x 8 mm including the 3 mm claw, orange-yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, c. 8 x 3 mm including the 2 mm claws, red with a yellow edge, apex rounded, incurved and overlapping the keel, base auriculate on the upper margin only, not or slightly saccate; *keel* half broadly elliptic, c. 8 x 2 mm including the 3 mm claws, red, apex rounded, base auriculate, saccate. *Style* very long, hooked, lower third slightly pubescent; *ovary* very shortly stipitate, densely pubescent; *ovules* c. 4. *Pod* and *seed* not seen.

Flowering period. October. *Fruiting period*. Unknown.

Distribution (Map 66). South-west Western Australia. *Gastrolobium whicherensis* is currently known only from the Whicher Range area, south of Perth.

Habitat. Grows on steep westerly slopes on red-grey sandy clay over quartzite, in *Eucalyptus haematoxylon* woodland.

Specimens examined. Only the type specimen was seen for this species.

Toxicity. Unknown.

Affinity. Similar to *Gastrolobium retusum*, which differs by having ± spathulate leaves, and the stipules do not have a thickened, grey-tomentose base, fewer flowers per inflorescence (8-12), and shorter peduncles (2-10 mm long).

Map 66. Distribution of *G. whicherensis*.

67. Gastrolobium ebracteolatum G.Chandler & Crisp, *nom. nov.* *Base name*: *Callistachys linearis* Benth. (1837a). *Oxylobium lineare* (Benth.) Benth. (1864, p. 17). *Chorizema lineare* (Benth.) F.Muell. (1863, p. 17), published as '*Chorozema*'. *Type citation*: none cited. *Lectotype* (here chosen): W (Swan River, Hügel); *isolecto*: K. *Notes*: a new specific epithet was required, as the name *G. lineare* was already taken.

Etymology. This species has often been confused with *Callistachys lanceolata*, which has bracteoles, so the specific epithet refers to the lack of bracteoles on *G. ebracteolatum*.

Slender, erect *shrubs*, 1.5-4 m high. *Branchlets* slightly angular, ascending, sparsely to moderately pubescent. *Petioles* terete, continuous and slightly decurrent with the branchlet, 2-3 mm long. *Leaves* spreading to ascending, scattered along the branchlet, linear-ovate to linear-elliptic, 50-115 x 3.5-10 mm, upper surface glabrous, lower surface glabrous to moderately sericeous, venation prominently reticulate; apex rounded, weakly mucronate; margins slightly recurved; base rounded to slightly cuneate. *Stipules* erect, hyaline, 2.5-4 mm long. *Inflorescences* terminal racemes, 20 to more than 30 flowered, moderately sericeous; *peduncle* 5-20 mm long; *rachis* 60-180

mm long; *subtending bracts* ultimately caducous but persisting until well after anthesis, scale-like, trilobed (although this may be obscured by the pubescent of the bract), middle lobe longer than the outer two, 4-5 mm long, densely villous. *Pedicels* terete, 1-3 mm long, densely villous. *Calyx* broadly campanulate, 9-10 mm long including the c. 1.5 mm receptacle, densely villous, bicoloured, with silvery hairs at the base becoming golden brown at the lobes, or occasionally unicoloured with all hairs golden brown, lobes not recurved, lower three lobes may be slightly incurved; upper two lobes united higher than the lower three, obtuse, 6-7 mm long; lower three lobes triangular, acute, 5-6 mm long. *Corolla*: *standard* transversely ovate, c. 12 x 13 mm including the 3 mm claw, pale yellow to maroon with a small yellow centre, apex emarginated, base cordate, saccate; *wings* ovate to oblong, c. 11 x 3.5 mm including the 2 mm claws, red, apex rounded, not incurved but with apices touching to slightly enclose the keel, base strongly auriculate on both margins, saccate; *keel* half broadly oblong, margins not incurved, c. 11 x 3.5 including the 2 mm claws, pale yellow to cream or red, apex rounded, base auriculate, saccate. *Style* long, slightly hooked, base pubescent; *ovary* stipitate, densely pubescent; *ovules* c. 18. *Pod* stipitate, ovoid, 11-12 x 5-6 mm, moderately to densely pubescent. *Seed* not seen.

Flowering period. October to December. *Fruiting period*. November and December.

Distribution (Map 67). Occurs throughout the Darling escarpment, mostly east and south of Perth from Helena Valley south to Tonebridge, but with one outlier near Gingin, north of Perth.

Habitat. Occurs in riverine habitats or in swampy woodlands on loam or sandy loam soils, in open woodland or Jarrah (*Eucalyptus marginata*) forest.

Selected specimens (17 examined). WESTERN AUSTRALIA: Darling District: Tonebridge, 34°15'S, 116°44'E, *M.D. Crisp 8471 & W. Keys*, 23 Sep. 1993 (CANB); Helena Valley, 31°56'S, 116°02'E, *J. Seabrook 451*, 12 Nov. 1977 (CANB, PERTH); Junction of Brookway Road & Bekin Road, near bridge over creekline, ca 13.5 km NE of Kirup, 33°39'19"S, 116°06'38"E, *T.R. Lally 1353 & B. Lepschi*, 17 Nov. 1996 (CANB, PERTH); 140 m S of Cloister Avenue, Canning River foreshore, 32°07'S, 116°01'E, *M.L. Clark 145*, 18 Sep. 1974 (CANB, PERTH); 10 km NW of Gingin, 31°18'S, 115°50'E, *K. Paijmas 3784*, 19 Sep. 1980 (CANB).

Toxicity. Unknown.

Map 67. Distribution of *G. ebracteolosum*.

Affinity. The long, linear leaves and long racemes does not resemble those of any other species of *Gastrolobium*, but this species has been confused with the linear-leaved form of *Callistachys lanceolata* in the past. In this case, flowers are required for a positive identification, preferably buds, as *C. laneolata* has caducous bracteoles on the calyx, whereas *G. ebracteolatum* lacks bracteoles. A further aid to identification is the distribution, with *C. lanceolata* generally confined to the south coast, whilst *G. ebracteolatum* occurring further north and east, mainly along the Darling Range escarpment.

68. Gastrolobium acutum Benth. in Lindley (1839, p.). *Oxylobium acutum* (Benth.) Benth. (1864, p. 24). *Callistachys acuta* (Benth.) Kuntze (1891, p. 168). *Nemcia acuta* (Benth.) Domin 1923a, p. 30). *Type citation*: not cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond, 1839); *isolecto*: BM x 2, CGE.

Bushy *shrubs*, to 1.5 m high. *Branchlets* ascending, angular, white tomentose. *Petioles* terete, continuous and slightly decurrent with the branchlet, 1-2 mm long. *Leaves* patent or retrorse, ternate, rigid, narrowly elliptic to ovate, 12-22 x 4-6 mm, glabrous, venation prominently reticulate, raised; yellow-green; apex acute, pungent-pointed; margins

incurved to unevenly plicate, entire; base rounded. *Stipules* erect, hyaline, c. 3 mm long. *Inflorescences* solitary or paired flowers in the axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, trilobed with a much longer middle lobe, lobes shorter than tube, 4-5 mm long, moderately pubescent outer surface, glabrous inner. *Pedicels* terete, 2-3 mm long, densely pubescent. *Calyx* campanulate, 6-8 mm long including the c. 1 mm receptacle, moderately pubescent, lobes not to slightly recurved; upper two lobes united higher than the lower three, acute, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, 8-9.5 x 9-9.5 mm including the 3.5-4.5 mm claw, yellow with a thick red area surrounding the tiny, yellow centre, apex emarginate, base truncate, not auriculate; *wings* obovate, 7-8 x 2.5-3 mm including the 2-2.5 mm claws, yellow, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, slightly saccate; *keel* half broadly obovate, 7-8 x 2-2.5 mm including the 2.5-3 mm claws, red, apex obtuse, base auriculate, saccate.. *Style* long, hooked, lower half pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, ovoid, 7-9 mm long, densely pubescent. *Seed* not seen.

Flowering period. August and September. *Fruiting period*. From October.

Distribution (Map 68). South-west Western Australia. Occurs from the Port Gregory region, near Northampton, south to Armadale, in the Perth region.

Habitat. Grows in gravel pits and shrubland with species such as *Dryandra sessilis*, *Boronia cymosa* and *Geleznowia verrucosa*.

Convsertation status. ROTAP: 3KC-. CALM: P3. This taxon is rare, though not considered to be at risk, and further survey work is required to further determine its conservation status.

Selected specimens (9 examined). WESTERN AUSTRALIA: Irwin District: Gravel pit, 15 km from Northampton on Port Gregory Road, 28°17'58"S, 114°30'37"E, *R. Davis 3598*, 8 July 1997 (CANB, PERTH). Darling District: Greenmount, 31°54'S, 116°03'E, ex Herb. *W.V. Fitzgerald s.n.*, Sep. 1900 (CANB, NSW); Darlington, Darling Range, 31°55'S, 116°04'E, *A. Morrison s.n.*, 11 Oct. 1906 (CANB, PERTH).

Toxicity. Unknown.

Affinity. Similar to *G. epacridoides*, which is easily differentiated by the lack of stipules, and also has shorter, broader leaves (11-14 x 8 mm). *Gastrolobium capitatum*

is also similar to *G. acutum*, but the former species can most easily be distinguished by the condensed terminal and axillary racemes, but also by the longer, relatively much narrower leaves (35-55 x 3-10 mm).

Map 68. Distribution of *G. acutum*.

69. Gastrolobium capitatum (Benth.) G.Chandler & Crisp, *comb. nov.* *Oxylobium capitatum* Benth. (1837, p. 28). *Callistachys capitata* (Benth.) Kuntze (1891, p. 168). *Nemcia capitata* (Benth.)Domin 1923a, p. 30). *Type citation*: "Swan-River et King Georges Sound. (Hügel.)." *Type specimens*: *Lectotype* (here chosen): K (K. Georges Sound, Hügel); *isolecto*: W.

Prostrate to low, bushy *shrubs*, to 1 m high. *Branchlets* trailing, white tomentose. *Petioles* terete, continuous but not decurrent with the branchlet, 1-2 mm long. *Leaves* spreading, opposite or alternate, narrowly to linear-elliptic to obovate, 35-55 x 3-10 mm, glabrous, venation prominently reticulate; apex acute with 3-4 mm long filiform mucro; margins not recurved; base cuneate. *Stipules* erect, filiform, 6-8 mm long. *Inflorescences* condensed terminal and axillary racemes, 2-6-flowered; *peduncle* 2-3 mm long; *rachis* 1-2 mm long; *subtending bracts* caducous, scale-like, filiform 4 mm long. *Pedicels* terete, 2-3 mm long. *Calyx* campanulate, 7-8 mm long including the c.

1.5 mm receptacle, moderately villous, lobes not or scarcely recurved; upper two lobes united higher than the lower three, rounded, c. 3 mm long; lower three lobes triangular, acute, c. 2.5 mm long. *Corolla*: *standard* transversely ovate, c. 10 x 15 mm including the 5 mm claw, orange-yellow red ring surrounding the yellow centre, apex emarginate, base strongly cordate, not auriculate; *wings* obovate, 11-12 x 4.5 mm long including the c. 4 mm claws, orange, apex rounded, incurved, overlapping and enclosing the keel, base auriculate on the upper margin only, saccate; *keel* half transversely elliptic, margins not incurved, c. 10 x 4 mm including the 4 mm claws, red, apex obtuse, base auriculate, saccate. *Style* long, incurved, pubescent at very base; *ovary* shortly stipitate, densely pubescent; *ovules* 4-8. *Pod* almost sessile, ovoid, 7-9 x 2.5-4 mm, moderately pubescent. *Seed* not seen.

Flowering period. June to September. *Fruiting period*. September to November.

Distribution (Map 69). South-west Western Australia. Widespread along the Darling Range escarpment, from Gin Gin in the north to Capel, near Busselton, and King Georges Sound in the south.

Map 69. Distribution of *G. capitatum*.

Habitat. Grows in a variety of habitats, from wet to quite dry, on sandy to loamy soils in woodland or open forest.

Selected specimens (36 examined). WESTERN AUSTRALIA: Darling district: Gin Gin cemetery, 31°21'S, 115°54'E, *A. Kanis 1503*, 7 Aug. 1973 (CANB); 0.5 km S of Yoongarillup Community Hall on Vasse Highway (c. 12 km SE of Busselton), 33°43'15"S, 115°26'00"E, *M.D. Crisp 8943 & W. Keys*, 12 Oct. 1996 (CANB, PERTH); Reserve 23172 (C58) along Harvey Rover, about 8 km E of Yalgorup, 32°52'S, 115°46'E, *B.J. Keighery & N. Gibson 120*, 2 Sep. 1993 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species is somewhat similar to *G. acutum*, which is easily distinguished by the inflorescence, which has flowers that are solitary or in pairs in the axils, and the leaves are shorter and relatively broader (12-22 x 4-6 mm). The broader-leaved form of *G. linearifolium* is similar to *G. capitatum*, but can be distinguished by the tomentose to villous indumentum, and the glabrate leaves that are generally obovate, whereas *G. capitatum* has a sericeous indumentum (or the calyx may tend to be villous), the leaves are more or less persistently sericous beneath, and are ovate to elliptic (rarely obovate).

70. Gastrolobium alternifolium G.Chandler & Crisp, *sp. nov. Type*: WESTERN AUSTRALIA: Darling District: West Talbot Road, 8 km E of Helena Road and 3.2 km W of Luelfs Road (= Gunapin Ridge Road), 32°00' 25"S, 116°35'40"E, *M.D.Crisp* 8513 & *W.Keys*, 27 Sep. 1993 (*holo*: CANB [CBG 9310973]; *iso*: PERTH).

A short shrub to 0.3 m high with paired or solitary flowers almost sessile in the upper branches, which is easily distinguished from most species of *Gastrolobium*, as the large, ovate leaves are alternately arranged, not opposite or whorled.

Frutex humilis ad 0.3 m altus floribus fere sessilis geminis vel solitariis in axilibus supernis; a *Gastrolobii* speciebus ceteris foliis magnis (25-50 x 12-30 mm) ovatis alternis nec oppositis nec verticillatis facile distincta.

Etymology. This species is named after the unusual leaf arrangement for *Gastrolobium*, being alternately arranged.

Open, many stemmed *shrubs*, to 0.3 m high. *Branchlets* ascending, angular, scruffy with mostly appressed hairs, glabrescent. *Petioles* terete, continuous and slightly decurrent with the branchlet, 1-2 mm long. *Leaves* spreading to ascending, alternate, ovate, 25-50 x 12-30 mm, glabrous, upper surface slightly glaucous, lower surface

green, venation prominently reticulate, raised; apex rounded, often somewhat emarginate, stiffly mucronate; margins very slightly crenulate and undulate; base cordate, rounded or obtuse. *Stipules* recurved, triangular, 2-4 mm long, base pubescent. *Inflorescences* single or paired flowers in upper axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, trilobed, lobes all about the same length as the tube, 4-5 mm long. *Pedicels* pubescent, less than 1 mm long. *Calyx* campanulate, 6-8 mm long including the c. 1 mm receptacle, densely villous, lobes not or scarcely recurved; upper two lobes united higher than the lower three, acute, 3.5-4 mm long; lower three lobes triangular, acute, 3.5-4 mm long. *Corolla*: *standard* elliptic, c. 11.5-13 x 10 mm including the 4 mm claw, yellow outer, red in the large, mid-part of the lamina, with a tiny, yellow centre, apex emarginate, base cordate; *wings* broadly obovate, c. 10 x 5 mm including the 3 mm claws, yellow and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on upper margin only, saccate; *keel* half obliquely very broadly elliptic, margins not incurved, c. 9-11 x 3.5 mm including the 3 mm claws, deep maroon, apex broadly rounded, base auriculate, saccate. *Style* strongly incurved, lower third pubescent; *ovary* sessile, densely pubescent; *ovules* 2-3. *Pod* sessile, ovoid, 6-8 mm long, softly grey pubescent. *Seed* not seen.

Flowering period. July to September. *Fruiting period*. October and November.

Distribution (Map 70). South-west Western Australia. Grows in the Darling escarpment region east of Perth, near York.

Habitat. Grows in sandy gravel in *Banksia attenuata* heath.

Conservation status. CALM: P3. This taxon is rare, but not considered to be at risk, but further survey work is required.

Specimens examined. WESTERN AUSTRALIA: Darling District: 33 km WNW of Beverley, W Talbot Road, 3 km NW of Gunapin Ridge Road turnoff, 32° 00'S, 116°35'E, M.D. Crisp 6727, 26 July 1980 (CANB, PERTH); West Talbot Road, 8 km E of Helena Road and 3.2 km W of Luelfs Road (= Gunapin Ridge Road), 32°00'25"S, 116°35'40"E, M.D. Crisp 8513 & W. Keys, 27 Sep. 1993 (CANB, PERTH); Kelmscott to Brookton Highway, V.E. Sands 638.6.7, 10 Aug. 1963 (PERTH); Brookton Highway, 1.7 km W of Warradale Road, 32°16'02"S, 116°29'15"E, F. Hort 556 & L. Boyle, 22 Aug. 1999 (CANB, PERTH).

Map 70. Distribution of *G. alternifolium*.

Toxicity. Unknown.

Affinity. The large, ovate, alternately arranged leaves easily distinguish this species from its close relatives *G. capitatum* and *G. acutum* which have opposite leaves. Furthermore, *G. capitatum* has narrower leaves (2-10 mm broad) and *G. acutum* has generally smaller leaves (12-22 x 4-6 mm).

71. Gastrolobium linearifolium G.Chandler & Crisp, *nom. nov.* *Callistachys oxylobioides* Meisn. (1844, p. 27). *Oxylobium reticulatum* Meisn. (1844, p. 29), *pro parte* (only those specimens based on *Callistachys oxylobioides* Meisn.). *Type citation*: "In arenosis sylvae prope deversorium publicum Pineapple (Perth) d. 6. Jun. Herb. Preiss. no. 842. et in calcareis inter frutices densos prope oppidum Freemantle, d. 18. Dec. 1839. No. 841." *Type specimens*: *Lectotype* (here chosen): LD (Preiss 842); *isolecto*: GOET x 2, MO (left hand specimen); NY (right hand and centre specimens), S (left hand specimen); W (2 sheets).

Notes. A new specific epithet is required because the name *Gastrolobium oxylobioides* is already occupied (see *Gastrolobium oxylobioides*).

Etymology. The new specific epithet refers to the linear leaves.

Low, bushy, sometimes almost prostrate *shrubs*, 0.3-1 m high. *Branchlets* spreading, angular, densely villous. *Petioles* terete, continuous and decurrent with the branchlet, 1-2 mm long. *Leaves* initially opposite and slightly obovate, rapidly becoming ternate in later developmental stages and very narrowly elliptic to essentially linear, 35-70 x 4-6 mm, glabrous, venation prominently reticulate, raised; apex recurved, prominently mucronate; margins becoming conduplicate; base cuneate. *Stipules* recurved, hyaline, 4-6 mm long. *Inflorescences* condensed axillary racemes or solitary flowers in the axils; *peduncle* 0-2 mm long; *rachis* 0-4 mm long; *subtending bracts* caducous, scale-like, trifid, the lobes about equal and much shorter than the tube, 2-3 mm long. *Pedicels* less than 3 mm long. *Calyx* campanulate, c. 7 mm long including the c. 1 mm receptacle, densely villous, lobes ; upper two lobes united slightly higher than the lower three, acute, c. 5.5 mm long; lower three lobes triangular, acuminate, 5 mm long. *Corolla*: *standard* transversely ovate, 13-14 x 14-16 mm including the c. 2.5 mm claw, yellow-orange, with a deep maroon reverse side, apex emarginate, base cordate, not auriculate; *wings* obliquely obovate, c. 9-11 x 3 mm including the 2.5 mm claws, red and yellow, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half broadly to very broadly ovate, 8-10 x 3 mm including the 3.5 mm claws, dark red-brown, apex rounded, base auriculate, saccate. *Style* long, strongly incurved, base pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 8-9. *Pod* almost sessile, broadly ovoid, 8-10 x 4-5 mm long, silky pubescent. *Seed* not seen.

Flowering period. August to October. *Fruiting period*. October and November.

Distribution (Map 71). South-west Western Australia. Occurs mainly north of Perth, on the coastal plain and in the Darling escarpment.

Habitat. Grows on the near-northern coastal sandplains and in the escarpment on sandy soils, in eucalypt woodland and scrub with a heath understorey.

Selected specimens (20 examined). WESTERN AUSTRALIA: Avon district: Waddington, 30°50'S, 116°16'E, *H.E. Groves s.n.*, 8 Aug. 1953 (CANB, PERTH). Darling district: 38 km N of Muchea along the Brand Highway, 31°15'S, 115°49'E, *M.D. Crisp 6454*, 15 July 1980 (CANB); 4.2 km from turnoff on Lancelin Road towards Seabird, 31°16'S, 115°27'E, *M.D. Crisp 8531 & W. Keys*, 3 Oct. 1993 (CANB, PERTH); 2 km from Seabird P.O. towards Wanneroo Road, 31°15'41"S, 115°26'42"E,

G.T. Chandler 540 et al., 21 Feb. 1998 (CANB). Irwin district: 2 km S of Cockleshell Gully and 13 km NE of Jurien Bay, 30°09'S, 115°07'E, *M.G. Corrick 8037*, 19 Sep. 1982 (CANB, MEL); 2 miles N of Reagans Ford, 30°59'S, 115°42'E, *R.J. Cranfield 210*, 19 July 1978 (CANB, PERTH).

Map 71. Distribution of *G. linearifolium*.

Toxicity. Unknown.

Affinity. This species has previously been confused with *Gastrolobium nervosum* Meisn. [syn. *Nemcia reticulata* (Meisn.) Domin], but differs in the dense, silky white, erect hairs on new growth and calyces, the ternate, conduplicate (more or less folded lengthwise) linear leaves with a size range of 35-70 x 4-8 mm, and the apex recurved and mucronate, rather than bilobed. The broader-leaved form of *G. linearifolium* is similar to *G. capitatum*, but the latter has a sericeous indumentum (or the calyx may tend to be villous), the leaves are more or less persistently sericous beneath, and are ovate to elliptic (rarely obovate), whereas *G. linearifolium* has a tomentose to villous indumentum, and the glabrate leaves that are generally obovate.

