Taxonomic notes on *Boronia* species of north-western Australia, including a revision of the *Boronia lanuginosa* group (*Boronia* section *Valvatae*: Rutaceae)

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Abstract

M.F. Duretto. Taxonomic notes on *Boronia* species of north-western Australia, including a revision of the *Boronia lanuginosa* group (*Boronia* section *Valvatae:* Rutaceae). Nuytsia 11(3): 301-346 (1997). The revision of *Boronia* (Rutaceae) in the Northern Territory, the Kimberley Region of Western Australia, and north-western Queensland is completed, and a key to all species is provided. The *B. lanuginosa* Endl. species group is characterized as those species with pinnate leaves, a calyx as large as or larger than the corolla, multiangular stellate hairs, and a pronounced ridge on the micropylar side of the seed. This clade comprises the *B. lanuginosa* species complex, *B. filicifolia* A. Cunn. ex Benth., *B. pauciflora* W. Fitzg. and five newly described species: *viz. B. decumbens* Duretto, *B. minutipinna* Duretto, *B. kalumburuensis* Duretto, *B. jucunda* Duretto and *B. tolerans* Duretto. The *B. lanuginosa* species complex has four available names and was analysed numerically using phenetic methods. Two taxa were identified in the analysis. *Boronia artemisiifolia* var. *wilsonii* F. Muell. ex Benth. is raised to specific status while *B. affinis* R. Br. ex Benth. and *B. artemisiifolia* F. Muell. are synonymized under *B. lanuginosa*. Additionally, *B. rupicola* Duretto is described, and *B. filicifolia, B. lanceolata* F. Muell., *B. lanuginosa* and *B. pauciflora* are lectotypified.

Introduction

This paper is the second to discuss the systematics of *Boronia* Sm. (Rutaceae) for the "Top End" of the Northern Territory (NT) and the Kimberley Region of Western Australia (WA). The first, Duretto & Ladiges (1997), discussed the *B. grandisepala* F. Muell. group: those species with simple leaves and sepals as large as or larger than the petals. Here, the pinnate-leaved taxa with sepals as large as or larger than the petals are addressed. Cladistic analysis (Duretto 1995; Duretto & Ladiges in prep.) shows that these taxa form a monophyletic group characterized by the presence of multiangular stellate hairs, pinnate leaves (except *B. pauciflora*, which sometimes has juvenile leaves that are trifoliolate, but has simple mature leaves), sepals as large as or larger than the petals, and shiny seeds with a prominent ridge on the micropylar side. Weston *et al.* (1984) called this clade (less *B. pauciflora*) the *B. affinis* group, but for reasons outlined below, it is more appropriate for it to be known as the *B. lanuginosa* group. This clade belongs to *Boronia* section *Valvatae* (Benth.) Engl. and consists of three species complexes: the *B. lanuginosa* and *B. filicifolia* complexes, plus another undescribed species complex.

The *B. lanuginosa* species complex is found from King Sound (WA) to Wollogorang (NT) (Figure 1) and consists of an uncertain number of taxa. Morphological variation within the complex is analysed numerically, using phenetic methods. Leaf anatomy and ontogeny, and the taxonomic status of the four available names within the complex (*viz. B. affinis*, *B. artemisiifolia*, *B. artemisiifolia* var. *wilsonii*, and *B. lanuginosa*) are discussed.

The *B. filicifolia* species complex is endemic to the Kimberley Region and consists of four species that are morphologically and geographically distinct. Wheeler (1992) recognized a number of forms within *B. filicifolia* including the Mitchell River (and type) form and a Kalumburu form (*B. kalumburuensis*, see below). A third form, from the Osmond Plateau, is described below as *B. minutipinna*. *Boronia pauciflora* is also placed in this species complex (Duretto 1995; Duretto & Ladiges in prep.).

The third species complex consists of three rare species, *B. decumbens* (NT), *B. jucunda* (WA) and *B. tolerans* (NT), that are newly described below.

To complete the revision of *Boronia* in the Northern Territory and the Kimberley Region, taxa are lectotypified where necessary (including *B. lanceolata*) and *B. rupicola* is described as new. *Boronia lanceolata* and *B. rupicola* are more closely related to east coast members of *Boronia* section *Valvatae* than to other species in north-western Australia (Duretto 1995; Duretto & Ladiges in prep.). At the final stages of manuscript preparation a 1995 collection (*J.R. Clarkson* 10473) from north-west Queensland, near the Northern Territory border, came to the authors' attention. The specimen is of a previously unknown taxon that has affinities with *B. alulata* Benth. of Cape York (Duretto submitted; Duretto & Ladiges in prep.), and so will be described in a forthcoming paper that deals with Queensland members of *Boronia* section *Valvatae* (Duretto submitted). As this species is sympatric with *B. lanceolata* (in Queensland) it will be included in the key as *Boronia* aff. *alulata* (NW Qld, *Clarkson* 10473). All *Boronia* species found in the Northern Territory, the Kimberley Region, and north-west Queensland are placed in section *Valvatae*.

The Northern Territory and Kimberley floras are treated here as a single unit for a number of reasons. Firstly, apart from *B. lanceolata* and *B. rupicola*, cladistic analysis shows that all taxa form a monophyletic group defined by the following synapomorphies: the calyx being as large as or larger than the corolla, the antesepalous anther being significantly smaller than the antepetalous anther, and the filament shape (Duretto 1995; Duretto & Ladiges in prep.). Secondly, the boronias of this region are widely separated from the east coast, South Australian, and south-west Western Australian members of *Valvatae*. Thirdly, and finally, the region covering the "Top End" of the Northern Territory and the Kimberley region is often recognized as being a distinct biogeographic region or a number of closely related regions; that is, regions that share a recent history (see Specht 1958b; Kikkawa & Pearse 1969; Hnatiuk & Pedley 1985; Cowie & Finlayson 1986; Cracraft 1991; Dunlop & Webb 1991; Crisp *et al.* 1995; Duretto 1995; Duretto & Ladiges in prep.).

The boundaries for these biogeographic units, at least for *Boronia*, roughly correspond to the boundaries of three geological basins (as outlined by Plumb & Derrick 1975; Plumb *et al.* 1980; G.S.W.A. 1990): the McArthur River Basin which extends from Mt Isa (north-west Queensland) to the Arnhem Land Plateau and surrounds (northern and western NT); the Victoria River Basin, especially the north-western heavily faulted area, which includes an area from the western Northern Territory to the Ord River (WA); and, the Kimberley Basin including the neighbouring King Leopold and Halls Creek orogens or mobile plates. These basins are characterized by Precambrian sandstones.

Boronia lanuginosa species complex

Endlicher (1837) described *B. lanuginosa* from material that was collected by Ferdinand Bauer and labelled King George's Sound. King George Sound is in south-western Australia, but Bauer had travelled with Matthew Flinders, on the "Investigator", around northern Australia (see Specht 1958a,b; Wilson 1975). Bentham (1863), who had not seen the type material of *B. lanuginosa*, applied this name to a south-western Western Australian species that is found growing around King George Sound (Wilson 1975). Later, Mueller (1859) described *B. artemisiifolia* (as *B. artemisifolia*) from material he collected while on Gregory's Northern Australian Expedition. Bentham (1863) used this later name (written as *B. artemisiaefolia*) in his "Flora Australiensis". Subsequently, and up until 1975, specimens of *Boronia* from northern Australia that had a dense indumentum, pinnate leaves and a large calyx have been called *B. artemisiifolia*, with orthographic variation. After studying type material of *B. lanuginosa,* Wilson (1975) realized Bentham's error and synonymized *B. artemisiifolia* with *B. lanuginosa.* He concluded that the type locality of *B. lanuginosa* was somewhere on the coast of Arnhem Land where Flinders' ship "The Investigator" had travelled on its second voyage. Robert Brown, who was on "The Investigator" with Bauer and Flinders, collected plant specimens from the islands of the Gulf of Carpentaria that are identical to the type material of *B. lanuginosa* (Wilson pers. comm.), strengthening Wilson's argument. The south-western Western Australian species that had previously been called *B. lanuginosa* is now known as *B. stricta* Bartl. (Wilson 1975).

Bentham (1863) described *B. affinis, B. filicifolia* and *B. artemisiifolia* var. *wilsonii* (presently synonymized under *B. lanuginosa*) from north-western Australia. The type material of *B. affinis* ("N. Australia. Islands of the Gulf of Carpentaria, and mainland opposite Groote Eylandt") was collected by Robert Brown while travelling with Matthew Flinders and Ferdinand Bauer on "The Investigator" in 1802-03. The main feature that has been used to distinguish *B. affinis* from *B. lanuginosa* is that *B. affinis* is glabrous or has a sparse indumentum while *B. lanuginosa* has a dense indumentum. There is much confusion surrounding the application of these two names.

Judging from present herbarium records and collections, *B. affinis* and *B. lanuginosa* are sympatric in the Northern Territory. *Boronia affinis* is considered to be rare, possibly endangered, and confined to the Northern Territory (Briggs & Leigh 1988 [not listed in Briggs & Leigh 1996]; Hnatiuk 1990) while *B. lanuginosa* (as currently circumscribed) is common and widespread from King Sound (WA) to Wollogorang Station (NT) (Figure 1).

Boronia lanuginosa has an ontogenetic sequence in leaf development from glabrous leaves, or leaves with a sparse simple and stellate indumentum, to leaves having a dense stellate indumentum, as has been observed in other members of section *Valvatae* (Duretto 1995; Duretto & Ladiges 1997, in prep.). Some specimens (e.g. *Dunlop* 5380; *Duretto* 500; *George* 13548; *Henshall* 1680; *Kenneally* 3025, 3075, 4455; *Wightman* 1374 *& Craven*; *Wolfe & Martin* 227) display this ontogenetic sequence. Many populations contain a variety of fertile forms that display varying degrees of hirsuteness (e.g. *Duretto* 477-481; 488-491; 503-504A; 522-524). Other populations, such as those in the Mt Cahill and Mt Basedow areas (Kakadu National Park), North Island (Gulf of Carpentaria) and the sand plains north of the Arnhem Land Plateau, consist of small plants that are glabrous or have a sparse indumentum and that are often determined as *B. affinis*. Interestingly, a range of hair densities, which is usually correlated with the density of hairs on the leaves, is also present on the abaxial surface of the perianth parts. This has led to some taxonomic confusion in the past.

