Systematics and Biology of *Hemigenia* R.Br. and *Microcorys* R.Br. (Lamiaceae)

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Contents

Abstract

The genera *Hemigenia* R.Br. and *Microcorys* R.Br. (Lamiaceae, tribe Westringieae) have not been revised since 1870 and the existing taxonomy is inadequate. The current generic classification requires re-evaluation in light of more detailed knowledge of comparative morphology. The generic status of the related genera *Hemiandra* R.Br. and *Westringia* Sm. also needs to be tested, as these genera share morphological characters with *Hemigenia* and *Microcorys*.

Microcharacters were examined in over 60 species using SEM. The external morphology of mericarps (shape, attachment scar type, sculpturing, exocarp cell shape and presence of trichomes) provided significant cladistic data. A pilot study revealed that microcharacters of leaf surfaces were either invariable at this level or showed too much variation for systematic use.

The floral biology of the genera was studied since floral characters, particularly of the stamens, are used in the current classification. The stamens of *Hemigenia* and *Microcorys* have elongated anther connective tissue which bears one or two thecae, and the modified anthers are typically mobile on the filament. Field observations showed that insect visitors lever the anthers onto their bodies whilst accessing nectar. Bearding on the sterile end of the anthers catches adjacent stamens and levers them in unison. In the abaxial stamens of *Microcorys*, the anthers are reduced to sterile lobes, and these staminodes guide pollinators into the flower. Identical staminodes are present in *Westringia* and *Hemigenia cuneifolia*. The presence of a second theca on the abaxial stamens in *Hemigenia* was used by Bentham in the infrageneric classification. However, SEM revealed that the distinction was false and that Bentham's proposed pattern for this character is erroneous.

A taxonomic revision of *Hemigenia* section *Malleantha* G.R.Guerin sect. nov was carried out, and the treatment included 26 species, including 13 new species. A cladistic dataset was compiled based on morphology, including floral and mericarp characters. A molecular dataset was constructed using the *trn*T-F region of the chloroplast genome. The two datasets were analysed both separately and combined using PAUP. The resulting phylogenies show both genera are polyphyletic. Evidence supports previous assertions that *Prostanthera* is sister to the other genera of the Westringieae.

A new classification is discussed, but further data are required before this can be finalised. In particular, multiple DNA markers (including nuclear regions) need to be sequenced with a slightly larger sample of species.

Statement

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Signed Greg Guerin

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1 Introduction

1.1 Introduction to Lamiaceae and Westringieae

Lamiaceae (also known as Labiatae, the 'mint family') is a large, cosmopolitan family of flowering plants containing in the order of 200 genera and 5000 species (Wink and Kaufmann 1996; Wagstaff *et al.* 1998) including well known aromatic culinary herbs such as Mint (*Mentha* spp.) and Basil (*Ocimum* spp.) (Wagstaff *et al.* 1998). The name Westringieae was applied by Bartling (1830) to a tribe of Lamiaceae genera endemic to Australia. The tribe now contains the genera *Hemiandra* R.Br., *Hemigenia* R.Br., *Microcorys* R.Br., *Prostanthera* R.Br., *Westringia* Sm., and the monotypic genus *Wrixonia* F.Muell. Bentham (1834) applied the name Prostanthereae to the tribe and this name has often been used since. However it is a younger synonym of Westringieae. The tribe contains approximately 200 described species (Abu-Asab and Cantino 1993a). *Prostanthera* is the largest genus with approximately 90 species, and also the most studied with taxonomic revisions published in modern times (Conn 1984; Conn 1988).

Westringieae exhibits morphological characters typical of the family such as opposite or whorled leaves, tubular, zygomorphic corollas, four stamens occurring in adaxial and abaxial pairs, a bifid style, and four indehiscent mericarps (here referred to mericarps) (Wagstaff and Olmstead 1997). An important morphological character of the Westringieae is the presence of elongated anther connective tissue, the arrangement of which is used in the current generic classification (Bentham 1870).

1.2 Taxonomic background

The genera *Hemigenia* and *Microcorys* were named by Robert Brown (1810) following his expedition to Australia on board the HMS Investigator. George Bentham and Ferdinand Von Mueller published many more species later in the 19th Century (Bentham 1848; Mueller 1859;

Mueller 1868; Bentham 1870; Mueller 1874; Mueller 1878; Mueller 1890; Mueller 1893). The first and, to date, only taxonomic revision of the genera was conducted by Bentham (1870). Other authors have sporadically contributed descriptions of smaller numbers of new species (Lindley 1840; Barlting 1845; Luehmann 1898; Moore 1899; Moore 1902; Andrews 1904; Diels 1905; Moore 1920; Gardner 1931; Gardner 1942; Kenneally 1982; Conn 1986) and the tally now stands at 38 species of *Hemigenia* and 19 of *Microcorys*.

Not only has there been no revision since 1870 to tie together numerous publications of small numbers of new species, but also a number of variants have been identified as putative new species (Packowska and Chapman 2000), and recent flora compilations have highlighted the need for taxonomic revision in these genera, particularly in problem groups (e.g. Marchant *et al.* 1987).

1.3 Phylogenetic analyses and classification

A number of independent studies of morphological and molecular data have agreed that the Westringieae represents a monophyletic group within the Lamiaceae (Cantino 1992a; Cantino 1992b; Abu-Asab and Cantino 1993b; Ryding 1995; Wink and Kaufmann 1996; Olmstead *et al* 1998). However, the generic classification within the tribe has been, and remains, problematic. For example, the generic names *Colobandra* (Lindley 1840) and *Atelandra* (Bartling 1845) have been synonymised with *Hemigenia*. Hemsley (1905) noted that the features delimiting genera within the group where unsatisfactory and perhaps only of specific importance. However, in the same paper, he described *Microcorys dielsii* Hemsl. (now *Hemigenia dielsii* (Hemsl.) C.A.Gardner), which, although somewhat *Microcorys*-like in habit, does not have staminodes, a character which clearly defines the genus from *Hemigenia* under the current classification. *Microcorys longifolia* (Benth.) Benth. was originally described as *H. longifolia*, and this species and other opposite-leaved *Microcorys* species are currently classified in *Microcorys* section *Hemigenioides*.

The current infrageneric classification of *Hemigenia* and *Microcorys* is that of Bentham (1870), which recognises four sections of *Hemigenia* (*Atelandra, Diplanthera, Hemigenia* and *Homalochilus*) and three sections of *Microcorys* (*Anisandra, Hemigenioides* and *Microcorys*). Gardner (1942) noted that the infrageneric classification of *Hemigenia* was unsatisfactory. The characters delimiting the groups are often ambiguous and some infrageneric taxa appear to represent single species complexes (e.g. *Hemigenia* sections *Atelandra* (the *H. incana* complex) and *Diplanthera* (*H. diplanthera* complex)).

Detailed phylogenetic analyses are needed in the Westringieae to determine the generic limits and internal relationships of the genera. Moreover, data are required to assess the current classification and to provide a basis for any revised classification, including objective data on the phylogenetic utility of various morphological characters. Work at lower levels can now proceed as workers have produced numerous higher level phylogenies showing the Westringieae to be monophyletic, and allowing selection of appropriate outgroups (Wink and Kaufmann 1996; Steane *et al.* 1997; Wagstaff and Olmstead 1997; Wagstaff *et al.* 1998; Oualidi *et al.* 1999). Within this framework, detailed phylogenetic work at lower levels has begun in other genera (e.g. Paton *et al.* 2004, Steane *et al.* 2004).

1.4 Pollination biology

Pollination is closely linked with floral evolution and therefore an examination of pollination biology is critical to understanding the functional morphology of flowers and floral parts (Proctor 1978; Fægri and van der Pijl 1979). The floral biology of members of the Westringieae, and particularly the genera *Hemigenia* and *Microcorys*, is of importance, given that the genera are delimited principally on stamen and corolla characters (Bentham 1870). Until now, there had been no published studies describing the function and morphology of the stamens in the Westringieae, and few reports of observations of pollination in the wild. The stamens are also of interest in *Hemigenia* and *Microcorys* as they possess the staminal level

mechanism also known in the Lamiaceae genus *Salvia* (Fægri and van der Pijl 1979; Hedge 1992; Huck 1992; Claßen-Bockhoff *et al.* 2003; Claßen-Bockhoff *et al.* 2004), in which expanded anther connective tissue makes the entire anther mobile on the filament. The morphology and function of the stamens may be key to the evolution and classification of the group.

1.5 Conclusion

1.5.1 Summary

The monophyly of the tribe Westringieae has been confirmed by a number of independent morphological and molecular datasets, but the generic classification remains untested and appears to be unsatisfactory. More data are needed to resolve relationships within the group, particularly with regard to the genera *Hemigenia* and *Microcorys*. The characters of the stamens and corolla which are used in the current classification need to be assessed morphologically and in terms of their function in pollination and homology and hence the likelihood, or degree, of convergence. New characters are sought to define generic and infrageneric groupings as part of a re-assessment of characters currently used in the classification.

Hemigenia and *Microcorys* are in need of taxonomic revision. The last review of the group was conducted by Bentham (1870) and a review of numerous subsequent publications and of putative new species is required.

1.5.2 Project aims

Hemigenia and *Microcorys* represent unresolved scientific problems on several fronts. The following methods and aims will be employed towards an improved understanding of the group:

- examination of the phylogenetic utility of morphological characters (e.g. mericarps, stamens)
    - Scanning Electron Microscopy (SEM) will be used where appropriate
- field and laboratory based studies of floral biology
    - what stamen characters are homologous?
    - how are the flowers pollinated and which pollen vectors are involved?
    - do the floral arrangements represent syndromes?
    - is pollination likely to have influenced the evolution of floral characters?
- taxonomic revision of *Hemigenia* section *Hemigenia*
    - section *Hemigenia* is the largest section and is known to contain several complex groups
- phylogenetic analyses of the Westringieae based on morphological and molecular data with an emphasis on the internal relationships of *Hemigenia* and *Microcorys*
- review of data towards improved generic and infrageneric classifications

2 Floral Biology

Abstract

The floral morphology and pollination of *Hemigenia* R.Br. and *Microcorys* R.Br. (Lamiaceae) were examined in the field and laboratory. The protandrous flowers have tubular, two-lipped corollas. Nine floral morphotypes are described. The stamens may be completely sterile (staminodal), or have one theca reduced or absent. The anthers typically have elongated connective tissue and are mobile on the filament. When the lower end of the anther is pushed, the upper end is levered towards the mouth of the corolla tube, hence dusting the pollinator precisely where receptive stigmas will later touch. Bearding on the anthers of the adaxial stamens catches adjacent anthers so that they lever in unison. Staminodes guide insect pollinators into the throat to allow precise pollen dusting. Detailed field observations show that bees and flies are the principle pollinators of most species. Floral morphologies are related to pollinator castes, and reproductive isolation and efficiency is enhanced by precise pollen deposition. Bird pollination is likely to have arisen independently in several taxa. The floral arrangement of these taxa is superficially similar but the syndrome is achieved through different anatomy.

2.1 Introduction

The Westringieae (Lamiaceae), a tribe endemic to Australia, includes the genera *Hemiandra* R.Br., *Hemigenia* R.Br., *Microcorys* R.Br., *Prostanthera* R.Br., *Westringia* Sm., and *Wrixonia* F. Muell. (Conn 1992; Abu-Asab and Cantino 1993a). *Hemigenia* and *Microcorys* are chiefly confined to south-west Western Australia and coastal eastern Australia. Stamen morphology is currently used to distinguish the genera of the Westringieae and the infrageneric sections of *Hemigenia* and *Microcorys* (Bentham 1870) (Table 2.1). However, the stamen types are complex, particularly in the genera discussed here, and need to be studied in detail. The current generic classification is inadequate, and the monophyly of the genera has not been established.

Much of the literature concerning pollination syndromes has concentrated on corolla morphology. The specific adaptations of stamens have largely been ignored or treated as secondary (Bernhardt 1996). In *Hemigenia* and *Microcorys*, the complex stamen morphology

is likely to be significant to pollination. Examination of corolla and stamen function in pollination is crucial to understanding the group. However, published information on the floral biology is patchy and only the pollination biology of *Prostanthera* is relatively well understood (Conn 1984; Huck 1992). Broad pollination syndromes within the two clades of this genus are uniform: insect in Section *Prostanthera*, bird in Section *Klanderia*. Keighery (1982) listed *Hemiandra*, *Hemigenia*, *Prostanthera* and *Microcorys* as gullet flowers, and considered the floral structure of *Microcorys* to be prohibitive for probing by honeyeaters. *Prostanthera* was listed as an outbreeding genus. No distinction was made between pollination syndromes.

There are sparse reports of insects visiting flowers of *Hemigenia* and *Microcorys*, but the details of pollination syndromes, function of the stamens, behaviour of visitors and whether they were likely to affect pollination, have never been reported in detail (Houston 2000; Mattner *et al.* 2002) (Table 2.2). Similarly, reports of pollination of related genera have tended to lack detail (*Hemiandra*: Morcombe 1968; Cochrane 2001. *Prostanthera*: Huck 1992).

Elongated anther connective tissue and modified thecae, characteristic of *Hemigenia* and *Microcorys*, are present in a number of unrelated Lamiaceae genera, and diversity of stamen morphology is common (Hedge 1992). Huck (1992) discussed the modification of thecae in *Hemigenia* and *Hemiandra*, and of whole anthers in *Westringia* and *Wrixonia*. However both *Hemigenia* and *Microcorys* have modified whole anthers. In *Hemigenia*, *Microcorys* and *Salvia* L., the anthers are typically monothecic and mobile, and staminodes may be present, although the relative position of the stamens and staminodes is reversed in *Salvia* (Fægri and van der Pijl 1979; Hedge 1992; Huck 1992; Claßen-Bockhoff *et al.* 2003; Claßen-Bockhoff *et al.* 2004). In *Salvia*, the lower ends of the mobile anthers are placed such that floral visitors (chiefly bees and birds) must push past them to gain access to nectar, and in doing so, lever the fertile upper end onto their bodies (Barrett *et al.* 2000; Claßen-Bockhoff *et*

Table 2.1. Bentham's (1870) classification of *Hemigenia* and *Microcorys*.

Classification and defining corolla/stamen characters	Species under current classification
Hemigenia Stamens all fertile, anthers with elongated connective bearing one or two fertile thecae, the lower end bearded, glabrous and attenuate, or bearing a second, imperfect theca.	
Hemigenia Section *Atelandra* Lower end of connective of abaxial anthers attenuate.	*H. incana* s.l. Benth. *H. platyphylla* Benth. *H. podalyrina* F. Muell.
Hemigenia Section *Diplanthera* Lower end of connective of abaxial anthers bearing a second, imperfect theca.	*H. conferta* B.J. Conn *H. diplanthera F. Muell.* *H. drummondii Benth.* *H. pimelifolia* F. Muell.
Hemigenia Section *Hemigenia* Lower end of connective of abaxial anthers attenuate.	*H. barbata* Bartl. *H. biddulphiana* F. Muell. *H. brachyphylla* F. Muell. *H. coccinea* C.A. Gardner *H. cuneifolia* Benth. *H. curvifolia* F. Muell. *H. dielsii* (Helmsl.) C.A. Gardner *H. divaricata* C. A. Gardner *H. exilis* S. Moore *H. humilis* Benth. *H. loganiacea* (Muell.) F. Muell. *H. pedunculata* Diels *H. purpurea* R.Br. *H. saligna* Diels *H. scabra* Benth. *H. sericea* Benth. *H. teretiuscula* F. Muell. *H. tysonii* F. Muell. *H. viscida* S. Moore *H. westringioides* Benth.
Hemigenia Section *Homalochilus* Lower end of connective of abaxial anthers attenuate or slightly clavate.	*H. macphersonii* Luehmann *H. macrantha* F. Muell. *H. microphylla* Benth. *H. pritzellii* S. Moore *H. ramosissima* Benth. *H. rigida* Benth.
Microcorys Anthers of abaxial stamens sterile, reduced to two linear or clavate lobes. Anthers of adaxial stamens with elongated connective bearing one fertile theca, the lower end dilated and bearded.	
Microcorys Section *Anisandra* Corolla included or rarely exserted (by calyx), the upper lip concave or hooded, with two large anterior lobes.	*M. capitata* Benth. *M. cephelantha* B.J. Conn *M. ericifolia* Benth. *M. exserta* Benth. *M. glabra* Benth. *M. pimelioides* F. Muell. *M. subcanescens* Benth.
Microcorys Section *Hemigenioides* Corolla tube exserted, the upper lip concave.	*M. eremophiloides* K.F. Kenneally *M. longiflora* F. Muell. *M. longifolia* Benth. *M. tenuifolia* Benth
Microcorys Section *Microcorys* Corolla tube included, the upper lip concave or hooded, without large anterior lobes.	*M. barbata* R.Br. *M. elliptica* B.J. Conn *M. lenticularis* F. Muell. *M. macrediana* F. Muell. *M. obovata* Benth. *M. purpurea* R.Br. *M. virgata* R.Br. *M. wilsoniana* B.J. Conn

Table 2.2. Insect visitation of *Hemigenia* and *Microcorys* flowers observed in field by author or reported by other collectors.

Plant taxon	Floral type (see text)	Insect taxon	Mode[A]	Vector?	Observer/ref.	Notes
H. diplanthera F. Muell.	5	Honey bees	b	Yes	Author	
		Megachile (*Chalicodoma*) sp. female (Megachilidae).	b	Yes	"	
		Butterfly (Lycaenidae).	c	No	"	
H. exilis S. Moore.	8	"Butterflies."	probably c	Unlikely	Mattner *et al.* (2002)	Observations of other species suggest butterfly pollination is unlikely
H. humilis s.l. Benth.	7	"Small bees."	?	?	Rogier deKok 1005	Collection notes
H. incana s.l. Benth.	4	*Exoneura* (*Exoneura*) sp. female (Apidae).	a	Yes	Author	
		Honey bees, native bees.	?	?	Rogier deKok 1007	Collection notes
		Megachile (*Chalicodoma*) sp. (Megachilidae).	a	Yes	Author	
H. macrantha F. Muell.	9	*Euryglossa sp.*	?	No	Houston (2000)	Insects are unlikely to pollinate this species
		Leioproctus sp.	?	No	"	
		Leioproctus rhodurus.	?	No	"	
H. scabra Benth.	5	"Small bee."	b	Yes	Author	
		Megachile (*Chalicodoma*) sp. female (Megachilidae).	b	Yes	"	
		Large wasp.	c	No	"	
Microcorys sp.	?	*Amegilla pulchra.*	?	?	Houston (2000)	
M. exserta Benth.	2	Large fly (Tabanidae).	b	Probable	Author	
		Unidentified large fly.	b	Probable	"	
M. obovata Benth.	1	*Amegilla* (*Amegilla*) sp. (Apidae).	b	Yes	"	
		Large fly (Acroceridae).	b	Yes	"	
		Large hoverfly.	c	No	"	
M. macrediana	1	"Small moths"	c probable	No	P.K. Latz 15891	Collection notes
M. wilsoniana B.J. Conn	4	Honey bees.	a	Probable	Author	
		Hoverfly.	c	No	"	

[A] Visitation modes: a: insect enters throat; b: insect accesses nectar externally; c: nectar theft, insect stands clears of fertile parts.

al. 2003; Claßen-Bockhoff *et al.* 2004). Claßen-Bockhoff *et al.* (2004) considered this a "key innovation", allowing for subtle divergence in floral interactions, leading to genetic isolation. Sympatric populations may be reproductively isolated due to flower shape and proportion, and the precision of the pollen-transfer mechanism. The length, shape and orientation of the staminal levers all affect pollen placement. Mechanical isolation here was considered to be due to precision (and hence differentiation) of pollen placement rather than specialisation to particular pollinators.

The general breeding systems of Lamiaceae are well understood, the floral morphology and prevalence of protandry favouring outbreeding (Haque and Ghoshal 1981; Huck 1992; Owens and Ubera-Jiménez 1992; Barrett *et al.* 2000). Barrett *et al.* (2000) and Haque and Ghoshal (1981) studied breeding systems in *Salvia*, but did not examine subtle isolation mechanisms in detail. However, it is likely that subtle floral differences, such as the arrangement of the stamens and close co-evolution with pollinators, are crucial to speciation in the Lamiaceae, and that convergence in floral morphology has occurred (Huck 1992).

Floral isolation may be achieved ethologically (ie. pollinator behaviour) or mechanically through differential exclusion of visitors or isolation of pollen on shared visitors. Mechanical isolation may be the result of grossly different floral arrangements or sizes, or more subtle variation such as minor changes in the positioning of fertile parts (Huck 1992; Armbruster *et al.* 1994; Grant 1994; Claßen-Bockhoff *et al.* 2003; Claßen-Bockhoff *et al.* 2004). Waser *et al.* (1996) suggested that floral generalisation should be favoured, given spatio-temporal variability, but this does not preclude mechanical specialisation.

While general aspects of the floral biology of Lamiaceae are well understood, detailed studies focusing on individual groups and making observations in the wild are needed (Huck 1992). This chapter reports details of the floral biology of *Hemigenia* and *Microcorys* gleaned from field and herbarium/laboratory studies with the following aims:

- understanding the functions of the floral parts and arrangements, hence the likelihood of convergence. In particular, the nature and function of the mobile anthers and staminodes will be investigated. Are they homologous, or has multiple evolution occurred? Is the distinction between anthers with one versus two thecae real? Categorisation of floral types based on combinations of corolla and stamen features will aid comparison.
- providing a basis for understanding the role of pollination in divergence and speciation. Can different corolla shapes and sizes, and stamen types and arrangements, create effective mechanical barriers to cross-pollination, whether via exclusion of mutual pollinators or by physical isolation of pollen on mutual pollinators? Which pollination syndromes are present?

2.2 Methods

Detailed field observations of floral morphology and pollination of *Hemigenia* and *Microcorys* species were made in various locations in southern Western Australia during October of 2002 and 2003. All insects visiting flowering populations of *Hemigenia* and *Microcorys* were observed from close by and photographed when possible using a Pentax P30 SLR camera. Representative specimens of insect visitors were captured by net or by closing a jar, containing a small amount of ethyl acetate (nail-polish remover), around flowers with insects on them. Once dead, the insects were removed and stored in 70% ethanol. Bees and flies were identified to genus by entomologists.

Herbarium-based information was gleaned from wet and dry specimens collected by the author in the field (Greg Guerin 001-151 & Penny McLachlan) supplemented by field notes and a range of herbarium specimens loaned from the following herbaria: AD, BRI, CANB, DNA, MEL, NSW, PERTH. Stamens removed from flowers stored in 70% ethanol were fixed using the final stages of the critical point drying technique: specimens where washed in 100% ethanol before the ethanol was gradually replaced with liquefied carbon dioxide by flushing

ten times in a chamber cooled to 10°C. The chamber was then heated to evaporate the fluid, the resulting gas allowed to escape, leaving the specimens dried without distortion. The fixed specimens were mounted on aluminium stubs using sticky tabs, sputter-coated with carbon and gold, then viewed with a Philips XL20 SEM (scanning electron microscope) operated at 10kV (Figs 2.1, 2.2).

2.3 Results

The leafy flowering branches of *Microcorys* and *Hemigenia* are interpreted here as indeterminate, leafy, spike-like or racemose inflorescences with axillary single or clustered flowers subtended by leaf-like or differentiated bracts, the flowers opening sequentially. A few species have sub-terminal, head-like inflorescences consisting of several contracted nodes subtended by differentiated bracts.

The strongly zygomorphic corolla is tubular, expanding at the throat (entrance), then dividing into two lips (upper/adaxial and lower/abaxial). The upper lip may be hooded, flat, or concave, and has two anterior lobes. The lower lip consists of two smaller lateral lobes and a larger median lobe.

The stamens are inserted on the interior of the corolla in two pairs (upper/adaxial and lower/abaxial). The filaments curve adaxially along the corolla tube, and the anthers are held vertically together in the centre of the throat. The adaxial anthers typically have a single theca held on elongated anther connective tissue which is heavily bearded at the lower end. The abaxial stamens may be staminodal (sterile) (both thecae aborted, leaving two club-like lobes), or have an elongated connective bearing one or two thecae (the lower theca usually reduced). Rarely, the stamens have a single near-sessile theca and a simple tapering connective.

Hemigenia purpurea R.Br. shows a morphological transition between these stamens and those of the related genus *Prostanthera*, in which the stamens have two sessile thecae and

a narrow connective terminating in a sparse beard. In this species, there connective is bearded with a single theca, but the theca is sessile on the filament as in *Prostanthera*.

The anthers are mobile on the filament, and provide passive mechanical pollen deposition. The distal end of the filament tapers to a point (Fig. 2.1A) which sits within a deep groove running beneath the anther (Fig. 2.1B). This allows free movement around the joint without disconnection. Movement is chiefly along the length of the groove although some lateral movement is possible. In order to access nectar, pollinators must push the lower end of the anther into the throat, and in doing so lever the upper end (bearing a perfect theca) onto their back, head or bill. The beard hairs on the lower end of the adaxial anthers catch neighbouring anthers, hence they move in unison when levered.

The flowers are protandrous, the undeveloped style initially held against the adaxial side of the tube, then growing and exserting towards the throat and becoming bifid after the stamens have withered. Biotic pollen vectors are required for pollination.

Floral types and details of observed visitation are reported below. These functional types are based on similarity in pollination syndrome achieved through corolla shape and size, and stamen type and arrangement. Combined, these features affect what animals are able to access nectar and how the interaction occurs. Key characters defining the types include corolla tube narrow-cylindrical or funnel-shape, upper corolla lip hooded or concave, stamens all fertile or abaxial stamens sterile. Flowers of a particular group have broadly similar pollination mechanisms. Stamen morphology and arrangement, and corolla shape vary in relation to pollination syndrome.

2.3.1 Floral Types in *Hemigenia* and *Microcorys*

2.3.1.1 Type 1

Corolla: upper lip small, hooded, anterior lobes small, tube narrow; abaxial stamens sterile.

Type 1 flowers are characteristic of much of *Microcorys* Section *Microcorys* (Table 2.3). The upper corolla lip is small relative to the lower lip and forms a more or less horizontal hood with a small split at the front (Fig. 2.3A). The base of the hood has two very short anterior lobes which spread laterally. The lower corolla lip is large in contrast, the median and lateral lobes broad and flat, forming a single downwards-directed plane. The corolla tube is circular in cross-section, narrow and elongated. The corolla colour is white or blue-purple. In coloured flowers, the throat has a small patch of white with coloured spots. In white flowers, there may be a ring of coloured spots surrounding the outside of the throat.

The adaxial anthers have a single theca held on broad, elongated connective tissue which is bearded and dilated at the lower end (Fig. 2.1D). The abaxial stamens are sterile, and protrude near the abaxial surface of the throat. The filaments are fused to the corolla for much of their length, and only the distal end is free. This short, free segment ends in two club-like lobes formed from the aborted thecae (Fig. 2.1C). The staminodes project out of the throat, more or less perpendicular to the lower lip of the corolla.

Observations of insect visitation were made for *Microcorys obovata* Benth. (Greg Guerin 037 & Penny McLachlan). Swarms of a native bee (*Amegilla* (*Amegilla*) sp. (Apidae)) were observed visiting many flowers, returning every few minutes to each plant. The bees are relatively large, with broad, stout bodies. The bee lands on the median lobe of the lower corolla lip, between the staminodes, then pushes its head down slightly into the throat, presumably using its long proboscis to access nectar at the base of the ovary. In pressing its head into the throat, the bee partially opens the slit between the anterior lobes of the upper corolla lip and presses the lower end of the adaxial anthers, levering the upper end down. Fertile thecae of both anthers were observed pressed firmly onto the top of the head. The visits are fast, the insect visiting a series of flowers on the same bush in succession before flying away to other plants. The specimen captured had pollen grains visibly dusted on the top of its head.

A second visitor, a species of large fly (family Acroceridae), was observed visiting the flowers. The fly's dimensions and mode of visitation and pollen dusting are similar to those of the bee, although the visitation time is longer for each individual flower.

Table 2.3. Floral types in *Hemigenia* and *Microcorys* (includes undescribed species referred to in text).

Functional type and key attributes	Species
Type 1: Corolla: upper lip small, hooded, anterior lobes small, tube narrow; abaxial stamens sterile.	*M. barbata* R.Br. *M. elliptica* B.J. Conn *M. lenticularis* F. Muell. *M. macrediana* F. Muell. *M. obovata* Benth. *M. purpurea* R.Br. *M. subcanescens* Benth. *M. virgata* R.Br.
Type 2: Corolla: upper lip small, hooded, anterior lobes large, erect, tube narrow; abaxial stamens sterile.	*M. ericifolia* Benth. *M. exserta* Benth. *M. glabra* Benth. *M. pimelioides* F. Muell.
Type 3: Corolla: upper lip equal to or longer than lower lip, hooded, anterior lobes variable, tube narrow; abaxial stamens sterile.	*M. capitata* Benth. *M. cephelantha* B.J. Conn *M. tenuifolia* Benth
Type 4; Corolla: upper lip large (shorter than lower lip), hooded, anterior lobes short, tube funnel-shape; abaxial stamens fertile or sterile.	*H. incana* s.l. Benth. ?*H. obovata* F. Muell. *H. platyphylla* Benth. *H. podalyrina* F. Muell. *M. wilsoniana* B.J. Conn
Type 5: Corolla: upper lip shorter than lower lip, anterior lobes horizontal, tube funnel-shape; abaxial stamens fertile.	*H. conferta* B.J. Conn *H. diplanthera* F. Muell. *H. drummondii Benth.* *H. microphylla* Benth. *H. pimelifolia* F. Muell. *H. pritzellii* S. Moore *H. purpurea* R.Br. *H. ramosissima* Benth. *H. rigida* Benth. *H. scabra* Benth. *H. viscida* S. Moore
Type 6: Corolla: upper lip small, anterior lobes ± horizontal, tube narrow; abaxial stamens fertile.	*H. barbata* Bartl. *H. curvifolia* F. Muell. *H. saligna* Diels *H. sericea* Benth.
Type 7: Corolla: upper lip shorter than lower lip, anterior lobes large, erect, tube funnel-shape; abaxial stamens fertile (*rarely sterile).	*H. biddulphiana* F. Muell. *H. brachyphylla* F. Muell. **H. cuneifolia* Benth. *H. dielsii* (Helmsl.) C.A. Gardner *H. divaricata* C. A. Gardner *H. humilis* Benth. *H. loganiacea* (Muell.) F. Muell. *H. macphersonii* Luehmann *H. pedunculata* Diels *H. appressa* (Greg Guerin ms) *H. teretiuscula* F. Muell. *H. westringioides* Benth.
Type 8: Corolla: upper lip shorter than lower lip, anterior lobes large, erect, tube narrow; abaxial stamens fertile.	*H. exilis* S. Moore *H. tysonii* F. Muell.
Type 9: Corolla: red (cf. typical white to mauve), upper lip variable, tube elongate, cuneate; stamens exserted or included, abaxial stamens fertile or sterile.	*H. coccinea* C.A. Gardner *H. macrantha* F. Muell. *M. eremophiloides* K.F. Kenneally *M. longiflora* F. Muell. *M. longifolia* Benth.

A large hoverfly was also observed visiting the flowers. This insect lands on the flower and remains there for some time to feed, employing a long proboscis. Since the species has very long legs, its body and head are kept clear of the floral parts, hence the stamens are not levered and no contact with the anthers or pollen is made.

2.3.1.2 Type 2

Corolla: upper lip small, hooded, anterior lobes large, erect, tube narrow; abaxial stamens sterile.

Type 2 flowers, typical of parts of *Microcorys* Section *Anisandra*, are similar to Type 1, with the following main differences: the hood is open at the front, giving it a vertical appearance, and the anterior lobes are large (only slightly smaller than the lobes of the lower lip) and erect (Fig 2.3B).

Several species of large fly of similar dimensions were observed visiting the flowers of *Microcorys exserta* Benth. (Greg Guerin 096, 105 & Penny McLachlan) (Fig. 2.3C). One species was observed visiting the flowers non-selectively, visiting other adjacent flowers at random. The fly lands on the lower lip, (presumably) accessing nectar without pushing its head into the mouth of the corolla.

Larger numbers of a second species of large fly (Tabanidae) were also observed visiting the flowers, foraging selectively on this species amongst a number of other flowering shrubs close by. The visits on individual flowers are quick, the flies visiting several flowers on a single bush before moving on. The fly lands on the lower corolla lip, the legs on the median and lateral lobes of the lower lip, and probes into the throat, pushing its head slightly forward but not entering the throat. Due to the speed of the visits, it was not possible to observe whether the anthers were pressed onto the fly at any stage. However the corolla morphology allows for the anthers to lever forward out of the open hood, and they are held so closely together that a fine probe levers them.

Populations of *Microcorys exserta* and *M. ericifolia* Benth. were observed growing in sympatry (within c. 50 m). These species appear to have identical corolla and stamen morphologies, matching in size, shape and colour. However, no hybrids or intergrades were apparent.

2.3.1.3 TYPE 3

Corolla: upper lip large (equal to or longer than lower lip), hooded, anterior lobes variable, tube narrow; abaxial stamens sterile.

The upper corolla lip of Type 3 flowers is large relative to the lower lip, with a long, deep hood, sometimes with small anterior lobes. The lower lip is quite short, the lobes truncate. The lips are held far apart. The short- to medium-length tube is narrow. In several species, the corolla is distinctively bicoloured, the upper lip a dark colour, the rest white. The corolla of other species is white to mauve.

The adaxial stamens, with mobile, bearded anthers, are held within the hood. Typically, the filament and lower end of the anther are short, whilst the fertile end of the anther is elongated. Staminodes similar to those of Types 1 and 2 protrude near the centre of the throat.

No observations of floral visitors were made for this group.

2.3.1.4 Type 4

Corolla: upper lip large (shorter than lower lip), hooded, anterior lobes short, tube funnel-shape; abaxial stamens fertile or sterile.

Type 4 flowers occur in taxa currently classified in different genera and sections. The upper lip is somewhat shorter than the lower lip. It has a large, broad hood which is split at the centre, and small anterior lobes which curl up laterally (Fig. 2.3D). The lower lip is more or less horizontal, with short, broad lobes. The tube is funnel-shape, dilating towards the throat.

The corolla colour is mauve, the bearded abaxial surface of the throat white with coloured spots. The sides of the throat may also have darker spots or streaks of colour.

The abaxial anthers bear a single fertile theca and a vestigial second theca on an elongated connective (Fig. 2.1E, 2.1F). The adaxial stamens, held directly behind the abaxial stamens, are similar to the abaxial stamens, except the lower end of the anthers is heavily bearded (Figs 2.1G, 2.1H).

Microcorys wilsoniana B.J. Conn has the above corolla shape but different stamens. The adaxial stamens are larger, the connective dilated at the sterile end (Figs 2.2A, 2.2B). The abaxial stamens are sterile (no thecae) and reduced, and lie flat on the lower corolla lip, but are similar in morphology to fertile stamens, including mobile anthers with vestigial bearding (Figs 2.2C-E).

Observations of insect visitation were made for *Microcorys wilsoniana* (Greg Guerin 100 & Penny McLachlan). Honey bees visited the flowers, pushing themselves deep inside the corolla to access nectar.

A hoverfly also visited the flowers, spending a long time standing on the outer corolla, accessing nectar with a long proboscis. The hoverfly's legs kept it clear of the corolla, and the head did not approach the throat.

Observations of insect visitation were made for *Hemigenia podalyrina* F. Muell. (Greg Guerin 033 and Penny McLachlan). Swarms of a relatively small bee (*Exoneura* (*Exoneura*) sp. (Apidae)) were observed visiting the flowers of an extensive population over a period of one to two hours (Fig. 2.3E). The bee lands on the median lobe of the lower corolla lip then walks into the throat until all but the tip of the abdomen has disappeared from view. As the insect enters the flower, it pushes against the lower end of the anthers, levering the upper end towards the throat. This occurs with the abaxial pair followed by the adaxial pair as the bee goes further in. The thecae are levered onto the bee and make contact dorsally. A captured female specimen had pollen visibly dusted on the dorsal surface of its thorax. After a short

visit, the bee backs out of the corolla until its wings are free to fly away. The bee visits a number of flowers close by in rapid succession before flying to a different plant, foraging within a group. The bees mainly visit flowers at the tops of the bushes.

Observations of insect visitation were made for a small, prostrate form of *Hemigenia incana* s.l. (Greg Guerin 135 and Penny McLachlan). Small numbers of medium size bees (*Megachile* (*Chalicodoma*) sp. (Megachilidae)) were observed visiting the flowers sporadically. The bee lands on the lower corolla lip and partially enters the throat, its rear half protruding. The bee quickly backs out and flies away to visit other flowers on the same individual or other plants. Foraging was selective on the *Hemigenia* plants.

2.3.1.5 TYPE 5

Corolla: upper lip shorter than lower lip, anterior lobes horizontal, tube funnel-shape; abaxial stamens fertile.

Type 5 flowers have relatively small corollas (Fig. 2.3F). The upper lip is more or less horizontal with anterior lobes flat or roof-shape (angling diagonally down laterally), the lower lip longer than the upper lip and downwards-directed. In a single species, *H. scabra* Benth., the upper lip is erect. The tube is short and funnel-shape but not particularly broad distally. The corolla is either blue to purple, the throat white with coloured spots or streaks, or white, marked with colours on the throat and corolla lips.

The abaxial anthers usually have two thecae, held equidistant from the filament on the elongated connective, the lower theca imperfect (reduced in size) or nearly sterile (containing few pollen grains) (Fig. 2.2F). Typically, the anthers are held diagonally on the filament, the thecae of adjacent stamens separated. The adaxial anthers are monothecic and bearded at the lower end (Figs 2.2G, 2.2H). The anthers are held together vertically in the centre of the throat, the lower ends resting between the abaxial stamens.

Insect visitation was observed for *Hemigenia diplanthera* F. Muell. (Greg Guerin 052 & Penny McLachlan). Honey bees were seen visiting the flowers. The bee spends a short time on each flower, the anthers visibly pressed on its head. In female stage, when the style has matured and exserted to the throat, the stigma touches the head of the bee in exactly the same place as the anthers as it lands.

A native bee species (*Megachile* (*Chalicodoma*) sp. (Megachilidae)) was also observed visiting flowers of *Hemigenia diplanthera*. The bee lands over the lower corolla lip and throat, sticking its head part way into the throat. The anthers could be seen pressing onto the bee's head. The bee has a long proboscis, which it presumably uses to access nectar.

A small butterfly (Lycaenidae) was also observed visiting the flowers. The butterfly visits several flowers of one plant, sitting on each for several seconds, fluttering its wings. This species has long legs and does not contact the floral parts or lever the mobile anthers.

Three species of insect (two relatively small bees and a wasp) were observed visiting flowers of *Hemigenia scabra* Benth. (Greg Guerin 056 & Penny McLachlan). A captured bee specimen belongs to *Megachile* (*Chalicodoma*) (Megachilidae), the same genus as was collected visiting flowers of *H. diplanthera*. The bee lands on the lower corolla lip, moving forward into the throat only far enough for its head to enter. The bee stays on one flower for a significant amount of time, during which the anthers are pressed onto its head. In female phase, the stigmas could be seen touching the insect's head where pollen had been deposited by other flowers. The wasp observed was long-legged, had a long proboscis, and did not put its head near the anthers. The bees moved further into the throat to reach nectar, and were dusted with pollen.

In this floral arrangement, the anthers of all four stamens are typically lined up in a single row, rather than separated in pairs. The throat of the corolla is small and visiting insects do not enter the flower deeply. Bearding on the adaxial anthers sticks to adjacent anthers, so that if a single anther is levered, all four move together.

2.3.1.6 TYPE 6

Corolla: upper lip small, anterior lobes ± horizontal, tube narrow; abaxial stamens fertile.

The upper lip of the corolla of Type 6 flowers is small, and either flat or barely hooded with small, rounded, erect to horizontal anterior lobes. The much larger lower lip is broad, and directed downwards (Fig. 2.3G). The corolla tube is short and narrow. Corolla colour varies from white to pink and purple.

All four stamens have mobile anthers with an elongated connective. The lower end of the abaxial anthers typically bears an second, imperfect theca, while in the adaxial anthers, it is bearded. The abaxial pair is held loosely together and, just behind them, the adaxial pair sits close together.

No observations of floral visitors were made for this group.

2.3.1.7 TYPE 7

Corolla: upper lip shorter than lower lip, anterior lobes large, erect, tube funnel-shape; abaxial stamens fertile (rarely sterile).

The upper corolla lip of Type 7 flowers is usually erect and slightly smaller than the lower lip. Rarely, there is a small hood behind the anterior lobes. The lower lip is flat and broad with a large median lobe, but is variable in shape. The tube is funnel-shape, the short, cylindrical base abruptly expanding distally, the throat therefore broad (Fig. 2.3H). Corolla colour is usually white to pink or purple.

Typically, all four stamens are fertile with mobile, elongated anthers, those of the adaxial pair bearded. The lower end of the abaxial anthers typically bears an imperfect theca. The exception, *Hemigenia cuneifolia* Benth., has sterile abaxial stamens similar to Types 1 to 3, but the floral morphology otherwise matches Type 7.

The only observation of animals visiting flowers of this group was for *H. dielsii* (Helmsl.) CA Gardner (Greg Guerin 140 & Penny McLachlan). A hoverfly was observed

landing on the lower lip. However, the insect did not appear to be successfully accessing nectar or contacting fertile parts.

2.3.1.8 TYPE 8

Corolla: upper lip shorter than lower lip, anterior lobes large, erect, tube narrow; abaxial stamens fertile.

The upper corolla lip of Type 8 flowers is erect and slightly smaller than the lower lip, while the lower lip is angled down or more horizontally and has long, separated lobes. The tube is narrow, cylindrical, and elongated. The corolla colour is mauve.

All four stamens are fertile. In *H. tysonii* F. Muell., the stamens have large, mobile anthers, those of the adaxial pair bearded. In *H. exilis* S. Moore, all four stamens are identical, with single near-sessile thecae and a short, tapering connective.

No observations of floral visitors were made for this group.

2.3.1.9 TYPE 9

Corolla: red (cf. typical white to mauve), upper lip variable, tube elongate, cuneate; stamens exserted or included (cf. typical included), abaxial stamens fertile or sterile.

Type 9 species have elongated, stout corollas, with relatively small lobes. Typically, the upper lip exceeds the lower lip, and the lobes of the latter are bent downwards or recurved around the tube. The corollas are red.

The stamens are variable. There are either four identical stamens bearing anthers with single, sessile thecae and a simple tapering connective, or two staminodes and two stamens with mobile anthers. The fertile parts are often exserted beyond the corolla tube, but not in every species. No observations of animal visitors were recorded in the field. However, a detailed description of the morphology follows.

Hemigenia macrantha F. Muell. and *Microcorys eremophiloides* Keneally are examples of this group (Figs 2.4A, 2.4B). The upper lips of the corollas far exceed the lower

lips which have three relatively small lobes recurved around the tube. The corollas are held erect, in *H. macrantha* directly from the axis of the inflorescence, in *M. eremophiloides* the pedicel is sharply bent at the insertion point of the bracteoles.

While the corollas have superficial similarities, the stamens are different. In *Hemigenia macrantha*, all four stamens are exserted beyond the corolla on elongated filaments. The single thecae are sub-sessile with a tapering connective. The adaxial and abaxial pairs sit in a square grid-like arrangement, the connectives directed across the adjacent filament, forming a semi-rigid frame which resists deformation. In *Microcorys eremophiloides,* the abaxial stamens are sterile and highly reduced. The filament, where it is fused to the corolla, is barely visible. The adaxial stamens are fertile with a single theca. The filaments are small compared to the entire structure (c. 3 mm) whilst the anthers are highly elongated (c. 15 mm). The lower end of the anthers is small, glabrous, and hooked. The anthers are mobile on the filament.

The only other Type 9 species in *Hemigenia* is *H. coccinea* C.A. Gardner, which has a shorter, more equally lipped corolla but stamens similar to *H. macrantha*. Also in *Microcorys* Sect. Hemigenioides are *M. longifolia* Benth and *M. longiflora* F. Muell. These species have similar floral arrangements to *M. eremophiloides* but shorter corollas, the lips more or less equal, and the stamens are more typical, the abaxial stamens sterile, the adaxial stamens small.

2.4 Discussion

2.4.1 Functional significance of floral variation

Repeated observations of floral visitors levering the mobile anthers onto their bodies in places that later touch receptive stigmas (dorsal surface (nototribic) or forehead) suggest that bees and flies are the principal pollinators of *Hemigenia* and *Microcorys* (excluding Type 9 species, see below). The bee-pollinated species match the typical bee syndrome: corolla white

to purple, zygomorphic, gullet-shape, tube fused, lower lip acting as a landing platform, coloured dots and staminodes directing the insect to the nectar reward in a way that ensures correct deposition of pollen (Fægri and van der Pijl 1979; Kevan 1983; Wyatt 1983; Richards 1986). Many species have a short indumentum on the exterior corolla. This catches sunlight and enhances the visibility of the flower (pers. obs.) and possibly acts as an additional insect attractant. Swarms of bees were sometimes observed solely visiting flowers held near the top of bushes, and this may have to do with ease of access and visibility.

The protandrous development of the flowers demonstrates the outbreeding tendency of the floral syndrome (Raven 1979; Wyatt 1983; Huck 1992; Owens and Ubera-Jiménez 1992; Bernhardt 1996). This combined with the floral arrangement makes autogamy unlikely. However geitonogamy is prevalent as flowering individuals generally have many open flowers of various ages at the same time, and pollinators were observed visiting multiple flowers on a single individual.

The group has made use of common insect pollinators (Armstrong 1979), but has morphologically specialised the interaction via mechanical isolation (Proctor 1978). The pollinators are generalists, and the plants are pollinated by castes defined by size, anatomy and behaviour. However, vectors were regularly observed preferentially foraging on flowers of the studied species, even when the population was scattered, implying ethological isolation (e.g. search image) may also be important (Grant 1994). This may reduce pollen waste, and could be important in reducing gene flow between divergent populations (Crepet 1983). Macior (1982) also noted pollination by castes rather than specific species in Scrophulariaceae, and similar pollinator-driven selection of floral types in unrelated species. Both bees and flies are capable of pollinating the same species of *Microcorys*, and the morphology of the flowers forces the vector to access nectar in a way that ensures precise pollen deposition, and may exclude inappropriate vectors (Proctor 1978; Claßen-Bockhoff *et*

al. 2004). For example, the long, narrow tube of Type 1 and 2 flowers prevents smaller insects from accessing nectar.

Field observations reveal specific functions for the corolla and androecium, and arrangements adapted to narrow pollination syndromes defined by pollinator castes and precise mechanical interactions. Flowers of similar mechanical function may have evolved convergently due to pollination by similar castes. For example, Types 1 and 6 are functionally similar. The corollas have similar dimensions, but the shape of the upper lip differs, and Type 1 has staminodes whereas Type 6 does not. It follows that the predicted pollination mechanism for Type 6 is identical to Type 1: a large insect landing on the lower lip and pushing its head into the throat to access nectar. The arrangement of the stamens allows them all to lever towards a probe at the same time, and this would be the same for the head of the insect.

Similarly, Type 8 flowers are functionally analogous to Type 2, but all four stamens are fertile (cf. staminodes of Type 2). The predicted pollination syndrome is therefore identical to Type 2, the pollinator likely to be a relatively large insect that lands over the narrow throat and accesses nectar from an external position. The open throat of Type 8 would allow the stamens to lever out towards the head of the pollinator, a comparable syndrome to the open-fronted hood of Type 2.

In Type 5 flowers, the stamens are typically arranged in a single row near the mouth, and insect visitors do not enter the tube. Stamens deeper in the tube would not contact the vectors. The strategy is effectively equivalent to Type 1, in that the pollinator is relatively large compared to the flower and does not enter the tube. The anthers must be arranged to dust the insect on the head the instant it lands. The key functional differences between the types are the number of fertile stamens (2:4) and the presence or absence of a hood. This, combined with the bearding of the anthers making them lever in unison, maximises pollen deposition and enables accuracy in the pollen dusting, since the anthers are all levered directly

towards the pollinator. It is only necessary for the two central (adaxial) stamens to be bearded for this to work.

Types 7 and 3 are not directly comparable to any others, but the likely pollination mechanisms can be estimated from the floral arrangement. Given the broad, open throat of Type 7 flowers, the predicted pollinators are insects which are small relative to the flower and which land on the lower lip and crawl deep into the throat to access nectar. The absolute size of the most appropriate vector may vary in proportion with the dimensions of the corolla tube. Indeed, the size of flowers in this type is variable, and may account for much of the mechanical isolation alone by attracting different pollinators or placing pollen on different parts of shared pollinators (Claßen-Bockhoff *et al.* 2004). The only known reference to insects visiting the flowers of Type 7 is from the collection notes of Rogier deKok (Table 2.2). The report of small native bees visiting flowers of *Hemigenia humilis* Benth. matches the prediction that an insect which is small relative to the corolla would enter the throat to access nectar, affecting pollination.

The predicted pollination mechanism of Type 3 is a relatively large insect landing on the lower lip and pushing its head into the throat to access nectar. In doing so, it levers the shorter lower end of the anther, and the elongated upper end is pushed onto the dorsal surface of its back or abdomen.

In all of the above cases, detailed field observations are required to confirm of reject the hypotheses, and in some cases, multiple observations are needed to confirm the role of castes.

Typically, the depth at which nectar is held in a flower correlates with the length of the mouthparts and foraging behaviour of the main pollinator (Bernhardt 1996). Similarly, the length and arrangement of the stamens are matched closely to the size and shape of the pollinator. Correspondingly, the arrangement of the stamens varies markedly in *Hemigenia* species whose floral architecture is otherwise similar. For example, in *H. podalyrina* the

adaxial stamens are held directly behind the abaxial stamens, so that small bees entering the throat are dusted sequentially, whereas in other species, the stamens are all held close together at the front.

The relationship between the size of a flower and its pollinators can be inverse. In insect-pollinated species of *Hemigenia* and *Microcorys*, large corollas with broad throats may be visited by small bees whose bodies fit within the tube, whereas small corollas with thin tubes may be visited by large bees or flies that access nectar externally.

It is unlikely that floral visitors other than bees, flies and birds are pollinators of *Hemigenia* and *Microcorys*. Mattner *et al.* (2002) reported butterflies visiting flowers of *Hemigenia exilis*. Although this species has stamens with near-sessile thecae and only a small, tapering connective, it is unlikely butterflies would affect pollination. Observations of butterflies and other long-legged insects visiting flowers demonstrate that the morphology and foraging behaviour of these insects prevents them from contacting fertile floral parts, hence they are nectar thieves.

Honey bees were observed visiting and potentially pollinating flowers. Since this insect is introduced to Australia, co-evolution has not occurred (Fægri and van der Pijl 1979). However, in some areas, honey bees, by effect of their abundance, may be the principle pollinators, and the interaction is an example of how the floral arrangements discussed here create precise mechanical interactions rather than relying on pollinator fidelity or specific pollinators (Richards 1986).

The staminodes of *Microcorys* are functional; the pollinator must land between them to access the throat, hence pollen may be dusted precisely, ensuring efficient delivery to receptive stigmas (Bernhardt 1996). The reduction of the abaxial stamens into staminodes is achieved via fusion of the filament to the corolla and abortion of the thecae (cf. *Microcorys eremophiloides*). Staminodes are present in species currently classified in *Hemigenia* (one species), *Microcorys* (all), *Westringia* (all), and *Wrixonia* (monotypic), ostensibly with the

same function. Cantino's (1992a) high-level phylogeny of the Lamiaceae was interpreted as a paraphyletic *Hemigenia* giving rise to *Hemiandra* and a *Microcorys-Westringia* clade. *Wrixonia* was nested within *Prostanthera*. This suggests staminodes are homologous is *Microcorys* and *Westringia* but evolved independently in *Wrixonia*. The staminodes of *Hemigenia cuneifolia*, *Microcorys* and *Westringia* are indistinguishable on external morphology, but a detailed phylogeny is required in order to know whether multiple evolution has occurred. The staminodes of *M. wilsoniana* have a less reduced morphology, but are probably non-functional since they lie flat on the corolla. Relative to *Hemigenia,* the lower end of fertile anthers in *Microcorys* is broad, and the stamens are placed closer to the opening of the throat. This compensates for having only two fertile stamens in the throat. In *Salvia*, the adaxial stamens are sterile, highly reduced, and probably vestigial (Claßen-Bockhoff *et al.* 2003).

In *Hemigenia*, the distinction between anthers with one or two thecae has been used in infrageneric classification (Bentham 1870). However, SEM has revealed that stamens with a single visible theca may have a small remnant of an aborted second theca, suggesting the distinction is artificial (Figs 2.1E-F). Moreover, Section *Hemigenia* typically has two visible thecae on the abaxial stamens, which is contrary to its original definition. The second theca need not be fertile because it is held on the lower end of the anther. However, it may act as a catching point for both the insect levering the anther, and the beard hairs of the adjacent stamens.

An important character in the infrageneric classification of *Microcorys* is corolla shape. This is related to pollination syndrome and is somewhat plastic, hence the homology of features used in classification, particularly the presence/absence of large, erect anterior corolla lobes, must be re-evaluated.

The pollination mechanisms reported here differ from those in other Westringieae genera despite similar floral morphology. This is not surprising, since stereotypic syndromes

do not tell us how the interaction functions (Herrera 1996). In insect-pollinated flowers of these genera, the anthers are held dorsally and passively dust insects with pollen (pers. obs.; Conn 1984). Mobile anthers are absent in all these genera. Probably, the character is ancestral to the *Westringia* clade (every genus except *Prostanthera* and *Wrixonia*) (Cantino 1992a; Cantino 1992b) and its absence in *Hemiandra* and *Westringia* represents secondary reduction. Evidence for this is the vestigial groove at the attachment point of the filament to the anther in *Hemiandra* (Rogier deKok pers. comm.). Detailed SEM examination shows that the anthers of *Hemigenia* and *Microcorys* are homologous. It follows that reduced anthers in *Hemigenia* species indicate secondary reversal.

The function of the mobile anthers of *Hemigenia* and *Microcorys* is identical to *Salvia* (Claßen-Bockhoff *et al.* 2003; Claßen-Bockhoff *et al.* 2004). While the evolution of this character has not yet been fully explored, its absence in *Prostanthera*, differences in external morphology, and high-level phylogenies showing *Salvia* is not close to the Westringieae (e.g. Wagstaff *et al.* 1998) suggest it has evolved twice in Lamiaceae, indeed it may have evolved more than once in *Salvia* (Claßen-Bockhoff *et al.* 2003; Claßen-Bockhoff *et al.* 2004). Elongated anther connective tissue is common in Lamiaceae (Hedge 1992), hence there may be a predisposition to the evolution of this mechanism.

2.4.2 Bird Pollination

Although no birds were observed visiting species of *Hemigenia* or *Microcorys* in the field, Type 9 species display classic characters of this pollination syndrome: long, tubular, robust, red corollas, the lower lip recurved, nectar guides absent, styles and stamens highly exserted beyond the corolla tube, filaments sturdy or locked together, woody branches that provide a robust landing stage (Sargent 1918; Fægri and van der Pijl 1979; Ford *et al.* 1979; Wyatt 1983; Richards 1986; Huck 1992). The floral syndrome is rare, occurring in only five species. These species are split between three of Bentham's infrageneric groups: *Hemigenia* Sect.

Homalochilus (1 species), *Hemigenia* Sect. *Hemigenia* (1 species), and *Microcorys* Sect. *Hemigenioides* (3 species). Houston (2000) reported bees visiting *H. macrantha*, but it is doubtful these are true pollinators as the landing platform is some distance from the exserted anthers and style. The interlocking, grid-like arrangement of the stamens may hold the androecium steady when contacting a bird's head.