72. Gastrolobium nervosum (Meisn.) G.Chandler & Crisp, *comb. & stat. nov.* *Oxylobium nervosum* Meissner (1855a, p. 12). *Type citation*: "Drum. Coll. VI. n. 21." *Type specimens*: *holo*: K; *iso*: W.

> *Oxylobium reticulatum* Meisn. (1844, p. 29). *Nemcia reticulata* (Meisn.) Domin 1923a, p. 30). *Type citation*: "In clivulis arenosis ad littus maria, d. 19. Jun. 1839. Herb. Preiss. No. 840. et in region. interior. Australiae merid.-occid. m. Febr. 1841 No. 831. (Drummond n. 215.)." *Type specimens*: *Lectotype* (here chosen): BM (Drummond 215).

Typification. A new specific epithet is required because the name *Gastrolobium reticulatum* is already occupied [see *Gastrolobium reticulatum*], so the next available name, *G. nervosum*, was chosen.

Small *shrubs*, 0.3-0.5 m high. *Branchlets* ascending, angular, moderately tomentose. *Petioles* terete, continuous and decurrent with the branchlet, 2-5 mm long. *Leaves* opposite, linear, narrowly spathulate, narrowly obovate to obovate, rarely longitudinally recurved, 25-40 x 20-22 mm, glabrous, venation prominently reticulate; apex bilobed or acute, unarmed or mucronate or rarely pungent-pointed; margins flat, slightly crenulate, or strongly undulate, sometimes incurved; base obtuse. *Stipules* erect, hyaline, 3-5 mm long. *Inflorescences* axillary umbels or in pairs in the axils; *peduncle* 0-4 mm long; *rachis* nil; subtending *bracts* caducous, scale-like, obtriangular, trilobed, lobes much longer than tube, 4-5 mm long. *Pedicels* terete, to 2 mm long. *Calyx* campanulate, 6-7 mm long including the c. 1 mm receptacle, densely tomentose; lobes not recurved; upper two lobes united higher than the lower three, acute, c. 3.5 mm long; lower three lobes triangular, acute, c. 3.5 mm long. *Corolla*: *standard* transversely ovate, 11-12 x 14-15 mm including the c. 3.5 mm claw, auriculate, yellow and red, apex emarginate, base truncate to slightly cordate, not auriculate; *wings* oblong, c. 9-10 x 3 mm including the 3 mm claws, yellow and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half very broadly elliptic, margins not incurved, c. 8-9 x 3 mm including the 3.5 mm claws, maroon, deeper at the apex, apex obtuse to slightly rounded, base auriculate, saccate. *Style* longer than the ovary, slightly hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 6-10. *Pod* stipitate, ovoid, 9-11 x 3-4 mm, moderately pubescent. *Seeds* ellipsoid, slightly ridged, c. 2.5 mm long, arillate.

Flowering period. August to October. *Fruiting period.* October and November.

Distribution (Map 72). South-west Western Australia. Occurs widely, from Eneabba south to Busselton.

Habitat. Grows on the coastal limestone plain and coastal sandplains north of Perth in heath and shrubland.

Selected specimens (11 examined). WESTERN AUSTRALIA: Darling district: City Beach, north of Perth, 31°56'S, 115°45'E, *J. Pulley 1323*, 12 Aug. 1973 (CANB, L); City Beach, 31°56'S, 115°45'E, *R.J. Cranfield 394*, 7 Sep. 1978 (CANB, PERTH); 1 km S of Seabird, 31°16'S 115°26'E, *M.D. Crisp 8526 & W. Keys*, 3 Oct. 1993 (CANB, NSW, PERTH, UWA); Whitford's Node's, Coast Road opp. Whitford's Ave, Wanneroo, 25 km N of Perth, 31°45'S, 115°48'E, *G.J. Keighery 7085*, 1 Aug. 1984 (CANB, PERTH).

Toxicity. Unknown.

Map 72. Distribution of *G. nervosum.*

Affinity. Gastrolobium nervosum is similar to *G. linearifolium*, which differs in habitat and has erect, villous hairs on new growth and the calyx. Also, *G. nervosum* always has opposite, obovate, mostly truncate or bilobed leaves, 25-40 x c. 20-25 mm, the margins

are often undulate or incurved, and are not conduplicate. *Gastrolobium nervosum* has also been confused with, and is vegetatively similar to *G. crispatum*, which is a tall shrub to 2 m high, with leaves in whorls of two to five, and terminal clusters of up to ten flowers, which serves to distinguish it quite easily.

73. Gastrolobium crispatum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Darling District: Track to Mount Byroomanning, NE of Bindoon, 31°22'09"S, 116°07'22"E, *M. Hislop 1700*, 27 Sep. 1999 (*holo*: PERTH; *iso*: CANB). *Notes*: this species has also been referred to as *Nemcia sparsa* (Crisp, ined.) in the past.

Tall shrubs with long internode distances on the yellow stems, the leaves are ternate, spathulate, and have cripsed to undulate margins, the subtending bracts are 4-5 mm long, entire, and tapering to a recurved apex, the inflorescence is a condensed raceme, the calyx is villous with silver white hairs at the base and golden brown hairs towards the lobe apices, all of which distinguish this species from all other species of *Gastrolobium*.

Frutices altis, ramuli flavi internodiis longis, folia ternata spathulata marginibus maxime undulatis, bracteae subtendentes 4-5 mm longae integrae et ad apicem recurvae attenuatae, inflorescentia racemus condensatus, calyx villosus pilis argenteis ad basim et aurei-brunneis versus lobiorum apices.

Etymology. The specific epithet refers to the crisped leaf margins.

Tall *shrubs*, to 2.5 m high. *Branchlets* ascending, angular, densely sericeous. *Petioles* terete, continuous and prominently decurrent with the branchlet, c. 5 mm long. *Leaves* bilobed in early developmental stages, opposite or in whorls of 3-5, spathulate, 20-35 x 15-20 mm, glabrous or with the lower surface slightly hispid, surfaces shining green, purplish in new growth, venation prominently reticulate; apex rounded, slightly recurved, slightly mucronate; margins crisped to undulate, somewhat recurved; base cuneate. *Stipules* erect, linear-triangular, 6-9 mm long, base pubescent. *Inflorescences* condensed terminal racemes, c. 10-flowered; *peduncle* 15-30 mm long; *rachis* 3-7 mm long; *subtending bracts* caducous, scale-like, entire, with a thick base, tapering to a long, recurved apex, 4-5 mm long. *Pedicels* terete, 2-4 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.5 mm receptacle, moderately to densely pubescent, with silky silvery hairs at the base and golden hairs on the lobes, lobes not or scarcely recurved; upper two lobes united higher than the lower three, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, apex

emarginate, base cordate, not auriculate, c. 8.5-12 x 8-12 mm including the 4 mm claw, yellow becoming orange basally; *wings* obovate, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, slightly saccate, c. 8.5-10 x 3 mm including the 3 mm claws, mainly yellow; *keel* half very broadly elliptic, apex rounded, base auriculate, saccate, c. 9-10 x 3 mm including the 3 mm claws, red. *Style* long, strongly incurved, base pubescent; *ovary* very slightly stipitate, densely pubescent; *ovules* 2. *Pod* ± sessile, ovoid, 6-7 x 3-3.5 mm, moderately pubescent. *Seeds* reniform, c. 2.5 mm long, arillate.

Flowering period. September and October. *Fruiting period.* October and November.

Distribution (Map 73). South-west Western Australia. Restricted to the Bindoon area, to the north of Perth.

Map 73. Distribution of *G. crispatum.*

Habitat. Grows in steep gullies in *Eucalyptus accedens* and *Corymbia calophylla* woodland with *Acacia* sp., *Xanthorrhea sp. Hypocalymma angustifolium*, *Melaleuca uncinata* and *Hakea undulata.*

Conservation status. ROTAP: 2K. CALM: P1. This species is rare, and is at some risk, with further survey work urgently required to determine the conservation status of this species.

Specimens examined. Western Australia: Darling District: Julimar Farm, Flat Rocks Road, Bindoon, c. 31°23'S, 116°06'E, *S. Patrick 458*, 8 Oct. 1988 (CANB, PERTH); Bindoon, c. 29°57'S, 115°12'E, *J. Elliot s.n.*, Nov. 1987 (CANB, PERTH).

Toxicity. Trace levels of fluoroacetate were found in this species (< 20 $\mu g.g^{-1}$; tested by the Chemistry Centre, Department of Mines, Western Australia, 24 Nov. 1988).

Affinity. The extremely undulate or crisped leaf margins of this species make it difficult to confuse with any other species of *Gastrolobium*.

74. Gastrolobium effusum (Crisp & Mollemans) G.Chandler & Crisp, *comb. nov.* *Nemcia effusa* Crisp & Mollemans (1993, p. 223). *Type citation*: "Western Australia, Wheatbelt (SE), Lake Grace Shire; c. 26 km SE of Kukerin, 25.6 km NE of Nyabing and 51.5 km east of Dumbleyung (precise locality withheld), 31° 21'S, 118°19'E, 26 Aug. 1992, *F.H.Mollemans* 4260". *Type specimens*: *holo*: PERTH; *iso*: CANB.

Diffuse, open, spreading, straggling *shrubs* to 1 m high and broad. *Branchlets* ascending, angular, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, c. 2 mm long, moderately pubescent. *Leaves* broadly spreading, ternate, narrow oblong to elliptic, 10-25 x 3-4 mm, glabrous, venation thickly reticulate, lower surface with areoles impressed-punctate; apex obtuse, scarcely recurved; margins entire, not recurved; base tapering into the petiole. *Stipules* erect, hyaline, prominent, 2-3 mm long. *Inflorescences* condensed axillary racemes, 2-6-flowered; *peduncle* 0-2 mm long; *rachis* 0-1 mm long; *subtending bracts* caducous, trifid, to 4 mm long, moderately sericeous. *Pedicels* terete, c. 0.5 long. *Calyx* campanulate, 4-5 mm long including the c. 0.5 mm receptacle, moderately villous, lobes not recurved; upper two lobes united much higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely broadly elliptic, c. 9.5 mm x 9 mm including the 3.5 mm claw, apricot with red-maroon markings, apex emarginate, base truncate; *wings* obovate, c. 8 x 3 mm including the 2 mm claws, apricot and maroon, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half broadly ovate, c. 8 x 2.5 including the 2 mm claws, maroon, apex ± acute, base auriculate, saccate. *Style* long, hooked, lower half pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. July to August. *Fruiting period.* Unknown.

Distribution (Map 74). South-west Western Australia. Occurs around Lake Grace.

Habitat. Grows on undulating dunes on gravelly, sandy soil in mallee and mixed scrub.

Conservation status. ROTAP: 2K. CALM: P2. This species is rare, but does not appear to be at risk.

Specimens examined. Only the type specimen was available for this taxon.

Toxicity. Unknown.

Map 74. Distribution of *G. effusum*.

Affinity. With the distinctive punctate pattern on the undersurface of the leaf, this species is unlikely to be confused with any other. *Gastrolobium punctatum* has similar leaf patterning, but much smaller leaves (8-12 x 2-3 mm) that are strongly recurved and exstipulate, and has single or paired flowers in the axils, rather than condensed racemes. *Gastrolobium stipulare* also shows some similarity to *G. effusum*, but has erect, linear

leaves (c. 2 mm broad) with craspedodromous venation lacking deeply impressed areoles on the lower surface, and the stipules are longer (up to 12 mm long).

75. Gastrolobium stipulare Meisn. (1848, p. 218). *Nemcia stipularis* (Meisn.) Crisp (1987, p. 128). *Type citation*: "Swan River, Drummond coll. III. No. 93." *Type specimens*: *Lectotype* (here chosen): K (the larger specimen); *isolecto*: K (the smaller, sterile specimen), FI-W, MEL, W; *klepto*: NY.

Erect, leafy *shrubs*, c. 0.5 m high. *Branchlets* ascending, ± terete, densely tomentose. *Petioles* terete, articulate with the branchlet, 1-2 mm long. *Leaves* patent to retrorse, in whorls of 3, linear, 20-30 x 2-3 mm, upper leaf surface with distinctive horizontally grooved venation, lower surface with only the midrib visible; apex pungent-pointed; margins recurved; base cuneate. *Stipules* erect, linear-triangular, 8-12 mm long, villous for most of the length. *Inflorescences* 2-3 solitary flowers in the axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, with lobes longer than tube, the middle lobe shorter usually than outer lobes, to 5 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 5-6 mm long including the c. 1 mm receptacle, moderately pubescent, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely ovate, 7-9 x 7-10 mm including the c. 2.5 mm claws, yellow with a red-brown centre, apex emarginate, base cordate, slightly auriculate; *wings* obovate, c. 7-9 x 2 mm including the 2.5 mm claws, yellow, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only, saccate; *keel* half broadly to very broadly elliptic, 7-9 x 2.5 mm including the 2.5 mm claws, red-brown, apex rounded, base auriculate, saccate. *Style* much longer than the ovary, slightly hooked, base pubescent; *ovary* sessile, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. September. *Fruiting period*. Unknown.

Distribution (Map 75). South-west Western Australia. Known only from a few collectons, and occurs around the Brookton and Boyagin Rock areas.

Map 75. Distribution of *G. stipulare*.

Habitat. Grows on sandy soils over laterite in heath.

Conservation status. IUCN: R. ROTAP: 2RCi. CALM: P4. This species is rare, but does not appear to be at risk.

Specimens examined. WESTERN AUSTRALIA: Darling District: 16 km W of Brookton, 32°21'S, 116°50'E, *P.C. Williams 121*, 13 Sep. 1984 (CANB, PERTH); Boyagin Rock, SW of Narrogin, 32°28'S, 116°34'E, *C.E. Woolcock W2342 & D.T. Woolcock*, 17 Sep. 1985 (CANB).

Toxicity. Unknown.

Affinity. This species has such distinctive leaves it is unlikely to be confused with any other species of *Gastrolobium*.

The *G. ilicifolium* group

This group contains species that generally have more than three pungent apices on each leaf, with clustered inflorescences.

76. Gastrolobium ilicifolium Meisn. (1844, p. 67). *Nemcia ilicifolia* (Meisn.) Crisp (1987, p. 126). *Type citation*: "In limoso-lapidosis umbrosis ad latus septentrionale montis Bakewell (York) d. 8. Sep. 1839. Herb. Preiss. No. 821. et in region interior. Australiae merid.-occid., m. Febr. 1841. No. 829. (Drummond n. 211.)." *Type specimens*: *Lectotype* (here chosen): BM (Drummond 211); *isolecto*: K (2 sheets), W (2 sheets).

> *Gastrolobium verticillatum* Meisn.(1855b, p. 28). *Gastrolobium ilicifolium* Meisn. var. *lobatum* Benth. (1864, p. 102). *Type citation*: "Drumm. Coll. VI. n. 24." *Type specimens*: *holo*: NY; *iso*: BM, CGE, K, LD, W.

Tall, erect *shrubs* to 4 m high. *Branchlets* ascending, angular, moderately villous. *Petioles* terete, continuous and decurrent with the branchlet, 1-2 mm long. *Leaves* spreading to ascending, ternate, ± spathulate, 18-48 x 15-30 mm, glabrous, venation prominently reticulate; apex truncate, fiercely pungent-pointed; margins lobed, with numerous pungent angles, slightly recurved; base cuneate. *Stipules* erect, hyaline, 7-8 mm long. *Inflorescences* dense, axillary clusters; *peduncle* 2-3 mm long; *rachis* 1-3 mm long; *subtending bracts* somewhat persistent, scale-like, trifid with the central lobe robust and shorter than the 2 outer, more acuminate lobes, c. 5 mm long. *Pedicels* terete, 2-5 mm long. *Calyx* campanulate, 6-7 mm long including the c. 1 mm receptacle, moderately to densely villous, lobes not recurved; upper two lobes united higher than the lower three, c. 3.5 mm long; lower three lobes triangular, acute, c. 3 mm long. *Corolla*: *standard* transversely elliptic, c. 9-10 x 9 mm including the 4 mm claw, yellow with some red present towards the centre, apex emarginate, base cordate, not auriculate; *wings* obovate, c. 9.5 x 3 mm including the 3 mm claws, yellow, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only, saccate, *keel* half circular, margins not incurved, c. 9 x 3 mm including the 6 mm claws, red, apex rounded, base strongly auriculate, saccate. *Style* long, strongly incurved to hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, broadly ellipsoid, c. 5 x 3 mm long, moderately to densely villous. *Seed* not seen.

Flowering period. August to October. *Fruiting period*. Unknown.

Distribution (Map 76). South-west Western Australia. Occurs from Dinner Hill (which is between Eneabba and Moora) south to Beverley, east of Perth, with an outlier further to the south at Kojonup.

Map 76. Distribution of *G. ilicifolium*.

Habitat. Grows on sand, sandy loam and lateritic clay in heathland and woodland.

Selected specimens (10 examined). WESTERN AUSTRALIA: Darling District: Kojonup, 33°50'S, 117°09'E, *C.F. Bailey & sons*, May 1962 (CANB, PERTH); Dinner Hill, 30°19'S, 115°37'E, *K. Newbey 2959*, 26 Aug. 1969 (PERTH); Marchagee Track, 15-20 km E of Brand Highway, 30°12'S, 115°38'E, *D. Foreman 468*, 1 Sep. 1984 (AD, CANB, MEL, PERTH); Mt Misery, W of Dandaragan, 30°41'S, 115°37'E, *E.A. Griffin 5044*, 11 Sep. 1988 (CANB, PERTH); Catchment Road, Sullivan State Forest, Beverley, 8 km SE of Qualen Road, 32°08'31"S, 116°38'07"E, *F. & J. Hort 631*, 6 Oct. 1999 (CANB, PERTH).

Toxicity. Unknown.

Affinity. The highly distinctive leaves make it difficult to confuse with any other species of *Gastrolobium*, as they are generally narrowly obovate to spathulate with numerous pungent points.

77. Gastrolobium rhombifolium G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Darling District: 10 km E (towards York) along Helena Road from West Talbot Road turnoff, 31°57'34"S, 116°37'55"E, *M.D. Crisp 8910 & W. Keys*, 8 Oct. 1996 (*holo*: CANB (CBG 9616013); *iso*: AD, K, MEL, PERTH).

> *Oxylobium dilatatum* Benth. var. *trilobum* Meisn. (1844, p. 29). *Type citation*: "In region. interior. Australiae merid.- occid. m. Febr. 1841, specimen mancum Herb. Preiss. No. 827." *Type specimens*: *holo*: LD; *iso*: NY.

Robust shrubs with rhomic to cruciform leaves that are fiercely pungent-pointed, the inflorescences are terminal clusters with a short peduncle and rachis (< 5 mm long each), and a bicoloured calyx, with white hairs at the base becoming golden brown on the lobes.

Notes. Known previously as *Nemcia triloba* (Meisn.) Crisp, ined., but a new specific name was required as previous homonyms already exist for both *G. trilobum* and *G. dilatatum*.

Fiercely robust *shrubs*, to 2 m. *Branchlets* ascending, angular, rigid, moderately to densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, 1-3 mm long. *Leaves* ascending, ternate, rhombic or cruciform, 20-49 x 8-25 mm, leaf surfaces with thickened venation; apex sub-acute, recurved, pungent-pointed; margins becoming complicate; base cuneate. *Stipules* erect, hyaline, 2-3 mm long. *Inflorescences* terminal clusters, -flowered; *peduncle* less than 5 mm long; *rachis* < 5 mm long; *subtending bracts* caducous, scale-like, either rhombic and sheathing or trilobed, the lobes shorter than the tube, 4-6 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* to 6 mm long, lobes much shorter than the tube, moderately villous, bicoloured with white silky hairs at the base becoming golden brown on the lobes, lobes not or slightly recurved; upper two lobes united higher than the lower three, obtuse, c. mm long; lower three lobes triangular, acute, c. 4 mm long. *Corolla*: *standard* transversely ovate, 10-11 x 12-13 mm including the 3 mm claw, yellow with a red ring around the white or yellow centre, apex emarginate, base cordate, not auriculate; *wings* oblong, c. 10 x 3 mm including the 3 mm claw, yellow with red markings, apex rounded, incurved and slightly overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, margins not or very slightly incurved, 9-10 x 3-3.5 mm

including the 3 mm claws, red, apex narrowly rounded, base auriculate, strongly saccate. *Style* very long, strongly incurved, lower third pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* c. 4. *Pod* and *seed* not seen.

Flowering period. September. *Fruiting period.* Unknown.

Distribution (Map 77). South-west Western Australia. Occurs east and south-east of Perth, on the eastern side of the Darling escarpment, particularly in the Boyagin Nature Reserve and Talbot regions.

Habitat. Grows on clay-loam over laterite, in Wandoo and Marri woodland.

Selected specimens (10 examined). WESTERN AUSTRALIA: Darling District: 10 km E (toward York) along Helena Road from West Talbot Road turnoff, 31°57'34"S, 116°37'55"E, *M.D. Crisp 8910, 8912 & W. Keys*, 8 Oct. 1996 (AD, CANB, K, MEL, PERTH); Catchment Road / Deefor Road junction, Talbot State Forest, York, 31°59'08"S, 116°35'44"E, *F.& J. Hort 632 & 636*, 6 Oct. 1999 (CANB, PERTH); 74.6 miles [120 km] from Perth towards New Norcia, along Geraldton Highway, *E.M. Canning s.n.*, 29 Sep. 1968 (CANB).

Map 77. Distribution of *G. rhombifolium*.

Toxicity. Unknown.

Affinity. The uniquely shaped leaves of this species, rhombic and generally fiercely pungent-pointed, make this species difficult to confuse with any other species of *Gastrolobium*. The only other species with rhombic leaves is *G. laytonii*, but the leaves are not as robust as *G. rhombifolium*, and the inflorescence is a long, open racemes (peduncle 3-10 mm long, rachis 25-55 mm long) with 15-30 flowers.