Along with this indumentum variation *B. lanuginosa* shows some morphological and floral variation across its range. Plants collected from the northern and eastern areas of the Northern Territory (including

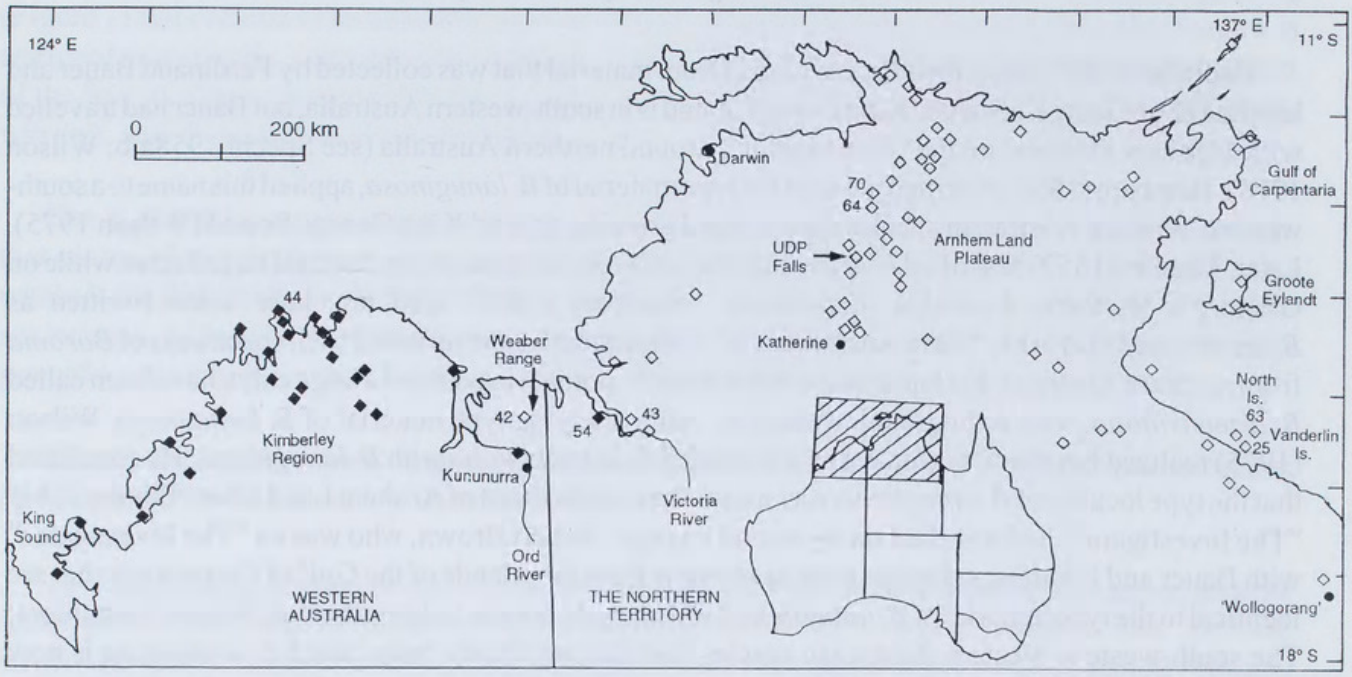

Figure 1. North-western Australia. Specimens used in analysis of *B. lanuginosa* species complex (25, 42-44, 54, 63, 64, 70); *B. lanuginosa*, Group A (◇); *B. wilsonii*, Group B (◆).

the islands of the Gulf of Carpentaria) have linear, revolute pinnae. Those collected south of UDP Falls (Kakadu National Park) to Nitmiluk National Park (NT) and west to the Weaber Range (WA) are similar but often have larger flowers. Kimberley plants have broad, recurved pinnae. Morphological variation within the complex is analysed numerically below, using phenetic methods.

Materials and methods

Material

Herbarium specimens were made available from AD, BRI, CANB, CBG, DNA, JCU, MBA, MEL, MELU, NSW, PERTH, QRS, TCD and WAU, cibachromes and slides were received from K, and slides were received from BM. Herbarium abbreviations follow Holmgren *et al.* (1990). These specimens were augmented with specimens from OSS (Office of the Supervisory Scientist, Kakadu National Park, NT) and material collected in the field during June and July of 1993.

Leaf anatomy

The central portion of the leaves of all taxa was sectioned. Material was fixed in Mirsky's fixative (MAA) or 70% ethanol. If fresh material was not available, herbarium samples were re-hydrated by being placed in water with a small amount of detergent, brought to the brink of boiling, left simmering for one hour and soaked overnight before fixing in MAA. All fixed material was placed in 70% ethanol overnight, dehydrated through a graded ethanol series up to 100% ethanol, infiltrated with 100% LR-White (London Resin) through a resin/ethanol series, and polymerized at 60°C. Sections, 2 µm in thickness, were cut on a Reichert Ultracut ultra-microtome, stained with 0.05% toluidine blue solution (pH 4.4) and observed and photographed using an Olympus BHS compound microscope. Anatomical features are described in the taxonomic descriptions.

Scanning electron microscopy

Trichomes (of leaves and stems) and seed surfaces of all taxa (where material was available) were surveyed using a Scanning Electron Microscope. Dry leaves, stems and seeds were mounted on stubs using double-sided or carbon tape with conductive carbon paint, coated with gold using an Edwards Sputter Coater S150B and examined and photographed at 5KV using a JEOL 840 Scanning Electron Microscope equipped with a lanthanum hexaboride filament. All photographs of seeds were taken of central areas on a lateral side, except where otherwise stated. Trichome and seed characters are described in the taxonomic descriptions.

Phenetic analyses

Characters

Seventeen characters (Table 1) were scored for 105 herbarium specimens (Tables 2, 3) that cover the entire geographic range of the *B. lanuginosa* species complex. Some collections were included more than once because they consisted of a number of plants with varying degrees of hirsuteness: *viz. Craven* 6705 (specimens 32 and 104), *Wightman* 1337 (specimens 71 and 72), and *Russell-Smith* 2861 (specimens 81-83). Scores are an average of five measurements (where five organs were available) and ratios are the

Table 1. Morphological characters used in scoring herbarium specimens.

Binary characters

1. Style glabrous/hirsute, 0/1
2. Leaves recurved/revolute, 0/1

Numeric characters

3. Length of petiole (mm)
4. Maximum leaflet number
5. Length of most proximal rhachis segment (mm)
6. Length of most distant rhachis segment (mm)
7. Length of terminal leaflet (TLL) (mm)
8. Width of terminal leaflet (TLW) (mm)
9. TLW/TLL
10. Length of lateral leaflet preceding the terminal leaflet (LLL) (mm)
11. LLL/TLL
12. Length of peduncle (mm)
13. Length of anthopodium (mm)
14. Length of sepal (SL) (mm)
15. Length of petal (PL) (mm)
16. PL/SL
17. Length of sepal on flower with mature fruit (mm)

Table 2. Data used in analysis of *B. lanuginosa* species complex. Principal collector given only. For quantitative characters mean values are given (see Table 1).

Specimen	Collector & number (or date)	Herbarium & sheet number	Character 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Wilson 126	DNA49945	0	1	0.8	7.0	3.0	4.0	9.8	1.7	0.18	8.0	0.83	0.5	2.0	7.0	5.0	0.71	?
2	Craven 3789	DNA55101	0	1	0.6	7.0	1.1	3.0	8.5	2.0	0.24	6.2	0.73	1.0	3.0	5.0	3.0	0.60	7.0
3	Hinz 110	DNA43449	0	1	0.5	7.0	2.7	3.5	11.2	2.1	0.19	7.6	0.67	1.5	4.0	6.0	4.0	0.67	?
4	Knight 1450	DNA339654	0	1	0.5	9.0	1.0	3.2	10.6	2.2	0.20	7.6	0.73	0.5	3.0	6.0	4.0	0.67	8.0
5	Thomson 2474	DNA84263	0	1	1.3	11.0	4.9	3.6	9.0	1.1	0.12	6.6	0.74	0.0	2.0	5.0	4.0	0.80	7.0
6	Craven 5963	CANB313896	0	1	0.6	9.0	1.5	2.3	8.8	1.2	0.15	7.6	0.87	0.0	2.0	6.0	4.0	0.67	8.0
7	Russell-Smith 5220	DNA47609	0	1	0.5	9.0	1.5	3.4	9.2	1.0	0.11	5.0	0.55	0.0	2.0	6.0	4.0	0.67	8.0
8	Wightman 4283	DNA50903	0	1	0.5	13.0	3.2	2.8	11.8	1.6	0.14	9.4	0.81	0.0	3.0	8.0	5.0	0.63	?
9	Lazarides 7928	DNA52723	0	1	0.7	13.0	1.7	3.0	10.8	1.1	0.11	7.6	0.71	0.0	2.0	5.0	4.0	0.80	8.0
10	Cleminson 261	DNA79417	0	1	0.5	9.0	2.0	3.0	10.6	1.5	0.14	9.2	0.86	0.0	2.5	6.0	4.0	0.67	8.0
11	Hinz 196	DNA43177	0	1	0.5	7.0	2.2	2.8	10.4	1.0	0.10	7.6	0.73	0.0	2.0	6.0	5.0	0.83	?
12	Wightman 1374	CANB352516	0	1	1.0	13.0	1.0	3.6	7.4	1.0	0.14	4.2	0.57	0.0	5.0	7.0	5.0	0.71	9.0
13	Craven 2299	CANB271721	0	1	0.6	7.0	1.7	3.0	10.2	1.0	0.10	8.4	0.85	0.0	5.0	7.0	5.0	0.71	12.0
14	Lazarides 9042	DNA19608	0	1	0.9	9.0	1.4	2.7	11.0	1.1	0.10	6.2	0.56	0.0	4.0	7.0	5.0	0.71	9.0
15	Hinz 26	DNA32735	0	1	1.3	17.0	2.4	3.2	6.2	1.1	0.19	4.0	0.66	0.0	1.0	5.0	4.0	0.80	6.0
16	Clark 1344	DNA34728	0	1	0.9	11.0	3.4	6.0	8.2	1.7	0.21	6.4	0.79	0.0	2.0	7.0	4.0	0.57	9.0
17	Parker 908	DNA11904	0	1	0.8	11.0	2.4	3.2	8.4	1.0	0.12	5.6	0.66	0.5	2.0	6.0	4.0	0.67	8.0
18	Henshall 1680	DNA54378	0	1	1.3	15.0	2.2	2.0	8.0	1.2	0.16	5.2	0.66	1.0	3.0	6.0	4.0	0.67	8.0
19	Wightman 1615	DNA23559	0	1	2.0	11.0	4.0	4.0	13.2	1.7	0.14	9.0	0.68	1.5	2.0	6.0	5.0	0.83	7.0
20	Maconochie 860	DNA85534	0	1	1.3	9.0	2.3	3.2	9.8	1.6	0.17	8.0	0.83	0.0	1.5	5.0	4.0	0.80	?
21	Pullen 9233	DNA315385	0	1	0.8	9.0	2.4	3.0	7.4	1.5	0.22	4.8	0.66	0.0	3.0	5.0	4.0	0.80	7.0
22	Jacobs 1587	NSW244407	0	1	1.0	11.0	3.4	3.6	9.3	1.6	0.18	6.4	0.71	1.0	3.0	6.0	5.0	0.83	8.5
23	Halford 84114	DNA76573	0	1	1.1	15.0	2.8	3.5	6.8	1.3	0.20	5.2	0.76	1.0	1.5	5.0	4.0	0.80	?
24	Maconochie 2096	DNA48271	0	1	0.8	11.0	1.2	3.7	7.2	1.3	0.18	4.4	0.61	0.0	4.0	5.0	4.0	0.80	7.0
25	Reichenbach 3.vii.1955	DNA40515	0	1	0.8	13.0	1.8	3.0	8.0	1.4	0.18	5.4	0.68	0.0	3.0	6.0	5.0	0.83	7.0
26	Gallen 58	DNA28469	0	1	0.5	13.0	2.3	3.4	10.0	2.1	0.23	7.0	0.72	1.0	1.0	7.0	5.0	0.71	7.0
27	Hartley 13828	DNA44421	0	1	0.7	11.0	1.8	3.6	9.2	1.8	0.20	6.0	0.66	1.0	2.0	5.0	4.0	0.80	?
28	Chappill 30.vi.1993	MEL	0	1	1.3	9.0	1.0	3.1	9.5	1.0	0.10	6.0	0.63	0.5	3.8	6.0	4.0	0.67	8.5
29	Leach 2757	BRI AQ462613	0	1	0.7	9.0	1.6	1.8	9.8	1.1	0.11	5.8	0.59	0.0	2.0	5.0	4.0	0.80	7.0
30	Menkhorst 357	MEL1582546	0	1	1.5	9.0	3.4	3.4	7.5	1.2	0.18	4.4	0.58	0.5	1.5	6.0	5.0	0.83	7.0
31	Cowie 1165	MEL1582645	0	1	0.5	9.0	2.1	5.0	12.8	0.8	0.06	8.6	0.70	0.5	2.0	6.0	4.0	0.67	7.0
32	King 298	DNA22700	0	1	0.5	11.0	0.9	2.8	9.8	1.0	0.11	8.4	0.86	0.0	4.0	10.0	8.0	0.80	11.0
33	Fryxell 4222	AD989251	0	1	0.5	11.0	1.0	2.6	10.2	1.0	0.10	7.0	0.69	0.0	4.0	10.0	8.0	0.80	12.0
34	Craven 6705	MEL626239	0	1	0.5	13.0	1.1	3.4	7.8	0.8	0.11	5.1	0.66	0.5	2.0	10.0	6.0	0.60	11.0
35	Fryxell 4907	DNA377233	0	1	0.3	11.0	0.9	3.6	16.0	1.0	0.07	13.0	0.82	0.0	4.0	5.0	4.0	0.80	10.0
36	King 42	DNA24457	0	1	0.4	17.0	0.7	3.0	11.4	1.0	0.10	7.4	0.68	0.0	2.0	6.0	4.0	0.67	10.0
37	King 2.vi.1982	DNA23248	0	1	0.4	15.0	1.2	2.4	7.2	1.0	0.14	5.8	0.81	0.0	2.0	6.5	5.0	0.77	10.0
38	Byrnes 88	DNA1034	0	1	0.6	13.0	1.6	4.4	12.0	1.0	0.08	7.8	0.66	0.0	2.0	7.0	5.0	0.71	13.0
39	Barlow 558	DNA20750	0	1	0.3	9.0	0.8	2.3	8.0	1.0	0.13	6.2	0.79	0.0	2.0	7.0	5.0	0.71	11.0
40	Dunlop 8086	DNA42635	0	1	0.5	11.0	1.4	1.4	7.4	1.0	0.14	6.6	0.90	0.0	4.0	7.0	6.0	0.86	12.0
41	Lazarides 8426	DNA56830	?	1	0.5	15.0	0.5	1.9	5.2	0.8	0.15	4.8	0.94	1.0	2.0	7.0	6.0	0.86	8.0
42	Clark 436	DNA27360	0	1	0.2	13.0	1.2	2.2	5.8	1.0	0.18	5.0	0.86	0.0	2.0	5.0	4.0	0.80	8.0
43	Dunlop 8216	DNA42766	0	1	0.5	15.0	2.6	3.8	8.4	1.0	0.13	6.6	0.81	0.5	4.0	9.0	8.0	0.89	10.0
44	Fryxell 4791	DNA31055	0	0	1.2	11.0	1.6	1.8	6.4	2.1	0.35	4.0	0.63	0.0	3.0	6.0	4.0	0.67	?
45	George 13548	CANB255846	1	0	3.0	19.0	3.0	2.9	5.2	1.9	0.40	3.2	0.62	0.0	3.0	6.0	4.0	0.67	7.0
46	Fryxell 4600	CANB377237	0	0	3.8	13.0	4.0	4.0	9.0	2.0	0.23	5.4	0.60	0.0	4.0	9.0	6.0	0.67	11.0
47	Lazarides 6799	DNA20749	0	0	2.0	13.0	4.0	3.0	10.8	3.8	0.36	5.0	0.46	0.0	4.0	5.0	4.0	0.80	7.0
48	Willis 31.v.1984	BRI AQ428115	0	0	2.0	13.0	5.4	4.2	9.4	4.1	0.44	6.6	0.70	0.0	3.0	6.0	4.0	0.67	7.0
49	Kenneally 9682	CANB367630	1	0	2.6	9.0	5.4	6.2	18.8	3.8	0.20	8.8	0.48	0.0	5.0	9.0	7.0	0.78	11.0
50	Kenneally 8319	CANB364052	1	0	1.9	13.0	3.4	3.3	11.8	3.2	0.28	6.6	0.57	0.0	5.0	7.0	6.0	0.86	9.0
51	Fryxell 4685	CANB377236	1	0	2.1	15.0	2.8	4.2	15.4	5.0	0.32	7.8	0.50	0.0	3.0	7.0	6.0	0.86	8.0
52	Dunlop 5380	DNA16746	1	0	2.2	15.0	5.0	4.6	13.8	3.6	0.27	8.6	0.62	0.0	3.0	5.0	4.0	0.80	8.0
53	Fryxell 4002	DNA31461	1	0	2.4	13.0	3.8	4.2	12.8	4.8	0.40	6.6	0.55	0.0	4.0	7.0	4.0	0.57	7.0
54	Leach 2399	BRI AQ1446448	1	0	2.0	15.0	2.2	1.8	4.0	2.0	0.53	3.4	0.85	0.0	3.5	5.0	5.0	1.00	7.0
55	Chesterfield 245	MEL1534491	1	0	1.5	9.0	3.0	3.4	11.4	4.0	0.36	8.0	0.71	0.0	4.0	7.0	6.0	0.86	8.0
56	Forbes 2059	MEL1534492	0	0	1.5	11.0	2.8	2.8	8.8	3.5	0.41	6.0	0.70	0.0	2.0	5.0	3.0	0.60	6.0