The staminodes of *M. eremophiloides* are vestigial, and would be useless in guiding a bird into the throat. However the utility of the staminodes in *M. longiflora* and *M. longifolia* is unclear. The fertile anthers of these three species are mobile. In *M. eremophiloides,* the upper end is elongated, and may lever onto a bird's head, a more complex system than in *H. macrantha*. In the other species, the mobile anthers are smaller and may dust the bill or side of the head. Both *H. macrantha* and *M. eremophiloides* have evolved exserted stamens, but the syndrome is achieved via elongated filaments versus elongated anthers, respectively.
Conn (1984) described complex bird pollination syndromes in *Prostanthera* which were quite different from those in *Hemigenia* and *Microcorys*. Claßen-Bockhoff *et al.* (2004) noted that bird-pollination has probably evolved more than once in S*alvia*. Clearly, bird-pollination has evolved more than once in the Westringieae, hence related floral characters must be treated with caution.

2.4.3 Reproductive isolation of populations

Breeding systems affect population dynamics, gene flow and speciation (Fægri and van der Pijl 1979; Ehlers and Pederson 2000). Restricted gene flow due to reproductive isolation can promote divergence and speciation, while limited genetic exchange may not prevent morphological divergence between populations (Wolf and Soltis 1992; Hiramatsu *et al.* 2001). Insect pollinators have limited ranges, hence gene flow can be limited (Hendel 1983; Wyatt 1983). Observations of *Hemigenia* and *Microcorys* have demonstrated floral morphology which deposits pollen precisely, allowing for efficient pollination and

reproductive isolation (Proctor 1978; Richards 1986; Claßen-Bockhoff *et al.* 2004), creating a barrier to gene flow in addition to isolation by distance (Grant 1994). Dispersal is apparently local, the mericarps dropping to the ground near the parent plant (barochory) (pers. obs.), although secondary dispersal agents may act on fallen mericarps (diplochory) (Bouman and Meeuse 1992). Local dispersal would further restrict gene flow (Bohonak 1999). Apparent barriers to gene flow were observed in *M. exserta* and *M. ericifolia*. Further detailed studies would be required to determine whether the species are genetically incompatible or subtle mechanical isolation prevents crossing.

Hemigenia contains unresolved complexes such as the *H. humilis* and *H. incana* groups. An understanding of gene flow between populations may explain the morphological diversity. Small populations occur in patches, often isolated by kilometres, and this may be prohibitive to crossing, exceeding the foraging ranges of the pollinators. Morphological variation can be extreme.

Mattner *et al.* (2002) examined genetic diversity in *Hemigenia exilis*, which occurs in isolated populations. Much of the diversity was held within populations, the level of total diversity partitioned between populations (16%) consistent with regular gene flow. However, this species does not display the polymorphism present in the complexes of *Hemigenia*.
A comparable study of the *Streptanthus glandulosus* complex found that gene flow between small, isolated populations was inadequate to counteract genetic drift, hence there was divergence of populations (Mayer *et al.* 1994). The genetic diversity corresponded to observations of morphological diversity, including variation in corolla colour.

Observations for two species in the *H. incana* complex (*H. podalyrina* and *H. incana* s.l.) showed differences in the size and behaviour of the pollinators. It seems likely that populations in the complexes are diverging due to gene flow inadequate to prevent drift, partly a factor of isolation distances and partly floral isolation. The current available data are inadequate to treat flower-pollinator morphometrics statistically. Floral isolation could be

better quantified with measurements of pollinators and the placement of pollen on them or artificial probes.

2.4.4 Pollinator-specific reproductive isolation

In species currently classified together, floral morphology can differ markedly, and there are examples of sympatric species (at least on a regional scale) that are morphologically similar, yet have divergent floral morphologies. For example, *Hemigenia coccinea* and *H. appressa* (Greg Guerin ms) occur in regional sympatry, sharing a limited range near Mullewa, Western Australia, favour similar sandy-gravelly soil, and have overlapping flowering times in spring. They appear to be closely related, sharing the following characters: leaves oblanceolate, closely folded or the margins conjoined; flowers pedicellate; bracteoles small, linear, erect; calyx tube rounded; calyx lobes elongated, narrowly triangular, far exceeding the tube; indumentum consisting of closely appressed antrorse hairs. *H. appressa* is distinguished by its relatively longer calyx lobes, denser indumentum, longer pedicels, longer, more terete leaves, bracteoles inserted on the distal half of the pedicel rather than the proximal half, and, most importantly, its floral morphology.

Hemigenia coccinea has Type 9 flowers, while *H. appressa* has Type 7 flowers. A detailed phylogeny is needed to examine the relationship between the two species and infer evolutionary changes, and would be valuable in comparing other sympatric species isolated by more subtle floral differences (Armbruster *et al.* 1994; Claßen-Bockhoff *et al.* 2004). The differences are a result of adaptation to very different pollinators (bees and birds), either the result of different pollinator frequencies or initial drift creating reproductive barriers between populations (Wilson and Thomson 1996). The case for species diverging via floral isolation in sympatry is weak, and it is more likely such cases are the result of initial divergence followed by secondary character displacement (Armbruster 1994; Grant 1994; Claßen-Bockhoff *et al.* 2004). Physical isolation of populations may inhibit gene exchange, and it may take only

minimal changes in floral syndrome to begin the process of divergence (Fægri and van der Pijl 1979; Grant 1994; Claßen-Bockhoff *et al.* 2004).

2.4.5 Conclusion

Pollination syndromes need to be considered when determining generic and infrageneric classifications of the Westringieae, as convergences in floral morphology are apparent. Floral arrangements should be treated with caution taxonomically. Currently, the genera of the Westringieae are defined almost solely on stamen type. Knowledge on the floral biology of the two genera considered here will be invaluable in determining homologies in a revised classification. Conversely, patterns of floral evolution can be fully understood only when they can be compared to a detailed phylogeny.

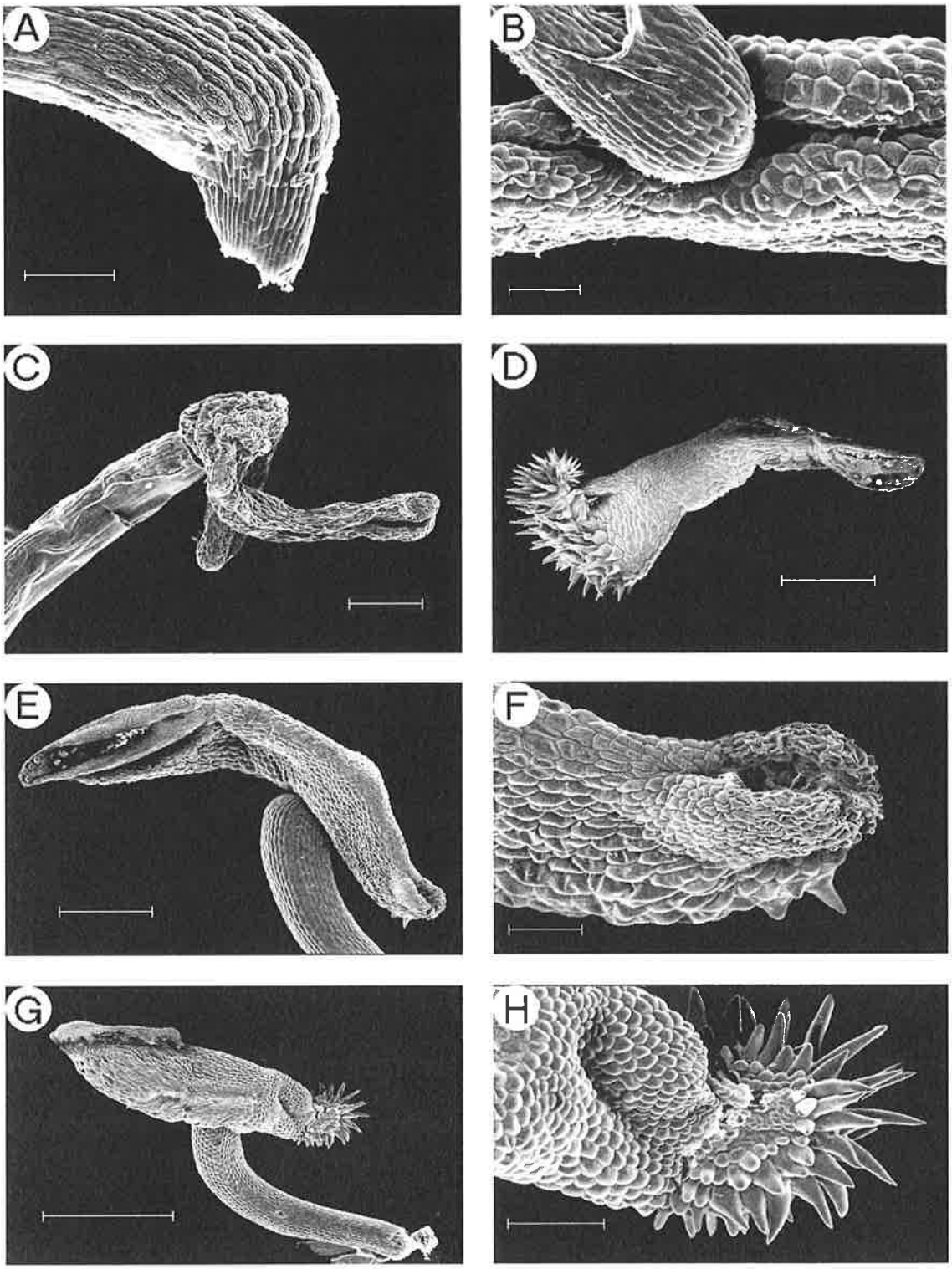


Fig. 2.1. Stamens of *Hemigenia* and *Microcorys*. SEMs: A: tapering end of filament of abaxial stamen of *H. diplanthera* (Greg Guerin 052 & Penny McLachlan), with anther removed. **B:** adaxial stamen of *H. diplanthera*, the filament attached within a groove in the anther. **C:** staminode of *M. obovata* (Greg Guerin 037 & Penny McLachlan). **D:** anther of *M. obovata*, the filament removed. **E:** abaxial stamen of *H. podalyrina* (Greg Guerin 033 & Penny McLachlan). **F:** anther from **E**, showing aborted second theca **G:** adaxial stamen of *H. podalyrina*. **H:** close up of trichomes from **G**. **Scale bars:** Figs 1A, 1B, 1F: 100 μm; figs 1C, 1H: 200 μm; figs 1D, 1E: 500 μm; fig. 1G: 1 mm.

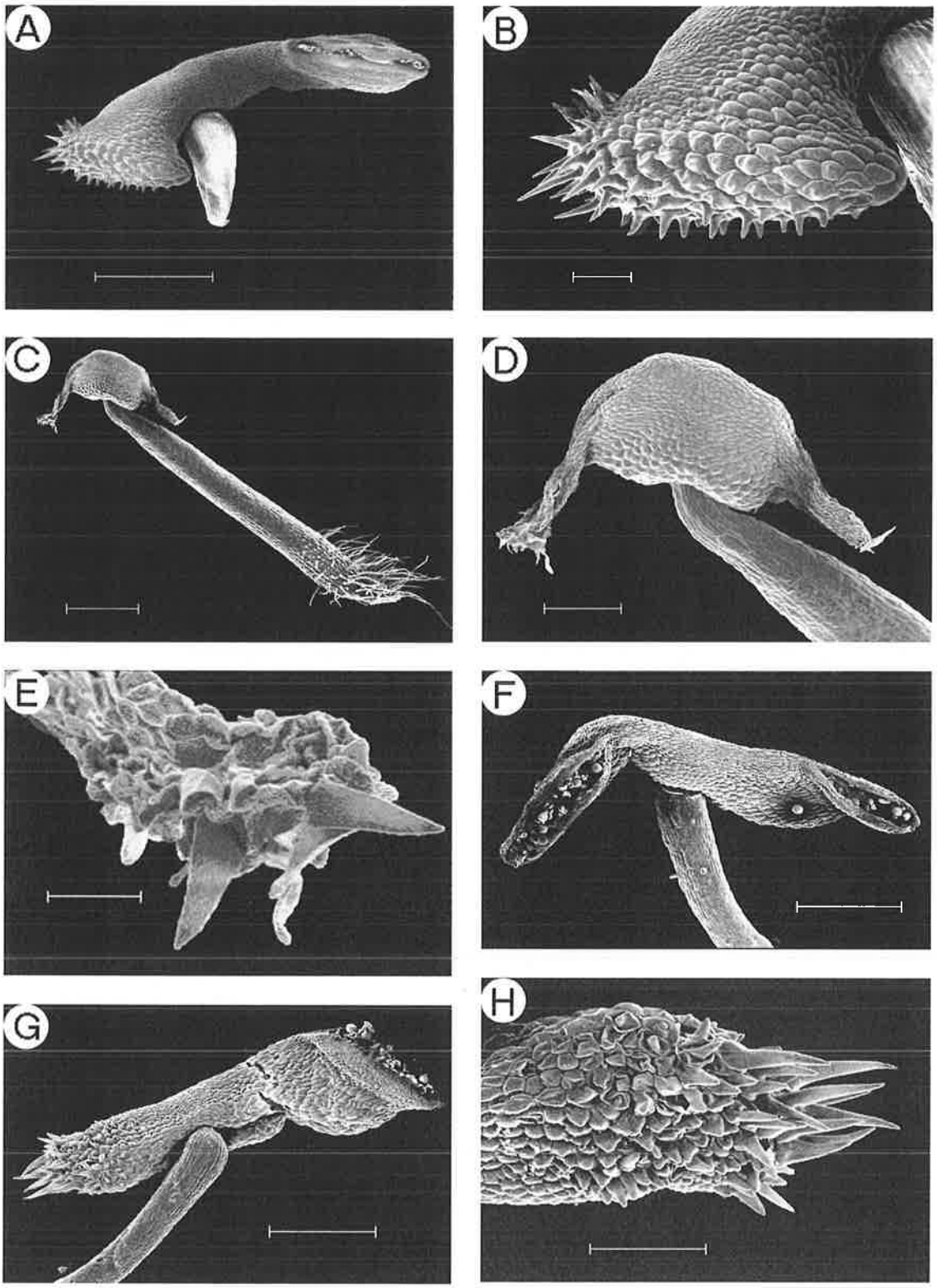


Fig 2.2. Stamens of *Hemigenia* and *Microcorys*. SEMs: A:. adaxial stamen of *M. wilsoniana* (Greg Guerin 100 & Penny McLachlan). **B:**. close up of dilated, bearded sterile end of anther of **A. C:** staminode of *M. wilsoniana*. **D:** close up of attachment point of sterile anther of **C**. **E:** bearding on sterile anther of **C**. **F:** abaxial stamen of *H. diplanthera*. **G:** adaxial stamen of *H. diplanthera*. **H:** close up of bearding of **G**. **Scale bars:** Fig. 1A: 1 mm; figs 2B, 2D, 2H: 200 μm; fig. 1E: 50 μm; figs 2C, 2F, 2G: 500 μm.

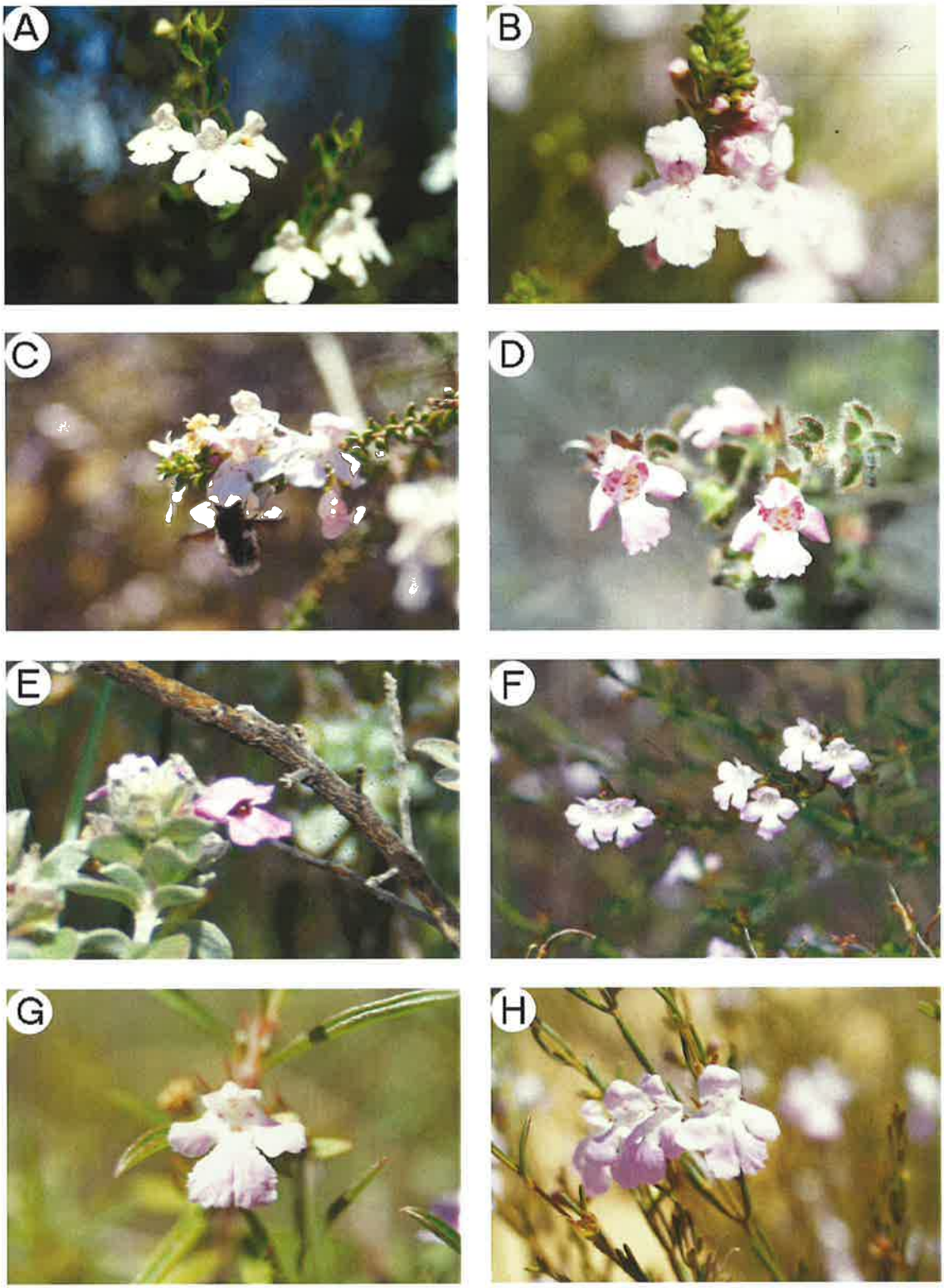


Fig. 2.3. Flowers of *Hemigenia* and *Microcorys*. Colour photographs: A: *M. obovata*. **B:** *M. exserta*. **C:** unidentified fly visiting *M. exserta*. **D:** *H. platyphylla*. **E:** bee (*Exoneura* (*Exoneura*) sp. (Apidae) female) visiting *H. podalyrina*. The bee's abdomen is visible in the throat of the corolla. **F:** *H. diplanthera*. **G:** *H. sericea var. parviflorus*. **H:** *H. teretiuscula*.

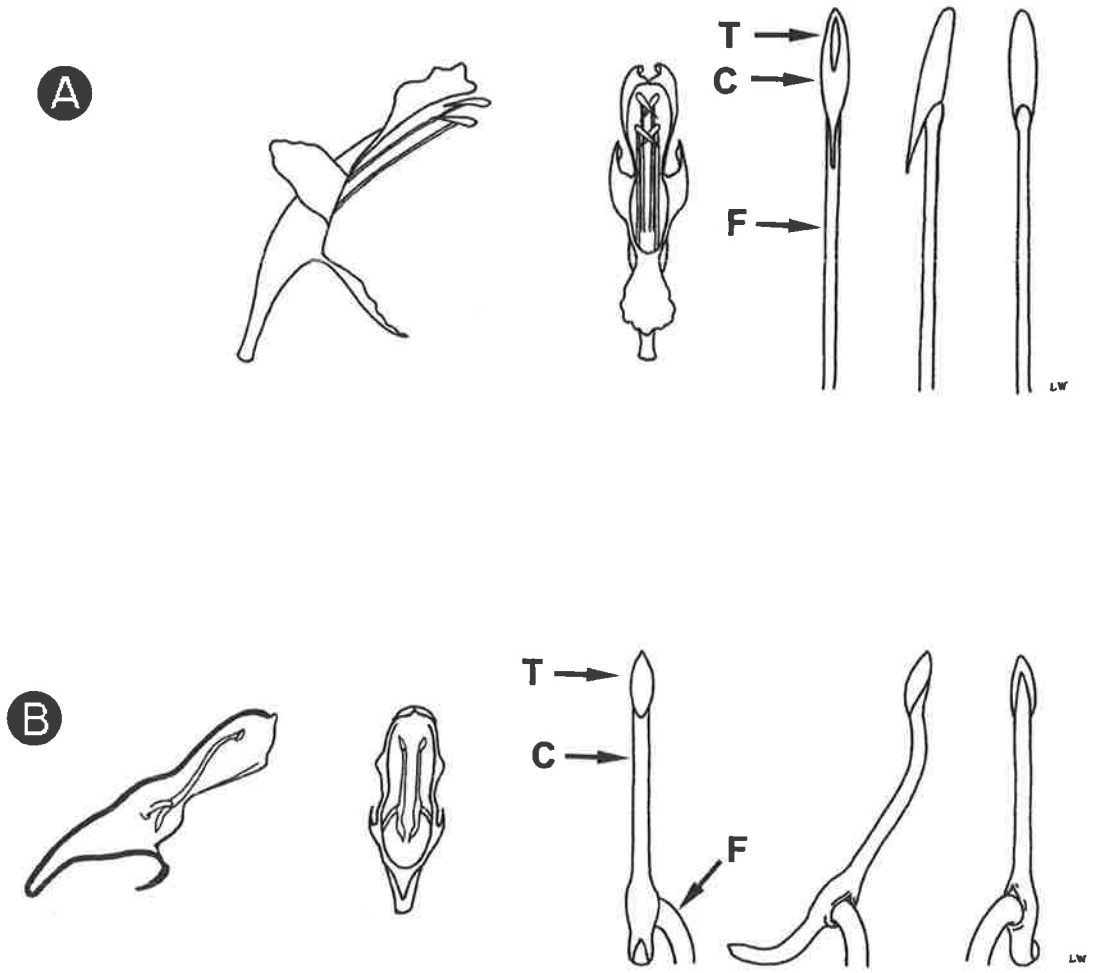


Fig. 2.4. Line drawings: A: flower of *Hemigenia macrantha*: lateral view of full flower, frontal view and stamen. **B:** flower of *Microcorys eremophiloides*: lateral view of half-flower, frontal view and stamen. **T**: theca; **C**: connective; **F**: filament.

3 Mericarp morphology

Abstract

Mericarps of *Hemigenia* R.Br. and *Microcorys* R.Br. were examined using SEM. Significant variation, mainly useful at the infrageneric level, was found in mericarp shape, nature of the attachment scar, nature of surface sculpturing, exocarp cell shape and sculpturing, and nature of the indumentum. Typical mericarps are ovoidal, strongly reticulate or rugose. The exocarp cells are isodiametric and convex to papillate. Also common are cylindrical mericarps, often with longitudinal ridging and papillate exocarp cells. Surface pitting and concave exocarp cells are rare. A cladistic analysis of mericarp characters suggests both *Hemigenia* and *Microcorys* are polyphyletic, and *Microcorys* paraphyletic with respect to *Westringia* Sm. Notwithstanding that, the infrageneric classification of *Hemigenia* was largely supported, while in *Microcorys*, there was support for sect. *Hemigenioides*, but sects *Anisandra* and *Microcorys* were not resolved as distinct.

3.1 Introduction

Use of micromorphological characters in cladistic analyses and classification within the Lamiaceae is growing (Cantino 1990; Husain *et al.* 1990; Marin *et al.* 1994; Oran 1996). Pollen, leaf surfaces, and mericarps have been surveyed. Surface features of seeds and mericarps have been used successfully in a range of systematic studies, and scanning electron microscopy (SEM) has aided character evaluation (Barthlott 1984; Mathews and Levins 1986; Stace 1989; Husain *et al.* 1990; Stuessy 1990, Hedge 1992; Marin *et al.* 1994; Oran 1996). Taxonomically useful characters include surface sculpturing, nature of the exocarp cells, internal anatomy, and indumentum (Roth 1977; Barthlott 1981; Barthlott 1984; Stace 1989), and these characters are applicable in Lamiaceae (Hedge 1992).

Mericarp characters can be used successfully at many taxonomic levels, depending on the characters chosen and the variation present. However, some characters may not be homologous. Trichomes on fruits are known to be involved in seed dispersal (anemochory or zoochory). For example, glandular trichomes may stick to animal fur (epizoochory; Bouman and Meeuse 1992), and tufts of trichomes on the apex of many Lamiaceae mericarps are

likely to have evolved several times (Paton 1992; Marin *et al.* 1994; Werker 2000). Sculpturing may relate to wind dispersal, water repellence or temperature modulation, although quantitative data are lacking (Barthlott 1981; Bouman and Meeuse 1992). Convergence can be detected through careful comparison of external morphology, for example the structure and sculpturing of trichomes.

Ryding (1993; 1994) studied mericarp characters of genera of Lamiaceae using SEM. Surfaces were typically smooth and sub-surface characters were used to distinguish taxa. Obvious large-scale sculpturing was absent. Marin *et al.* (1994) characterised mericarps of *Teucrium* by the presence and density of oil glands. They concluded that mericarp characters were potentially useful within the Lamiaceae at the level of section, genus and species. Oran (1996) found that gross mericarp morphology and surface sculpturing in species of *Salvia* L. was variable and taxonomically useful, and developed descriptive categories for shape, surface sculpturing pattern and cellular deposits. Husain *et al.* (1990) studied micromorphology in the Lamiaceae tribe Saturejeae. Sculpturing patterns (most commonly reticulate) were the most useful characters. Colour, size and shape of mericarps were considered unimportant, either because they did not vary or the variation was random or too great. Attachment scars were invariable, but the authors suggested variation at higher levels may be significant. Sebsebe Demissew and Harley (1992) found that variation in mericarp surface sculpturing and exocarp cellular morphology matched infrageneric groups of *Stachys*.

Cantino (1992) and Ryding (1998) used mericarp characters, including ultrastructure, surface morphology and shape, in cladistic analyses within Lamiaceae, but did not elaborate on the nature or selection of the characters. Husain *et al.* (1990) also concluded that features of mericarps were useful in providing evidence for phylogenetic reconstruction.

In tribe Westringieae, the monophyly of *Hemigenia* R. Br. and *Microcorys* R.Br. and the validity of the infrageneric classification (Bentham 1870) are yet to be tested. Stamen characters are principally used to delimit genera and infrageneric sections. Conn (1992)

performed a cladistic analysis of Westringieae, including twelve terminal taxa, but no mericarp characters.

The mericarps of *Hemigenia* and *Microcorys* have never been examined in detail, and potentially informative microcharacters are needed for phylogenetic analyses and re-classification. Although Ryding (1992) tested mericarps of Westringieae for mucilage, none was found, hence related characters can be excluded from consideration here. This paper investigates mericarp morphology in *Hemigenia* and *Microcorys* with the following aims:

- evaluating morphological variation and categorising similar types to aid description
- assessing homologies and producing a phylogenetic tree based on mericarps characters, in order to assess their utility

3.2 Preliminary micromorphological study

The only previous detailed micromorphological study of Westringieae examined pollen shape and sculpturing under SEM, and sampled 14 species of *Hemigenia* and *Microcorys* (Abu-Asab and Cantino 1993a). The pollen grains are tricolpate, the tectum perforate to reticulate, plus-or-minus spinulose sculpturing. The only exception is *Prostanthera* Section *Klanderia*, which has 6-8-colpate grains. The pollen types described were unique in the Lamiaceae, providing evidence for the monophyly of Westringieae, but providing no characters of use at the generic level. Any characters distinguishing genera were considered marginal. In comparison, Abu-Asab and Cantino (1993b) reported large variation in pollen morphology in tribe Ajugeae, concluding the tribe was likely polyphyletic.

Cantino (1990) included 18 species from Westringieae (five of *Hemigenia* and *Microcorys*) in his examination of stomata and trichomes in the family. However, some characters were highly variable and the survey was not exhaustive enough to infer internal relationships.

A pilot study was conducted to further investigate the systematic utility of microscopic leaf surface characters in the Westringieae. Leaf samples were examined from a selection of species to survey the variability of microcharacters. Small leaf samples were cut from recent herbarium collections and mounted directly on aluminium stubs using sticky tabs to display the abaxial and adaxial surfaces of each species. Specimens were sputter-coated with carbon and gold and viewed under a Philips XL20 Scanning Electron Microscope operated at 10 kV.

Examination of samples revealed little visible epidermal cell detail due to waxy deposits on the cuticle. Trichomes and stomata were visible but epidermal cell shape and the subsidiary cells of stomata were often obscured. The pilot study concluded that stomatal complexes were invariable between species and genera, either paracytic or anisocytic with the third subsidiary cell smaller, and with random orientation. In contrast, trichome characters appeared to be too variable to be of systematic use at this level. Further detailed studies may reveal useful levels of variation in leaf surface characteristics within the tribe. However, as mericarps provided the most potentially useful dataset, the micromorphological study focused in this area.

3.3 Materials and methods

3.3.1 Evaluation of morphological variation.

Mericarps were examined from all species of *Hemigenia* and *Microcorys* with available material (Table 3.1). Specimens of *Hemiandra* R.Br., *Prostanthera* R.Br. and *Westringia* Sm. were included for comparison. Two to four mericarps were examined for each species after a number of specimens had been compared under light microscope for similarity.

Mature mericarps were obtained from herbarium collections from the following herbaria: AD, CANB, DNA, MEL, NSW, PERTH. Mericarps were removed from the receptacle, mounted directly on aluminium stubs using sticky tabs, sputter coated with carbon and gold, and viewed with a Philips XL 20 Scanning Electron Microscope, operated at 10 kV.

Micrographs were compared to develop a character set based on observed morphological variation. Descriptive terminology was developed for shape, surface sculpturing, cellular morphology, and trichomes. Where possible, descriptive terminology is comparable to that used by Husain *et al.* (1990), Marin *et al.* (1994) and Oran (1996). However, the use of the same term does not necessarily indicate homology at higher levels. Terminology for trichomes follows Payne (1978) and Werker (2000). The term 'rugose' is used in the sense of 'wrinkled'. 'Reticulate' refers to sculpturing where the ridges connect to form lacunae.

3.3.2 Phylogenetic Analysis.

Once homologies had been assessed, 31 characters (Table 3.2) were scored for 60 taxa (Table 3.3). A parsimony analysis was conducted using PAUP* 4.0 (beta version) (Swofford 2003). Heuristic searches were performed with 20 random addition sequence replicates. All characters were unweighted. *Ajuga australis* R.Br. was included as a putative outgroup. Phylogenetic trees were produced using Treeview (Page 1996).

3.4 Results

In general form, mericarps of *Hemigenia* and *Microcorys* match that typical of Lamiaceae as described by Ryding (1993; 1994). Intraspecific variation is minimal. Twelve descriptive types were recognised (Table 3.4).

Type 1 mericarps are ovoidal, with a large attachment scar (more than half the length of the mericarp) (Figs 3.1-3.7). The surface is strongly reticulate with depressed, rounded to angular lacunae. The exocarp cells are isodiametric, convex, often becoming minutely papillate (Figs 3.3-3.4). *Hemigenia curvifolia, H. sericea,* and *H. teretiuscula* have sparse thick, flattened, short, minutely-tuberculate trichomes in the lacunae (Fig. 3.6). *Hemigenia teretiuscula* differs in its much deeper lacunae (Fig. 3.7). The surface of *H. viscida* has sparse sub-sessile peltate glandular trichomes.

Type 2 mericarps are elongate, and the attachment scar is very small (Figs 3.8-3.18). In *H. humilis*, *Microcorys glabra, M. longiflora* and *M. wilsoniana* the attachment scar is near-circular with a smooth, raised rim (Fig. 3.12), and the mericarp surfaces have raised longitudinal ridges, the cells of the ridges usually with partially fused papillae (Fig. 3.13). The cells between the ridges are convex to shortly papillate. The surface of *M. glabra* has sparse sub-sessile peltate glandular trichomes, denser at the apex, and more pronounced papillose cellular sculpturing laterally. The mericarp surface of *H. microphylla* has scattered sub-sessile peltate glandular trichomes, more dense towards the apex (Fig. 3.16). The mericarps of *M. exserta* are more obovoid, the exocarp cells isodiametric and raised towards the base of the mericarp, distinctly conical towards the apex (Figs 3.17, 3.18). The apex has numerous distinctive sub-sessile peltate glandular trichomes with structured stalks, the basal part broad and conical, the distal part short and straight-sided. Mericarps of *M. subcanescens* are more ovoidal, almost intermediate between ovoidal and elongate. The surface and exocarp cell sculpturing are the same as the *M. wilsoniana* group, but the attachment scar is relatively larger. Mericarps of *M.* sp. *aff. wilsoniana* are also intermediate, and the sculpturing is intermediate: longitudinal basally, rugose distally.

Type 3 mericarps are ovoidal-spherical, the attachment scar just under half the entire length (Figs 3.19-3.24). The mericarp surfaces of *H. dendritica* ms and *H. diplanthera* are smooth basally (adjacent to attachment scar) and deeply pitted distally, the ridges thick and rounded (Figs 3.19, 3.21). The mericarp surface of *H. scabra* is similar but appears more reticulate due to narrower, more angular ridges (Fig. 3.23). All three have numerous long, rounded, tuberculate trichomes, with those of *H. dendritica* ms and *H. diplanthera* occurring on the ridges and having prominent bases (Figs 3.20, 3.22, 3.24). In *H. dendritica* ms, the trichomes are often dendritic. *Hemigenia scabra* sometimes has sparse multi-cellular trichomes and sparse glandular trichomes (Fig. 3.24), the stalk of which has a conical basal part and a straighter distal part, the head being quite small.

Type 4 mericarps are ovoidal with large attachment scars (Figs 3.25-3.32). The surface is rugose, the ridges rounded and only slightly raised. The exocarp cells are isodiametric and convex. *Microcorys elliptica* has barely defined ridges and is characterised by a dense apical indumentum of tuberculate, multi-cellular, rounded, broad, tapering trichomes, the basal part enlarged, the apical section flat (Figs 3.28, 3.29). *Microcorys macrediana* has a moderately dense apical indumentum consisting of long, tuberculate, flattened, simple hairs arising from enlarged, convex cells, and scattered sub-sessile peltate glandular trichomes (Fig. 3.31). The ridges of *M. tenuifolia* are very broad. The ridges of *Westringia cheellii* and *W. dampieri* (Fig. 3.32) are more raised and prominent, as are those of *M. capitata, M.* sp. *aff. tenuifolia* 3, and *M. tenuifolia*. These are nearly intermediate between rugose and reticulate, except the ridges do not regularly join and the lacunae are not depressed as in Type 1. *Westringia dampieri* has very sparse sub-sessile peltate glandular trichomes.

Type 5 mericarps are cuneate, the base tapering to a point, the apex broadly rounded, the attachment scar small (Figs 3.33-3.35). The surface sculpturing is smooth basally, reticulate/pitted distally, the ridges broad and rounded, or more angular (Fig. 3.33). The exocarp cells of *Hemigenia macphersonii* are isodiametric, concave on the smooth part of the mericarp, convex on the sculptured part (Fig. 3.34). The apex has moderately dense trichomes on the ridges and in the lacunae of two types: peltate sub-sessile glands with a structured base (the basal part conical, the distal part straight), and long, non-glandular, multi-cellular trichomes with a short, smooth, rounded base and a flattened, tuberculate, slightly tapering upper part (Fig. 3.35). The surface of *H. macrantha* is more glabrous, with short, simple, rounded trichomes, concentrated on the ridges.

Type 6 mericarps are rounded-spherical (more ovoidal in *Hemigenia drummondii*), the attachment scar small in *H. drummondii* and *H. pritzellii*, large in *H. incana* and *H. westringioides* (Figs 3.36-3.40). The surface is covered with large, shallow pits, the ridges

Table 3.1. Mericarp specimens examined.

Species	Group	Specimen viewed with SEM
Hemiandra		
Hd. pungens R.Br.	12	B.J. Conn 3285 & J.A. Scott AD 99443153, 1989
Hd. chimaera (B.J.Conn ms)	12	Greg Guerin (064) & Penny McLachlan AD 137693, 2002
Hemigenia		
H. appressa (G.R.Guerin ms)	1	Golding s.n. Perth 1988
"	"	Weber 5122 AD 97546003
H. benthamii (G.R.Guerin ms)	1	Ashby 5215 MEL 689070
H. biddulphiana F. Muell.	9	A. Bean 14840 MEL 295750
H. botryphylla (G.R.Guerin ms)	1	Shaw 633 AD, 1996
"	"	Ashby 5396 MEL 1534147
H. brachyphylla F. Muell.	1	Corrick 9322 MEL 670436
H. cerebracarpa (G.R.Guerin ms)	8	Corrick 9330 MEL 670435
"	"	Greg Guerin (050) & Penny McLachlan AD 137678, 2002
H. ciliata (G.R.Guerin ms)	1	Gardner 13545 PERTH 04264274
H. coccinea C.A. Gardner	1	Patrick 2071 PERTH, 1994
H. cuneifolia Benth.	1	Gibson & Miller 1999 NSW 432633
H. curvifolia F. Muell.	1	Whibley 4909 AD 07447198
H. dendritica (G.R.Guerin ms)	3	Cayzer 571 CANB 9805337.1, 1998
H. dielsii (Helmsl.) C.A. Gardner	10	Gardner 13551 PERTH 03670473
H. diplanthera F. Muell.	3	Cranfield & Spencer 8680 PERTH 02931958, 1992
H. drummondii Benth.	6	S. Patrick 2069 PERTH 04107225, 1994
H. exilis S. Moore	1	Kluken PERTH 04623789, 1996
H. glomerata (G.R.Guerin ms)	3	M.E. & M.G. Tozer 004, NSW 238865, 1990
H. humilis s.l. Benth.	2	A.R. Annels 5270 PERTH 04078985, 1995
H. incana s.l. Benth.	6	Foreman 1079 MEL 680967, 1985
"	"	Davis 2923 PERTH 05870410
H. incana s.s.	6	Rodd 48584 & Fernioni NSW 202184, 1985
H. macphersonii Luehmann	5	Chinnock 8536 & Richmond AD 99350007
"	"	B.H. Smith 456 AD 98827077, 1984
H. macrantha F. Muell.	5	Greg Guerin (053) & Penny McLachlan AD 137681, 2002
H. microphylla Benth.	2	G.J. Keighery 9514 PERTH 01870696, 1987
H. pachyphylla (G.R.Guerin ms)	1	A.M. Ashby 4776 AD 97421133
H. pedunculata Diels	1	Cranfied 11766 PERTH 04941349, 1997
H. pritzelii S. Moore	6	Orchard 4369 CANB 330965, 1974
"	"	H. Demarz 9220 PERTH 01172492, 1982
H. purpurea R.Br.	9	D'Aubert 706 & Dart NSW 226019
H. ramosissima Benth.	8	M. Graham MSG 1116 PERTH 05589703, 1999
H. scabra Benth.	3	A.M. Lyne 936, L. Craven & F. Zich PERTH 03395057, 1992
H. sericea s.s. Benth.	1	Warren 58 PERTH 05323436
H. sericea s.l.	1	Patrick & Papertus 5 PERTH 05099471, 1997
"	1	George 6832 PERTH 01870548
H. teretiuscula F. Muell.	1	Croxford 6187 PERTH 04352815
H. tomentosa (G.R.Guerin ms)	1	Taylor JFT 22 PERTH 04629147, 1995
H. tysonii F. Muell.	1	Weber 5062 AD 97549142, 1975
"	"	George 17483 PERTH 06071740, 1998
H. westringioides Benth.	6	R.K.Brummitt & B.R. Maslin 20524 PERTH 06355949, 2001
H. viscida S. Moore	1	F. Hort 411 PERTH 05377315, 1999
H. sp. aff. microphylla	8	E. Bishop 75 PERTH 05062586, 1996
H. sp. aff. pedunculata 1	4	Roy 6778 MEL 302564, 1961
H.sp. aff. pedunculata 2	1	Scymgeour 1562 PERTH 03671135
Microcorys		
M. barbata R.Br.	7	Davis 772 PERTH 04459091, 1996
M. capitata Benth.	4	D.B. Foreman 1096 PERTH 01561189, 1985
M. cephelantha B.J.Conn	4	D.P. Ebsary 1 PERTH 02117584, 1991
M. elliptica B.J.Conn	4	Brennan 3791 DNA D0152743, 1999
M. eremophiloides Kenneally	2	Greg Guerin (039) & Penny McLachlan AD 137667, 2002
M. exserta Benth.	2	D.J.E. Whibley 5371 PERTH 03721434, 1974
M. glabra Benth.	2	W.R. Archer PERTH 05899842, 1995
M. longiflora F. Muell.	2	A.S. George 7244 PERTH 01126067, 1965
M. longifolia Benth.	2	K. Macey 220 PERTH 05755867, 2000
M. macrediana F. Muell.	4	Latz, P.K. 15891 CANB 00523260
M. obovata Benth.	4	Greg Guerin (037) & Penny McLachlan AD 137665, 2002
M. purpurea R.Br.	4	Greg Guerin (014) & Penny McLachlan AD 137642, 2002
M. subcanescens Benth.	2	Archer 258 MEL 2039189, 1996

Species	Group	Specimen viewed with SEM
M. tenuifolia Benth.	4	R. Davis 2039 PERTH 04600274, 1997
M. wilsoniana B.J.Conn	2	Gardner 14837 PERTH 04406702
M. virgata R.Br.	7	Rodd 5101 & McCarthy PERTH 01165151, 1985
M. sp . aff. subcanescens 1	4	Cranfield 4725 PERTH 03722430, 1983
M. sp.aff. tenuifolia 1	1	G. Barrett s.n. PERTH 04237285, 1994
M. sp. aff. tenuifolia 2	4	B.H. Smith 565 PERTH 01561685, 1984
M. sp. aff. tenuifolia 3	4	W.R. Archer 1912922 MEL 2035195, 1992
M sp. aff. wilsoniana	2	J.W. Wrigley CANB 038035, 1968
Prostanthera		
P. behriana Schlecht.	11	Greg Guerin (075) & Penny McLachlan AD 139669, 2002
P. striatiflora F. Muell.	11	B. Andrews AD 96919314, 1968
Westringia		
W. cheellii Maiden & Betche	4	J.B. Cleland 11918 AD 96933663
W. dampieri R.Br.	4	H.P. Vonow 825 AD 98929215, 1988

Table 3.2. Characters used in the cladistic analysis of mericarp morphology.

0. = present; 1. = absent

SHAPE:
1. Ovoidal: (0) or (1)
2. Cylindrical: (0) or (1)
3. Oblong: (0) or (1)
4. Cuneate: (0) or (1)

SURFACE SCULPTURING:
5. Reticulate: (0) or (1)
6. Rugose: (0) or (1)
7. Rugose, the ridges very prominent: (0) or (1)
8. Longitudinally ridged: (0) or (1)
9. Smoothly pitted: (0) or (1)
10. Cerebral/coarsely reticulate: (0) or (1)
11. Deep narrow pits: (0) or (1)
12. Lacunae broad/sunken: (0) or (1)
13. Base smooth/apex sculptured: (0) or (1)

ATTACHMENT SCAR:
14. Raised rim: (0) or (1)
15. Spine-like projection: (0) or (1)
16. Longer than half mericarp: (0) or (1)
17. Small, ± circular: (0) or (1)
18. Small, ± oval: (0) or (1)
19. Smooth rim: (0) or (1)
20. Deeply concave: (0) or (1)

EXOCARP CELLULAR SCULPTURING:
21. Convex: (0) or (1)
22. Discoid: (0) or (1)
23. Minutely discoid: (0) or (1)
24. Flat, cells clearly visible: (0) or (1)

TRICHOMES:
25. Short, flattened hairs in lacunae: (0) or (1)
26. Long, rounded hairs at apex: (0) or (1)
27. Short, flattened, truncate hairs at apex: (0) or (1)
28. Reticulae with clustered, flattened hairs: (0) or (1)
29. Rounded, tuberculate hairs with broad bases on ridges (only) (± branched): (0) or (1)
30. Thick, rounded, minutely tuberculate, patent simple hairs randomly all over (no broad base): (0) or (1)
31. Short-stalked glands with structured (two-part) base, base not smoothly conical: (0) or (1)

being very broad and rounded. The cellular sculpturing of *H. incana* and *H. westringioides* varies from smooth to discoid (Fig. 3.40). Mericarps of *H. pritzellii* have sparse, scattered sub-sessile peltate glandular trichomes, and the exocarp cells are isodiametric and slightly convex. The surface pits of *H. drummondii* are shallow and less defined, and no cellular sculpturing is visible. The shape of the mericarp is very similar to *H. diplanthera* (Type 3).

Type 7 mericarps are flattened-elongate, those of *Microcorys barbata* broader (Figs 3.41, 3.42). The attachment scars are very small. The surface is ± smooth, the cellular sculpturing discoid (Fig. 3.41). Laterally, there are short trichomes; apically, there is a dense tuft of long, rounded, tuberculate trichomes.

Type 8 mericarps are spheroidal, with very coarse surface sculpturing and a small attachment scar (Figs 3.43-3.45). *Hemigenia cerebrecarpa* ms has 'cerebral' sculpturing, with deep, irregular pits and large, convoluted ridges, and tessellate exocarp cells (Figs 3.43, 3.44). *Hemigenia ramosissima* has very coarse reticulate sculpturing, the ridges broad and enlarged, the exocarp cells papillate (Fig. 3.45). *Hemigenia* sp. *aff. microphylla* has less coarse reticulae, the exocarp cells isodiametric and convex. It has very sparse sub-sessile peltate glands.

Type 9. MERICARPS of *Hemigenia purpurea* are elongate, with a very small attachment scar, while mericarps of *H. biddulphiana* are ovoidal-spherical, with a large attachment scar (Figs 3.46-3.47). The mericarp surfaces have numerous deep, narrow, coarse pits, and the exocarp cells are minutely papillate. *Hemigenia purpurea* has numerous short, truncate, flattened, thickened, tuberculate, simple trichomes at the apex (Fig. 3.48).

Type 10. Mericarps of *Hemigenia dielsii* are spheroid, with a small attachment scar (Fig. 3.49). Surface sculpturing is minimal, consisting of sparse, shallow ridges and shallow reticulae on the apex. The exocarp cells are isodiametric or elongate, slightly convex. The apex has dense, simple, flattened, tuberculate trichomes on the ridges and lacunae.

Type 11. Mericarps of *Prostanthera behriana* are elongate, and mericarps of *P. striatiflora* are ovoidal-spherical, the attachment scars small (Figs 3.50-3.52). *Prostanthera behriana* has numerous short, truncate, flattened, thickened, simple trichomes at the apex, which have no secondary sculpturing. The exocarp cellular sculpturing of both, where present, is minutely discoid, the cells with raised rims (Fig. 3.51). The mericarp surface of *P. striatiflora* is heavily sculptured with irregular, coarse chasms, the ridges rough and chaotically shaped. It has scattered, large, sub-sessile peltate glandular trichomes, the apices flattened. The mericarp surface of *P. behriana* is shallowly reticulate, the lacunae shallow and square, with coarse pitting at the apex.

Type 12 mericarps are ovoidal, the attachment scar large, with a prominent spine-like projection (Figs 3.53-3.54). The surface is pitted, the lacunae shallow, the ridges angular, higher where they meet. The exocarp cells are isodiametric, hexagonal, flat but with 'pinched' secondary sculpturing (narrow, elongate central projection). Long, smooth, flattened trichomes are dense on the ridges.

Table 3.3. Mericarp data matrix.

	1	6	1	1	2	2	3
			1	6	1	6	1
Ajuga australis (outgroup)	01110	11111	11111	01110	11111	11111	1
Hemiandra chimaera	01110	11111	11110	01110	11111	11011	1
Hd. pungens	01110	11111	11110	01110	11111	11⁰/₁11	1
Hemigenia appressa ms	01110	11111	11111	01100	01111	11111	1
H. benthamii ms	01110	11111	11111	01100	01111	11111	1
H. biddulphiana	01111	11111	01111	01110	01111	11111	1
H. brachyphylla	01110	11111	11111	01100	01111	11111	1
H. cerebrecarpa ms	11111	11110	11111	11111	11111	11111	1
H. ciliata	01110	11111	11111	01110	01111	11111	1
H. coccinea	01110	11111	11111	01100	01111	11111	1
H. cuneifolia	01110	11111	11111	011⁰/₁0	01111	11111	1
H. curvifolia	01110	11111	11111	01100	01110	11111	1
H. dendritica ms	01111	11101	11011	01100	01111	11101	1
H. dielsii	1111⁰/₁	11111	11⁰/₁11	11110	01111	11111	1
H. diplanthera	01111	11101	11011	01100	01111	11101	1
H. drummondii	01111	11101	11111	01110	01111	11111	1
H. exilis	01110	11111	11111	01100	01111	11111	1
H. glomerata ms	01110	11111	10111	01110	01111	11110	0
H. humilis	10111	11011	11111	10111	01111	11111	1
H. incana	11111	11101	11111	01110	10111	11111	1
H. macphersonii	11101	11111	11011	11111	01111	11111	1
H. macrantha	11101	11111	11011	11111	11111	11111	1
H. microphylla	10111	11111	11111	11011	10111	11111	1
H. pedunculata	01110	11111	11111	01110	01111	11111	1
H. pritzellii	11111	11101	11111	11111	01111	11111	1
H. purpurea	11011	11111	01111	11111	01111	10111	1
H. ramosissima	11111	11110	11111	11111	01111	11111	1
H. scabra	01110	11111	10111	011⁰/₁0	01111	11110	0
H. sericea	01110	11111	11111	01100	01110	11111	1
H. sp. *aff. pedunculata* 1	01111	01111	11111	01110	01111	11111	1
H. sp. *aff. pedunculata* 2	01110	11111	11111	01110	01111	11111	1
H. teretiuscula	01110	11111	11111	01100	01110	11111	1
H. tomentosa	01110	11111	11111	01100	01111	11111	1
H. tysonii	01110	11111	11111	01100	01111	11111	1
H. viscida	01110	11111	11111	01100	01111	11111	1
H. westringioides	11111	11101	11111	01110	10111	11111	1
Microcorys barbata	11111	11111	11111	11111	10111	01111	1
M. capitata	01111	01111	11111	01100	01111	11111	1
M. cephelantha	01111	01111	11111	01100	01111	11111	1
M. elliptica	01111	01111	11111	01110	01111	11111	1
M. eremophiloides	10111	11111	11111	10111	11101	11111	1
M. exserta	11111	11111	11111	11111	11111	11111	1
M. glabra	10111	11011	11101	10111	01111	11111	1
M. longiflora	10111	11011	11101	10111	01111	11111	1
M. longifolia	10111	11011	11111	10111	11101	11111	1
M. macrediana	01111	01111	11111	01110	01111	11111	1
M. obovata	01111	01111	11111	01110	01111	11111	1
M. purpurea	01111	01111	11111	01110	01111	11111	1
M. sp. *aff. tenuifolia* 1	01110	11111	11111	011⁰/₁0	01111	11111	1
M. sp. *aff. tenuifolia* 2	01111	01111	11111	01100	01111	11111	1
M. sp. *aff. tenuifolia* 3	01111	00111	11111	01110	01111	11111	1
M. sp. *aff. Wilsoniana*	01111	⁰/₁1⁰/₁11	11111	11111	01111	11111	1
M. subcanescens	00111	01011	11101	01110	01111	11111	1
M. tenuifolia	01111	00111	11111	01110	01111	11111	1
M. virgata	11111	11111	11111	11111	10111	01111	1
M. wilsoniana	10111	11011	11101	10111	01111	11111	1
Prostanthera behriana	11011	11111	11111	11011	11011	10111	1
P. striatiflora	11011	11111	11111	11011	11011	11111	1
Westringia cheelii	01111	00111	11111	01110	01111	11111	1
W. dampieri	01111	00111	11111	01110	01111	11111	1

Table 3.4. Defining mericarp characters of descriptive types in *Hemigenia* and *Microcorys*.

Defining characters	Species	Sections
Type 1: Ovoidal, attachment scar large, reticulate, exocarp cells convex.	*H. appressa ms* *H. benthamii* ms *H. botryphylla* ms *H. brachyphylla* *H. ciliata ms* *H. coccinea* *H. cuneifolia.* *H. curvifolia* *H. exilis* *H. pachyphylla* ms *H. pedunculata* *H. sericea* *H. teretiuscula.* *H. tomentosa* ms *H. tysonii.* *H. viscida* *H.* sp. *aff. pedunculata* 2. *M.* sp.*aff. tenuifolia* 1	*H.* sect. *Hemigenia* *M.* sect. *Hemigenioides*
Type 2: Elongate, attachment scar small, longitudinally ridged to flat, exocarp cells flat to convex.	*H. humilis* *H. microphylla* *M. eremophiloides* *M. exserta* *M. glabra* *M. longiflora* *M. longifolia* *M.* sp. *aff. wilsoniana* *M. subcanescens* *M. wilsoniana*	*H.* sect. *Hemigenia* *H.* sect. *Homalochilus* *M.* sect. *Anisandra* *M.* sect. *Hemigenioides*
Type 3: Ovoidal-spherical, attachment scar medium, pitted to reticulate, exocarp cells convex, trichomes on ridges.	*H. dendritica* ms *H. diplanthera* *H. glomerata* ms *H. scabra*	*H.* sect. *Diplanthera* *H.* sect. *Hemigenia*
Type 4: Ovoidal, attachment scars large, rugose, exocarp cells convex.	*H.* sp. *aff. pedunculata* 1 *M. capitata* *M. cephelantha* *M. elliptica* *M. macrediana* *M. obovata* *M. purpurea.* *M.* sp . *aff. subcanescens* 1 *M.* sp. *aff. tenuifolia 2* *M.* sp. *aff. tenuifolia 3* *M. tenuifolia* *W. cheellii* *W. dampieri*	*H.* sect. *Hemigenia* *M.* sect. *Anisandra* *M.* sect. *Microcorys* *M.* sect. *Hemigenioides* *Westringia*
Type 5: Cuneate, attachment scars small, reticulate/pitted distally, exocarp cells concave to convex. Trichomes on ridges or in lacunae.	*H. macphersonii* *H. macrantha*	*H.* sect. *Homalochilus*
Type 6: Rounded-spherical, attachment scars small, pitted, exocarp cells discoid to convex.	*H. drummondii* *H. incana* *H. pritzellii* *H. westringioides*	*H.* sect. *Atelandra* *H.* sect. *Diplanthera* *H.* sect. *Hemigenia* *H.* sect. *Homalochilus*
Type 7: Flattened-elongate, attachment scars very small, smooth, exocarp cells discoid, dense trichomes at apex.	*H. barbata* *H. virgata*	*M.* sect. *Microcorys*

Defining characters	Species	Sections
Type 8: Spheroidal, attachment scars small, cerebral/coarsely reticulate, exocarp cells tesselate or convex/papillate.	*H. cerebrecarpa* ms *H. ramosissima* *H.* sp. *aff. microphylla*	*H.* sect. *Homalochilus*
Type 9: Elongate/ovoidal-spherical, attachment scars variable, pitted (deep narrow pits), exocarp cells minutely papillate.	*H. biddulphiana* *H. purpurea*	*H.* sect. *Hemigenia*
Type 10: Spheroid, attachment scar small, shallowly ridged/reticulate, exocarp cell slightly convex.	*H. dielsii*	*H.* sect. *Hemigenia*
Type 11: Elongate/ovoidal-spherical, attachment scar variable, sculpturing variable, exocarp cells minutely discoid.	*P. behriana.* *P. striatiflora*	*Prostanthera*
Type 12: Ovoidal, attachment scars large with spine-like projection, pitted, exocarp cells flat, flattened trichomes on ridges.	*Hemiandra chimaera* *Hd. pungens*	*Hemiandra*

3.4.1 Results of cladistic analysis.

The analysis produced 988 maximum parsimony trees of length 52. The strict consensus tree was poorly resolved. The 50% majority rule consensus tree shows 22 resolved nodes (Fig. 3.55). There was 100% support for the monophyly of the main clade (Node 1), with *Ajuga* and *Hemiandra* resolved as outgroups. Four significant clades are: **1.** *Prostanthera*, most of *Microcorys* sect. *Hemigenioides*, *Hemigenia* sect. *Homalochilus*, *H.* sect. *Atelandra*, and parts of *M.* sects *Microcorys* and *Anisandra* and *H.* sect. *Hemigenia*; **2.** *Westringia* and the majority of *M.* sects *Microcorys* and *Anisandra*; **3.** *H.* sect. *Diplanthera*; **4.** the majority of *H.* sect. *Hemigenia*. The relationships of a number of other species were unresolved. Support for major branches was mostly high.