78. Gastrolobium tricuspidatum Meisn. (1844, p. 66). *Nemcia tricuspidata* (Meisn.) Crisp (1987, p. 128). *Type citation*: "In region. interior. Australiae merid.-occid., m. Oct. 1840. Herb. Preiss. No. 839." *Type specimens*: *holo*: NY; *iso*: GOET, K (2 sheets), LD, MO, S, W (2 sheets).

> *Gastrolobium tricuspidatum* Meisn. var. *latifolium* Meisn. (1844, p. 66). *Type citation*: "Swan River. Drummond n. 212." *Type specimens*: *holo*: BM; *iso*: K (2 sheets), W.

Erect, villous *shrubs*, to 1 m high. *Branchlets* ascending, angular, densely villous. *Petioles* terete, continuous and decurrent with the branchlet, < 1 mm long. *Leaves* ascending, crowded, mostly ternate, trilobed-spathulate, 20-30 x 5-15 mm, venation prominently reticulate; apex acute, trilobed, pungent-pointed; margins apically trilobed, with all angles pungent-pointed; base cuneate. *Stipules* erect, ± broad at base, then hyaline, 4-5 mm long. *Inflorescences* condensed axillary racemes, 2-5-flowered; *peduncle* 1-3 mm long; *rachis* 0-3 mm long; *subtending bracts* trilobed with lobes similar size to tube, all about equal, c. 2-3 mm long. *Pedicels* terete, 1-3 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.75 mm receptacle, densely villous with golden brown hairs, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3.5 mm long. *Corolla*: *standard* transversely elliptic, 8-10 x 8-10 mm including the 4 mm claw, yellow with a dark red centre, apex emarginate, base cordate, not auriculate; *wings* obovate, c. 7-8 x 2.5 mm including the 2 mm claws, yellow, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half very broadly elliptic, margins not incurved, c. 7-8 x 2.5 mm including the 3 mm claws, red, apex obtuse, base auriculate, saccate. *Style* very long, strongly incurved to hooked, lower third pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. September to October. *Fruiting period*. Unknown.

Distribution (Map 78). South-west Western Australia. This species has quite a narrow distribution, and occurs around the Dudinin and Kulin areas.

Map 78. Distribution of *G. tricuspidatum.*

Habitat. Grows on undulating dunes over laterite, in open mallee woodland or mixed heath.

Specimens examined. WESTERN AUSTRALIA: Avon District: Dudinin, 32°52'S, 117°54'E, *C.A. Gardner s.n.*, Oct. 1934 (CANB, PERTH); Nature Reserve No. 36598, 26 km SSW of Kulin on Grays Road no. 19, 32°53'S, 118°05'E, *J.M. Brown 129*, 8 Oct. 1984 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species is vaguely similar to *G. ilicifolium*, which differs by having larger leaves (18-48 x 15-30 mm), and has more than 3 pungent points per leaf.

The *G. cruciatum* group

These species all lack stipules at the base of the leaf, and used to belong to *Nemcia*. Their affinities to other groups are uncertain, as they were not included in the molecular

analysis, with future work to determine which other species of *Gastrolobium* that they are most closely related to.

79. Gastrolobium cruciatum G.Chandler & Crisp *sp. nov.* *Type*: WESTERN AUSTRALIA: Roe district: 16 km from Newdegate towards Lake King, 33°05'46"S, 119°10'56"E, *M.D. Crisp 8521 & W. Keys*, 28 Sep. 1993 (*holo*: CANB; *iso*: GAUBA, MEL, NSW, PERTH, UWA, K).

Similar to *Gastrolobium reticulatum*, but the plants are spreading shrubs 20-50 cm high and wide with tiny leaves that are conspicuously opposite and decussate, not whorled as in *G. reticulatum*, the calyces are bicoloured yellow and red (they are unicoloured in *G. reticulatum*), the lobes are much shorter than the calyx tube (they are c. equal to the tube in *G. reticulatum*), and both lobes and tube are only moderately pubescent with appressed white hairs, where *G. reticulatum* has a densely villous calyx.

G. reticulato similis sed habitu effuso 20-50 cm alto latoque, foliis minutis (2-8 mm longis) conspicue decussatis, calyce bicolorato flavo ruboque tantum pubescenti pilis albis adpressis, lobis tubo multo brevioribus differt.

Etymology. From the Latin *crux* (genetive *crucis*) = a cross, and refers to the erect leaves which are appressed to the branchlet in a cross-like (decussate) fashion.

Spreading *shrubs*, 20-50 cm high and wide. *Branchlets* ascending, angular, moderately to densely tomentose. *Petioles* terete, continuous and slightly decurrent with the branchlet, < 0.5 mm long. *Leaves* erect and appressed to the branchlet, stem clasping, opposite and decussate, oblong to ovate, 2-8 x 1.5-5 mm, glabrous, venation thickly reticulate; apex rounded, slightly recurved, unarmed; margins incurved; base broadly rounded. *Stipules* absent. *Inflorescences* with flowers solitary in upper axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, entire, ovate, 1-2 mm long, moderately pubescent. *Pedicels* terete, 1-2 mm long, moderately pubescent. *Calyx* campanulate, 3-4 mm long including the c. 0.5 mm receptacle, moderately pubescent, lobes slightly recurved; upper two lobes united slightly higher than the lower three, obtuse, c. 2 mm long; lower three lobes triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely elliptic, 6-8 x 6.5-7 mm including the c. 2.5 mm claw, rich golden yellow with a red ring surrounding the yellow centre, apex emarginate, base cordate, not auriculate; *wings* obovate, c. 6-7 x 1.5 mm including the 2 mm claws, yellow with red markings, apex rounded, incurved and just overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half very broadly elliptic, margins

incurved, c. 6-7 x 2 mm including the 2 mm claws, red, apex sub-acute, base auriculate, saccate. *Style* long, incurved, very base pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Mature pods* and *seed* not seen.

Flowering period. September. *Fruiting period*. Unknown, but probably October.

Distribution (Map 79). South-west Western Australia. Occurs around the Newdegate and Lake King areas.

Habitat. Grows on undulating landscapes on sand over laterite, in *Grevillea* and *Allocasuarina* heath.

Specimens examined. WESTERN AUSTRALIA: Roe District: 16 km E of Newdegate, 33°05'S, 119°12'E, *J. Taylor 2296 & P. Ollerenshaw*, 26 Sep. 1983 (CANB, PERTH); 20 km S of Lake King, 33°15'S, 119°44'E, *C.E. & D.T. Woolcock W 2356*, 1 Oct. 1985 (CANB); Lot 2665, Newdegate, *R. Dewar s.n.*, 21 Oct. 1992 (CANB, PERTH).

Toxicity. Unknown.

Map 79. Distribution of *G. cruciatum*.

Affinity. Similar to *Gastrolobium reticulatum*, but spreading shrubs 20–50 cm high and wide with exstipulate, tiny leaves that are noticeably arranged opposite and decussate, not whorled. Calyces are bicoloured yellow and red, the lobes much shorter than the calyx tube, both lobes and tube only moderately pubescent (under surface visible) with appressed white hairs.

80. Gastrolobium epacridoides Meisn. (1844, p. 72). *Nemcia epacridoides* (Meisn.) Crisp (1987, p. 126). *Type citation*: "In rupestribus ad jugum montium Darling's-range prope Cataractam (Perth) d. 16. Jan. 1840. Herb. Preiss. No. 837. (Drummond n. 196.)" *Type specimens*: *Lectotype* (here chosen): LD (Preiss 837); *isolecto*: MO, NY, S, W.

Narrow, erect *shrubs* to 1 m high. *Branchlets* ascending, angular, densely villous. *Petioles* terete, continuous and decurrent with the branchlet, < 1 mm long. *Leaves* broadly spreading to retrorse, ternate, ovate, 11-14 x c. 8 mm, glabrous, venation prominently reticulate; apex with a c. 3 mm long pungent point; margins becoming plicate; base broadly rounded. *Stipules* absent. *Inflorescences* single or paired flowers in upper axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, trilobed, the middle lobe much longer, 3-4 mm long. *Pedicels* to 5 mm long. *Calyx* campanulate, 4-6 mm long including the c. 0.5 mm receptacle, sparsely to densely pubescent, lobes recurved; upper two lobes united higher than the lower three, acute, c. 2 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* very broadly elliptic, 10-12 x 8-9 mm including the 3 mm claw, yellow with a crimson centre, with a tiny yellow centre, apex emarginate, base slightly cordate, slightly auriculate; *wings* obovate, apex rounded, 8-9 x 2.5 mm including the 2 mm claws, yellow and crimson, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, or slightly auriculate on the lower margin as well, saccate; *keel* half broadly elliptic, margins not incurved, 7-8 x 2.5 mm including the 2 mm claws, crimson, apex slightly rounded, base auriculate, saccate. *Style* very long, strongly incurved, base pubescent; *ovary* ± sessile or very shortly stipitate, densely pubescent; *ovules* 2. *Pod* enclosed in the calyx, sessile, ovoid, c. 8 x 3 mm, densely pubescent. *Seed* not seen.

Flowering period. August and September. *Fruiting period*. October.

Distribution (Map 80). South-west Western Australia. Occurs from around Toodyay south to the Dale Forest.

Map 80. Distribution of *G. epacridioides*.

Habitat. Grows on sandy or loamy soils in open woodland.

Specimens examined. WESTERN AUSTRALIA: Darling District: 26 km south-east of the Great Northern Highway along Toodyay Road. 31°25'S 116°21'E, *P.S. Short 2769 et al.*, 8 Sep. 1986 (CANB, PERTH); 20 km beyond Keenan College toward New Norcia, *N. Ollerenshaw 101*, 4 Oct. 1975 (CANB); between Toodyay and Bindoon, *C.E. & T.D. Woolcock W678*, 24 Aug. 1982 (CANB); Dale Forest Block, 32°06'29"S, 116°17'28"E, *F. Hort 170*, 3 May 1998 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species is often confused with *Gastrolobium acutum*, but the latter species is easily distinguished by the presence of stipules, but also has longer, narrower, elliptic leaves (12-22 x 4-6 mm).

81. Gastrolobium punctatum (Turcz.) G.Chandler & Crisp, *comb. nov.* *Eutaxia punctata* Turcz (1853, p. 272). *Nemcia punctata* (Turcz.) Crisp (1987, p. 127). *Type citation*: "Drum. V. n. 69." *Type specimens*: *holo*: KW; *iso*: BM, K (2 sheets).

> *Gastrolobium reticulatum* (Meisn.) Benth. var *recurvum* E. Pritz., in Diels & Pritzel (1904, p. 253). *Type citation*: "Ex interioribus distr. Stirling: Cranbrook (D. 4469), Kalgan super. (D. 4605), usque ad regiones interiores distr. Eyre pr. Gibsons Soak extendit (D. 5428). Fl. m. Sept., Oct." *Type specimens*: unknown, possibly destroyed when the Berlin herbarium was bombed.

Small, compact *shrubs* 0.3-1 m high. *Branchlets* ascending to erect, ± terete, moderately sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, c. 1 mm long. *Leaves* whorled, stem clasping, oblong to ovate, 8-12 x 2-3 mm, upper leaf surface rarely seen, lower surface with distinctive thickened raised venation, somewhat punctate; apex slightly recurved; margins incurved; base rounded. *Stipules* absent. *Inflorescences* single or paired flowers in the axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, ± entire to slightly trifid, 2-3 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* 4.5-6 mm long including the mm receptacle, sparsely to moderately pubescent, unicoloured, lobes not to slightly recurved; upper two lobes united higher than the lower three, acute, 2-3 mm long; lower three lobes triangular, acute, 2-3 mm long. *Corolla*: *standard* transversely elliptic, c. 7.5-9 x 7-9 mm including the 3 mm claw, rich yellow with brown on the reverse, apex emarginate, base ± truncate, auriculate; *wings* obovate, c. 6-7.5 x 2 mm including the 2-2.5 mm claws, yellow, apex rounded, curvature unknown, base auriculate, slightly saccate; *keel* half very broadly elliptic, margins incurved, 6-8 x 2-3 mm including the 2.5-3 mm claws, red, apex rounded, base auriculate, saccate. *Style* long, strongly incurved to hooked, lower half quite pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* half enclosed in the calyx, sessile, globose, 5-6 x 5-6 mm, moderately pubescent. *Seeds* ellipsoid, 1-2 mm long, bluntly ridged, arillate.

Flowering period. September and October. *Fruiting period.* November to January.

Distribution (Map 81). South-west Western Australia. Occurs in a band from Katanning east to the Lake King-Ravensthorpe area.

Habitat. Grows on sandy soils in heath and mallee.

Map 81. Distribution of *G. punctatum*.

Selected specimens (10 examined). WESTERN AUSTRALIA: Eyre District: Ravensthorpe area, 25 km from Ravensthorpe along Lake King road, 33°25'S 119°55'E, *B. Barnsley 478*, 10 Jan. 1979 (CANB, PERTH); between Newdegate & Lake Grace, 1.6 km from Newdegate (at 248 milepeg), *E.M. Canning WA/69, 7370*, 7 Nov. 1968 (CANB); 19 km S of Lake King, 33°14'S, 119°44'E, *C.E & T.D. Woolcock W2357*, 1 Oct. 1985 (CANB).

Toxicity. Unknown.

Affinity. Similar to *G. reticulatum*, which differs most notably by the lower surface of the leaf being honeycombed with raised reticulation, but not with the thickened reticulation of *G. punctuatum*. *Gastrolobium cruciatum* differs by having smaller leaves (2-8 x 1.5-5 mm) that are strictly opposite and decussate, and the calyx is bicoloured (with yellow and rusty hairs).

82. Gastrolobium reticulatum (Meisn.) Benth. (1864, p. 99). *Eutaxia reticulata* Meisn. (1844, p. 65). *Nemcia carinata* Crisp (1987, p. 124). *Type citation*: "In regionibus interioribus Australiae meridionali-occidentalis, m. Oct. 1840 specimina pauca imperfecta Herb. Preiss. No. 870." *Type specimens*: *holo*: LD; *iso*: NY.

Erect *shrubs* to 1.2 m high. *Branchlets* moderately to densely tomentose. *Petioles* absent. *Leaves* stem clasping and in whorls of 3, elliptic, less than 10 x 2 mm, upper leaf surface rarely seen, lower surface with prominent, finely reticulate venation, not punctate; apex obtuse; margins slightly incurved; base decurrent with the branchlet. *Stipules* absent. *Inflorescences* single or paired flowers in the axils; *peduncle* nil; *rachis* nil; *subtending bracts* sheathing, apiculate; pedicels less than 3 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.5 mm receptacle, villous, unicoloured, lobes not recurved; upper two lobes united higher than the lower three, acute, 2-2.5 mm long; lower three lobes triangular, acute, 1.5-2 mm long. *Corolla*: *standard* very broadly ovate, 7-8 x 7-8 mm including the c. 2.5mm claw, orange with a white or pale yellow centre, apex emarginate, base slightly cordate, slightly auriculate; *wings* obovate, 6-7 x 1.5-2 mm including the 2-2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half very broadly obovate, margins not or slightly incurved, c. 6-7 x 2 mm including the 2.5-3 mm claws, dark red-brown, apex sub-acute, base auriculate, saccate. *Style* long, strongly incurved, lower third pubescent; *ovary* sessile, densely pubescent; *ovules* 2. *Pod* half enclosed in the calyx, sessile, 5-6 x 3-4 mm long, moderately pubescent. *Seed* ellipsoid, 1-2 mm long, arillate.

Flowering period. July to October. *Fruiting period*. Unknown.

Distribution (Map 82). South-west Western Australia. Occurs from Dryandra south and east to Kamballup.

Habitat. Grows on white sand over laterite in heathland and open forest.

Selected specimens (6 examined). WESTERN AUSTRALIA: Darling District: Dryandra Forest. 32°47'S, 116°58'E, *M.G. Corrick 8406*, 12 Oct. 1982 (CANB, MEL); 3 miles [5 km] E of Kamballup, corner of Synid Road, 34°35'S, 118°02'E, *T.E.H. Aplin 6027*, 25 Sep. 1974 (CANB, PERTH); c. 20 km WSW of Harrismith, 3 km SSW of Wedin, 33°00'S, 117°41'E, *M.D .Crisp 6150 et al.*, 26 Sep. 1979 (CANB, NSW, PERTH, US); Highbury, 16 km S of Narrogin, 33°04'S, 117°14'E, *C.A. Gardner*, Aug. 1934 (CANB, PERTH).

Map 82. Distribution of *G. reticulatum*.

Toxicity. Unknown.

Affinity. Differs from the close exstipulate relatives, *G. cruciatum* and *G. punactatum*, in having leaves that are whorled, not opposite and decussate (see *G. cruciatum*), and the lower surface of the leaf is honeycombed with raised reticulation that is not thickened as in *G. punctuatum*.

The *G. pyramidale* group

These species all have somewhat crenulate leaves, large, orange flowers in terminal and/or axillary clusters, and appear somewhat intermediate between the typical, bee-pollinated flowers of most species of *Gastrolobium* and the red-flowered group of species, the *G. celsianum* group.

83. Gastrolobium coriaceum (Sm.) G.Chandler & Crisp, *comb. nov.* *Chorizema coriaceum* Smith (1808, p. 254), as 'Chorozema'. *Podolobium coriaceum* (Smith) DC. (1825, p. 103). *Callistachys coriacea* (Sm.) Kuntze (1891, p. 168). *Oxylobium coriaceum* (Sm.) C.A.Gardner (1930, p. 56). *Type citation*: "Found also by Mr.

Menzies at King George's Sound". *Type specimens*: *Lectotype* (here chosen): LINN (King George's Sound, west coast of New Holl[d]., Pat. 35 Menzies. 1803).

Oxylobium retusum R.Br. ex Lindl. (1825, t. 913). *Type citation*: "...native of King George's Sound in New Holland, whence seeds were brought by Mr. J. Richardson. The specimens from which our drawing was made were communicated from Mr. Colvill's Nursery..." *Nom. superfl.* & *illeg.* (*Chorizema coriaceum* Smith given as synonym).

Oxylobium capitatum Benth., var. *ternifolium* Meisn. (1844, p. 30). *Type* citation: "In glareoso-lapidosis inter frutices densos sylvae ad radices montis Manypeak v. T'jilberup (Plantagenet) d. 23. et 28. Nov. 1840, Herb. Preiss Nl. 805 et 814." *Type specimens*: *lectotype* (here chosen): LD (Preiss 814), *iso*: NY.

Oxylobium ovalifolium Meisn. (1844, p. 28). *Gastrolobium ovalifolium* (Meisn.) Lemaire (1853, t. 324) (nom illeg.). *Callistachys ovalifolia* (Meisn.) Voss, in Siebert & Voss (1894, p. 193). *Type citation*: "In glareosis inter frutices densos prope montem Manypeak (Kent) 27 Nov. Herb. Preiss. no. 813 et in rupestribus ad radices montibus Baldhead (Sinus Regis Goergii III) 16 Oct. 1840 no. 820." *Type specimens*: *Lectotype* (here chosen): LD (Preiss 820); *isolecto*: GOET, K, MO, NY, S, W (2 sheets).

Callistachys tetragona Turcz. (1853, p. 249). *Type citation*: "Drummond. coll. III. n. 83." *Type specimens*: *holo*: KW; *iso*: K, W.

Erect *shrubs*, to 2 m high. *Branchlets* ascending, angular, moderately to densely villous. *Petioles* terete, continuous and decurrent with the branchlet, 6-10 mm long. *Leaves* spreading to ascending, mainly ternate, ovate, 25-80 x 6-30 mm, venation prominently reticulate, raised; apex bilobed to emarginate, mucronate; margins crenulate, undulate; base rounded to almost truncate. *Stipules* erect, rigid, lanceolate, 4 -5 mm long, base pubescent. *Inflorescences* condensed, terminal racemes, floral internodes very short (< 3 mm long); *peduncle* angular, up to 40 mm long, densely pubescent; *rachis* condensed, 0.5-7 mm long; *subtending bracts* caducous, scale-like, entire, ovate, 3-4 mm long. *Pedicels* terete, 3-4 mm long, densely pubescent. *Calyx* campanulate, 7-12 mm long including the c. 1.5 mm receptacle, densely villous, hairs bicoloured, with the basal silky-white hairs becoming golden brown towards the lobes, lobes not recurved; upper two lobes united higher than the lower three, triangular,

obtuse, 3-3.5 mm long; lower three lobes triangular, acute, 3-3.5 mm long. *Corolla*: *standard* very broadly elliptic, 11-12 x 14-16 mm including the 4 mm claw, orange with a red ring surrounding the orange to yellow centre, apex emarginate, base ± truncate; *wings* obovate, 10.5-11 x 3.5-4 mm including the 2.5-3 mm claws, orange, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half broadly elliptic, margins not incurved, 10-11 x 4 mm including the 3 mm claws, pink and red, apex rounded, base auriculate, saccate. *Style* long, incurved, lower quarter pubescent; *ovary* very shortly stipitate, almost sessile, densely pubescent; *ovules* 4. *Pod* very shortly stipitate, ovoid, 5-6(-8) mm long, moderately to densely villous. *Seed* ellipsoid, 1-2 mm long, arillate.

Flowering period. September and October. *Fruiting period*. November and December.

Distribution (Map 83). South-west Western Australia. Occurs along the south coast, from around Albany in the Mt Manypeaks area east to Fitzgerald River National Park, but with an outlier recorded from the Whicher Range (C.E. & D.T. Woolcock W2355).

Habitat. Grows on sandplains or mountain slopes often over limestone on sand, or occasionally on granite, in shrubland or heathland.

Map 83. Distribution of *G. coriaceum*.