average of the individual ratios of the five organs measured. There are some problems associated with the use of ratios in phenetic analyses (see Duretto & Ladiges 1997 and references therein for discussion): here ratios are used as a means of quantifying and standardizing leaf shape (characters 9 and 11), and measuring the relative lengths of the sepals and petals (character 16).

Table 3. Data used in the phenetic analysis of the *B. lanuginosa* species complex, analysis 3, juvenile leaved plants only. Principal collector given only. For quantitative characters mean values are given (see Table 1).

Specimen	Collector & number (or date)	Herbarium & sheet number	Character 14	15	16	17
57	Craven 3480	DNA55102	6.0	5.0	0.83	?
58	Latz 10096	DNA	7.0	6.0	0.86	9.0
59	Craven 5796	DNA19609	6.0	5.0	0.83	?
60	Tidemann 13	DNA51300	6.0	4.0	0.67	?
61	Russell-Smith 3072	DNA43330	4.0	3.0	0.75	6.0
62	Must 1041	DNA4995	4.0	3.0	0.75	6.0
63	Grinns 3	DNA82012	6.0	4.0	0.67	8.0
64	Craven 6311	DNAS19618	6.0	5.0	0.83	6.0
65	Wightman 2229	DNA26585	6.0	4.0	0.67	?
66	Clark 1363	DNA49016	?	?	?	6.0
67	Russell-Smith 2766	DNA30067	6.0	5.0	0.84	8.0
68	Smith 579	DNA39890	6.0	5.0	0.84	7.0
69	Clark 1178	DNA34488	6.0	5.0	0.84	7.0
70	Cowie 26.xi.1985	DNA48810	5.0	4.0	0.80	?
71	Wightman 1337	NSW244394	4.0	3.0	0.75	5.0
72	Wightman 1337	NSW244394	4.0	3.0	0.75	5.0
73	Wightman 647	DNA21610	5.0	4.0	0.80	5.0
74	Clark 1529	DNA34617	5.0	4.0	0.80	6.0
75	Symon 7736	DNA67794	5.0	3.0	0.60	6.0
76	Maconochie 1482	DNA35810	6.0	4.0	0.67	8.0
77	Must 1018	DNA4890	5.0	4.0	0.80	6.5
78	Wightman 1981	DNA26336	6.0	5.0	0.83	9.0
79	Bowman 308	DNA26280	7.0	4.0	0.57	7.0
80	Wightman 1084	DNA22555	5.5	4.0	0.73	8.0
81	Russell-Smith 2861	DNA29879	6.0	5.0	0.84	?
82	Russell-Smith 2861	DNA29879	5.0	4.0	0.80	7.0
83	Russell-Smith 2861	DNA29879	5.0	4.0	0.80	7.0
84	Wightman 1130	DNA22554	5.0	4.0	0.80	?
85	Hartley 7.vi.1974	DNA8233	5.0	5.0	1.00	5.0
86	Wightman 3798	DNA30364	5.0	5.0	1.00	5.0
87	Latz 3462	DNA36986	5.0	3.0	0.60	8.0
88	Menkhorst 337	DNA43605	5.0	4.0	0.80	6.0
89	Craven 6063	CANB313897	6.0	4.0	0.67	?
90	Muir 5976	AD98904071	6.0	4.0	0.67	?
91	Muir 6057	AD9890623	5.0	4.0	0.80	5.5
92	Martensz AE583	BRI [AQ151157]	10.0	5.0	0.50	12.0
93	Cowie 272	DNA27078	10.0	7.5	0.75	?
94	Gittens 2612	NSW244427	12.0	9.0	0.75	13.0
95	Henry 896	DNA49279	12.0	8.0	0.67	?
96	Bowman 383	DNA37156	6.0	5.0	0.83	7.0
97	Ollerenshaw 1594A	DNA50113	6.0	4.0	0.67	7.0
98	Lazarides 8944	DNA19605	6.0	4.0	0.67	9.0
99	Brown 9.vii.1985	DNA26772	5.0	4.0	0.80	?
100	Leach 2829	DNA47633	7.0	5.0	0.71	8.0
101	King 16.vi.1981	DNA18842	7.0	5.0	0.71	?
102	Pullen 10602	CANB264130	8.0	5.0	0.63	9.0
103	Brooker 3149	CANB259815	11.0	8.0	0.73	15.0
104	Craven 6705	DNA20963	8.0	6.0	0.75	?
105	King 45	DNA20464	9.0	6.0	0.67	10.0

For numerical analyses (cladistic or phenetic) homologous features only should be compared. For example, comparing leaf measurements at different stages of development would be erroneous and results would be misleading. Also, as there is an ontogenetic sequence from glabrous to hirsute plants in the *B. lanuginosa* species complex, characters such as hair density are unusable. The phenetic analysis, outlined below, uses morphological data from mature plants (i.e. with a dense indumentum) only and, floral data from specimens with mature and/or juvenile foliage.

Data analysis

All data sets were analysed using PATN (Belbin 1987) following the methodology outlined in Duretto (1995) and Duretto & Ladiges (1997). Data were range-standardized before Manhattan dissimilarity measures were calculated. For cluster analysis, both flexible UPGMA (unweighted pair group arithmetic averages) and flexible WPGMA (weighted pair group arithmetic averages) were utilized as fusion strategies. Data were ordinated in three dimensions using the multidimensional scaling, MDS, KYSP algorithm (Kruskal *et al.* 1973). The Hybrid option of Faith *et al.* (1987) was chosen. Twenty different random starting points were used for each analysis and the run with the lowest stress value is shown. Character correlations with the ordination vectors were calculated using the PCC function of PATN. Minimum spanning trees, MST, were also calculated. Three analyses were completed.

Taxon descriptions

Descriptive terminology follows Theobald *et al.* (1979) and Hewson (1988) for hairs; Briggs & Johnson (1979) and Weston (1990) for inflorescence structure; and Murley (1951), Powell & Armstrong (1980), Barthlott (1984) and Duretto & Ladiges (1997) for seed surfaces. Conservation codes follow the format of Briggs & Leigh (1996) for all taxa, and that of the Western Australian Department of Conservation and Land Management for Western Australian taxa (Nuytsia 10, p. 471, 1996). Authority abbreviations are as given in Brummitt & Powell (1992).

Specimen citation

In order to accord with the policy of the journal, specimen citations have been deliberately abbreviated to achieve less precision in order to protect taxa with conservation codes of E, V or K. A complete list of specimens seen is available from the author on request.

Results of phenetic analysis

Analysis 1 (specimens 1-56, characters 1-14)

The first analysis includes plants with mature (having a dense indumentum) foliage only, specimens 1-56, and characters 1-14. Two groups, A and B, are recognizable in the UPGMA (Figure 2) and WPGMA (not shown) classifications, ordination (Figure 3), and MST (Figure 4). Group A includes all specimens from the Weaber Range (WA) to "Wollogorang" (NT) (specimens 1-43) except specimen 54 (Figure 1). Group B includes all Kimberley specimens west of the Ord River (specimens 44-53, 55, 56) and specimen 54 from the lower Victoria River area (NT). In the MST (Figure 4), Groups A and B are linked by specimens 25 (and 17, 18, 21 etc) and 44 (and 45, 56 etc), which are from Vanderlin Island (Gulf of Carpentaria) and Bougainville Peninsula (Kimberley Region) respectively (Figure 1).

Characters that are highly correlated with the vectors in the ordination (Figure 3) are: characters 2, 3, 8, 11 for vector 1; 1, 4, 7 and 10 for vector 2; and, 12 for vector 3 (not shown). Group A is characterized by small petioles (character 3), fewer pinnae (character 4), and pinnae that are short (character 7), narrow (characters 8 and 9) and revolute (character 2). Group B is characterized by longer petioles, and longer, broader and recurved pinnae (Table 4).