3.5 Discussion

The morphological variation observed in mericarps is phylogenetically informative. In mericarps examined, shape, surface sculpturing, attachment scar, exocarp cell shape and sculpturing, and indumentum varied significantly. Ovoidal, rugose to reticulate mericarps with convex to papillate exocarp cells were most common. Unlike fruits of many other groups of Lamiaceae (Barthlott 1981), no secondary sculpturing of exocarp cells was evident, except

in *Hemiandra*. Secondary sculpturing (e.g. tuberculae) of trichomes, in contrast, was common. Trichomes were diverse, sometimes too variable for cladistic use. Given their complex nature, homologies had to be determined through careful comparison of external morphology.

Several species have autapomorphic characters (e.g. *Hemigenia dielsii* (Type 10)), but comparable characters were found among groups. The level of variation is mainly useful at the infrageneric level. The cladistic analysis of mericarp characters groups species not currently classified together.

Hemigenia is polyphyletic because it is split between each major clade. *Hemigenia* sect. *Hemigenia* is polyphyletic because *H. humilis* (Type 2) and *H. westringioides* (Type 6) are related to *Microcorys* sect. *Hemigenioides* (Clade 1, Node 8) and *H.* sect. *Atelandra* (Clade 1, Node 15), respectively, and several other species were placed outside the main clade. *Hemigenia incana* (*H.* sect. *Atelandra*) and *H. westringioides* are sister taxa (Node 15) with mericarps that are nearly indistinguishable (Type 6): rounded-spherical, surface pitted, exocarp cell sculpturing discoid, attachment scar shallow. Excluding the above exceptions, *H.* sect. *Hemigenia* mericarps are ovoidal with reticulate sculpturing, the lacunae depressed, exocarp cells isodiametric, convex to papillate (Type 1, Clade 4, Node 7). *Hemigenia curvifolia*, *H. sericea* and *H. teretiuscula* are grouped together (Node 20; 100% support) and have the synapomorphy of trichomes in the lacunae.

For *Hemigenia* sect. *Homalochilus* (Types 5 and 8), *H. macphersonii* and *H. macrantha* form a clade (Node 12). The relationships of the other species in the section were unresolved in Clade 1 (Node 5), despite the similar mericarps of *H. cerebrecarpa* ms and *H. ramosissima*.

The phylogeny resolved *Hemigenia* sect. *Diplanthera* as monophyletic (Clade 3, Node 18). Mericarps of *H. dendritica* ms and *H. diplanthera* (Type 3) are near-indistinguishable except for the branched trichomes of *H. dendritica* ms and the species were grouped together

(Node 19). Mericarps of *H. drummondii* (Type 6) are similar in shape to *H. diplanthera*, but the surface is pitted all over and glabrous. Mericarps of other species are unavailable due to limited collections.

Microcorys is polyphyletic with a number of species being placed in Clade 1. Excluding these species, mericarps of sections *Anisandra* and *Microcorys* are indistinguishable: ovoidal with rugose sculpturing, the exocarp cells isodiametric and convex. These characters are synapomorphies for Clade 2/Node 6, which includes all other species of *Microcorys* and *Westringia*. *Westringia* groups with *M. tenuifolia* and *M.* sp. *aff. tenuifolia* 3 (Node 16) based on the presence of raised ridges. *Westringia* shares other morphological characters with *Microcorys*, such as whorled leaves and sterile abaxial stamens. Conn's (1992) cladistic analysis also placed the two genera together.

Mericarps of *Hemigenia humilis*, *Microcorys longiflora,* and *M. wilsoniana* (Type 2) are virtually indistinguishable: cylindrical, the attachment scar small with a rounded, raised rim, surface sculptured with longitudinal ridges with papillate exocarp cells, exocarp cells elsewhere convex. Mericarps of *M. glabra* are similar but slightly shorter, and the attachment scar is relatively larger. Mericarps of *M. eremophiloides* and *M. longifolia* are similar but broader and lack longitudinal ridges and papillate exocarp cells. *M. longifolia* is a synonym of *M. eremophiloides* and their placement together in the phylogeny (Node 11) is expected. The above six species form a clade (Node 8), suggesting *M.* sect. *Hemigenioides* is paraphyletic, unless *H. humilis* and *M. glabra* are included. *M. tenuifolia* (Type 4) was grouped in Clade 2 and perhaps should *not* be in *M.* sect. *Hemigenioides*.

Hemigenia sp. *aff. pedunculata* 1 was placed in the main *Microcorys* clade (Clade 2) and shares all the synapomorphies defining this clade. The relationships of *H. pedunculata* and *H.* sp. *aff. pedunculata* 2 lie elsewhere (Node 1), thus further investigation into the generic placement of these species is required.

Mericarps of *Microcorys barbata* and *M. virgata* (Type 8, Clade 1) are near-identical, with the following synapomorphies: elongate, discoid exocarp cell sculpturing, tufted, long trichomes at the apex. They are grouped together in the phylogeny (Node 13). The main difference between the species appears to be the presence/absence of a dense calyx indumentum. Population studies are required to determine if both species should be recognised.

Mericarps of the two species of *Hemiandra* examined are identical, characterised by numerous flattened trichomes on the ridges, and the spine-like projection of the attachment scar (Type 12, Node 22). The distinctive morphology of the mericarps placed it outside the main clade.

Mericarps of the two species of *Prostanthera* examined have similar apical sculpturing, attachment scars, and exocarp cell sculpturing (Type 11), but different shape and indumentum. The truncate trichomes at the apex of *P. behriana* are similar to those of *H. purpurea*, but lack secondary sculpturing. The two *Prostanthera* species are grouped together in the phylogeny (Node 14). The mericarps of *Prostanthera* share no obvious synapomorphies with the other taxa examined here. Their placement in Clade 1 here warrants further investigation.

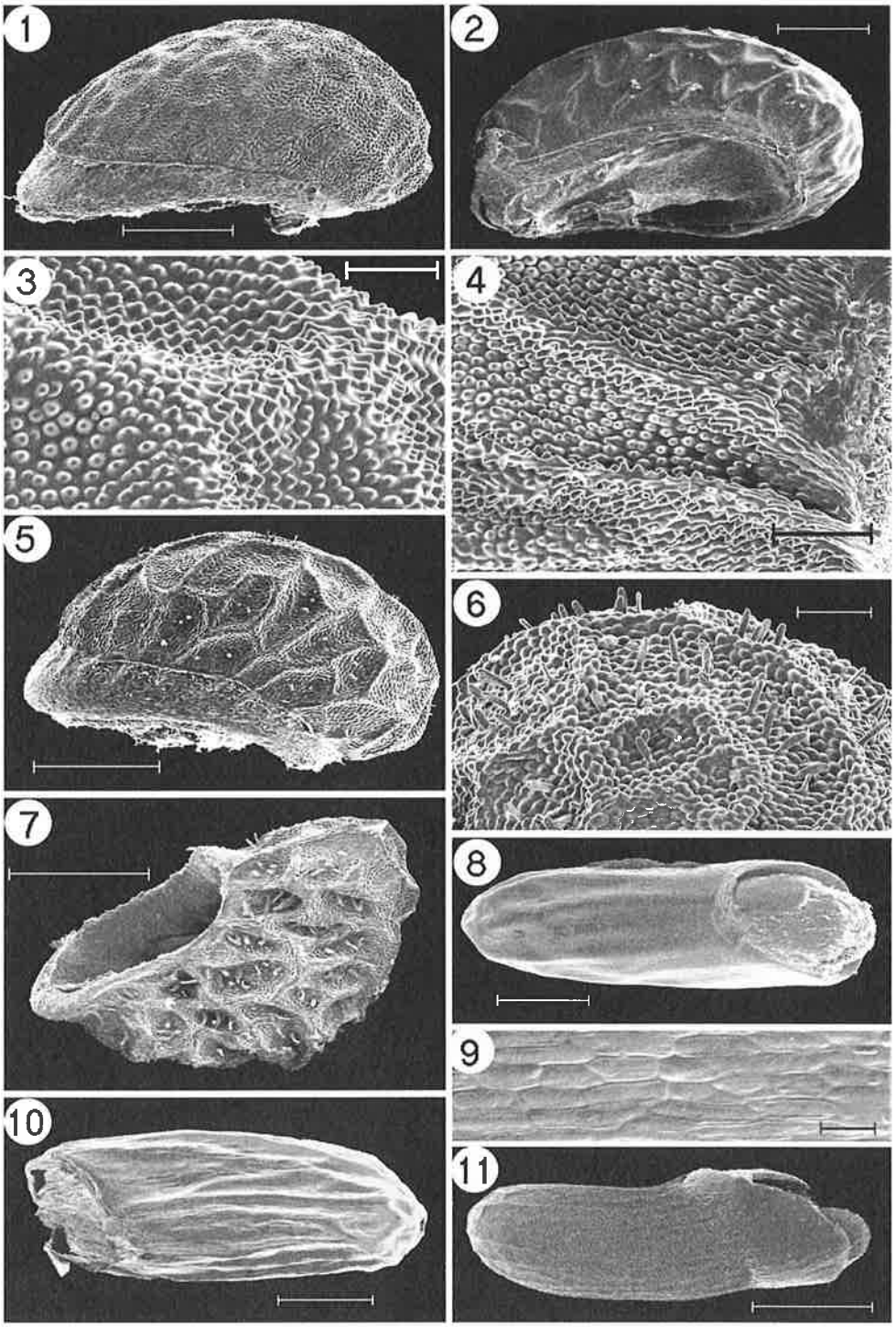
Species with the same mericarp type tended to group together, suggesting the character combinations are relatively stable and derived through ancestry rather than convergence. Moreover, this suggests that the use of mericarp characters in cladistic analyses is sound.

Many of the variable mericarp characters examined here are also of systematic value in other groups of Lamiaceae, particularly surface sculpturing (Husain *et al.* 1990; Oran 1996). However, Husain *et al.* (1990) found that mericarp shape and the nature of the attachment scar were invariable in Tribe Saturejeae, and thus of little taxonomic use, whereas in the Westringieae, these characters vary significantly. Marin *et al.* (1994) found the density

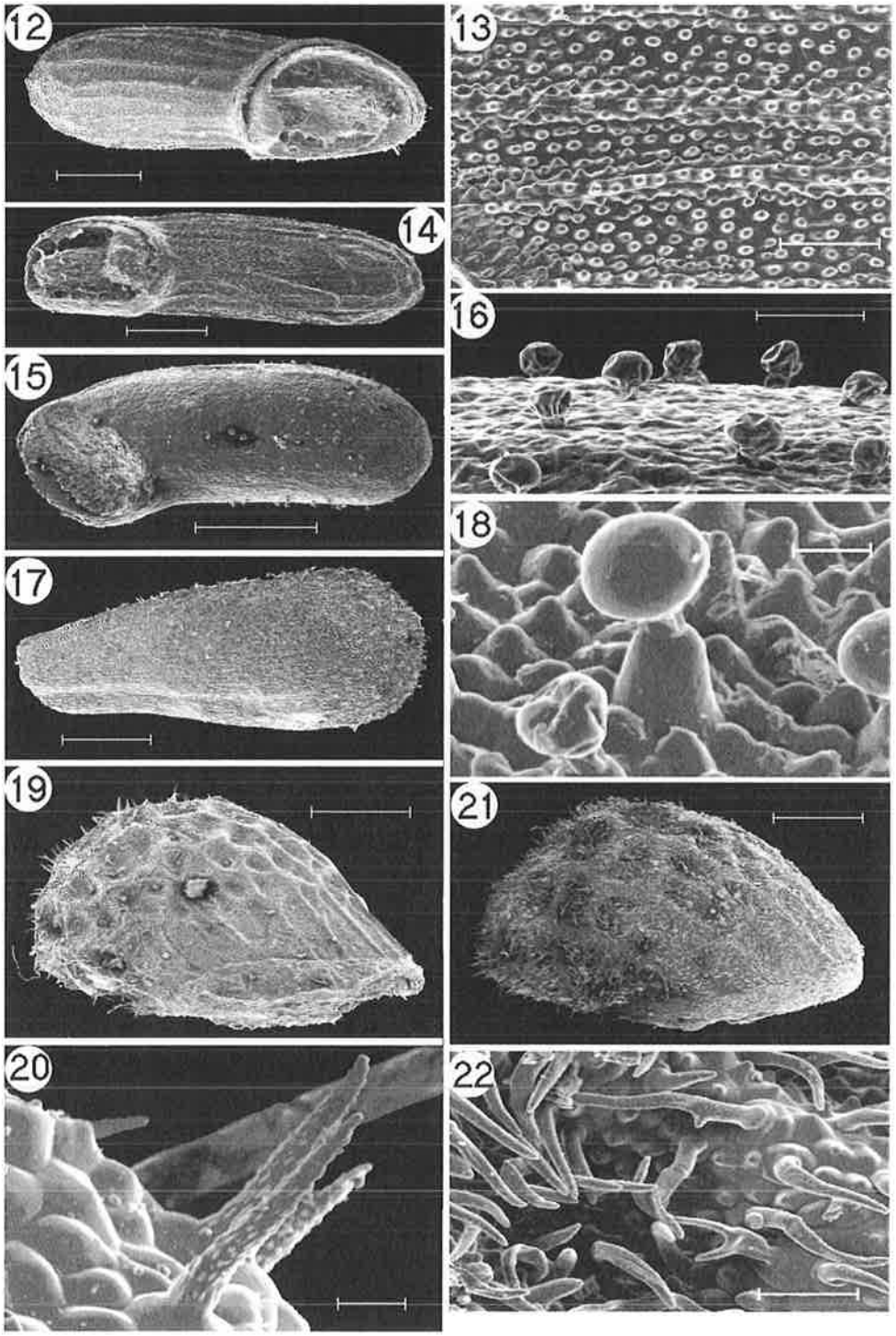
of glandular trichomes to be the most useful character. Although the density of glandular trichomes was variable here, it was not a useful character. Mericarps of the Westringieae tend to have a more distinctly sculptured surface than other Lamiaceae, and pitting is less common (Husain *et al.* 1990; Marin *et al.* 1994; Oran 1996). Ryding's (1995) assertion that exocarp cells of Westringieae are intermediate between smooth (typical of much of the Lamiaceae) and conic to papillose (as in *Dicrastylis*) agrees with these data. Most mericarps of *Hemigenia* and *Microcorys* have convex exocarp cells, and in many species the cells have papillate, or rarely nearly conical (e.g. *M. exserta*), projections. Typically, mericarp exocarp cells of other Lamiaceae are concave, and pitted in appearance (Husain *et al.* 1990; Marin *et al.* 1994; Oran 1996). The data disagree with Ryding's finding that pericarp structure was rarely taxonomically useful at the generic level, although the variation observed here is most useful at the infrageneric level.

3.5.1 Conclusion

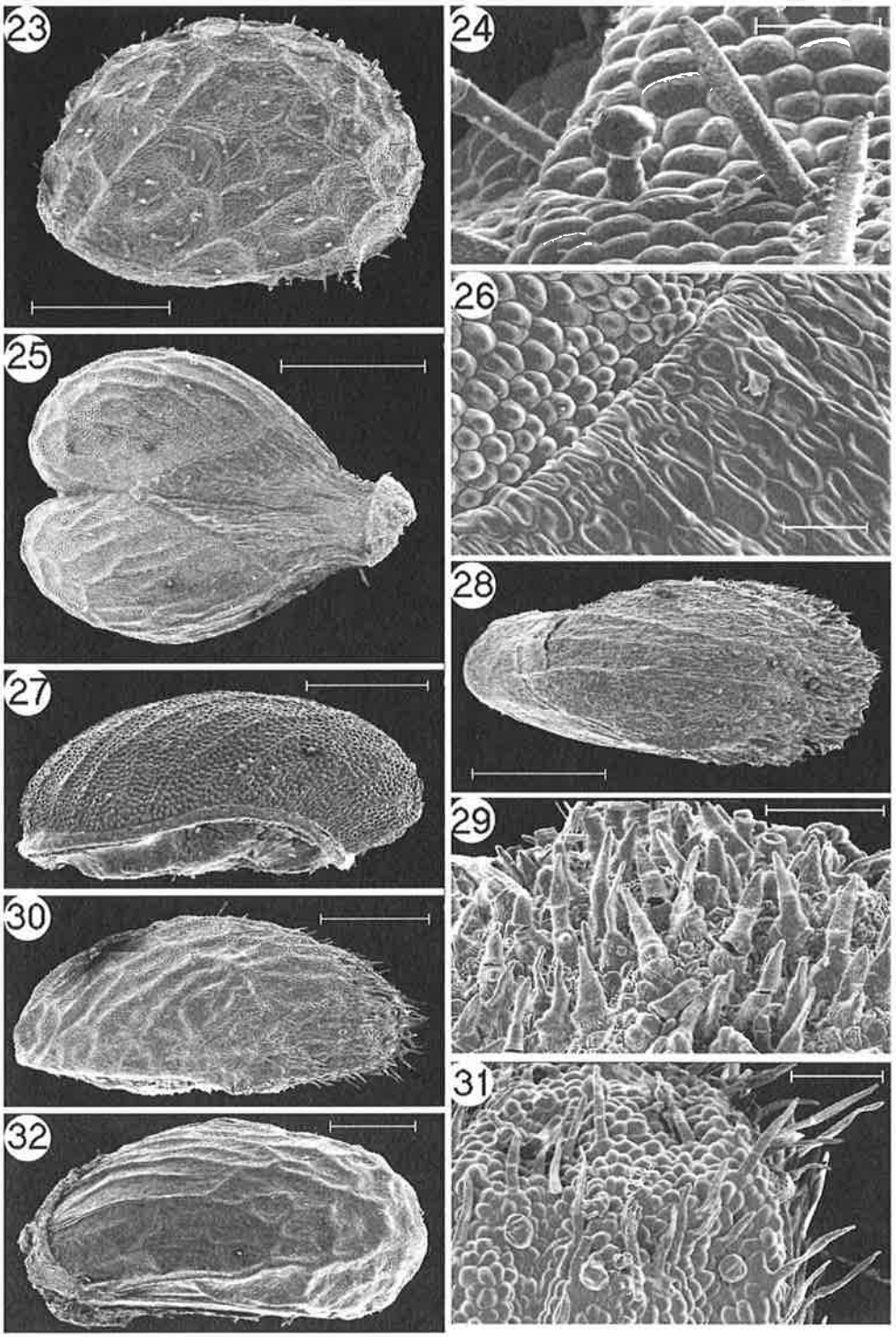
Mericarp micromorphology in Westringieae has produced a moderately resolved phylogeny. However, the data must be combined with a broader range of morphological characters in order to resolve the positions of key taxa, such as *Hemiandra*, *Westringia* and *Prostanthera* (Barthlott 1981; Husain *et al.* 1990). In the Westringieae, it is likely that ovoidal mericarps with isodiametric, convex exocarp cells are plesiomorphic, while elongate mericarps, pitting, and discoid exocarp cellular sculpturing are derived characters states that have evolved more than once.



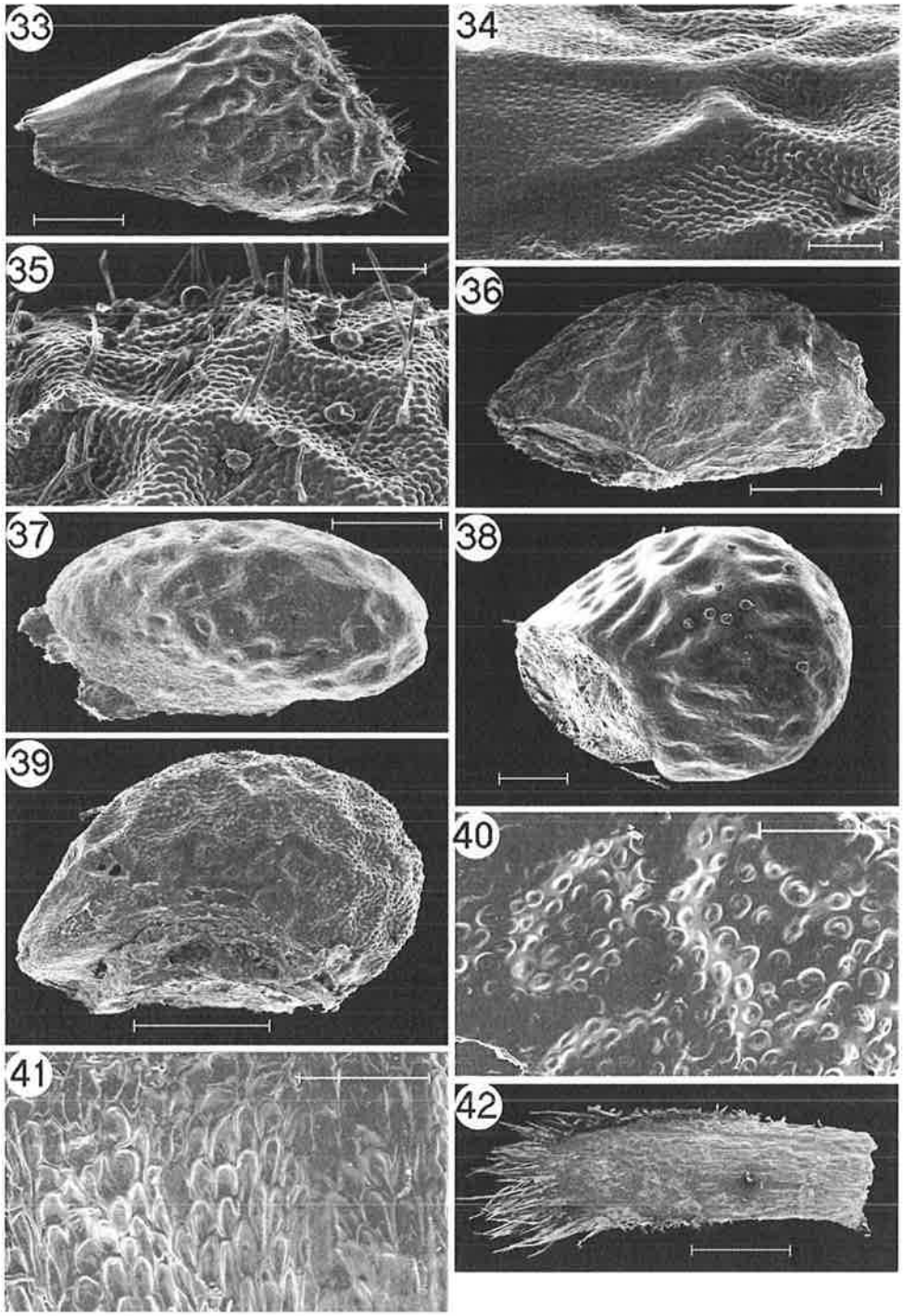
Figs 3.1-3.11: SEMs of mericarps: **Fig. 3.1.** *H. coccinea.* **Fig 3.2.** *H. tysonii*. **Fig. 3.3.** Surface of *H. pedunculata*, showing convex, slightly papillate sculpturing of exocarp cells. **Fig. 3.4.** Surface of *H. appressa* ms, showing papillose sculpturing of exocarp cells. **Fig. 3.5.** *H. sericea* s.l. **Fig. 3.6.** Apex of *H. curvifolia*, showing short trichomes in the lacunae. **Fig. 3.7.** *H. teretiuscula.* **Fig. 3.8.** *M. eremophiloides*. **Fig. 3.9.** Surface of *M. eremophiloides,* showing elongate exocarp cells. **Fig. 3.10.** *M. longifolia.* **Fig. 3.11.** *H. humilis*. Scale bars: **Figs 3.8, 3.10, 3.11** 1 mm, **Figs 3.1, 3.2, 3.5, 3.7** 500 μm, **Figs 3.4, 3.6** 100 μm, **Fig. 3.3** 50 μm, **Fig. 3.9** 20 μm



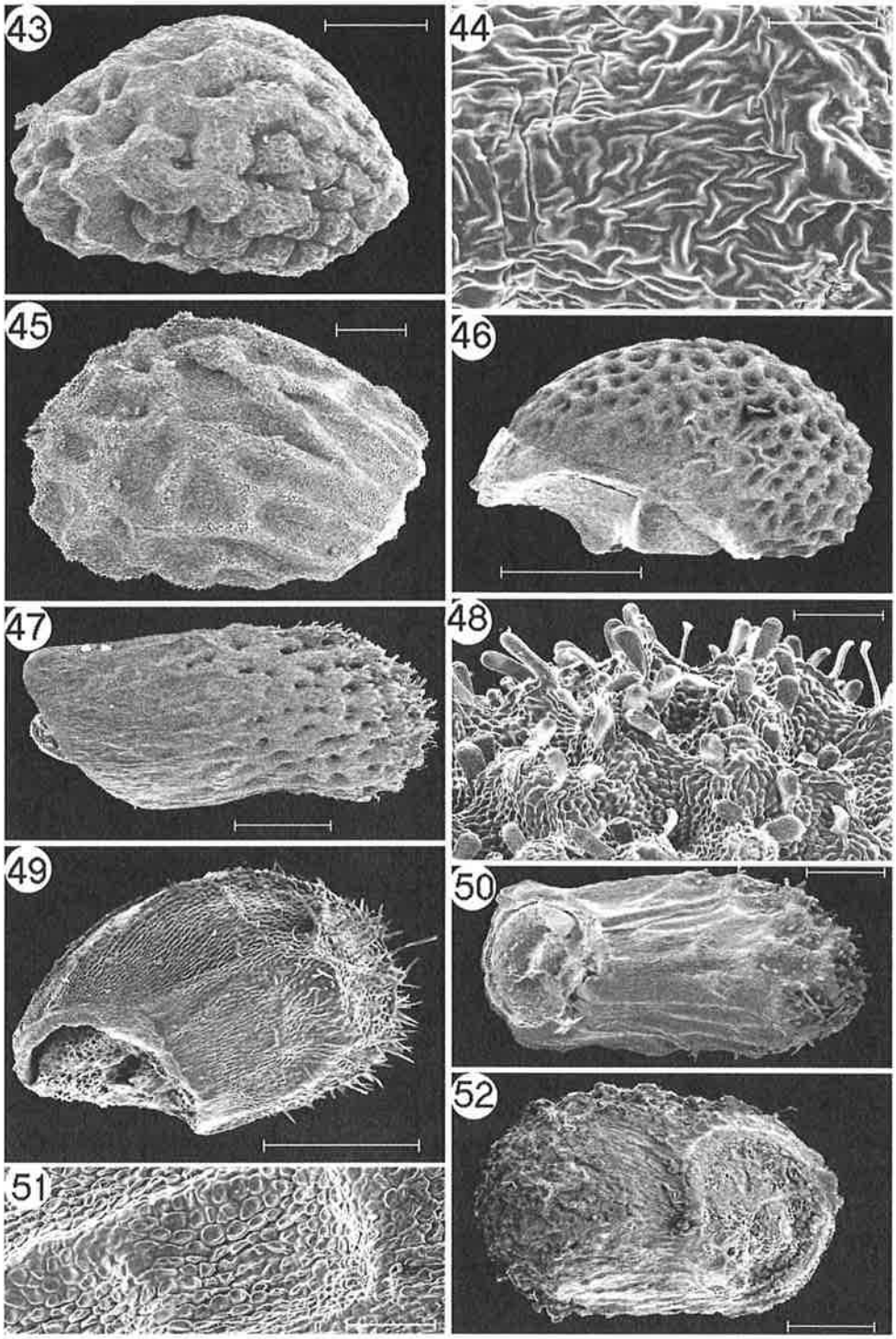
Figs 3.12-3.22: SEMs of mericarps. **Fig. 3.12.** *M. wilsoniana.* **Fig. 3.13.** Surface of *M. wilsoniana*, showing longitudinal ridges and exocarp cellular sculpturing. **Fig. 3.14.** *M. longiflora.* **Fig. 3.15.** *H. microphylla.* **Fig. 3.16.** Lateral surface of *H. microphylla*, showing sub-sessile peltate glandular trichomes. **Fig. 3.17.** *M. exserta.* **Fig. 3.18.** Surface of *M. exserta*, showing structured glandular trichomes and conical, sculptured exocarp cells. **Fig. 3.19.** *H. diplanthera.* **Fig. 3.20.** Close up of *H. diplanthera*, showing convex exocarp cells and tuberculate, rounded trichomes. **Fig. 3.21.** *H. dendritica* ms. **Fig. 3.22.** Surface of *H. dendritica*, showing simple and branched trichomes. Scale bars: **Figs 3.12, 3.14, 3.15, 3.17, 3.19, 3.21** 500 μm, **Fig. 3.13** 100 μm, **Figs 3.16, 3.22** 50 μm, **Figs 3.18, 3.20** 20 μm



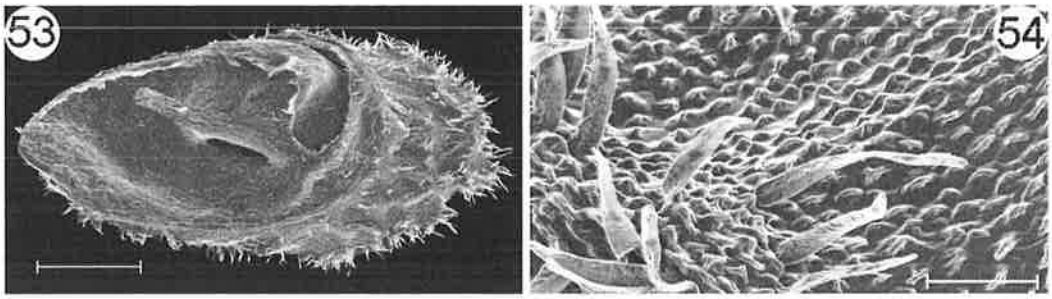
Figs 3.23-3.32: SEMs of mericarps: **Fig. 3.23.** *H. scabra.* **Fig. 3.24.** Surface of *H. scabra*, showing simple trichomes and sub-sessile peltate glandular trichomes. **Fig. 3.25.** Two mericarps of *M. obovata* on the receptacle. **Fig. 3.26.** Surface of *M. obovata*, showing convex exocarp cells and discoid sculpturing of receptacle cells. **Fig. 3.27.** *M. cephelantha.* **Fig. 3.28.** *M. elliptica.* **Fig. 3.29.** Apex of *M. elliptica*, showing sculptured multicellular trichomes. **Fig. 3.30.** *M. macrediana.* **Fig. 3.31.** Surface of *M. macrediana*, showing sub-sessile peltate glandular trichomes and simple, flattened trichomes. **Fig. 3.32.** *W. dampieri.* Scale bars: **Fig. 3.25** 1 mm, **Figs 3.23, 3.27, 3.28, 3.30, 3.32** 500 μm, **Figs 3.29, 3.31** 100 μm, **Figs 3.24, 3.26** 50 μm



Figs 3.33-3.42: SEMs of mericarps: **Fig. 3.33.** *H. macphersonii.* **Fig. 3.34.** Surface of *H. macphersonii*, showing exocarp cell sculpturing ranging from pitted to convex. **Fig. 3.35.** Apex of *H. macphersonii*, showing simple trichomes and sub-sessile peltate glandular trichomes. **Fig. 3.36.** *H. drummondii.* **Fig. 3.37.** *H. incana* s.l. **Fig. 3.38.** *H. pritzellii.* **Fig. 3.39.** *H. westringioides.* **Fig. 3.40.** Surface of *H. westringioides*, showing discoid sculpturing of exocarp cells. **Fig. 3.41.** Discoid exocarp cellular sculpturing of *M. barbata.* **Fig. 3.42.** *M. virgata.* Scale bars: **Figs 3.33, 3.36, 3.37, 3.39, 3.42** 500 μm, **Fig. 3.38** 200 μm, **Figs 3.34, 3.35, 3.40, 3.41** 100 μm



Figs 3.43-3.52: SEMs of mericarps. **Fig. 3.43.** *H. cerebrecarpa* ms. **Fig. 3.44.** Surface of *H. cerebrecarpa*, showing tessellate cellular sculpturing. **Fig. 3.45.** *H. ramosissima*. **Fig. 3.46.** *H. biddulphiana*. **Fig. 3.47.** *H. purpurea*. **Fig. 3.48.** Apex of *H. purpurea*, showing numerous short, flattened, tuberculate trichomes. **Fig. 3.49.** *H. dielsii*. **Fig. 3.50.** *P. behriana*. **Fig. 3.51.** Surface of *P. behriana*, showing sculptured exocarp cells: minutely discoid with raised rims. **Fig. 3.52.** *P. striatiflora*. Scale bars: **Fig. 3.46** 1 mm, **Figs 3.43, 3.45, 3.47, 3.49, 3.50, 3.52** 500 μm, **Figs 3.48, 3.51** 100 μm, **Fig. 3.44** 50 μm



Figs 3.53-3.54: SEMs of mericarps. **Fig. 3.53.** *Hemiandra chimaera* ms. **Fig. 3.54.** Surface of *Hd. chimaera*, showing secondary sculpturing of exocarp cells and tuft of flattened, simple trichomes on ridge. Scale bars: **Fig. 3.53** 500 μm, **Fig. 3.54** 50 μm

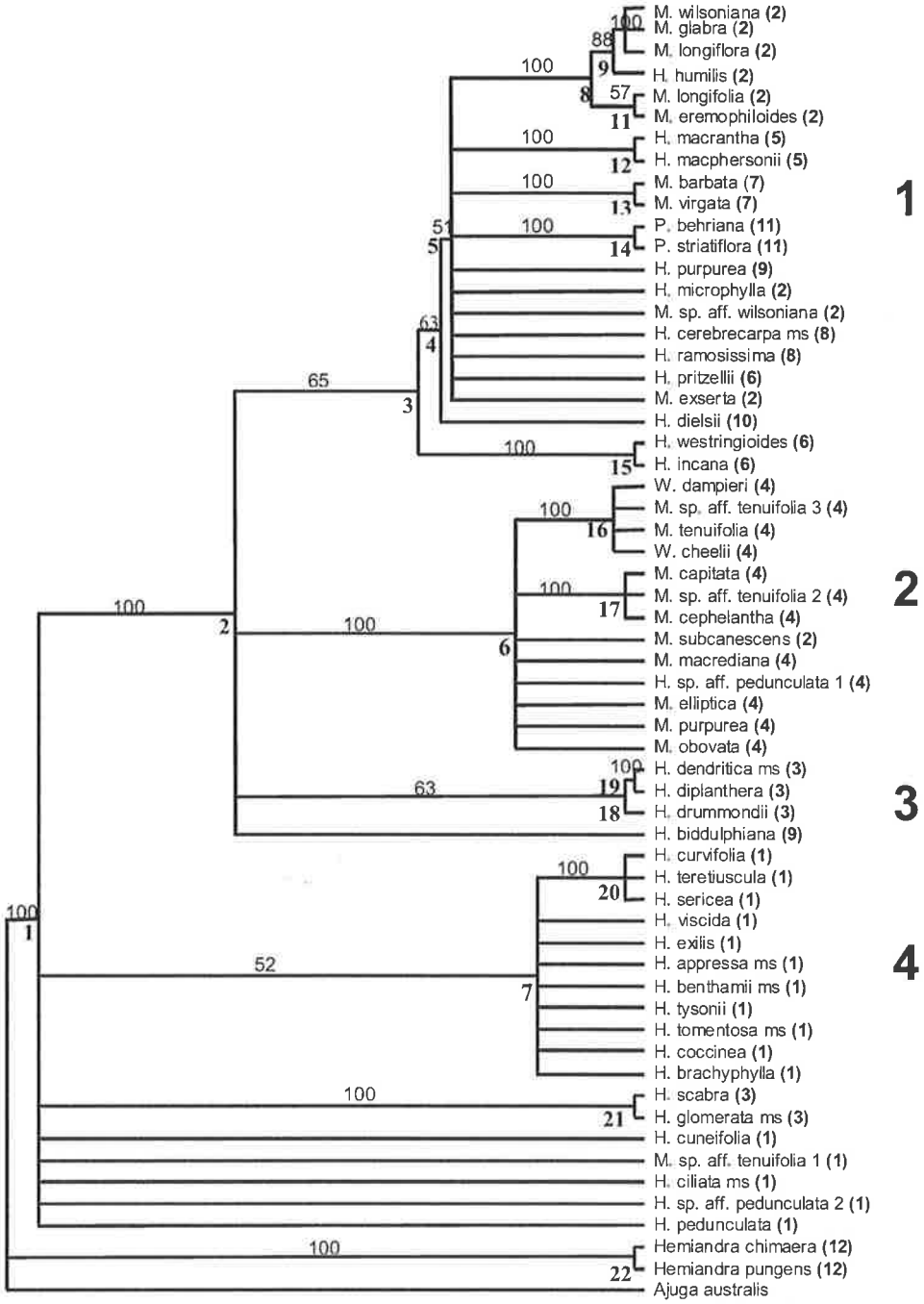


Fig. 3.55. 50% majority rule consensus of 988 MP trees produced in the cladistic analysis of mericarp characters. Nodes are numbered below. Support values over 50% are shown above branches. Branch lengths shown are non-significant. Bracketed numbers refer to mericarp types. Major clades are numbered on the right.

4 Taxonomic revision of *Hemgenia* R.Br. section *Malleantha* G.R.Guerin sect. nov

Abstract

A new section of *Hemigenia*, sect. *Malleantha* G.R.Guerin, is split from the typical section of *Hemigenia*, as the members of the new section were not considered to belong with the type species of the genus (and therefore of the typical section), *H. purpurea*. A taxonomic revision of *H.* sect. *Malleantha* was undertaken. Section *Malleantha* is considered here to contain 26 species, including thirteen new species: *H. appressa* G.R.Guerin, *H. benthamii* G.R.Guerin, *H. botryphylla* G.R.Guerin, *H. bracteosa* G.R.Guerin, *H. buccinata* G.R.Guerin, *H. ciliata* G.R.Guerin, *H. dulca* G.R.Guerin, *H. pachyphylla* G.R.Guerin, *H. royceana* G.R.Guerin, *H. tenelliflora* G.R.Guerin, *H. tomentosa* G.R.Guerin, *H. virescens* G.R.Guerin and *H. wandooana* G.R.Guerin. *Hemigenia parviflora* Bartl. is reinstated from synonymy under *H. sericea* Benth., while *H. eutaxioides* C.R.P.Andrews is synonymised with *H. teretiuscula* F.Muell.

4.1 Introduction

Hemigenia R.Br. (Lamiaceae) was last revised by Bentham (1870). A small number of species have since been described, but the taxonomy has been inadequate. Marchant *et al.* (1987) highlighted the need for revision, citing difficulties in the specific delimitations within sections *Hemigenia* (*H. barbata-H. sericea* group), *Atelandra* (*H. incana* complex) and *Homalochilus*. This chapter set out to deal with the typical section of the genus (ie. section *Hemigenia*).

The original generic and infrageneric classification of both *Hemigenia* and the related genus *Microcorys* R.Br. is under review (see section 5). More data are needed before any formal changes can be made across the group. However, it is clear that the species of section *Hemigenia* with whorled leaves and/or distinctly hooded corollas are not morphologically related to the remainder of the species. Therefore, the latter are here excluded from section *Hemigenia* and placed in a new section (see taxonomy below) which is recognised here to include 26 species. The type species of *Hemigenia* is *H. purpurea* R.Br, which has both

whorled leaves and a strongly hooded corolla, hence the group treated here represents a new section.

This segregated portion of *Hemigenia* section *Hemigenia* is the largest group and contains the greatest undescribed diversity in the genus and problem groups such as the *H. sericea* complex. Further detailed taxonomic work is needed in the remaining sections of *Hemigenia* and *Microcorys* as a number of putative new species have been identified and several complexes remain unresolved.

The descriptions presented here were compiled based on material loaned from the following herbaria: AD, BM, BRI, CANB, GH, K, MEL, NSW, PERTH.

Information on the habit, habitat, colour, and flowering times was taken solely from herbarium specimen labels supplemented where possible with my own additional field notes. For this reason, this information is sometimes incomplete (few collection notes, for example, describe flower colour in detail), and should be taken only as a guide.Due to delays in gaining access to updated specimen data. distribution maps are currently unavailable at the time of publication of this thesis.

4.1.1 Terminology and morphological interpretation

Terminology used follows Radford *et al.* (1974) as much as possible. However, "acute" apices are here defined as forming a terminal angle of less than 90°, whereas "acuminate" refers to acute apices with a concave margin. "Caudate" refers to apices with a long, tail-like appendage. "Viscid" is used here exclusively wth regard to indumenta which are glandular but without visible glands, giving a smooth, shiny appearance.

The leafy inflorecence of *Hemigenia* is treated here as spike-like or racemose, with single or clustered flowers at nodes subtended by a bract which is often indistinguishable from vegetative leaves. Pedicels were measured from the axil of the subtending bract to the base of the calyx, regardless of the attachment point of the bracteoles. Measurements of

bracteoles and calyces were taken from flowering material with the corolla still attached, as the calyx generally enlarges with the development of fruits.

The stamens of *Hemigenia* have the thecae separated by expanded anther connective tissue (Guerin 2005a). In contrast to previous work (e.g. Diels 1905), the nature of the lower (typically reduced or aborted) theca of the abaxial stamens is considered of little taxonomic significance, even at the species level. The presence or absence of this theca varies and can be difficult to interpret accurately. The adaxial stamens consistently have only a single theca as the lower theca is aborted.

The flowers of *Hemigenia* are protandrous. Measurements of the style and stigma were taken from mature material only. This stage is judged by the style becoming exserted and the stigma becoming bifid, while the stamens become withered.

The degree of zygomorphy of the calyx is a useful character in *Hemigenia*. However, it can be difficult to assess, particularly in herbarium specimens. For the new section of *Hemigenia* revised here, all calyces are considered to be more or less actinomorphic. Measurements of calyx lobe lengths apply usually to all lobes, except in species where the median adaxial lobe is significantly enlarged, in which case this was measured separately. The calyx tube was measured from the base to the most basal point of the calyx lobes.

Extreme measurements are reported together with the typical range. Outside ranges of all measurements are given where discontinuous data (disjunct from minimum or maximum of range by $\geq 10\%$) represented $\leq 5\%$ of the available data.

Measurements of "internode on leafy branches" applies to young wood (generally still green) that has foliage.

Indumentum densities described correspond approximately to the following ranges: sparse (0-50/mm^2), moderately dense (50-100/mm^2), dense (100-150/mm^2), and very dense (>150/mm^2). Hair lengths are given as minute (< 0.1 mm), short (0.1-0.2 mm), medium (0.2-0.3 mm), and long (> 0.3 mm).

4.1.2 Typification

The typification process used follows the International Code of Botanical Nomenclature (ICBN) (Greuter *et al.* 2000). Unless stated otherwise, lectotypes were chosen from material held at the host institution of the original author, and specimens were selected that represent the most diagnostic material. The types of two species (*Hemigenia barbata* and *H. sericea*) were unable to be located despite detailed searches, hence those species could not be typified (see notes under each species). There are herbaria yet to be contacted which may potentially house these unlocated types, and so neotypes have not yet been designated. The approach used for neotypification in the case of type material having been destroyed (*H. saligna*) was to select material that matches the protologue and was collected from near the type locality.

4.1.3 New taxa

Descriptions of thirteen new species are presented below. Diagnoses are not included as this thesis is not intended to represent effective publication of the new names under the ICBN. Therefore, these names will remain informal until such time as a this work is effectively and validly published. In the interim, phrase names have been applied to the species for the purpose of reference and so that rare species can be recognised by the Western Australian Department of Conservation and Land Management (CALM). Specimens cited here have been labelled with these names (Table 4.1). Similarly, the description of the new section of *Hemigenia* is not intented to represent formal publication.

Table 4.1 Phrase names applied to new species described here.

Phrase name	Mansucript name
**Hemigenia* sp. "Wilroy" pn (B.J. Conn 2150)	*Hemigenia appressa* ms
H. sp. "Red Hummock" pn (R.D. Royce 10394)	*H. royceana* ms
H. sp. "Bunched Leaves" pn (A.M. Ashby 5396)	*H. botryphylla* ms
H. sp. "Belele Station" pn (A.L. Payne 80)	*H. virescens* ms
H. sp. "Sweet Webb" pn (R.J. Chinnock 8266)	*H. dulca* ms
H. sp. "Sticky Terete" pn (B.H. Smith 449)	*H. ciliata* ms
**H.* sp. "Cue" pn (K.F. Kenneally 47A)	*H. benthamii* ms
**H.* sp. "Dalwallinu" pn (W.E. Blackall 2870)	*H. bracteosa* ms
**H.* sp. "Glenburgh" pn (R.J. Cranfield 9725)	*H. pachyphylla* ms
H. sp. "White Trumpet" pn (M.G. Corrick 9322)	*H. buccinata* ms
**H.* sp. "Edah" pn (J.W. Green 1601)	*H. tomentosa* ms
H. sp. "Jaurdi Station" pn (L.W. Sage & F. Hort 2241)	*H. tenelliflora* ms
H. sp. "Wandoo" pn (V. Crowley DKN 700)	*H. wandooana* ms

* phrase names retained from Paczkowska and Chapman (2000)

4.2 Taxonomy and classification

The following is intended to provide a systematic and taxonomic framework for this revision. Although a new section of *Hemigenia* is described, the classification largely follows the existing system. With more data, it is likely that names and delimitations will change, perhaps at a generic level. The information provided below should therefore not be seen as final.

Family Lamiaceae

Tribe Westringieae Bartl. Ord. Nat. Pl.: 182 (1830).

[*Prostanthereae* Benth. Labiat. Gen. Spec.: 447 (1834); Benth. Fl. Austral. 5: 72 (1870).]

Hemigenia R.Br. Prod.: 502 (1810); Benth. DC. Prod. xii. 565 (1848); Benth. Fl. Austral. 5: 111 (1870); Engl. & Prantl. Nat. Pflanzenfam. 3A: 218 (1897); Stanley and Ross Fl. South-eastern Queensland 2: 382 (1986); Bailey Queensland Fl. iv: 1204 (1901); Marchant *et al.* Fl. Perth Region i: 558 (1987); B.J.Conn Fl. New South Wales 3: 645 (1992); Carolin and Tindale Fl. Sydney Region: 608 (1994).

[*Atelandra* Lindl. Swan Riv. App. 40 (1839); *Colobandra* Bartl. Pl. Preiss. i. 357 (1845)]

Type. Hemigenia purpurea R.Br. Prod.: 502 (1810).

Diagnosis. Differs from *Hemiandra* by the non-pungent leaves, from *Prostanthera* by the monothecate adaxial stamens, and from *Microcorys* and *Westringia* by the fertile abaxial stamens.

Description. Perrenial shrubs or subshrubs. *Stems* rounded to square in cross-section. *Leaves* opposite or whorled, entire, 1-nerved or with several other indistinct veins or venation indistinct, the apex not pungent. *Inflorescences* leafy, spike-like or racemose, with single flowers subtended by single leaf-like or rarely (*H. conferta* B.J. Conn) differentiated bracts, or clusters of 2 to many flowers in the axils subtended by differentiated bracts or sub-terminal head-like inflorescences consisting of several contracted nodes and subtended by differentiated bracts, or on short axillary flowering shoots consisting of several single flowers, the shoot subtended by differentiated bracts. *Bracteole pair* opposite, inserted along the pedicel. *Calyx* more or less actinomorphic with five nearly equal lobes (or with the median adaxial lobe larger or the two abaxial lobes larger) or distinctly zygomoprhic and 2-lipped. *Corolla* bilabiate, the tube elongated or dilating distally, adaxial lip 2-lobed, horizontal to erect, not distinctly hooded, or distinctly (sections *Atelandra* and *Hemigenia* s.s) hooded, emarginate, abaxial lip consisting of two lateral lobes and a median lobe. *Fertile stamens* 4, inserted in the corolla tube, terminating within tube or exserting beyond; *fertile thecae* 1 per stamen (or second reduced theca present on abaxial anther), dorsifixed, dehiscing by longitudinal slit; *adaxial pair* inserted laterally, anther mobile, monothecate; *filaments* straight or curved around the roof of the corolla tube, *connective* elongated, bearded and dilated or tapering and glabrous at lower end; *abaxial pair* inserted laterally further towards the distal end of corolla tube than adaxial pair (except *H. coccinea* C.A.Gardner), anther mobile, monothecate or bithecate; *filaments* straight or curved, *connective* elongated, lower end bearing a reduced or aborted second theca, or tapering. *Ovary* 4-celled, glabrous or with glands or hairs; style filiform, curving adaxially, bifid at maturity, glabrous. *Mericarps* attached basally, cuneate, ovoidal or ovoidal-spherical, the surface pitted or reticulate, rarely smooth, glabrous or with trichomes in the lacunae or at the apex.

Notes. Although the above broad concept of *Hemigenia* retains the status quo with regard to the generic classification, it is not considered here to include *H. cuneifolia*, which has staminodes.

Sections of *Hemgenia*:

Leaves whorled; calyx actinomorphic; corolla distinctly hooded; mericarps ovoidal or elongated, deeply pitted... **sect. Hemigenia s.s.** (This section contains the type species of the genus, *H. purpurea,* which has affinites with *Microcorys* in its whorled leaves and hooded corolla).

Leaves opposite; calyx actinomorphic (lobes may be unequal in length); corolla not distinctly hooded; mericarps ovoidal, reticulate... **sect. Malleantha sect. nov** (See below).

Leaves opposite; calyx lobes equal but the lips divided; corolla not distinctly hooded; mericarps ovoidal-spherical, pitted... **sect. Diplanthera Benth.** (This section contains a small group of similar species forming something of a complex centred around *H. diplanthera* and *H. drummondii*).

Leaves opposite or whorled; calyx distinctly bilabiate with reduced or fused lobes; corolla not distinctly hooded; mericarps variable: elongate, cuneate, or ovoidal-spherical, smooth to pitted or coarsely reticulate... **sect. Homalochilus Benth.** (This section contains half a dozen species and is morphologically distinct from the rest of *Hemigenia* with its usually whorled leaves and strongly zygomorphic calyx).

Leaves opposite; calyx 5-toothed but zygomorphic and the lobes unequal in length; corolla distinctly hooded; mericarps ovoidal-spherical, pitted... **sect. Atelandra Benth.** (This section contains a single, unresolved complex, *Hemigenia incana* s.l. Its status as a section is under review. It appears to have close affinities with *Microcorys*, particularly in the strongly hooded corolla).

Hemigenia section ***Malleantha*** G.R.Guerin, *sect. nov.*

Type (here designated): *Hemigenia teretiuscula* F.Muell.

Diagnosis. Differs from *Hemigenia* section *Hemigenia* s.s. by the presence of opposite, not whorled, leaves and the adaxial corolla lip, which is concave, not strongly hooded.

Shrubs. Leaves opposite. Inflorescence leafy, spike-like or racemose. Flowers axillary, single or clustered. Bracteoles 2 beneath the calyx. Calyx 5-toothed and more or less actinomorphic. Corolla tube narrow or dilated; adaxial lip concave, without an obvious hood; emarginate; abaxial lip spreading, 3-lobed, the middle lobe larger and emarginate. Stamens 4, adaxial anthers monothecate with expanded connective tissue which is bearded at the distal end or tapering and glabrous, abaxial anthers bithecate with expanded connective tissue, the lower end bearing a reduced or aborted theca, then appearing monothecate. Mericarps ovoidal, reticulate.

Key to the species of *Hemigenia* sect. *Malleantha*:

1.
Indumentum includes branched hairs ..... **2.**
Indumentum lacks branched hairs ..... **3.**

2.
Leaves (at least young leaves) densely covered with sprawling many-branched dendritic hairs; indumentum may be non-glandular to moderately glandular (glands mostly on calyx), but never with simple or sparsely branched hairs; bracteoles (2.0-) 2.3-3.0 (-5.6) mm long ..... **1. *H. tysonii***
Leaves mostly sparsely hairy, indumentum usually distinctly glandular, includes simple or sparsely branched hairs; bracteoles (1.5-) 3.7-8.1 mm long..... **2. *H. virescens***

3.
Leaves with dense stalked glands, usually also with sparser simple hairs ..... **4.**
Leaves viscid or with sessile glands, or predominately non-glandular, rarely with some stalked glands ..... **6.**

4.
Bracteoles ± linear, 1-2 mm long ..... **3. *H. dulca***
Bracteoles ovate to obovate, 2-6 mm long ..... **5.**

5.
Corolla 14-32 mm long, leaves and calyx with stalked glands, rarely with sparse simple hairs..... **4. *H. benthamii***
Corolla 10-14 mm long, leaves and calyx with stalked glands and dense mixed-length simple hairs..... **5. *H. bracteosa***

6.
Mature leaves folded or terete ..... **7.**
Mature leaves unfolded, more or less flat ..... **18.**

7.
Calyx lobes subulate, mostly longer than tube; indumentum of calyx sparse to moderately dense appressed antrorse hairs ..... **8.**
Calyx lobes deltate to narrowly triangular or long-acuminate from a broader base, mostly shorter or equal to the tube; indumentum of calyx lacking simple hairs, or hairs patent or retrorse (then ± appressed) ..... **9.**

8.
Bracteoles inserted in the distal half of pedicel (mostly near base of calyx); leaves mostly conjoined, ± terete, corolla mauve, broad ..... **6. *H. appressa***
Bracteoles mostly inserted in the proximal half of pedicel, leaves folded but not conjoined; corolla red, elongated .....**7. *H. coccinea***

9.
Leaves distinctly viscid or with glandular hairs ,..... **10.**
Leaves not glandular ..... **14.**

10.
Calyx viscid, lacking visible glands ..... **11.**
Calyx not viscid, with visible glands ..... **12.**

11.
Calyx lobes equal to tube, ciliate but otherwise glabrous ..... **8. *H. ciliata***
Calyx lobes shorter than tube, calyx shortly pubescent all over or lacking hairs .....
..... **9. *H. buccinata***

12.
Bracteoles widely ovate to widely elliptic, base obtuse, apex abruptly acuminate/apiculate, longer than the calyx tube ..... **10. *H. royceana***
Bracteoles shortly linear, much shorter than calyx ..... **13.**

13.
Calyx median adaxial lobe obviously enlarged; corolla ca. 12-30 mm long .....
.....**11. *H. divaricata***
Calyx more or less actinomorphic, median adaxial lobe only slightly enlarged; corolla ca. 6-17 mm long ..... **12. *H. brachyphylla***

14.
Calyx with glands..... **11. *H. divaricata*** (also keyed above)
Calyx non-glandular ..... **15.**

15.
Leaves tomentose ..... **13. *H. tomentosa***
Leaves glabrous or with sparse hairs or becoming so ..... **16.**

16.
Calyces with dense, loose spreading hairs, appearing fluffy; lobes equal to or longer than tube
..... **14. *H. dielsii***
Calyces glabrous or with sparse to moderately dense patent to retrorse hairs, not appearing fluffy; lobes shorter than tube ..... **17.**

17.
Calyx lobes deltate to triangular; tube longitudinally ridged ..... **15. *H. botryphylla***
Calyx lobes abruptly acuminate from a shallowly triangular base; tube smooth, or rarely the basal half longitudinaly ridged, the distal half warty ..... **16. *H. teretiuscula***

18.
Leaf surface distinctly minutely scabrous, also hispid with thick, blunt hairs; flowers single or in contracted, subterminal, head-like spikes ..... **17. *H. scabra***
Leaf surface not scabrous, not hispid; flowers single or clustered (rarely forming a short axillary shoot) in the axils, not forming a contracted, subterminal, head-like spike ..... **19.**

19.
Flowers single in the axils of leaf-like bracts (only 1 flower per bract, 2 flowers per node) .....
..... **20.**
Flowers clustered in the axils of differentiated bracts (at least 2 flowers per bract, 4 per node)
..... **24.**

20.