Selected specimens (17 examined). WESTERN AUSTRALIA: Darling District: Whicher Range, Sabina Road, c. 33°51'S, 115°20'E, *C.E. & D.T. Woolcock W2355*, 20 Sep. 1985 (CANB). Eyre District: Road to Little Beach, W end of Two People Bay, 34°58'36"S, 118°10'31"E, *G.T. Chandler 725 & S. Donaldson*, 31 Oct. 1998 (CANB, MEL, PERTH); 1.9 km along Mt Richards Road, turn c.3 km N Nanarup, 34°59'05"S, 118°01'36"E, *G.T. Chandler 723 & S. Donaldson*, 31 Oct. 1998 (CANB, MEL, PERTH); ravine leading from East into Fitzgerald Inlet, just south of widest part; Fitzgerald River National Park, 34°05'S, 119°35'E, *A.S. Weston 6397*, 22 July 1971 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species is similar to *G. congestum*, *G. pyramidale* and *G. crenulatum*. *Gastrolobium congestum* has a longer rachis [(5-)13-80 mm long] and has a greater number of flowers per inflorescence (30 to more than 50), *G. pyramidale* has rust-coloured hairs on the stems, underside of the leaves and inflorescence axes (whereas *G. coriaceum* has white hairs), and *G. crenulatum* has crenulate leaves and two ovules.

84. Gastrolobium crenulatum Turcz. (1853, p. 273). *Nemcia crenulata* (Turcz.) Crisp (1987, p. 125). *Type citation*: "Drum. V. n. 55." *Type specimens*: *holo*: KW; *iso*: BM, K (3 sheets), W.

Erect *shrubs*, to 1.2 m high. *Branchlets* ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, c. 3 mm long. *Leaves* spreading, in whorls of 3 or 4, ± oblong or obovate, 11-35 x 9-20 mm, glabrous to glabrescent, venation prominently reticulate, raised; apex emarginate to bilobed, unarmed; margins crenulate; base truncate. *Stipules* erect, hyaline, 2-3 mm long. *Inflorescences* condensed axillary racemes, 3-6-flowered; *peduncle* 3-8 mm long; *rachis* to 5 mm long; *subtending bracts* caducous, scale-like, prominently trifid, 4-6 mm long. *Pedicels* terete, less than 2 mm long. *Calyx* campanulate, c. 5 mm long including the c. 1 mm receptacle, densely villous, hairs bicoloured, with silky white hairs at the base becoming golden brown towards the apices of lobes, lobes not recurved; upper two lobes united higher than the lower three, obtuse, 3.5 mm long; lower three lobes triangular, acute, 3 mm long. *Corolla*: *standard* very broadly elliptic, 7-8 x 9.5 mm including the 2.5 mm claw, rich yellow, apex emarginate, base cordate, not auriculate;

wings broadly obovate, 7.5-9 x 3-3.5 mm including the 2 mm claws, rich yellow, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half transversely elliptic, 7-8 x 3.5 mm including the 2 mm claws, dark red, apex rounded, base auriculate, saccate. *Style* long, hooked, lower third pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* half enclosed in the calyx, sessile, ovoid, 5-8 mm long, densely pubescent. *Seed* not seen.

Flowering period. September to November. *Fruiting period.* November and December.

Distribution (Map 84). South-west Western Australia. Occurs along the south coast and slightly inland, in the Barren and Stirling Ranges.

Map 84. Distribution of *G. crenulatum.*

Habitat. Grows on mountain slopes on skeletal sediment in open woodland.

Conservation status. ROTAP: 2KC-. CALM: P2. This species is rare, but does not appear to be at risk.

Selected specimens (11 examined). WESTERN AUSTRALIA: Eyre District: 36.5 km along Stirling Range Drive from Red Gum Pass Road, 34°22'18"S, 118°04'26"E, *G.T.*

Chandler 490 et al., 17 Feb. 1998 (CANB); Mt Toolbrunup, west Gorge, 34°23'S 118°03'E, *A. Morrison s.n.*, 4 Oct. 1902 (CANB, PERTH); Thumb Peak range, *A.S. George 7146B*, (CANB, PERTH); Stirling Range, Mt Hassell carpark, 34°23'S, 118°04'E, *M.D. Crisp 8492 & W. Keys*, 24 Sep. 1993 (CANB, GAUBA, PERTH, UWA); 1.65 km NNE of Ellen Peak, near base of steep spur, 34°20'30"S, 118°20'03"E, *M.D. Crisp 8947 & W. Keys*, 15 Oct. 1996 (CANB); Thumb Peak Range, c. 34°02'S, 119°43'E, *A.S. George 7146B*, 31 Oct. 1965 (PERTH).

Toxicity. Unknown.

Affinity. This species is similar to *G. congestum*, *G. coriaceum* and *G. pyramidale*. *Gastrolobium congestum* has a longer inflorescence rachis [(5-)13-80 mm long] and has a greater number of flowers per inflorescence (30 to more than 50), *G. coriaceum* differs by not having crenulate leaves, and has a greater number of ovules (5-8 ovules), and *G. pyramidale* has rust-coloured hairs on the stems, underside of the leaves and inflorescence axes, whereas *G. crenulatum* has white hairs.

85. Gastrolobium pyramidale T. Moore (1852, p. 81). *Nemcia pyramidalis* (T.Moore) Crisp (1987, p. 126). *Type citation*: "...was raised by Messrs. Henderson of the Edgeware Road, from seeds forwarded by Mr. Drummond from the Swan River colony." *Type specimens*: *Lectotype* (here chosen): the plate.

> *Gastrolobium polycephalum* Turcz. (1853, p. 274); *Gastrolobium pyramidale* T. Moore (1853, p. 202). *Type citation*: "Hab. ad fl. Cygnorum N. Hollandiae, Drummond, ser. 5. no. 54." *Type specimens*: *Lectotype* (here chosen): K; *isolecto*: BM, K (2 sheets), W.

Erect *shrubs*, to 1.5 m. *Branchlets* ascending, angular, densely pubescent with rusty brown hairs. *Petioles* terete, continuous and decurrent with the branchlet, 5-6 mm long. *Leaves* broadly spreading, opposite or in whorls of 3, stem clasping, oblong to slightly obovate, 25-50 x 12-25 mm, upper surface glabrous, lower surface sparsely to densely tomentose with rust-coloured hairs (particularly when younger), venation prominently reticulate; apex emarginate, slightly mucronate; margins slightly crenulate; bases rounded or cordate. *Stipules* recurved, hyaline, 9-12 mm long. *Inflorescences* condensed terminal racemes, 5-12-flowered, densely villous with rust-coloured hairs; *peduncle* 1-15 mm long; *rachis* to 3 mm long; *subtending bracts* caducous or somewhat persistent, scale-like, obtriangular, prominently trilobed, the lobes as long as the base, 5-6 mm long including the c. 3 mm lobes; all villous with golden brown hairs. *Calyx* 6-9

mm long including the c. 1 mm receptacle, densely pubescent, lobes slightly recurved; upper two lobes united very slightly higher than the lower three, broadly triangular, ± acute, c. 4 mm long; lower three lobes triangular, acute, c. 4 mm long. *Pedicels* terete, 2-4 mm long. *Corolla*: *standard* transversely ovate, 10-12 x 15 mm including the 4 mm claw, orange and yellow with a darker centre, apex emarginate, base cordate, not auriculate; *wings* obovate, c. 11x 4.5 mm including the 2 mm claws, orange-yellow, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate; *keel* half very broadly elliptic, c. 10 x 4 mm including the 3 mm claws, dark red, apex broadly rounded, base auriculate, strongly saccate. *Style* very long, strongly incurved, lower half pubescent; *ovary* sessile, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. September and October. *Fruiting period*.

Distribution (Map 85). South-west Western Australia. Occurs in the Stirling Range.

Map 85. Distribution of *G. pyramidale*.

Habitat. Grows on flats, hills or saddles, sometimes in quite craggy places, on skeletal sandy or sandy clay, often stony soils, in tall heath dominated by *Dryandra* and *Allocasuarina*, or in mallee-heath.

Selected specimens (13 examined). WESTERN AUSTRALIA: Eyre District: Stirling Range, foothill NW of Barnett Peak, 34°23'47"S, 117°52'46"E, *M.D. Crisp 8964 & W. Keys*, 17 Oct. 1996 (CANB, PERTH); Stirling Range, Mondurup walking track, 100 m from road, 34°24'S, 117°49'E, *M.D. Crisp 8501 & W. Keys*, 25 Sep. 1993 (CANB, GAUBA, PERTH); Stirling Range, saddle 3 km ESE of Donelly Peak, 34°21'S, 117°45'E, *M.D. Crisp 8475 & W. Keys*, 23 Sep. 1993 (CANB, PERTH); Red Gum Springs, Stirling Range, 34°22'S, 117°47'E, *J.W. Wrigley WA/68-4349*, 10 Oct. 1968 (CANB).

Toxicity. Unknown.

Affinity. This species is outwardly similar to *G. congestum*, *G. coriaceum* and *G. crenulatum*, but can be easily distinguished by the rust-coloured hairs on the stems, underside of the leaves and inflorescence axes, which are not present on these other species.

The *G. celsianum* group

This group of species all have red flowers that are putitively modified for bird pollination, such as red flowers and a reduced standard petal.

86. Gastrolobium leakeanum Drumm. (1849, p. 247). *Oxylobium atropurpureum* Turcz. (1853, p. 250). *Callistachys atropurpurea* (Turcz.) Kuntze (1891, p. 168). *Nemcia atropurpurea* (Turcz.) Domin 1923a, p. 27). *Nemcia leakeana* (Drumm.) Crisp (1987, p. 126). *Type citation*: "...it is abundant on Congineerup, near the east end of the mountain, growing in all sorts of soil, from the base to the summit." *Type specimens*: *Lectotype* (here chosen): KW (Drumm. Coll. V. n. 53).

Erect *shrubs*, 1-2 m high. *Branchlets* ascending, compressed, ridged, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, c. 15 mm long. *Leaves* spreading, opposite, broadly elliptic, 50-65 x 20-40 mm, glabrous, venation prominently reticulate; apex slightly emarginate; margins slightly crenulate; base rounded. *Stipules* recurved, hyaline, 8-12 mm long. *Inflorescences* axillary umbels, 2-4-flowered, densely villous; *peduncle* 4-6 mm long; *rachis* nil; *subtending bracts* ±

persistent, scale-like, trifid, lobes much shorter than tube, 5-6 mm long, densely tomentose, middle lobe shorter than outer lobes. *Flowers*: resupinate; *pedicels* terete, 2-3 mm long, densely pubescent. *Calyx* c. 10 mm long including the c. 1 mm receptacle, densely villous, hairs unicoloured to bicoloured, lobes not or scarcely recurved; upper two lobes united much higher than the lower three, obtuse, c. 5 mm long; lower three lobes triangular, acute, 4.5 mm long. *Corolla*: *standard* broadly elliptic to circular, often somewhat folded up longitudinally, c. 18-20 x 14 mm including the 4 mm claw, red or more rarely orange-yellow, with a small, yellow centre, apex emarginate, base cordate; *wings* elliptic, incurved longitudinally, c. 15-16 x 5 mm including the 4 mm claws, red or more rarely orange-yellow, apex rounded, not incurved, not enclosing the keel, base scarcely or not auriculate, saccate; *keel* half very broadly elliptic to circular, incurved longitudinally, margins slightly incurved, c. 15-16 x 6 mm including the 5 mm claws, red, apex rounded, base auriculate, saccate. *Style* very long, strongly incurved to hooked, lower quarter pubescent; *ovary* ± sessile, densely pubescent; *ovules* 4. *Pod* sessile, ovoid, c. 12 x 4-5 mm, moderately to densely villous. *Seed* not seen.

Flowering period. September. *Fruiting period*. November.

Distribution (Map 86). South-west Western Australia. Occurs along the ridge between Ellen Peak and Bluff Knoll, in the Stirling Range.

Habitat. Grows on mountain peaks on skeletal sandy soil in scrubby heath and mallee.

Selected specimens (10 examined). WESTERN AUSTRALIA: Eyre district: 1.65 km NNE of Ellen Peak, near base of steep spur, 34°20'30"S, 118°20'03"E, *M.D. Crisp 8946 & W. Keys*, 15 Oct. 1996 (CANB); Stirling Range, Bluff Knoll walking track, c. 0.7 m above carpark, 34°22'S, 118°15'E, *M.D. Crisp 8481 & W. Keys*, 24 Sep. 1993 (CANB, GAUBA, PERTH); Stirling Range, 34°25'S, 117°53'E, *A.S. Weston s.n.*, 2 June 1978 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species can be distinguished from *G. rubrum*, *G. vestitum* and *G. luteifolium* by the often somewhat resupinate flowers, the silvery haired calyx, and very long petioles at the base of the discolorous leaves. Its closest relative, however, is *G. mondurup*, which differs in having smaller leaves (25-58 x 11-24 mm), the standard petal is not fully reflexed, the inflorescences rarely extend beyond the leaves and are often racemose (rather than consistently umbellate), and the calyx is consistently

bicoloured, with white villous hairs towards the base with dense golden brown hairs towards the tips of the lobes.

Map 86. Distribution of *G. leakeanum*.

87. Gastrolobium mondurup G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Eyre District: Stirling Range, Mondurup, summit ridge, 100 m above 1st saddle, 34°24'S, 117°49'E, 25 Sep. 1993, *M.D. Crisp 8495 & W. Keys* (*holo*: CANB; *iso*: K, PERTH).

Similar to the close relative *Gastrolobium leakeanum* in having resupinate flowers and a somewhat reduced standard petal, but *G. mondurup* differs in the smaller leaves (25-58 x 11-24 mm as opposed to the 50-65 x 20-40 mm leaves of *G. leakeanum*), the standard petal is not fully reflexed, the calyx is consistently bicoloured (white villous towards the base with dense golden brown hairs towards the tips of the lobes), and the inflorescences rarely extend beyond the leaves.

G. leakeano arte affinis sed foliis paulo minoribus et proportione angustioribus (25-58 x 11-24 mm), vexillo vix expanso cucullato, carina aliis longiore (19-24 mm longa) prominenti, inflorescentia folia raro excedenti distinguenda.

Etymology. Named after the peak from which it was first collected, Mondurup Peak, in the Stirling Range.

Erect *shrubs*, 2-3 m high. *Branchlets* ascending, prominently angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, 6-10 mm long. *Leaves* spreading, alternate, elliptic to oblong, 25-58 mm x 11-24 mm, glabrous, venation prominently reticulate; apex emarginate to bilobed, mucronate; margins crenulate; base rounded. *Stipules* hyaline, 6-10 mm long. *Inflorescences* axillary racemes or umbels, not exceeding the leaves, 4-5-flowered; *peduncle* angular to compressed, ridged, 5-7 mm long, pubescent; *rachis* 0-5 mm long; *subtending bracts* caducous, scale-like, apex trilobed, 4-5 mm long, densely tomentose. *Flowers*: resupinate; *pedicels* 5-10 mm long, densely pubescent. *Calyx* campanulate, 10-12 mm long including the c. 1.5 mm receptacle, densely villous, mostly unicoloured with white villous hairs but often some golden brown hairs appearing towards the tips of the lobes, lobes not recurved; upper two lobes united higher than the lower three, rounded, c. 5 mm long; lower three lobes triangular, acute, c. 5 mm long. *Corolla*: *standard* very broadly elliptic, 16-18 x 14-15 mm including the 4.5 mm claw, rosy red with a yellow centre, apex emarginate, base cordate; *wings* elliptic, 20-24 x 4 mm including the 6 mm claws, rosy red, apex rounded, not incurved, not enclosing the keel, base scarcely auriculate on the lower margin only, saccate; *keel* half ovate, margins incurved, 19-24 x 6-7 mm including the 4-5 mm claws, rosy red, apex obtuse, base auriculate, saccate. *Style* very long, incurved, lower half pubescent; *ovary* ± sessile, densely pubescent; *ovules* 5. *Pod* and *seed* not seen.

Flowering period. September. *Fruiting period*. Unknown.

Distribution (Map 87). South-west Western Australia. This species is restricted to several peaks in the central Stirling Ranges.

Habitat. Grows on mountain peaks on skeletal soils in heath, or dense mallee-heath.

Specimens examined. WESTERN AUSTRALIA: Eyre district: Stirling Range, Mt Magog, S slope, (upper), 34°23'50"S, 117°56'38"E, *M.D. Crisp 8971 & W. Keys*, 18 Oct. 1996 (CANB, PERTH); ibid., *M.D. Crisp 8972, 8973 & W. Keys*, 18 Oct. 1996 (CANB); Mount Magog, 34°24'00"S, 117°48'00"E, *S. Barrett 102*, 15 Oct. 1994 (CANB, PERTH); central summit of Barnett Peak, 34°21'05"S, 117°52'48"E, 17 Oct. 1996, *M.D. Crisp 8966& W. Keys*, 17 Oct. 1996 (CANB, MEL, PERTH); Mondurup,

summit ridge, 100 m above first saddle, 34°24'S, 117°49'E, *M.D. Crisp 8496, 8497& W. Keys*, 25 Sep. 1993(CANB, NSW, UWA).

Map 87. Distribution of *G. mondurup*.

Toxicity. Unknown.

Affinity. This species is very similar to *G. leakeanum* in having somewhat resupinate flowers and a partially reduced standard petal, but *G. leakeanum* differs most notably by the standard petal being longer than the wing and keel petals (in *G. mondurup* it is the other way around), and also in having larger leaves (50-65 x 20-40 mm), a fully reflexed standard petal (in *G. mondurup* it is only partially recurved), the inflorescence is consistently umbellate rather than often a raceme (rachis up to 5 mm long) and extends beyond the leaves, and the calyx is unicoloured with white, villous hairs, or sometimes bicoloured, with white hairs at the base and rust-coloured hairs towards the apex.

88. Gastrolobium luteifolium (Domin) G.Chandler & Crisp, *comb.nov. Nemcia luteifolia* Domin 1923a, p. 27). *Type citation*: "W.A.: Warrunup Hill, Stirling Range, leg. Capt. A.A. DORRIEN-SMITH (Herb. Kew)". *Type specimens*: *holo*: K.

Tall, erect *shrubs*, 1-1.3 m high. *Branchlets* ascending, compressed, prominently ridged, glabrous. *Petioles* terete, tuberculate, continuous and decurrent with the branchlet, 8-10 mm long. *Leaves* opposite, obovate to elliptic, 30-50 x 20-30 mm, glabrous, venation prominently reticulate; yellow-green; apex truncate, may be emarginate; margins crenulate, undulate; base rounded. *Stipules* erect, thickly lanceolate, plicate, 2-3 mm long. *Inflorescences* short, axillary umbels, 4-5-flowered; *peduncles* compressed, with sheathing, basal bracts that are up to 15 mm long, 10-12 mm long; *rachis* nil; *subtending bracts* ± caducous, scale-like, bilobed, slightly trifid or ± entire, c. 13 mm long, densely tomentose. *Flowers*: resupinate; *pedicels* terete, 2-3 mm long. *Calyx* slightly ventricose, 13-15 mm long including the c. 1.5 mm receptacle, bicoloured, with basal white silky hairs becoming golden on the lobes, upper two lobes recurved, lower three lobes straight; upper two lobes united higher than the lower three, obtuse, c. 5 mm long; lower three lobes triangular, rounded, c. 5 mm long. *Corolla*: *standard* very broadly elliptic, c. 13-17 x 15 mm including the 6 mm claw, red with yellow guide marks, apex emarginate, base cordate; *wings* elliptic, incurved longitudinally, c. 17-18 x 5-6 mm including the 6 mm claws, red, apex rounded, incurved and slightly overlapping to ± enclose the keel, base auriculate on both margins, saccate; *keel* half very broadly elliptic, incurved longitudinally, margins scarcely incurved, c. 18-19.5 x 7 mm including the 6.5 mm claws, red, noticeably longer than standard, apex rounded, base auriculate, strongly saccate. *Style* very long, incurved, base pubescent; *ovary* scarcely stipitate, densely pubescent; *ovules* 6. *Pod* and *seed* not seen.

Flowering period. September. *Fruiting period*. Unknown.

Distribution (Map 88). South-west Western Australia. Occurs in the Stirling Ranges, and is known only from Mt Trio.

Habitat. Mountain slopes and the summit area of Mt Trio, on skeletal sandy soils in shrubland.

Conservation status. CALM: P2. This species is rare, but does not appear to be at risk.

Specimens examined. WESTERN AUSTRALIA: Eyre District: Stirling Range, summit of Warrungup Peak (Mt Trio), 34°21'S, 118°07'E, *M.D. Crisp 8507 & W. Keys*, 25 Sep. 1993 (CANB, PERTH).

Map 88. Distribution of *G. luteifolium*.

Toxicity. Unknown.

Affinity. This species has been reinstated in this treatment, and is noticeable for the bicoloured calyces and the keel petals being longer than the standard petal. *Gastrolobium luteifolium* is very similar to *G. vestitum*, but the latter differs by the leaf margins being strongly recurved (rather than undulate in *G. luteifolium*), the leaves are villous on both leaf surfaces and are tardily glabrescent, with the midrib remaining villous (the leaves of *G. luteifolium* are sericeous, glabrate, and the midrib is soon glabrous), the subtending floral bracts are smaller (6-10 mm long), and the flowers are generally smaller (c. 18 mm long).

89. Gastrolobium vestitum (Domin) G.Chandler & Crisp, *comb. nov.* *Nemcia vestita* Domin 1923a, p. 28). *Type citation*: "W.A.: Pass in Stirling Range, East of Mt. Toolbrunup, leg. Capt. A.A. DORRIEN-SMITH (Herb. Kew)." *Type specimens*: *holo*: K.