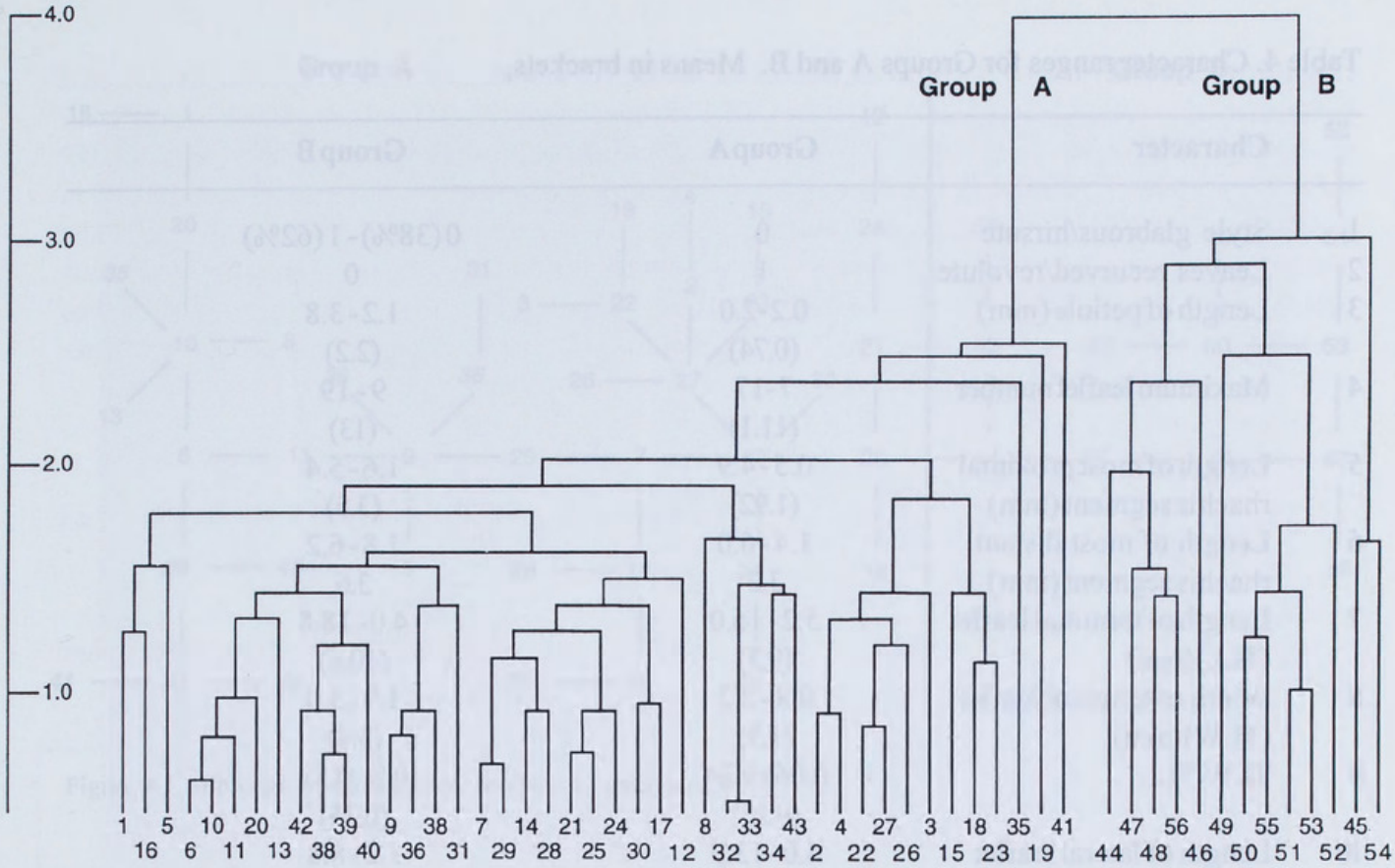

Figure 2. UPGMA classification, analysis 1, specimens 1-56.

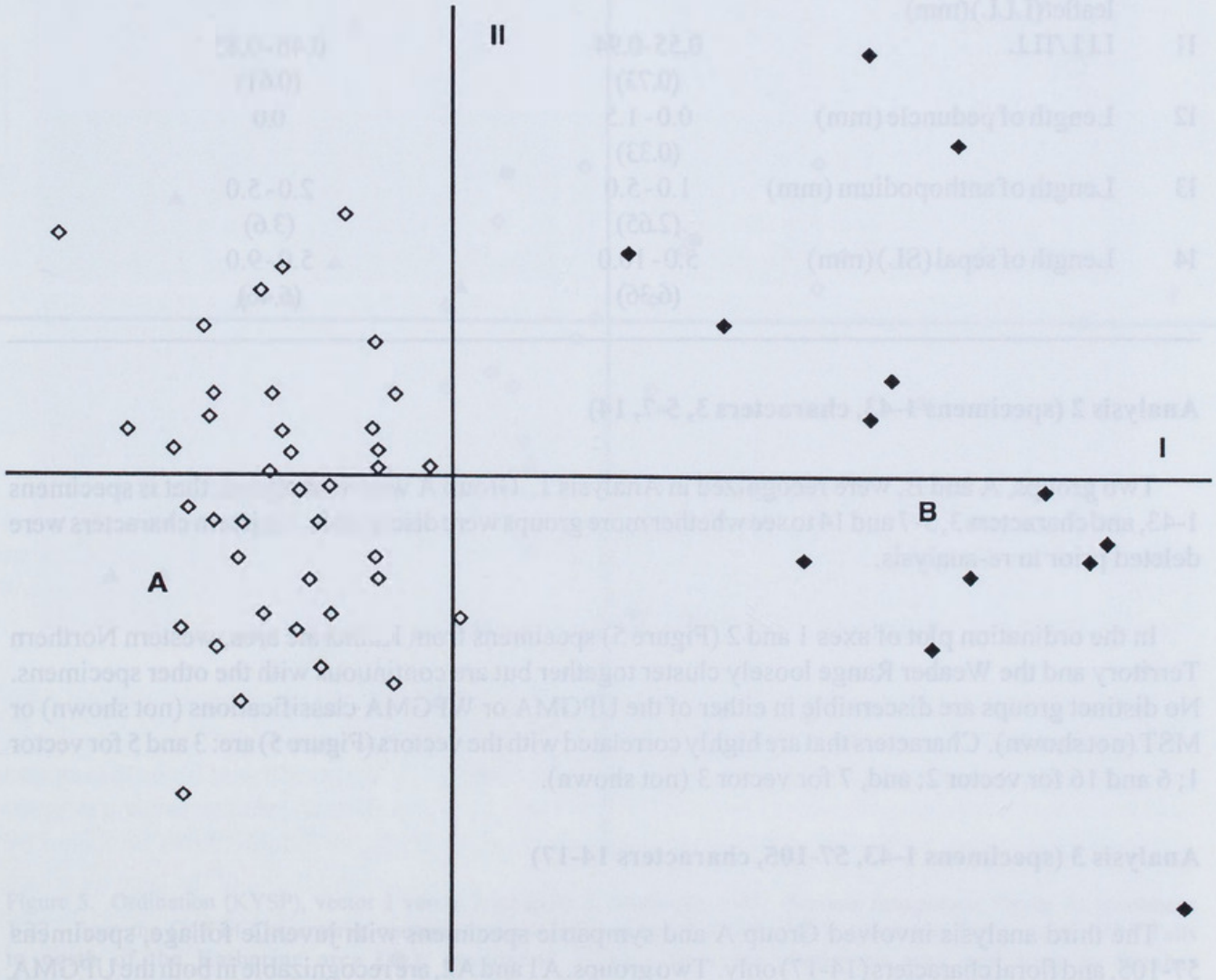

Figure 3. Ordination (KYSP), vectors 1 and 2, analysis 1, specimens 1-56. *Boronia lanuginosa*, Group A (◇); *B. wilsonii*, Group B (◆). Specimens referred to in text are numbered.

Table 4. Character ranges for Groups A and B. Means in brackets.

	Character	Group A	Group B
1	Style glabrous/hirsute	0	0 (38%) - 1 (62%)
2	Leaves recurved/revolute	1	0
3	Length of petiole (mm)	0.2-2.0 (0.74)	1.2-3.8 (2.2)
4	Maximum leaflet number	7-17 (11.1)	9-19 (13)
5	Length of most proximal rhachis segment (mm)	0.5-4.9 (1.92)	1.6-5.4 (3.5)
6	Length of most distant rhachis segment (mm)	1.4-6.0 3.2	1.8-6.2 3.6
7	Length of terminal leaflet (TLL)(mm)	5.2-16.0 (9.3)	4.0-18.8 (10.6)
8	Width of terminal leaflet (TLW)(mm)	0.8-2.2 (1.3)	1.9-5.0 (3.4)
9	TLW/TLL	0.06-0.24 (0.15)	0.2-0.53 (0.35)
10	Length of lateral leaflet preceding the terminal leaflet(LLL)(mm)	4.0-13.0 (6.7)	3.2-8.8 (6.2)
11	LLL/TLL	0.55-0.94 (0.73)	0.46-0.85 (0.61)
12	Length of peduncle (mm)	0.0-1.5 (0.33)	0.0
13	Length of anthopodium (mm)	1.0-5.0 (2.65)	2.0-5.0 (3.6)
14	Length of sepal (SL) (mm)	5.0-10.0 (6.36)	5.0-9.0 (6.46)

Analysis 2 (specimens 1-43, characters 3, 5-7, 14)

Two groups, A and B, were recognized in Analysis 1. Group A was re-analysed, that is specimens 1-43, and characters 3, 5-7 and 14 to see whether more groups were discernible. Uniform characters were deleted prior to re-analysis.

In the ordination plot of axes 1 and 2 (Figure 5) specimens from Katherine area, western Northern Territory and the Weaber Range loosely cluster together but are continuous with the other specimens. No distinct groups are discernible in either of the UPGMA or WPGMA classifications (not shown) or MST (not shown). Characters that are highly correlated with the vectors (Figure 5) are: 3 and 5 for vector 1; 6 and 16 for vector 2; and, 7 for vector 3 (not shown).

Analysis 3 (specimens 1-43, 57-105, characters 14-17)

The third analysis involved Group A and sympatric specimens with juvenile foliage, specimens 57-105, and floral characters (14-17) only. Two groups, A1 and A2, are recognizable in both the UPGMA

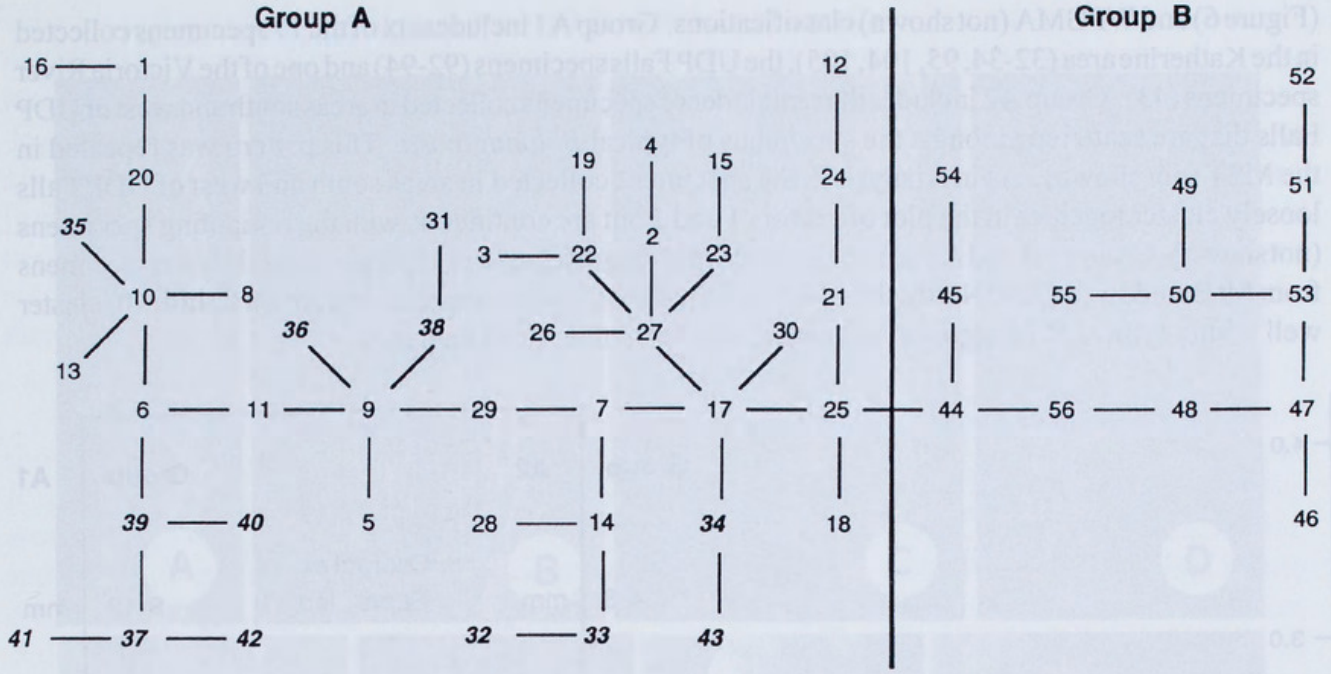

Figure 4. Minimum Spanning Tree, analysis 1, specimens 1-56.