Corolla tube very narrow and elongated, far-exceeding the calyx..... **21.**
Corolla tube broad and/or or not far-exserted from the calyx ..... **22.**

21.
Leaves linear-elliptic, 10-42 mm long; apices acute ..... **18. *H. exilis***
Leaves obovate, 5-11mm long; apices obtuse/rounded ..... **19. *H. tenelliflora***

22.
Calyx lobes shorter than tube ..... **23.**
Calyx lobes longer than tube ..... **20. *H. parviflora***

23.
Leaves 18-55 mm long ..... **21. *H. pachyphylla***
Leaves 1-13 mm long ..... **15. *H. botryphylla*** (also keyed above)

24.
Leaves truncate to broadly rounded, orbicular to widely obovate, flat or folded; folded leaves strongly recurved (often at least the apex folded) ..... **22. *H. curvifolia***
Leaves acute, rounded or obtuse, lanceolate to oblanceolate or ovate to obovate, flat, straight ..... **25.**

25.
Leaves ovate, elliptic or obovate; indumentum loosely woolly or appressed ..... **26.**
Leaves lanceolate, narrowly elliptic or oblanceolate; indumentum not loosely woolly, more or less appressed ..... **27.**

26.
Leaves elliptic or obovate, sparsely to moderately sericeous, ± longer hairs on the leaf bases, not distinctly woolly; apices rounded to obtuse (rarely sub-acute); base long-attenuate or tapering; interior of calyx lobes sparsely to moderately antrorse hairy..... ..... **23. *H. wandooana***
Leaves elliptic or ovate, woolly or the base tufted with long woolly hairs; apices mostly acute; base abruptly attenuate; interior of calyx lobes glabrous (rarely very sparse antrorse hairs)..... ..... **24. *H. barbata***

27.
Leaves lanceolate to narrowly elliptic (single northern collection with obovate leaves); indumentum pannose, dark silver (especially young leaves), hairs closely appressed ..... **25. *H. saligna***
Leaves narrowly elliptic to oblanceolate; indumentum sericeous, silky in appearance, hairs not closely appressed ..... **26. *H. sericea***

1. Hemigenia tysonii F. Muell. Vic. Nat. 10: 109 (1893); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 94 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 443 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000).

Lectotype (here chosen): Isaac Tyson s.n., s.dat., Upper Murchison, Western Australia (*lecto*: MEL 98622! - left specimen; *isolecto*: MEL 98622! - right specimen, K!).

Dense, intricately, divaricately branched, spinescent, sprawling, rarely more upright, low shrubs, (0.3-) 0.4-0.5 (-0.8) m high, 0.35-1.2 m wide; *branches* semi-decumbent, circular in cross-section, densely to sparsely hairy, hairs dendritic, many-branched, occasionally with both sessile and stalked glands; *internodes* on leafy branches 1.0-11.6 mm long.

Leaves grey-green, occasionally appearing clustered due to dense axillary growths, sessile, usually erect, straight to recurved, densely covered by sprawling many-branched dendritic hairs and occasionally with both sessile and stalked glands, the adaxial interior surface occasionally densely pubescent with thick hairs; *lamina* mostly conduplicate (often open when subtending axillary growth), obovate to oblanceolate to oblong (1.5-) 2.0-5.5 (-12.9) mm long, 0.5-1.0 (-1.5) mm wide, the length to width ratio (1.2-) 2.5-10.0 (21.5), the widest point (0.22-) 0.5-0.96 of the entire length; *base* cuneate; *apex* rounded in open leaves, usually recurved in conduplicate/folded leaves and then with a hardened tip around the mid-rib, acute; *venation*: indistinct. Mid-rib sometimes visible.

Inflorescence of 1-2 (-4) flowering nodes with single flowers subtended by opposite leaf-like bracts, flowers sessile or on *pedicels* to 0.3 mm long; *bracteole pairs* inserted from the mid-point of the pedicel to the base of the calyx, erect (appressed against calyx), much shorter to

shorter than calyx tube or rarely slightly longer than calyx tube, widely ovate to lanceloate, rarely near-orbicular or widely obovate, (2.0-) 2.3-3.0 (-5.6) mm long, 0.6-2.3 (-3.0) mm wide, the length to width ratio (1.1-) 1.5-2.7 (-6.7), with dense, rarely only moderately dense, dendritic hairs, flat or rarely loosely folded, acuninate or shortly apiculate from an obtuse to truncate base, the base cuneate, the apex acute.

Calyx actinomorphic with five equal lobes or with the two abaxial lobes larger and separated slightly from the adaxial lobes, densely covered with dendritic hairs, ± becoming glabrous, the tube sometimes with sessile or stalked glands or dense glands and very sparse, slightly branched hairs; *tube* deeply and distinctly longitudinally ridged, obtriangular, 4.0-4.8 (-5.5) mm long, (2.3-) 2.4-2.8 (-3.5) mm wide, the length to width ratio 1.4-1.8 (-2.4), base sub-rounded, the interior with sparse antrorse, semi-appressed hairs 0.1-0.2 mm long; *lobes* straight, triangular, narrowly triangular or rarely caudate, shorter than tube, 0.2-0.4 times the entire calyx lobe length, (1.0-) 1.2-2.8 (-4.0) mm long, 1.0-1.5 mm wide at base, the length to width ratio (0.7-) 1.2-1.5 (-2.7), the margins straight, the apex acute or acuminate, the interior densely dendritic-hairy, rarely the hairs more or less simple with only short terminal branches.

Corolla 8.0-11.0 (-17.0) mm long, light pink to purple with red spots around white throat, ± pale yellow lines along lower sides of throat, rarely white with a few purple spots on base of lower lip; *exterior surface* covered with randomly orientated hairs, the hairs c. 0.13-0.27 mm long, ± sparse stalked glands; *interior surface* mostly glabrous but with a dense tufted beard of loose patent hairs c. 0.4 mm long on the lower throat between the stamens; *tube* very narrow, broadening only just before lips, 5.4-7.0 mm long, roughly equal to, or rarely slighty exserted beyond, the calyx lobes, 1.5-2.5 (-3.0) mm wide at mouth; *abaxial median lobe* abruptly spathulate, the stalk attenuate, the blade widely obtrullate, (2.5-) 4.0-6.5 mm long, (3.1-) 4.2-8.0 mm wide, the length to width ratio (0.78-) 0.81-0.95, the margin entire, the apex

rounded, the sinus 0.9-1.8 (-2.0) mm long; *lateral lobes* oblong, obovate, or rarely ovate, (1.8-) 3.3-5.3 (-6.4) mm long, 1.5-2.0 (-2.8) mm wide, the length to width ratio (1.2-) 2.1-2.7 (-3.0), the margin entire, the apex broadly rounded, the sinus absent; *adaxial median lobe-pair* oblong, 2.3-5.5 mm long, 1.8-3.5 mm wide the length to width ratio 1.3-1.6, emarginate with sinus 1.4-1.6 mm deep, the margin entire, the apex rounded, the interior surface often with a tuft of long white hairs confined to the mid-region.

Stamens: *adaxial pair* with *filaments* inserted 3.0-4.5 (-5.5) mm from base of corolla, 2.0-2.5 mm long, glabrous, *theca* 0.7-0.9 mm long, the *connective* (1.0-) 1.1-1.5 mm long, teminating at sterile end in a densely bearded appendage of triangular trichomes 0.05-0.1 (-0.15) mm long; *abaxial pair* with *filaments* inserted (3.5-) 5.0-6.3 mm from base of corolla, 2.0-2.5 (-3.5) mm long, glabrous, *fertile theca* 0.7-0.9 (-1.0) mm long, the *connective* 1.25-2.0 mm long, bearing a second, much smaller, imperfect theca or appearing to taper, rarely sterile and bearded as for adaxial stamens.

Ovary c. 1.3 mm long, c. 0.8 mm wide, the length to width ratio 1.60, glabrous; s*tyle* 5.0-9.0 mm long, the stigma lobes 0.4-1.3 mm long. *Mericarps* tan or brown, ovoidal, reticulate or with longitudinal ridging basally, 1.8-2.6 mm long, 1.1-1.6 mm wide, the length to width ratio 1.60-1.70, attachment scar 1.6-2.0 mm long, 0.70-0.81 times the entire mericarp length, glabrous.

Flowers recorded: May to October.

Ecology:Occurs on flat red sand or rocky hillslopes, associating with *Acacia* woodland. Locally abundant.

Notes: Palatable to cattle. The leaves are aromatic. Similar to *H. botryphylla* and *H. tomentosa*. It is easily dinstinguished by its dendritic indumentum and larger bracteoles. It is also similar to *H. benthamii*, especially when its indumentum is more glandular, but the flowers are smaller with a narrower corolla tube, and the indumentum is dendritic. It is morphologically close to *H. virescens*, which differs most notably in having simple hairs as well as only sparsely branched hairs, usually longer leaves, and longer bracteoles. Also, the adaxial anthers of *H. virescens* are barely bearded, with reduced trichomes, and the interior indumentum of the calyx of *H. virescens* lacks the typical dense, branched hairs of *H. tysonii*.

Typification: The type locality was cited as 'On hills near Mount Narryer' in the protologue. The specimen is labelled as 'Upper Murchison' with a note 'Grown about the hills'.

Specimens examined: Western Australia: J.Z. Weber 5062, 12.x.1975, Ca. 500 m east of Homestead of Curbur Station, (AD97549142, MEL 676381, CANB 8905857, CANB 373082); *S.J.J. Davies* 4851, ?-.vi.1968, 1 mile nth, woolshed on Mileura, Cue (CANB 00525828); *R.J. Chinnock* 7142, 13.ix.1986, 27.6km NW of Glen (AD89706170); *R.J. Cranfield* 9645, 5.v.1995, 11km SSW of Byro Hstd (PERTH 04350588); *A.A. Mitchel* 870, 28.vii.1981, Coodardy Station, Cue (PERTH 01073990); *A.L. Payne* 49, ?-.viii.1985, Mt Hale (PERTH 01073966); *A.M. Ashby* 4761, 1.vii.1973, 41 miles south of Woolshed Junction (MEL 689065); *A.L. Payne* 217, 1989, ?N.E. Goldfield Survey (PERTH 01593536); *A.S. George* 17483, 13.x.1998, c. 2 km NNW of Mt Narryer (peak) (PERTH 06071740); *A.S. George* 17276, 26.viii.1996, Mt Narryer, NW of main peak (PERTH 06059406); *J. Stretch* s.n., 19.ix.1988, Curbar Station, Murchison (PERTH 01073974); *B. Thomson & J. Mattner* B 6, 30.x.1992, Byro Station RMS 1 (PERTH 02930994).

2. Hemigenia virescens G.R.Guerin sp. nov.

H. sp. "Cue" pn (K.F. Kenneally 47A): Paczkowska and Chapman (2000) 273 auct. non as to Payne 80).

Typus: A.L. Payne 80, ?-.viii.1985, Belelle[sic.] Station, Western Australia (holo: PERTH 03672042! - lower left specimen; iso: PERTH 03672042! - upper right specimen).

Etymology: the epithet refers to the leaves, which become green with age.

Small shrubs 0.4-0.6 m high; *branches* erect, nearly circular in cross-section, with dense stalked glands, otherwise glabrous or sparsely to moderately hispid-hispidulous with hairs 0.2-0.4 mm long; *internodes* on leafy branches 2.5-10.8 mm long.

Leaves sessile, erect, often adpressed, sparsely hispid, with moderately dense to dense stalked glands and sparse, rarely moderately dense, patent, simple to few-branched hairs 0.2-0.7 mm long, juvenile foliage with denser, more branched hairs; *lamina* conduplicate or some open, lanceolate to oblanceolate, mostly narrowly oblong, 3.5-14.0 mm long, 0.7-3.1 mm wide, the length to width ratio (2.1-) 3.43-10.8, the widest point 0.16-0.9 of the entire length, the base straight or cuneate, the apex usually recurved, acute, rarely rounded, *venation*: indistinct.

Inflorescence of 1-3 (-7) flowering nodes subtended by leaf-like bracts; *pedicels* 1.0-1.7 mm long, with dense stalked glands; *bracteole-pairs* inserted at the base to mid-point of the pedicel at a point 0.00-0.60 times the length, erect, longer than calyx tube, lanceolate or rarely oblanceolate, 3.7-8.1 mm long, 0.9-2.0 mm wide, the length to width ratio 3.25-5.10, with or without sparse to dense stalked glands, denser near the margins, and sparse to moderately

dense simple to sparsely branched hairs 0.2-0.7 mm long, the base abruptly cuneate, the apex long-acuminate or acute.

Calyx with moderately dense to dense stalked glands concentrated on the ridges, with dense stalked glands concentrated on the ribs of the tube and long, ± sparsely branched hairs 0.3-0.7 mm long, the lobes mainly hairy on the margins, rarely with moderately dense branched hairs; *tube* deeply and prominently ribbed/corrugated, obtriangular to oblong, 3.0-5.0 mm long, 2.0-4.0 mm wide, the length to width ratio 1.08-2.40, the base rounded, the interior with sparse antrorse, semi-appressed to spreading hairs 0.1-0.2 mm long; *lobes* straight, triangular ± concave margins, shorter than tube, 0.33-0.49 times the entire calyx length, 1.6-4.1 mm long, 0.7-2.0 mm wide, the length to width ratio 1.73-2.93, the margins straight, the apex acute or long-acuminate, usually recurved, the interior with indumetum equal to or denser than tube but also with moderately dense stalked or sub-sessile glands.

Corolla 8.5-18.1 mm long, purple to pale lilac; *exterior surface* with moderately dense stalked glands, usually with sparse, simple to slightly branched hairs 0.2-0.9 mm long on the exterior of lobes; *interior surface* with a dense beard throughout with hairs 0.5 mm long, or with only a sparse tuft 0.2 mm long between the stamens; *tube* narrowly oblong, 4.9-8.5 mm long, exceeding the calyx, 1.3-3.5 mm wide at mouth; *median abaxial lobe* abruptly spathulate, the stalk square, the blade oblate, 2.3-8.2 mm long, 1.8-6.0 mm wide, the length to width ratio 0.77-1.50, the margin undulate, the apex rounded, the sinus 0.2-2.1 mm; *lateral lobes* ovate or oblong, 2.0-3.1 mm long, 1.0-1.7 mm wide, the length to width ratio 1.20-2.60, the margin unevenly crenate, the apex rounded, the sinus absent; *adaxial median lobe-pair* oblong-elliptic, 2.5-4.0 mm long, 1.5-2.9 mm wide, the length to width ratio 1.14-1.87, emarginate with sinus 0.9-1.0 mm long, the margin nearly entire, the apex rounded or the lobes acute.

Stamens: *adaxial pair* with *filaments* inserted c. 5.2 mm from base of corolla, glabrous, 1.8-2.0 mm long, the *connective* 1.2-1.5 mm long, glabrous, *theca* 0.8-0.9 mm long, glabrous, the sterile end tapering and with minute sparse hairs reduced to blunt projections < 0.1 mm long; *abaxial pair* with *filaments* inserted 5.5-6.0 mm from base of tube, 1.5-2.4 mm long, glabrous, the *connective* 1.3-1.5 mm long, glabrous, *fertile theca* 0.9-1.0 mm long, the lower end sterile, tapering.

Ovary 1.0-1.3 mm long, 1.0-1.1 mm wide, the length to width ratio 1.00-1.18, the style 7.2-8.9 mm long, the stigma lobes to c. 0.3 mm long, glabrous. *Mericarps* olive-brown, ovoidal-elongate, longitudinally ridged, or reticulate but the lacunae slightly elongate and arranged longitudinally, 2.6-3.5 mm long, 1.1-1.5 mm wide, the length to width ratio 2.00-2.80, the attachment scar 1.8-2.5 mm long, 0.60-0.71 time entire mericarp length, glabrous.

Flowers recorded: July, August.

Ecology: Recorded only in the Belele Station area on sand banks.

Notes: Similar to *H. tysonii* but can be distinguished by the much more glandular indumentum, the presence of less branched hairs and simple hairs, typically longer bracteoles, and more elongate mericarps. Also similar to *H. benthamii* but distinguished by the presence of branched hairs and the usually shorter corolla with a much narrower tube.

Other specimens examined: *N.H. Speck* 947, 13.vii.1958, 33 miles north of Belele (CANB 231528); *A.R. Fairall* 2173, 1.viii.1966, 25.8 m. Meekathara to Belele (CANB 00525256);

N.H. Speck 928, 13.vii.1958, 11.15 miles north of Belele. Wanderrie bank (CANB 231533); *A.L. Payne* 3/2, 6.iv.1987, NW of West tank, Annean Station (CANB 00524400, PERTH).

3. Hemigenia dulca G.R.Guerin sp. nov.

H. sp. Dalwallinu (W.E. Blackall 2870) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. (2000), partly, excluding *H. bracteosa.*

Etymology: the epithet refers to the sweet-scented glandular foliage.

Typus: *R.J. Chinnock* 8266, 5.x.1990, 3.9 km E of N Warrachuppin road on Webb road, Western Australia (holo: AD99131034! - upper left specimen; iso: AD99131034! [excluding holo], PERTH 05405726!).

Small upright to spreading, spindly to compact, highly branched shrub, becoming open with age, 0.45-0.6 m high, 0.5-1.2 m wide; *branches* erect, nearly circular in cross-section, moderately to densely pubescent-hirsute with moderately dense to dense mixed short and long, thin patent hairs 0.1-0.2 or 0.7-1.0 mm long and dense stalked to sessile glands; *internodes* on leafy branches 2.1-15.5 mm long.

Leaves sessile, erect, straight, with dense stalked to sessile glands and usually sparse mixed-length, thin, patent hairs 0.05-0.6 mm long; *lamina* open or rarely loosely folded, obovate to oblanceolate, rarely oblong-elliptical, very rarely ovate, (2.5-) 3.4-8.3 (-10.2) mm long, 0.8-2.1 (-2.7) mm wide, the length to width ratio 2.00-6.00, the widest point (0.24-) 0.6-0.9 of the entire length; *base* rounded to cuneate; *apex* rounded; *venation*: the mid-rib is often distinct.

Inflorescence of 1-3 (-7) flowering nodes with single flowers subtended by opposite leaf-like bracts; *pedicels* 1.3-2.1 mm long, with sparse short hairs c. 0.1 mm long and glands or nearly glabrous; *bracteole pairs* inserted at a point (0-) 0.36-0.5 times the length of the pedicel, erect, much shorter than the calyx, linear-narrowly oblong to narrowly elliptic, rarely oblanceolate, 1.0-2.2 mm long, (0.1-) 0.2-0.35 mm wide, the length to width ratio 3.3-7.3 (-20.0), with moderately dense stalked glands and short-long hairs. 0.1-0.5 mm long, the margins strongly incurved, the base cuneate, the apex acute.

Calyx light green, very slightly two-lipped, a small division between the upper lip (three lobes) and the lower lip (two lobes) but the lobes approximately equal in length, pubescent-hirsute with sparse to moderately dense short to long hairs 0.1-0.6 mm and dense stalked to sessile glands, the lobes with more glandular hairs; *tube* indistinctly longitudinally ribbed or smooth, rounded or shallowly obdeltate to obtriangular with convex margins, 2.0-3.9 mm long, (1.1-) 2.0-2.8 (-3.2) mm wide, the length to width ratio 0.8-1.4, the interior with very sparse, long, hairs 0.3-0.9 mm long ± sessile glands; *lobes* straight to spreading, deltate to triangular, shorter than the tube, 0.34-0.47 times the entire calyx length, (1.1-) 1.6-1.9 (-2.5) mm long, 1.0-1.2 (-1.4) mm wide at base, the length to width ratio 1.1-2.5, the margins straight, the apex acute to acuminate, the interior with moderately dense (denser than tube) hairs 0.3-0.9 mm long, ± stalked or sessile glands.

Corolla 8.3-12.8 (-15.5) mm long, dark purple to light mauve, throat white spotted mauve or light brown onto base of median abaxial lobe, sides of throat spotted dark pink, lobes pinkish purple, tube white basally, bluish purple or light mauve distally; *exterior surface* near glabrous, with scattered hairs, or sparsely to moderately hairy with medium loose hairs 0.1-0.4 mm long, ± sparse sessile glands, ± denser tufts of long hair 0.2-0.6 mm long on the lateral lobes and median adaxial lobe; *interior surface* moderately bearded at distal end of

tube with hairs c. 0.4 mm long, the interior of lobes with sparse curved hairs c. 0.1-0.2 mm long; *tube* cuneate or indistinctly funnel-shaped, 5.0-9.9 mm long, exserted beyond calyx lobes, 3.0-4.2 mm wide at mouth; *abaxial median lobe* depressed obovate to depressed flabellate, 2.9-6.2 mm long, 4.4-8.7 mm wide, the length to width ratio 0.60-0.70, the margin coarsely and unevenly crenate, the apex truncate, the sinus rounded basally, 1.3-3.0 mm long; *lateral lobes* widely to widely depressed obovate, rarely widely oblong, 2.0-5.7 mm long, (2.8-) 3.0-5.9 mm wide, the length to width ratio 0.7-1.1, the margin unevenly dentate to entire, the apex obtuse, the sinus broad, 0.9-1.4 mm long; *median adaxial lobe* depressed to widely depressed obovate, 2.8-4.5 mm long, 4.4-8.1 mm wide, the length to width ratio 0.6-0.8, emarginate with sinus 1.4-3.2 mm long, the margin entire, the apex obtuse.

Stamens: *adaxial pair* with *filaments* inserted 2.5-5.7 mm from base of corolla tube, white, 2.0-3.8 mm long, glabrous, *theca* black, (0.5-) 0.7-0.8 mm long, *the connective* white, 2.0-2.1 mm long, the sterile end densely bearded with triangular trichomes 0.2-0.3 mm long; *abaxial pair* with *filaments* inserted 3.0-5.9 mm from base of corolla tube, white, 2.8-5.0 mm long, glabrous, *fertile theca* black, (0.5-) 0.8-1.0 mm long, glabrous, *the connective* white, 2.1-2.7 mm long, bearing a second smaller theca, glabrous.

Ovary 1.1-1.4 mm long, c. 0.8 mm wide, the length to width ratio 1.40-1.80, glabrous, the style white, (3.8-) 5.0-9.0 mm long, the stigma lobes 0.2-0.5 mm long. *Mericarps* not seen.

Flowers recorded: April, October.

Ecology: Occurs in sandy orange to brown soil in *Acacia/Melaleuca* shrubland.

Notes: Known from only three collections from the same roadside locality.

See notes regarding the affinity of this species under *H. bracteosa.*

Other specimens examined: Western Australia: *Frans H. Mollemans* 2483, 24.iv.1990, 2.5 km approx. S (5° E of S) of Chutawalakin Hill, which is 38 km WNW of Bullfinch (AD99020074, PERTH 03670740); *Greg Guerin* 147 & *Penny McLachlan*, 29.x.2003, Shire of Westonia on Webb Rd 3.7 km west of junction with Boodarockin North Rd on N roadside (AD [not databased], PERTH only).

4. Hemigenia benthamii G.R.Guerin sp. nov.

H. sp. Cue (K.F. Kenneally 47A) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. 273 (2000).

Typus: *M. Officer MO* 136, 12.ix.1996, 27 km NW of Woolgorong Homestead, Bilga Paddock, Western Australia (holo: PERTH 04700007! - lower left specimen; iso PERTH 04700007! - upper right specimen).

Etymology: the epithet recognises the work of George Bentham who described many of the early species of *Hemigenia* and published the first revision of the genus in 1870.

Dense, tangled, erect to spreading shrubs c. 0.45-1.0 m high, c. 0.6-1.2 m wide; *branches* erect, circular in cross-section, with dense stalked glands, rarely also sparsely puberulent with sparse short, patent hairs 0.1 mm long; *internodes* on leafy branches 3.0-12.4 mm long.

Leaves green, sessile, erect to adpressed, straight, with moderately dense stalked glands, very rarely with very sparse hairs 0.1-0.4 mm; *lamina* open or loosely folded, then often with the

apex recurved, ovate, elliptic, or narrowly oblong, rarely lanceolate, or oblanceolate, (3.3-) 4.0-10.2 (-12.8) mm long, 0.9-2.7 (-3.2) mm wide, the length to width ratio 2.4-5.7 (-9.2), the widest point 0.3-0.5 (-0.9) of the entire length; *base* cuneate, rarely rounded; *apex* apiculate, acute, or rounded *venation*: indistinct, the mid-rib sometimes visible.

Inflorescence of 1-2 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* (0.7-) 1.5-3.0 mm long, with moderately sparse stalked glands; *bracteole pairs* inserted at a point 0.50-0.70 times the length of the pedicel, erect, often appressed against calyx, much shorter than the calyx, ovate, elliptic, narrow-elliptic or (most commonly) obovate, (2.1-) 2.8-4.0 (-4.7) mm long, 0.7-3.0 mm wide, the length to width ratio 1.2-3.3 (-6.7), the margins flat, slightly incurved, rarely folded, with stalked glands, especially near the margins, very rarely with sparse to moderately dense very long hairs to 1.3 mm, the base long-attenuate, tapering, or more rarely rounded, the apex shortly acuminate or sub-acute.

Calyx more or less actinomorphic, but the lips slightly separated, and the median adaxial lobe enlarged, with stalked glands, very rarely some long hairs to 1.3 mm long; *tube* distinctly longitudinally ribbed, obdeltate to obtriangular, 3.3-5.4 mm long, 3.0-3.5 (-4.7) mm wide, the length to width ratio 1.00-1.60, the base rounded, the interior with very sparse long hairs 0.2-0.3 or 1.2-1.7 mm long or stalked glands; *lobes* straight, narrow triangular to triangular or ovate, slightly shorter than tube, 0.30-0.50 times the entire calyx length, but the median adaxial lobe equal or slightly longer, 0.50-0.60 times the entire calyx length, 2.0-4.6 mm long, 0.9-1.8 mm wide at base, the length to width ratio 1.70-3.10 (adaxial median lobe: (3.0-) 3.6-5.8 (-6.3) mm long, 1.4-2.5 mm wide at base, the length to width ratio 1.7-3.2), the margins straight or rarely convex, ± recurved, the apex acute, the interior with very sparse long hairs 1.2-1.7 mm long and some stalked glands (usually denser towards margins) or as for exterior.

Corolla (14.1-) 16.8-28.1 (-31.5) mm long, mauve/purple with paler spots in throat, rarely white; *exterior surface* glabrous or with sparse loose hairs 0.4-0.9 (-1.4) mm long on the tube and denser hair on the lobes, rarely with sparse stalked or sessile glands; *interior surface* glabrous but with a moderately dense beard on the lower throat with hairs 0.1-0.7 mm long; *tube* ± obtriangular, 10.3-18.2 mm long, far exceeding the calyx, (4.5-) 6.0-10.2 mm wide at mouth; *abaxial median lobe* very widely obovate, widely depressed obovate, or depressed obovate/near-flabellate, 4.3-13.2 mm long, 6.4-13.0 mm wide, the length to width ratio 0.6-1.0, the margin coarsely and unevenly dentate, the apex truncate, the sinus 0.9-2.5 mm long; *lateral lobes* obovate, very widely ovate, or obtrullate, rarely near-circular, very rarely widely depressed ovate, (2.5-) 4.0-8.9 mm long, 2.6-5.4 mm wide, the length to width ratio 0.9-1.3 (-2.0), the margin near entire or slightly crenate-undulate, the apex rounded, the sinus 0.4-1.1 mm long; *adaxial median lobe-pair* widely ovate to widely depressed ovate, 3.8-8.0 mm long, 4.9-10.0 mm wide, the length to width ratio 0.60-1.60, emarginate with sinus 1.1-2.5 mm long, the margin entire or slightly undulate-crenate, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 5.2-8.9 mm from base of corolla, 5.1-6.3 mm long, glabrous; *theca* (0.7-) 1.2-1.4 mm long, glabrous, the *connective* 3.8-4.5 mm long, glabrous, the sterile end bearded, the hairs 0.1-0.3 mm long, triangular; *abaxial pair* with *filaments* inserted 6.8-9.5 mm from base of corolla, much longer than adaxial pair, 7.0-10.5 mm long, glabrous, *fertile theca* (1.2-) 1.3-1.5 (-1.6) mm long, glabrous, the *connective* (3.6-) 4.0-5.0 mm long, bearing a second smaller fertile theca, glabrous.

Ovary 0.8-1.7 mm long, 1.0-1.4 mm wide, the length to width ratio 0.80-1.20, the syle 15.8-16.1 mm long, glabrous, the stigma lobes 0.2-0.5 mm long. *Mericarps* dark brown, ovoidal, reticulate, 2.0-2.4 mm long, 1.1-1.3 mm wide, the length to width ratio 1.50-2.20, the attachment scar 1.6-1.7 mm long, c. 0.70 the entire mericarp length, glabrous.

Flowers recorded: June, August-November.

Ecology: Occurs mainly in lateritic sandy and gravelly soils in *Acacia* shrubland or heath. Recorded in shrubland regenerating after fire.

Notes: Similar to *H. tysonii* and *H. virescens* but can be distinguished by the lack of any branched hairs and the larger corolla with a broader tube. Also similar to *H. bracteosa* but can be distinguished by its larger corolla and lack of mixed-length simple hairs over all vegetative organs and the calyx, and ribbed calyx.

Other specimens examined: Western Australia: *R.J. Cranfield* 8596, 22.xi.1992, 7.5km SSE Rothsay Mine (PERTH 03048411); *A.Chant, G. Kitson & P. Docherty* S 2 B 5, 1.vi.2000, Barnong Station, E boundary of CALM aquisition (PERTH 05743109); *H. Pringle* 3239, 27.x.1992, Thundelarra Station site I98 (PERTH 04181832); *R.J. Cranfield* 5249, 27.vi.1985, 1.5 km S of Jingemarra homestead (PERTH 03675386); *M. Hislop* 2085, 2.viii.2000, NW slopes of unnamed hill immediately to NW of Yandhanoo Hill, Ninghan Station (PERTH 05878986); *E. Bennett* GG113, 26.x.1996, Below Gossan Hill, ca 50 km S of Yalgoo (PERTH 05028787); *A.M.Ashby* 5215, 24.viii.1975, Wuraga. Ca. 170 km east-north-east of Geraldton (MEL 689070); *K.F. Kenneally* 47A, 2.x.1965, E. Hellmuths Exp. Site-Cue (PERTH 03674827); *S. Van Vreeswyk* 3792, 17.viii.1993, Mellenbye Station (PERTH 04445066); *M.G. Corrick* 11461 *& B.A. Fuhrer*, 14.x.1996, Mullewa-Yalgoo road at junction with road S to Morawa (NSW457209, MEL 2038679).

5. Hemigenia bracteosa G.R.Guerin sp. nov.

H. sp. Dalwallinu (W.E. Blackall 2870) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. 273 (2000), partly, excluding *H. dulca*.

Typus: *W.E. Blackall* 2870, 25.ix.1932, Nr. Dalwallinu, 200 km NE of Perth, Western Australia (holo: PERTH 01071327! - right specimen; iso: PERTH 01071327! [excluding holo]).

Etymology: The epithet refers to the prominent bracteoles of this species, which are an important diagnostic character in distinguishing it from *H. dulca*.

Open, spindly shrubs c. 30 cm high; *branches* erect, nearly circular in cross-section, hispid with moderately dense mixed short and long patent hairs 0.2-1.5 mm long and mixed-length glandular hairs; *internodes* on leafy branches (1.0-) 2.8-11.0 mm long.

Leaves sessile, erect, straight, with dense stalked glands, ± sparsely hispid with sparse, mixed-length thick patent hairs 0.2-1.0 (-1.5) mm long; *lamina* open or loosely folded, obovate, oblong-elliptic, or rarely ovate, 4.4-10.3 mm long, 0.7-3.8 mm wide, the length to width ratio 2.4-7.9, the widest point (0.3-) 0.5-0.9 of the entire length; *base* cuneate to rounded; *apex* rounded; *venation*: indistinct, mid-rib occasionally visible.

Inflorescence of 1 flowering node with single flowers subtended by opposite leaf-like bracts; *pedicels* 0.5-1.2 mm long, with dense stalked glands, ± pubescent-hispid with sparse to moderately dense short and very long hairs. 0.1-0.2 or 0.6-1.1 mm long; *bracteole pairs* inserted at the mid-point of the pedicel, erect, loosely appressed against calyx, equal to or exceeding the calyx, obovate to oblanceolate, 3.1-6.0 mm long, 1.1-2.5 mm wide, the length to width ratio 2.0-4.0, with moderately dense stalked glands, ± hispid-hispidulous with minute

to long hairs 0.05-0.6 mm long, the margins ciliate with minute and long hairs 0.05-1.2 mm long, flat, the base long-attenuate, the apex acuminate or acute.

Calyx slightly two-lipped, a small division between the upper lip (three lobes) and the lower lip (two lobes), the median upper lobe usually slightly larger than the others, with dense mixed-length stalked glands, ± pubescent-hispid with sparse to moderately dense short and long hairs 0.1-0.2 or 0.6-1.1 mm long,; *tube* indistinctly to distinctly longitudinally ribbed, shallowly to widely obdeltate with convex margins, 2.5-4.0 (-4.5) mm long, 3.4-4.1 mm wide, the length to width ratio 0.8-1.3, the interior with very sparse short hairs 0.1 mm long; *lobes* straight but spreading, widely deltate to triangular with convex margins, roughly equal to or shorter than tube, 0.32-0.51 times the entire calyx length, 1.8-3.8 mm long, 1.2-2.7 mm wide at base, the length to width ratio (0.9-) 1.2-2.5), the margins straight, the apex acute, the interior with sparser stalked glands, ± very sparse tufted long hairs 1.3 mm long.

Corolla 10.0-14.0 mm long, violet to light violet; *exterior surface* with sparse to moderately dense short to long loose hairs 0.1-1.0 mm long, denser on the lobes, with longer hairs, the tube sometimes near-glabrous; *interior surface* sparsely bearded around mouth with hairs 0.5 mm long ; *tube* cuneate or funnel-shaped, 6.8-9.2 mm long, exserted slightly beyond calyx lobes, 2.8-7.0 mm wide at mouth; *abaxial median lobe* 4.7-4.8 mm long, the sinus c. 1.5 mm long; *lateral lobes* 2.8-3.6 mm long, the margin slightly undulate; *adaxial median lobe-pair* 2.3-3.3 mm long, the margin undulate-crenate.

Stamens: *adaxial pair* with *theca* c. 0.7 mm long, glabrous, the *connective* c. 2.4 mm long, the sterile end sparsely bearded with hairs 0.1 mm long; *abaxial pair* with *fertile theca* c. 1.2 mm long, glabrous, the *connective* c. 3.0 mm long, bearing a second smaller theca.

Ovary c. 1.8 mm long, c. 1.2 mm wide, the length to width ratio c. 0.70, with sparse sessile glands, the style c. 7.0 mm long, the stigma lobes 0.4-0.5 mm long. *Mericarps* light brown, ovoidal, reticulate, 1.5-1.6 mm long, 0.8-1.0 mm wide, the length to width ratio 1.60-1.90, the attachment scar c. 0.9 mm long, c. 0.60 times the entire mericarp length, glabrous.

Flowers recorded: August, September.

Ecology: Recorded in yellow sand on a hillside and 'heath-scrub'.

Notes: Similar to *H. benthamii,* but can be distinguished by its shorter corolla, and the long and short hairs on the stems, leaves and calyx. Also resembles *H. dulca* but can be distinguished most easily by its large bracteoles which equal or exceed the calyx. Also similar to *H. royceana* from which it can be distinguished by the bracteoles, which in *H. bracteosa* are acute (cf. obtuse/acumintae) with a long-attenuate base (cf. obtuse) and the open to loosely folded leaves with stalked glands (cf. conjoined leaves with sessile glands).

Other specimens examined: Western Australia: *E.M. Goble-Garratt & E.M. Mattiske* 83, 30.iii.1988, 4.5 km N of northern edge of township of Dalwallinu. W side of Wubin-Dalwallinu road (PERTH 03674835); *B.R. Maslin* 1987, 13.viii.1971, 5 miles (8 km) N Kununoppin to Mount Stevens (PERTH 06508405).

6. Hemigenia appressa G.R.Guerin sp. nov.

H. sp. Wilroy (B.J. Conn 2150) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000).

Typus: *B.J. Conn* 2150, 15.ix.1985, Wilroy Siding, Western Australia (holo: PERTH 03674118!).

Etymology: the epithet refers to the closely appressed indumentum of this species.

Erect, upright, open shrubs 0.45-1.0 m high, c. 0.3 m wide; *branches* erect, ± quadangular in cross-section, moderately hairy with appressed, antrorse hairs 0.05-0.1 mm long; *internodes* on leafy branches 6.0-19.5 mm long.

Leaves green, sessile, erect, straight to slightly recurved, covered by moderately dense, appressed antrorse hairs 0.1-0.2 mm long, or becoming glabrescent; *lamina* conduplicate and conjoined along margins to form an adaxial groove which is densely pubescent, rarely odd leaves not conjoined or open, near-terete to flattened, linear-oblanceolate (2.0-) 13.0-24.9 (-27.5) mm long, (0.3-) 1.5-1.1 (-1.3) mm wide, the length to width ratio 6.7-51.6, the widest point 0.6-0.8 of the entire length; *base* straight; *apex* sub-acute to rounded;; *venation*: not visible.

Inflorescence of 1-3 (-5) flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* (4.8-) 7.0-12.8 mm long, sparsely antrorse hairy with hairs 0.1 mm long, rarely some hairs patent, sometimes becoming glabrous towards proximal end; *bracteole pairs* inserted in the distal half of the pedicel at a point 0.8-1.0 times the length, erect, linear-narrowly elliptic, rarely linear-oblanceolate, 1.9-2.6 mm long, 0.1-0.5 mm wide, the length to width ratio 5.0-6.5 (-24.0), much shorter than the calyx tube, the abaxial surface sparsely antrorse hairy, the adaxial surface densely hairy with hairs 0.1 mm long, the margins strongly incurved/inrolled or folded, often becoming near-terete, the base straight, the apex rounded to acute.

Calyx green, actinomorphic with five more or less equal lobes, covered by moderately dense appressed antrorse hairs 0.1 mm long, rarely also with sparse sessile to stalked yellowish glands; *tube* longitudinally ribbed, obdeltate to obtriangular ± convex margins, 2.2-3.4 mm long, 1.8-3.0 mm wide, the length to width ratio 0.9-1.9, the interior sparsely antrorse hair with hairs 0.3 mm long, increasing in density towards distal end; *lobes* straight, nearly linear, narrowly triangular or subulate, longer than tube, 0.60-0.70 times the entire calyx length, (3.5-) 4.0-5.5 (-6.1) mm long, 0.55-1.3 (-1.8) mm wide at base, the length to width ratio 3.20-7.60, the margins strongly recurved and touching, the apex acute, the interior very densely hairy.

Corolla (7.8-) 8.9-13.0 (-16.4) mm long, mauve, white on inner and outer abaxial surfaces with orange-brown dots in throat; *exterior surface* densely covered with long, scruffy hairs 0.3 mm long; *interior surface* with sparse long hairs 0.4 mm long on tube and lobes, particularly around the insertion point of stamens, sometimes extending part way up the filaments; *tube* indistinctly funnel-shaped to obtriangular, (4.3-) 7.1-7.8 (-10.5) mm long, usually not exceeding the calyx, broadening steadily distally, 2.9-5.1 mm wide at mouth; *abaxial median lobe* widely depressed obovate to obovate, or widely depressed obtrullate, 2.1-5.5 (-6.4) mm long, 2.6-5.5 mm wide, the length to width ratio 0.7-0.9 (-1.5), the margin deeply and unevenly dentate, the apex truncate or rounded, the sinus 0.55-0.9 (-2.0) mm long; *lateral lobes* widely depressed ovate to ovate, rarely oblong or obovate, (1.5-) 2.0-3.6 (-6.0) mm long, 1.7-4.0 mm wide, the length to width ratio 0.6-2.2, the margin entire to moderately crenate, the apex rounded, the sinus absent or rarely 0.3-0.5 mm long; *adaxial median lobe-pair* transversely elliptic to widely depressed obovate, 2.5-4.5 m long, 3.0-5.6 mm wide, the length to width ratio 0.5-0.9, emarginate with sinus 0.8-0.9 (-1.5) mm long, the margin moderately crenate or entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted (2.6-) 4.0-5.3 mm from base of corolla, white, 2.3-2.5 (-3.4) mm long, glabrous or with minute patent waxy hairs, *theca* purple laterally, (0.3-) 0.6-1.1 mm long, very rarely nearly aborted and subtended by a dense beard equivalent to the sterile end, the *connective* 1.8-2.5 mm long, terminating at sterile end in a tufted or elongated beard, the hairs 0.1-0.2 mm long, triangular, or to 0.5 mm long and linear, rarely hairs of decreasing length adorning much of the connective; *abaxial pair* with *filaments* inserted 3.3-5.5 mm from base of corolla, very rarely inserted closer to base of corolla than adaxial pair, white, usually much longer than adaxial pair, 2.7-5.2 mm long usually with sparse hairs decreasing to c. 0.03 mm long along length, *fertile theca* purple laterally, 0.8-1.1 mm long, the *connective* 1.4-2.0 mm long, bearing a second fertile cell nearly as large as the first, sometimes bearing trichomes similar to those on the bearded appendages of the adaxial pair c. 0.1 mm long.

Ovary 1.0-1.5 mm long, 0.8-1.1 mm wide, the length to width ratio 1.00-1.50, glabrous, the style white, 8.2-9.6 mm long, the stigma lobes c. 0.3 mm long. *Mericarps* brown to light brown, ovoidal, reticulate, 1.6-2.2 mm long, 0.9-1.1 mm wide, the length to width ratio 1.70-2.40, the attachment scar 0.9-1.5 mm long, 0.60-0.70 time entire mericarp length), glabrous.

Flowers recorded: July, September, October, December.

Ecology: Sparse field notes suggest that this species occurs in mixed shrubland on lateritic gravel ± overlying sand.

Notes: Superficially resembles *H. westringioides* but is easily distinguished by its antrorse indumentum throughout and long, narrow calyx lobes. See also notes for *H. coccinea*.

Exceedingly rarely, a fifth stamen is present.

Other specimens examined: Western Australia: *E.D. Kabay* 476, 1.ix.1994, Along railway reserve east of Mullewa (PERTH 03708128); *R. Melville & J. Calaby* 4262, 21.vii.1953, 12 mls. S of Mullewa on Mullewa-Goomalling Road (NSW217650, MEL 537656); *B. Nordenstam & A. Anderberg* 453, 8.x.1989, 106 km W of Yalgoo (MEL 1592340, PERTH 02110881); *C.A. Gardner* 13945a, 22.vii.1962, Near Cockleshell Gully, E. of Mt. Leseur (PERTH 03674045); *D.A. Golding* s.n., ?-.xii.1988, 20 km E of Mullewa (PERTH 03674797); *M.E. Phillips* s.n., 20.ix.1968, 5 miles from Pindar, W.A., towards Tardun (PERTH 03670619); *E. Wittwer* 35, 30.ix.1962, 5 mls South of Pindas [sic.] (PERTH 03674592); *J.Z. Weber* 5122, 15.x.1975, Willroy [sic.], ca. 15 km south of Mullewa (AD97546003).

7. **Hemigenia coccinea** CA Gardner in Jour. Roy. Soc. W.A. 4, Austral. Xxvii, 196 (1942); Blackall & Grieve, Western Austral. Wildfl. 3:584 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 440 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Lectotype (here chosen): *C.A. Gardner* 2661, 18.ix.1931, Nr. Canna Siding in loamy gravelly sand, Western Australia (*lecto*: PERTH 01180886! - centre right specimen; *isolecto*: PERTH 01180886! [excluding lectotype]).

Low, spreading shrubs 0.3-0.6 m high; *branches* weak, erect, circular in cross-section, with many erect to spreading laterals, sparsely to moderately antrorse hairy with hairs 0.2-0.4 mm long; *internodes* on leafy branches 6.7-15.0 mm long.

Leaves green, sometimes appearing clustered due to dense axillary growths, sessile, erect to reflexed, straight to recurved, with sparse antrorse hairs 0.2 (-0.5) mm long; *lamina* mostly conduplicate, obovate to oblanceolate, very rarely ovate (1.3-) 2.1-10.0 (-16.0) mm long, 0.8-2.9 (-3.4) mm wide, the length to width ratio (1.3-) 2.1-13.8 (-16.0), the widest point (0.45-) 0.6-0.9 of the entire length; *base* cuneate; *apex* rounded ± recurved, or obcordate in some open leaves; *venation*: indistinct.

Inflorescence of 1 (-2) flowering nodes with single flowers (occasionally appearing clustered due to axillary growth) subtended by opposite leaf-like bracts; *pedicels* 3.8-6.5 (-8.1) mm long, with sparse antrorse hairs 0.2-0.3 mm long; *bracteole pairs* inserted at a point (0-) 0.2-0.5 (-0.66) times the length of the pedicel, erect, linear-narrowly elliptic, rarely linear-oblanceolate, 2.1-2.7 mm long, 0.2-0.4 mm wide, the length to width ratio 6.60-13.0, the margins strongly incurved and with hairs 0.2 mm long, the base straight or slightly cuneate, the apex acute, straight or sometimes recurved.

Calyx actinomorphic with five ± equal lobes, rarely the lobes uneven in length or width or the abaxial two shorter and broader, glabrous or with sparse to moderately dense, antrorse medium hairs 0.2 mm long; *tube* ± longitudinally ribbed, shallowly to widely obdeltate ± convex margins, (1.7-) 2.3-3.1 mm long, 2.0-2.6 mm wide, the length to width ratio 0.8-1.3, the interior glabrous; *lobes* straight to spreading, the surface usually wrinkled, nearly equal to or slightly longer than tube, (0.46-) 0.51-0.69 times the entire calyx length, narrowly triangular-subulate, (1.5-) 2.4-4.1 (-4.5) mm long, 0.3-1.0 mm wide at base, the length to width ratio (1.5-) 2.4-8.3 (-12.7)), the margins straight, the apex near acute to rounded, the interior usually with antrorse hairs only on the inner margin, rarely extending further in.

Corolla (8.8)- 12.3-21.2 (-27.4) mm long, dark or dull red with darker red spots on throat and interior of lower lobes, sometimes with a yellow background beneath the spots, gently curving towards the abaxial side; *exterior surface* mainly glabrous on tube, sparsely to moderately hairy with mainly antrorse hairs on lobes 0.1 mm long; *interior surface* with randomly orientated hairs 0.2 mm long clustered near the base, otherwise glabrous; *tube* cuneate, (5.0-) 6.8-14.4 (-17.7) mm long, long-exserted beyond calyx lobes, broadening steadily towards distal end, (1.7-) 2.5-5.6 mm wide at mouth; *abaxial median lobe* obovate, 2.4-6.3 mm long, 1.9-3.6 mm wide, the length to width ratio 1.30-2.40, the margin unevenly dentate-crenate, the apex rounded, the sinus absent; *lateral lobes* very widely ovate to ovate, rarely oblong to widely obovate, (1.5-) 1.9-4.3 mm long, (1.0-) 1.8-4.0 mm wide, the length to width ratio 0.8-1.3 (-1.5), the margin unevenly dentate-crenate, rarely undulate, ± minutely ciliate, the apex rounded to truncate, the sinus absent; *adaxial median lobe-pair* widely depressed obovate to obovate, 2.0-5.4 (-6.4) mm long, (2.4-) 2.8-4.8 (-6.5) mm wide, the length to width ratio 0.8-1.4, emarginate with sinus (1.0-) 1.3-2.2 mm long, the margins ± dentate-crenate-undulate, the apex rounded to truncate.

Stamens: *adaxial pair* with *filaments* inserted nearer distal end of corolla than abaxial pair or nearly equal, 6.0-14.3 mm from base of corolla, red, 3.6-7.3 mm long, glabrous, *theca* 0.9-1.5 mm long, white, the *connective* 1.0-1.9 mm long, terminating at sterile end in a glabrous tapering appendage; *abaxial pair* with *filaments* inserted 6.0-13.0 mm from base of corolla, red, 4.5-7.4 mm long, glabrous, *fertile theca* white, 0.9-1.5 mm long, the *connective* (0.6-) 1.0-1.9 mm long, terminating at sterile end in a glabrous tapering appendage or very rarely in a second much smaller imperfect theca.

Ovary 1.0-1.5 mm long, 0.6-1.0 mm wide, the length to width ratio 1.50-1.70, glabrous, the style dull red, 10.5-21.5 mm long, the stigma lobes lighter in colour, 0.3-0.4 mm long.

Mericarps olive-green, ovoidal, reticulate, c. 1.9 mm long, c. 1.1 mm wide, the length to width ratio c. 1.80-1.90, the attachment scar 1.1-1.5 mm long, 0.6-0.8 times the entire mericarp length, glabrous.

Flowers recorded: July to October.

Ecology: Occurs on sandy (rarely clay) loam or gravel in open scrub, associating with heath communities.

Notes: Very similar to *H. appressa* which also occurs in the Pindar region. This species can be distinguished from *H. coccinea* by the following characters: bracteoles inserted along the distal half of the pedicel, calyx lobes far exceeding the tube in length, corolla broad, mauve, adaxial stamens with bearded appendages, leaves conjoined, indumentum denser throughout.

The arrangement of stamens in this species is unusual; the adaxial pair are usually inserted closer to the distal end of the corolla than the abaxial pair or rarely at the same distance.

Selected specimens examined (ca. 25 seen): Western Australia: *S. Donaldson* 1896 *& G.T. Chandler*, 24.x.1998, 41.8 km S of Mullewa toward Morawa on Mullewa-Wubin Road (CBG 9809776.1); *F.W. Humphreys* 8638/62/2, ?-.?-.1963, 280 mls on road from Morawa to Geraldton via Mullewa (PERTH 03670201); *W.E. Blackall* 2791, 24.ix.1932, Betwn Mullewa & Morawa (PERTH 03670333); *A.M. Ashby* 4881, 29.viii.1973, Halfway between Mingenew and Morawa (PERTH 03670678, AD 97422004); *E. Leyland* 12, s.dat., Mullewa (PERTH 02879577); *N.R. Marriott* s.n., ?-.?-.1985, 20 km south of Morawa on Mullewa-Morawa road (MEL 1548009); *J. Glass (for A.M. Ashby* 2171), 22.vii.1967, South of Pindar (PERTH 03670406, AD 968071250); *C.I. Stacey* 166, 5.ix.1972, 275.9 mile peg Mullewa Road

(PERTH 01696556); *A.R. Fairall* 1343, 10.ix.1963, 282 mpeg Road Mullawa[sic.]-Morawa (PERTH 03675092); *G.J. Keighery, J.J. Alford* 2050, 15.viii.1990, Kowald's farm-CAnna (off Arrinooka Rd.) (PERTH 01610686); *J. Galbraith* 405, 21.viii.1964, Mullewa (PERTH 03721205); *S. Patrick* 2071, 7.x.1994, Canna Nature REserve, N end, ca 200 m NE of railwayline, at 100 m W of eastern boundary (PERTH 05704332); *M.E. Ballingall* 1925, 23.viii.1985, Mullewa-Yalgoo Rd, 14.1 km E of Mullewa (PERTH 03670449); *E. Leyland* LP748169, ?-.?-.1988, Bradys road, Mullewa (PERTH 03670422); *Bro. W. Van Veen* 3, ?-.viii.1990, Pallottine Mission, Tardun (PERTH 01245333).

8. Hemigenia ciliata G.R.Guerin sp. nov.

H. sp. Payne's Find (A.C. Beauglehole 49138) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000), partly, excluding *H. buccinata.*

Typus: *B.H. Smith* 449, 3.x.1984, Payne's Find to Wubin Road, 24.75 miles from old No. 2 Vermin fence, Western Australia (holo: AD98827076!; iso: PERTH 03671704!, NSW217070!, CBG 8905216!, MEL 1527745!).

Etymology: the epithet refers to the distinctive ciliate calyx lobes.

Compact to loose, much-branched, erect to spreading low shrubs c. 0.2-1.0 m high, c. 0.3-1.2 m wide; *branches* ascending, near-square in cross-section (especially flat between the leaf bases), viscid, rarely sparsely puberulent-pubescent with sparse short patent hairs 0.05-0.1 (-0.3) mm long, mainly between the leaf bases; *internodes* on leafy branches (1.5-) 2.4-8.7 (-13.3) mm long.

Leaves bright green, sessile, semi-erect to patent, straight, viscid or with dense sessile glands, rarely with sparse short patent hairs 0.1 mm long on the adaxial surface; *lamina* terete to flat, conduplicate (margins usually fused into a deep adaxial groove), linear-oblanceolate, (3.8-) 4.5-14.0 (-23.3) mm long, (0.3-) 0.4-0.8 (-0.9) mm wide, the length to width ratio 7.3-22.0 (-38.8), the widest point 0.70-0.94 of the entire length; *base* straight; *apex* acute, usually recurved, rarely rounded; *venation*: invisible.

Inflorescence of 1-2 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* 0.7-1.5 mm long, viscid, with sparse short patent hairs 0.1 mm long, usually between the bracteoles; *bracteole pairs* inserted at a point 0.37-0.70 times the length of the pedicel, erect to appressed against calyx, much shorter than calyx, slightly recurved, folded, viscid, narrowly elliptic to linear, (1.0-) 1.5-2.6 (-3.3) mm long, 0.2-0.4 mm wide, the length to width ratio 3.3-10.0 (-13.2)), the margin ciliate with hairs to 0.1 mm long, rarely the hairs also scattered on the abaxial surface, the base cuneate, the apex acute.

Calyx light green, more or less actinomorphic, rarely the lobes slightly uneven, viscid; *tube* smooth to distinctly ribbed, rarely warty distally, widely to shallowly obdeltate, 2.0-3.5 mm long, 2.4-3.4 mm wide, the length to width ratio 0.8-1.1, the base sub-rounded, the interior viscid; *lobes* spreading, triangular, very rarely widely deltate, near-equal to or slightly shorter than tube, (0.36-) 0.43-0.53 (-0.58) times the entire calyx length, (1.2-) 1.6-2.7 (-3.5) mm long, (0.9-) 1.0-1.4 (-1.8) mm wide at base, the length to width ratio 1.3-2.7, the margins straight, rarely convex, rarely inrolled apically, inner margin moderately to densely ciliate with hairs 0.1 mm long, the apex acute, rarely appearing acuminate due to inrolled apical margins, the interior viscid and with sparse antrorse, semi-apressed hairs 0.1-0.2 mm long.