Erect, arborescent *shrubs*, 1-3 m high. *Branchlets* ascending, compressed, angular, ridged, densely villous. *Petioles* terete, continuous and decurrent with the branchlet, to

10 mm long. *Leaves* spreading, opposite, elliptic to ± rhombic, 30-45 x 25-35 mm, upper surface with prominent venation, lower surface moderately to densely villous, especially along the veins; apex truncate to retuse; margins strongly recurved; base rounded. *Stipules* erect, c. 15 mm long, mostly villous. *Inflorescences* axillary umbels, 4-flowered; *peduncle* compressed, ridged, 10-18 mm long; *rachis* nil; *subtending bracts* somewhat persistent to caducous, scale-like, semi-globose, shallowly trifid, to 18 mm long including 8-13 mm midrib decurrent extension, densely tomentose. *Flowers*: upright, erect; *pedicels* terete, 4-5 mm long, densely pubescent. *Calyx* 12-13 mm long including the c. 1.5 mm receptacle, densely pubescent, unicoloured, with either golden brown or white villous hairs only present, or bicoloured, with both golden brown and white hairs present, upper two lobes recurved, lower three lobes straight; upper two lobes united higher that the lower three, ± obtuse, c. 6 mm long; lower three lobes triangular, sub-acute, c. 5.5 mm long. *Corolla*: *standard* transversely elliptic, fleshy, not fully reflexed, giving a hooded appearance, 16-18 x 17-18 mm including the 6.5 mm claw, margins orange, deep red at base with yellow markings, apex emarginate, base cordate, slightly auriculate; *wings* broadly obovate, 16-17 x 6 mm including the 5.5-6 mm claws, deep red, apex rounded, incurved and touching, ± enclosing the keel, base truncate, not or very scarcely auriculate on the upper margin only, saccate; *keel* half broadly elliptic, incurved longitudinally, 16-17 x 6 mm including the 6 mm claws, deep red, margins not incurved, apex broadly rounded, base auriculate, saccate. *Style* very long, strongly incurved, lower third pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 4 or more. *Pod* sessile, ovoid, 10-12 x 6-7 mm, moderately to densley villous. *Seed* not seen.

Flowering period. October. *Fruiting period*. November and December.

Distribution (Map 89). South-west Western Australia. Occurs in the Stirling Range, and is known only from Mt Toolbrunup and the adjacent Mt Hassell.

Habitat. Grows on the summit to mid-slopes of Mt Toolbrunup on skeletal soils, in heathland.

Conservation status. ROTAP: 2KC-t. CALM: P2. This species is rare, but does not appear to be at risk.

Map 89. Distribution of *G. vestitum*.

Specimens examined. WESTERN AUSTRALIA: Eyre District: Stirling Range, Toolbrunup Peak walking track, scree immediately below summit knoll, 34°23'S, 118°03'E, *M.D. Crisp 8489 & W. Keys*, 24 Sep. 1993 (CANB, K, PERTH); ibid., *M.D. Crisp 8490 & W. Keys*, 24 Sep. 1993 (CANB, GAUBA, PERTH, UWA); Stirling Range National Park: walking track from carpark to Toolbrunup Peak, 34°23'S, 118°03'E, *J.M. Fox 88/264*, 9 Oct. 1988 (CANB, PERTH); Mt Toolbrunup, 34°23'S, 118°03'E, *A. Morrison s.n.*, 4 Oct. 1902 (CANB, PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium vestitum* is similar to *G. leakeanum*, *G. luteifolium*, *G. mondurup* and *G. rubrum*, but *G. vestitum* differs from all of these species in its fleshy petals, the rhombic leaves and recurved leaf margins, and is generally more hairy. Additional characters for the other species follow. *Gastrolobium leakeanum* differs by the very long, distinct petioles at the base of the discolorous leaves, the often somewhat resupinate flowers, and the silvery-haired calyx. *Gastrolobium luteifolium* differs in the rusty tomentose, sheathing bracts to 15 mm long on the peduncle, and having a keel

petal longer than the standard petal. *Gastrolobium mondurup* differs by having narrower leaves (11-24 mm broad), smaller peduncles and subtending floral bracts (peduncle to 7 mm long, bracts 4-5 mm long), and much larger flowers (e.g. keel 19-24 mm long). *Gastrolobium rubrum* differs in the obovate to elliptic leaves, the shorter peduncle and subtending floral bracts (peduncle 7-8 mm long, bracts 3-4 mm long), the ventricose calyx, and the larger flowers (e.g. keel 18-24 mm long).

90. Gastrolobium rubrum (Crisp) G.Chandler & Crisp, *comb. nov.* *Nemcia atropurpurea* (Turcz.) Domin var. *minorifolia* Domin 1923a, p. 27). *Nemcia rubra* Crisp (1987, p. 127). *Type citation*: "W.A.: cum praecedenti." ("W.A.: Warrunup Hill, Stirling Range, Capt. A.A. DORRIEN-SMITH."). *Type specimens*: *holo*: K.

Erect, slender *shrubs*, to 1.5 m high. *Branchlets* ascending, angular to compressed, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, tuberculate, 6-8 mm long, shortly pubescent. *Leaves* spreading, opposite and ternate, stem clasping, obovate to elliptic, 30-70 x 12-30 mm; leaf surfaces with prominent venation; apex emarginate, slightly mucronate; margins slightly crenulate; base rounded. *Stipules* hyaline, 5-6 mm long. *Inflorescences* condensed, axillary racemes, 3-6-flowered; *peduncle* 6-8 mm long; *rachis* to 1-3 mm long; *subtending bracts* caducous, scale-like, entire, sheathing, 3-4 mm long. *Flowers*: nutant, not resupinate; *pedicels* terete, 2-3mm long. *Calyx* campanulate, ventricose, 10-12 mm long including the c. 1.5 mm receptacle, tube truncate at the base, densely villous, hairs bicoloured, with white hairs at the base becoming golden brown near the apices on a maroon surface; upper two lobes united much higher than the lower three, obtuse, c. 5.5 mm long; lower three lobes triangular, ± acute, c. 5 mm long. *Corolla*: *standard* very broadly elliptic to ± circular, longitudinally folded up so that the face is rarely visible, 18-20 x 14-18 mm including the 6 mm claw, orange and red, base truncate, slightly auriculate; *wings* ovate, 18-20 x 6-7 mm including the 4-5 mm claws, red, apex acute to narrowly rounded, not incurved, not enclosing the keel, base auriculate on the lower margin only, not saccate; *keel* half ovate, margins not incurved, c. 18-22 x 6-7 mm including the 5 mm claws, red, apex sub-acute to slightly obtuse, base truncate, only very slightly auriculate, saccate. *Style* very long, slightly incurved, base pubescent; *ovary* very shortly stipitate, densely pubescent; *ovules* 6. *Pod* wholly enclosed in the calyx, sessile, ovoid, c. 9 x 5 mm, moderately to densely pubescent. *Seed* not seen.

Flowering period. September and October. *Fruiting period*. Unknown.

Distribution (Map 90). South-west Western Australia. Widespread in the Stirling Range, at both high and low elevations, but is also known from elsewhere, such as near Denmark.

Map 90. Distribution of *G. rubrum*.

Habitat. Mountain slopes and peaks and valleys on skeletal sandy soils, in heath.

Selected specimens (9 examined). WESTERN AUSTRALIA: Eyre District: Stirling Range, Bluff Knoll walking track, c. 600 m from carpark, 34°22'S, 118°15'E, *M.D. Crisp 8483 & W. Keys*, 24 Sep. 1993 (CANB, GAUBA); Stirling Range, Mondurup, summit ridge, 100 m above 1st saddle, 34°24'S, 117°49'E, *M.D. Crisp 8498 & W. Keys*, 25 Sep. 1993 (CANB, PERTH); Stirling Range National Park: walking track from car park to summit of Toolbrunup Peak, 34°23'S, 118°03'E, *J.M. Fox 88/273*, 9 Oct. 1988 (CANB, MEL); 21 km along Stirling Range Drive from Red Gum Pass Road, 34°24'40"S, 117°57'38"E, *G.T. Chandler 489 et al.*, 17 Feb. 1998 (CANB).

Toxicity. Unknown.

Affinity. Fairly easily distinguished from its close relatives *G. leakeanum*, *G. luteifolium*, *G. mondurup* and *G. vestitum* by the large nodding, not resupinate red

flowers, with the reduced standard not opening, and the ventricose calyx with very white hairs at the base becoming golden brown at the apices.

91. Gastrolobium melanopetalum (F.Muell.) G.Chandler & Crisp, *comb. nov.* Base name: *Brachysema melanopetalum* F. Muell. (1863, p. 11). *Type citation*: "Ad flumina Don et Tone River Australiae occidentalis." *Type specimens*: *holo*: MEL; *iso*: K.

> *Brachysema melananthum* Voss, in Siebert & Voss (1894, p. 193). *Type citation*: None cited. *Notes*: Insufficiently described for certain application, but probably an erroneous transcription of *Brachysema melanopetalum* F. Muell.
>
> *Brachysema sericeum* (Smith) Domin var. *angustifolium* (Benth.) Domin 1923b, p. 26). *Base name*: *Brachysema undulatum* Ker Gawler var. *angustifolium* Benth. (1864, p. 11). *Type citation*: "Gordon, Tone, and Blackwood rivers, Oldfield." *Type specimens*: *lecto*: Blackwood River (K); *isolecto*: MEL; *syn*: G, K, MEL.

Ascending to erect *shrubs*, to 3 m high. *Branchlets* ascending, slightly angular, glabrescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* broadly spreading, mostly alternate, more rarely with some opposite, narrowly ovate to almost elliptic, becoming oblong, 14-60 x 4-20 mm, glabrescent, venation prominently reticulate; apex rounded to acute, mucronate, occasionally emarginate; margins crenulate, undulate or not, slightly recurved; base rounded or obtuse. *Stipules* recurved, filiform, 2-3 mm long. *Inflorescences* reduced axillary racemes maturing 1 or 2 flowered, rarely more, with an aborting, terminal bud; *peduncle* spreading to recurved, wiry, 5-20 mm long; *rachis* 0-3 mm long; *subtending bracts* caducous, scale-like or resembling a reduced leaf, sometimes cupped around calyx: if scale-like: trifid, c. 1 mm long. *Flowers*: pendulous; *pedicels* terete, 0-1.5 mm long. *Calyx* inflated in the lower half, somewhat constricted in the middle, truncated at base, 6-8 mm long including the 1-2 mm receptacle, densely sericeous, lobes not recurved; united slightly higher and slightly broader than the lower three, ovate, obtuse, 3-4 mm long; lower three lobes triangular to ovate, middle lobe the longest, acute, 3-4 mm long. *Corolla*: *standard* strongly reflexed, broadest across the auricles, c. 13 x 5 mm including the 5 mm claws, purple-black, occasionally paler, tapering to a narrowly emarginate apex, lamina bent forwards with incurved margins, base auriculate; *wings* narrowly oblong, c. 13 x 3.5 mm including the 3 mm claws, purple-black, occasionally

paler, apex broadly rounded, not incurved, not enclosing the keel, base auriculate, not saccate; *keel* half ovate, margins not incurved, c. 14 x 6 mm including the 3 mm claws, purple-black, occasionally paler, apex broadly rounded, base auriculate, saccate. *Style* long, incurved, base pubescent; *ovary* slightly stipitate, with a disc at the base, densely pubescent; *ovules* c. 17. *Pod* partly enclosed in the calyx, obliquely obloid, 9-13 x 4-5 mm, moderately villous. *Seed* not seen.

Flowering period. September to December. *Fruiting period.* December.

Distribution (Map 91). South-west Western Australia. Occurs from Kojonup and Frankland, in the Darling escarpment south of Perth, west to the Blackwood River.

Map 91. Distribution of *G. melanopetalum.*

Habitat. Grows on the margins of freshwater swamps and streams, where it forms thickets.

Selected specimens (8 examined). WESTERN AUSTRALIA: Darling District: Darling District: 20 km E of Tonebridge towards Frankland; Kulunilup Nature Reserve, 34°13'05"S, 116°54'00"E, *M.D. Crisp 8473 & W. Keys*, 23 Sep. 1993 (CANB, K, PERTH); 15 kn along Northern Road from turnoff at Perup Road at 40 km E of

Manjimup, 34°12'S, 116°35'E, *M.D. Crisp 8470 & W. Keys*, 23 Sep. 1993 (CANB, GAUBA, PERTH, UWA); Manjimup, 34°14'S, 116°08'E, *R.D. Royce 2732*, 28 Sep. 1948 (B, CANB, PERTH).

Toxicity. Unknown.

Affinity. The deep purple, almost black flowers of *G. melanopetalum* immediately distinguish it from all other species of *Gastrolobium*, except for *G. subcordatum*, which has deep burgundy-coloured flowers. However, *G. subcordatum* has stictly opposite, cordate, broadly ovate or suborbicular leaves, the inflorescence has several flowers (2-6) that are not pendulous, and a standard petal with a truncate apex.

92. Gastrolobium sericeum (Sm.) G.Chandler & Crisp, *comb.nov.* *Base name*: *Chorizema sericeum* Smith (1808, p. 253), "*Chorozema*". *Brachysema sericeum* (Smith) Domin 1923b, p. 25). *Type citation*: "Gathered at King George's Sound by Mr. Menzies." *Type specimens*: Holo: King George's Sound, west coast of New Holland, lat. 35, Menzies, 1803 (LINN); *iso*: BM.

> *Brachysema undulatum* Ker Gawler (1822, t. 642). *Type citation*: "Lately raised by Messrs. Colvill, of the Chelsea Nursery, from seed said to have been collected in the recently explored interior of New South Wales." *Type specimens*: unknown; *holo*: the plate (t. 642).

Prostrate or weakly ascending *shrubs*, to 1 m high, often straggling up through other shrubs. *Branchlets* ascending, ± terete, glabrescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* ascending, alternate, elliptic to orbicular, occasionally ovate or obovate, 6-50 x 6-30 mm, brittle, glabrescent, venation prominently reticulate; apex rounded to acute, sometimes emarginate, mucronate; margins crenulate, undulate, recurved; base rounded or broadly obtuse. *Stipules* recurved, filiform, 2-3 mm long. *Inflorescences* reduced axillary racemes, 1-2-flowered (rarely more), with an aborted, terminal bud, densely sericeous; *peduncle* 5-18 mm long; *rachis* c. 1-3 mm long; *subtending bracts* caducous, scale-like or resembling a reduced leaf, sometimes cupping the base of the calyx; if scale-like: trifid, c. 1 mm long. *Flowers*: pendulous; *pedicels* terete, 0-1.5 mm long. *Calyx* inflated in the lower half, slightly constricted in the middle, base truncated, 6-10 mm long including the c. 1.5 mm receptacle, densely sericeous, lobes not recurved; upper two lobes broader and united scarcely higher than the lower three, obtuse, c. 2.5-4.5 mm long; lower three lobes ovate, acute, middle lobe the longest, 2.5-4.5 mm long. *Corolla*: *standard* ± ovate,

strongly reflexed, lamina bent forwards, margins incurved, c. 15 x 5 mm including the 5 mm claw, pale yellow-green, occasionally infused with pink, drying red-brown, apex peaked, acute, base slightly cordate, auriculate; *wings* narrowly oblong, c. 16 x 3.5 mm including the 3 mm claws, pale yellow-green, occasionally infused with pink, apex rounded, not incurved, not enclosing the keel, sitting above the keel, base auriculate on the upper margin only, slightly saccate; *keel* half obliquely ovate, margins slightly incurved, c. 17 x 6 mm including the 3 mm claws, pale yellow-green, occasionally infused with pink, apex rounded, base auriculate, saccate. *Style* very long, slightly incurved, base pubescent; *ovary* sub-sessile, with a disc present at the base, densely pubescent; *ovules* 12-14. *Pod* half enclosed in the calyx, slightly stipitate, obliquely oblong, 9-11 x 4-5 mm, sparsely villous. *Seed* not seen.

Chromosome number. 2n = 16 (Sands 1975).

Flowering period. September to December. *Fruiting period*. December.

Distribution (Map 92). South-west Western Australia. Occurs from Denmark, east of Albany, to Cranbrook, on the western edge of the Stirling Range.

Habitat. Grows on the banks of water courses and at swamp margins on clay or sandy soils in open shrubland.

Selected specimens (10 examined). WESTERN AUSTRALIA: Darling District: 9 km N of Albany, 1 km along road to Two People Bay, 34°56'S, 117°54'E, *M.D. Crisp 6095 et al.*, 24 Sep. 1979 (AD, CANB, PERTH); Cranbrook turnoff, Albany Highway, 34°17'S, 117°30'E, *M.D. Crisp 8474 & W. Keys*, 23 Sep. 1993 (CANB, GAUBA, PERTH, UWA); Porongurup Range, W slopes of Nancy's Peak, 34°41'S, 117°52'E, *P.G. Wilson 4254*, 29 Sep. 1966 (CANB, PERTH).

Toxicity. Unknown.

Affinity. *Gastrolobium sericeum* is a very variable species, but is quite distinctive, characterised by the slender, few-flowered inflorescence, pendulous turgid flowers with yellow-green petals. The prostrate forms of *G. sericeum* may be confused with *G. minus*, which is easily distinguished by possessing a standard petal with recurved margins, an inflorescence rachis much shorter [1-3(-5) mm long] and not recurved, and the hairs on the pod sericeous, not villous.

Map 92. Distribution of *G. sericeum*.

93. Gastrolobium minus (Crisp) G.Chandler & Crisp, *comb. nov.* *Base name*: *Brachysema minor* Crisp (1995, p. 334). *Type citation*: "Western Australia, Mount Barker, Crisp 6105". *Type specimens*: *holo*: CANB (CBG no. 7908644); *iso*: CANB (CBG no. 7908644), K, PERTH.

Prostrate, trailing *shrubs*, 0.2 m high. *Branchlets* spreading, terete, densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-8 mm long. *Leaves* ± erect, alternate, ovate, elliptic or orbicular, 10-75 x 10-40 mm, upper surface glabrous, lower surface densely sericeous, venation reticulate; apex obtuse to rounded, often emarginate, mucronate; margins undulate; base rounded, usually slightly cordate. *Stipules* erect, setaceous, ± angular, concave on lower surface, slightly denticulate, 2-7 mm long. *Inflorescences* very condensed axillary racemes, 1 or 2 per axil, usually 1-flowered, often with an aborted bud above the flower; *peduncle* with c. 2 barren basal bracts, 1-3(-5) mm long; *rachis* ± nil; *subtending bracts* caducous, scale-like, cupulate, strongly trifid, c. 3 mm long. *Flowers*: upright; *pedicels* terete, 2-4 mm long. *Calyx* campanulate, ventricose, 8-10 mm long including the 1.5-2.5 mm receptacle, densely sericeous, lobes not recurved; upper two lobes united scarcely higher than the lower

three, ovate, 3.5-4.5 mm long; lower three lobes ovate, acute, middle lobe longer than the rest, 3.5-5 mm long. *Corolla*: *standard* strongly reflexed, oblong, deeply concave, constricted above the broad, rounded auricles, c. 16 x 5.5 mm including the 5 mm claw, red and yellow, or rarely almost white, apex truncate, ± emarginate, becoming obtuse as upper corners recurve with age, base slightly cordate, strongly auriculate; *wings* narrowly oblong, margins incurved, c. 17 x 2.5 mm including the 6 mm claws, red, apex rounded, not incurved, not enclosing the keel, base slightly auriculate, saccate; *keel* half elliptic, c. 17 x 5 mm including the 6 mm claws, red, apex obtuse, sometimes apiculate, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* scarcely stipitate, with a disc at the base, densely pubescent; *ovules* 12-13. *Pod* partly enclosed in the calyx, ± sessile, obliquely oblong, 9-13 x 5-8 mm, sparsely sericeous. *Seed* not seen.

Flowering period. July to October, rarely in summer. *Fruiting period*. September to October.

Distribution (Map 93). South-west Western Australia. Occurs in the Mount Barker and Cranbrook area, with an outlier near Middle Mount Barren, in Fitzgerald River National Park.

Habitat. Grows on sandy loam and gravelly clay soils in *Eucalyptus marginata* open forest.

Selected specimens (8 examined). WESTERN AUSTRALIA: Darling District: midway between Denmark and Mount Barker, 34°45'S, 117°30'E, *C.E. Woolcock s.n. & D.T. Woolcock*, 6 Sep. 1982 (CANB); Mt Barker, town limits, on road to Porongurups, 34°37'58"S, 117°40'24"E, *M.D. Crisp 8922 & W. Keys*, 10 Oct. 1996 (CANB); 8 miles [13 km] from Cranbrook towards Mount Barker on Albany Highway, 34°25'S, 117°34'E, *J.W. Wrigley WA/68-4429*, 11 Oct. 196 (CANB); 45 km from Denmark towards Mount Barker, 34°39'S, 117°36'E, *J.W. Wrigley WA/68-4558*, 13 Oct. 1968 (CANB).

Toxicity. Unknown.

Affinity. *Gastrolobium minus* is vegetatively similar to *G. latifolium*, but the latter species has terete, filiform stipules, larger flowers (e.g. calyx 10-12 mm long, keel c. 43 mm long), the calyx lobes do not overlap as far (c. 0.3 mm zone of overlap, compared with a 0.8-1 mm zone of overlap in *G. minus*), and a villous (not sericeous) pod.

Gastrolobium modestum also bears some resemblance to *G. minus*, but has stoloniferous shoots, which usually bear the inflorescences, larger flowers (e.g. calyx 8-12 mm long, keel c. 19 mm long) and creamy pink petals.

Map 93. Distribution of *G. minus*.

94. Gastrolobium modestum (Crisp) G.Chandler & Crisp, comb. nov. *Brachysema modestum* Crisp (1995, p. 336). *Type*: Western Australia, Smith Rd, Treeton Block, State Forest, 33°48'03.7"S, 115°17'28.3"E, *B.J. Keighery & N. Gibson 1*, 15 Oct. 1992. *Type specimens*: *holo*: PERTH; *iso*: CANB (CBG no. 9612608), K, MEL, NSW.