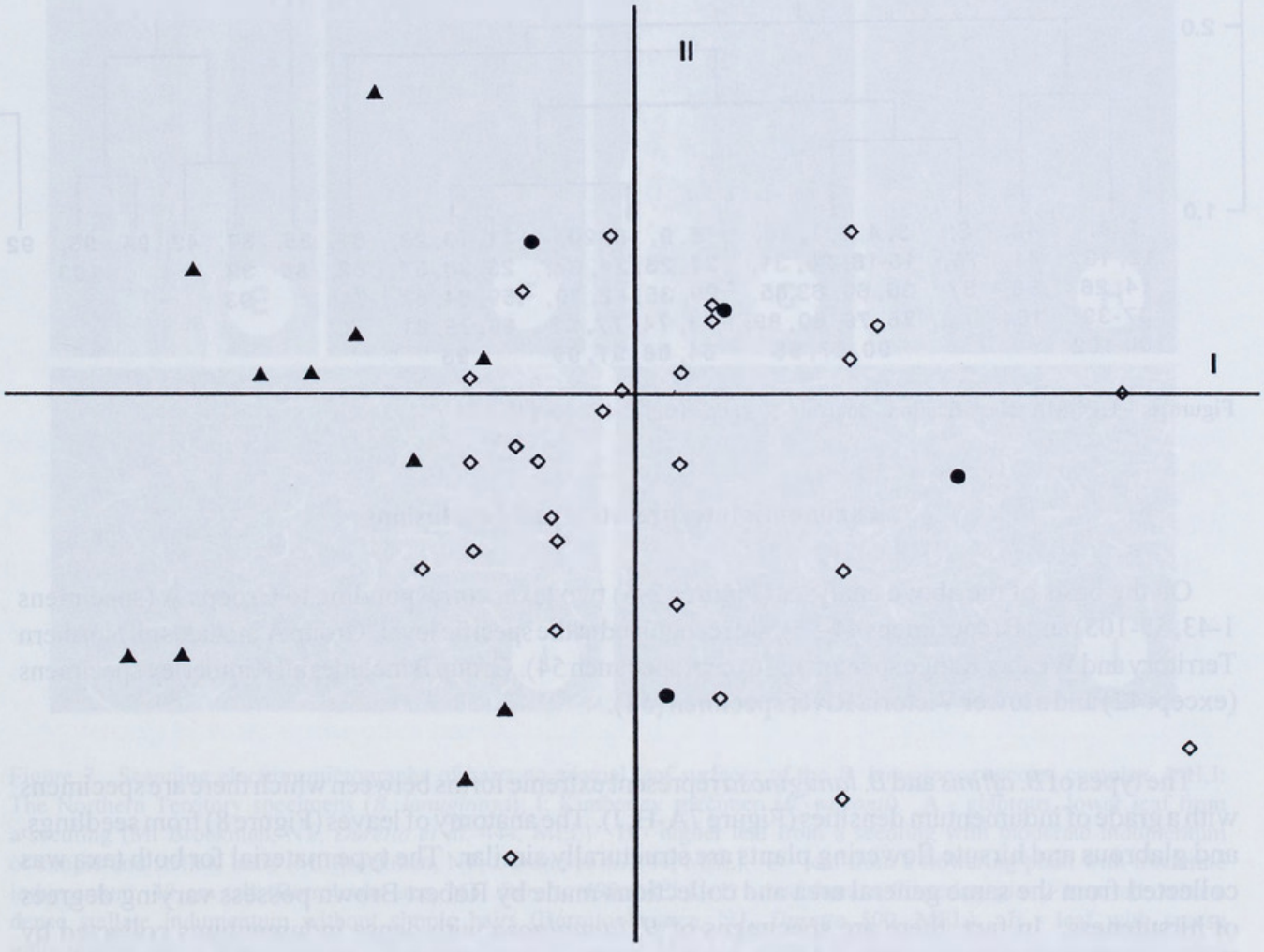

Figure 5. Ordination (KYSP), vector 1 verses 2, analysis 2, specimens 1-43. *Boronia lanuginosa*, Group A; specimens 1-27 - from the Gulf of Carpentaria, northern Arnhem Land to Jim Jim Falls (◇); specimens 28-31 - from UDP Falls to north of the Katherine area (●); specimens 32-43 - from the Katherine area and west to Weaber Range (▲).

(Figure 6) and WPGMA (not shown) classifications. Group A1 includes six of the 17 specimens collected in the Katherine area (32-34, 95, 104, 105), the UDP Falls specimens (92-94) and one of the Victoria River specimens (43). Group A2 includes the remainder of specimens collected in areas south and west of UDP Falls that are scattered amongst the specimens of typical *B. lanuginosa*. This pattern was repeated in the MST (not shown). As in Analysis 2, the specimens collected in areas south and west of UDP Falls loosely cluster together in the plot of vectors 1 and 2 but are continuous with the remaining specimens (not shown). Groups A1 and A2 differ mainly in sepal length (character 14; Figure 6). Glabrous specimens from Mt Basedow (64) and North island (63), and the almost glabrous specimen from Mt Cahill (70) cluster well within typical *B. lanuginosa* but away from each other in all analyses.

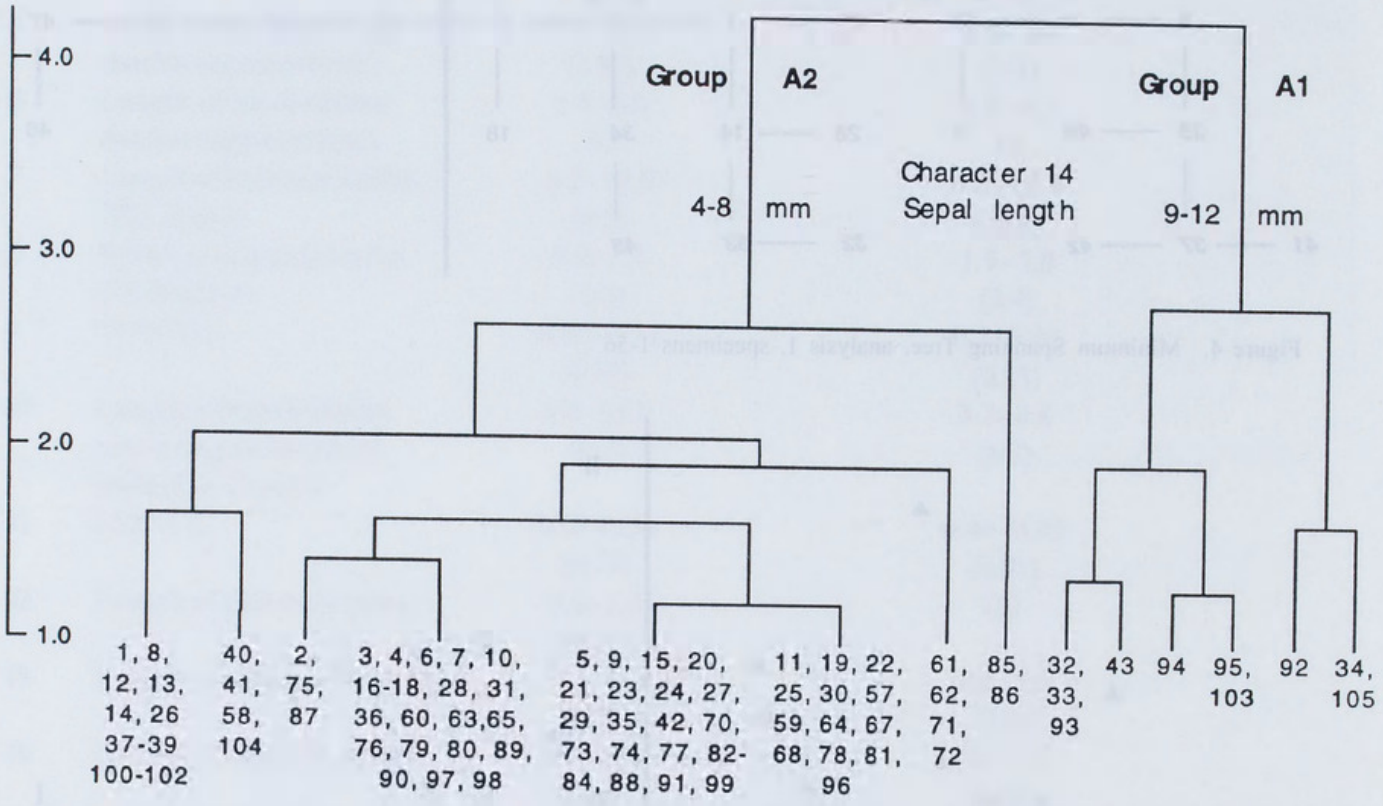

Figure 6. UPGMA classification, analysis 3, specimens 1-45, 55-105.

Taxonomic interpretation and conclusions

On the basis of the above analyses (Figures 2-6) two taxa, corresponding to Groups A (specimens 1-43, 57-105) and B (specimens 44-56), are recognized at the specific level. Group A includes all Northern Territory and Weaber Range specimens (except specimen 54). Group B includes all Kimberley specimens (except 42) and a lower Victoria River specimen (54).

The types of *B. affinis* and *B. lanuginosa* represent extreme forms between which there are specimens with a grade of indumentum densities (Figure 7A-H, J). The anatomy of leaves (Figure 8) from seedlings, and glabrous and hirsute flowering plants are structurally similar. The type material for both taxa was collected from the same general area and collections made by Robert Brown possess varying degrees of hirsuteness. In fact, there are specimens of *B. lanuginosa* with dense indumentums collected by Brown at BM that originated from Vanderlin Island (Figure 1). This Island is one of the type localities of *B. affinis*. It would appear that Bentham (1863) described *B. affinis* from several of the less hirsute specimens that Brown collected. Here it is proposed that the type material of *B. affinis* and *B. lanuginosa* represent different ontogenetic stages of the same taxon, juvenile and mature respectively, and as