Corolla 8.2-16.5 mm long, mauve to pink, white basally, lower throat white with variously coloured spots, sides of throat with pink dots; *exterior surface* glabrous, or with sparse loose hairs on lobes, or with sparse to moderately dense loose hairs 0.1-0.2 mm long all-over; *interior surface* glabrous except the lower tube sparsely to moderately bearded between the stamens with hairs 0.3-0.4 mm long, rarely the lobes with sparse hairs 0.1 mm long, very rarely hairy throughout; *tube* funnel-shaped or obtriangular, 5.2-9.6 mm long, exceeding the calyx, (3.3-) 3.7-6.2 mm wide at mouth; *abaxial median lobe* abruptly spathulate, the stalk transversely to narrowly transversely oblong, rarely obtrullate, the blade depressed obovate, oblate, transversely elliptic, or widely depressed trullate, rarely obdeltate, or rarely not abruptly spathulate: widely depressed obtrullate, the margins concave, or depressed flabellate, 2.6-6.4 mm long, 3.8-7.8 mm wide, the length to width ratio 0.6-1.05, the margin crenate-dentate ± undulate, the apex truncate, the sinus 0.6-2.4 mm long; *lateral lobes* widely to very widely to widely depressed obovate, oblong, or widely to widely depressed ovate, (1.9-) 2.3-3.5 (-4.9) mm long, 1.7-3.6 (-4.3) mm wide, the length to width ratio 0.81-1.5 (-1.8), the margin near-entire, the apex rounded, the sinus 0.3-1.2 mm long; *adaxial median lobe-pair* depressed (rarely widely depressed) ovate, or transversely widely oblong, rarely obovate, (1.8-) 2.8-3.8 (-5.6) mm long, 2.6-7.0 mm wide, the length to width ratio 0.58-1.1 (-1.5), emarginate with sinus 0.7-2.9 mm long, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.9-4.5 mm from base of corolla, white, 1.2-2.9 mm long, glabrous, very rarely with sparse to moderately dense patent hairs 0.1 mm long, *theca* purple, (0.6-) 0.7-0.8 mm long, glabrous, the *connective* white to purple, 1.0-2.3 mm long, glabrous, the sterile end bearded with a tuft of triangular trichomes 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted 3.5-5.5 mm from base of corolla, white, 2.0-4.9 mm long, glabrous, very rarely with sparse to moderately dense patent hairs 0.1 mm long, *fertile*

theca purple, (0.6-) 0.7-0.9 mm long, glabrous, the *connective* white-purple, (1.3-) 1.5-2.3 mm long, glabrous, bearing a second smaller theca.

Ovary 1.0-1.1 mm long, 0.7-1.1 mm wide, the length to width ratio 1.0-1.4, the stye white, 7.6-8.6 mm long, the stigma lobes 0.1-0.5 mm long. *Mericarps* brown to dark brown, ovoidal, reticulate, 1.1-2.6 mm long, 0.8-1.3 mm wide, the length to width ratio 1.4-2.06, the attachment scar 1.2-1.7 mm long, 0.60-0.70 times the entire mericarp length, glabrous.

Ecology:

Occurs in a range of soils including laterite, brown-orange-yellow-red sand, granitic soil, and disturbed roadside gravel, usually in shrubland, often dominated by *Acacia* spp. Has been recorded in heath regenerating after fire.

Flowers recorded: March, July to November.

Affinities: Very similar to *H. buccinata*, which occurs in the same region. *Hemigenia ciliata* can be distinguished by the following features: calyx lobes ciliate, nearly equal to the tube (*H. buccinata* pubescent or glabrous), leaves usually 4.5-14.0 mm long (*H. buccinata* usually 2.2-5.8 mm long), stems square (*H. buccinata* ± rounded), corolla mauve (never white) (*H. buccinata* white (rarely pale mauve)), the tube funnel-shaped, margins not concave (*H. buccinata* corolla tube trumpet-shape), leaf-margins fused (*H. buccinata* folded but not fused), lack of short patent hairs over most organs (*H. buccinata* usually densely covered). Also similar to *H. brachyphylla*, which differs in the simple hairs and stalked glands of the calyx.

Selected other specimens examined (ca. 50 seen): Western Australia: *Greg Guerin* 47 & *Penny McLachlan*, 22.x.2002, 47.2 km along the Great Northern Highway from Wubin towards Payne's Find, on W side of road, c. 5 m from road (AD 137675, PERTH); F.*H.* & *M.P. Mollemans* 3058, 10.vii.1990, Bimbijy Road, 11.8 km north by road from Dromedaries Hill, 10 km NNE of Mt. Churchman (AD99114028); *J. D'Alonzo* 489, 22.ix.1985, Great Northern Highway. At roadside 70.7km north east of Wubin (PERTH 03633888); *C.A. Gardner* 13545, 10.x.1961, Mount Churchman (PERTH 04264274); *E.D. Kabay* 1197, Along the road between Wubin and Payne's Find (PERTH 04086090); *Fairall* 1778, 19.vii.1966, 211 m.p. Wubin-Payne's Find (CANB 376144); *J.V. Blockley* 470, 28.xi.1966, 50 m S. of Payne's Find (PERTH 03671941); *H. Demarz* 2384, 12.viii.1970, 212 mile post, Payne's Find Road (Great Northern Highway) (PERTH 01870467); *J.S. Beard* 6428, 7.ix.1973, 29 m E of Wubin on road to Payne's Find (PERTH 03673804); *A.M. Lyne* 874, *L. Craven F. Zich*, 24.x.1992, C. 50 km direct SW of Payne's Find at "Mount Gibson" station, c. 2 km along Mount Gibson road from homestead towards Great Northern Highway (MEL 714575, CBG 9215718, PERTH 03395073); *J.Z. Weber* 5210, 20.x.1975, Ca. 40 km north-east of Cleary. Ca. 15 km south of Vermine [sic.] Proof Fence along the road "North-South" (MEL 1554202, MEL 302620); *R. Davis* 6475, 25.viii.1998, 36.5 km NE Wubin on Great Northern Highway (PERTH 05281172); *P. Roberts* 213, ?-.?-.1983, 14 km E of Bimagee Station (PERTH 03671666); *W.E. Blackall* 3799, 6.ix.1938, 46 ml. from Wubin towards Payne's Find (PERTH 03671852); *A. Strid* 20215, 8.ix.1982, 84 km from Dalwallinu along Great Northern Highway to Payne's Find (AD98321077, PERTH 03673782).

9. Hemignia buccinata G.R.Guerin sp. nova

H. sp. Payne's Find (A.C. Beauglehole 49138) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. (2000), partly, excluding *H. ciliata*.

Typus: *Corrick, M.G.* 9322, 24.x.1984, Great Northern Highway, 6 km south-west of Payne's Find', Western Australia (holo: PERTH 06338585! - lower right specimen; iso PERTH 06338585! - upper left specimen, MEL 670436!).

Etynology: The epithet refers to the trumpet-shaped corolla tube.

Erect to spreading low shrubs 0.2-0.5 m high, to 1.5 m wide; *branches* erect, ± circular in cross-section, viscid, usually densely puberulent with dense minute patent hairs, rarely otherwise glabrous; *internodes* on leafy branches 3.0-6.7 (-7.7) mm long.

Leaves sessile, erect, ± straight, viscid, usually puberulent with dense minute patent hairs, rarely otherwise glabrous; *lamina* conduplicate, the margins free, oblanceolate, very rarely narrowly oblong, (1.9-) 2.2-5.8 (-9.6) mm long, 0.3-0.8 (-1.3) mm wide, the length to width ratio (2.8-) 4.0-10.0 (-16.0), the widest point 0.70-0.90 of the entire length (except when oblong, then 0.50); *base* rounded, cuneate, or straight; *apex* recurved to straight, acute to rounded; *venation*: indistinct.

Inflorescence of 1-2 (-5) flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* (0.5-) 0.7-1.5 mm long, viscid, puberulent with dense short patent hairs 0.05-0.1 mm long; *bracteole pairs* inserted at a point 0.20-0.80 times the length of the pedicel, erect, much shorter than the calyx tube, straight, narrowly elliptic, 0.9-1.5 mm long, 0.1-0.4 mm wide, the length to width ratio 3.3-5.0 (-8.7), loosely folded, viscid, with sparse minute hairs, rarely with sparse longer mixed-length hairs 0.1-0.3 mm long, the base rounded, the apex acute ± recurved.

Calyx more or less actinomorphic, or the median adaxial lobe slightly larger, viscid, usually densely puberulent with dense mostly minute patent hairs < 0.1 mm long; *tube* smooth, oblong or cup-shaped, 2.0-3.0 mm long, 1.2-2.8 mm wide, the length to width ratio (0.87-) 1.1-2.0, the base rounded, the interior viscid; *lobes* straight to slightly spreading, deltate, triangular, or the apex long-acuminate or triangular from a very shallowly triangular to shallowly deltate base, much shorter than tube, 0.25-0.39 (-0.44) times the entire calyx length, 1.0-1.5 (-1.8) mm long, 0.75-1.2 (-1.4) mm wide at base, the length to width ratio (0.92-) 1.0-1.6 (-2.25), the margins flat or rarely inrolled apically, the apex acute, the interior viscid, with dense short patent hair to c. 0.1 mm long, rarely near-glabrous, rarely with sparse sessile glands.

Corolla (7.6-) 8.3-15.5 (-16.4) mm long, white or rarely some flowers very pale mauve, with brown to purple spots on base of lower lip and throat; *exterior surface* glabrous or with sparse hairs 0.1-0.3 mm long; *interior surface* glabrous apart from a moderately dense beard on the lower throat between the stamens with hairs 0.2-0.3 mm long; *tube* trumpet-shape — elongate, very narrow basally, broadening abruptly apically, the margins concave, to indistinctly funnel-shaped, (4.8-) 5.9-8.6 mm long, far exceeding the calyx, (2.0-) 2.5-4.5 (-5.1) mm wide at mouth; *abaxial median lobe* abruptly spathulate, the stalk oblong to transversely oblong or obtriangular, the blade transversely elliptic, 2.8-4.2 mm long, 3.2-4.4 mm wide, the length to width ratio 0.75-1.2, the margin slightly crenate to very unevenly crenate, the apex broadly rounded, the sinus 0.5-0.8 mm long; *lateral lobes* square, or near-oblong to ovate to depressed ovate, 1.4-3.0 mm long, 2.0-2.7 mm wide, the length to width ratio 0.7-1.0 (-1.5), the margin slightly crenate, the apex rounded, the sinus absent; *median adaxial lobe-pair* depressed to widely obovate, 2.2-3.7 mm long, 2.4-4.5 mm wide, the length to width ratio 0.67-1.25, emarginate with sinus to c. 1.2 mm long, the margin slightly crenate to entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 4.0-4.2 mm from base of corolla, 1.9-2.3 mm long, glabrous, very rarely with sparse patent hairs 0.1-0.2 mm long, *theca* 0.4-0.7 mm long, glabrous, the *connective* 1.3-1.8 mm long, glabrous but the sterile end bearded, the hairs 0.2-0.3 (-0.4) mm long, usually with increasingly shorter hairs extending partway along the connective; *abaxial pair* with *filaments* inserted 4.2-6.3 mm from base of corolla, 2.8-3.1 mm long, glabrous, very rarely with sparse patent hairs 0.1-0.2 mm long, *fertile theca* purple, 0.5-0.8 mm long, glabrous, the *connective* 1.0-2.2 mm long, bearing a second smaller theca, glabrous.

Ovary 0.9-1.2 mm long, 0.75-0.9 mm wide, the length to width ratio 1.1-1.3, glabrous, the style 9.2-11.5 mm long, the stigma lobes 0.2-0.4 mm long. *Mericarps* light brown, ovoidal, reticulate, 1.6-2.1 mm long, 1.1-1.25 mm wide, the length to width ratio 1.45-1.75, the attachment scar 1.1-1.5 mm long, 0.55-0.71 times the entire mericarp length, glabrous.

Flowers recorded: August to October.

Ecology: Occurs mainly on red sandy or lateritic soils but also in brown and yellow soils, in shrubland, often dominated by *Acacia spp.*

Notes: See notes regarding the affinities of this species under *H. ciliata.*

Other specimens examined: Western Australia: *A.C. Beauglhole* 49138, 23.viii.1974, Great Northern Highway. 6. km west-south-west of Payne's Find +/- 145 km south-south-west of Mt. Magnet Post Office (AD 97614287, PERTH 03670392); *S. Toole* SLT 42, 30.viii.1995, Vacant crown land E of Kirkalocka Station, Transect 2, Grid Ref. 45-63 (PERTH 04622634);

S. Patrick 2918, 29.iii.1997, Burnerbinmah Station, E side of Nangal Paddock, 1.7 km N along fence track from junction with track from Wadda Wadda Well (PERTH 04995430); *S. Donaldson* 1401 *& G. Flowers*, 1.ix.1997, 4.7 km SW of Payne's Find towards Wubin, on Great Northern Highway (PERTH 05433096, CBG 9708458); *R. Chinnock* 5207, 18.x.1981, 67.5km SSW of Youangarra on Sandstone-Payne's Find road (AD98209013); *S. Patrick* 3036, 19.x.1998, Burnerbinmah Station, E of Coonthiago Mill, at 700 m W of E boundary (PERTH 05416876).

10. Hemigenia royceana G.R.Guerin sp. nov.

Typus: *R.D. Royce* 10394, 14.x.1972, 62 miles north of Sandstone, towards Wiluna, Western Australia (holo: MEL 302537! - upper left specimen; iso: MEL 302537! [excluding holo]).

Etymology: the epithet recognises the collector of the type (and to date the only known) specimen of this species, R.D. Royce.

Shrubs c. 0.60 m high; *branches* ± erect, sub-quadrangular in cross-section, hispid, with sparse, rarely moderately dense, hairs 0.2-0.9 mm long, and moderately dense to dense sessile, rarely sub-sessile, glands; *internodes* on leafy branches 1.1-7.5 mm long.

Leaves sessile, erect, with moderately dense to dense sessile, rarely sub-sessile, glands and very sparse spreading hairs 0.2-0.3 mm long; *lamina* conduplicate, the margins ± fused, flat, linear-oblanceolate, 4.5-9.0 mm long, 0.5-1.0 mm wide, the length to width ratio 6.43-12.20, the widest point 0.75-0.90 of the entire length; *base* straight; *apex* slightly recurved, rounded or acute; *venation*: indistinct.

Inflorescence of 1-4 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* 0.6-1.5 mm long, with indumentum similar to stems but the non-glandular hairs 0.3-0.5 mm long; *bracteole pairs* inserted approximately at the mid-point of the pedicel at a point 0.45-0.50 times the length, erect, held against calyx, nearly equal to the calyx tube, widely obovate or widely elliptic, rarely near-orbicular, 2.5-3.2 mm long, 2.0-3.0 mm wide, the length to width ratio 1.07-1.25, with sparse, spreading, long, thick hairs 0.2-1.1 mm long ± sparse stalked glands concentrated on the margins, the margins flat, the base obtuse, the apex very abruptly acuminate to apiculate from an obtuse to truncate base.

Calyx actinomorphic or the lobes slightly unequal, with moderately dense stalked glands and long stiff spreading hairs 0.6-1.3 mm long, the surface scabrous, the lobes with indumentum equal to the tube but with sparser very thick hairs (hispid), denser near the margins, ± denser stalked glands around the margins; *tube* smooth, shallowly obtriangular or obdeltate, 2.0-2.9 mm long, 3.0-3.7 mm wide, the length to width ratio 0.67-0.97, the base rounded, the interior ± with sparse stalked glands and ± appressed thick hairs 0.1-1.1 mm long; *lobes* straight, widely deltate to triangular, slightly shorter than or equal to the tube in length, 0.41-0.51 times the entire calyx length, 2.0-2.1 mm long, 1.0-1.6 mm wide, the length to width ratio 1.25-2.00, the margins straight, the apex acute, the interior equal to that of the tube but sparser.

Corolla 6.5-7.8 mm long, mauve; *exterior surface* with sparse to dense stiff hairs 0.2-0.4 mm long and sparse stalked and sessile glands; *interior surface* with sparse hairs 0.1-0.2 mm long and glands; *tube* narrowly oblong or abruptly funnel-shaped distally, 3.1-5.2 mm long, shorter than or shortly exserted from calyx lobes, 2.3-2.5 mm wide at mouth; *median abaxial lobe* ± widely obovate, 2.9-3.2 mm long, c. 2.8 mm wide, the length to width ratio c. 1.14, the margin nearly entire or finely crenate, the sinus c. 0.5 mm long; *lateral lobes* very widely

ovate to widely depressed ovate, 2.0-2.1 mm long, 2.0-2.5 mm wide, the length to width ratio 0.84-1.00, the margin ± entire, the apex rounded, the sinus absent; *adaxial median lobe-pair* 1.5-2.5 mm long, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* c. 1.3 mm long, glabrous, *theca* 0.5-0.8 mm long, glabrous, the *connective* 1.2-1.3 mm long, glabrous, the sterile end with a sparse beard of hairs c. 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted c. 3.5 mm from base of corolla, c. 2.6 mm long, glabrous, *fertile theca* 0.6-0.8 mm long, glabrous, the *connective* c. 1.0-1.1 mm long, glabrous, the lower end bearing a large second theca.

Ovary c. 1.0 mm long, c. 1.1 mm wide, the length to width ratio c. 0.91, with short tufted hairs 0.1-0.2 mm long and dense sessile glands at the apex, the style c. 8.4 mm long. *Mericarps* brown, ovoidal, densely reticulate, c. 1.6 mm long, c. 1.0 mm wide, the length to width ratio c. 1.60, the attachment scar c. 1.1 mm long, c. 0.69 times the entire mericarp length, with sparse scattered sessile glands.

Flowers recorded: October.

Ecology: recorded in red sandy soil in association with *Triodia*.

Notes: known only from the type collection.

11. Hemigenia divaricata CA Gardner in Jour. Roy. Soc. W.A. 4, Austral. Xxvii, 195 (1942); Blackall & Grieve, Western Austral. Wildfl. 3:583 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 439 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Lectotype (here chosen): *C.A. Gardner* 2624, 16.ix.1931, Granite soil west of Pindar, Western Australia (*lecto*: PERTH 01179268! - lower left specimen; *isolecto*: PERTH 01179268! - upper right specimen, PERTH 04249259a!, PERTH 01179241!).

Erect to straggling shrubs 0.3-1.5 m high; *branches* erect, nearly square in cross-section, with many spreading laterals, densely puberulent in longitudinal rows with very dense, minute, patent hairs, much sparser between rows, rarely with very sparse sessile glands; *internodes* on leafy branches (2.0-) 4.5-14.9 mm long.

Leaves sometimes appearing clustered due to dense axillary growths, sessile, erect, straight to slightly recurved, glabrous or rarely with sparse sessile (rarely stalked) glands, sometimes with minute hairs and denser sessile glands on the adaxial surface, very rarely puberulent with dense, minute, patent hairs over entire surface; *lamina* mostly conduplicate, oblanceolate (1.7-) 4.5-10.4 (-15.1) mm long, 0.4-0.9 (-1.8) mm wide, the length to width ratio (3.4-) 7.6-11.5 (-18.9), the widest point (0.60-) 0.71-0.83 of the entire length; *base* cuneate; *apex* acute to rounded; *venation*: indistinct.

Inflorescence of 1-5 flowering nodes with single flowers subtended by opposite leaf-like bracts; *pedicels* 1.5-1.8 mm long, pubescent with very dense patent hairs 0.1-0.2 mm long, ± sessile glands, rarely stalked glands; *bracteole pairs* inserted near the mid-point of the pedicel or rarely to a point 0.70 times the length, erect, much shorter than the calyx tube, linear-narrowly elliptic, 1.8-2.8 (-4.5) mm long, 0.3-0.9 (-1.2) mm wide, the length to width ratio 2.1-9.3, the margins strongly incurved, rarely to near flat, with short and long cilia to 0.5 mm long ± sparse sessile glands on the abaxial surface, rarely shortly pubescent all over, the base cuneate or straight, the apex rounded, ± recurved.

Calyx partially two-lipped, the upper lip with three lobes, the median lobe much larger, the lower lip divided from upper lip with two equal lobes, sparsely hirsute with sparse to moderately dense long hairs 0.3-0.6 (-0.8) mm long and sparse stalked or sessile glands, typically sparser on the lobes; *tube* smooth to faintly ribbed, rounded to shallowly obdeltate with convex margins, expanding in the distal half, 2.7-3.7 mm long, 2.8-4.2 mm wide, the length to width ratio 0.7-0.9 (-1.1), the interior glabrous or rarely with randomly orientated, loosely appressed hairs or sparse stalked glands; *lobes* straight to recurved, triangular, slightly shorter to or slightly longer than the tube, the median adaxial lobe 0.50-0.64 times the entire calyx length, the other calyx lobes 0.40-0.48 (-0.54) times the entire calyx length, (1.7-) 2.2-3.7 mm long, 1.0-1.5 mm wide at base, the length to width ratio 1.7-2.8 (adaxial median lobe: (2.7-) 3.2-4.2 (-5.5) mm long, 1.3-2.5 mm wide at base, the length to width ratio 1.6-4.0), the margin incurved or flat, ciliate with hairs 0.1 mm long, the apex acute or appearing long-acuminate, ± recurved, the interior with sparse randomly orientated, loosely appressed hairs 0.1 mm long and very sparse sessile and stalked glands.

Corolla (12.2-) 16.5-23.2 (-29.8) mm long, mauve, violet or purplish red, throat white with darker spots; *exterior surface* with sparse long loose hairs 0.2-0.5 mm long; *interior surface* with loosely appressed, randomly orientated hairs 0.2-0.6 mm long on the basal area of all lobes, and a dense tufted beard of hairs 0.5-1.0 mm long on the lower throat between the stamens, towards the proximal end of tube; *tube* broadly cuneate or indistinctly funnel-shaped,, (10.2-) 12.5-13.7 (-16.0) mm long, long-exserted beyond calyx lobes, (4.3-) 6.0-8.7 (-10.1) mm wide at mouth; *abaxial median lobe* flabellate or abruptly spathulate, the stalk shallowly triangular, the blade shallowly obobdeltate or widely depressed obtrullate, 4.6-6.0 (-9.8) mm long, 7.5-9.3 (-11.3) mm wide, the length to width ratio 0.70-0.90, the margin unevenly crenate ± ciliate, the apex obtuse to truncate, the sinus 1.0-2.0 mm long; *lateral*

lobes ovate to obovate or very widely obtrullate, (3.6-) 4.5-7.0 mm long, (2.4-) 3.8-5.5 (-6.4) mm wide, the length to width ratio 0.8-2.2 (-2.5), the margin nearly entire, ± ciliate, the apex rounded, the sinus absent or 0.8-1.6 (-2.2) mm long; *adaxial median lobe-pair* widely depressed obovate, 5.2-7.5 (-8.1) mm long, 6.5-9.4 mm wide, the length to width ratio 0.7-0.9 (-1.1), emarginate with sinus (1.4-) 2.0-2.7 mm long, the margin slightly crenate ± ciliate, the apex ± rounded.

Stamens: *adaxial pair* with *filaments* inserted 7.2-8.5 mm from base of corolla, 3.1-4.0 mm long, glabrous, *theca* 1.2-1.4 mm long, with sparse waxy hairs c. 0.1-0.2 (-0.3) mm long, *connective* 3.2-3.5 mm long, terminating at sterile end in broad to tapering appendage bearded with sparse triangular trichomes 0.2-0.3 mm long, sometimes extending along the proximal length of connective; *abaxial pair* with *filaments* inserted 8.5-10.5 mm from base of corolla, 3.5-5.0 mm long, glabrous, *fertile theca* 1.3-1.6 mm long, with sparse waxy hairs c. 0.1-0.2 (-0.3) mm long, the *connective* 3.2-4.0 mm long, bearing a second smaller theca.

Ovary 1.3-1.8 mm long, 1.0-1.4 mm wide, the length to width ratio c. 1.30, glabrous, the style c. 15.0 mm long, the stigma lobes uneven, 0.3-0.7 mm long. *Mericarps* brown, ovoidal, strongly reticulate, 2.2-2.4 mm long, 1.1-1.4 mm wide, the length to width ratio 1.60-2.20, the attachment scar c. 1.9 mm long, c. 0.76 times the entire mericarp length, glabrous.

Flowers recorded: September.

Ecology: Limited field notes indicate that this species occurs in lateritic gravel in *Acacia* scrub or mallee.

Notes: Similar to *H. benthamii* but lacks stalked glands on the leaves, the bracteoles are narrower, and the calyx tube is not prominently ribbed and is less densely glandular.

Isolectotype PERTH 04249259 contains mixed collections on the first sheet. PERTH 04249259a is *Hemigenia divaricata* while 04249259b is *H. coccinea.*

Specimens examined: Western Australia: *W.E. Blackall* 664, 16.ix.1931, Pindar, 115 km E of Geraldton (PERTH 03670945, PERTH 03675335); *A.C. Burns* 76, 22.ix.1968, 2 mi E of Mullewa towards Pindar (PERTH 03671461); *E. Leyland* 9, s.dat., Mullewa (PERTH 03675246); *R. Bates* 3969, 1.ix.1984, 20 km N of Mullewa (PERTH 03118762); *R. Coveny* 7951, 1.ix.1976, 12.6 km NNE of Mullewa (PERTH 03671437); *S. Patrick* 2865, 12.xi.1996, E of Pindar, vacant crown land, 50 m along track running S from Fegan Road 19.8 km SE of highway (PERTH 05704553); *A.M. Ashby* 2580, 1.ix.1968, Mullewa which is ca. 90 km east-north-east of Geraldton (AD 97110031, PERTH 03671348); *M.E. Phillips* WA/68 1335, 20.ix.1968, 3 ml from Mullewa, W.A., towards Pindar (CANB 042075, PERTH 03671259); *M.E. Phillips* WA/68 1336, 20.ix.1968, 5 miles from Mullewa, W.A., towards Pindar (CANB 042691).

12. Hemigenia brachyphylla F. Muell. Fragm. 10: 19 (1876); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 586 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 443 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Lectotype (here chosen): *Young* s.n., s.dat. Near Ularing, Western Australia (lecto: MEL 2750! - bottom left specimen; isolecto: MEL 2750! [exluding lecto]).

Compact, rarely more open, erect to spreading low shrubs 0.2-0.6 m high, 0.3-1.2 m wide; *branches* erect to decumbent, sub-quadrangular in cross-section (flat between the leaf bases), viscid, densely pubescent in longitudinal rows with dense short patent hairs concentrated between the leaf bases, ± dense sessile glands all over, rarely hirsute with moderately dense longer, loose hairs 0.1-0.6 mm long all over; *internodes* on leafy branches (1.4-) 2.5-10.8 (-12.1) mm long.

Leaves dull light to dark green, sessile, erect, rarely appressed against stem, straight to recurved, viscid or with dense sessile (rarely stalked) glands, ± short patent hairs on the margins, rarely with sparse, long, loose hairs 0.05-0.1 or 0.3-0.4 mm long, very rarely antrorse hairs 0.2-0.3 mm long tufted at base adaxially; *lamina* conduplicate, flat to near-terete in cross section but the margins free, oblanceolate, very rarely linear, (2.5-) 2.8-10.5 (-12.5) mm long, 0.4-1.0 mm wide, the length to width ratio (4.5-) 5.7-16.3 (-19.8), the widest point 0.76-0.93 of the entire length; *base* straight; *apex* acute to sub-rounded, straight to recurved; *venation*: indistinct.

Inflorescence of 1-2 (-5) flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* 0.8-2.0 mm long, viscid, ± glandular hairs, ± pubescent with moderately dense to dense short to medium length patent hairs 0.1-0.2 mm long; *bracteole pairs* inserted near the mid-point of the pedicel at a point 0.40-0.71 times the length, erect, much shorter than the calyx, narrowly elliptic, rarely elliptic, lanceolate, or oblanceolate, (0.8-) 1.5-2.5 mm long, 0.2-0.4 (-0.8) mm wide, the length to width ratio (1.6-) 3.0-8.3 (-10.0), with moderately dense loose hairs 0.05-0.3 (-0.7) mm long, mainly on the margins, ± stalked or sessile glands, the margins loosely folded, rarely flat, the base cuneate, rarely attenuate to long-attenuate, the apex acute, rarely apiculate.

Calyx more or less actinomorphic but the lips slightly separated and the median adaxial lobe slightly enlarged, with dense stalked glands, very rarely just viscid, usually with sparse (rarely moderately dense to dense) mixed-length hairs 0.1-0.7 (-1.0) mm long; *tube* ± finely longitudinally ribbed, shallowly to widely obdeltate, 2.2-3.4 mm long, 2.0-3.2 mm wide, the length to width ratio 0.8-1.2, the base rounded, the interior with sparse to moderately dense antrorse appressed hairs 0.1-1.4 mm long, becoming glabrous proximally; *lobes* straight, triangular, rarely widely deltate to deltate, shorter than or equal to the tube, 0.33-0.50 times the entire calyx length, (1.0-) 1.5-2.7 mm long, 0.7-1.8 mm wide at base, the length to width ratio 1.00-2.90, the margins straight, rarely convex, the apex acute, rarely acuminate, the interior with moderately dense antrorse (rarely randomly orientated) appressed hairs 0.1-1.4 mm long, ± sparse sessile or stalked glands apically.

Corolla (6.5-) 7.5-16.8 mm long, mauve or purple, lower throat and base of the medain abaxial lobe white with purple dots, brown dots on sides of throat, base of tuhe white; *exterior surface* with loose moderately dense hairs 0.1-0.3 (-0.4) mm long, rarely near-glabrous, ± sparse sessile glands; *interior surface* with sparse hairs on the lobes or glabrous, but the lower throat densely bearded between the stamens with hairs 0.3-0.5 mm long; *tube* funnel-shaped, 4.5-9.0 (-10.3) mm long, exceeding the calyx, (3.0-) 3.5-6.5 (-7.5) mm wide at mouth; *abaxial median lobe* variable: widely depressed obovate, widely flabellate, deltate to shallowly obdeltate, or abruptly spathulate, the stalk transversely oblong, the blade transversely elliptic, (1.4-) 2.7-6.1 mm long, (3.0-) 4.2-7.1 mm wide, the length to width ratio 0.7-1.2, the margin ± slightly undulate, ± unevenly crenate to dentate, the apex truncate or rounded, the sinus 0.5-2.7 mm long; *lateral lobes* oblong-elliptic to transversely elliptic-oblong, or obovate to very widely obovate, rarely widely depressed ovate (1.3-) 1.9-4.5 (-5.5) mm long, 2.1-3.7 mm wide, the length to width ratio 0.60-1.80, the margin entire, rarely slightly undulate or slightly broadly crenate, the apex rounded, the sinus 0.0-1.0 mm long; *adaxial median lobe-pair*

transversely widely oblong, transversely elliptic, or depressed ovate, rarely widely obovate (1.7-) 2.5-5.2 (-5.8) mm long, 3.0-7.4 mm wide, the length to width ratio 0.5-0.9 (-1.3), emarginate with sinus 0.9-2.4 mm long, the margin broadly crenate or entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.1-5.2 mm from base of corolla, white, 1.8-3.7 mm long, glabrous, *theca* purple, 0.6-0.8 mm long, glabrous, the *connective* white tinged purple, 1.1-2.4 mm long, glabrous, but the sterile end with a dense, compact tufted beard, the hairs linear-narrow triangular, 0.1-0.2 mm long, rarely the beard undeveloped and a second much smaller theca present, very rarely sparse beard hairs extending along the connective; *abaxial pair* with *filaments* inserted 2.7-6.8 mm from base of corolla, white, 1.5-5.9 mm long, glabrous, *fertile theca* purple, 0.7-0.9 mm long, glabrous, the *connective* white tinged purple, 1.4-2.2 mm long, bearing a second smaller theca, glabrous.

Ovary 0.9-1.8 mm long, 0.7-1.4 mm wide, the length to width ratio 1.1-1.5, the style 6.6-11.1 mm long, glabrous, the stigma lobes (0.2-) 0.3-0.8 (-1.2) mm long. *Mericarps* light (rarely dark) brown, ovoidal, reticulate, 1.7-2.1 mm long, 1.0-1.2 mm wide, the length to width ratio 1.50-1.90, the attachment scar 0.9-1.5 mm long, 0.53-0.66 times the entire mericarp length, glabrous.

Flowers recorded: April, September to December.

Ecology: Occurs mainly on red and yellow gravelly, sandy or clayey soils in open scrub or shrubland, often in association with *Eucalyptus* and *Acacia*. Favours disturbed habitats such as roadsides and gravel pits.

Notes: the northern populations of this species tend to have shorter leaves which are nearly appressed against the stem, giving the plant a distinctive appearance. However, the variation is not significant as there are no other differences and the populations are mixed with more typical individuals.

See notes for *H. ciliata* regarding the affinities of this species.

Selected specimens examined (ca. 30 seen): Western Australia: *Greg Guerin* 146 *& Penny McLachlan*, 28.x.2003, Gravel pit on Lake Seabrook-Yellowdine Rd, ca. 7.7 km S. of vermin fence on W. side (AD [not databased], PERTH, CANB); *D. J. Edinger* 1734, 20.iv.2000, Diemals, S boundary fence on track N to Mount Elvire (PERTH 05729475); *R.J. Cranfield* 11810, 4.xii.1997, 3 km SW of Lake Julia (PERTH 04982274); *N. Gibson & M. Lyons* 2623, 18.x.1996, On west side of track, ca. 4km W of Landing Ground, c. 11.5 km NE of Barcooting Hill, Ennuin Station [Plot KNOLL02] (PERTH 05271800); *K. Newbey* 9584, 23.ix.1982, 0.5 km N of Ennuin Tank, ca. 30 km NW of Bullfinch (PERTH 05481228, PERTH 03516822, MEL 1546987); *G.J. Keighery* 4369, 25.xi.1981, 40 km SSE of Mt. Jackson homestead (CANB 348601, PERTH 4369); *Corrick, M.G.* 9117, 30.ix.1984, 11 km east of Riverina H.S. on rad to Menzies (MEL 670438, AD 136408); *R. Cranfield, P. Spencer* 7725, ?-.ix.1989, 1.5 km SW of Vermin Proof Fence, Ennuin Stn (PERTH 03674789); *A.V. Milewski* AVM21, s.dat., 3 km NE of Comet Vale townsite and 1.5 km NW of edge of Lake Goongarrie (PERTH 01294121CANB 9103633); *A.V. Milewski* AVM403, s.dat., 2.5 km NE of Comet Vale townsite and 2 km NW of edge of Lake Goongarrie (PERTH 01593471); *H. Pringle* 3915, 17.ix.1993, S of Christmas Bora, Yuinmery Station (PERTH 04553772); *R.J. Cranfield* 8133, 2.x.1991, 19.5 km SE of Mt. Jackson, Bungalbin Hill track (PERTH 01693506); *B.A. Fuhrer* 97/50, 28.ix.1997, Southern Cross-Bullfinch Road, 11 km from Southern Cross (PERTH 05105846); *F. Lullfitz* 3105, 7.xii.1963, Bullfinch to Southern Cross (CANB 376141); *P. Boswell* G20, ?-.?-.1967, Cundeelee. (PERTH 03671453).

13. Hemigenia tomentosa G.R.Guerin sp. nov.

H. tysonii F.Muell. auct. non Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 94 (s.dat. [1965]) as to collections with simple hairs.

H. sp. Edah (J.W. Green 1601) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000).

H. sp. 21 Blackall & Grieve, W. Austral. Wildfl. 3B: 444 (1981);

Typus: *J.F. Taylor* JFT 33, ?-.ix.1995, 5 km N of Yuin homestead, Western Australia (holo: PERTH 04629167! - bottom left specimen; iso: PERTH 04629167! [excluding holo]).

Etymology: the epithet refers to the tomentose indumentum of all vegetative organs in this species.

Erect to spreading compact shrubs 0.25-1.0 m high, 0.4-? m wide; *branches* erect to semi-decumbent, circular in cross-section, tomentose with dense, loosely appressed antrorse hairs 0.1-0.2 mm long; *internodes* on leafy branches 1.4-6.0 mm long.

Leaves grey-green, occasionally appearing clusterd due to dense axillary growths, sessile, usually erect, straight to recurved, very densely tomentose, with loosely appressed, antrorse hairs 0.1-0.2 mm long; *lamina* mostly conduplicate (often open when subtending axillary growth), rarely all open, obovate to oblanceolate to oblong 1.4-6.7 (-12.4) mm long, 0.5-1.5

(-3.0) mm wide, the length to width ratio (1.2-) 2.2-4.7 (-5.8), the widest point 0.64-0.94 of the entire length; *base* cuneate or straight; *apex* rounded or obcordate in open leaves, usually recurved in conduplicate/folded leaves and then slightly mucronate; *venation*: indistinct, mid-rib occasionally visible.

Inflorescence of 1-6 flowering nodes with single flowers subtended by opposite leaf-like bracts; *pedicels* 0.4-1.9 mm long, densely tomentose with loosely appressed, antrorse hairs; *bracteole pairs* inserted at base of calyx to mid-point of pedicel, erect, much shorter than the calyx tube, obovate to oblanceloate or rarely near narrowly elliptic, 1.0-2.5 (-3.5) (-5.0, Trevor Brown 1) mm long, 0.6-0.9 mm wide, the length to width ratio (1.7-) 2.5-3.1 (-5.8), rarely longer and some as long or longer than the calyx tube (Trevor Brown 1), densely tomentose with simple loosely appressed antrorse hairs, flat or the margins incurved, the base cuneate or straight, the apex acute, or sub-acuminate, ± recurved.

Calyx actinomorphic with five nearly equal lobes or with the abaxial pair slightly larger, densely tomenstose with loosely appressed, antrorse hairs, rarely more glabrous,; *tube* distinctly longitudinally ribbed, obdeltate to obtriangular, (2.0-) 3.2-4.2 mm long, 1.9-3.0 (-4.0) mm wide, the length to width ratio (0.9-) 1.1-1.7, the base ± rounded, the interior with sparse, semi-appressed, antrorse hairs 0.2-0.7 mm long, more dense towards distal end ; *lobes* straight, triangular or rarely deltate ± convex margins, much shorter than tube, 0.21-0.33 times the entire calyx length, (0.6-) 1.0-1.2 (-1.9) mm long, 0.5-1.2 (-2.2) mm wide at the base, the length to width ratio (0.7-) 1.0-1.5 (-2.4), the margins straight, the apex acute or shortly acuminate, the interior moderately to densely tomentose.

Corolla (4.6-) 7.8-13.0 (-15.0) mm long, white to lilac with red-brown spots; *exterior surface* with sparse to dense randomly orientated minute to medium hairs to 0.3 mm long, usually

with denser hair on the lower lip, rarely completely glabrous; *interior surface* mostly glabrous but the upper lip often with appressed antrorse long hairs and throat with a dense tufted beard of loose patent hairs 0.2-0.3 mm long on the lower throat between the stamens; *tube* very narrow, (2.8-) 4.0-7.2 mm long exserted beyond or rarely equal to the calyx lobes, barely broadening before lips, 1.0-2.0 mm wide at mouth; *abaxial median lobe* abruptly spathulate, the stalk attenuate or rarely narrowly obtrullate, the blade flabellate, (3.1-) 3.6-4.5 (-6.9) mm long, (3.0-) 4.6-5.7 mm wide, the length to width ratio (0.6-) 0.8-1.0 (-1.2), the margin usually crenate-undulate, the apex rounded, the sinus (0.1-) 1 mm long; *lateral lobes* oblong to obovate, (1.5-) 2.0-4.4 mm long, (1.0-) 1.7-2.3 (-3.2) mm wide, the length to width ratio 1.1-2.4, the margin entire, the apex broadly rounded, the sinus usually absent, rarely to 0.3 mm; *adaxial median lobe-pair* widely oblong or rarely widely obovate, 2.5-4.5 mm long, 2.8-3.2 mm wide, the length to width ratio c. 1.20), emarginate with sinus 0.8-0.9 mm long, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.8-7.5 mm from base of corolla, 1.0-2.0 mm long, glabrous, *theca* (0.4-) 0.75-0.9 mm long, glabrous, the *connective* 0.67-1.25 mm long, terminating at the sterile end in a small densely bearded appendage of minute, triangular trichomes; *abaxial pair* with *filaments* inserted 3.0-8.2 mm from base of corolla, 0.8-1.0 mm long, glabrous or rarely with sparse hairs, *fertile theca* 0.7-0.9 mm long, glabrous, the *connective* 0.7-1.5 mm long, glabrous, tapering at sterile end, a second theca usually not visible.

Ovary 0.6-1.0 mm long, 0.5-0.9 mm wide, the length to width ratio 1.1-1.2), glabrous, the style 4.8-7.0 mm long, the stigma lobes 0.1-0.2 mm long. *Mericarps* olive-brown, ovoidal, shallowly reticulate, 2.2-2.3 mm long, 1.3-1.4 mm wide, the length to width ratio 1.6-1.7, the attachment scar c. 1.5 mm long, c. 0.7 times the entire mericarp length.

Flowers recorded: June to September.

Ecology: Occurs on red, brown and yellow sands or in rocky lateritic soil, occasionally on breakaways, in open shrubland often associating with *Acacia* and hummock grasses.

Notes: See notes for *H. tysonii*.

Other specimens examined: Western Australia: *E. Wittwer* 1256, 30.vii.1974, Payne's Find (PERTH 03674991); *A.M. Ashby* 2889, 8.vii.1969, North of Tallering Peak (AD 97121121, PERTH 03721264, MEL 598500); *K. Ashby* s.n., 24.viii.1996, s.loc., (PERTH 04663586); *R.J. Cranfield* 5231, 27.vi.1985, 3 km ESE of Murgoo Homestead from Three Mile Bore (PERTH 03721256, CANB 360459); *R. J. Cranfield* 9579, 2.vi.1995, 12km W of Muggamurra Hill, Billabalong Stn (PERTH 04344774); *S. Patrick A. Cochrane* SP 3438, 6.viii.2000, 3.8 km N of Meekatharra & 1 km W of Great Northen Highway (PERTH 05704979); *J.W. Green* 1601, 26.viii.1959, 6 miles E. of Edah (PERTH 03673774); *C.A. Gardner* s.n., 14.vii.1931, Meekatharra (PERTH 03675009); *R.J. Cranfield* 6068, 15.ix.1987, 2 km N of Anniversary Bore, Jingemarra Station (PERTH 03675033); *R.J. Cranfield* 8059, 21.xi.1992, 19km SSW of Mt. Gibson (PERTH 03048489); *J.S. Beard* 2652, 10.viii.1963, 20 miles N. from Payne's Find in mulga country (PERTH 03675270); *Trevor Brown* 1, 1.ix.1998, Adjacent to Barrambie Station Homestead, near Sandstone (PERTH 05398428); *S. Patrick et al.* 3048, 21.x.1998, Burnerbinmah Station, 1.6 km E of shearers quarters (PERTH 05407060).

14. Hemigenia dielsii (Hemsl.) C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 586 (1965); J.S. Beard, Descr. Cat. W.

Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 441 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Microcorys dielsii Hemsl. Hook. Ic. Pl. [series 4 {"t"}] 2783 (1905).

Holotype: G.H. Thiselton-Dyer s.n., ?-.x.1903, Railway between Cundendin and Dedari', Western Australia (holo: K!).

Upright, open shrubs, 0.2-1.2 m high, 0.2-0.9 m wide; *branches* erect, ± square in cross-section, with moderately dense, short antrorse hairs 0.1-0.2 mm long, or only minute patent hairs between the leaf bases; *internodes* on leafy branches 2.5-29.5 mm long.

Leaves sessile or sub-petiolate (petiole 0.6-1.5 mm long), erect, recurved, with moderately dense, short appressed antrorse hairs 0.1-0.2 mm long, becoming glabrous, rarely with minute sessile glands; *lamina* conduplicate, flat, oblanceolate, (7.0-) 8.0-29.9 (-36.1) mm long, (0.7-) 0.8-1.7 (-3.4) mm wide, the length to width ratio (5.5-) 10.0-22.5 (-37.0), the widest point 0.61-0.86 of the entire length; *base* cuneate, rarely attenuate; *apex* recurved, acute with a hardened tip, ± slightly mucronate, rarely ± truncate; *venation*: pinnate, with laterals sub-parallel.

Inflorescence of 1-7 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* (0.5-) 1.2-2.2 mm long, with dense antrorse, patent to spreading, short hairs 0.1-0.3 mm long, tending to be in longitudinal rows; *bracteole pairs* green to red, usually inserted on the distal half of the pedicel at a point 0.42-1.00 times the length, erect, shorter than the calyx tube, linear-lanceolate to linear-oblanceolate, 1.5-4.2 (-5.0) mm long, 0.2-0.5 (-0.7) mm wide,

the length to width ratio 5.40-14.0 (-17.3), with dense spreading hairs 0.1-0.3 mm long all over, the margins flat, the base straight, the apex acute.

Calyx actinomorphic or the lobes slightly unequal, with dense, short, usually antrorse hairs 0.1-0.2 mm long all over and a dense tuft of patent to spreading multicellular hairs 0.3-0.5 mm long concentrated distally on the tube and basally on the lobes, sometimes viscid or with small sessile glands; *tube* smooth or with five ribs, widely to shallowly obdeltate, 2.6-3.9 (-4.6) mm long, 2.5-4.5 mm wide, the length to width ratio 0.70-1.30, the base cuneate, the interior glabrous or with sparse, appressed, antrorse hairs 0.1 mm long; *lobes* straight, triangular to narrowly triangular, usually slightly longer than tube, (0.40-) 0.47-0.70 times the entire calyx length, (2.0-) 3.2-5.3 (-6.5) mm long, 1.0-1.8 mm wide, the length to width ratio 1.70-5.00, green with maroon tinge, the margins straight, the apex acuminate or acute, the interior with sparse, appressed, antrorse hairs 0.1 mm long.

Corolla 10.1-20.9 mm long, white with brown or purple spots on throat and base of median abaxial lobe, ± purple streaks on sides of throat, rarely pale mauve; *exterior surface* with short to long, sparse to moderately dense, spreading, curved hairs 0.1-0.6 mm long; *interior surface* with a dense, compact beard of hairs 0.2-0.5 mm long on the lower throat between the stamens, otherwise mostly glabrous but with short, appressed hairs 0.1-0.3 mm long on the base of the lobes; *tube* funnel-shaped, 5.6-9.6 mm long, exceeding the calyx, 4.3-9.0 mm wide at mouth; *median abaxial lobe* abruptly spathulate, the stalk square to oblong, the blade transversely oblong-elliptic to circular-square, rarely widely depressed trullate or shallowly obdeltate, or very rarely the entire lobe obovate, (3.8-) 4.3-10.2 mm long, 4.0-7.4 (-8.4) mm wide, the length to width ratio 0.70-1.50, the margin deeply unevenly crenate-dentate ± undulate, the apex truncate, the sinus 0.6-1.8 mm long, rarely absent; *lateral lobes* obovate to very widely obovate, oblong or ovate, rarely obtrullate, 3.0-8.0 mm long, (2.0-) 2.5-5.5 mm

wide, the length to width ratio (0.8-) 1.1-2.0, the margin ± crenate, ± undulate, or nearly entire, the apex truncate or rounded, the sinus 0.0-1.1 (-1.5) mm long; *adaxial median lobe-pair* obovate to widely depressed obovate or transversely elliptic, (2.7-) 3.7-8.6 mm long, (3.0-) 4.0-6.7 (-8.3) mm wide, the length to width ratio 0.70-1.50, emarginate with sinus (0.7-) 1.0-3.5 mm deep, the margin crenate ± unevenly dentate, rarely nearly entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 3.0-5.4 mm from base of corolla, white ± tinged yellow, 1.6-4.0 mm long, glabrous, *theca* brown, mauve or pink, 0.8-1.2 mm long, glabrous, the *connective* white ± tinged purple, 1.4-2.1 mm long, glabrous, the sterile end with a sparse beard of hairs c. 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted 3.2-6.0 mm from base of corolla, white ± tinged yellow, 2.2-5.0 mm long, glabrous, *fertile theca* brown, mauve or pink, 0.7-1.3 mm long, glabrous, the *connective* white ± tinged purple, 1.4-2.0 mm long, glabrous, bearing a smaller second theca.

Ovary 1.0-1.5 mm long, 0.8-1.5 mm wide, the length to width ratio 1.00-1.40, with short tufted hairs 0.1 mm long at the apex, the style white ± tinged yellow, 8.5-13.5 mm long, the stigma lobes 0.2-0.8 mm long. *Mericarps* usually dark brown, spheroidal, ± shallowly ribbed, 1.3-1.7 mm long, 1.0-1.4 mm wide, the length to width ratio 1.20-1.50, the attachment scar 0.6-0.8 mm long, 0.40-0.53 times the entire mericarp length, with a tuft of hairs 0.1-0.2 mm long at the apex.

Flowers recorded: August to November.

Ecology: Occurs principally on yellow sand in shrubland dominated by *Acacia*, *Casuarina*, *Eucalyptus* and *Hakea*, but also on brown sand, sand over laterite and granitic sand. It favours disturbed sites such as road verges.

Selected specimens examined (ca. 70 seen): Western Australia: *Greg Guerin* 137 *& Penny McLachlan*, 27.x.2003, 4.0 km along Scott Rd from Bulls Head rd, on both sides of road (AD [not databased], PERTH, CANB); *Greg Guerin* 140 *& Penny McLachlan*, 27.x.2003, 7.0 km along Cramphorne Rd from Merredin-Narembeen Rd on both roadsides (AD [not databased], PERTH only); *B.J. Conn* 2231, 18.ix.1985, No. 2 Rabbit Proof Fence road junction with Cadoux-Koorda Rd (MEL 693218); *Smith, B.H.* 1819, 22.x.1995, 7.02 miles E of No. 1 Rabbit fence on track to Clamptom (MEL 2082922); *Smith, B.H.* 1793, 2.ix.1995, 6.9 miles E of No. 1 Rabbit fence on track to Clampton (MEL 2082923); *M.G. Corrick* 7781, 14.x.1981, 6 km west of Koorda, on road to Cadoux (MEL 605798, PERTH 03670651); *C.A. Gardner* s.n., s.dat., Ca 13 km W of Lake Cronin (PERTH 04861523); *K. Newbey* 6627, 3.xi.1979, 15 km W. of Lake Croni, ca 70 km E. of Hyden (PERTH 03324419); *F. Lullfitz* L3829, 24.xi.1964, 35 mls east of Hyden (PERTH 03670775); *M.E. Phillips* s.n., 10.ix.1968, 40 miles W. of Southern Cross (PERTH 03670856, CANB 027716); *R. Storer* 228, 29.ix.1998, Koorda-Mollerin Road (PERTH 05421314); *C. Stacey* 238, 16.xi.1972, 12.6 miles E of Mukinbudin (PERTH 03670767, PERTH 01651684); *R.J. Cranfield* 10520, 16.x.1995, 49km E of Hyden (PERTH 04411757); *A.M. Ashby* 4952, 2.xi.1973, West of Southern Cross (near Nulla Nulla) (AD 97422183); *S.B. Rosier* 384, 27.x.1963, North of Gabbin (PERTH 03670597).

15. Hemigenia botryphylla G.R.Guerin sp. nov.

H. sp. Jibberding (J.D'Alonzo 418) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. (2000). *H. sp. Pindar (H. Demarz 7428)* Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. (2000).

Typus: *A.M. Ashby* 5396, 4.ix.1976, Pindar. Ca. 120 km north-east of Geraldton, Western Australia (holo: MEL 1554147! ("Sheet 2 of 2") - upper right specimen; iso MEL 1554147! [excluding holo]; MEL 1554172! ("Sheet 1 of 2"); MEL 302587!).

Etymology: the epithet refers to the axillary growths common in this species which give it the appearance of having bunched leaves.

Low, spreading or rarely erect compact shrubs 0.15-0.6 (-1.2) m high, 0.3-1.2 m wide; *branches* spinescent with short perpendicular to erect lateral shoots, erect to semi-decumbent, circular to sub-quadrangular in cross-section, glabrous to densely hairy with antrorse, patent or retrorse hairs 0.3-1.0 mm long, continuous or in loose longitundinal rows; *internodes* on leafy branches 2.0-9.1 mm.

Leaves dark green, usually appearing clustered due to dense axillary growths, sessile, erect, straight or rarely recurved, glabrous or sparsely covered by curved, antrorse to retrorse hairs 0.1-0.2 mm long, the margins rarely with minute blunt cilia; *lamina* closely conduplicate ± conjoined, rarely open, obovate to oblanceolate, vary rarely odd leaves ovate, (1.2-) 2.3-8.9 (-13.2) mm long, 0.4-1.5 (-5.2) mm wide, the length to width ratio 1.50-13.6 (-22.3), the widest point 0.81-0.96 of the entire length; *base* cuneate or attenuate; *apex* rounded, obcordate in open leaves, strongly recurved and slightly mucronate in conduplicate leaves; *venation*: indistinct, mid-rib occasionally visible.

Inflorescence of 1 (-4) flowering nodes with single flowers subtended by opposite leaf-like bracts; *pedicels* 0.7-1.2 mm long, densely covered by antrorse, patent or retrorse hairs 0.1 mm long (or a mixture, giving scruffy appearance); *bracteole pairs* inserted usually either at base of pedicel or at the half way point, rarely to 0.9 the length of the pedicel, erect (held against pedicel), usually much shorter than calyx tube, narrowly elliptic, very rarely oblanceolate or lanceolate, (0.6-) 0.9-2.5 (-3.2) mm long, 0.15-0.35 (-0.9) mm wide, the length to width ratio 3.0-6.7 (-10.0), the margins strongly inrolled/incurved, ciliate with hairs 0.1 mm long, decreasing in length towards the apex, sometimes with sparse hairs on the abaxial surface, the base straight, the apex acute.

Calyx actinomorphic with five more or less equal lobes, glabrous or with sparsely, rarely moderately, dense retrorse (rarely appressed) or patent long hairs 0.3-1.0 mm long, very rarely with sparse white waxy deposits/trichomes on the tube; *tube* distinctly longitudinally ribbed, widely obdeltate to obtriangular (2.0-) 2.4-4.3 mm long, (1.2-) 1.8-2.5 (-4.0) mm wide, the length to width ratio (0.7-) 1.1-1.4 (-2.1), the base rounded, the interior with sparse to moderately dense, semi-appressed antrorse long hairs 0.7-1.3 mm long; *lobes* straight, deltate to triangular, shorter than tube, 0.27-0.43 times the entire calyx length, (0.6-)1.2-2.0 mm long, (0.5-) 0.7-1.1 (-2.4) mm wide at base, the length to width ratio 0.8-1.6 (-2.6), the margins straight, the apex acute or acuminate, the interior with moderately dense to dense, semi-appressed, antrorse long hairs 0.7-1.3 mm long increasing in density towards apex.

Corolla (4.6-) 7.0-10.0 (-14.0) mm long, white or sometimes mauve-pale mauve with red spots in the throat; *exterior surface* glabrous to sparsely hairy with hairs 0.1-0.2 mm long; *interior surface* mostly glabrous but the upper lip sometimes with sparse tufts of patent hair and the throat with a dense tufted beard of loose patent hairs (0.2-) 0.3-0.4 mm long on the lower throat between the stamens; *tube* narrow, 3.0-6.7 mm long, exserted beyond calyx

lobes, broadening only slightly before lips, 0.8-2.2 mm wide at mouth; *abaxial median lobe* shape variable: obovate, flabellate or abruptly spathulate (the stalk oblong, the blade obdeltate or widely obtrullate with rounded corners), (1.5-) 2.1-3.8 (-5.4) mm long, (1.8-) 2.1-4.0 (-5.0) mm wide, the length to width ratio 0.6-1.5, the margin unevenly moderately crenate, the apex rounded or rarely truncate, the sinus acute 0-0.6 (-1.5) mm long; *lateral lobes* obovate or oblong, rarely ovate or widely ovate (1.3-) 2.0-3.8 (-4.5) mm long, (1.2-) 1.8-2.9 (-3.4) mm wide, the length to width ratio (0.6-) 1.1-2.3, the margin sometimes with minute transluscent cilia, the apex rounded and entire, the sinus 0-0.6 (-1.5) mm long; *adaxial median lobe-pair* widely oblong/oblong to obovate, 2.0-3.2 (-5.5) mm long, 1.7-2.5 (-4.9) mm wide, the length to width ratio 1.0-1.3, emarginate with sinus (0.9-) 1.1-1.5 (-1.9) mm long, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.8-4.7 mm from base of corolla, 1.0-1.7 mm long, glabrous or very rarely with sparse loose hairs c. 0.7 mm long, *theca* 0.5-0.7 mm long, the *connective* 0.5-0.9 (-1.0) mm long, terminating at sterile end in a small, sparsely bearded appendage with trichomes 0.05-0.1 mm long; *abaxial pair* with *filaments* inserted 3.8-5.5 mm from base of corolla, 1.4-1.8 mm long, glabrous or very rarely with sparse loose hairs c. 0.5-1.0 mm long, *fertile theca* 0.6-0.8 mm long, the *connective* 0.9-1.3 mm long, glabrous, tapering at the sterile end or rarely ending in a second smaller theca, very rarely with minute trichomes resembling those of the beard of the adaxial stamens.