Prostrate to clumped *shrubs*, to 0.5 m high and 1-3 m broad. *Branchlets* prostrate or ascending, with the prostrate branchlets stoloniferous, often rooting at the nodes, terete, moderately sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-6 mm long. *Leaves* ± erect, alternate, elliptic, ovate or orbicular, 15-70 x 8-45 mm, upper surface glabrescent, lower surface sericeous, venation reticulate; apex obtuse to rounded, occasionally emarginate, mucronate; margins undulate, not recurved; base rounded to cuneate. *Stipules* erect, setaceous, ± angular, concave on lower face, slightly denticulate, 2-6 mm long. *Inflorescences* dimorphic: those on leafy aerial stems consist

of 1 or 2 very condensed racemes per axil, usually 1-flowered, with an aborting bud above the flower, *rachis* 1-3 mm long; those on stolons similar but aggregated into loose panicles by suppression of leaves, up to 30 cm long, with only the flowers emerging from the litter, unit racemes 1-2-flowered, *rachis* up to 25 mm long; *subtending bracts* caducous, scale-like, cupulate, strongly trifid, 1.5-1.5 mm long. *Pedicels* terete, 4-12 mm long. *Calyx* campanulate, ventricose, 8-12 mm long including the 2-3 mm receptacle, densely sericeous, lobes not recurved; lobes sub-equal, upper two not united prominently higher than the lower three, ovate, apiculate, 4-6 mm long, the lower-most lobe being slightly longer and narrower than the others. *Corolla*: cream to pale green, infused with pale pink; *standard* strongly reflexed, truncate, recurved to curled with age, constricted above the broad, rounded auricles, c. 16 x 5.5 mm including the 6 mm claw, apex emarginate, base truncate, strongly auriculate; *wings* narrowly obovate, sigmoid with incurved margins, c. 19 x 3 mm including the 5 mm claws, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half broadly elliptic, c. 19 x 5 mm including the 6 mm claws, apex apiculate, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* scarcely stipitate, with a disc at the base, densely pubescent; *ovules* c. 13. *Pod* enclosed in the calyx, ± sessile, obliquely obloid, turgid, c. 8 x 4 mm, sparsely villous. *Seed* not seen.

Flowering period. September to October. *Fruiting period.* Unknown.

Distribution (Map 94). South-west Western Australia. Occurs near Busselton, south of Perth, on the edge of the Whicher Range.

Habitat. Grows on the edges of an ironstone flat on shallow red clay-loam or grey sand, in an ecotone between a seasonal swamp-heath dominated by *Dasypogon* and *Xanthorrhoea*, and open forest dominated by Jarrah (*Eucalyptus marginata*) and Marri (*E. calophylla*).

Conservation status. IUCN: V. ROTAP: 2V. CALM: R. This species is very rare, and considered to be vulnerable, and measures need to be taken to ensure the survival of this species.

Specimens examined. WESTERN AUSTRALIA: Darling District: Smith Road, 16 km SSW of Busselton, near Vasse River, 33°48'S, 115°18'E, *M.D. Crisp 8465 & W. Keys*, 22 Sep. 1993 (CANB, GAUBA, K, MEL, PERTH, UWA); Smith Rd, Treeton Block, State Forest, 33°48'03.7"S, 115°17'28.3"E, *B.J. Keighery & N. Gibson 1*, 15 Oct. 1992

(CANB, PERTH); Smith Road, Treeton Forest Block at base of Whicher Range, 33°48'03"S, 115 17 28"E, *B.J. Keighery 734 & N. Gibson*, 9 Nov. 1992 (CANB, PERTH); ibid., *B.J. Keighery 683 & N. Gibson*, 15 Oct. 1992 (CANB, PERTH).

Map 94. Distribution of *G. modestum*.

Toxicity. Unknown.

Affinity. This species is distinguished by its inflorescence-bearing stolons, 0.5 m or longer, which makes it difficult to confuse with any species of *Gastrolobium* except for *G. minus*, which has a similar general aspect, and shares with *G. modestum* the unique character of recurved margins at the apex of the standard. However, *G. minus* differs in the inflorescence-bearing stems which, while prostrate, are leafy and never stoloniferous, the inflorescences are never paniculate, the flowers are smaller (e.g. keel c. 17 mm long) and the petals are typically red with yellow markings on the standard.

95. Gastrolobium bracteolosum (F.Muell.) G.Chandler & Crisp, *comb. nov. Base name*: *Brachysema bracteolosum* F. Muell. (1863, p. 10). *Type citation*: "In Nova Hollandia austro-occidentali. Maxw." *Type specimens*: *holo*: MEL.

Brachysema lanceolatum Meisn. {var.} beta *glabrescens* Meisn. (1844, p. 25).

Type citation: "Ad promontor. Cape Riche, 21 Nov. 1840, Herb. Preiss. no. 822." (Locality & date wrong, vide Crisp, 1995). *Type specimens*: *lecto*: LD; *isolecto*: G, NY.

Cupulanthus bracteolosus (F. Muell.) Hutch. (1964, p. 341). *Base name*: *Brachysema bracteolosum* F. Muell. *Notes*: nom. nud. & inval. - no reference is made to the original place of publication of the base name.

Prostrate or straggling *shrubs*, to 1 m high. *Branchlets* spreading, angular, moderately sericeous to glabrescent. *Petioles* terete, continuous and sometimes slightly decurrent with the branchlet, 2-5 mm long. *Leaves* ascending, alternate, linear-elliptic, becoming broader and obovate towards the base of the branchlet, 30-125 x 2-22 mm, glabrescent, venation reticulate; apex acute or obtuse, rarely truncate and emarginate, mucronate; margins recurved; base tapering into the petiole. *Stipules* ± caducous, recurved, subulate, 3-6 mm long. *Inflorescences* reduced axillary racemes, 1-flowered, 1-3 per axil; *peduncle* recurved, wiry, continuing as a sterile tip 1-2 mm beyond the insertion of the flower, 8-20 mm long; *rachis* 1-2 mm long; *subtending bracts* persistent, enlarged and cupped around the base of the calyx, with two round lobes, the midrib continued as a 1 mm mucro between the lobes, 5-7 mm long, glabrescent. *Flowers*: pendulous, sessile; *pedicels* nil. *Calyx* campanulate, scarcely ventricose, 13-18 mm long including the 3-4 mm receptacle, densely sericeous, lobes not recurved; upper two lobes united higher than the lower three, obtuse, 6-9 mm long; lower three lobes ovate, sub-acute, 6-9 mm long. *Corolla*: orange-red, red-brown or deep red, with purple markings, or yellow-green; *standard* ± ovate, with two broad round auricles abruptly constricted above into a short, narrow, hooded lamina and constricted below into a long claw, 15-20 x 9-10 mm including the c. 10 mm claw, apex truncate, ± emarginate, base obtuse, auriculate; *wings* narrowly oblon, c. 25 x 3 mm including the 10 mm claws g, apex truncate, base auriculate on the upper margin only, saccate; *keel* half ovate to oblong, margins slightly incurved, c. 25 x 5 mm including the 8 mm claws, apex obtuse, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* sub-sessile, with a disc at the base, densely pubescent; *ovules* 6-8. *Pod* fully enclosed in the calyx, ellipsoid, c. 15 x 8 mm, densely pubescent. *Seed* ovoid, c. 3.5 mm long, arillate.

Chromosome number. 2n = 16 (Sands, 1975).

Flowering period. July to November. *Fruiting period*. October to November.

Distribution (Map 95). South-west Western Australia. Occurs along the south coast from Bremer Bay to Mt Manypeaks, near Albany, and north to the Stirling Range.

Map 95. Distribution of *G. bracteolosum.*

Habitat. Grows on broad dunes or occasionally in moist sites, on sand or clay, in mallee and heathland.

Selected specimens (21 examined). WESTERN AUSTRALIA: Eyre District: Gully between Mondurup and Baby Barnett Hill, 3.6 km along Stirling Drive from Red Gum Pass, 34°24'S, 117°49'E, *M.D. Crisp 8503 & W. Keys*, 25 Sep. 1993 (CANB, GAUBA, NSW, PERTH, UWA); 4 km E of Kalgan River, 34°53'S, 118°02'E, *R.D. Royce 4270*, 30 July 1953 (CANB, PERTH); 1.9 km along Swamp Road towards Fitzgerald River National Park, from Bremer Bay Road, 34°23'12"S, 119°17'18"E, *G.T. Chandler 426 et al.*, 15 Feb. 1998 (CANB); 2 mls [3 km] S of Chester Pass, Stirling Range, 34°25'S, 118°06'E, *M.E. Phillips s.n.*, 10 Oct. 1962 (CANB).

Toxicity. Unknown.

Affinity. *Gastrolobium bracteolosum* is easily distinguished from all other species of the genus *Gastrolobium* by its combination of narrow leaves, enlarged, 2-lobed bracts cupped around the calyx, a long claw on the standard, and an elongated aril on the seed.

96. Gastrolobium subcordatum (Benth). G.Chandler & Crisp, *comb. nov*. *Base name*: *Brachysema subcordatum* Benth. (1864, p. 11). *Type citation*: "W. Australia, Drummond, 5th Coll. n. 21." *Type specimens*: *lecto*: K; *isolecto*: BM, FI-W*, G*, K (2 sheets), MEL, OXF, P, PERTH, W.

Bushy, erect or spreading *shrubs*, to 1.5 m high. *Branchlets* ascending, slightly angular, densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* spreading, decussate, broadly to very broadly ovate or suborbicular, 6-45 x 7-35 mm, upper surface glabrous, lower surface densely sericeous, venation prominently reticulate; apex obtuse, rounded or slightly emarginate, mucronate; margins crenulate, strongly undulate; base slightly cordate. *Stipules* erect to recurved, setaceous, to 5 mm long. *Inflorescences* terminal racemes on short shoots or axillary, 2-4(-6)-flowered, rarely once-branched, densely sericeous; *peduncle* occasionally with a pair of barren basal bracts, 0-4 mm long; *rachis* 2-8 mm long; *subtending bracts* caducous, leaf-like or scale-like; if scale like: trifid, c. 2 mm long. *Flowers*: not resupinate; *pedicels* terete, 1-2 mm long. *Calyx* campanulate, ventricose, 6-8 mm long including the c. 1 mm receptacle, densely sericeous, lobes not recurved; upper two lobes united scarcely higher than the lower three, obtuse, c. 2.5-3.5 mm long; lower three lobes triangular, acute to acuminate, 3-4 mm long. *Corolla*: *standard* ± oblong, strongly reflexed, strongly concave, constricted around the large basal auricles, c. 10 x 5 mm including the 4 mm claw, burgundy, apex emarginate, base truncate, strongly auriculate, causing the base to flare; *wings* narrowly obovate, slightly recurved longitudinally, c. 14 x mm including the 4-5 mm claws, burgundy, apex obtuse, not incurved, not enclosing keel, base auriculate on the upper margin only, saccate; *keel* half obliquely elliptic, margins not incurved, c. 12.5 x mm including the 4 mm claws, burgundy, apex rounded, base auriculate, slightly saccate. *Style* long, incurved, lower third pubescent; *ovary* sub-sessile, with a disc present at the base, densely pubescent; *ovules* 2-6. *Pod* ± enclosed in the calyx, ± sessile, obliquely ovoid, 8-9 x 4.5-6 mm, sparsely pubescent. *Seed* reniform, c. 3 mm long, arillate.

Flowering period. September to October. *Fruiting period*. October and November.

Distribution (Map 96). South-west Western Australia. This species occurs in the

Porongurup Range, and may extend into the Stirling Range.

Map 96. Distribution of *G. subcorcatum*.

Habitat. Grows in granite declivities on sandy soils, in open shrubland and the margins of *Eucalyptus diversicolor* forest.

Conservation status. IUCN: R. ROTAP: 2RC-. This species is rare, but does not appear to be in any immediate danger.

Selected specimens (6 examined). WESTERN AUSTRALIA: Eyre District: Porongurup Range, Devils Slide, base of granite dome, 34°41'S, 117°52'E, *M.D. Crisp 6097 et al.*, 24 Sep. 1979 (AD, CANB, NSW, PERTH); Porongurup Range, track to Hayward Peak, c. 1 km from Tree in the Rock, 34°41'S, 117°52'E, *M.D. Crisp 8511 W. Keys*, 26 Sep. 1993CANB, GAUBA, PERTH, UWA); Porongurup Range, W slopes of Nancy's Peak, , *P.G. Wilson 4254*, 29 Sep. 1966 (CANB, PERTH).

Toxicity. Unknown.

Affinity. This species is somewhat similar to *G. melanopetalum* in its floral morphology and its dark petals, which differs by always having mostly alternate leaves, the leaf base is never consistently cordate, and the lower leaf surface is glabrescent.

97. Gastrolobium celsianum (Lemaire) G.Chandler & Crisp, *comb. nov.* *Brachysema celsianum* Lemaire (1843, p. 33). *Type citation*: None cited. *Type specimens*: *holo*: the plate.

Brachysema platypterum Lemaire (1843, p. 33) '*platyptera*'. *Notes*: Nom. inval., given as a synonym of *Brachysema celsianum*.

Brachysema acuminatum Jacques (1863, p. 643). *Type citation*: None cited; description made from a cultivated plant. *Type specimens*: Unknown.

Brachysema lanceolatum Meisn. (1844, p. 24). *Type citation*: Preiss 823 (var. alpha *hypargyreum*), Preiss 822 (var. beta *glabrescens*) and Preiss 815 (var. gamma *planifolium*). See infraspecific taxa. *Type specimens*: *lecto* (here chosen): LD (Preiss 823).

Brachysema lanceolatum Meisn. [var.] alpha *hypargyreum* Meissner (1844, p. 25). *Type citation*: "In planitie arenosa prope montem Manypeak 1. Tjilberup (Kent) 16. Nov. 1840. Herb. Preiss. no. 823." (Locality & date wrong, vide Crisp, 1995). *Type specimens*: *lecto*: LD; *isolecto*: NY.

Brachysema lanceolatum Meisn. [var.] gamma *planifolium* Meisn. (1844, p. 25), '*planifolia*'. *Type citation*: "In glareosis sylvae 15 mill. a Kojonup (Goderich) m. Febr. 1841. Herb. Preiss. no. 815." *Type specimens*: *lecto*: NY; *isolecto*: LD.

Brachysema speciosum Lescuyer (1864, p. 264, t. 18), '*speciosa*'. *Type citation*: none cited. *Type specimens*: Unknown; *holo*: plate 18.

Prostrate, scrambling or bushy ascending *shrubs*, to 1.2 m high. *Branchlets* spreading to ascending, terete, densely sericeous. *Petioles* terete, continuous but not decurrent with the branchlet, 2-5 mm long. *Leaves* broadly spreading, decussate or some alternate, ovate, narrowly ovate or rarely sub-linear, 15-100 x 4-55 mm, upper surface glabrous, lower surface densely sericeous, venation reticulate; apex acute, acuminate or rarely rounded, mucronate, uncinate or rarely cirrhous; margins ± undulate, crenulate, not recurved; base rounded. *Stipules* erect to recurved, setaceous, 3-5 mm long. *Inflorescences* axillary racemes, 2-6-flowered; *peduncle* 1-3 mm long; *rachis* 0-10 mm long; *subtending bracts* caducous, leaf-like or scale-like and trifid, 3-4 mm long. *Flowers*: resupinate; *pedicels* terete, 2-3 mm long. *Calyx* campanulate, scarcely ventricose, 12-16 mm long including the 3-4 mm receptacle, densely sericeous, lobes

not recurved; upper two lobes united higher than the lower three, obtuse, 5-7 mm long; lower three lobes triangular, middle lobe narrower than the other two, 5-7mm long. *Corolla*: *standard* sub-reflexed, narrowly ovate to oblong, concave, c. 15 x 4 mm including the 5 mm claw, red with a yellow centre, apex emarginate, base, cordate, strongly auriculate; *wings* obliquely narrowly obovate, c. 17 x 4-5 mm including the 2 mm claws, red, apex sub-acute, base auriculate on both margins, saccate; *keel* half elliptic, margins not incurved, c. 30 x 7 mm including the 9 mm claws, red, apex acute, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* stipitate, with a disc at the base, densely pubescent; *ovules* 14-18. *Pod* ± enclosed in the calyx, ellipsoid, 10-15 x 3-5 mm, densely pubescent. *Seed* reniform, c. 2.5 mm long, arillate.

Chromosome number. 2n = 16 (Sands, 1975).

Flowering period. August to November, more rarely in July. *Fruiting period*. October and November.

Distribution (Map 97). South-west Western Australia. Occurs from Wagin south to Bremer Bay, with outliers occurring on the Moore River, near Busselton, and near Ravensthorpe.

Habitat. Grows along watercourses on sandy, gravelly soils, but also extends to flats or moist depressions in mallee and woodland.

Selected specimens (18 examined). WESTERN AUSTRALIA: Eyre District: Pallinup River crossing (Mara Bridge) on Albany-Jerramungup road, 34°24'S, 118°45'E, *E.M. Canning WA/68-7446*, 9 Nov. 1968 (CANB); Junction of Brassey Road and Cranbrook to Broomehill Road, 33°52'46"S, 117°39'09"E, *T.R. Lally 1245 & B. Lepschi*, 21 Sep. 1996 (CANB, PERTH); Moore River, 2.5 km NNW of Mogumber, 21°02'03"S, 116°01'00"E, *M.D. Crisp 9009 & W. Keys*, 24 Oct. 1996 (CANB, PERTH); Ongerup to Ravensthorpe Road, 20 km E of Ongerup, 33°57'S, 118°42'E, *D.E. Albrecht 4513*, 17 Sep. 1990 (CANB, MEL).

Map 97. Distribution of *G. celsianum*.

Toxicity. Unknown.

Affinity. *Gastrolobium celsianum* is easily identifiable by its distinctive floral morphology, particularly the wing petals being about half the length of the keel and scarcely emergent from the calyx, making it difficult to confuse with any other species of *Gastrolobium*. The long, curving keel is the most conspicuous feature of the flower.

98. Gastrolobium formosum (Kippist ex Lindl.) G.Chandler & Crisp, *comb.nov.* *Base name*: *Jansonia formosa* Kippist ex Lindley (1847, p. 307). *Type citation*: "...from the south-west coast of New Holland,...specimens...in museums of Mr. Heward and Dr. Leman." *Type specimens*: Drumm. 100: G. *Notes*: Kippist read a paper describing *Jansonia* to a meeting of the Linnean Society of London on 4 May 1847, but the full text was not published until 1851, in the *Transactions of the Linnean Society*. Meanwhile, versions of the paper appeared in a succession of periodical articles (Hervey 1847; Kippist 1847; Lindley 1847; Kippist 1848), among which Lindley's appears to have effected valid publication of the name *Jansonia formosa*.

Cryptosema pimeleoides Meisn. (1848, p. 207). *Type citation*: "In colonia ad fl. Cygnorum detexit Jacobus Drummond. coll. III. no. 100 (Herb. Shuttleworth!)." *Type specimens*: *Holo*: BM; *iso*: CGE, E, G, K (4 sheets), LD, MEL (2 sheets), NY, OXF, W.

Jansonia pimeleoides (Meissner) C.A.Gardner (1930, p. 56). Enum. Pl. Austral. Occid. : 56. *Base name*: *Cryptosema pimeleoides* Meissner *Notes*: Nom. superfl. because the correct name *Jansonia formosa* Kippist ex Lindley is given in synonymy.

Small, trailing *shrubs*, to less than 1 m high. *Branchlets* ascending, angular, glabrous to sparsely pubescent. *Petioles* terete, to 5 mm long. *Leaves* opposite, lanceolate, base slightly cordate, 40-55 x 10-18 mm, softly pubescent, venation prominently reticulate; apex rounded, softly mucronate; margins almost flat, crenulate or undulate; base rounded. *Stipules* recurved to slightly coiled, hyaline, to c. 5 mm long. *Inflorescences* terminal capitula, usually on a short, axillary shoot, 4-flowered, enclosed in sheathing globose decurrent bracts; *peduncle* to 5 mm long; *rachis* nil; *subtending bracts* persistent, scale-like, globose, trifid, sheathing the base of the inflorescence, 10-12 mm long, densely golden pubescent. *Pedicels* nil. *Calyx* 15-17 mm long including the c. 2 mm receptacle, densely pubescent, bicoloured, with hairs towards the base silvery, and hairs in the upper half golden-brown, lobes not recurved; upper two lobes united lower than the lower three and much reduced, acute, c. 3 mm long; lower three lobes enlarged, with the middle lobe longer and broader than the other two, ovate to triangular, sub-acute, middle lobe c. 10 mm long, other two lobes c. 8 mm long. *Corolla*: *standard* considerably reduced to less than a third the length of wings, strongly reflexed, ovate, c. 6.5 x 3 mm including the 3 mm claw, red, apex triangular, acute, entire, base cuneate, not auriculate; *wings* elliptic, c. 14 x 5 mm including the 5 mm claws, red, apex rounded, not incurved, not enclosing the keel, base auriculate on the upper margin only, saccate; *keel* half elliptic, margins not incurved, c. 16 x 4 mm including the 4 mm claws, red, apex ± obtuse, base auriculate, saccate. *Style* very long, hooked, lower third pubescent; *ovary* slightly stipitate, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. November. *Fruiting period*. Unknown.

Distribution (Map 98). South-west Western Australia. Occurs in the wetter, far SW corner of this region, around Margaret River and Augusta.

Habitat. Grows along river banks or in swamps on clay loam soils, in marri forest or swamp vegetation.

Map 98. Distribution of *G. formosum*.

Selected specimens (6 examined). Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: NNE of Augusta, *R. Davies 164*, 19 Sep. 1995 (CANB, PERTH); Margaret River crossing, Bussel Highway, *J.M. Taylor 2057 & P. Ollerenshaw*, 21 Sep. 1983 (AD, CANB, MEL, MO, PERTH); Scott River, Brennan Ford, *M.D. Crisp 8933 & W. Keys*, 11 Oct. 1996 (CANB).

Toxicity. Unknown.

Affinity. The unique inflorescence of *G. formosum*, a 4-flowered capitulum enclosed in sheathing bracts with the large calyx lobes obscuring the corolla, makes it very difficult to confuse with any other species of *Gastrolobium*.

99. Gastrolobium papilio (Crisp) G.Chandler & Crisp, comb. nov. *Brachysema papilio* Crisp (1995, p. 326). *Type*: Western Australia, Williamson Rd, Abba Block, State Forest, 33°42'S, 115°32'E, *B.J. Keighery & N. Gibson 2*, 16 Oct. 1992. *Type specimens*: *holo*: PERTH; *iso*: CANB (CBG no. 9612609).