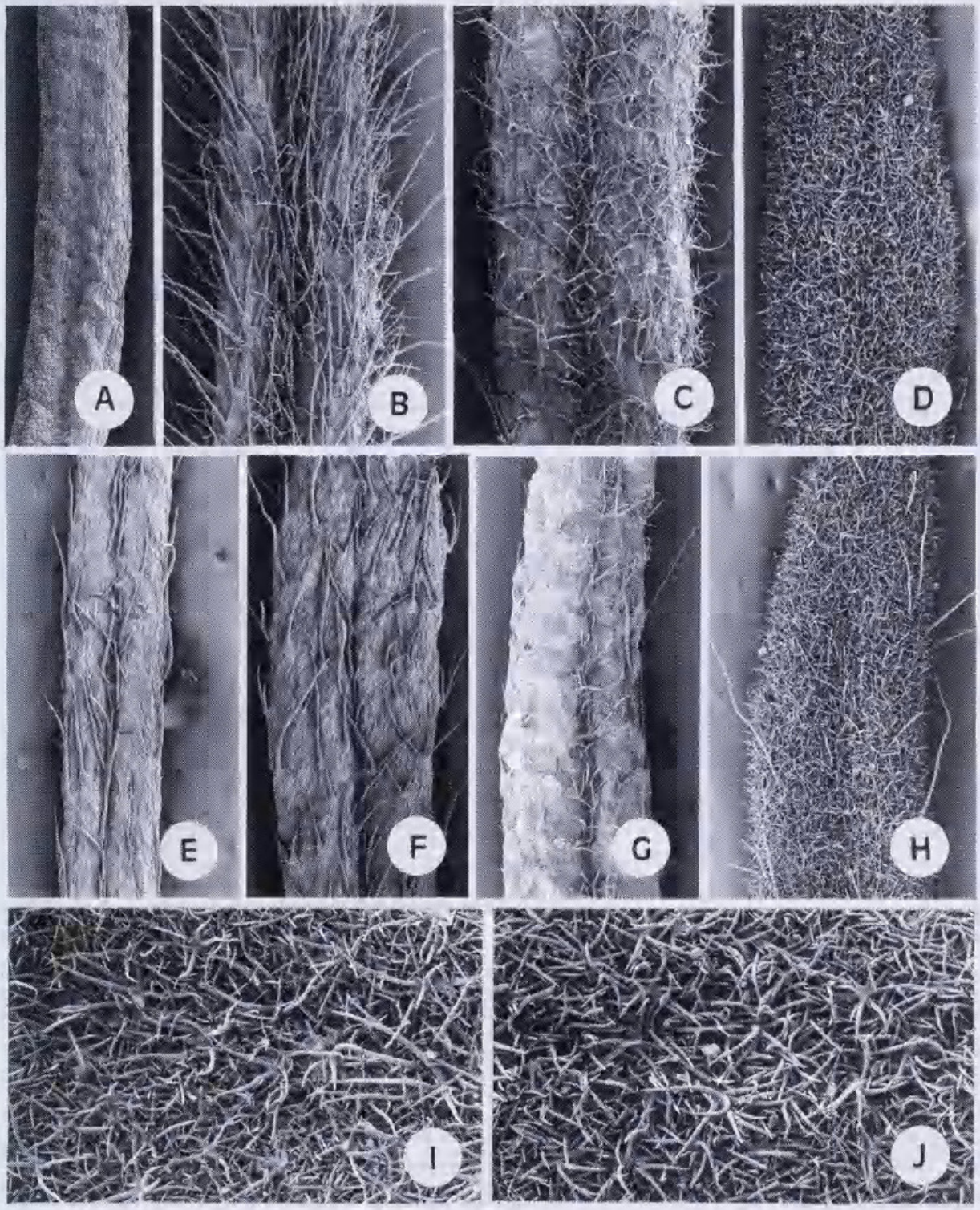

Figure 7. Scanning electron micrographs of hairs on adaxial leaf surfaces of the *B. lanuginosa* species complex A-H,J: The Northern Territory specimens (*B. lanuginosa*); I: Kimberley specimen (*B. wilsonii*). A - glabrous, lower leaf from a seedling (Mt Brockman, NT, *Duretto et al.* 444, MEL). B - higher leaf from a seedling with moderate indumentum of simple and stellate hairs (Mt Brockman, NT, *Duretto et al.* 444, MEL). C - leaf from a flowering plant with moderate indumentum, 40 cm tall (Borroloola area, NT, *Duretto* 499, MEL). D - leaf from a flowering plant, 1 m tall, with a dense stellate indumentum without simple hairs (Borroloola area, NT, *Duretto* 500, MEL). E - leaf with sparse indumentum from a flowering plant (Mt Cahill, NT, *Duretto* 449, MEL). F - leaf with sparse indumentum from a flowering plant (sand plains north of Arnhem Land Plateau, NT, *Duretto et al.* 414, MEL). G - leaf from a flowering plant, 1 m tall, with a sparse indumentum of simple and stellate hairs (Borroloola area, NT, *Duretto et al.* 504A, MEL). H - leaf from a flowering plant, 1 m tall, with a dense indumentum of stellate and simple hairs (Borroloola area, NT, *Duretto et al.* 503, MEL). I - leaf from a flowering plant, 1 m tall, with a dense stellate indumentum (Anjo Peninsula, WA, *Willis s.n.*, 31 May 1984, BRI). J - leaf from a flowering plant, 1 m tall, with a dense stellate indumentum (Borroloola area, NT, *Duretto* 500, MEL). Scales: x20 (A-H) and x550 (I-J).

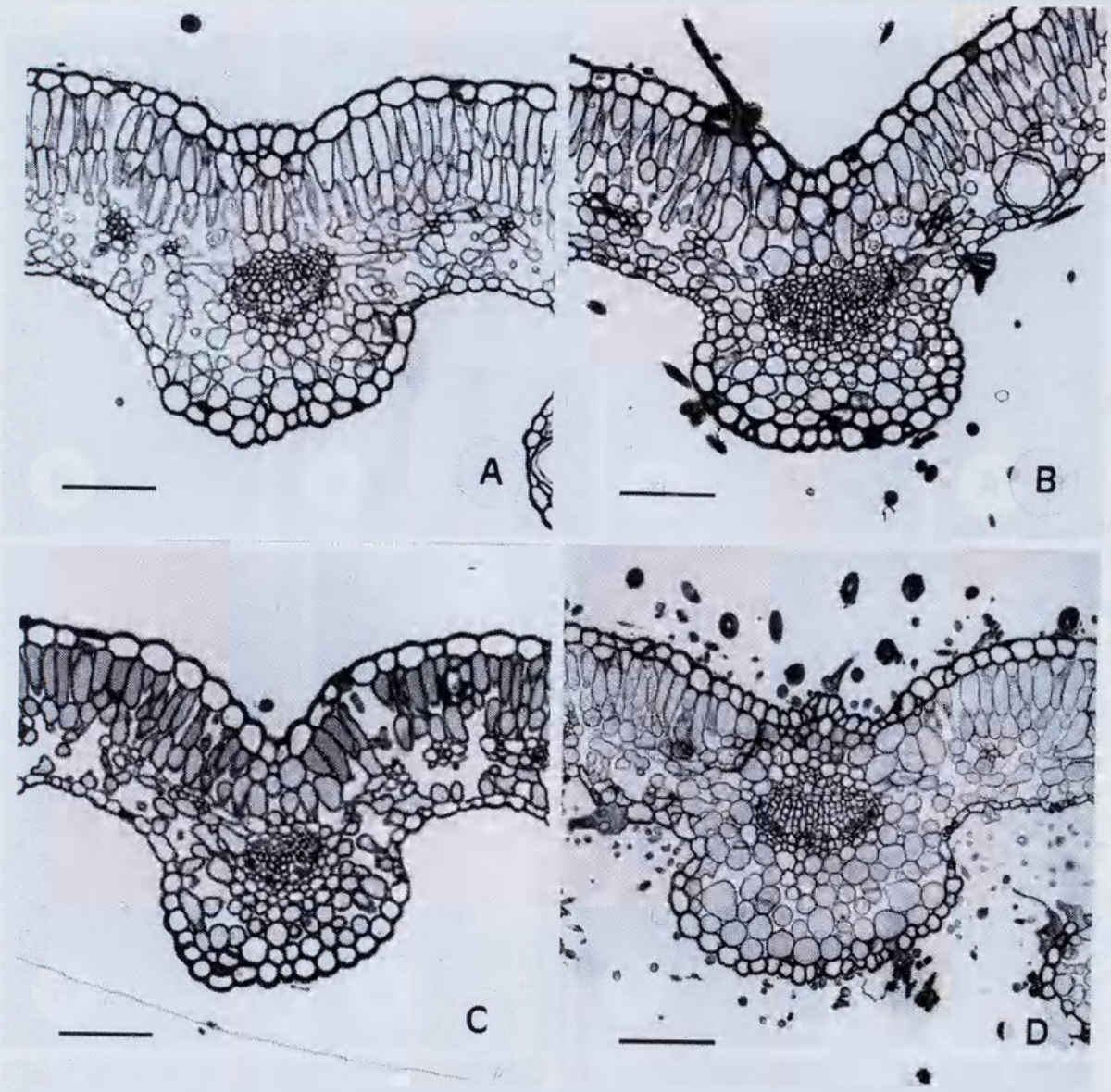

Figure 8. Light micrographs of transverse sections of leaves of *B. lanuginosa*. A - lower leaf from a seedling (*Duretto* 501, MEL). B - leaf from a flowering shrub with sparse indumentum (Borroloola area, NT, *Duretto et al.* 504A, MEL). C - leaf from a flowering shrub (Mt Cahill, NT, *Duretto* 448, MEL). D - leaf from a flowering plant with mature foliage (UDP Falls, NT, *Duretto et al.* 479, MEL). A-D - x 110. Scales: x100 (A-D); scale bar = 0.1 mm.

B. lanuginosa has priority, *B. affinis* is synonymized (see below). Group A contains specimens that are similar to the type material of *B. lanuginosa* and so retains that name. Group B corresponds to Bentham's taxon *B. artemisiifolia* var. *wilsonii,* which is raised to specific rank below.

Analyses 2 (Figure 5) and 3 (Figure 6) demonstrate that the glabrous specimens from Mt Basedow (64) and North Island (63), and the almost glabrous Mt Cahill specimen (70) do not warrant taxonomic recognition on the basis of floral data. Morphological data at present suggest that these populations are made up of small, possibly neotenous plants that may behave as annuals due to the present fire regime or the extended dry period of the "Top End" of the Northern Territory.

The hypothesis that the populations south and west of UDP Falls are distinct from typical *B. lanuginosa* is not supported by the data used in Analyses 2 and 3. As with indumentum density,

variation in floral size may be more complex than assumed in the analysis. Plants from the south and west of UDP Falls appear to have larger flowers on younger plants. Also, many of the leaves from these juvenile plants appear to be larger. The data (Tables 2, 3) were collected from plants at different stages of development, and so may not be directly comparable. This species complex requires seedling trials from a wide range of populations to determine whether any populations have significantly larger flowers and leaves at earlier stages of development. Leaves and flowers need to be measured and compared at specific nodes to assure homology. Seedling trials fell outside the scope of this project because seed was not readily available, and boronias are notoriously difficult to germinate. Other sources of data (e.g. oils, flavonoids, isoenzymes) may be required to resolve this problem.

If further work is completed, and the populations of *B. lanuginosa* south and west of UDP falls are shown to be distinct species, the name *B. artemisiifolia* should be reinstated. The type material of *B. artemisiifolia* is of this larger flowered form (see below). The boundary between the distributional areas of these taxa would approximately correspond to that of the two subspecies of *B. grandisepala*, and that of the related taxa *B. verecunda* Duretto and *B. xanthastrum* Duretto (Duretto 1995; Duretto & Ladiges 1997). Congruent patterns like these, and the diversity of boronias on the western escarpment of the Arnhem Land plateau (Duretto 1995; Duretto & Ladiges 1997, in prep.), make this region one of great biogeographical interest.

Key to *Boronia* species in the Northern Territory, the Kimberley Region of Western Australia, and north-west Queensland.