Ovary 0.7-1.0 mm long, 0.5-0.9 mm wide, the length to width ratio 1.0-1.4, glabrous, the style 3.8-6.5 mm long, the stigma lobes c. 0.2 mm long. *Mericarps* light brown, ovoidal, shallowly reticulate, 1.1-1.7 mm long, 0.6-0.9 mm wide, the length to width ratio 1.8-1.9, the attachment scar c. 1.4 mm long, 0.7-0.8 times the entire mericarp lenth, glabrous.

Flowers recorded: July to November.

Ecology. Occurs in red (rarely yellow) sand plains , typically in open shrubland or grassland associated with *Acacia* and hummock grasses.

Notes: See notes under *H. tysonii* regarding the affinities of this species. There is some geographic variation in this species. Specimens from the immediate Pindar area tend to to have smaller leaves and more compact habit and populations further inland tend to have a retrorse indumentum but there is no close correlation between variable characters and the variation is not considered taxonomically significant.

Selected other specimens examined (ca. 35 seen): Western Australia: *M. Officer* MO 119, 15.viii.1996, Pindan Paddock, 16 km NW of Woolgorong Homestead (PERTH 04664647); *J.Z. Weber* 5147, 16.x.1975, Ca. 15 km north of Morawa. Ca. 1 km south of Pintharuka Railway Siding (MEL 302556); *M.E. Phillips* WA/68 1337, 20.ix.1968, 3 ml. from Mullewa, W.A. towards Pindar (CANB 042696); *N. Forde* 1381, ?-.?-.1960?, s.loc., (CANB 261540); *H. Pringle* 395, 24.ix.1993, 1 km N of Quartz Dam, Lake Barlee Station (PERTH 04453077); *B.H. Smith* 1519, 17.ix.1991, 35.27 miles S of Youanmi, towards Lake Barlee (MEL 2011052, PERTH 02795264); *M. Hislop* 562, 15.ix.1996, In remnant vegetation bordering Black Road between Glamoff and Lehmann Roads in locailty of Goodlands, ca 65 km NE of Kalannie (PERTH 05050316); *E.A. Shaw* 633, 4.x.1966, Ca. 15 km east of Mullewa (AD 96832255); *J. D'Alonzo* 418, 21.ix.1985, Jibberding Reserve, 24.4km +/- NE of Wubin along the Great Northern Highway (PERTH 03633896); *H. Demarz* D7428, 22.viii.1979, 1 km E of Pindar (PERTH 03671518); *C.A. Gardner* 7544, 29.viii.1943, N of Tardun (PERTH 04353817); *S. Patrick* SP 2860, 12.xi.1996, 1.5 km E of Pindar (PERTH 04646800); *G. Flowers* 137 *& S. Donaldson*, 31.viii.1997, 57 km N of Cleary towards Payne's Find on

Maroubra Road (PERTH 05398525, CBG 9709012); *H. Pringle* 2485, 25.viii.1989, Mt. Weld Station (PERTH 01115774); *M. Hudson & K. Stratford* 2982, 20.vii.1997, Site 12, Marshall Pool, 70 km N of Leonora (PERTH 05061075).

16. Hemigenia teretiuscula F.Muell. Fragm. 6: 111 (1868); Benth. Fl. Austral. 5: 118 (1870); Engl. & Prantl., Nat. Pflanzenfam. 3A: 219 (1897); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, W. Austral. Wildfl. 3: 586 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl. 94 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 443 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000).

H. eutaxioides CRP Andrews Jour. W.A. Nat. His. Soc. i. 42 (1904); C.A.Gardner Enum. Pl. Austral. Occ. 113 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 582 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 437 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000). Type: C. Andrews s.n., ?-.x.1903, "S of Norseman", Western Australia (syn: PERTH 03671860!, NSW 217069!).

H. brachyphylla auct. non Corrick *et al.*, Wildfl. S. W. Austral. 89 (1996).

Lectotype (here chosen): Maxwell, East River Stoke's Inlet' Western Australia (lecto: MEL 646664!; isolecto: Maxwell, Stoke's Inlet, Western Australia - K!; syntype not lectotype: Maxwell, Kydenup Range, Western Australia - MEL 646665!).

Slender open shrubs, rarely broader and compact, (0.15-) 0.3-0.6 (-0.8) m high, 0.3 (-0.8) m wide*; branches* erect to steeply ascending, rarely semi-decumbent, sharply angled to nearly

circular in cross-section, glabrous or puberulent with rows of dense, minute, patent hairs; *internodes* on leafy branches (1.7-) 5.0-9.5 (-15.0) mm long.

Leaves sessile, usually erect, straight, glabrous; *lamina* terete (margins fused into an adaxial groove), linear to oblanceolate, (3.0-) 5.0-10.0 (-20.3) mm long, (0.3-) 0.5-0.8 (-1.6) mm wide, the length to width ratio (3.6-) 10.0-12.9 (-25.1), the widest point 0.55-0.82 entire length; *base* straight; *apex* acute to rounded ± mucronate; *venation*: not visible.

Inflorescence of 1-2 (-4) flowering nodes with single flowers at each axil subtended by opposite leaf-like bracts; *pedicels* 0.7-1.5 mm long, very densely puberulent with minute patent hairs, generally restricted to longitudinal rows, or rarely glabrous; *bracteole pairs* inserted from a point (0.55-) 0.60 times the length of pedicel to just below calyx, erect, much shorter than the calyx tube, narrowly oblong-linear, (0.7-) 1.0-1.2 (-1.4) mm long, 0.1-0.2 mm wide, the length to width ratio 5.0-7.0, the margins strongly incurved, densely long-ciliate with hairs 0.2 mm long, the base straight, the apex acute to rounded.

Calyx actinomorphic with five equal lobes, green, glabrous; *tube* usually smooth, rarely the basal half longitudinally ribbed, the distal half rough and warty in appearance, shallowly deltate, ± convex margins, (2.2-) 2.7-4.0 mm long, 2.1-3.4 (-4.5) mm wide, the length to width ratio 0.8-0.9; *lobes* straight, abruptly long-acuminate from a shallowly triangular base, shorter than tube, 0.23-0.38 times the entire calyx length, (0.7-) 1.2-2.0 (-2.7) mm long, (0.9-) 1.1-1.6 (-2.0) mm wide at base, the length to width ratio 0.31-0.81 (-2.0), the margins straight, the apex acute, the interior densely pubescent (sometimes the hairs confined to margins) with hairs c. 0.1 mm long.

Corolla (5.0-) 7.0-12.0 (-17.0) mm long, blue to purple or pink, rarely white, inner and outer surface of lower throat white usually with brown, sometimes purple, red or orange spots; *exterior surface* glabrous or very rarely with sparse, patent or loosely appressed minute hairs (mostly on the adaxial side); *inner surface* mostly glabrous but with a dense tufted beard of loose patent hairs c. 0.5 mm long on the lower throat between the stamens; *tube* funnel shape, 4.7-6.5 mm long, exserted beyond calyx lobes, (2.0-) 3.5-4.5 (-10.0) mm wide at mouth; *abaxial median lobe* abruptly spathulate, the stalk oblong or narrowly obtrullate-obtrullate, the blade orbicular to widely obtrullate, rarely widely rhombic, 3.1-4.2 (-4.8) mm long, (3.3-) 4.9-6.7 mm wide, the length to width ratio 0.84-0.95 (-1.1), the margin moderately crenate to entire, the apex rounded to obtuse, the sinus 0.7-0.9 (-2.0) mm long, rarely absent; *lateral lobes* orbicular to oblong, rarely obtrullate, 1.5-4.7 mm long, 1.5-4.9 mm wide, the length to width ratio (0.91-) 1.0-1.4 (-2.0), the margin entire, the apex broadly rounded, the sinus usually absent, rarely to 0.3 (-1.5) mm long; *adaxial median lobe-pair* oblong, 2.8-6.2 mm long, 3.5-5.0 mm wide, the length to width ratio (1.1-) 1.5-1.6, emarginate with sinus 1.5-2.1 mm long, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.0-4.0 mm from base of corolla, white, 1.1-2.5 (-4.5) mm long, glabrous, *theca* brown, 0.7-1.1 mm long, glabrous, the *connective* white, 0.6-1.25 mm long, teminating at sterile end in a bearded appendage of moderately dense triangular trichomes c. 0.1 mm long; *abaxial pair* with *filaments* inserted 2.5-4.7 (-5.0) mm from base of corolla, white, 1.0-2.0 (-4.5) mm long, glabrous, *fertile theca* brown, 0.6-1.0 mm long, the *connective* white, 1.0-1.25 mm long, terminating at sterile end in a second, smaller theca.

Ovary 0.8-0.9 (-1.5) mm long, 0.8-1.5 wide, the length to width ratio (0.6-) 1.0-1.3, glabrous, the style 4.8-11.6 mm long, the stigma lobes 0.25-0.4 (-0.9) mm long. *Mericarps* brown,

ovoidal, reticulate, c. 1.5 mm long, 0.9 mm wide, the length to width ratio c. 1.7, the attachment scar c. 0.8 mm long, 0.54 times the entire mericarp length, with sparse, flattened trichomes 0.1 mm long in the deep lacunae.

Flowers recorded: January to May, July to December.

Ecology: Occurs in small to large populations in a variety of well-drained sandy or gravelly soils, often on gentle slopes or near disturbed areas, associating with mallee and heath communities.

Selected specimens examined (ca. 110 seen): Western Australia: *Greg Guerin* 81 *& Penny McLachlan*, 12.x.2003, Norseman to Hyden Rd, 76 km west of Norseman, Gravel Pit no. 5 (left side of Rd) (AD [not databased], PERTH, CANB); *Greg Guerin* 82 *& Penny McLachlan*, 12.x.2003, Ca. 82 km E of Norseman on Rd to Hyden, S. side of road on margin of granite hill, by track (AD [not databased], PERTH only); *Greg Guerin* 84 *& Penny McLachlan*, 12.x.2003, 8 km W. along Hyden to Norseman rd past road to McDermid Rock (AD [not databased]); Lake King, C.A. Gardner 2930, 24.xi.1931, (PERTH 03673650, PERTH 03673847); ca. 17 km north-north-west of Young River crossing on Ravensthorpe-Esperance main road, N.N. Donner 2794, 27.ix.1968, PERTH (03673758), AD (97118061); 24.5 km due E of Muckinwobert Rock, M.A. Bungman & S. McNee MAB2691, 3.x.1983, PERTH (03673693); Between Esperance and Ravensthorpe, 26.8 km west of Oldfield River along highway 1, R. Spjut, G. White, R. Phillips & L. Lacy 7327, 3.x.1981, PERTH (03673863); 37 km SW of Ravensthorpe WA, K. Newbey 10842, 23.x.1984, PERTH (03556824); Ravensthorpe Range, WA, A. Sanders AS 26, 16.vii.1998, PERTH (05267897); 17 km W of Lake King, R.J. Cranfield 10611, 19.x.1995, PERTH (04414063); 58 km SW of Norseman, R.J. Cranfield 10225, 20.viii.1995, PERTH (04393279); 5.4 km WNW of Thomas

Road on Aerodrome Road, ca 18 km WNW of Ravensthorpe WA, B.J. Lepschi & B.A. Fuhrer BJL 3749, 27.x.1997, PERTH (04987489); Between West River and Old Ongerup road on Ravensthorpe road WA, E.J. Croxford 5744, 28.x.1988, PERTH (03758435); ca. 115.7 km E. of Lake King, R.J. Hnatiuk 760862, 18.ix.1976, PERTH (03673669); 1/2 mi. south of Lake King, W.A., F. Lullfitz 5533, 6.x.1966, PERTH (03673731); Oldfield River, C.A. Gardner 12902, 20.x.1960, PERTH (036735499/03673871 (dup.)); Western Australia: 278 mi (445 km) by road SE of Perth & W of Lake, E. of Lake Grace, F. Lullfitz 5548, 8.x.1966, PERTH (03673642); 74 km W of Kumarl, which is ca. 122 km N of Esperance, P.G. Wilson 5709, 10.x.1966, PERTH (03728366).

17. Hemigenia scabra Benth. Flora Australiensis Vol. 5. Myoporinae to Proteaceae, London 1870; Engl. & Prantl., Nat. Pflanzenfam. 3A: 219 (1897); Diels in Engl. Bot. Jahrb. 35: 528 (1905); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 584 (1965). J.S. Beard, Descr. Cat. W. Austral. Pl.: 94 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 440 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000).

Lectotype (here chosen): Drummond, W. Australia., Western Australia (lecto: K! - far right specimen; isolecto: K! [excluding lectotype], MEL 646641!, MEL 646642!).

Upright to sprawling, open to compact shrubs or sub-shrubs, 0.3-1.2 m high, 0.3-1.5 m wide; *branches* erect to semi-decumbent, ± circular to flattened or sub-quadrangular in cross-section, hispid-hispidulous with sparse to moderately dense, medium-long, patent, randomly bent hairs 0.2-0.7 mm long, or densely puberulent in longitudinal rows with short patent hairs c. 0.1 mm long, with or without sparse to moderately dense stalked glands; *internodes* on leafy branches (2.9-) 4.4-15.8 mm long.

Leaves sessile, very rarley sub-petiolate (petiole to 0.5 mm long), erect to patent, straight, scabrous, sparsely to densely hispid with thick, randomly bent hairs 0.1-0.6 mm long, at least at first, with or without sparse stalked glands or viscid; *lamina* open, flat, oblong-elliptic to oblanceolate or spathulate, (4.3-) 5.7-16.9 (-27.9) mm long, (1.1-) 2.8-6.5 (-9.3) mm wide, the length to width ratio (1.40-) 1.82-5.40, the widest point 0.50-1.00 of the entire length; *apex* obtuse, truncate or rounded; *base* long-cuneate or tapering; *venation*: the mid-rib is distinct.

Inflorescence of 1-5 (-c. 10) flowering nodes with single flowers subtended by leaf-like bracts, often in a contracted or non-contracted terminal or sub-terminal raceme subtended by differentiated bracts (bracts elliptic-oblong, rarley slightly obovate, flat or the margins incurved, (1.4-) 2.0-4.1 mm long, (0.5-) 1.3-3.0 mm wide, the length to width ratio 1.11-4.33 (-5.00), usually nearly glabrous or sparsely hisid with hairs c. 0.2-0.3 mm long, the terminal contracted racemes sometimes with the appearance of a terminal head; *pedicels* (0.9-) 1.2-2.5 mm long, moderately hispid-hispidulous with hairs 0.1-0.5 mm long, ± sparse stalked glands; *bracteole pairs* inserted on the distal half of the pedicel at a point 0.50-0.90 times the length, erect, longer than the calyx tube, oblanceolate or rarely narrowly elliptic, (2.4-) 3.3-5.6 mm long, (0.4-) 0.5-1.0 (-1.5) mm wide, the length to width ratio 2.73-9.33, hispid, especially on the margins, with sparse to dense spreading hairs 0.2-0.5 mm long, the margins flat or incurved, the adaxial surface ± glabrous, the apex acute or acuminate, the base (± long-) attenuate.

Calyx actinomorphic or the lobes slightly unequal, the abaxial lobes slightly divided from the adaxial lobes, sparsely to densely hispid with medium-long, patent to spreading, usually bent hairs 0.1-0.4 (-1.5) mm long all over, and sparse stalked glands, or the lobes more glabrous, with hairs concentrated near the margins; *tube* with numerous, fine, longitudinal ridges,

shallowly obdeltate to obdeltate, 2.0-4.0 mm long, 2.0-5.3 mm wide, the length to width ratio 0.68-1.03, the base rounded, the interior glabrous or with sparse sessile glands; *lobes* straight, triangular or rarely widely deltate, slightly shorter than, or approximately equal in length to the tube, 0.38-0.54 times the entire calyx length, 2.0-3.1 (-3.5) mm long, 1.2-2.0 mm wide, the length to width ratio 1.60-2.08 (-2.42), the margins straight, the apex acuminate or acute, the interior ± glabrous or with some stalked glands near the margins, or with sparse spreading hairs 0.3-0.7 mm long mostly near the margins.

Corolla 5.5-9.5 mm long, white to pale mauve, base of lobes and throat streaked pink to purple, with purple to brown dots leading into throat, throat yellowish; *exterior surface* moderately to densely hairy with non-appressed spreading to antrorse hairs 0.1-0.3 mm long; *interior surface* with a dense, compact beard of hairs 0.3-0.5 (-0.7) mm long on the lower throat between the stamens, usually also with shorter hairs leading onto the base of the lower lobes; *tube* oblong or indistinctly funnel-shaped, (1.8-) 3.3-5.8 mm long, shorter than the calyx lobes, or rarely slightly longer, (1.5-) 2.0-3.0 mm wide at mouth; *median abaxial lobe* flabellate, obdeltate or abruptly spathulate, the stalk transversely oblong or obdeltate, the blade oblate to transversely elliptic, (1.5-) 2.5-6.3 mm long, 2.1-6.1 mm wide, the length to width ratio (0.71-) 0.80-1.14, the margin ± entire or (± indistinctly) crenate-dentate, the apex rounded or truncate, the sinus 0.2-2.4 mm long or absent; *lateral lobes* oblong or obovate, (1.9-) 2.3-6.4 mm long, 1.3-3.9 mm wide, the length to width ratio 1.03-2.54, the margin entire, the apex rounded or truncate, the sinus absent; *adaxial median lobe-pair* transversely oblong, ± square-circular, or very widely obovate, (1.8-) 2.0-5.7 mm long, (1.5-) 2.6-6.0 mm wide, the length to width ratio 0.71-1.21 (-1.36), emarginate with sinus 0.5-2.9 mm deep, the margin entire, rarely slightly undulate, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted (1.8-) 2.6-3.7 mm from base of corolla, 0.7-2.1 mm long, glabrous, *theca* (0.5-) 0.7-0.8 mm long, glabrous, the *connective* 0.7-1.6 mm long, glabrous, the sterile end with a sparse to dense tuft of hairs 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted (2.3-) 3.0-4.4 mm from base of corolla, 0.8-2.6 mm long, glabrous, *fertile theca* (0.4-) 0.8-1.0 mm long, glabrous, the *connective* 0.5-1.1 mm long, glabrous, the lower end bearing a second much smaller to quite large theca, very rarely sterile and with a sparse tuft of hairs 0.1 mm long similar to the adaxial stamens.

Ovary 0.8-1.1 (-1.6) mm long, (0.6-) 0.8-1.0 (-1.9) mm wide, the length to width ratio 0.80-1.13 (-1.33), moderately hairy, with short patent hairs c. 0.1 mm long and stalked glands, or hairy only at the apex, the style 4.5-5.5 mm long, the stigma lobes 0.1-0.4 mm long. *Mericarps* light brown, ovoidal, reticulate, 1.2-1.5 mm long, 0.6-1.1 mm wide, the length to width ratio 1.36-2.00, the attachment scar 0.8-0.9 mm long, 0.57-0.65 times the entire mericarp length, with patent hairs c. 0.1 mm long and stalked glands in the lacunae.

Flowers recorded: May to November.

Ecology: Occurs on white to yellow and grey sandplains principally in heath dominated by Proteaceae, Myrtaceae, Casuarinaceae or *Acacia*, but also in mallee and *Eucalytpus* woodland.

Notes: M.E. & M.G. Tozer 004 is an anomolous collection of this species from Hyden (growing near granite outcrop) a significantly disjunct location from all other populations. The specimen has a distinctive look with dense contracted inflorescences with long hairs, giving them a fluffy appearance, and has some leaves and flowers smaller than typical *H. scabra*. However, the differences appear to be taxonomically insignificant.

Selected and cited specimens examined (ca. 30 seen): Western Australia: *M.E. & M.G. Tozer* 004, 6.ix.1990, Marble Rocks, near Hyden (NSW 238865); *Greg Guerin* 56 *& Penny McLachlan*, 25.x.2002, 3.55 km E of turn-off to Hawk's Head on Ajana-Kalbarri Road, Kalbarri National Park (AD 137684, PERTH, CANB); *W.E. Blackall* 4789, ?-.ix.1940, Between Yuna & Dartmoor (PERTH 03722007); *M.E. Phillips* 1338, 26.ix.1962, N. or Murchison River, W.A., on highway (PERTH 00301639, CANB 057764); *Gardner & Blackall* 589, 28.viii.1931, 48 km N. of Ajana, N. of Geraldton (PERTH 03673383); *C.A. Gardner* 2579, 30.viii.1931, North of Murchison River (PERTH 03673562); *R. Davis* 3536, 24.vi.1997, N end of Bella-Whelerra road, 35 km N of intersection with Ogilvie Road (PERTH 04866819); *G. Stapp* 98, 16.ix.1998, Indarra Springs Reserve, site D1, along track to sring (PERTH 05773954); *D.R. & B. Bellairs* 1508, 20.viii.1988, Main roadside, Junga Dam, Kalbarri area (PERTH 01870718); *A.M. Lyne* 936*, L. Craven & F. Zich*, 27.x.1992, Kalbarri National Park, c. 4 km by road from the Hawks Head turnoff on the Ajana-Kalbarri road towards the North-West Coastal Highway (PERTH 03395057, CBG 9215781); *G. Flowers* 212 *& S. Donaldson*, 6.ix.1997, 100 km N of Northhampton on North West Coastal Highway (CBG 9708737); *W.E. Blackall* 716, 21.ix.1931, Mullewa Plains, E of Geraldton (PERTH 03673405, CBG 9211361, PERTH 02111772); *C.A. Gardner* 8601, 2.ix.1947, Ajana sandplain (PERTH 03674975); *R. Bates* 4053, 30.viii.1984, Kalbarri National Park (PERTH 03118789); *A.S. George* 7929, 8.ix.1966, 27 miles E. of Kalbarri (MEL 302459).

18. Hemigenia exilis S. Moore Jour. Linn. Soc., Bot. 34: 216 (1899); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 442 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Lectotype (here chosen): *S. Moore* s.n., -.iv.1896, Creek between Wilson's Pool & Lake Darlôt', Western Australia (lecto: photo ex BM007932962! - far central right specimen; *isolecto*: photo ex BM007932962! [excluding lectotype]).

Upright to spreading, compact to open woody shrubs, 0.3-2.0 m high, up to 1.5 m wide; *branches* erect, ± circular in cross-section, glabrous, rarely with very sparse, minute patent hairs in the groove between the leaf bases (hairs to c. 0.1 mm long); *internodes* on young branches 3.0-23.0 mm long.

Leaves sessile to sub-sessile, the bases continuous with the stem, erect to depressed, falcate to straight, glabrous; *lamina* flat, linear-narrowly elliptic, rarely slightly ovate or obovate, (10.2-) 11.9-32.6 (-42.9) mm long, 1.1-3.9 (-5.2) mm wide, the length to width ratio 6.40-14.30, the widest point (0.35-) 0.40-0.59 (-0.68) the entire length; *base* cuneate to long- attenuate; *apex* straight, acute ± slightly mucronate, rarely acuminate, very rarely obtuse to rounded; *venation*: indistinct.

Inflorescence of 1 (-3) flowering nodes with single flowers subtended by leaf-like bracts; *pedicel* 1.5-5.6 (-7.8) mm long, glabrous, slightly flattened; *bracteole pair* loosely conduplicate, usually inserted on the distal half of the pedicel at a point (0.41-) 0.51-0.88 (-1.00) times the length, erect, much shorter than the calyx tube, narrowly oblong, linear or lanceolate, 0.6-1.6 mm long, 0.1-0.2 (-0.3) mm wide, the length to width ratio 3.00-10.0 (-12.0)), glabrous but ciliate with hairs 0.1 mm long, the margins flat, the base straight, the apex acute, usually recurved.

Calyx actinomorphic or the lobes slightly unequal, mostly glabrous; *tube* smooth, very rarely slightly 5-ribbed, obdeltate to obtriangular, 1.8-2.6 (-3.2) mm long, (1.0-) 1.4-2.1 mm wide,

the length to width ratio 1.10-1.90 (-2.40), the base cuneate or funnel-shape, the interior glabrous; *lobes* straight, triangular to widely deltate or long-acuminate from a deltate to shallowly triangular base, shorter than tube, 0.27-0.47 times the entire calyx length, 0.8-1.8 (-2.3) mm long, 0.6-1.0 mm wide, the length to width ratio 1.10-3.00, the margins involute or straight, ± sparsely minutely ciliate, the apex acute, usually recurved or bent, the interior glabrous or with sparse sessile glands.

Corolla (6.1-) 7.3-12.5 (-14.5) mm long, white to purple, throat and base of median abaxial lobe white to pale whitish yellow, spotted brown-purple; *exterior surface* with short, sparse to moderately dense, spreading hairs 0.1 mm long; *interior surface* with a sparse to dense, spreading beard on the lower throat between the stamens, ± spreading onto the base of the lower lobes, with hairs 0.2-0.5 mm long, otherwise glabrous; *tube* narrowly oblong to cuneate, 4.2-8.0 mm long, far exceeding the calyx, 1.5-2.5 mm wide at mouth; *median abaxial lobe* abruptly spathulate, the stalk square, very rarely oblong, the blade transversely elliptic to oblate, very rarely shallowly obdeltate, 2.4-5.9 mm long, 2.3-5.7 mm wide, the length to width ratio 0.80-1.20, the margin slightly crenate to unevenly crenate-dentate, rarely slightly undulate, the apex rounded, the sinus 0.3-1.0 mm long; *lateral lobes* ovate, oblong, or obovate to widely obovate, very rarely very widely obovate, 1.9-4.5 mm long, 1.0-3.5 mm wide, the length to width ratio 1.00-2.40, the margin entire or slightly crenate, ± ciliate, the apex rounded, the sinus 0.2-0.7 mm long or absent; *adaxial median lobe-pair* obovate to depressed obovate, 2.2-4.3 (-4.9) mm long, 2.2-4.4 mm wide, the length to width ratio 0.7-1.1 (-1.8), emarginate with sinus 0.9-1.3 mm deep, the margin entire, ± minutely ciliate, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 3.4-5.4 mm from base of corolla, 1.7-2.5 mm long, glabrous, *theca* sub-sessile, 0.5-0.8 mm long, glabrous, the *connective* 0.5-1.2 mm long,

glabrous, the sterile end glabrous, tapering; *abaxial pair* with *filaments* inserted 4.3-6.5 mm from base of corolla, 1.7-2.4 mm long, glabrous, *fertile theca* sub-sessile, 0.5-0.7 mm long, glabrous, the *connective* 0.6-1.1 mm long, glabrous, the sterile end glabrous, tapering.

Ovary glabrous, 1.1-1.3 mm long, 0.9-13 mm wide, the length to width ratio 0.90-1.40, the style 5.4-7.5 mm long, the stigma lobes 0.1-0.4 mm long. *Mericarps* light to dark brown, ovoidal, reticulate, 1.7-2.5 mm long, 0.9-1.5 mm wide, the length to width ratio 1.60-2.00, the attachment scar 1.3-2.0 mm long, 0.64-0.83 times the entire mericarp length, glabrous.

Flowers recorded: June, August to December.

Ecology: Recorded on flat ground and banks above creeks on red sand and clay and brown clay loam, or lateritic outcrops. Typically in *Acacia aneura* (Mulga) shrubland, associating frequently with *Eremophila* and *Ptilotus*.

Notes: See notes under *H. tenelliflora* regarding the affinities of this species. This species was thought to be extinct until the discovery of numerous populations during the 1990s.

Selected specimens examined (17 seen): Western Australia: *E. Bennett* He 1, 29.x.1997, Ca. 5 km E of Lake Carey on Glenorn Station (PERTH 06367593); *E. Bennett & C. Harding* Hf 4, 30.x.1997, Murrin Murrin lease. Glenorn Station (PERTH 06367380); *E. Bennet* He 3, 29.x.1997, Low rise above Lake Carey (PERTH 06367585); *E. Bennett* He 2, 29.xii.1997, Eucalyptus lease ca 2 km E of Lake Carey (PERTH 06367437); *E.M. Bennett* 5913, 15.xi.1995, Copperfield Base Station, (Newcrest) Mount Ida, S ca. 109 km SW of Leonora (PERTH 04189108); *E.M. Bennett* 5905, 13.xi.1995, Poison Creek on Leonora-Agnew road (PERTH 04189094); *E.M. Bennett* 5909, 14.xi.1995, Glenorn/Minara Station, E of Leonora

(PERTH 04189051); *E.M. Bennett* 5907, 14.xi.1995, Glenorn Station, E of Leonora (PERTH 04189116); *E.M. Bennett* 5906, 13.xi.1995, Poison Creek on Leonora-Agnew Road (PERTH 04189132); *R.J. Chinnock* 8570 *& G.S. Richmond*, 28.x.1993, Road to Melrose Station, 8.4 km from the Leonora-Leinster road (PERTH 05288959, AD99350038); *C. Day* HE 24.2, 28.v.1996, Wilson Creek, W of Teutonic Bora Mining Centre, Leonora (PERTH 04623797); *D. Kluken* HE 27.2, ?-.vi.1996, Wilson Creek, N of Minnirichie Well, Leonora (PERTH 04623789); *D. True & C. Day* MM 3/105, 19.viii.1995, Mining and Pastoral Lease, Minara Station, Murrin Murrin, c. 40 km E of Leonora (PERTH 04185668); *E.M. Bennett & C. Day* 5902, 20.ix.1995, Minara Station, between Leonora and Laverton (PERTH 04189159); *C.A. Gardner* 19059, 22.x.1966, 12 miles E of Wiluna (PERTH 06007392).

19. Hemigenia tenelliflora G.R.Guerin sp. nov.

Typus: *L.W. Sage & F. Hort* 2241, 12.x.1999, Sandplain on S side of Trans-Australian Rail line, 3.2 km W of Darrine Siding, Jaurdi Station, Western Australia (holo: PERTH 06202969!).

Etymology. the epithet refers to the slender, delicate flowers of this species

Dwarf shrub, c. 0.2 m high; *branches* erect, near-circular to sub-quadrangular in cross-section, moderately shortly pubescent-puberulent with rows of short patent or curved antrorse to retrorse hairs hairs 0.1 mm long in longitudinal rows; *internodes* on leafy branches (2.7-) 3.3-6.9 mm long.

Leaves sub-sessile, erect to patent, straight, glabrous; *lamina* open, flat, obovate to oblanceolate, 5.7-11.0 mm long, 1.9-3.4 (-3.8) mm wide, the length to width ratio (2.31-)

2.70-3.50, the widest point 0.55-0.79 of the entire length; *base* attenuate; *apex* obtuse to rounded, rarely shortly apiculate; *venation*: indistinct other than the prominent mid-rib on the abaxial surface.

Inflorescence of 1-2 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* 4.2-4.5 mm long, glabrous; *bracteole pair* inserted in the distal quarter of the pedicel at a point 0.79-0.84 times the length, erect, more or less appressed against calyx, much shorter than the calyx tube, narrowly elliptic to narrowly oblong, rarely oblanceolate, 1.5-1.7 mm long, 0.2-0.3 mm wide, the length to width ratio 5.00-8.00, the margins loosely folded or inrolled, ciliolate with sparse minute curved antrorse white hairs 0.05 mm long, otherwise glabrous, the base straight to slightly attenuate, the apex acute, recurved.

Calyx more or less actinomorphic, the lobes nearly equal, glabrescent; *tube* smooth, warty, or finely and indistinctly longitudinally ribbed, obtriangular to widely deltate ± convex margins, 2.0-2.3 mm long, 1.5-2.0 mm wide, the length to width ratio 1.10-1.50, the base sub-rounded, the interior glabrous; *lobes* spreading or recurved, triangular, shorter than tube 0.36-0.43 times the entire calyx length, 1.3-1.5 mm long, 0.6-1.0 mm wide, the length to width ratio 1.30-2.20, the margins straight, ciliolate with sparse, antrorse, curved, minute hairs, the apex acute, interior glabrous.

Corolla 7.0-13.0 mm long, white; *exterior surface* glabrous, or with sparse, sub-appressed, minute hairs on the lobes; *interior surface* mostly glabrous, but very sparsely bearded on the lower throat between the stamens with hairs 0.1-0.2 mm long; *tube* narrowly oblong, 4.7-6.3 mm long, far-exceeding the calyx, 1.3-1.9 mm wide at mouth; *abaxial median lobe* near-shallowly obdeltate, 2.8-4.1 mm long, 3.2-4.5 mm wide, the length to width ratio c. 0.90, ciliate with hairs 0.1 mm long, unevenly dentate, the apex nearly truncate, the sinus 0.3-1.2

mm long; *lateral lobes* widely ovate, widely obtrullate, or depressed obovate, 1.9-2.9 mm long, 2.0-2.8 mm wide, the length to width ratio 0.70-1.30, the margin ciliate, slightly crenate, the apex rounded or truncate, the sinus 0.4-0.9 mm long; *adaxial median lobe-pair* oblate, 2.3-3.0 mm long, c. 3.2 mm wide, the length to width ratio c. 0.90, emarginate with sinus c. 0.9 mm deep, the margin ciliate, entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted c. 4.3 mm from base of corolla, c. 1.2 mm long, glabrous; *connective* c. 0.8 mm long, glabrous, ending in a simple tapering appendage, *theca* 0.5-0.6 mm long, glabrous; *abaxial pair* similar to *adaxial pair*: *filaments* inserted c. 5.0 mm from base of corolla, c. 1.2 mm long, glabrous; *connective* c. 0.8 mm long, glabrous, ending in a simple tapering appendage, *theca* 0.5-0.6 mm long, glabrous.

Ovary 0.9-2.1 mm long, 0.6-1.1 mm wide, the length to width ratio 1.50-1.90, glabrous; style 5.6-6.6 mm long, the stigma lobes 0.2-0.3 mm long. *Mericarps* light brown, ovoidal, reticulate, c. 1.7 mm long, 0.9 mm wide, the length to width ratio c. 1.89, the attachment scar c. 1.1 mm long, c. 0.65 times the entire mericarp length, glabrous.

Flowers recorded: October.

Ecology: Recorded on light brown or yellow sand, in low open *Eucalyptus* woodland or *Acacia* heath. Locally abundant.

Notes: Closely related to *H. exilis* but occurs further south and can be distinguished by its much shorter and relatively broader leaves with obtuse to rounded apices (cf. acute), the presence of rows of short hairs on the stems, and the white corolla.

Known only from the type collection.

20. Hemigenia parviflora Bartl. in Pl. Preiss. i. 359 (1845); Benth. DC. Prod. xii. 567 (1848).

H. sericea var. parviflora Benth. Fl. Austral. 5: 116 (1870); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 441 (1981).

H. sericea Benth. sensu Marchant *et al.* Fl. Perth Region i: 560-561 (1987).

Type: Preiss 2321, In arenosis ad fluvium Cygnorum, Western Australia (syn: GOET; isosyn: MEL 646646!, MEL 646649!).

Typification: Bartling (1845) cites Preiss 2321 'In arenosis ad fluvium Cygnorum (In sandy areas of the River Cygnet). The two MEL duplicates are similar and match the protologue. The GOET specimen was not seen and hence appropriate lectotypification was not possible.

Sprawling to prostrate compact weak shrub or mat-like sub-shrub, 0.3-1.1 m high, 0.5-1.0 m wide; *branches* mainly semi-decumbent, circular to quadrangular in cross-section, pubescent-puberulent or tomentose with moderately dense to dense short patent to antrorse hairs c. 0.1 mm long; *internodes* on leafy branches (2.2-) 4.5-14.1 (-16.1) mm long.

Leaves light green tinged red, sessile or rarely sub-petiolate, the petiole 0.6-1.0 mm long, patent to descending, straight to slightly recurved, sparsely villous, with soft antrorse curly hairs 0.1-0.2 mm long, the bases of young leaves moderately villous, becoming glabrous; *lamina* open or the young leaves loosely folded, flat or the margins slightly inrolled,

oblanceolate, rarely narrowly elliptic, (4.5-) 7.5-26.9 (-35.4) mm long, (0.6-) 1.0-3.8 (-4.9) mm wide, the length to width ratio (3.41-) 6.39-21.91 (-28.13), the widest point 0.46-0.76 of the entire length; *base* cuneate, rarely attenuate; *apex* acute, rarely sub-acute, ± slightly mucronate; *venation*: the mid-rib is distinct.

Inflorescence of 1-8 flowering nodes with single flowers subtended by leaf-like bracts; *pedicels* 0.9-2.4 mm long, moderately to densely villous or tomentose with hairs 0.1-0.2 mm long; *bracteole pairs* green and red, inserted on the distal half of the pedicel at a point 0.67-0.91 times the length, erect, recurved, equal to or exceeding the calyx tube, linear-oblanceolate, very rarely lanceolate, 2.0-4.0 mm long, 0.2-0.4 (-0.5) mm wide, the length to width ratio 7.00-20.00, moderately sericeous with silky antrorse hairs 0.2-0.3 mm long, the margins flat, the base cuneate to long-attenuate, the apex acute.

Calyx actinomorphic, with sparse antrorse hairs 0.1-0.2 mm long mostly on the lobes, especially at the base; *tube* smooth, shallowly obdeltate, rarely obdeltate, very rarely widely obdeltate, 1.3-2.2 mm long, 1.7-2.5 mm wide, the length to width ratio 0.62-1.22, the base slightly rounded, the interior glabrous or with sparse spreading hairs 0.1-0.2 mm long; *lobes* straight or recurved, appearing long-acuminate from a triangular to widely deltate base, slightly longer than the tube, 0.52-0.67 times the entire calyx length, (1.7-) 2.1-3.0 (-3.4) mm long, 0.8-1.3 mm wide, the length to width ratio (1.70-) 2.18-2.90 (-3.44), light green, tinged red at the apex, the margins revolute, the apex acute, the interior glabrous or with sparse spreading hairs 0.1-0.2 mm long.

Corolla (3.9-) 4.8-9.2 mm long, light purple, tube white, base of the lower lobes white streaked dark purple, upper lobe streaked dark purple, with a single light brown spot between lateral lobes; *exterior surface* glabrous to moderately hairy with appressed hairs c. 0.1 mm

long; *interior surface* with a dense, compact beard of fine hairs 0.3-0.4 mm long on the lower throat between the stamens; *tube* oblong, 1.7-3.2 mm long, shorter than the calyx lobes, rarely barely exceeding them when the calyx lobes are recurved, 1.6-3.0 mm wide at mouth; *median abaxial lobe* abruptly spathulate, the stalk square ot shallowly obtriangular, the blade transversely elliptic to transversely oblong, rarely the entire lobe shallowly obdeltate, 2.0-5.3 mm long, 2.3-6.4 mm wide, the length to width ratio 0.78-1.23, the margin unevenly dentate, the apex truncate, the sinus 0.3-1.4 mm long; *lateral lobes* obovate to very widely obovate or obtrullate to widely obtrullate, rarely transversely oblong, 1.3-4.4 mm long, 1.2-3.4 mm wide, the length to width ratio 0.81-1.65, the margin nearly entire or slightly crenate, the apex obtuse, rarely truncate, the sinus absent; *adaxial median lobe-pair* widely elliptic to transversely elliptic or nearly square to transversely oblong, 1.3-4.2 mm long, 1.6-3.7 mm wide, the length to width ratio 0.58-1.19, emarginate with sinus 0.5-1.1 mm deep, the margin entire, ciliolate with hairs c. 0.05 mm long, the apex rounded or the lobes sub-acute.

Stamens: *adaxial pair* with *filaments* inserted 1.0-1.7 mm from base of corolla, white, 0.9-1.3 mm long, glabrous, *theca* dark purple, 0.6-0.7 mm long, glabrous, the *connective* white, 0.7-1.0 mm long, glabrous, the sterile end with a dense spreading tuft of hairs 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted 1.7-2.3 mm from base of corolla, white, 1.1-1.8 mm long, glabrous or with hairs to c. 0.1 mm long on the proximal half, *fertile theca* dark purple, 0.5-0.7 mm long, glabrous, the *connective* white, 0.5-0.8 mm long, glabrous, the lower end bearing a second smaller theca.

Ovary 0.7-1.1 mm long, 0.6-1.1 mm wide, the length to width ratio 1.00-1.17, glabrous or with sparse short, patent hairs c. 0.1 mm long at the apex, the style 2.4-4.0 mm long, white, the stigma lobes 0.1-0.2 mm long. *Mericarps* brown, ovoidal, shallowly reticulate, 1.3-1.4 mm long, 0.6-0.8 mm wide, the length to width ratio 1.75-2.17, the attachment scar 0.8-1.0

mm long, 0.62-0.77 times the entire mericarp length, with sparse minute trichomes to c. 0.05 mm long in some of the lacunae.

Flowers recorded: August to December.

Ecology: Recorded on lateritic gravel and loam, on breakaway ridges and near granite outcrops in *Eucalyptus margata*, *E. wandoo* and *Corymbia calophylla* woodland, often on gentle slopes, associating with *Acacia*, *Grevillea*, *Hakea*, *Hibbertia*, *Macrozamia* and *Xanthorrhoea*.

Specimens examined: Western Australia: *Greg Guerin* 131 *& Penny McLachlan*, 25.x.2003, Bibbulmun track btw the start at Kalamunda & Piesse Brook ca. 1 km on track or ca. 500 m from carpark of Kalamunda Community Centre, along track to Jorgenstern Park before track heads down steep gully (AD [not databased], PERTH, CANB); *s.coll.* [ex herb. A. Morrison], ?-.vii.1901, Greenmount (Midland Junction) (NSW217273); *A.R. Fairall* 713, 16.x.1962, 38 m.p. Albany Hwy (PERTH 02111004); *s.coll.* [ex herb. A. Morrison], 5.xii.1903, Swanview (PERTH 02111020, CANB 136600); *J. Seabrook* 200, 7.ix.1977, Helena Valley (PERTH 02110989, PERTH 01871250); *C.T. White* 5191, 1.vi.1927, Hills between Darlington & Bellevue (PERTH 02111012, HUH); *C. Andrews* s.n., ?-.viii.1901, Bellevue, Perth (PERTH 02110997); *K. Macey* 143, 18.viii.2000, Bibbulmun Track between Piesse Brook and Kalamunda (PERTH 05688434); *R. Helms* s.n., 25.viii.1897, Greenmount (PERTH 02111039); *E.Holland EH* 100, ?-.x.1993, Reserve 14275, Wundowie, 50 km E of Perth (PERTH 04627717); *s.coll.* [ex herb. A. Morrison], 17.xi.1900, Darlington-Gooseberry Hill (CANB 136603).

21. Hemigenia pachyphylla G.R.Guerin sp. nov.

H. sp. Glenburgh (R.J. Cranfield 9725) Paczkowska & Chapman, W. Austral. Fl. Descr. Cat. 273 (2000).

Typus: *R.J. Cranfield* 9725, 8.v.1995, 8km WSW of Glenburgh Hstd, Western Australia (holo: PERTH 04349377!).

Etymology: The epithet refers to the distinctive large, rather thick leaves of this species.

Upright, compact, large shrubs 1.0-1.5 m high, c. 0.95 m wide; *branches* erect, near-circular to sub-quadrangular in cross-section, tomentose with dense appressed antrorse hairs 0.1-0.2 mm long; *internodes* on leafy branches (1.5-) 2.1-13.0 (-31.9) mm long.

Leaves sessile to petiolate (petiole 0.0-2.0 mm long), erect, straight, with moderately dense to dense appressed antrorse hairs 0.1 mm long, becoming glabrous, rarely also with sparse minute sessile glands; *lamina* open, flat, narrowly sub-elliptic or barely oblanceolate (18.0-) 23.4-55.3 mm long, (2.2-) 2.5-5.3 (-6.7) mm wide, the length to width ratio 6.30-11.8 (-12.7), the widest point 0.45-0.67 of the entire length; *base* cuneate, rarely long-attenuate; *apex* acute, usually slightly mucronate; *venation*: mostly longitudinal, the mid-rib prominent.

Inflorescence of 1 (-3) flowering nodes with single flowers subtended by leaf-like bracts; *pedicel* 2.5-6.0 mm long, with very dense short antrorse hairs 0.1 mm long; *bracteole pair* inserted approximately halfway along the pedicel at a point 0.48-0.74 times the length, usually immediately deciduous, when present erect, much shorter than the calyx (not reaching the base of the tube), narrowly oblong, 0.9-1.4 mm long, 0.2-0.3 mm wide, the length to width ratio 4.50-6.50, with sparse to moderateley dense spreading hairs 0.1-0.2 mm long,

concentrated and longer on the margins,the margins loosely folded or inrolled, the base straight, the apex sub-rounded.

Calyx more or less actinomorphic but the median adaxial lobes slightly larger and the lobes very slightly uneven in length, with moderately dense appressed antrorse hairs c. 0.1-0.15 mm long all over; *tube* smooth, cup-shape, 2.0-2.8 mm long, 1.8-2.7 mm wide, the length to width ratio 0.90-1.30, the base rounded, the interior glabrous; *lobes* straight, shallowly to widely deltate, rarely shortly acuminate from a shallowly triangular base, usually much shorter than tube, 0.23-0.41 times the entire calyx length, 0.7-1.9 mm long, 0.7-1.5 mm wide, the length to width ratio 0.80-1.30, the margins straight, rarely convex, the apex acute, rarely obtuse to rounded, the interior with moderately dense appressed antrorse hairs 0.1-0.2 mm long.

Corolla 6.2-15.5 mm long, white, base of median abaxial lobe yellow, other lobes streaked or solid maroon/red/purple towards base; *exterior surface* densely to very densely hairy with short, spreading hairs 0.1-0.2 mm long, the margins densely ciliate; *interior surface* bearded on the lower throat between the stamens with hairs 0.3-0.4 mm long and with scattered short spreading hairs 0.1 mm long on the lobes *tube* oblong, rarely square, 3.2-5.3 mm long, exceeding the calyx, 1.8-3.9 mm wide at mouth; *median abaxial lobe* abruptly spathulate: the stalk obtrullate, to widely depressed obtrullate, rarely transversely oblong, the blade transversely elliptic to narrowly transversely elliptic, 2.1-7.6 mm long, 3.0-9.3 mm wide, the length to width ratio 0.60-1.10, the margin crenate-dentate, undulate, the apex rounded or truncate, the sinus 0.4-1.1 mm long; *lateral lobes* oblong, ovate to widely ovate, or obovate to widely depressed obovate, 2.0-6.2 mm long, 1.5-4.5 mm wide, the length to width ratio 0.90-1.80, the margin entire or slightly undulate or dentate, the apex rounded to truncate, the sinus 0.0-0.7 mm long; *adaxial median lobe-pair* square to oblong, or obovate to widely depressed

obovate, 2.8-7.1 mm long, 2.7-5.5 mm wide, the length to width ratio 0.90-1.80, emarginate with sinus 0.7-2.2 mm deep, the margin slightly undulate to entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 3.3-3.5 mm from base of corolla, 1.1-1.5 mm long, glabrous, *theca* 0.6-1.0 mm long, glabrous, the *connective* 1.0-1.2 mm long, glabrous, sterile end tapering, glabrous or sparsely bearded with minute hairs c. 0.05 mm long; *abaxial pair* similar to *adaxial pair*: *filaments* inserted 4.0-4.3 mm from base of corolla, 1.5-2.5 mm long, glabrous, *fertile theca* 0.6-1.0 mm long, glabrous, the *connective* 1.0-1.2 mm long, glabrous, the sterile end glabrous, tapering.

Ovary 1.2-1.8 mm long, 1.0-1.3 mm wide, the length to width ratio 1.10-1.50, glabrous, style 7.0-8.2 mm long, the stigma lobes 0.2-0.4 mm long. *Mericarps* dark brown, ovoidal, reticulate, 2.0-2.1 mm long, 1.0-1.3 mm wide, the length to width ratio 1.60-2.00, the attachment scar 1.4-1.5 mm long, 0.70-0.71 times the entire mericarp length, with sparse, minute trichomes in the lacunae.

Flowers recorded: May, August.

Ecology: Recorded on stoney flats and brown stoney clay over sandstone/hardpan, in *Acacia* shrubland or in drainage lines.

Notes: Similar to *H. exilis* but *H. exilis* has much smaller leaves which are often falcate, and is mostly glabrous.

Other specimens examined: Western Australia: *R.J. Chinnock* 6837, 20.viii.1986, 10.1km SE of Dairy Creek (AD98706266); *A.M. Ashby* 4776, s.dat., South bank of Wooramel River on Old Carnarvon Road that is north of Mullewa (AD 97421133).

22. Hemigenia curvifolia F. Muell. Fragm. i. 210 (1859); Benth. Fl. Austral. 5: 117 (1870); Engl. & Prantl., Nat. Pflanzenfam. 3A: 219 (1897); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 442 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

H. obovata F. Muell. auct. non Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Lectotype (here chosen): *Oldfield* s.n. s.dat., Rocky hills, Hill River, Western Australia [this location was cited in the protologue but does not appear on the specimen] (lecto: MEL 646390! - left specimen; isolecto: MEL! 646390 - right specimen, K!).

Slender, open shrubs 0.5-1.0 m high, 0.5-2.0 m wide; *branches* erect, ± circular in cross-section, densely hoary or villous-villosulous with dense to very dense random hairs 0.1 (-0.7) mm long; *internodes* on leafy branches (2.4-) 3.0-14.0 mm long.

Leaves sessile, erect to adpressed, straight or prominently recurved (when folded), sparsely villous, particularly on the mid-rib and margins, or woolly all over with mainly antrorse, curved hairs 0.1-0.3 (-1.5) mm long, sometimes scabrous with blunt projections; *lamina* open or conduplicate (then prominently recurved), flat, obovate, elliptic or oblong, rarely nearly circular, (4.8-) 5.5-15.1 (-16.3) mm long, (1.7-) 2.7-5.8 mm wide, the length to width ratio

1.03-3.15 (-5.03), the widest point 0.48-0.69 of the entire length; *base* abruptly attenuate; *apex* obtuse, truncate or ounded, very rarely sub-acute, often slightly mucronate; *venation*: the mid-rib is distinct.

Inflorescence of 3-11 flowering nodes with leaf-like bracts, each bract with clusters of 4 flowers subtended by differentiated bracts (bracts loosely folded adaxially, straight, oblong-elliptic to obovate or narrowly oblong to oblanceolate, very rarely ovate, 1.3-2.8 (-3.2) mm long, 0.5-1.1 (-1.3) mm wide, the length to width ratio (1.16-) 1.40-4.00, villous to tomentose with dense straight to curved hairs 0.1-0.2 mm long, rarely hoary or woolly with hairs to 0.5 mm long, the margin straight, the base straight, the apex acute to truncate), sometimes with the terminal nodes contracted into a loose head; *pedicels* 0.7-2.6 mm long glabrescent; *bracteole pairs* inserted on the proximal half of the pedicel at a point 0.27-0.50 times the length, erect, straight, shorter than the calyx tube, linear-oblanceolate, 1.3-2.3 mm long, 0.2-0.3 (-0.4) mm wide, the length to width ratio 4.67-11.00, with curved antrorse hairs 0.1-0.2 mm long, becoming moderately dense on the distal half, the margins straight, the base long-attenuate, the apex acute to rounded.

Calyx actinomorphic, with moderately dense, mostly antrorse, loose hairs 0.2-0.3 (-0.7) mm long, denser on the margins of the lobes, sparser on the tube, and the proximal half of the tube glabrous or rarely sparsely hairy; *tube* smooth or slightly ribbed, shallowly obdeltate, 2.2-3.9 mm long, 2.2-3.4 mm wide, the length to width ratio 0.71-1.05, the base cuneate to rounded, the interior mostly glabrous or with a few spreading hairs 0.1-0.2 mm long; *lobes* straight, triangular to narrowly triangular or linear-narrowly triangular from a deltate base, approximately equal to the tube, 0.42-0.57 times the entire calyx length, 1.6-3.8 mm long, 0.9-1.3 mm wide, the length to width ratio 1.45-3.56, the margins involute and concave, the

apex acute, the interior mostly glabrous or with a few spreading hairs 0.1-0.2 mm long, denser near the margins of the lobes.

Corolla 6.0-13.9 mm long, mauve or white-tinged-mauve, tube white, adaxial lobes and base of lateral lobes sreaked dark maroon, base of abaxial lobes with pale brown to dull orange spots or colouration; *exterior surface* with moderately dense appressed thick, triangular hairs 0.1 mm long, more and less glabrous on the tube; *interior surface* with a dense tufted beard of hairs 0.4-0.6 mm long on the lower throat between the stamens and appressed hairs 0.1-0.2 mm long at the base of the lower lobes; *tube* oblong, 3.2-4.9 mm long, shorter than the calyx lobes, 1.9-3.1 mm wide at mouth; *median abaxial lobe* obtriangular or abruptly spathulate, the stalk square or shallowly obdeltate to obdeltate, the blade transversely elliptic, rarely the entire lobe obovate (1.9-) 2.5-5.4 (-6.3) mm long, 2.4-6.0 mm wide, the length to width ratio 0.69-1.30, the margin crenate-dentate, the apex truncate, the sinus 0.5-1.4 mm long; *lateral lobes* elliptic-oblong to narrowly oblong, obovate or square to circular, rarely barely ovate, 2.0-4.8 mm long, 1.3-2.9 mm wide, the length to width ratio 1.00-2.20 (-2.69), the margin entire, rarely slightly crenate, rarely finely ciliate, the apex obtuse, rounded or truncate, the sinus absent or very rarely to 0.3-0.6 mm long; *adaxial median lobe-pair* widely oblong-square or obtriangular to obovate, rarely oblate, (2.0-) 2.4-4.0 (-5.0) mm long, 1.8-3.9 mm wide, the length to width ratio 0.84-1.52, emarginate with sinus 0.4-1.5 mm deep, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 3.2-3.7 mm from base of corolla, white, 1.5-1.7 mm long, glabrous, *theca* tinged mauve or maroon, 0.5-0.9 mm long, glabrous, the *connective* white, 0.6-1.3 mm long, glabrous, the sterile end with sparse terminal hairs 0.1 mm long; *abaxial pair* with *filaments* inserted 3.3-3.9 mm from base of corolla, white, 1.5-2.0 mm long,

glabrous, *fertile theca* tinged mauve or maroon, 0.7-1.0 mm long, glabrous, the *connective* white, 0.6-1.0 mm long, glabrous, the lower end bearing a second very small, aborted theca.

Ovary 1.0-1.3 mm long, 0.9-1.1 mm wide, the length to width ratio 1.11-1.22, glabrous, the style 4.6-5.3 mm long, the stigma lobes 0.1-0.3 mm long. *Mericarps* brown to light brown, ovoidal, reticulate, 1.4-1.5 mm long, 0.8-0.9 mm wide, the length to width ratio 1.67-1.75, the attachment scar c. 0.9-1.0 mm long, c. 0.64-0.67 times the entire mericarp length, with minute hairs in the lacunae.

Flowers recorded: September to November.

Ecology: Recorded in sandy soil in heath, shrubland and woodland often dominated by *Banksia* and *Callitris*. Recorded on disturbed track edges.

Notes: Some specimens of this species have incorrectly been referred to *Hemigenia obovata*. However, the type of this species is quite different. *Hemigenia curvifolia* may have open, flat leaves or folded, recurved leaves, or a combination of both.