Tangled, clumped *shrubs*, to 1.5 m high, often climbing through other shrubs. *Branchlets* ascending, wiry, terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-3 mm long. *Leaves* spreading to ascending, opposite (seedling leaves with some sub-alternate), mostly obcrescentic, tending to transversely narrowly rhombic or obtriangular, 5-18 x 10-28 mm, glabrescent, venation reticulate; apex stiffly mucronate, almost pungent-pointed, often with a small triangular lobe; margins undulate, crenulate, recurved; base rounded or cordate. *Stipules* recurved to curled up, setaceous, 3-5 mm long. *Inflorescences* racemes, axillary or terminal on short, axillary shoots, 2(-4)-flowered; *peduncle* 15-25 mm long; *rachis* 0-15 mm long; *subtending bracts* leaf-like or reduced to trilobed scales c. 3 mm long. *Flowers*: pendulous, not resupinate; *pedicels* wiry, 6-10 mm long. Calyx campanulate, 12-13 mm long including the 2-3 mm receptacle, densely villous, lobes not recurved; upper two lobes united higher than the lower three, acute, 7-9 mm long; lower three lobes triangular, acute, incurved, 8-10 mm long. *Corolla*: cream to red, darkening with age; *standard* reflexed, narrowly oblong, constricted above the auricles, c. 15 x 6 mm including the 6 mm claw, apex emarginate, base strongly auriculate; *wings* narrowly elliptic, c. 18 x 4 mm including the 5 mm claws, apex rounded-obtuse, not incurved, not enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half elliptic, c. 20 x 6 mm including the 5 mm claws, apex rounded, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* stipitate, with a disc present at the base, densely pubescent; *ovules* c. 12. *Pod* ± enclosed by the calyx, slightly stipitate, obliquely narrowly ellipsoid, 13-15 x c. 5 mm, moderately villous. *Seed* not seen.

Flowering period. From October. *Fruiting period*. Unknown.

Distribution (Map 99). South-west Western Australia. Occurs near Busselton, south of Perth, on the edge of the Whicher Range.

Habitat. Grows on flat plains on sandy clay over ironstone, in low, open, mixed heath.

Conservation status. IUCN: E. ROTAP: 2V. This species is quite rare, and is thought to be endangered.

Specimens examined. Due to the conservation status of this species, precise localities are not given. WESTERN AUSTRALIA: Darling District: *M.D. Crisp 8461* (CANB, GAUBA, PERTH); ibid., *M.D. Crisp 8462*, (CANB, PERTH); ibid., *M.D. Crisp 8463*, (CANB, PERTH); Williamson Rd, Abba Block, State Forest, *B.J. Keighery & N.*

Gibson 2, 16 Oct. 1992 (CANB, PERTH); base of Whicher Range, near Williamson Road in State Forest, *B.J. Keighery 1058*, 16 Oct. 1992 (CANB, PERTH).

Map 99. Distribution of *G. papilio*.

Toxicity. Unknown.

Affinity. This species is very difficult to confuse with any other species of *Gastrolobium*, due to the leaf shape and texture, and the nodding, paired flowers. The only exception would be *G. praemorsum*, which has slightly similar leaves, but which differs by having softer, herbaceous leaves that are not pungent, the leaf shape is obovate to obtriangular, rather than crescentic, there is a paler marginal band on the leaf that contrasts with the darker leaf tissue which is absent in *G. papilio*, and the flowers are erect, resupinate, and larger (e.g. keel c. 30 mm long).

100. Gastrolobium praemorsum (Meisn.) G.Chandler & Crisp, *comb. nov. Base name*: *Brachysema praemorsum* Meisn. in Lehm. (1844, p. 25). *Type citation*: "In solo limoso ad ripam fluvii Preston (Wellington) d. 13. Dec. 1839. Herb. Preiss. no. 824."

Type specimens: *lecto*: NY; *isolecto*: BR, C (2 sheets), FI-W*, G (3 sheets)*, GOET, HBG, K, L (3 sheets), LD, MEL (2 sheets), MO, P, S (2 sheets), W (2 sheets).

Tangled, ± prostrate *shrubs*, to 0.6 m high. *Branchlets* tangled, spreading, terete, moderately pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-6 mm long. *Leaves* spreading, opposite, broadly to transversely broadly obcordate to obovate, 9-55 x 7-52 mm, glabrescent, venation prominently reticulate, often with a paler marginal band 1-2 mm broad on both faces; apex rounded to ± truncate, occasionally emarginate, often with a small triangular lobe at the apex, mucronate; margins undulate, crenulate, recurved; base rounded to cuneate. *Stipules* recurved, setaceous, 3-5 mm long. *Inflorescences* racemes, axillary or terminal on short shoots, 2-4-flowered, rarely once-branched; *peduncle* 3-15 mm long; *rachis* 4-25 mm long; *subtending bracts* leaf-like and indistinguishable from the leaves, or progressively reduced to 3 mm long and scale-like with three subulate lobes. *Flowers*: resupinate; *pedicels* terete, 4-10 mm long. *Calyx* campanulate, 13-16 mm long including the 2-3 mm receptacle, moderately to densely pubescent, lobes not recurved; upper two lobes united slightly higher than the lower three, triangular, acuminate, 8-10 mm long; lower three lobes triangular, acuminate, middle lobe the longest, c. 13 mm long. *Corolla* initially dull red to greenish, becoming a darker and purer red with age: *standard* sub-reflexed, narrowly oblong, concave, constricted near the middle of the lamina, c. 18 x 6 mm including the 5 mm claw that has a broader, rounded base, apex emarginate, base truncate, prominently auriculate; *wings* narrowly elliptic, c. 22 x 5 mm including the 5 mm claws, apex rounded-obtuse, not incurved, not enclosing the keel, base auriculate on the upper margin only, slightly saccate; *keel* half elliptic, c. 30 x 8 mm including the 5 mm claws, apex acute, base auriculate, saccate. *Style* long, slightly incurved, base pubescent; *ovary* stipitate, with a disc present at the base, densely pubescent; *ovules* c. 19. *Pod* partly enclosed in the calyx, slightly stipitate, ellipsoid, c. 15 x 6 mm, moderately villous. *Seed* reniform, c. 3 mm long, arillate.

Chromosome number. 2n = 16 (Sands, 1975).

Flowering period. August to December. *Fruiting period*. Unknown.

Distribution (Map 100). South-west Western Australia. Occurs from Geographe Bay east to Albany, with outliers as far north as Bullsbrook, which is just north of Perth.

Habitat. Grows very well in disturbed areas, and occurs in a wide variety of habitats, from wet, boggy areas to laterite ridges on sandy and clay soils, in jarrah forest, wandoo woodland and shrubland.

Map 100. Distribution of *G. praemorsum*.

Selected specimens (18 examined). WESTERN AUSTRALIA: Darling District: Tonebridge, 34°15'S, 116°44'E, *M.D. Crisp 8472 & W. Keys*, 23 Sep. 1993 (CANB); 20 miles [32 km] from Pingelly towards Wandering, along northern road, 32°35'S, 116°55'E, *J.W. Wrigley WA/68-4243*, 8 Oct. 1968 (CANB); 10 km along Woogenelup Road, Mt Barker to Stirling Range, 34°33'41"S, 117°44'21"E, *Chandler 792 & S. Donaldson*, 31 Oct. 1998 (CANB, MEL, PERTH); 1 S of Kojonup on Albany Highway, 33°51'S, 117°09'E, *G.J. Keighery 6182*, 21 July 1983 (CANB, PERTH).

Toxicity. Unknown.

Affinity. The unusual shape of the leaves of this species makes is difficult to confuse with any other species of *Gastrolobium*, except for *G. papilio*, which shares similarly shaped leaves, but differs in having consistently crescentic leaves with a pungent-point,

and no paler marginal band, and the flowers are pendulous and shorter (e.g. keel 20 mm long).

Unplaced species

These species were not included in any phylogenetic analysis of *Gastrolobium*, and their morphology alone is not sufficient to place them into any particular group without further evidence.

101. Gastrolobium ferrugineum G.Chandler, Crisp & R.J.Bayer, *sp.nov.* *Type*: WESTERN AUSTRALIA: Eyre District: Ca 20 km SW of Narrikup, *L.R. Anderson SPN 1027*, 11 Aug. 1992 (*holo*: PERTH; *iso*: PERTH).

Vegetatively similar to *G. reflexum* and *G. spectabile*, but *G. reflexum* has prominent, reflexed stipules, a more open, terminal raceme, and the peduncle and rachis are terete. *Gastrolobium spectabile* has prominent recurved to reflexed stipules, long, terminal racemes and a terete inflorescence axis, whereas the stipules of *G. ferrugineum* are absent, the inflorescence is condensed, often axillary, the inflorescence axes are generally covered in short, rust-coloured hairs, and the peduncle and rachis are angular.

G. reflexo et *G. spectabili* vegetative similis sed stipulis nullis, inflorescentia condensata saepe axillari et pedunculo rhachideque angulato distinguenda.

Etymology. From the Latin *ferrugineus* = rust-coloured, and refers to the short, generally rust-coloured hairs on the inflorescence axes.

Erect *shrubs*, 2.5-3 m high. *Branchlets* spreading to ascending, angular, glabrous to sparsely pubescent. *Petioles* sometimes absent; when present: angular, continuous and decurrent with the branchlet, 0-0.5 mm long. *Leaves* spreading, opposite, very broadly triangular, 20-30 x 23-39 mm, glabrous, venation prominently reticulate, intramarginal vein prominent; apex obtuse to barely acute, mucronate or shortly pungent-pointed; margins minutely crenulate, not recurved; base cordate. *Stipules* usually absent; when present erect, very small, c. 0.25 mm long. *Inflorescencess* terminal or axillary racemes or rarely umbels, 1-4 per terminus or axil, 3-10-flowered; *peduncle* angular, 10-27 mm long; *rachis* angular, 0-10 mm long; *subtending bracts* ± persistent, scale-like, entire, elliptic, 6-8 mm long. *Pedicels* terete, c. 2 mm long. *Calyx* campanulate, 5.5-7 mm long, bicoloured, with densely villous white hairs at the base and rust-coloured hairs at the apex of the lobes which are not recurved; upper two lobes united into an almost truncate lip, rounded, c. 3 mm long; lower three lobes triangular, sub-acute, c. 2.5 mm

long. *Corolla*: *standard* transversely ovate, c. 13 x 12 mm including the 5.5 mm claw, yellow to yellow-orange with a maroon ring surrounding the yellow centre, apex emarginate, base truncate, slightly auriculate; *wings* obovate, c. 11 x 3 mm including the 4 mm claws, yellow and maroon, apex rounded, base auriculate on the upper margin only, not saccate; *keel* half broadly elliptic, margins not incurved, c. 11 x 3 mm including the 4 mm claws, maroon and pink, apex rounded, base auriculate, saccate. *Style* long, incurved to hooked, very broadly flattened, slightly pubescent at the very base only; *ovary* stipitate, densely pubescent; *ovules* 4. *Pod and seed* not seen.

Flowering period. May to September. *Fruiting period*. Unknown.

Distribution (Map 101). South-west Western Australia. Known only from a few collections south of Perth in the Narrikup and Mount Barker regions.

Map 101. Distribution of *G. ferrugineum*.

Habitat. Grows on sandy gravelly soil in *Eucalyptus marginata* forest.

Conservation status. CALM: P2. This species is poorly known and apparently rare, and further survey work is required to fully determine its conservation status.

Specimens examined. WESTERN AUSTRALIA: Darling District: Mount Barker area, *R. Bowering s.n.*, 8 May 1989 (PERTH); Mt Barker – Ravensthorpe, *Heritage Wildflowers s.n.*, 3 May 1990 (CANB, K, NSW, PERTH); 20 km SW of Narrikup, Albany N, 34°53'37"S, 117°33'17"E, *L. Anderson 1072*, 11 Aug. 1992 (PERTH); Ca 20 km SW of Narrikup, 34°53'S, 117°33'E, *L.R. Anderson SPN 1027*, 11 Aug. 1992 (PERTH).

Toxicity. Unknown.

Affinity. Vegetatively similar in appearance to *G. reflexum* and *G. spectabile. Gastrolobium reflexum* has prominent, reflexed stipules, a more open, terminal raceme, and the peduncle and rachis are terete, whereas the stipules are absent in *G. ferrugineum* are absent, the inflorescence is condensed, and often axillary, and the peduncle and rachis are angular. *Gastrolobium spectabile* differs by its prominent recurved to reflexed stipules, long terminal racemes (peduncle 10-20 mm long and rachis 40-60 mm long) and has a terete inflorescence axis.

102. Gastrolobium humile G.Chandler & Crisp, *sp. nov. Type*: South Stirlings, *F.L. Counsel s.n.*, Nov. 1967 (*holo*: CANB; *iso*: PERTH).

The long stipules (4-8 mm long) which are partly fused and triangular, and the relatively long, many-flowered racemes (15 to more than 30 flowered, peduncle 4-10 mm long, rachis 20-45 mm long) distinguish this species from *G. stowardii*, which it most closely resembles, which has 3-4 mm long hyaline stipules and single or paired flowers in the axils or small axillary racemes with up to 4 flowers, with a peduncle 0-3 mm long, and no rachis.

Hac species *G. stowardii* arte simulans sed stipulis longis (4-8 mm longis) partim connatis triangularibusque, racemibus longioribus (pedunculus 4-10 mm longus, rhachis 20-45 mm longa) floribus plus (a 15 ad plus quam 30) distincta.

Etymology. The specific epithet refers to the low-growing habit of this species.

Low *shrubs*. *Branchlets* ascending, slightly angular to ± terete, densely pubescent. *Petioles* terete, continuous but not decurrent with the branchlet, 1-1.5 mm long. *Leaves* spreading to ascending, opposite, cuneiform, 8-11 x 4-6 mm, upper surface glabrous, lower surface moderately to densely villous, venation reticulate; apex truncate to bilobed, weakly mucronate, recurved; margins irregularly recurved; base rounded. *Stipules* erect, partly fused behind the axillary bud, triangular with a long, acuminate

than 30 flowered, densely pubescent; *peduncle* 4-10 mm long; *rachis* 20-45 mm long; *subtending bracts* not seen. *Pedicels* terete, 2-3 mm long, densely pubescent. *Calyx* campanulate, c. 4 mm long including the c. 0.5 mm receptacle, moderately to densely pubescent, lobe recurvature unknown; upper two lobes united higher than the lower three, obutse, c. 2.5 mm long; lower three lobes triangular, acuminate, c. 2.5 mm long. *Corolla* not seen. *Style* long, incurved, pubescent in the lower third; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* shortly stipitate, ovoid, c. 4 x 3.5 mm, densely pubescent. *Seed* ellipsoid, c. 2.5 mm long, arillate.

Notes. Very little is known about this species. Despite separate searches by G.T. Chandler and M.D. Crisp, this species has not been relocated, and only one collection is known. It is probable that it is very localised in the vicinity of South Stirling, where there is a large nature reserve, and is difficult to locate.

Flowering period. Unknown. *Fruiting period*. Beginning in November.

Distribution (Map 102). South-west Western Australia. Known from only the one, vague locality at or near South Stirling, c. 30 km S of the Stirling Range.

Map 102. Distribution of *G. humile*.

Habitat. Unknown.

Conservation status. No official conservation status has been given to this new species, but after a number of searches throughout this study, this species has not been found. It is quite possible that its habitat was cleared for farmland, and that this species is extinct. Following the IUCN guidelines, it is recommended that this species be coded Ex/E (possibly extinct in the wild), pending further searches in the future.

Specimens examined. The only specimen seen is the type specimen.

Toxicity. Unknown.

Affinity. The leaf shape is similar to that of *G. stowardii*, but the large stipules and long, racemose inflorescence distinguish *G. humile* from this species.

103. Gastrolobium venulosum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Eyre District: 14 km SW of Fitzgerald River Bridge, Ravensthorpe-Jerramungup road, 33°53'S, 119°07'E, *M.D. Crisp 6070, J. Taylor & R. Jackson*, 22 Sep. 1979 (*holo*: CBG; *iso*: NSW, PERTH).

Gastrolobium crassifolium is similar but has relatively narrower leaves (12-25 x 4-14 mm), and openly reticulate leaf venation, which is obscured byglaucousness of the upper leaf surface. Also, *G. crassifolium* has a distinctive keel, which has a prominently spout-like apex and a hole in the base of the lower margin near the claws, through which the stamens are exposed. *Gastrolobium venulosum* also has a spout-like apex, but it is not as acute as in *G. crassifolium*, and the lower margin is entire.

G. crassifolio similis sed foliis proporione latioribus (20-27 x 4-7 mm), venatione aperte reticulata et carinae apice orem hydriae simulanti sed vix acuto et margine infero integro differt.

Etymology. From the Latin *venulosus* = veined, and refers to the prominently open reticulate venation on the leaves.

Erect, bushy shrubs, c. 0.5 m high. *Branchlets* ascending, angular, glabrous. *Petioles* terete, continuous and somewhat decurrent with the branchlet, 1-1.5 mm long. *Leaves* ascending, in whorls of 3, elliptic, 20-27 x 4-7 mm, glabrous, lower surface sometimes glaucous, glabrous, with hairs along the midrib, or densely sericeous; apex rounded, occasionally slightly emarginate, slightly mucronate; margins slightly recurved, occasionally slightly conduplicate; base rounded. *Stipules* erect, hyaline, c. 2 mm long. *Inflorescences* terminal racemes, 18-30-flowered, internodes between flowers quite

short (< 5 mm long); *peduncle* with a sheath of barren bracts at the base, 3-6 mm long, densely pubescent; *rachis* 20-30 mm long, densely pubescent; *subtending bracts* caducous, scale-like, entire or slightly trifid, ovate, c. 2 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.75 m receptacle, sparsely pubescent; upper two lobes not recurved, united into an almost truncate lip, obtuse, c. 2 mm long; lower three lobes recurved, triangular, acute, c. 1.5 mm long. *Corolla*: *standard* transversely elliptic, c. 6 x 6.5 mm including the 2 mm claw, orange, sometimes with a reddish tinge, with a red ring surrounding the yellow centre, apex emarginate, base cordate; *wings* obovate, c. 7 x 2.5 mm including the 2.5 mm claws, orange and red, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate; *keel* half transversely elliptic, c. 5 x 3 mm including the 1.5 mm claws, maroon, apex acute, spout-like, base auriculate, saccate. *Style* long, hooked, lower third pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Pod* stipitate, broadly ellipsoid to globose, 4-5 x 4-4.5 mm, moderately pubescent. *Seed* not seen.

Flowering period. August and September. *Fruiting period*. October.

Distribution (Map 103). South-west Western Australia. Occurs along the inland part of the south coast, from west of Jerramungup to Ravensthorpe and as far north as near Lake King.

Habitat. Grows on undulating landscapes on sand, in mallee heath.

Specimens examined. WESTERN AUSTRALIA: Eyre District: Dunn Rock Nature Reserve, 30 km SW of Lake King, 33°20'S, 119°30'E, *D.J. Backshall 202*, 15 Apr. 1984 (PERTH); West River (via Ravensthorpe), 33°40'S, 119°40'E, *S. Kuiper 194*, Aug. 1964 (PERTH); Ravensthorpe Range, *G. Grewar s.n.*, Oct. 1959 (PERTH); Jerramungup, 33°56'S, 118°55'E, *E. Lindgren s.n.*, 29Aug. 1957 (PERTH); 20 km N of Ravensthorpe, 33°25'S, 120°01'E, *C.E. Woolcock W 265 & D.E. Woolcock*, 1 Aug. 1981 (CANB); west of Jerramungup, *C.E. Woolcock W 265 & D.E. Woolcock*, 14 Aug. 1982 (CANB); north slopes of Mt Short, 5.5 km E on Mt Short Road, c. 20 km N of Ravensthorpe, 32°27'32"S, 120°00'04"E, *G.T. Chandler 920 et al.*, 18 Sep. 1999 (CANB, MEL, PERTH); ibid., *G.T. Chandler 708 & S. Donaldson*, 28 Oct. 1998 (BRI, CANB); ibid., *G.T Chandler 709 & S. Donaldson*, 28 Oct. 1998, seedlings (CANB, PERTH); 511 km S of Perth on Lake King-Ravensthorpe road, E to Mount Short (ca 30

km NW of Ravensthorpe), 33°23'S, 119°49'E, *R.A. Saffrey 373*, 8 Aug. 1968 (CANB, PERTH);

Map 103. Distribution of *G. venulosum*.

Toxicity. Unknown.

Affinity. This species resembles *G. crassifolium*, but can be distinguished by the relatively narrower leaves of *G. crassifolium* (12-25 x 4-14 mm), and by the leaf venation pattern, which is more obscured on *G. crassifolium* due to the glaucousness of the upper leaf surface. Also, *G. crassifolium* has a distinctive keel, which it shares with the rest of the *G. floribundum* group, which has a prominently spout-like apex and a hole in the base of the lower margin near the claws, exposing the stamens, whereas *G. venulosum* has a spout-like apex, but which is not as acute as in *G. crassifolium*, and the lower margin is entire.

104. Gastrolobium axillare Meisn (1855b, p. 29). *Oxylobium reticulatum* Meisn. var. *gracile* Benth. (1864, p. 23). *Nemcia reticulata* (Meisn.) Domin var. *axillaris* (Meisn.)

Domin 1923a, p. 30). *Nemcia axillaris* (Meisn) Crisp (1987, p. 124). *Type citation*: "Drum. Coll. VI. n. 22." *Type specimens*: *Holotype* (here chosen): NY; *iso*: BM, K, P.