1. Sepals much smaller than petals 2
1: Sepals equal to or larger than petals 4
2. Leaves to 25-pinnate, margins strongly recurved; leaflets linear to narrowly elliptic, to 1 mm wide; sepals narrowly deltoid (NW Qld) ..... **B.** aff. **alulata** (NW Qld, *Clarkson* 10473)*
2: Leaves simple or 1-7 pinnate, margins flat; leaves and leaflets elliptic to oblanceolate, 1-27 mm wide; sepals ovate-deltoid (NW Qld, NT) 3
3. Pendulous shrubs; leaves simple or pinnate, midrib not raised prominently abaxially; petals 2-2.5 mm long ..... 10. **B. rupicola**
3: Erect shrubs (rarely pendulous); leaves always simple, midrib prominently raised abaxially; petals usually greater than 3 mm long ..... 11. **B. lanceolata**
4. Leaves pinnate 5
4: Leaves simple 13
5. Juvenile leaves sometimes trifoliolate, mature leaves simple; leaves and pinnae glabrescent or glabrous, leaves and pinnae never linear ..... 6. **B. pauciflora**
5: Leaves 3-55-pinnate though first few leaves may be simple, sparsely to densely hirsute, pinnae often linear 6
6 Leaves with more than 25 pinnae (on average) 7
6: Leaves with less than 25 pinnae (on average) 8
7. Terminal pinnae (1.5)3-8 mm long, lateral pinnae 0.5-5 mm long; anthopodium (2)6-21 mm long; sepal abaxial surface glabrous or with few hairs at base ..... 7. **B. filicifolia**
7: Terminal pinnae 1-3 mm long, lateral pinnae 0.5-1.5 mm long; anthopodium 1-6 mm long; sepal abaxial surface with a sparse indumentum ..... 9. **B. minutipinna**

8. Leaves sessile; pinnae linear-elliptic, margins flat or slightly recurved; plants glabrous or with a sparse simple/stellate indumentum 9

8: Leaves petiolate; pinnae linear-elliptic to elliptic, margins flat to revolute; plants glabrous or with a sparse to dense stellate indumentum 11

9. Branches obviously glandular; leaves trifoliolate (WA) ..... 5. **B. jucunda**

9: Branches not glandular; leaves with (3)5-7(9) pinnae (NT)

10. Plants decumbent, with a sparse to moderate simple indumentum (stellate hairs rare); margin slightly recurved ..... 3. **B. decumbens**

10: Plants erect, with a sparse stellate indumentum; margins flat ..... 4. **B. tolerans**

11. Sepals about the same size or slightly larger than petals, 3-5 mm long; anthopodium 7-24 mm long; plants with a sparse to moderate indumentum ..... 8. **B. kalumburuensis**

11: Sepals much larger than petals, (4)5-14 mm long; anthopodium 3-6(10) mm long; plants with a sparse to dense indumentum 12

12. Pinnae linear, abaxial surface of lamina not usually visible as margins strictly revolute; sepals (4)5-14 mm long, glabrous or with a sparse to dense indumentum (NT, E Kimberley E of Ord River) ..... 1. **B. lanuginosa**

12: Pinnae elliptic to lanceolate, abaxial surface of lamina visible; sepals 5-9 mm long, always with a dense indumentum (Kimberley, W of Ord River, NT in the Victoria River area) ..... 2. **B. wilsonii**

13. Plants glabrous apart from flowers; stems purple and quadrangular; leaves glaucous 14

13: Plants sparsely to densely hirsute; stems brownish and terete; leaves not glaucous 15

14. Horizontal shrub growing perpendicular from vertical rock faces; leaves petiolate; sepals and petals 2.5-3 mm long ..... **B. viridiflora** *

14: Erect shrub, preferring ridge tops; leaves sessile; sepals 6-10 mm long; petals 4-5 mm long ..... **B. quadrilata** *

15. Sepals more or less equal to petals; leaves sometimes trifoliolate when juvenile (Kimberley) ..... **B. pauciflora**

15: Sepals much larger than petals; leaves always simple (NT) 16

16. Hairs with prominent stalks, rays 0.5-1 mm long; fruits glabrous; plants usually less than 50 cm tall 17

16: Hairs without prominent stalks, rays to 0.5 mm long; fruits hirsute; plants usually greater than 50 cm tall 18

17. Hairs white and flexuous; new shoots pinkish to white; leaves narrowly elliptic; petal adaxial surface glabrous ..... **B. verecunda** *

17: Hairs yellow and straight; new shoots yellow; leaves elliptic; petal adaxial surface hirsute ..... **B. xanthastrum** *

18. Older stems with massive cork development; leaves with minute indumentum ..... **B. suberosa** *

18: Older stems without massive cork development; indumentum clearly visible 19

19. Plants sprawling, with a moderate indumentum (rarely dense on the abaxial leaf surface); sepals less than 7 mm long before fruit matures 20

19: Plants erect or sometimes spreading (then with a dense indumentum), with a moderate to dense indumentum; sepals greater than 7 mm long or, if less than then plant densely hirsute 22

20. Peduncles to 4 mm long ..... **B. laxa** group *
20: Peduncles greater than 4 mm long 21
21. Leaves lanceolate to ovate, most leaves much greater than 4 mm wide; rays of hairs not appressed ..... **B. prolixa** group *
21: Leaves narrowly elliptic, to 4 mm wide; rays of hairs appressed to leaves and stem ..... **B. amplectens** *
22. Plants grey in appearance with a very dense indumentum (leaf epidermis not visible) ..... **B. grandisepala** *
22: Plants with a moderate indumentum (leaf epidermis visible) 23
23. Petals 3.5 mm long ..... **B. laxa** group *
23: Petals 4-4.5 mm long (5-6 mm with fruit) ..... **B. grandisepala** *

+Taxon to be discussed fully in Duretto (submitted), a paper dealing with Queensland species of *Boronia* section *Valvatae*.

* Taxa discussed fully in Duretto & Ladiges (1997) and not dealt with further here.

Taxonomic descriptions

Boronia section *Valvatae* (Benth.) Engl.

Section *Valvatae* has recently been revised (see Duretto 1995, submitted; Duretto & Ladiges in prep.). To avoid confusion a short description is given here.

Inflorescence axillary. *Sepals* valvate, persistent with mature fruit. *Petals* valvate, tip not inflexed, persistent with mature fruit. *Stamens* 8, all fertile; anthers glabrous. *Seed* elliptic in outline, adaxial surface flattened.

1. Boronia lanuginosa Endl., *In*: Endl. *et al.*, Enum. Pl. Hügel, 16 (1837). *Type:* 'King George's Sound' [probably Gulf of Carpentaria, the Northern Territory], *Ferd Bauer* (*lecto* (here designated): W *n.v.* (photo PERTH 1610171)).

[*Boronia artemisioides* F. Muell., Hookers J. Bot. 9: 196 (1857), *nom. inval.*, provisional name only.]

Boronia artemisiifolia F. Muell., Fragm. 1: 66 (1859) (as *B. artemisifolia*). *Type citation*: In plagis arenosis et rupestribus terrae Arnhem's Land et sinus Carpentaria Gulf. *Type*: In montibus rapid. fluvibus flum. Fitzmarie River [Northern Territory], October 1855, *F. Muell.* (*syn:* K *n.v.* (cibachrome & slide MEL), MEL); Sea Range [Northern Territory], December 1855, *F. Mueller* (*syn:* K *n.v.* (cibachrome & slide MEL), MEL); McAdam Range [Northern Territory], October 1855, *F. Muell.* (*syn:* BM *n.v.* (slides DNA, MEL), MEL, TCD (slide MEL)).

Boronia affinis R. Br. ex Benth., Fl. Austral. 1: 311 (1863). *Type citation*: N. Australia, Islands of the Gulf of Carpentaria, & mainland opposite Groote Eylandt [Northen Territory], 1802-1805, *R. Brown. Type:* Islands [North and Vanderlin Islands, Sir Edward Pellew Group] of the Gulf of Carpentaria and mainland opposite Groote Island [Northern Territory]), December 1802-January 1803, *R. Brown* No. 5293 (*syn:* BM *n.v.* (slides DNA, MEL), CANB 278461, K *n.v.* (cibachrome & slide MEL), MEL, NSW).

Illustrations. P.G. Wilson, Aust. Pl. 8: 200 (1975); K. Brennan, Wildfl. Kakadu 14, Figure 9 (1986) as *Boronia* sp.; J. Brock, Top End Native Plants, 99 (1988); J. Brock, Native Plants N. Aust. 99 (1993).

Erect, much branched *shrub* to 150 cm high; ontogenetic sequence in indumentum density on the branches, leaves, inflorescence and abaxial surfaces of the perianth parts: juvenile plants with a sparse simple and/or stellate indumentum and mature plants with a dense stellate indumentum throughout (Figure 7A-H, J). *Multiangular stellate hairs* sessile, with 2-15 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, white to faintly yellow, to 1 mm long. *Simple hairs* reflexed, 0.5-1(-2) mm long (Figure 7B, E-H). *Branches* terete to quadrangular, not obviously glandular, decurrencies absent, hair distribution even, little or no cork development. *Leaves* opposite decussate, imparipinnate, 11-27 pinnae, not becoming unifoliolate with age, 6-80 mm long, 5-50 mm wide; lamina discolourous, slightly paler beneath, dorsiventral, palisade mesophyll usually tightly packed, not obviously glandular, non-secretory glands scattered in mesophyll (Figure 8), epicuticular waxes absent; margins entire, revolute; midribs of leaflets and rachis segments impressed adaxially, prominently raised abaxially, tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening (Figure 8); pinnae sessile, linear to narrowly elliptic, tip acute; terminal pinnae 5-26 mm long, 0.5-3 mm wide, midvein straight; lateral pinnae opposite or rarely subopposite, 4-26 mm long, 0.5-2 mm wide; rachis segments winged, triangular, distal end wider, 0.5-10 mm long, 1-1.5 mm wide; petiole not winged, 0.5-3 mm long; juvenile leaves larger than mature leaves, initially glabrous, becoming progressively more hirsute along stem. *Inflorescence* cymose, 1(3)-flowered; peduncle terete in cross section, absent to 1 mm long, non-woody and deciduous with flower; prophylls linear, minute to minutely unifoliolate, to 0.5 mm long, persistent; metaxyphylls absent or minute, persistent; anthopodium 4-10 mm long. *Flowers* white to deep pink. *Sepals* longer and wider than petals, ovate-deltoid, acute to acuminate, (4-5)7-14 mm long, 2-4 mm wide, enlarging to 8-15 mm long with fruit; adaxial surface densely and minutely pubescent sometimes becoming glabrous towards centre and base. *Petals* abaxial midrib not or slightly raised at base, 3-9 mm long, 1-2 mm wide, enlarging to 5.5-10 mm long and 1.5-2.5 wide with mature fruit; adaxial surface with a sparse to moderate simple or stellate indumentum, becoming glabrous towards base. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5-2 mm long, distal 0.5-1 mm prominently glandular; antepetalous filaments smooth, 1-1.5 mm long; anthers abaxial surface not or slightly frosty, antepetalous anthers much larger than antesepalous anthers, apiculum absent. *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style glabrous; stigma rounded, not or scarcely wider than style. *Cocci* with a moderate to dense simple and/or stellate indumentum, 4.5-6 mm long, 2-2.5 mm wide. *Seeds* elliptic in outline, adaxial side flattened and with prominent ridge, shiny, black, uniform in colour, 4-4.5 mm long, 2-2.5 mm wide, elaiosome (placental portion of endocarp) yellow-white; surface at magnification tuberculate to colliculate; tubercles and collicles, smooth, unfused, anticlinal walls ± visible, 6-55 μm across (Figure 9A,B). **Star Boronia, Engbajengbaja**

Specimens examined (selected from c. 200 collections). NORTHERN TERRITORY; DARWIN & GULF DISTRICT: Dhupuya Outstation road, 6 km N of Gove to Bulman River, Arnhem Land, 12°43'S, 135°32'E, 22 Sep. 1987, *M.J. Clark* 1363 (DNA); 18.4 km along Oenpelli-Gove track from Nabarlek turn off near Cooper Creek crossing, Arnhem Land, 12°12.32'S, 133°20.18'E, 13 June 1993, *M.F. Duretto* 410-7, *J. Chappill, G. Howell & K. Brennan* (MEL); Near Mt Brockman outlier on track to Radon Gorge, 12°44.68 S, 132°54.02 E, 15 June 1993, *M.F. Duretto* 441-4, *J. Chappill & G. Howell* (MEL); Mt Cahill, Kakadu National Park, SE of summit, 12°52.00'S, 132°42.27'E, 16 June 1993, *M.F. Duretto* 448-53, *J. Chappill & G. Howell* (MEL); Top of UDP Falls, Waterfall Creek, Kakadu National Park, 13°25.84'S, 132°25.03'E, 18 June 1993, *M.F. Duretto* 477-81 *& J. Chappill* (MEL); 42.4 km from Borroloola towards Wollogorang, 16°8.01'S, 136°36.70'E, 21 June 1993, *M.F. Duretto* 495-502 (MFD495-498, 501-502 - MEL; MFD499 - DNA, MEL; MFD500 - DNA, CANB, MEL); Fletcher Creek crossing, 43.8 km from Borroloola towards Wollogorang, 16°8.34'S, 136°37.32'E, 21 June 1993, *M.F. Duretto* 503-4A (MFD503 - MEL;