Specimens examined: *E.A. Griffin* 5390, 1.x.1988, AMG 50JLL991974 Gravel Reserve (25256), cnr Boundary Rd. and Barberton W Rd, E of Dandaragan (PERTH 03673456); *B.J. Conn* 3886 *& M.E. Tozer*, 22.x.1993, On fire track, 31.5 km (by road) E of Brand of Highway, on Watheroo West Road (4.3 km W of junction with Agaton road). Watheroo National Park (AD 93817081, NSW279259, PERTH 05857392, MEL 2051471); *B.J. Conn* 3863 *& M.E. Tozer*, 17.x.1993, Western extension of Namban West Road, 25.7 km (by road) W of Midlands Road, SW boundary of Park. Watheroo National Park (CANB 00522999, MEL 286341, NSW279236, PERTH 04313828); *E.A. Griffin* 5422, 2.x.1988, AMG

50JLL957960 roadverge Barberton West Rd., W of Moora (PERTH 01103911); *R.D. Royce* 9555, 4.x.1971, Watheroo National Park (PERTH 01028138); *J.S. Beard* 1858, 23.ix.1962, Moora-Badgingarra (CANB 00525262, PERTH 01028111); *N.H. Speck* s.n., 28.ix.1957, Jurien Bay Road. N. from Dandaragan (PERTH 01027700); *D.J.E. Whibley* 4909, 2.xi.1974, 15km West of Coomberdale (AD 97447198);

23. Hemigenia wandooana G.R.Guerin sp. nov.

H. sericea Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000), partly.

Typus: *V. Crowley* DKN 700, 14.x.1995, Near firebreak on edge of forest, W side of Location 4091, ca. 4.5-5 km ENE of Bowelling, Western Australia (holo: PERTH 05322545!).

Etymology: the epithet refers to the preferred habitat of this species, which usually occurs in Wandoo (*Eucalytpus wandoo*) woodland.

Prostrate to erect, open and few-branched to compact many-branched small shrubs 0.3-1.1 m high, to c. 0.4 m wide; *branches* erect to spreading, nearly circular to sub-qudrangular in cross-section, woolly/lanate, hoary, or tomentose with dense to very dense antrorse hairs 0.2-1.1 mm long, sometimes with longer hairs extending onto the leaf bases; *internodes* on leafy branches (3.6-) 4.5-11.5 (-14.5) mm long.

Leaves sessile, erect, straight, sparsely sericeous with antrorse white hairs 0.1-0.4 mm long, ± minute sessile glands, especially near the margins, sometimes with longer hairs extending onto leaf bases from stems; *lamina* open, flat, narrowly elliptic to elliptic or obovate, (5.9-) 8.5-15.1 (-17.5) mm long, 2.8-5.5 (-6.6) mm wide, the length to width ratio 1.83-3.34, the

widest point 0.48-0.74 of the entire length; *base* attenuate; *apex* obtuse or rounded, rarely sub-acute, usually slightly apiculate; *venation*: the mid-rib is distinct.

Inflorescence of 2-10 flowering nodes with leaf-like bracts, each bract with clusters of 2 flowers subtended by differentiated bracts (bracts straight, narowly elliptic-oblong, 1.4-2.8 (-3.9) mm long, 0.5-1.0 mm wide, the length to width ratio (1.22-) 2.22-3.60 (-4.33), densely tomentose with antrorse hairs 0.2-0.3 mm long, the margin slightly involute/inrolled, the base straight or long-attenuate, the apex acute to rounded); *pedicels* 0.8-2.4 mm long, with loose, scruffy, antrorse white hairs 0.1-0.2 mm long; *bracteole pairs* inserted shortly after the mid-point of the pedicel at a point (0.33-) 0.50-0.67 times the length, erect, straight, shorter than the calyx tube, linear oblanceolate, 1.2-2.3 mm long, (0.1-) 0.2-0.3 (-0.4) mm wide, the length to width ratio 5.00-13.33, ciliate or with hairs all over with scruffy antrorse hairs 0.1-0.3 mm long, the margins straight, the base straight or long-attenuate, the apex acute.

Calyx actinomorphic, tomentose, with sparse to moderately dense appressed antrorse hairs 0.3-0.4 mm long, denser on the lobes with hairs 0.2-0.3 mm long, very rarely the tube glabrous and the lobes also with denser tufts of hair at the base; *tube* smooth, rarely slightly ribbed, obdeltate, rarely shallowly obdeltate, (1.4-) 2.0-4.5 mm long, 2.1-4.2 mm wide, the length to width ratio 0.77-1.08, the base cuneate, the interior glabrous; *lobes* straight, narrowly triangular, approximately equal to the tube, (0.40-) 0.45-0.61 times the entire calyx length, 1.6-5.0 mm long, (0.5-) 1.0-1.8 mm wide, the length to width ratio 1.90-3.50 (-5.00), the margins straight or slightly concave, the apex acute or acuminate, the interior with sparse randomly orientated, but mostly antrorse, hairs 0.1 mm long.

Corolla (5.3-) 7.0-15.5 mm long, white, pale mauve, lilac or pink, upper lobes streaked dark red; *exterior surface* glabrous or with sparse short hairs to 0.1 mm long, or the lobes ciliate;

interior surface with a mostly wedge-shaped beard of hairs 0.2-0.6 mm long on the lower throat between the stamens; *tube* narrowly oblong or narrowly funnel-shape, expanding abruptly distally, (2.5-) 3.9-4.9 mm long, shorter than the calyx lobes, 1.8-2.5 mm wide at mouth; *median abaxial lobe* obovate or abruptly spathulate, the stalk square to oblong or depressed obovate, the blade transversely elliptic to oblate, rarely transversely rhombic, (2.2-) 2.7-5.8 (-7.4) mm long, 2.2-5.8 mm wide, the length to width ratio 0.84-1.38 (-1.68), the margin undulate or unevenly crenate, the apex truncate, the sinus 0.4-2.4 mm long; *lateral lobes* obovate or widely oblong, rarely square, very rarely widely depressed obovate, (1.5-) 2.4-4.5 (-52) mm long, (1.1-) 1.7-3.8 mm wide, the length to width ratio (0.88-) 1.03-2.00 (-2.45), the margin crenate or entire, ± minutely ciliate, the apex rounded or truncate, the sinus absent; *adaxial median lobe-pair* widely to very widely obovate, 2.6-5.0 mm long, 2.5-4.5 mm wide, the length to width ratio 0.87-1.40 (-2.80), emarginate with sinus 0.6-1.9 mm deep, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.5-4.7 mm from base of corolla, 1.1-1.9 mm long, glabrous, *theca* 0.6-0.8 mm long, ± sub-sessile, glabrous, the *connective* (0.4-) 0.7-1.5 mm long, glabrous, the sterile end with a sparse to dense tuft of deltate to triangular hairs 0.1 mm long; *abaxial pair* with *filaments* inserted 2.8-4.8 mm from base of corolla, 1.1-2.4 mm long, glabrous, *fertile theca* 0.5-0.9 mm long, ± sub-sessile, glabrous, the *connective* 0.5-1.3 mm long, glabrous, the lower end bearing a second smaller theca or tapering.

Ovary 0.8-1.5 mm long, 0.6-1.0 mm wide, the length to width ratio 1.10-1.50, glabrous, the style 5.2-6.4 mm long, the stigma lobes 0.2-0.5 mm long. *Mericarps* light brown, ovoidal, reticulate, 1.1-1.2 mm long, 0.7-0.9 mm wide, the length to width ratio 1.33-1.71, the attachment scar 0.7-0.9 mm long, c. 0.65-0.70 times the entire mericarp length, glabrous.

Flowers recorded: September to November.

Ecology: Recorded in a range of soils including granite, lateritic gravel, clay and sand, almost exclusively in *Eucalyptus wandoo* woodland, often in association with *Dryandra spp.* and other heath species, rarely also in patches of open heath adjacent to *E. wandoo* woodland or in *E. marginata* forest. Usually locally abundant. Recorded on woodland edges, firebreaks edges and in forest regenerating after logging.

Notes: Easily distinguishable from *H. sericea* by its shorter, broader leaves with rounded apices. Also similar to *H. barbata* which can be be distinguished by its more ovate, acute leaves and typically looser, wooly indumentum.

Other specimens examined: *F. Hort* 584, 16.ix.1999, Gunapin Ridge Road, Gunapin State Forest, ca 400 m SE of Ref. Tree AZ92/1, York (PERTH 05419409); *A.M.* s.n., 13.xi.1904, Valley in Mt Saddleback, Darling Ranges (PERTH 02110911); *P.C. Kimber* 226, 2.ix.1966, Forests Reserve, Dwellingup-Big Brook crossing, N.E. Road (PERTH 03673545); *J.S. Beard* 1806, 5.ix.1962, Boyagin Rock Reserve (PERTH 03673529); *K. McDougall* 329, 1.x.1993, Edge of Windsor Road (ca 100 m N of intersection with North-East Road) (PERTH 06141854); *F. Lullfitz* L1692, Cuthill, York Rd. (PERTH 03673553); *D.M. Rose* 434, 27.x.1987, Dryandra State Forest (PERTH 01446142); *G.J. Keighery* 10528, 5.ix.1989, Clackline Reserve, 20 km west of Toodyay (PERTH 01610619); *R.J. Cranfield* 4304, 20.ix.1983, 20.6 km E of Grt Northern Hwy on Dewars Pool Road (PERTH 03675122); *G.J. Keighery and J.J. Alford* 1257, 11.xi.1985, Wambyn Nture reserve, 15 km west of York (PERTH 03674738).

24. Hemigenia barbata Bartl. in Pl. Preiss. i. 360 (1845); Benth. DC. Prod. xii. 567 (1848); Benth. Fl. Austral. 5: 116 (1870); Engl. & Prantl., Nat. Pflanzenfam. 3A: 219 (1897); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (1965); Blackall & Grieve, W. Austral. Wildfl. 3B: 442 (1981); ?Marchant *et al.* Fl. Perth Region i: 559 (1987); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 271 (2000).

Type: Preiss 2320, In Australia occidentali, Western Australia.

Typification: Bartling (1845) cites the holotype (Preiss 2320). The author has been unable to locate this specimen (no record on GOET database) and so the species cannot be typified. However, the description given in the protologue closely matches the specimens included here under *H. barbata* and it is likely that the type is conspecific.

Upright, much-branched shrubs 0.5-1.2 m high, rarely lower spreading bushes to 0.6 m wide; *branches* erect, ± circular in cross-section, rarely sub-qudrangular, woolly-lanose with long and short hairs or shortly, densely hoary, sometimes in longitudinal rows between the leaf bases, usually with loose, fluffy hairs extending onto the leaf bases, with dense to very dense hairs 0.1-1.0 mm long; *internodes* on leafy branches 3.2-11.8 (-24.6) mm long.

Leaves sessile, erect, straight, woolly-lanose or densely villous, at least at the base, sometimes becoming ± glabrous, with antrorse to loose spreading hairs (0.2-) 0.3-2.0 mm long; *lamina* open, flat, ovate or sub-elliptic, rarely lanceolate or some leaves obovate, (8.5-) 10.8-20.7 (-38.1) mm long, 3.0-6.6 (-7.9) mm wide, the length to width ratio 2.18-6.00, the widest point 0.28-0.53 (-0.66) of the entire length; *base* abruptly cuneate or slightly attenuate; *apex* acute

or acuminate and slightly mucronate, rarely obtuse to sub-rounded; *venation*: the mid-rib is distinct.

Inflorescence of 6-20 flowering nodes with leaf-like bracts, each bract with dense clusters of usually 3 or more flowers subtended by differentiated bracts (bracts folded but remaining open, straight or slightly recurved, ovate or narrowly elliptic, 2.0-5.0 mm long, 0.7-1.5 mm wide, the length to width ratio 2.00-5.88, densely woolly or hoary, adaxial surface glabrous to woolly, with spreading hairs 0.4-1.7 mm long, the margin straight, the base straight, the apex acute or sometimes acuminate); *pedicels* 1.0-2.0 mm long, sparsely to very densely villous with soft, loosely antrorse hairs 0.2-0.3 mm long; *bracteole pairs* inserted on the distal half of the pedicel at a point 0.57-0.80 times the length, erect, straight, shorter than the calyx tube, oblanceolate or linear, 1.8-2.6 (-3.0) mm long, 0.2-0.5 mm wide, the length to width ratio 5.02-12.00, moderately densely villous or hairy in patches with antrorse hairs 0.2-0.4 mm long, the margins straight, the base narrowly long-attenuate, the apex acute, sometimes acuminate.

Calyx actinomorphic, with dense, messy, antrorse hairs 0.1-0.6 mm long, sometimes sparser towards the base of the tube; *tube* smooth, obdeltate to shallowly obtriangular, 1.9-3.0 mm long, 2.0-3.2 mm wide, the length to width ratio 0.66-1.03, the base cuneate or slightly rounded, the interior glabrous, very rarely with very sparse antrorse hairs 0.1-0.2 mm long; *lobes* straight, triangular, rarely narrowly triangular, appearing subulate or long-caudate due to strongly involute/incurved, concave margins, equal to or slightly longer than the tube, 0.50-0.63 times the entire calyx length, 1.9-4.2 mm long, 0.8-1.4 mm wide, the length to width ratio 1.36-4.34, the margins straight to involute/incurved, the apex acute or acuminate, the interior glabrous, very rarey with very sparse antrorse hairs 0.1-0.2 mm long.

Corolla 5.7-12.0 mm long, mauve to lilac, throat white with yellow or dark spots, upper lobes striated; *exterior surface* glabrous or with patchy sparse to moderately dense random hairs 0.1 mm long; *interior surface* with a dense tufted beard of hairs 0.3-0.5 mm long on the lower throat between the stamens; *tube* narrowly oblong or obtriangular, expanding only towards the end, 2.5-4.9 mm long, shorter than the calyx lobes, 1.0-2.5 mm wide at mouth; *median abaxial lobe* widely depressed obtrullate or abruptly spathulate, the stalk transversely oblong, rarely oblong to narrowly oblong or deltate, the blade shallowly obtriangular, transversely oblong or transversley rhombic, very rarely orbicular, 2.8-6.0 mm long, 2.5-6.5 mm wide, the length to width ratio 0.85-2.40, the margin dentate or unevenly crenate, the apex ± truncate, the sinus 0.4-1.9 mm long; *lateral lobes* ovate to very widely ovate, obovate to very widely obovate or oblong, (2.0-) 2.6-4.6 mm long, (1.3-) 1.7-3.4 mm wide, the length to width ratio 1.03-1.94, the entire, rarely slightly undulate to crenate, sometimes minutely ciliate, the apex rounded, rarely truncate, the sinus absent or rarely to 0.2 mm long; *adaxial median lobe-pair* widely oblong or widely to very widely obovate, 2.4-4.9 mm long, 2.4-4.4 mm wide, the length to width ratio 0.92-1.46, emarginate with sinus 0.7-1.5 mm deep, the margin entire, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 3.0-3.2 mm from base of corolla, 1.4-1.6 mm long, glabrous, *theca* 0.5-1.0 mm long, glabrous, the *connective* 0.6-1.1 mm long, glabrous, the sterile end with a sparse tuft of hairs 0.1 mm long; *abaxial pair* with *filaments* inserted 3.4-3.6 mm from base of corolla, 1.2-1.8 mm long, glabrous, *fertile theca* 0.6-1.0 mm long, glabrous, the *connective* 0.7-1.3 mm long, glabrous, the lower end usually bearing a second smaller theca.

Ovary 0.8-1.0 mm long, 0.7-0.9 mm wide, the length to width ratio 1.00-1.25, glabrous, the style 4.4-5.6 mm long, the stigma lobes 0.1-0.3 mm long. *Mericarps* brown to light brown,

ovoidal, reticulate, 1.2-1.4 mm long, 0.7-0.8 mm wide, the length to width ratio 1.50-2.00, the attachment scar c. 0.9 mm long, c. 0.75 times the entire mericarp length, glabrous.

Flowers recorded: July to December.

Ecology: Recorded in a range of soils including sand, loam, lateritic gravel and coastal limestone in heath, shrubland and open woodland.

Notes: See notes under *H. wandooana*.

Specimens examined: Western Australia: *Drummond* 77 (K, PERTH, MEL 646370); *C. A. Gardner* s.n., 28.viii.1941, Bullsbrook (PERTH 03670112); *R.J. Chinnock* 3208, 28.ix.1976, 38 km S of the Geraldton Highway turnoff on the Eneabba road (AD97651140); *R.T. Wills RTW* 231, 29.viii.1984, Site 68, Beekeepers Reserve Collection (PERTH 06530729); *K.F. Kenneally* s.n., 8.vii.1971, 36 mile ped on Toodyay Rd. (PERTH 03671593); *Susan [Pellst]* s.n., 23.viii.1969, 37 mile peg, Toodyay Rd. (PERTH 01071777); *A.S. George* 6832, 25.ix.1965, 36-37 miles N. of Perth on Great Northern Hwy (PERTH 01870548); *E.A. Griffin* 6159, 14.xi.1990, Road verge Head Road 5.3 km at 258 degrees from juntion of Great Northern Highway and road to Wannamal (PERTH 01615076); *J. Drummond* 454, Swan River (PERTH 01178792); *F. Lullfitz* L1871, 12.xii.1962, Opposite 65 m.p. Gt. Northern Hwy (PERTH 02110938); *R. Wills* s.n., 31.vii.1985, Beekeepers Reserve collection (PERTH 06399762); *R.J. Cranfield* 4194, 18.ix.1983, 1.1 km SW of Hay Flat Rd along Head Road, Wannamal (PERTH 03675130); *R.T. WIlls RTW* 232, 14.xii.1984, Site 68, Beekeepers Reserve Collection (PERTH 06531466); *H. Steedman* s.n., ?-.ix.1927, Muchea (PERTH 03670090); *J. Drummond* 77, Swan River Colony (PERTH 01180908); *C.A. Gardner* s.n., ?-

.ix.1960, Mogamber (PERTH 01073885); *W.H. Butlet* 1, ?-.vii.1963, Stockyard Gully, Jurien Bay (PERTH 03670163).

25. Hemigenia saligna Diels in Engl. Bot. Jahrb. 35: 528-9 (1905); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 584 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 93 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 439 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 272 (2000).

Neotype (here selected): *A.M. Ashby* 2290, 4.ix.1967, Casuarinas Road, ca. 25 km off Mullewa Road (neo: AD 968041078! - upper right specimen; iso: AD 968041078! [excluding neo], Casuarinas Road, SE of Walkaway, SE of Geraldto' PERTH 01073877!).

Typification: Diels collected the type and named this species. The type material ("indistr. Irwin pr. Champion Bay, D. 3209"), held at B, was destroyed during World War II. No other duplicates have been located and it is likely that none exist. The species presented here closely matches the description in the protologue and the type location, so it is highly probable that the selected neotype is appropriate. The neotype was collected from a locality near the original type collection and matches the description in the protologue well.

Mostly upright, foliose shrubs 1.0-2.0 m high; *branches* erect, slightly qudrangular in cross-section, pannose or shortly sericeous with moderately dense to dense appressed antrorse hairs to 0.1 mm long; *internodes* on leafy branches 5.5-16.7 (-24.7) mm long.

Leaves sessile, erect, straight, densely, shortly pannose-sericeous, dark silver in appearance, with closely appressed antrorse straight hairs 0.1-0.2 (-0.4) mm long, often with the abaxial surface nearly glabrous or hairy only on the mid-rib or only moderately hairy, or with longer

hairs 0.2-0.3 mm long extending from the branches onto the leaf bases, becoming glabrous; *lamina* open, flat or the margins involute, lanceolate or narrowly elliptic to narrowly oblong, rarely some leaves oblanceolate, exceedingly rarely all oblanceolate (G.J. Keighery & N. Gibson 1323), (11.3-) 16.2-31.4 (-37.1) mm long, (0.9-) 2.5-5.3 (-7.3) mm wide, the length to width ratio (3.77) 4.57-7.49 (-15.11), the widest point 0.32-0.53 (-0.75) of the entire length; *base* straight or shortly cuneate; *apex* usually acuminate, less often acute or obtuse, ± slightly mucronate; *venation*: the mid-rib is distinct.

Inflorescence of 1-12 flowering nodes with leaf-like bracts, each with clusters of 2-4 flowers subtended by differentiated bracts (bracts straight to slightly incurved, ovate or narrowly oblong, 2.2-4.4 nmm long, (0.4-) 0.5-1.4 (-1.8) mm wide, the length to width ratio 2.22-5.75, shortly, densely sericeous with appressed silky hairs 0.1-0.2 (-0.5) mm long, ± patchy sessile glands, the margin involute, the base straight, the apex acute or obtuse; *pedicels* 1.1-2.2 mm long, densely to very densely, shortly sericeous with silky antrorse hairs 0.1-0.2 mm long; *bracteole pairs* inserted approximately on the middle third of the pedicel at a point 0.36-0.75 times the length, erect, straight to slightly recurved, shorter than or rarely equal to or slightly exceeding the calyx tube, oblanceolate or linear-narrowly elliptic, 1.8-3.4 mm long, 0.2-0.6 mm wide, the length to width ratio 4.83-15.00, moderately to densely sericeous with silky antrorse hairs 0.1-0.3 mm long, the margins slightly involute, the base long-attenuate, the apex acuminate.

Calyx actinomorphic, with moderately dense to dense silky antrorse hairs 0.1-0.3 mm long, denser on the lobes with hairs 0.2-0.4 (-0.5) mm long, or nearly glabrous towards the base of the tube; *tube* smooth, shallowly obdeltate to obdeltate, 2.3-3.5 mm long, 2.5-3.5 mm wide, the length to width ratio 0.78-1.13, the base cuneate, the interior glabrous; *lobes* straight, triangular, rarely nearly subulate, approximately equal to the tube, 0.43-0.63 times the entire

calyx length, 2.1-4.0 mm long, 1.0-1.6 mm wide, the length to width ratio 1.47-3.00, the margins slightly involute, the apex acute or acuminate, the interior indumentum equal to that of the exterior or less commonly with only sparse hairs 0.1-0.2 mm long, rarely glabrous.

Corolla (6.5-) 7.7-13.6 mm long, mauve; *exterior surface* glabrous or with sparse random hairs 0.1 mm long; *interior surface* with a dense, diffuse beard of hairs 0.3-0.6 mm long on the lower throat between the stamens, sometimes extending onto the base of the lower lobes; *tube* oblong, expanding only at the end, 3.1-5.4 mm long, shorter than the calyx lobes, 1.7-3.3 mm wide at mouth; *median abaxial lobe* abruptly spathulate, the stalk oblong, square or obtriangular, the blade circular to transversely oblong, or the entire lobe obovate to widely obovate, (3.5-) 4.2-7.6 mm long, (2.5-) 3.0-6.0 mm wide, the length to width ratio (0.76-) 1.00-1.56, the margin finely crenate, undulate, dentate to deeply dentate, or entire, sometimes sparsely ciliate with hairs 0.1 mm long, the apex truncate or rounded, the sinus 0.4-0.9 (-1.4) mm long, rarely absent; *lateral lobes* obovate, rarely to very widely obovate, oblong, rarely to narrowly oblong, rarely widely elliptic, very rarely widely ovate, (2.2-) 2.9-6.6 mm long, 1.6-3.6 (-5.0) mm wide, the length to width ratio 1.00-2.24 (-2.94), the margin slightly undulate, sometimes densely ciliate with hairs 0.1 mm long, the apex rounded or truncate, the sinus absent or rarely to 1.0 mm long; *adaxial median lobe-pair* obovate to widely obovate, (3.2-) 4.0-6.2 mm long, (2.1-) 3.1-4.4 mm wide, the length to width ratio 1.18-1.64, emarginate with sinus 0.8-2.0 mm deep, the margin entire, rarely minutely, moderately ciliate, the apex rounded.

Stamens: *adaxial pair* with *filaments* inserted 2.5-3.8 mm from base of corolla, 1.1-1.9 mm long, glabrous, *theca* 0.8-0.9 mm long, glabrous, the *connective* 0.8-1.2 mm long, glabrous, the sterile end with a small, dense tuft of hairs 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted 2.9-4.3 mm from base of corolla, 1.6-2.7 mm long, glabrous or with minute patent

hairs, *fertile theca* 0.8-1.0 mm long, glabrous, the *connective* 0.8-1.4 mm long, glabrous, the lower end bearing a second theca of variable size.

Ovary 0.7-1.1 mm long, 0.6-0.9 mm wide, the length to width ratio 1.00-1.33, glabrous, the style 3.0-6.0 mm long, the stigma lobes 0.1-0.3 mm long. *Mericarps* light to dark brown, ovoidal, reticulate, 1.3-1.7 mm long, 0.9-1.1 mm wide, the length to width ratio 1.44-1.60, the attachment scar 1.0-1.1 mm long, 0.63-0.77 times the entire mericarp length, glabrous.

Flowers recorded: June to October.

Ecology: Recorded in yellow sand over lateritic gravel in low heath and open mallee.

Notes:

G.J. Keighery & N. Gibson 1323 is from a more northerly location than other collections of this species. It is atypical in having obovate leaves with more rounded apices but is otherwise indistinguishable.

Similar to *H. sericea* but the disjunct range is further north and it can be distinguished by its lanceolate to narrowly elliptic leaves (cf. oblanceolate) and more appressed, silvery indumentum.

Other specimens examined: Western Australia: *G.J. Keighery & N. Gibson* 1323, 26.viii.1994, 59.4 km W along State Barrier Fence Access (S of fence) track from NW Coastal Highway. (Site: zu2). (PERTH 04989872); *A.M. Ashby* 1898, 14.viii.1966, South of Eradu (PERTH 01073907, AD 96730170); *J & M Pocock* s.n., 12.ix.1968, Geraldton (AD 96923599); *A.M. Ashby* 4882, 29.viii. 1973, Casuarina's road off Mullewa road (AD 97422005); *P.G. Armstrong* s.n., 27.vi.1997, Site 49, 3.8 km SE of The Casuarinas on

Casuarinas Road, 4.2 km S of Nangetty West Road (PERTH 05942527); *S. Patrick* 3254 A, 22.ix.1999, Casuarinas Road, 11.3 km NE of Burma Road, both sides of road edges (PERTH 05510155); *A.M. Ashby* 5164, 14.vi.1975, Approximately ca. 1 km west of Casuarinas Road, which is ca. 25 km off Mullewa Road, between Indarra and Ambaniana., joining Burma Road and Mullews Road (AD 97549192); s.coll. [label with Mueller's handwriting (at least the species name) and Bentham's initial has squiggle in lower left corner that may denote a collector], s.dat., Champion Bay (MEL 646657, MEL 646656); *D. Jones* s.n., ?-.?-.1879, Greenough (MEL 646659); *A.C. Burns* 15, 24.vii.1966, Casuarina Road, S.E. of Geraldton (MEL 646663, PERTH 01073893); *A.M. Ashby* 5198, 9.viii.1975, Found south if Casuarinas by Saddleworth Farm (AD 97549191); *E.A. Griffin* 7531, 24.x.1992, AMG-Zone 50324987mE 6807313mN; Unmade Rd, E of Casuarinas Rd, E of Geraldton (PERTH 03545458); *Stuart Clarey* [?] s.n., ?-.?-.1884, Between Northhampton & Shark Bay (MEL 646681); *Ch. Gray* [?] s.n., ?-.?-.1869, Greenough Flat (MEL 646661).

26. Hemigenia sericea Benth. in Hueg. Enum. Pl. 80 (1837); Bartl. Pl. Preiss. i. 360 (1845); Benth. DC. Prod. xii. 567 (1848); Benth. Fl. Austral. 5: 116 (1870); Engl. & Prantl., Nat. Pflanzenfam. 3A: 219 (1897); C.A.Gardner Enum. Pl. Austral. Occ. 114 (1931); Blackall & Grieve, Western Austral. Wildfl. 3: 585 (1965); J.S. Beard, Descr. Cat. W. Austral. Pl.: 94 (s.dat. [1965]); Blackall & Grieve, W. Austral. Wildfl. 3B: 441 (1981); Paczkowska & Chapman, W. Austral. Fl. Descr. Cat.: 273 (2000), partly, excluding *H. parviflora* and *H. wandooana*.

H. argentea Bartl. in Pl. Preiss. i. 360 (1845); Benth. DC. Prod. xii. 567 (1848).

H. sericea var. lanosa Benth. Fl. Austral. 5: 116 (1870); Blackall & Grieve, W. Austral. Wildfl. 3B: 441 (1981).

?*H. aff. sericea* Marchant *et al.* Fl. Perth Region i: 561 (1987).

Type: *Hügel*, Swan River.

Typification. The type of this species could not be located, hence typification was not possible. However, specimens which Bentham later cited along with this collection were seen, and it is highly likely that the Hügel collection is conspecific. The species as recognised here matches the description given in the protologue.

Variable, upright, rarely spreading, open to compact shrubs 0.25-1.7 m high, 0.5-2.0 m wide; *branches* mostly erect, sometimes semi-decumbent, sub-quadrangular cross-section, densely hoary with dense, loosely antrorse hairs 0.2-0.5 mm long, or the young branches densely tomentose-sericeous; *internodes* on leafy branches (2.5-) 4.1-26.3 (-35.1) mm long.

Leaves sessile, erect, patent or reflexed, straight, rarely slightly falcate, densely sericeous, or becoming glabrous-glabrescent, young leaves densely silky-tomentose, with loosely appressed antrorse hairs 0.2-0.3 mm long or with fine hairs to 0.6 mm long at the base; *lamina* open, flat or the margins incurved, narrowly oblong-elliptic, or oblanceolate to sub-narrowly obtrullate, rarely some individual leaves ovate, (7.7-) 12.3-37.4 (-43.5) mm long, (1.5-) 2.3-7.5 mm wide, the length to width ratio 3.35-7.37 (-21.00), the widest point (0.42-) 0.48-0.73 (-0.84) of the entire length; *base* straight to cuneate, rarely abruptly attenuate; *apex* (± abruptly) acute to obtuse or acuminate, often slightly mucronate; *venation*: a distinct mid-rib is distinct or also with minor indistinct veins.

Inflorescence of 3-9 flowering nodes with leaf-like bracts, each bract with clusters of 2-3 flowers subtended by differentiated bracts (bracts flat or loosely folded, straight, ovate, lanceolate, or widely elliptic, rarely elliptic or narrowly oblong, 1.6-5.4 (-15.9) mm long, 0.4-3.0 (-3.6) mm wide, the length to width ratio 1.17-4.42, with short, appressed antrorse hairs along the central nerve or shortly sericeous with antrorse hairs 0.1-0.2 mm long, the margin straight or slightly incurved, the base straight, the apex obtuse to sub-acute or rounded, rarely minutely apiculate), or some flowers single, or with single flowers in short axillary racemes subtended by differentiated bracts (ie. the axis of the axillary clusters elongated),or head-like; *pedicels* 1.2-3.1 mm long, densely tomentose with loosely antrorse hairs 0.3 mm long, usually with a tuft of longer, denser hair at the base of the calyx; *bracteole pairs* inserted on the distal half of the pedicel at a point 0.56-1.00 times the length, erect, held against the calyx, straight, rarely slighty recurved, exceeding the calyx tube, less often equal to or shorter than it, linear-oblanceolate or ovate, 1.8-5.8 mm long, 0.2-0.7 (-0.9) mm wide, the length to width ratio (2.33-) 3.80-12.00 (-13.33), sparsely to densely sericeous with antrorse hairs 0.2-0.3 mm long, the margins straight or slightly infolded, the base straight, cuneate or long-attenuate, the apex acute to sub-acute.

Calyx light green, actinomorphic or the lobes slightly unequal in length, densely sericeous to lanate with antrorse hairs 0.2-0.6 (-0.9) mm long, or the tube or base of tube only moderately so, rarely the entire calyx only sparsely to moderately hairy (typical for coastal limestone variant); *tube* smooth, obdeltate to shallowly obdeltate, 2.0-3.4 mm long, 2.2-3.5 mm wide, the length to width ratio 0.77-1.14, the base cuneate to rounded, the interior glabrous; *lobes* straight to spreading or curving laterally, triangular or subulate, rarely oblong, approximately equal to the tube, 0.49-0.61 times the entire calyx length, 1.9-3.7 mm long, 0.9-1.5 mm wide, the length to width ratio 2.07-3.00, the margins straight to concave, the apex acute, rarely acuminate, the interior densely sericeous with hairs 0.3-0.5 mm long, rarely glabrous.

Corolla 5.3-14.2 mm long, pale to dark, pink to purple, tube white, darker purple streaks on sides of throat and base of the lateral and upper lobes, and brown splotches on the base of throat and base of the lower lobes; *exterior surface* with sparse, appressed, random hairs 0.1 mm long; *interior surface* with a dense, compact, tufted beard of hairs 0.2-0.4 mm long on the lower throat between the stamens, extending onto the median abaxial lobe; *tube* narrowly oblong, 2.9-5.0 mm long, shorter than the calyx lobes, 1.7-2.4 mm wide at mouth; *median abaxial lobe* shallowly obdeltate to obdeltate or abruptly spathulate, the stalk square or transversely oblong, the blade oblate or transversely oblong, rarely orbicular, rarely the entire lobe widely obovate, (2.0-) 2.5-6.4 (-7.9) mm long, 2.4-7.9 mm wide, the length to width ratio 0.72-1.28, the margin crenate-undulate or dentate to deeply, unevenly dentate, the apex truncate or obtuse, the sinus to 1.7 mm long or absent; *lateral lobes* obovate to widely obovate, rarely very widely obovate, very rarely sub-ovate, (1.6-) 2.0-6.5 mm long, (1.2-) 1.8-4.1 (-5.7) mm wide, the length to width ratio (0.83-) 1.12-1.71, the margin crenate or nearly entire, the apex rounded or truncate, the sinus absent or 0.4-0.5 mm long; *adaxial median lobe-pair* obovate, oblate or widely elliptic, 2.1-6.4 mm long, 1.6-4.8 mm wide, the length to width ratio 0.77-1.44, with a slight central hood, emarginate with sinus 0.3-2.0 mm deep, the margin entire, the apex rounded to truncate.

Stamens: *adaxial pair* with *filaments* inserted 1.8-3.0 mm from base of corolla, white, 1.2-1.5 mm long, glabrous, *theca* purple,0.5-0.9 mm long, glabrous, the *connective* white, 0.8-1.3 mm long, glabrous, the sterile end with a dense tuft of hairs 0.1-0.2 mm long; *abaxial pair* with *filaments* inserted 2.8-3.0 mm from base of corolla, white, 1.0-1.8 mm long, glabrous, *fertile theca* purple, 0.4-1.2 mm long, glabrous, the *connective* white, 0.6-1.2 mm long, glabrous, the lower end bearing a second smaller theca.

Ovary 1.0-1.6 mm long, 1.0-1.5 mm wide, the length to width ratio 1.00-1.25, glabrous, the style 3.2-4.8 mm long, the stigma lobes 0.1-0.3 mm long. *Mericarps* brown to light brown, ovoidal, reticulate, 1.4-1.7 mm long, 0.9-1.1 mm wide, the length to width ratio 1.27-1.89, the attachment scar 0.9-1.4 mm long, 0.60-0.82 times the entire mericarp length, glabrous or with minute hairs in the lacunae.

Flowers recorded: July to December.

Ecology: Recorded in a wide range of soils and situations including sand, clay, laterite, granite outcrops and coastal limestone, in vegetation ranging from heath to forest. Recorded from undisturbed sites but often on track edges or sand/gravel pits.

Notes: A highly variable species with several recognisable morpho-/eco-types. Populations occurring on coastal limestone have large leaves which are mostly glabrous except when young and the internode is contracted, giving the erect leaves a crowded appearance. A race occurs throughout the Wongan Hills area which tends to have smaller leaves which are held less erect than other forms, and young foliage which is densely silvery/sericeous, the hairs more appressed. This race is probably what was once named *H. argentea* (type not seen). This race overlaps morphometrically with the typical form and the silvery indumentum of young shoots is not unique. These races are not considered to be of taxonomic significance.

Hemigenia sericea is the most abundant and variable species of a complex which includes *H. barbata*, *H. curvifolia*, *H. parviflora*, *H. saligna*, and *H. wandooana*. It is most morphologically similar to *H. wandooana* and *H. saligna*. See notes under these species.

Selected specimens examined (ca. 50 seen): Western Australia: *Preiss* 2333 (MEL 646653, MEL 646643); *Greg Guerin* 112 *& Penny McLachlan*, 17.x.2003, 650 m along O'Connor

track from Dardadine Rd South (junction ca. 10 km from Albany Hwy) around old gravel pit adjacent to track (AD [not databased], PERTH only); *Greg Guerin* 125 *& Penny McLachlan*, 22.x.2003, On stockyard rd, 2.05 km west of Quindanning-Darkan rd, rock outcrop at intersection with Winooka road. Plants occurring around edge of granite outcrop & along roadside (AD [not databased], PERTH, CANB); *E.A. Griffin* 4203, 3.ix.1985, Prop Mt Lesueur Res. S of Green Head Road (PERTH 01073958); *J. Havel* 314, 25.viii.1966, Mt Wabling, N. of Yanchep (PERTH 03670155); *R.J. Cranfield* 4462, 21.x.1983, 9.5 km E of Great Southern Hwy, 8 km SSE of Brookton (PERTH 03675149); *M.I.* 540, ?-.xi.1892, Avon District (PERTH 02110962); *A.S. George* s n., 22.x.1979, Avondale Research Station, W. of Beverley (PERTH 05991021); *R. Davis* 4643, 26.xi.1997, 2.4 km W along Stockyard Road from junction of Quindanning-Darkan Roads (PERTH 04934547); *P.C. Jobson* 2397, 12.x.1993, Great Southern Highway at Hotham River crossing, 40 km N of Narrogin (MEL 2025571); *R.D. Royce* 7892, 29.vii.1963, Boyargin Reserve, S. of Brookton (PERTH 02034433, CBG 9301023); *R. Helms* s.n., 5.ix.1899, Plympton (NSW217118); *C.A. Gardner* 639, 17.viii.1920, Goomalling (PERTH 02111047); *P. Roberts* 138, 15.viii.1983, NW of Wongan Hills, reserve 16148 (PERTH 03674940, PERTH 03674681); *Ross J.H.* 2860, 30.ix.1984, 3km north of Wongan Hills town in Water Reserve (PERTH 06338631, MEL 1528172); *E. & S. Pignatti* 224, 29.ix.1985, Wongan Hills (PERTH 03674851).

5 Phylogenetic evaluation

Abstract

The phylogeny of tribe Westringieae (Lamiaceae) was examined based on morphological, molecular and combined analyses. The morphological analysis included 63 species and 83 characters The analyses confirmed that the tribe is monophyletic and that *Prostanthera* is sister to the remaining genera. The results suggest that both *Hemigenia* and *Microcorys* are polyphyletic. The staminal lever mechanism characteristic of *Hemigenia* and *Microcorys* appears to have evolved after the split from *Prostanthera*, and its absence in *Hemiandra* and *Westringia* suggests secondary reversal. Changes to the generic delimitations and classification within the group are inevitable, but further molecular data are required to confirm the internal relationships before names changes can be proposed with certainty of nomenclatural stability in the future.

5.1 Introduction

A number of high-level phylogenies for the Lamiaceae family are now available (e.g. Wink and Kaufmann 1996; Wagstaff and Olmstead 1997), and within this framework, detailed and meaningful phylogenetic studies at lower levels have been possible (e.g. Paton *et al.* 2004; Steane *et al.* 2004). Several high-level studies agree that tribe Westringieae is monophyletic (e.g. Cantino 1992a; Cantino 1992b; Wink and Kaufmann 1996; Olmstead *et al* 1998). The internal relationships within the Westringieae are less clear and have been subject to alternative hypotheses. Some studies have not included enough taxa from the Westringieae to determine relationships within it (Wink and Kaufmann 1996; Wagstaff *et al.* 1998). Where the scope of analyses has allowed for conclusions to be drawn, data have consistently supported the notion that *Prostanthera* (considered here to include the genera *Eichlerago* and *Wrixonia*) is sister to the remaining genera (Conn 1992; Cantino 1992b; Olmstead *et al.* 1998). Cantino's (1992b) morphological analysis placed *Westringia* sister to *Microcorys*, with this clade part of a 3-way polytomy with *Hemigenia* and *Hemiandra*. This contrasts with the results of Olmstead *et al.* (1998), who found that *Westringia* was sister to a *Hemiandra-Hemigenia-Microcorys* clade in which *Hemigenia-Microcorys* was sister to *Hemiandra*.

However, a 'proofing note' attached to the article states that '*Hemigenia* sp.' = *M. obovata*, hence no representatives of *Hemigenia* were actually included in the analysis.

Attempts to elucidate the exact relations of the genera *Hemiandra, Hemigenia, Microcorys* and *Westringia* have been partly hampered by the confusion between species and genera in these groups at the level of herbarium material. This is further complicated by the fact that some studies have presented representative of the group as OTU's, without justifying the choice or explaining which species characters have been read from (Conn 1992; Cantino 1992b), or included unidentified (or unspecified) species as terminal taxa. The example of uncertain identification in Olmstead *et al.* (1998) cited above is a prime example. The problem appears to be partly the choice of methods employed by workers and partly the poor alpha taxonomy and resulting poor curation of the group in herbaria.

These attempts to examine the internal relationships of the tribe follow a history of poor generic delimitation within the group with regard to *Hemigenia* and *Microcorys*. A number of alternative genera (e.g. *Colobandra* Bartl and *Atelandra* Lindl.) and classifications have been proposed and a number of species have been changed between genera (Bentham 1834; Bentham 1848; Lindley 1840; Bartling 1845). Hemsley (1905) noted that the features delimiting the genera were highly unsatisfactory, and stated that the stamen characters which defined the genera were of little more than specific importance.

To date, no comprehensive dataset has been produced to examine internal relationships within the tribe. To provide robust results and conclusions, multiple datasets are an important tool (Mugridge *et al.* 2000). Here, the results of a morphological analysis and an analysis based on sequences from the chloroplast *trn*T-*trn*F region are presented. The latter has been used with success in other Lamiaceae genera at a similar level (Paton *et al.* 2004). The results are intended to provide preliminary data towards a resolution of the phylogeny of the Westringieae and a re-worked classification.

Guerin (2005b) produced a phylogeny of the Westringieae based on a cladistic analysis of mericarp characters, but emphasised the need for analysis of a more comprehensive morphological dataset along with molecular data. The results suggested both *Hemigenia* and *Microcorys* are polyphyletic, whilst *Microcorys* is paraphyletic with respect to *Westringia*. The infrageneric classification of the genera was largely supported, but differences between *Microcorys* sections *Microcorys* and *Anisandra* were not apparent. Guerin (2005a) examined floral structures in a functional sense and provided the ground-work for a determination of likely homologies with regard to corolla and stamen characters.

The correct methods for cladistic analyses of morphological data have been debated for some time. For the purposes of objectivity in an analysis where characters are chosen, it is important to include outgroups as terminal taxa, rather than constraining them as outgroups, and allowing parsimony to test the monophyly of the ingroup (Nixon and Carpenter 1993). The inclusion of multiple outgroups can stabilise a phylogeny, but character selection should allow their internal relationships to be resolved, an approach taken here. The selection of outgroups near the Westringieae can be conducted by assessing published higher-level phylogenies (e.g. Ryding 1995, Wink & Kaufmann 1996; Wagstaff *et al.* 1998).

Grandcolas *et al.* (2001) claimed that little weight should be given to the examination of primary homologies, instead suggesting as many characters as possible should be included in the analysis to allow parsimony to independently determine the evolutionary pattern and therefore secondary homologies. This approach is problematic, because without selection of characters deemed to be primarily homologous, the results of the analysis will be confounded by excessive homoplasy. The selection of characters for cladistic analysis without any pre-conceived notion of evolutionary pattern is difficult. The approach taken here is to include as many characters as possible that upon careful examination are considered to be homologous. Homoplasy will still account for some of the character polarity, but a useful phylogeny is

more likely to result. Comparison with a phylogeny based on DNA sequences will be important in determining the plausibility of the results.

In molecular analyses, homoplasy arises from both the fact that equivalent bases derived from different evolutionary histories are indistinguishable, and from incorrect alignment of sequences (Morrison and Ellis 1997). The latter can arise from using algorithms which erroneously align sequences based on overall similarity rather than homology. For smaller datasets, careful hand alignment can minimise this problem, and this is the approach taken here.

5.2 Methods

5.2.1 Molecular dataset:

Total plant DNA was extracted from the leaves of 29 selected species using the MasterPure™ Plant Leaf DNA Purification Lit (Epicentre) with the protocol specified by the manufacturer. Species were selected to represent the morphological diversity known to exist in *Hemigenia* and *Microcorys*. Representatives of *Hemiandra, Prostanthera* and *Westringia* were used as putative outgroups within the Westringieae and *Dicrastylis* was included as a putative outgroup to the Westringieae (Table 5.1). A Retsch mixer mill (type MM 300) was used to grind dry leaf tissue with the extraction buffer at a frequency of $25s^{-1}$ for approximately 2 minutes. PCR products for the *trn*T-*trn*F chloroplast region (*trn*T-*trn*L intergenic spacer, *trn*L intron, *trn*L-*trn*F intergenic spacer) were obtained using the primers and protocol of Taberlet *et al.* (1991). The most common combinations of primers used were a-b, c-d, e-f and c-d. To test PCR products, 5 µL mixed with 2 µL of loading buffer was run on an 1.5% agarose gel run at ca. 100 V for ca. 45 minutes, stained in ethidium bromide for ca. 15 minutes and viewed under a UV lamp. PCR products were cleaned using the UltraClean™ PCR Clean-up Kit (MO BIO) with the protocol specified by the manufacturer. Sequencing reactions (20 µL) containing the following reagents: 6 µL nuclease-free water, 4 µL 2.5X Big Dye Buffer, 4 µL

2.5X Big Dye 3.1, 1 μL primer, 5 μL template. PCR primers were used successfully in sequencing reactions. Sequences were cleaned by adding 80 μL of 75% cold isopropanol and leaving for ca. 15 minutes at room temperature. Reaction mixtures were then centrifuged for 20 minutes and the resulting supernatant decanted before adding a further 250 μL of isopropanol and spinning for a further 5 minutes. The supernatant was again decanted and the tubes were placed in a drying rack for ca. 1 minute to dry.

The resulting sequences (read using the dye-termination method) were edited using SeqEd (A.B.I. 1992) and aligned manually using Se-al v.2 (Rambaut 1996). Phylogenetic analyses were conducted using PAUP* 4.0 (beta version) (Swofford 2003). Heuristic searches were conducted with 500 random addition sequence replicates and islands limited to 100 trees. Starting trees were obtained via stepwise addition. Gaps were treated as missing data. Support for branches was tested with 1000 bootstrap replicates (Felsenstein 1985). Data were also analysed using the likelihood criterion with a rearrange limit of 1000 per tree and a transition to transversion ratio of 2. Assumed nucleotide frequencies were set at A = 0.35912, C = 0.15053, G = 0.16570, T = 0.32465. The Rogers-Swofford approximation method was used for starting branch lengths. Trees more than 5% away from the target score were rejected. Starting trees were obtained via stepwise addition.

5.2.2 Morphological dataset:

Sixty-three species of *Hemigenia* and *Microcorys* were scored for 83 morphological characters (Table 5.2). Mericarp characters taken from Guerin (2005b) were largely unchanged, while floral characters were based on an assessment of homologies following the previous work of Guerin (2005b). A range of material was examined including herbarium specimens from the following herbaria: AD, BRI, CANB, MEL, NSW, PERTH.

Phylogenetic analyses were conducted using PAUP* 4.0 (beta version) (Swofford 2003). Heuristic searches were performed with 200 random addition sequence replicates and

islands of trees limited to a maximum of 100. All trees longer than the shortest trees were discarded. All characters were initially unweighted. Putative outgroups from both within (ie. *Hemiandra*, *Prostanthera*, *Westringia,*) and outside (ie. *Ajuga*, *Dicrastylis*, *Teucrium*, *Scutellaria*) the Westringieae were included in the analysis.

The characters were then reweighted *a posteriori* using the "reweight" command of PAUP to reduce the weight of more homoplastic characters so that the Rescaled Consistency Index (RI) was maximised. The analysis was then repeated with the reweighted data as above. Support for branches was tested with 50 bootstrap replicates (each with 50 random addition sequence replicates).

5.2.3 Combined dataset

The molecular and morphological datasets were combined. All those taxa for which sequence data was available were included, with the exception of *Hemigenia conferta*, which was not included in the original morphological analysis due to a lack of fruiting material in the collections. The resulting datamatrix was analysed heuristically using PAUP with 500 random addition sequence replicates and islands limited to 100 trees. The characters were then reweighted as described for the morphological dataset and the anaysis repeated. Support for branches in the both the unweighted and reweighted analyses was tested with 100 bootstrap replicates (each with 50 random addition sequence replicates).

Table 5.1. Species used in the analysis of *trn*T-*trn*F nucleotide data.

Species	Specimen number
OUTGROUP:	
Dicrastylis doranii	Latz PK 12918 AD 99510060 1992
Prostanthera behriana	GG 075 AD 139669 2002
Westringia dampieri	GG 019 AD 137647 2002
Hemiandra pungens	GG 025 AD 137653 2002
INGROUP:	
Hemigenia biddulphiana	PI Forster PIF24793 + R Booth, F Carter MEL 302700 1999
H. brachyphylla	GG 146 AD 2003
H. cerebrecarpa ms	GG 050 AD 137678 2002
H. conferta	S Donaldson 2192, GT Chandler, A Morro CANB 602359.1 1999
H. cuneifolia	P.C. Jobson 5235 & S.A. Mills NSW 434308 1997
H. dendritica ms	K. Kershaw, L. Kerrigan KK 2405 PERTH 06506682 2001
H. dielsii	GG 137 AD 2003
H. diplanthera	GG 052 AD 137680 2002
H. humilis	GG 114 AD 2003
H. incana	GG 120 AD 2003
H. macphersonii	K. Ashby s.n. PERTH 04663578 1996
H. macrantha	GG 053 AD 137681 2002
H. pedunculata	GG 150 AD 2003
H. ramosissima	GG 113 AD 2003
H. scabra	GG 056 AD 137684 2002
H. sericea	GG 125 AD 2003
H. tysonii	AS George 17483 PERTH 06071740 1998
H. viscida	GG 133 AD 2003
H. westringioides	GG 086 AD 2003
Microcorys barbata	R. Davis 10243 PERTH 05628059 2002
M. capitata	J. Foss, P. Gurry 140 PERTH 06346308 2001
M. exserta	GG 094 AD 2003
M. longifolia	GG 132 AD 2003
M. obovata	GG 037 AD 137665 2002
M. tenuifolia	R. Davis 2039 PERTH 04600274 1997

Table 5.2. Characters used in the cladistic analysis of morphology

0 = present; 1 = absent

MERICARPS:

Shape:

1. Ovoidal (0 or 1)
2. Cylindrical (0 or 1)
3. Oblong (0 or 1)
4. Cuneate (0 or 1)

Surface sculpturing:

5. Reticulate (0 or 1)
6. Rugose (0 or 1)
7. Rugose, the ridges very prominent (0 or 1)
8. Longitudinal ridging (0 or 1)
9. Smoothly pitted (0 or 1)
10. Cerebral (0 or 1)
11. Deep narrow pits (0 or 1)
12. Base smooth/apex sculptured (0 or 1)

COROLLA cont.

44. Anterior lobes small, fringing hood, concave (0 or 1)
45. Anterior lobes small, rounded, held at base (0 or 1)
46. Anterior lobes both emarginate, the central lobe larger (0 or 1)
47. Presence of beard on lower throat (0 or 1)
48. Lateral lobes fused to lower lobe, not attached to upper lip (0 or 1)
49. Lower lip far exceeding the upper lip- more than twice as long (0 or 1)
50. Interior of upper lip streaked with colour (0 or 1)
51. Hood as long as lower lip and widely separated (0 or 1)
52. Abaxial median lobe abruptly spade-shaped (0 or 1)

STAMENS:

Attachment scar:

13. Raised rim (0 or 1)
14. Spine-like projection (0 or 1)
15. Longer than half mericarp (0 or 1)
16. Small, ± circular (0 or 1)
17. ± oval, small (0 or 1)
18. With a smooth rim (0 or 1)
19. Deeply concave (0 or 1)

Exocarp cellular sculpturing:

20. Convex (0 or 1)
21. Discoid (0 or 1)
22. Minutely discoid (0 or 1)
23. Flat, cells clearly visible (0 or 1)

Trichomes:

24. Short, flattened hairs in lacunae (0 or 1)
25. Long, rounded hairs at apex (0 or 1)
26. Short, flattened, truncate hairs at apex (0 or 1)
27. Reticulae with clustered, flattened trichomes (0 or 1)
28. Rounded tuburculate trichomes on ridges (only) (± branched), broad base (0 or 1)

LEAVES:

29. Opposite (0 or 1)
30. Whorled (0 or 1)
31. Folding of leaves (0 closely folded/conduplicate or 1 open)
32. Apex pungent (0 or 1)
33. Axillary growths dense/contracted (0 or 1)
34. Leaves secondarily lobed/sinuous (0 or 1)
35. Foliage distincltly viscid/strongly glandular (0 or 1)

COROLLA:

36. Distinctly bicoloured (0 or 1)
37. Tube funnel-shape (0 or 1)
38. Tube narrow-cylindrical (0 or 1)
39. Upper lip hooded (0 or 1)
40. Hood with anterior slit (0 or 1)
41. Anterior lobes ± erect, emarginate, concave (0 or 1)
42. Upper lip flat, erect, anterior lobes divided apically, lip larger than lower (0 or 1)
43. Anterior lobes flat, horizontal (0 or 1)
53. Fertile thecae sessile (upper) (0 or 1)
54. Connective of upper stamens elongated (0 or 1)
55. Upper stamens- 2 thecae (0 or 1)
56. Upper stamens: thecae 1 (0 or 1)
57. Thecae shape (0. Elongated or 1 ± rounded)
58. Lower stamens fertile (0 or 1)
59. Lower stamens: club-like staminodes present (0 or 1)
60. Upper stamens- connective broad and ± densely bearded (0 or 1)
61. Lower stamens dimidiate (0 or 1)
62. Stamens highly exserted beyond corolla upper lip (0 or 1)
63. Connective of upper stamens mobile, or with vestigial groove (0 or 1)
64. Lower end of connective of adaxial anthers abruptly dilated (0 or 1)
If connective expanded, then equal width along length

CALYX:

65. Distinctly 2-lipped, the upper lip with three reduced/rounded lobes (0 or 1)
66. Actinomorphic (0 or 1)
67. Distinctly 2-lipped, the upper lip entire (0 or 1)
68. Madl slightly larger (0 or 1)
69. Distinctly 2-lipped, the lobes of the upper lip acute (0 or 1)
70. With a single prominent rib per lobe (0 or 1)
71. Becomes papery when mature (0 or 1)
72. Abaxial lip closes over fruit (0 or 1)
73. Adaxial lip becomes larger at maturity (0 or 1)
74. Distinctly glandular (non-bronze glands) (0 or 1)
75. Lobes caudate from oblong base (0 or 1)

PEDICELS:

76. 'Adnexed' to stem (0 or 1)
77. Some or all bent (0 or 1)
78. Prominently flattened (0 or 1)

BRACTEOLES:

79. Reduced and appressed to pedicel (0 or 1)
80. Deciduous (0 or 1)

BRACTS:

81. Differentiated, much smaller than leaves, apex rounded/truncate (0 or 1)

FLOWERS:

82. ± sessile, clustered in axils (0 or 1)
83. In dense, sessile heads (0 or 1)

5.3 Results

5.3.1 Molecular dataset:

The final datamatrix contained 1479 characters, with 182 variable characters and 63 informative sites (Appendix A). The parsimony analysis produced 281 Maximum Parsimony trees of length 301. The Strict Consensus of these trees is shown in Fig. 5.1. There was 100% support for the monophyly of the Westringieae, which shows *Prostanthera* as sister to all other species, which fall into three main clades: *Hemigenia cuneifolia* and *Microcorys tenuifolia*; the bulk of *Hemigenia* sections *Malleantha, Diplanthera, and Homalochilus*; and *Microcorys, Westringia, Hemiandra* and *Hemigenia* section *Hemigenia* plus several species from section *Malleantha* and one from section *Homalochilus*. Likelihood analysis produced a tree with identical topography.