Spreading *shrubs* to 1.2 m high , 0.5 m wide. *Branchlets* ascending, angular, moderately to densely tomentose. *Petioles* terete, continuous but not decurrent with the branchlet, 3-4 mm long. *Leaves* spreading, opposite, elliptic to almost orbicular in earlier developmental stages, 20-40 x 7-22 mm, upper surface glabrous, lower surface softly pubescent, venation prominently reticulate, raised; apex obtuse, pungent-pointed; margins slightly undulate; base cuneate. *Stipules* erect, subulate, 3-4 mm long. *Inflorescences* condensed terminal or axillary racemes, 4-8-flowered, densely pubescent; *peduncle* 2-4 mm long; *rachis* 1-3 mm long; *subtending bracts* caducous, scale-like, entire, c. 4 mm long including 1 mm long mucro. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, ventricose, c. 9 mm long including the 1.5 mm receptacle, moderately to densely villous, lobes not or scarcely recurved; upper two lobes united higher than the lower three, ovate, acute, c. 3 mm long; lower three lobes triangular, acuminate, c. 2.5 mm long. *Corolla*: *standard* very broadly elliptic, 9-10 x 9-10 mm including the c. 4 mm claw, orange yellow with a red ring surrounding the white centre apex emarginate, base obtuse, slightly auriculate; *wings* obovat, c. 8.5-9 x 3 mm including the 2 mm claws, orange-yellow, red at base e, apex rounded, not or scarcely incurved, may slightly overlap to partially enclose the keel, base auriculate on the upper margin only, slightly saccate; *keel* half very broadly elliptic, margins not incurved, c. 8.5-9 x 3 mm including the 3 mm claws, maroon, apex ± acute, base auriculate, saccate. *Style* long, hooked, lower third pubescent; *ovary* sessile, densely pubescent; *ovules* 4. *Pod* sessile, ovoid, 6-7 mm long, moderately pubescent. *Seed* not seen.

Flowering period. September. *Fruiting period*. October.

Distribution (Map 104). South-west Western Australia. Occurs north of Perth, from around Eneabba south to Dandaragan.

Habitat. Grows on rolling hills to steep hillsides on sand over laterite, in heath and woodland.

Conservation status. ROTAP: 3KC-. CALM: P3. This taxon is fairly rare, and poorly known, and further survey work is required.

Selected specimens (7 examined). WESTERN AUSTRALIA: Darling District: 12.9 km along Badgingarra Road from North West Road, towards Dandaragan, 30°30'53"S, 115°36'54"E, *G.T. Chandler 241 & W. Keys*, 13 Sep. 1997 (CANB, NSW, PERTH);

Hi Vallee property (D. & J. Williams), Warradarge - track at northern head of main valley, 30°06'06"S, 115°24'03"E, *M. Hislop 1541*, 13 Sep. 1999 (CANB, PERTH). Irwin District: 2.5 km along Tootbardie Road, from highway, north of Badgingarra, 30°08'59"S, 115°23'40"E, *G.T. Chandler 621 & S. Donaldson*, 23 Oct. 1998 (CANB, MEL, PERTH).

Map 104. Distribution of *G. axillare*.

Toxicity. Unknown.

Affinity. The juvenile foliage of *G. axillare* somewhat resembles that of *G. nudum*, but the latter always has orbicular leaves which are concolorous and softly pubescent on the lower surface.

105. Gastrolobium nudum G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: c. 900 m from Governors Drive, northern side of south break, near old track, Avon Valley National Park, 31°34'S, 116°15'E, 28 February 1990, *B. Evans* 181 (*holo*: PERTH 01878751). *Note*: this species has also been known as *Nemcia congesta* Crisp ined., but the the name *Gastrolobium congestum* is pre-empted elsewhere in this monograph.

Similar in appearance to *Gastrolobium axillare*, but differing in the calyces having lobes about the same length of the tube and concolorous, glabrescent leaves. A short shrub with leaves opposite, mostly in the upper branches, and with sessile, congested clusters of flowers also in the upper axils.

Frutex humilis, folia opposita maximum partem versus ramulorum apices, floribus sessilibus congestis in axillis supernis. *G. axillare* similis sed calyce lobis tubum c. aequantibus et foliis concoloribus glabrescentibus distinguenda.

Etymology. From the Latin *nudus* = naked, and refers to the fact that there are few leaves on the lower portions of the branchlets.

Spreading, twiggy *shrub* to 0.8 m high, new stems angular ridged, silky white pubescent, glabrescent. *Petioles* terete, continuous and decurrent with the branchlet, 1-2 mm long, pubescent. *Leaves* mostly in upper branches, opposite, broad ovate to orbicular, 15-34 x 15-34 mm, glabrous, somewhat glaucous, venation reticulate, main veins prominently yellow; apex rounded to emarginate, semi-pungent; margins minutely crenulate, not recurved; base rounded to slightly cordate. *Stipules* strongly recurved to reflexed, hyaline, to 4 mm long. *Inflorescences* sessile clusters in upper axils; *peduncle* less than 1 mm long; *rachis* 1-2 mm long; *subtending bracts* caducous trifid to trilobed to 4 mm long. *Pedicels* 2-3 mm long, densely pubescent. *Calyx* campanulate, 4-5 mm long including the c. 1 mm receptacle, densely pubescent, lobes not recurved; upper two lobes united higher than the lower three, obtuse, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* very broadly elliptic, apex emarginate, base cordate, not auriculate, 8–10 x c. 7 mm including the c. 2.5 mm claw, orange with a red ring surrounding the yellow centre; *wings* obovate, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate, 6.5-8 x c. 1.5 mm including the c. 2.5 mm claws, orange; *keel* half transversely elliptic, margins not incurved, apex rounded, base auriculate, saccate, 6.5-8 x c. 2.5 mm including the 3 mm claws, red. *Style* long, incurved, lower third pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* and *seed* not seen.

Flowering period. February. *Fruiting period*. Unknown.

Distribution (Map 105). South-west Western Australia. This species is known only from the Avon Valley National Park and the Chittering area.

Habitat. Found in low heath on laterite with *Eucalyptus accedens*, Marri, *Hakea lissocarpa* and *Xanthorrhea preissii*.

Map 105. Distribution of *G. nudum.*

Specimens examined. WESTERN AUSTRALIA: Sth Break, Avon Valley National Park, c. 31°37'S, 116°12'E, *B. Evans s.n.*, 26 Nov.1989 (PERTH); ibid., *B. Evans s.n.*, 29 Oct. 1990 (CANB, PERTH); Yandan Nature Reserve gazetted Reserve No. 39571, N side along breakaway for 50 m S from firebreak on top and c. 20 m below breakaway, 30°46'S, 115°36'E, *S.J. Patrick 654a*, 31 July 1991 (PERTH, CANB); Chittering, 31°28'S, 116°26'E, *H.E. Braine s.n.*, 25 Sep. 1956 (PERTH).

Affinity. This species is morphologically similar to *Gastrolobium axillare* but the latter species has calyx lobes much longer than the tube, and discolorous green leaves with the abaxial surface softly pubescent.

106. Gastolobium cyanophyllum G.Chandler & Crisp, *sp. nov. Type*: WESTERN AUSTRALIA: Darling district: West Talbot Road, 7.8 km W of Helena Road and 3,4 km W of Luelfs Road (Gunapin Ridge Road), 32°00'19"S, 116°35'34"E, *M.D. Crisp* 8517 & *W. Keys*, 27 Sep. 1993 (*holo*: CANB; *iso*: GAUBA, PERTH, UWA, K).

Very similar to *Gastrolobium dilatatum* but differing conspicuously in the blue-glaucous leaves (both surfaces) with fiercely pungent, recurved apices.

G. dilatato similis sed foliis cyano-glaucis (in superficiebus ambabus) et apicibus recurvis ferociter pungentibus conspicue differens.

Etymology. From the Greek *cyaneus* = blue and *phyllon* = leaf, and refers to the blue-green leaves.

Spreading *shrub* 0.8 x 1.2 m. *Branchlets* ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, c. 1 mm long. *Leaves* patent or retrorse, opposite, obtriangular, 15-30 x 15–20 mm, glabrous, glaucous-blue, venation reticulate; apex acute, recurved, fiercely pungent-pointed; margins flat to plicate; base cuneate. *Stipules* erect, hyaline, 6-7 mm long, red. *Inflorescences* condensed racemes in upper axils; *peduncle* 0-2 mm long; *rachis* 1-13 mm long, *subtending bracts* caducous, scale-like, trifid to trilobed, c. 4 mm long, outer surface densely pubescent. *Pedicels* terete, 1-3 mm long. *Calyx* campanulate, 5-6 mm long including the c. 0.5 mm receptacle, densely pubescent, lobes strongly recurved to reflexed; upper two lobes united higher than the lower three, acute, c. 2.5 mm long; lower three lobes triangular, acute, c. 2 mm long. *Corolla*: *standard* transversely elliptic, apex emarginate, base cordate, not auriculate, c. 8-11 x 8-10 mm including the 2.5 mm claw, orange with a red ring surrounding the white centre; *wings* obovate, apex rounded, slightly incurved, not enclosing the keel, base auriculate on upper margin only, saccate, c. 7-9 x 2 mm including the 2 mm claws, orange; *keel* half elliptic, margins incurved, apex rounded, base auriculate, saccate, c. 7.5-9 x 2 mm including the 2.5 mm claws, red. *Style* long, incurved to hooked, base pubescent; *ovary* stipitate, densely pubescent; *ovules* 2. *Mature pods* and *seed* not seen.

Flowering period. September to November. *Fruiting period*. Unknown.

Distribution (Map 106). South-west Western Australia. Occurs around the York region, NE of Perth, in the Gunapin State Forest and on Cut Hill.

Habitat. Grows on undulating landscapes on yellow-brown sand over laterite, in open Eucalypt woodland and *Banksia* scrub.

Specimens examined. WESTERN AUSTRALIA: Darling District: W Tuckey property, Mawson, c. 32°00'S, 117°10'E, *C. Brown s.n.*, 16 Jan. 1988 (CANB, PERTH); Qualen Road, Gunapin State Forest, York: take Qualen Road E of Catchment Road for 12.5 km

then track W for ca 800 m to top of the breakaway, 32°05'15"S, 116°39'41"E, *F. Hort, J. Hort & M. Hislop 788*, 20 Nov. 1999 (CANB, PERTH), Cut Hill, 31°54'S, 116°43'E, *O.H. Sargent 693*, 8 Oct 1908 (CANB, NSW).

Map 106. Distribution of *G. cyanophyllum*.

Toxicity. Unknown.

Affinity. Similar to *G. dilataum*, which differs in the non-glaucous leaves, which are less fiercely pungent-pointed and not recurved.

107. Gastrolobium dilatatum (Benth.) G.Chandler & Crisp, *comb.nov*. *Oxylobium dilatatum* Benth., in Lindley (1839, p. 12). *Oxylobium cuneatum* Benth. var. *dilatatum* (Benth.) Benth. (1864, p. 24). *Nemcia cuneata* (Benth.) Domin var. *dilatata* (Benth.) Domin 1923a, p. 30). *Nemcia dilatata* (Benth.) Crisp (1987, p. 125). *Type citation*: None cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond 1839); *isolecto*: CGE, K.

> *Oxylobium cuneatum* Benth. in Lindley (1839, p. 12). *Oxylobium obovatum* Benth. var. *angustatum* Meisn. (1844, p. 29). *Callistachys cuneata* (Benth.) Kuntze (Nov. 1891, p. 168). *Nemcia cuneata* (Benth.) Domin 1923a, p. 30).

Type citation: None cited. *Type specimens*: *Lectotype* (here chosen): K (Swan River. Drummond 1839); *isolecto*: BM (2 sheets), K.

Oxylobium obovatum Benth., in Lindley (1839, p. 12). *Oxylobium cuneatum* Benth. var. *obovatum* (Benth.) Benth. (1864, p. 24). *Type citation*: None cited. *Type specimens*: K (Swan River. Drummond 1839); *isolecto*: CGE.

Oxylobium cuneatum Benth. var. *cuneifolium* Benth. (1864, p. 24). *Nemcia cuneata* (Benth.) Domin var. *cuneifolia* (Benth.) Domin 1923a, p. 30). *Type citation*: "Swan River, Drummond, 1st Coll., also n. 71 and 207 (partly)." *Type specimens*: *Lectotype* (here chosen): K (Drummond, 1st Coll.).

Oxylobium obovatum Benth. var. *latifolium* Meisn. (1844, p. 29). *Type citation*: "In region. interior. Australiae meridionale-occidentalis Herb. Preiss No. 828. (Drummond coll. I, sine no.)". *Type specimens*: LD (Preiss 828).

Erect *shrubs*, to 1 m high. *Branchlets* ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, sheathing the stem, < 0.5 mm long. *Leaves* patent, in whorls of 3 or 4, mostly conduplicate, ± obovate, 20-40 x 8-20 mm, glabrous, venation prominently reticulate, raised; apex semi-pungent; margins becoming plicate; base cuneate. *Stipules* erect, hyaline, 6–7 mm long. *Inflorescences* solitary or paired flowers in upper axils; *peduncle* nil; *rachis* nil; *subtending bracts* caducous, scale-like, trilobed with a robust middle lobe and hyaline outer lobes, c. 4 mm long. *Pedicels* terete, 1-2 mm long. *Calyx* campanulate, 6-7 mm long including the c. 0.75 mm receptacle, base densely pubescent, becoming less dense towards the apex, hairs basically bicoloured, with the lower hairs silvery and the upper hairs golden brown, occasionally all hairs golden brown, lobes recurved; upper lobes united into an emarginate, truncate lip or united higher than the lower three and ± triangular, c. 4 mm long; lower lobes triangular, acute c. 3 mm long. *Corolla*: *standard* very broadly elliptic, apex emarginate, base slightly cordate, c. 11-12 x 9 mm including the 3.5 mm claw, orange with a dark red centre, with a tiny, dirty-yellow centre; *wings* obovate, apex rounded, incurved and overlapping to enclose the keel, base auriculate on both margins, saccate, c 10 x 3 mm including the 3 mm claws, orange; *keel* half very broadly elliptic, apex sub-acute, base auriculate, saccate, c. 9-10 x 3 mm including the 3 mm claws, red. *Style* very long, strongly incurved, base pubescent; *ovary* shortly stipitate, densely pubescent; *ovules* 2. *Pod* ± sessile, broadly ovoid, c. 8 x 4-5 mm long, densely villous. *Seed* not seen.

Flowering period. August and September. *Fruiting period.* October and November.

Distribution (Map 107). South-west Western Australia. Occurs in the Darling escarpment east and south of Perth.

Map 107. Distribution of *G. dilatatum.*

Habitat. Grows throughout the Darling escarpment on sandy soils in heath and woodland.

Selected specimens (19 examined). WESTERN AUSTRALIA: Darling District: Darlington, Darling Range, 31°55'S, 116°04'E, *A. Morrison s.n.*, 6 Nov. 1900 (CANB, PERTH); West Talbot Road, 8 km E of Helena Road and 3.2 km W of Luelfs Road (=Gunapin Ridge Road), 32°00'25"S, 116°35'40"E, *M.D. Crisp 8515 &W. Keys*, 27 Sep. 1993 (CANB, GAUBA, PERTH); Kingsbury Drive 2 km from Southwestern Highway, 32°22'S, 116°02'E, *M.G. Corrick 9418*, 2 Nov. 1984 (MEL, CANB, HO).

Toxicity. Unknown.

Affinity. This species is very similar to *G. cyanophyllum*, which differs in having glaucous leaves that are fiercely pungent-pointed and longitudinally recurved Also, the

upper two calyx lobes are not united into an emarginate, truncate lip, and the subtending bracts are trilobed and not hyaline.

108. Gastrolobium elegans G.Chandler & Crisp, *sp. nov.* *Type*: WESTERN AUSTRALIA: Eyre District: Stirling Range, unnamed hill in SW corner of park, 34°23'11"S, 117°42'19"E, *M.D. Crisp 8958 & W. Keys*, 16 Oct. 1996 (*holo*: CANB; *iso*: CANB, MEL, PERTH).

An erect, slender shrub 2–3 m high, with opposite, narrowly elliptic or oblong, undulate, discolorous leaves, the undersurface silky pubescent; flowers in pedunculate, erect, axillary clusters, less than 15 mm long, mainly orange and yellow with red markings; calyces silky pubescent and bicoloured, with white hairs on the tube and golden brown hairs on the lobes.

Frutex erectus gracilis 2-3 m altus, folia opposita anguste elliptica vel oblonga undulata discoloria, pagina inferna sericea, inflorescentia fasciculata axillaris stricta pedunculata, flores minus quam 15 mm longa, petala vitellina maculis rubris, calyx sericeus bicolor pilis albis in tubo et pilis aurei-brunneis in lobis.

Etymology. The specific epithet refers to the elegant appearance of this shrub.

Erect, slender *shrubs*, 2-3 m high. *Branchlets* ascending, angular, densely tomentose. *Petioles* terete, continuous and decurrent with the branchlet, c. 6 mm long. *Leaves* broadly spreading, opposite, narrowly elliptic or oblong, 25-40 x 5-7 mm, upper surface glabrous, lower surface densely sericeous, venation prominently reticulate; apex rounded, semi-pungent-pointed; margins recurved, prominently undulate; base rounded to almost truncate. *Stipules* erect, hyaline, 4-5 mm long. *Inflorescences* axillary clusters, 4-6-flowered; *peduncle* angular, to 10 mm long, pubescent *rachis* angular, to 5 mm long; *subtending bracts* caducous, scale-like, trilobed, the middle lobe longest, 5-6 mm long, densely pubescent on outer surface. *Pedicels* terete, 4-5 mm long. *Calyx* campanulate, 8-9 mm long including the c. 1 mm receptacle, densely villous, bicoloured with silky white hairs on tube, golden brown hairs on lobes, lobes strongly recurved; upper two lobes united higher than the lower three, ± acute, c. 4 mm long; lower three lobes triangular, c. 4 mm long. *Corolla*: *standard* transversely elliptic, apex emarginate, base cordate, not auriculate, 14-15 x 17-18 mm including the 3 mm claw, yellow-orange with a red centre; *wings* obovate, apex rounded, incurved and overlapping to enclose the keel, base auriculate on the upper margin only, saccate, c. 11-12 x 6 mm including the 1.5 mm claws, yellow and red; *keel* half very broadly obovate, strongly incurved

longitudinally, margins not incurved, apex obtuse, base auriculate, saccate, c. 10-11 x 4 mm including the 2.5 mm claws, dark pink. *Style* very long, strongly incurved, very base slightly pubescent; *ovary* ± sessile, densely pubescent; *ovules* 4. *Pod* and *seed* not seen.

Flowering period. September and October. *Fruiting period*. Unknown.

Distribution (Map 108). South-west Western Australia. This species is endemic to the western end of the Stirling Range, on a low ridge.

Map 108. Distribution of *G. elegans*.

Habitat. Grows on hillsides on skeletal stony quartzite in heath with *Lambertia ericifolia, Xanthorrhoea sp. Hakea cucullata, Eucalyptus pachyloma* and *E. preissiana.*

Specimens seen. WESTERN AUSTRALIA: Eyre district: Hill, 3 km S.E. Peak Donelly; Stirling Range, 43°21'S, 117°41'E, *G.J. Keighery s.n.*, 15 Sep. 1986 (PERTH); Stirling Range, saddle between hills 4 km SW of Donelly Peak, 34°21'S, 117°32'E, 350 m alt., 25 Sep. 1993, *M.D. Crisp 8504 & W. Keys*, 25 Sep. 1993 (CANB, GAUBA, PERTH, K).

Toxicity. Unknown.

Affinity. This species can be distinguished from *G. leakeanum*, *G. mondurup*, *G. luteifolium* and *G. rubrum* by by the erect (ie. not resupinate) yellow-orange flowers with red markings that are less than 15 mm long, and the paired leaves which are narrowly oblong with very undulate margins and the silky pubescent indumentum on the lower surface makes the leaves conspicuouely discolorous.

109. Gastrolobium lehmannii Meisn. (1844, p. 70). *Nemcia lehmanni* (Meisn.) Crisp (1987, p. 127). *Type citation*: "In regionibus interioribus Australiae meridionali-occid., m. Febr. 1841. Herb. Preiss. No. 806". *Type specimens*: *holo*: NY; *iso*: LD.

(Due to a lack of available material of this species, the description is incomplete.) Erect *shrubs*. *Branchlets* ascending, either terete or slightly angular, pubescence unknown. *Petioles* terete, continuous and decurrent with the branchlet, c. 1 mm long. *Leaves* spreading to ascending, opposite or in whorls of 3, oblong to elliptic, 36-50 x 12-14 mm, upper surface glabrous, lower surface densely pubescent; apex rounded to truncate, recurved, unarmed or slightly mucronate; margins recurved; base rounded. *Stipules* erect, hyaline, 5-6 mm long. *Inflorescences* condensed axillary racemes, 6-10-flowered; *peduncle* not measured; *rachis* not measured; *subtending bracts* not seen. *Calyx* campanulate, less than 5 mm long, densely sericeous, lobes not recurved; upper two lobes united higher than the lower three, acute, c. 3 mm long; lower three lobes triangular, acute, c. 3 mm long. *Flowers* yellow and purple; *pedicels* terete, 2-3 mm long. *Corolla*: *standard* transversely to very broadly elliptic, apex emarginate, base truncate, auricles unknown, c. 11-15 x 10 mm including the 4.5 mm claw; *wings* obovate, apex rounded, unknown if it encloses the keel, base auriculate, saccae unknown, c. 8-10 x 2.5 mm including the 2 mm claws; *keel* half very broadly elliptic, margin curvature unknown, apex sub-acute, base auriculate, saccae unknown, 8-10 x 3 mm including the 3 mm claws. *Style* long, incurved to slightly hooked, lower third pubescent; *ovary* ± sessile, densely pubescent; *ovules* 2. *Pod* sessile, ovoid, c. 7 x 3 mm, moderately pubescent. *Seed* not seen.

Flowering period. September to October. *Fruiting period*. Unknown.

Distribution (Map 109). South-west Western Australia. Known from early collections near Cranbrook, at the western end of the Stirling Ranges, but now presumed extinct.

Habitat. Unknown.

Map 109. Distribution of *G. lehmannii*.

Conservation status. IUCN: Ex. ROTAP: 2X. CALM: X. This taxon is presumed extinct, because numerous searches have failed to relocate it.

Specimens examined. Only photocopies and slides of specimens were available for this species, and included copies of PERTH specimens 01101765, 01101803, 01101781, 01101730, 01044761 and 01101749.

Toxicity. Unknown.

Affinity. The leaves of this species are somewhat similar to those of *G. crenulatum*, but there is not enough information to give exact distinctions between these species.

Nomina incertae sedis

Gastrolobium makoyanum Heynh. (1846: p. 255), *nom. nud.*

Gastrolobium splendens Heynh. (1846: p. 255), *nom. nud.*

Gastrolobium verticillatum Heynh. (1846: p. 255), *nom. nud.*

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