5.3.2 Morphological dataset:

Eighty-two of the 83 characters used in the analysis were parsimony-informative (Table 5.3). Character 27 was a synapomorphy of *Hemiandra*, but the character was sometimes absent in *H. pungens*. The analysis of unweighted morphological characters produced 16101 Maximum Parsimony trees of length 227. *A posteriori* reweighting produced 194 Maximum parsimony trees of length 66.74, the consensus of which was better resolved than in the unweighted analysis (Fig. 5.2).

The monophyly of the Westringieae was supported, with *Prostanthera* sister to the remaining genera and *Hemigenia macrantha* sister to the remainder of the ingroup. The three main clades consist of *Hemigenia* sect. *Homalochilus* (minus *H. macrantha*), *Microcorys* sections *Microcorys* and *Anisandra* with *Westringia*, and *Hemigenia* sections *Malleantha* and *Diplanthera* with *Microcorys* section *Hemigenioides*. *Hemigenia* section *Hemigenia* s.s. is

split with *H. purpurea* basal to the two main clades, *H. biddulphiana* on an unresolved polytomy with the two main clades and *H. cuneifolia* sister to *Microcorys* and *Westringia*.

5.3.3 Combined dataset

The combined analysis produced 45 Maximum Parsimony trees of length 489. Analysis of reweigted data produced 9 Maximum Parsimony trees of length 487, the strict consensus of which was almost identical except that Node 36 contained slightly better resolution (Fig. 5.3). The strict consensus tree shows three major clades: Node 36 (*Microcorys* sects *Anisandra* and *Microcorys* plus sect. *Hemigenioides*, *Hemigenia* sect. *Hemigenia* (represented by *H. cuneifolia*) and *Westringia*); Node 21 (*H.* sects *Diplanthera*, *Hemigenia* s.l. (part) and *Homalochiuls*; and Node 5 (*H.* sects *Atelandra* and *Hemigenia* s.l. (part) plus *M.* sect. *Hemigenioides*).

Table 5.3. Data matrix for the cladistic analysis of morphological characters

Taxon	1	6	11	16	21	26	31	36	41	46	51	56	61	66	71	76	81
Ajuga australis	01110	11111	11110	11101	11111	11101	11101	11111	11111	11001	11010	11011	10111	01111	11111	11111	111
Dicrastylis doranii	11111	11011	11111	11110	11111	11101	11111	11011	11111	10111	11010	11011	11111	01111	11111	11111	111
Scutellaria humilis	11111	11111	11111	11110	11111	11101	11101	11101	11111	10011	11010	11011	11111	10111	01111	11111	111
Teucrium racemosum	01111	11111	11110	11101	11111	11101	11111	11111	11111	10001	11011	01011	10111	01111	11111	10111	111
Hemiandra chimaera	01110	11111	11100	11101	11111	10101	10111	10111	01111	10111	10101	00011	11011	11101	10111	11111	111
Hemiandra pungens	01110	11111	11100	11101	11111	1[0/1]101	10111	11111	01111	10111	10101	00011	11011	11101	1[0/1]111	11111	111
H. purpurea	11011	11111	01111	11110	11111	01110	01111	11101	11111	10111	11001	00010	01111	01111	11111	11111	111
H. cuneifolia	01110	11111	11110	11[0/1]00	11111	11110	11111	11101	11111	10111	11101	00100	01011	01111	11111	11111	111
H. biddulphiana	01111	11111	01110	11100	11111	11110	11111	10101	11111	10111	11101	00010	01011	01111	11111	11111	111
P. behriana	11011	11111	11111	10111	10111	01101	11111	10111	11111	11111	11000	10011	11111	10111	00011	11111	111
P. striatiflora	11011	11111	11111	10111	10111	11101	11111	10111	11111	11111	11000	10011	11111	10111	00011	11111	111
W. dampieri	01111	00111	11110	11100	11111	11110	11111	11011	10111	11111	11101	00101	11111	01110	11111	11111	111
W. cheelii	01111	00111	11110	11100	11111	11110	11111	11011	10111	11111	11101	00101	11111	01111	11111	11111	111
M. tenuifolia	01111	00111	11110	11100	11111	111[0/10/1]	11111	01000	11101	11111	01101	00100	11001	0111[0/1]	11111	11111	111
M. sp. "Cape Arid"	01111	00111	11110	11100	11111	11110	11111	01000	11101	11111	01101	00100	11001	01111	11111	11111	111
H. westringioides	11111	11101	11110	11101	01111	11101	01111	10100	11101	10111	11101	00010	01011	01110	11101	11011	111
H. incana	11111	11101	11110	11101	01111	11101	11111	10100	11101	10111	11101	00010	01011	01011	11101	11111	111
H. humilis	10111	11011	11111	01110	11111	11101	11111	10100	11101	10111	11101	00010	01011	01111	11111	11111	111
M. wilsoniana	10111	11011	11011	01110	11111	11101	11111	10100	11101	10111	11101	00110	11001	01011	11101	11111	111
M. longiflora	10111	11011	11011	01110	11111	11101	11111	11100	11101	11111	11101	00100	11011	01011	11101	10111	111
M. longifolia	10111	11011	11111	01111	11011	11101	11111	11100	11101	11111	11101	00100	11011	01010	11101	10111	111
M. eremophiloides	10111	11111	11111	01111	11011	11101	11111	11100	11101	11111	11101	00111	11011	01010	11111	10111	111
M. subcanescens	00111	01011	11010	11100	11111	11110	11111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
M. obovata	01111	01111	11110	11100	11111	11110	11111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
M. purpurea	01111	01111	11110	11100	11111	11110	11111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
M. capitata	01111	01111	11110	11000	11111	11110	11111	11001	11111	11111	11101	00100	11001	01111	11111	11111	110
M. cephelantha	01111	01111	11110	11000	11111	11110	11111	11001	11111	11111	11101	00100	11001	01111	11111	11111	110
M. barbata	11111	11111	11111	11111	01110	11110	11111	11000	11110	11111	11101	00100	11001	01111	11111	11110	111
M. virgata	11111	11111	11111	11111	01110	11110	11111	11000	11110	11111	11101	00100	11001	01111	11111	11110	111
M. glabra	10111	11011	11011	01110	11111	11110	11111	11001	11111	11111	11101	00100	11001	01111	11111	11111	111
M. exserta	11111	11111	11111	11111	11111	11110	11111	11001	11111	11111	11101	00100	11001	01111	11111	11111	111

Taxon	1	6	11	16	21	26	31	36	41	46	51	56	61	66	71	76	81
M. elliptica	01111	01111	11110	11100	11111	11110	11111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
H. sp. "Merredin"	01111	01111	11110	11100	11111	11101	01110	10100	11101	10111	11101	00010	01011	0101	11101	10001	111
H. macrantha	11101	11111	10111	11111	11111	11101	11111	11111	11111	11111	11101	00011	11011	10111	00111	11111	111
H. macphersonii	11101	11111	10111	11110	11111	11101	11111	10111	11111	10111	11101	00010	01010	11111	00011	11111	111
H. pritzelii	11111	11101	11111	11110	11111	111	11111	10101	11011	10111	11101	00010	01010	11111	00011	11111	111
H. ramosissima	11111	11110	11111	11110	11111	11110	11111	10101	11011	10111	11101	00010	01010	11111	00011	11111	111
H. cerebrecarpa ms	11111	11110	11111	11111	11111	11110	01111	10101	11011	10111	11101	00010	01010	11111	00011	11111	111
H. pedunculata	01110	11111	11110	11100	11111	11101	11110	101	11111	0111	11101	00010	01011	01110	11101	10001	111
H. sp. "Yalgoo"	01110	11111	11110	11100	11111	11101	01110	111	11111	10111	11101	00010	01011	01110	11101	10001	111
H. dendritica ms	01111	11101	10110	11000	11111	11001	11111	10111	01111	10111	11101	00010	01011	01111	11111	11111	111
H. diplanthera	01111	11101	10110	11000	11111	11001	11111	10111	11011	10111	11101	00010	01011	01111	11110	01111	111
H. drummondii	01111	11101	11110	11100	11111	11101	11111	10111	11011	10111	11101	00010	01011	01111	11110	01111	111
H. viscida	01110	11111	11110	11000	11111	11101	11110	10101	11111	10111	11101	00010	01011	01111	11101	11111	111
H. scabra	01110	11111	11110	1100	11111	11101	11111	10111	01111	10110	10101	00010	01011	01111	111	11111	011
H. curvifolia	01110	11111	11110	11000	11101	11101	1111	11011	01111	10110	10101	00010	01011	01111	11111	11111	001
H. sericea	01110	11111	11110	11000	11101	11101	11111	110	1111	10110	10101	00010	01011	01111	11111	11111	001
H. teretiuscula	01110	11111	11110	11000	11101	11101	01111	10111	01111	10111	10101	00010	01011	01111	11110	11111	111
H. brachyphylla	01110	11111	11110	11000	11111	11101	01110	101	01111	00111	101	00010	01011	01011	11101	11111	111
H. ciliata	01110	11111	11110	11100	11111	11101	01110	10111	01111	00111	10101	00010	01011	01111	11101	11111	111
H. coccinea	01110	11111	11110	11000	11111	11101	01011	11111	01111	11111	11101	00011	11011	01111	11111	11111	111
H. tomentosa	01110	11111	11110	11000	11111	11101	01011	11011	01111	10111	10101	00010	01011	01111	11111	11111	111
M. sp. "Crooked Creek"	01110	11111	11110	11100	11111	11110	11111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
W. blakeana	01111	00111	11111	11100	11111	111	11111	10111	10111	10111	11101	00101	11111	01111	11111	11111	111
H. tysonii	01110	11111	11110	11000	11111	11101	01011	11011	01111	10111	10101	00010	01011	01011	111	11111	111
H. microphylla	10111	11111	11111	10111	11111	11110	11111	10101	11011	10111	11101	00010	01011	10111	00011	11111	111
M. sp. "Mt Gibson"	01111	01111	11110	11000	11111	111	11111	11001	11111	11111	11101	00100	11001	01111	11111	11111	111
M. sp. "Forrestania"	01110	11111	11110	1100	11111	111	11111	01000	11101	11111	01101	00100	11001	01111	11111	11111	111
M. macrediana	01111	01111	11110	11100	11111	11110	01111	11000	11101	11111	11101	00100	11001	01111	11111	11111	111
H. benthamii ms	01110	11111	11110	11000	11111	11101	1110	10111	01111	10111	11101	00010	01011	01011	11101	11111	111
H. appressa ms	01110	11111	11110	11000	11111	11101	01111	10111	01111	10111	11101	00010	01011	01111	11111	11111	111
H. exilis	01110	11111	11110	11000	11111	11101	11111	11011	01111	10111	10101	00011	11011	01111	11111	11111	111
H. dielsii	1111	11111	1	11	11	00	11111	11101	01111	10111	01111	10111	10101	00010	01011	01111	11111	11111	111

5.4 Discussion

5.4.1 Comparison of molecular and morphological datasets

Both the molecular and morphological datasets confirm that the Westringieae is monophyletic and that *Prostanthera* is sister to the remaining genera in the tribe, with high support for both conclusions. The consensus trees have much in common, and the main differences are in the relative placement of clades and particular species, particularly of *Microcorys* sect. *Hemigenioides, Hemigenia* sect. *Homalochilus* and elements of *H.* sect. *Hemigenia* s.l.. The monophyly and generic placement of *H.* sect. *Hemigenia* s.l. is of particular interest here.

A difference in the topology of the consensus trees for uncombined data is the placement of *Hemigenia* section *Homalochilus* (*H. cerebrecarpa* ms, *H. macrantha, H. macphersonii, H. pritzelii, H. microphylla, H. ramosissima*). While *H. macrantha* is basal to the rest of the tribe (excluding *Prostanthera*) in the morphological tree (Node 3), it is placed within *Microcorys* in the molecular tree (Nodes 4 & 25). *Hemigenia macphersonii* is basal to the rest of the Westringieae excluding *Prostanthera* and *H. macrantha* in the morphological tree (Node 4), but basal to a clade containing the bulk of *Hemigenia* sects *Diplanthera, Homalochilus* and *Hemigenia* s.l. (ie. *Malleantha*) in the molecular tree (Node 30).

Hemigenia macrantha and *H. macphersonii* (and closely related species *H.* sp. "Yuna" pn) are morphologically distinct. *Hemigenia macrantha*, in particular, is not similar to any other species. The placement of these species is significant with regard to which generic names should be applied, and as a basal placement above *Prostanthera* would suggest generic status is warranted. The placement of *H. macrantha* with *Hemiandra* in the molecular analysis (Node 25) requires investigation. Both *H. macrantha* and *H. macphersonii* have the strongly zygomorphic calyx characteristic of section *Homalochilus* (although that of *H. macrantha* is somewhat entire-lobed and prostantheroid), but they both have opposite leaves, in contrast to the whorled leaves of most of the other members of the section.

The basal placement of *Hemigenia* sect. *Homalochilus* in the morphological tree reflects prostantheroid characters noticeable in the group, particularly the strongly zygomorphic calyx which typically becomes papery, translucent and enlarged in fruit. These characters are either plesiomorphic to the Westringieae and have been retained in this group, or are the result of convergence or secondary reversal. It is noteworthy that the calyx of *Hemigenia macrantha* does not resemble *Prostanthera* in fruit.

The intermixing of species from *Hemigenia* sects *Diplanthera* and *Homalochilus* in the molecular tree (Node 32) is peculiar given that the species from section *Homalochilus* have the characteristic presence of whorled leaves and a distinctly two-lipped calyx (cf. opposite leaves and equally five-lobed calyx, albeit deeply divided between upper and lower lips). The taxa in this clade do have similar corolla morphologies (see section 2.3.1.5) defined by a usually horizontal upper lip and relatively short lobes. Support for these nodes is relatively weak with bootstrap values of just 51 and 69.

There is consensus on the placement of *Westringia* with the main *Microcorys* clade. However, while *Hemiandra* was nested within the main *Hemigenia* clade on morphological characters, the molecular dataset placed it within the main *Microcorys* clade.

The molecular tree differs in the inclusion of the *Hemigenia* sect. *Hemigenia* s.l. species *H. brachyphylla* and *H. dielsii* in the *Microcorys* clade (Node 16). The trees for both datasets show other *H.* sect. *Hemigenia* species *H. pedunculata* (and its allies *H.* sp. "Yalgoo" and *H.* sp. "Merredin"), *H. viscida*, *H. westringioides* and *H. humilis* included within a clade containing most of *M.* sect. *Hemigenioides*. The morphological tree, however, has this clade allied to the bulk of *H.* sect. *Hemigenia* s.l. (Node 8) whereas the molecular trees has it mixed with *M.* sects *Anisandra* and *Microcorys*. *Hemigenia dielsii* is not closely allied to any other species and has autapomorpic mericarps (see section 3.4). On the current classification, it fits morphologically with the bulk of *Hemigenia*. It has a *Microcorys*-like habit, but this is a difficult character to define.

A significant difference in the molecular results is that *Hemigenia cuneifolia* and *Microcorys tenuifolia* are placed in a clade which is basal to all of the Westringieae excluding *Prostanthera*. The corolla morphology of the *M. tenuifolia* and several similar undescribed species is distinctive. The upper and lower lips are often different colours, and the hooded upper lip is large relative to the lower lip and widely separated from it. The flowers overall are very small. This group was nested within the main *Microcorys* clade in the morphological results. However, *H. cuneifolia* is not known to share the peculiar floral morphology of the other members of this group. *Microcorys tenuifolia* is currently placed in *M.* sect. *Hemigenioides*. This needs to be re-evaluated.

Two unresolved complexes in *Hemigenia, H. humilis* s.l. and *H. incana* s.l. (the latter comprising *H.* sect. *Atelandra*) appear to be closely related to *Microcorys* sect. *Hemigenioides*, which is characterised by species such as *M. longifolia* (Node 8–molecular and Node 42–morphological). Synapomorphies of the group include a strongly hooded upper corolla lip and opposite leaves (cf. whorled leaves in other *Microcorys* species). A number of species in the group also have distinctive elongated mericarps with longitudinal ridging (see section 3.4), in fact, the mericarps of *H. humilis* and *M. longifolia* are almost indistinguishable. The differences between insect- and bird-pollinated species in this group may have confounded their classification together (see section 2).

5.4.2 Combined analysis

The combined consensus tree is well resolved with robust support for most branches from bootstrap analyses. The pairing of *Hemigenia macrantha* and *Hemiandra pungens* has 99% bootstrap support but the position of the species in the phylogeny is unresolved due to ambiguous placement in equally parsimonious trees. *Microcorys* sects *Anisandra* and *Microcorys*, containing most of the diversity of the genus, are supported as a monophyletic group if *H. cuneifolia* and *M. tenuifolia* are included (Node 37). However, the basal

placement of the latter species was robust in the molecular analysis. *Westringia* is shown as sister to this group (Node 36).

The monophyly of *H.* sects *Diplanthera* and *Homalochilus* (excluding *H. macrantha*) is supported, which is reconcilable with the morphology discussed above. A third major clade in the tree contains *M.* sect. *Hemigenioides* and a group of 'microcoryoid' hemigenias (Node 5). The crucial result of the combined analysis is the splitting of species included within *H.* sect. *Malleantha* here in section 4 between Nodes 23 and 6. There are no clear morphological characters known which agree with this result and this needs to be further investigated.

5.4.3 Comparison with published phylogenies

Incongruence between datasets, and gene versus species trees, is a perpetual problem in the construction of phylogenies which can lead to difficulty producing classifications which balance the need to reflect the natural groups but also use interpretable morphological characters (Cantino *et al.* 1999). For this reason, the combined molecular and morphological analysis proved a powerful tool to reconcile the data and produced a well-resolved tree that is mostly intuitive.

The results of the analyses presented here adopt the consensus that the Westringieae is monophyletic, and that *Prostanthera* is sister to *Hemiandra, Hemigenia, Microcorys* and *Westringia*. Further comparisons are hampered by the limited number of studies which include enough taxa from the tribe to examine internal relationships in detail. The results are compatible with the partially resolved phylogeny of Cantino (1992b) and agrees in the placement of *Microcorys* near *Westringia*. However, the results conflict with those of Olmstead *et al.* (1998), who found that *Westringia* was sister to the other genera, although, as discussed in the introduction, the analysis did not actually include a representative of *Hemigenia* due to confusion over the identity of *'Hemigenia* sp.' which appeared as a terminal taxon. Therefore, this result is potentially reconcilable with those presented here. Again, the

significance of this is difficult to assess given that Cantino used 'OTUs' rather than species as terminal taxa, and *Hemiandra, Hemigenia* and *Microcorys* were represented as unidentified species. Without additional species in these analyses and confirmation, or better explanation, of the taxa and specimens used in the analyses, these previous results are best treated tentatively.

5.4.4 Evolution of morphological characters

By reading morphological characters on the phylogenies of the Westringieae, it is clear that while expanded anther connective tissue is a synapomorphy of the Westringieae, the staminal level mechanism evolved after the split of *Prostanthera* with the remaining genera, of which it is an ancestral character. Dimidiate or monothecate mobile anthers and staminodes are derived characters. It follows that the absence of the staminal lever mechanism *Hemiandra*, *Westringia*, and several species of *Hemigenia* (i.e. *H. coccinea, H. exilis, H. macrantha*) represents secondary reversal. Indeed, the lack of mobile anthers is a key character delimiting both *Westringia* and *Hemiandra*.

Staminodes are present in species within two clades of the combined consensus tree: the typical section of *Microcorys* and *Westringia* (Node 36) and within the "hemigenioid" *Microcorys* species (Node 15). The character therefore remains a key defining character of *Microcorys* s.s. along with whorled leaves and the short hooded adaxial lips of the corollas. *Microcorys longifolia* and its allies (*M. eremophiloides, M. longiflora, M. wilsoniana*) are a staminodal group nested with a clade of other species with four fertile stamens. Assessing this *a posteriori*, it seems likely that this represents an independent evolutionary event. Not only is this the most parsimonious path, but the staminodes of some of the above species are morphologically distinct from those seen in the typical section of *Microcorys*. *Microcorys wilsoniana* has staminodes which are only moderately reduced, in which the staminal lever morphology is still present (see section 2). At the other extreme, *M. eremophiloides* has

staminodes which are so reduced as to be vestigial, a clear adaptation to bird pollination. If *M. tenuifolia* and *H. cuneifolia* are indeed sister to the remaining taxa of their respective genera, then staminodes may have evolved a third time in the group, although no obvious differences are known in the staminode morphology of these species.

There is clearly phylogenetic signal to the presence of whorled versus opposite leaves, but convergence or reversal is apparent. Species in the *Westringia*-typical *Microcorys* clade all have whorled leaves, some species in *Hemigenia* sect. *Homalochilus* have whorled leaves and *H. biddulphiana* and *H. purpurea* in *Hemigenia* s.s. have whorled leaves.

The degree of zygomorphy of the calyx, while a useful character, is difficult to assess as it is something of a continuous character and can be variable in related species. It is still a strong synapomorphy of *Hemigenia* sect. *Homalochilus*, which has strongly zygomorphic calyces, but within the species of Nodes 22 and 5 it varies from very actinomorphic (e.g. *H. westringioides*) to very zygomorphic (e.g. *H. incana* s.l.), with the intermediate state often being an enlarged median adaxial lobe (e.g. *H. pedunculata*). The species of *H.* sect. *Diplanthera* typically have equal calyx lobes but the lips are deeply divided.

Mericarp characters show strong phylogenetic signal within the group (see section 3). Ovoidal mericarps with convex exocarp cellular sculpturing (Types 1 and 4) appear to be plesiomorphic to the '*Westringia*' clade, with elongated mericarps present in some species, notably in *H. humilis, M. wilsoniana, M. longifolia* and their allies (Type 2), the mericarps of which have distinctive longitudinal ridging (Node 15). A number of species have evolved autapomorphic mericarps (e.g. *H. dielsii*, Type 10) or varied surface or exocarp cellular sculpturing (e.g. the pitting of mericarps in *H. westringioides* and *H. incana* s.l. Type 6). The surface sculpturing of the *Westringia-Microcorys* clade is rugose (Type 4) (except *H. cuneifolia*) while ovoidal nutlets in the remaining groups are typically reticulate (Type 1).

The shape of the corolla, while difficult to interpret, appears to show phylogenetic signal, despite convergence in some characters due to pollination syndromes (see section 2).

The presence of a strongly hooded (Nodes 12, 13, 20 and 37) versus concave or erect adaxial lip (Nodes 7, 11, 23 and 51) is an important character, as is the shape of the corolla tube (ie. whether narrow or funnel-shape). Since the assignment of Floral Types in section 2 was based on overall function in pollination, it is not surprising that some are homoplastic. Even so, the following Floral Types are confined to particular Nodes of the combined consensus tree: Types 1-3 (Node 37); Type 4 (Node 14); Type 5 (almost all species in Nodes 26 and 32); Types 6 and 8 (Node 23). Type 7 is present in a diverse range of species mostly from *Hemigenia* sect. *Hemigenia* s.l. and Type 9 includes species with red/bird-pollinated flowers, which appear to have evolved three times in the *Hemigenia*/*Microcorys*. The presence of Floral Type 5 in a number of species in *Hemigenia* sects *Diplanthera* and *Homalochilus* is quite a strong result and the overall similarities do not appear to be the result of convergence due to functionality. Individual characters of the corolla and stamen morphology are phylogenetically significant across all groups.

5.4.5 Towards an improved classification of the Westringieae

Within the Westringieae, only the limits and delimitation of *Prostanthera* are clear. The relations among the remaining taxa are complex in both phylogenetic and morphological terms.

The presence of staminodes is still a powerful character common to species in Node 36 (combined tree). Staminodes are also present in some species in or strongly allied to Node 5 (specifically, *M. wilsoniana, M. longiflora, M. longifolia* and *M. eremophiloides*), although the staminodes of two species are morphologically different (see above).

An important character is the presence of a significant hood in the adaxial lip of the corolla. However, this is absent in several species in the 'hemigenioides' clade (Node 5), namely *H. brachyphylla, H. pedunculata* (although present in at least one of its undescribed allies) and *H. dielsii,* and it is a difficult character to interpret, especially as an identification

tool (the character is often obscured in pressed herbarium specimens), and since some taxa in *Hemigenia* have a very slightly hooded corolla. The complexity of corolla shapes in the group has demonstrated the need for detailed field studies to understand characters which are difficult to interpret from herbarium specimens.

The presence of whorled leaves defines some groups such as *Hemigenia* sect. *Homalochilus* (excluding *H. macrantha* and *H. macphersonii*), *Westringia* and *Microcorys* sections *Anisandra* and *Microcorys*, but is not entirely consistent within clades in combined tree. For example, *H. biddulphiana* has whorled leaves whereas the rest of the species in Node 5 have opposite leaves.

The current generic placement and affinities of all three eastern Australian *Hemigenia* species (*H. biddulphiana, H. cuneifolia* and *H. purpurea*) is questionable. All three have hooded corollas and whorled leaves and *H. cuneifolia* has staminodes. The affinity of these species with others currently classified in *Microcorys* is unmistakable. *Hemigenia purpurea* is the type species of the genus. Although it is basal to all of the '*Westringia*' clade except for *H.* sect. *Homalochilus* in the morphological tree, it has close affinities with *H. biddulphiana*, notably the mericarp sculpturing (see section 3) and is highly likely to belong with it among microcoryoid hemigenias and *M.* sect. *Hemigenioides* at Node 5 of the combined tree. Unfortunately, several attempts to create PCR products from the DNA of this species failed despite access to material collected within the preceding five years.

There are two alternative solutions to the unresolved generic classification. The simplest of these is to synonymise *Hemiandra, Hemigenia* and *Microcorys* with *Westringia* (an earlier name). However, the morphological and phylogenetic differentiation apparent in the group warrant recognition of more than one genus, so this solution is perhaps not the best. The alternative is to raise *H.* sect *Malleantha* to generic level (*Malleantha.* sects *Diplanthera, Homalochilus* and *Malleantha*) so that the generic name *Hemigenia* applies to all of Node 5 (combined tree). The latter is a sound measure as it bypasses any uncertainty in the generic

status of the clade represented at Node 5 owing to its ambiguous positioning within the overall phylogeny (ie. whether allied to *Malleantha* or the *Microcorys-Westringia* group). The status of *Microcorys* sects *Anisandra* and *Microcorys* is doubtful as there seems to be little separating them and the presence of elongate lobes above the hooded adaxial lip of the corolla is clearly homoplastic. *Microcorys* sect. *Anisandra* should be synonymised with *M.* sect. *Microcorys*. If the placement of *Westringia* as sister to this group is correct as shown at Node 36 of the combined tree, its delimitation need not be changed, nor should the generic name *Microcorys* be synonymised with it. However, it will be important to gather more data before concluding that *Westringia* is not nested within *Microcorys* s.s. The *M. tenuifolia-H. cuneifolia* clade may need to be raised to generic status, although clear morphological characters would be needed to delimit the genus.

The second set of options would appear to be the best way to deal with the data. The key to making such changes a success will be both considered placement of taxa in the altered classification but also defining morphological characters which adequately differentiate the genera, particularly with regard to the inclusion of species with concave adaxial corolla lips such as *H. brachyphylla* in *Hemigenia* s.s.

Changes to generic delimitations and classification are required in the Westringieae. The data presented here show that both *Hemigenia* and *Microcorys* are polyphyletic. Further data would be useful in proposing a definitive generic classification which is unlikely to undergo further nomenclatural instability in the future and to resolve the generic position of taxa such as *Hemiandra* and *H. macrantha*. A second molecular dataset (preferably a nuclear marker), and the inclusion of a wider range of species in the molecular analyses, are recommended, as is the inclusion of the type species of *Hemigenia*, *H. purpurea*.

5.4.6 Conclusion

The results of phylogenetic analyses based on morphological and molecular (cpDNA *trn*T-F) datasets presented here confirm that both *Hemigenia* and *Microcorys* are polyphyletic. Within the Westringieae, only the limits and status of *Prostanthera* are clear. There is little doubt that this genus is monophyletic and sister to the remaining genera in the tribe.

Of particular interest here, *Hemigenia* sect. *Hemigenia* s.l. is polyphyletic with a large number of Western Australian species clearly not closely related to the type species, *H. purpurea*. These species were assigned to *H.* sect. *Malleantha* in section 4.

Changes to the generic classification of the Westringieae are inevitable. However, a final resolution to the problem and proposal of a revised classification must await further data. In particular, the inclusion of sequence data at least from one nuclear marker, is recommended.

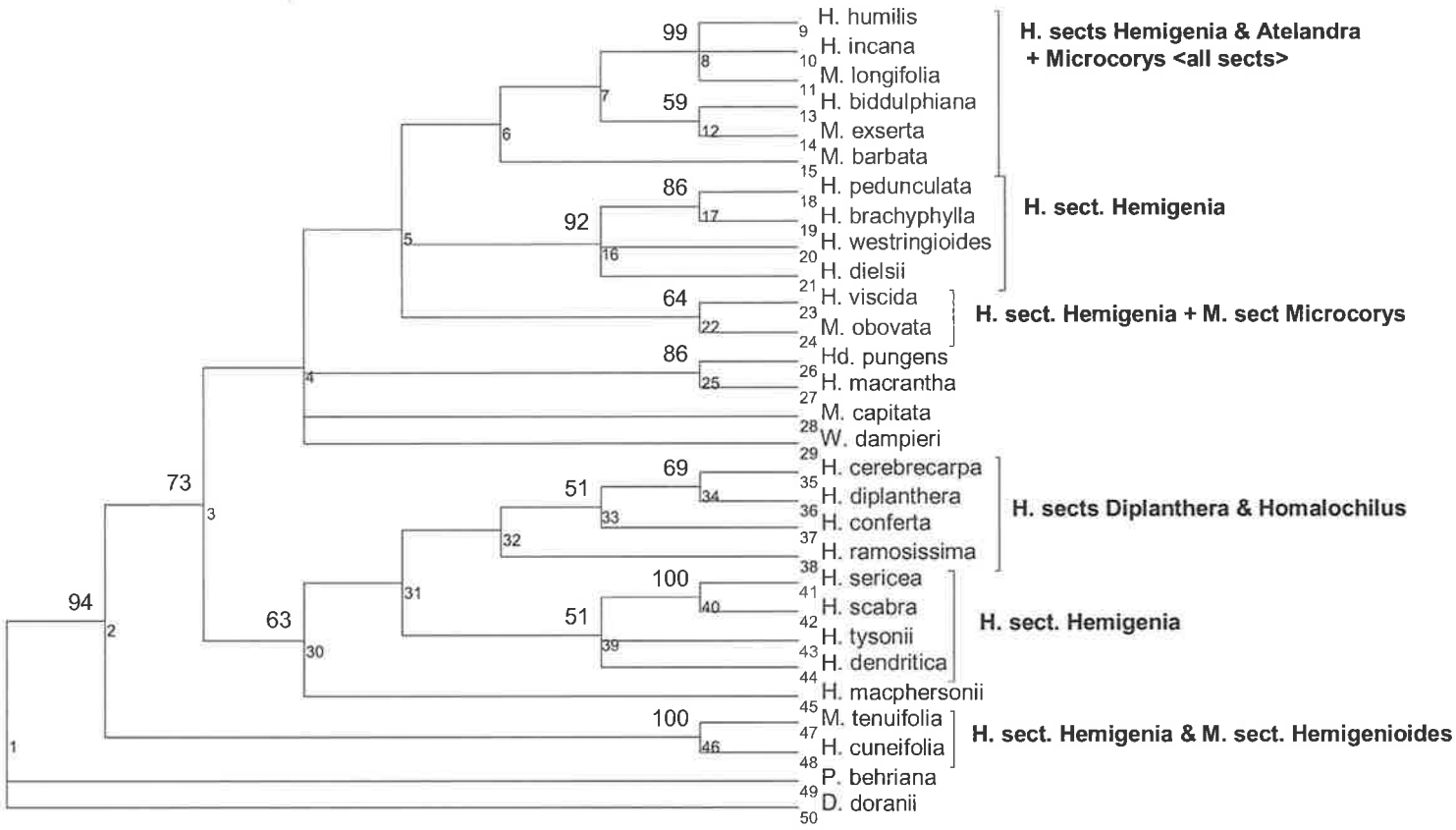


Fig. 5.1 Strict consensus of 281 Maximum Parsimony trees found in the phylogenetic analysis of *trn*T-*trn*F nucleotide data (500 random addition sequence replicates). Bootstrap values over 50% are shown above branches (1000 replicates). Branch lengths are non-significant. Tree length = 301; CI = 0.883, HI = 0.116, CI (excluding uninformative characters) = 0.675, HI (excluding uninformative characters) = 0.324, RI = 0.777, RC = 0.687.

Fig. 5.2. Strict Consensus of 16101 Maximum Parsimony trees resulting from the reweighted cladistic analysis of 83 morphological characters (200 random addition sequence replicates). Bootstraps over 50% are shown above branches (100 replicates). Branch lengths are non-significant. Tree length = 66.74; CI = 0.6006; HI = 0.3994; RI = 0.8591; RC = 0.5159).

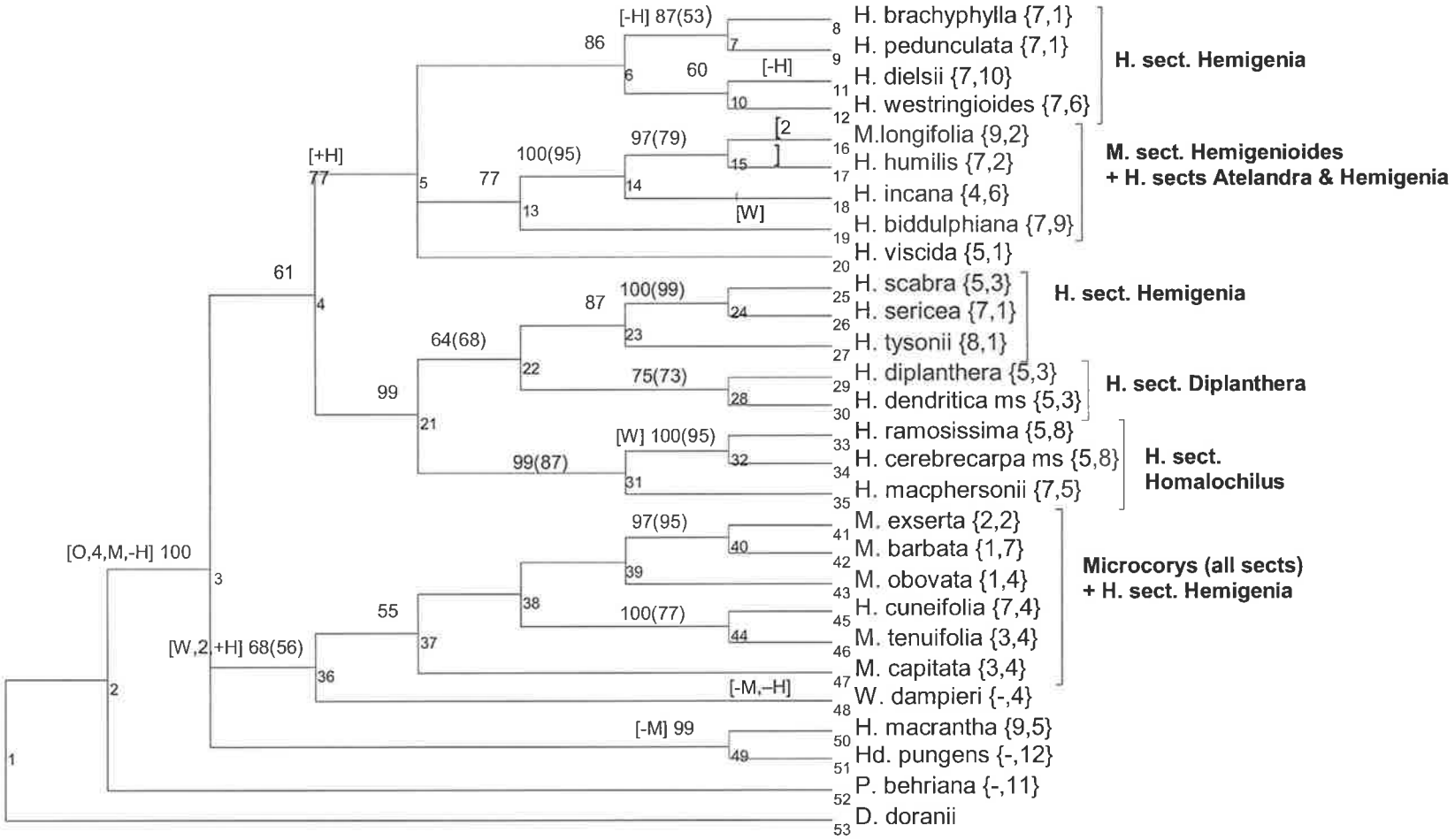


Fig. 5.3. Strict consensus of 9 trees from analysis of reweighted, combined molecular *trn*T-F and morphological data (500 random addition sequence replicates). Bootstrap values above 50% are shown above branches (unweighted bootstraps in parentheses) (100 replicates). Bracketed numbers after species indicate Floral (see section 2.3.1) and Mericarp (see section 3.4) Types respectively. Square brackets indicate character states as follows: Leave opposite **O**, whorled **W**; fertile stamens **2** or **4**; fertile stamens mobile on filament **±M**; corolla distinctly hooded **±H**. Character state changes are read relative to nodes to the left. These can be taken as a theory of character evolution but are primarily intended to enable reading of key morphological characters across the tree. Tree length=487; CI = 0.6920; HI = 0.3080; RI = 0.5935; RC = 0.4107.

6 Summary and conclusions

The tribe Westringieae is here supported as a natural, monophyletic group within the Lamiaceae, confirming previous results (see section 5). Morphological, molecular and combined data also support the notion that the genera *Hemigenia* and *Microcorys*, as currently delimited, are not monophyletic and that changes to the generic classification of these genera, and potentially also *Hemiandra* and *Westringia*, are inevitable. However, proposal of formal changes to the classification must wait until further datasets have been compiled and a satisfactory generic concept likely to remain stable in the future is therefore attainable.

Despite the above, it is clear that species currently within *Hemigenia* section *Hemigenia* with whorled leaves and/or strongly hooded corollas (and this includes the type species *H. purpurea*) are distinct from species in the section which have opposite leaves and corollas lacking obvious hoods. The latter are here treated as a new section, *Hemigenia* section *Malleantha* G.R Guerin sect. nov. The taxonomic work on this new section presented here is the first revision conducted on the genus since Bentham (1870) (see section 4). The description here of 13 new species out of a group of 26 species indicates the level of inadequacy of the current taxonomy. Further revisions are now needed for the remaining sections of *Hemigenia* as well as *Microcorys*. The new taxa described here are to be considered as manuscript names only, and formal publication (with Latin diagnoses) will be required before these taxa (and names) can be accepted.

Hemigenia and *Microcorys* have anthers with elongated connective tissue which bears one or two modified thecae, and the anthers are typically mobile on the filament. Field observations showed this structure acts as a lever mechanism in depositing pollen onto insect vectors such as bees and flies (see section 2). Although convergence in corolla shape is apparent in some groups as a response to similar pollination syndromes, a number of systematically useful characters was also identified in the study.

A cladistic dataset was compiled based on morphology, including floral and mericarp (see section 3) characters. A molecular dataset was made using *trn*T-F region of the chloroplast. These data were analysed separately and as a combined dataset (see section 5). The results show that the Westringieae is monophyletic, with *Prostanthera* sister to the remaining genera. *Hemigenia* and *Microcorys* are polyphyletic.

Important characters have been identified which have phylogenetic signal in the groups of interest within the Westringieae. The number of leaves per whorl (ie. whether opposite or whorled), the presence or absence of staminodes, the shape of the upper corolla lip (ie. whether erect or strongly hooded) and the nature of the mericarps (shape and surface sculpturing) are all significant.

Results presented here work towards an improved classification of the Westringieae, but further data are required before a satisfactory classification can be proposed with sufficient evidence to ensure nomenclatural stability in the future. In particular, multiple DNA markers (including nuclear regions) need to be sequenced, sampling a larger number of species. However, based on the results presented here, it is likely that the circumscription of a new genus, *Malleantha,* containing sections *Malleantha, Diplanthera* and *Homalochilus* is the best option. *Hemigenia* s.s. will then consist of *Microcorys* sect. *Hemigenioides* plus a number of species currently in *H.* sect. *Hemigenia* s.l. *Microcorys* will apply to all species in the genus which have whorled leaves, ie. species of sections *Anisandra* and *Microcorys. Microcorys* sect. *Anisandra* should probably be synonymised with the typical section The generic position of *Hemigenia macrantha* cannot be accurately assessed at this time.

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Appendix A

Molecular sequence data

*trnT-trn*F dataset

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                    1         11        21        31        41        51        61        71        81        91
Species             |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii AAAAGAATAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
Hemigenia biddulphiana ----------------------------------------------------------GG-AG-CATAAGCGATTT-AT-ATAGCG-A
H. brachyphylla     AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. cerebrecarpa ms  ----------AATCTATAGTTCCCAATAGAATAT-TGCGAT-ATTA----------------T-AG-AGACATAACG-ATTT-AT-ATAGCG-A
H. conferta         AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. cuneifolia       AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. dendritia ms     AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. dielsii          AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. diplanthera      AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. humilis          AAAAAA-TAGAATCTATAATTTCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. incana           AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. macphersonii     AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-CT-ATAGCG-A
H. macrantha        AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. pedunculata      AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. ramosissima      AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. scabra           AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. sericea          AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. tysonii          AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
H. viscida          AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
H. westringioides   AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
Hemiandra pungens   ARAAAA-TAAAATCTATAATTCCCAATA-AATRTATGC-ATTATTA----------------TTRGCAAGCATAACGGATTTCATCATAGGGGA
Microcorys barbata  AAAAAA-TCGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-C
M. capitata         AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-TATAACG-ATTT-AT-ATAGCG-A
M. exserta          AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
M. longifolia       AAAAA--TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
M. obovata          AAAAAA-TAGAATCTATAATTCCAAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
M. tenuifolia       ----------AATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AG-CATAACG-ATTT-AT-ATAGCG-A
Prostanthera behriana AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTAATAAATATTGGATATTAT-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
Westringia dampieri AAAAAA-TAGAATCTATAATTCCCAATA-AATAT-TG-GAT-ATTA----------------T-AG-AA-CATAACG-ATTT-AT-ATAGCG-A
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                      111       121       131       141       151       161       171       181       191       201
Species               |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii   TTCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAAT
Hemigenia biddulphiana TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. brachyphylla       TCCG-ATTTCTTTATC-AC-AATT--CTAAATTTGAATAC-AACTTGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-T
H. cerebrecarpa ms    TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTTGAATATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-T
H. conferta           TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. cuneifolia         TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. dendritia ms       TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. dielsii            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTTGAATAC-AATTTGAATATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. diplanthera        TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. humilis            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. incana             TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-T
H. macphersonii       TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----T-----------------------T
H. macrantha          TCCG-ATTTCTTTATC-AC-AATT--ATAAATTCGAATAC-AATTCAAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-T
H. pedunculata        TCCG-ATTTCTTTATC-AC-AATT--CTAAATTTGAATAC-AATTTGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-T
H. ramosissima        TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-T
H. scabra             TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. sericea            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. tysonii            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAG-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
H. viscida            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-T
H. westringioides     TCCG-ATTTCTTTATC-AC-AATT--CTAAATTTGAATAC-AATTTGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
Hemiandra pungens     TCTGGATTTCKKKATCTACCAATTAATMAA-TTCAAATACCAATATCAAAA-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-T
Microcorys barbata    TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
M. capitata           TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
M. exserta            TCCG-ATTTCTTTATC-AC-AATT--TTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
M. longifolia         TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
M. obovata            TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-T
M. tenuifolia         TCCG-ATTTCTTTATA-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
Prostanthera behriana TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAAT
Westringia dampieri   TCCG-ATTTCTTTATC-AC-AATT--CTAAATTCGAATAC-AATTCGAATATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-T
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                          161       171       181       191       201       211       221       231       241       251
Species                   |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii       ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana    ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms        ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii                ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------GAAA
H. humilis                ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii           ATTATTCTATTC-GATAGTCAA----T-------------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha              ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens         A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana     ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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                    161       171       181       191       201       211       221       231       241       251
Species             |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla     ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms  ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms     ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii          ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera      ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------GAAA
H. humilis          ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii     ATTATTCTATTC-GATAGTCAA----T-------------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata      ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima      ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea          ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii          ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida          ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides   ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens   A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata  ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta          ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata          ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT----------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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                          161       171       181       191       201       211       221       231       241       251
Species                   |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii       ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana    ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms        ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii                ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------------GAAA
H. humilis                ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii           ATTATTCTATTC-GATAGTCAA----T-----------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha              ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens         A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana     ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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Species	161 171 181 191 201 211 221 231 241 251
Dicrastylis doranii	ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana	ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms	ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii	ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------GAAA
H. humilis	ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii	ATTATTCTATTC-GATAGTCAA----T----------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida	ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens	A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata	ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana	ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA

Species	161 171 181 191 201 211 221 231 241 251
Dicrastylis doranii	ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana	ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms	ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii	ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------GAAA
H. humilis	ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii	ATTATTCTATTC-GATAGTCAA----T----------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida	ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens	A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata	ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana	ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri	ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA

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                      161       171       181       191       201       211       221       231       241       251
Species               |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii   ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms    ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii            ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------GAAA
H. humilis            ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii       ATTATTCTATTC-GATAGTCAA----T-------------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha          ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida            ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides     ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens     A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata    ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata            ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT----------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri   ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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                          161       171       181       191       201       211       221       231       241       251
Species                   |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii       ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana    ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms        ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii                ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------GAAA
H. humilis                ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii           ATTATTCTATTC-GATAGTCAA----T-------------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha              ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens         A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana     ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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                          161       171       181       191       201       211       221       231       241       251
Species                   |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii       ATTATTCTATTC-GATAATAAA----TCTTAAATATTTTT-AGATAGTCAAATTTT------CTTTTTTATTTTTGATTTTGAATTCAT--ATGACATTTGAAA
Hemigenia biddulphiana    ATTATTCTATTCCGATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. brachyphylla           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cerebrecarpa ms        ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. conferta               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. cuneifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dendritia ms           ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. dielsii                ATTATTC------GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. diplanthera            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TT----------------------------------------------GAAA
H. humilis                ATTATTCTATTC-GATAGGCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. incana                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-CGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macphersonii           ATTATTCTATTC-GATAGTCAA----T-------------------------TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. macrantha              ATTATTCTATTC-GATAGTCAA----TCTTAAATATTATT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. pedunculata            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCCA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. ramosissima            ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTTAAGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. scabra                 ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. sericea                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. tysonii                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. viscida                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCGA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
H. westringioides         ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Hemiandra pungens         A-TATTGTKCGTGATTCGGTGGCCGCTCKTAAATATTATT-GGATAGCCCA-TCCCTTTTT-CTTTTT-------GATTTKGAATATCTCCATGACATTTGAAA
Microcorys barbata        ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. capitata               ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTTAAA
M. exserta                ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. longifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTT-CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. obovata                ATTATTCTATTC-GATAATCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTT--CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
M. tenuifolia             ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTTTTTCTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
Prostanthera behriana     ATTATTCTATTC-GATAGTCAA----TCTTAACTATTTTT-AGATAGTCAAATTTTTTTT---------ATTTAAGATTTTGAATTCAC--ATGACATTTGAAA
Westringia dampieri       ATTATTCTATTC-GATAGTCAA----TCTTAAATATTTTT-AGATAGTCAA-TTTTTTT---CTTTTT-------GATTTTGAATTCAC--ATGACATTTGAAA
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                    1031       1041       1051       1061       1071       1081       1091       1101       1111       1121
                    |          |          |          |          |          |          |          |          |          |
Species
Dicrastylis doranii CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
Hemigenia biddulphiana CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTATACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. brachyphylla     CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. cerebrecarpa ms  ----------------------------------------------------------------------------------------------------
H. conferta         CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. cuneifolia       CTGATTAATCGGACGAGAATAAAGAGAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. dendritia ms     CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. dielsii          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. diplanthera      CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. humilis          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTTTAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. incana           CTGATTAATCGGACGAGAATAAAGATAGAGTCCCGTTCTACATGTCAATACCGGCAACAATGAAATTTTTAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. macphersonii     CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. macrantha        CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. pedunculata      CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. ramosissima      CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. scabra           CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATC-
H. sericea          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. tysonii          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. viscida          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
H. westringioides   CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
Hemiandra pungens   CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
Microcorys barbata  CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
M. capitata         CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
M. exserta          ----------------------------------------------------------------------------------------------------
M. longifolia       CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGCAATTTTTAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
M. obovata          CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
M. tenuifolia       CTGATTAATCGGACGAGAATAAAGAGAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
Prostanthera behriana CTGATTAATCGGACGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
Westringia dampieri CTGATTAATCGGATGAGAATAAAGATAGAGTCCCATTCTACATGTCAATACCGGCAACAATGAAATTTATAGTAAGAGGAAAATCCGTCGACTTTAAAAATCG
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                          1131      1141      1151      1161      1171      1181      1191      1201      1211      1221
Species                   |         |         |         |         |         |         |         |         |         |
Dicrastylis doranii       TG-------CCCCCTTTTTCGTTATCGGTTCGAAATTCCTTTATCTTTCTGATTCTTTGACAAA------CGT-ATTTGGGCGCAAA----GGACTTTCTCTT
Hemigenia biddulphiana    TG-------CCCCTTTTT-----------------------------------------------------------------------------------
H. brachyphylla           TG-------CCCTTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. cerebrecarpa ms        ---------CCACTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTT
H. conferta               TG-----------------------------TCCAAATTYYYYYATCTTTCKGAATCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. cuneifolia             TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTTCTTTATCTTTCTGATTCTTTGACAAACA------T-ATTTGGGCATAAA----TGACTTTCTCTT
H. dendritia ms           TG-------CCCCTTTTT-CATTAGTGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. dielsii                TG-------CCCCCTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. diplanthera            TG-------CCACTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTT
H. humilis                TG-----------------------GGGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. incana                 TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCGCTT
H. macphersonii           TG-------CCCCTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAACACAAACGT-ATTTGGGCGTAAATAAATGACTTTCTCTT
H. macrantha              TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. pedunculata            TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. ramosissima            TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTTTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. scabra                 ---------CCCCTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. sericea                TG-------CCCCTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. tysonii                TG-------CCCCTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTT
H. viscida                TG-------CCCTTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAA------ACGT-ATTTGGACGTAAA----TGACTTTCTCTT
H. westringioides         TG-------CCCCCTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
Hemiandra pungens         TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
Microcorys barbata        TG-----------------------------TCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
M. capitata               TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
M. exserta                ---------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
M. longifolia             TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAAC------GT-ATTTGGGCGTAAA----TGACTTTCTCTT
M. obovata                TG-------CCACTTTTT-CATTAGCGGTTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTATATCTT
M. tenuifolia             TG-----------------------------------------TCTTTCTGATTCTTTGACAAA------CGTGATTTGGGCATAAA----TGACTTTCTCTT
Prostanthera behriana     TG-------CCCCTTTTTTCATTAGCGATTCCAAATTCCTTTATCTTTCTGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGCCTTTCTCTT
Westringia dampieri       TG-------CCCCTTTTTTCATTAGCGGTTCCAAATTCCTTTATCTTTCGGATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTT
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Species	1181	1191	1201	1211	1221	1231	1241	1251	1261	1271
Dicrastylis doranii	GATTCTTTGACAAA------CGT-ATTTGGGCGCAAA----GGACTTTCTCTTATCACATGGGA-TATAGAATACACATCCAAATTAAGC-AAGGAATCCCTT									
Hemigenia biddulphiana	----------									
H. brachyphylla	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. cerebrecarpa ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. conferta	GAATCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGCGAAGGAATCCCTT									
H. cuneifolia	GATTCTTTGACAAACA------T-ATTTGGGCATAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. dendritia ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. dielsii	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. diplanthera	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. humilis	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. incana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCGCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. macphersonii	GATTCTTTGACAAACACAAACGT-ATTTGGGCGTAAATAAATGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. macrantha	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. pedunculata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. ramosissima	GATTTTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. scabra	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGAA--TAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. sericea	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGAA--TAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. tysonii	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGC-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. viscida	GATTCTTTGACAA------ACGT-ATTTGGACGTAAA----TGACTTTCTCTTATCCCATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
H. westringioides	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
Hemiandra pungens	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
Microcorys barbata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
M. capitata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
M. exserta	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
M. longifolia	GATTCTTTGACAAAC------GT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
M. obovata	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTATATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
M. tenuifolia	GATTCTTTGACAAA------CGTGATTTGGGCATAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									
Prostanthera behriana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGCCTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTATGC-AAGGAATCCCTT									
Westringia dampieri	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATTACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTT									

Species	1181	1191	1201	1211	1221	1231	1241	1251	1261	1271	1
Dicrastylis doranii	GATTCTTTGACAAA------CGT-ATTTGGGCGCAAA----GGACTTTCTCTTATCACATGGGA-TATAGAATACACATCCAAATTAAGC-AAGGAATCCCTTT										
Hemigenia biddulphiana	----------										
H. brachyphylla	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. cerebrecarpa ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. conferta	GAATCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGCGAAGGAATCCCTTT										
H. cuneifolia	GATTCTTTGACAAACA------T-ATTTGGGCATAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. dendritia ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. dielsii	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. diplanthera	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. humilis	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. incana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCGCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. macphersonii	GATTCTTTGACAAACACAAACGT-ATTTGGGCGTAAATAAATGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. macrantha	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. pedunculata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. ramosissima	GATTTTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. scabra	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGAA--TAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. sericea	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGAA--TAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. tysonii	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGC-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. viscida	GATTCTTTGACAA------ACGT-ATTTGGACGTAAA----TGACTTTCTCTTATCCCATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
H. westringioides	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
Hemiandra pungens	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
Microcorys barbata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
M. capitata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
M. exserta	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
M. longifolia	GATTCTTTGACAAAC------GT-ATTTGGGCGTAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
M. obovata	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTATATCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
M. tenuifolia	GATTCTTTGACAAA------CGTGATTTGGGCATAAA----TGACTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										
Prostanthera behriana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGCCTTTCTCTTATCACATGTGA-TATAGAATACACATCCAAATTATGC-AAGGAATCCCTTT										
Westringia dampieri	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTTTCTCTTATTACATGTGA-TATAGAATACACATCCAAATTACGC-AAGGAATCCCTTT										

	1181	1191	1201	1211	1221
Species	|	|	|	|	|
Dicrastylis doranii	GATTCTTTGACAAA------CGT-ATTTGGGCGCAAA----GGACTT
Hemigenia biddulphiana	----------
H. brachyphylla	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. cerebrecarpa ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. conferta	GAATCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. cuneifolia	GATTCTTTGACAAACA------T-ATTTGGGCATAAA----TGACTT
H. dendritia ms	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. dielsii	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. diplanthera	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. humilis	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. incana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. macphersonii	GATTCTTTGACAAACACAAACGT-ATTTGGGCGTAAATAAATGACTT
H. macrantha	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. pedunculata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. ramosissima	GATTTTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
H. scabra	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. sericea	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. tysonii	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTT
H. viscida	GATTCTTTGACAA------ACGT-ATTTGGACGTAAA----TGACTT
H. westringioides	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
Hemiandra pungens	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
Microcorys barbata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
M. capitata	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
M. exserta	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT
M. longifolia	GATTCTTTGACAAAC------GT-ATTTGGGCGTAAA----TGACTT
M. obovata	GATTCTTTGACAAAGACAAACGT-ATTTGGGCGTAAA----TGACTA
M. tenuifolia	GATTCTTTGACAAA------CGTGATTTGGGCATAAA----TGACTT
Prostanthera behriana	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGCCTT
Westringia dampieri	GATTCTTTGACAAA------CGT-ATTTGGGCGTAAA----TGACTT