MFD504A - DNA, CANB, MEL); On track to Biddlecombe Cascades, Nitmiluk National Park, 14°15.60'S, 132°25.83'E, 28 June 1993, *M.F. Duretto* 522-4 & *G. Howell*, (MEL); Groote Eylandt, *F.R. Fosberg & R.C. Buckley* 62318, (BRI); 40 km W of Wollogorang, Calvert Hills road, 17°09'S, 137°41'E, 13 May 1974, *S. Jacobs* 1587 (CANB, NSW); Wessell Island, 11°13'S, 136°38E, 10 Oct. 1972, *P.K. Latz* 3462 (CANB, DNA, PERTH); *c.* 11 miles [17.6 km] SSW of Mt Gilruth, 13°11'S, 133°11'E, 28 Feb. 1973, *M. Lazarides* 7928 (CANB, DNA, MEL, NSW); 8 km E of Goyder River Crossing, 12°51'S, 135°05'E, *J.R. Maconochie* 1482 (DNA); 8 km NNE of Mt Evalyn, Kakadu National Park, 13°32'S, 132°56'E, 6 Apr. 1989, *Menkhorst* 337 (DNA, MEL); Murganella airstrip & surrounding vicinity, Murganella, Arnhem Land, 11°33'S, 132°55'E, 29 May 1988, *A.A. Muir* 5976 (AD, MEL); 8 km W of Roper Bar, 14°42'S, 134°27'E, 22 June 1977, *M.O. Parker* 908 (BRI, CANB, DNA, NSW); Groote Eylandt, 2 km SW of Umbakumba, 13°53'S, 136°48'E, *J. Russell-Smith* 2861 & *D. Lucas* (DNA); Nhulunbuy, Gove Peninsula, 12°10S, 136°46E, 21 Jan. 1988, *G.M. Wightman* 4283 (CANB, DNA).
VICTORIA RIVER DISTRICT: Victoria River, Gregory National Park, 15°28'S, 130°07'E, 7 Feb. 1986, *M. Clark* 436 & *G. Wightman* (DNA); 4 km W of Kodendong Valley, 14°39'S, 130°11'E, 13 May 1994, *I. Cowie* 4874 & *D.E. Albrecht* (DNA, MEL); 20 km S of Daly River Police Station (3 km S of Mt Boulder), 13°57'S, 130°42'E, 23 June 1985, *P.A. Fryxell, L.A. Craven & J. McD.Stewart* 4907 (CANB).
WESTERN AUSTRALIA; KIMBERLEY REGION: Limestone hills W of Weaber Range, *c.* 50 km N of Kununurra & *c.* 13 km NW of Point Springs, 8 Mar. 1978, *M. Lazarides* 8426 (CANB, DNA, PERTH).

Possible hybrids. Possible hybrids with *B. tolerans* are described under that species.

Distribution. Common and widespread throughout the "Top End" of the Northern Territory from Wollogorang to the Arnhem Land plateau and Cobourg Peninsula areas. Isolated collections have been made further west in the Macadam Range and Victoria River areas (NT) and the Weaber Range (WA). (Figure 1). *Boronia lanuginosa* has recently been collected from north-western Queensland (P.I. Forster pers. comm.).

Habitat. Found growing on sandstone and sands in open woodland and forest. Notes on the Weaber Range collection state that it was collected on limestone.

Phenology. Flowering material has been collected from January to September, and fruiting material from January to November.

Conservation status. Under no threat and found in a number of reserves though populations to the east and west are not protected.

Etymology. The specific epithet is derived from the Latin, *lanugo* - the down of plants, and refers to the dense indumentum on this species.

Typification. Endlicher (1837) cited only one specimen when describing *B. lanuginosa*: King George's Sound (Ferd. Bauer). A specimen matching this locality has been located at W by Wilson (1975). Despite the confusion surrounding the collection site (see earlier discussion, pp. 312, 314), this specimen is designated the lectotype.

Affinities. Mueller (1861: 179) thought that *B. artemisiifolia* (=*B. lanuginosa*) may be a form of *B. grandisepala*. Though closely related, these taxa are distinct, as Bentham (1863) concluded. *Boronia lanuginosa* is most closely related to *B. wilsonii* from which it can be distinguished by having narrower and longer leaflets, shorter anthopodia, and usually larger flowers.

Notes. Though *B. lanuginosa* is known from Western Australia (one collection), the Kimberley species referred to as *B. lanuginosa* by Green (1985), Hnatiuk (1990) and Wheeler (1992) is more than likely to be *B. wilsonii*.

White (1942), Hnatiuk (1990) and Henderson (1994) state that *B. lanuginosa* has been collected in the Cook district of Queensland. The collection cited by White, '*B. artemesiaefolia*: The Gorge, Mt Mulligan, *Dr. H. Flecker*, 2 Apr. 1934 (BRI)', and probably referred to by the others, is the first published record of an undescribed species that is sister to *B. alulata* (Duretto 1995, submitted; Duretto & Ladiges in prep.).

The Warnindilyakwa people of Groote Eylandt call *B. lanuginosa* Engbajengbaja, and use a preparation made from the leaves to treat headaches, body aches and pains, and chest colds (Levitt 1981).This is one of the few recorded uses of a member of section *Valvatae* by indigenous people.

2. Boronia wilsonii (F. Muell. ex Benth.) Duretto, *stat. nov.*

Boronia artemisiifolia var. *wilsonii* F. Muell. ex Benth., Fl. Austral. 1: 311 (1863) as *B. artemisiaefolia* var. *Wilsoni. Type:* Vansittart's Bay [Western Australia], 1819, *Alan Cunningham* 432, (*lecto* (here designated): PERTH 1610198; *isolecto:* BM *n.v.* (slides MEL, PERTH), K *n.v.* (cibachrome & slide MEL)). *Residual syntypes:* Victoria River, *Wilson* (*syn:* K *n.v.* (cibachrome & slide MEL), MEL); N.W. Coast, *Bynoe* (*syn*: K *n.v.* (cibachrome & slide MEL)).

Illustration. J.R. Wheeler, Fl. Kimb. 669, Figure 206 B1,B2 (1992) (as *B. lanuginosa*).

Erect, much branched *shrub* to 100 cm high; juvenile plants with a sparse simple and/or stellate-indumentum and mature plants with a dense stellate indumentum (Figure 7I). *Multiangular stellate hairs* sessile, with 4-12 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, white to faintly yellow, 0.05-0.1(0.25) mm long. *Simple hairs* reflexed, 0.5-2 mm long. *Branches* terete to quadrangular, not obviously glandular, decurrencies absent, hair distribution even, becoming glabrous with age, little or no cork development. *Leaves* opposite decussate, imparipinnate, 13-23 pinnae, not becoming unifoliolate with age, 17-34(61) mm long, 6-21 mm wide; lamina discolourous, paler beneath, dorsiventral, palisade mesophyll usually tightly packed (fresh material not available), not obviously glandular, non-secretory glands scattered in mesophyll, epicuticular waxes absent; margins entire, recurved to revolute; midribs of leaflets and rachis segments impressed adaxially, prominently raised abaxially, tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening; pinnae sessile to subsessile, narrowly elliptic to elliptic or lanceolate, tip acute; terminal pinnae, 3-23 mm long, 1-6 mm wide, midvein straight; lateral pinnae opposite or rarely subopposite, 1.5-12 mm long, 1-4 mm wide; rachis segments winged, triangular, distal end wider, 2-6 mm long, 1-2.5 mm wide; petiole not winged, 0.5-7 mm long; juvenile leaves larger than mature leaves, initially glabrous, becoming progressively more hirsute along stem. *Inflorescence* cymose, 1(3)-flowered; peduncle absent; prophylls 0.5-1(9) mm long, to 4 mm wide, persistent; metaxyphylls absent or minute, persistent; anthopodium 3-7 mm long. *Flowers* cream to pink. *Sepals* longer and wider than petals, ovate-deltoid, acuminate, 5-9 mm long, 2-3 mm wide, enlarging to 6-10 mm long and 3-4.5 mm wide with fruit; adaxial surface with a dense stellate and simple indumentum near margins becoming sparse simple towards centre and glabrous towards base; abaxial surface with a dense stellate indumentum. *Petals* midvein not or slightly raised at base abaxially, 4-5 mm long, 1.5-2.5 mm wide, enlarging to 5.5-6 mm long with mature fruit; adaxial surface with a sparse simple indumentum, becoming glabrous towards base; abaxial surface with a dense stellate indumentum. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective,

1.5-2 mm long, distal 0.5-1 mm prominently glandular; antepetalous filaments smooth, 1-1.5 mm long; anthers abaxial surface not or slightly frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum minute, glabrous. *Ovary* glabrous; style glabrous or rarely hirsute; stigma rounded, not or scarcely wider than style. *Cocci* with a moderate to dense simple and/or stellate indumentum, 4-5 mm long, 2-2.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black, uniform in colour, 3.5-4.5 mm long, 2-2.5 mm wide, elaiosome yellow-white; surface at magnification as with *B. lanuginosa* (see Figure 9A,B).

Specimens examined (selected from c. 50 collections). NORTHERN TERRITORY; VICTORIA RIVER DISTRICT: Victoria River area, 15°16'S, 129°35'E, 9 Mar. 1989, *G.J. Leach* 2399 & *C. Dunlop* (BRI, DNA). WESTERN AUSTRALIA; KIMBERLEY REGION: *c.* 50 km NE of Mitchell River Homestead, King Edward River, 14°47'S, 126°17'E, 23 Aug. 1978, *A.C. Beauglehole & E.G. Errey* B58912 E2612 (CANB, PERTH); Napier Broome Bay, West Governor Island, South Bay, 13°56'S, 126°41'E, 19 May 1984, *E.A. Chesterfield* 245 (CBG, DNA, MEL, NSW, PERTH); King Edward River, 14°54'S, 126°12'E, 1 Mar. 1980, *C.R. Dunlop* 5380 (DNA, PERTH); Napier Broome Bay, West Governor Island, South Bay, 13°57'S, 126°41'E, 19 May 1984, *S.J. Forbes* 2059 (MEL, NSW); Middle Springs, 18 km NW of Kununurra, 15°38'S, 128°40'E, 8 May 1985, *P.A. Fryxell & L.A. Craven* 4002 (AD, BRI, CANB, DNA, MEL, PERTH); Koolan Island, 16°07'S, 123°46'E, 2 June 1985, *P.A. Fryxell, L.A. Craven & J. McD. Stewart* 4600 (CANB, PERTH); Peninsula NE of Frederick Harbour at mouth of Hunter River [15°01'S, 125°23'E], 8 June 1985, *P.A. Fryxell, L.A. Craven & J. McD. Stewart* 4685 (PERTH); Base of Bougainville Peninsula, on E shore of Admiralty Gulf, 14°11'S, 126°10'E, 14 June 1985, *P.A. Fryxell, L.A. Craven & J. McD. Stewart* 4791 (DNA, CANB); Near junction of Drysdale River & Mogurnda Creek, Drysdale River National Park, 15°02'S, 126°55'E, 8 Aug. 1975, *A.S. George* 13548 (CANB, PERTH); Near Solea Falls, Drysdale River, Drysdale River National Park, 14°40'S, 127°E, 12 Aug. 1975, *A.S. George* 13745 (CANB, PERTH); Boiga Falls, Drysdale River National Park, 15°08'S, 127°06'E, 3 Aug. 1975, *K.F. Kenneally* 3025 (CANB, PERTH); *ibid*, 4 Aug. 1975, *K.F. Kenneally* 3075 (CANB, PERTH); Planigale Creek, Drysdale River National Park, 14°43'S, 126°54'E, 19 Aug. 1975, *K.F. Kenneally* 4455 (CANB, PERTH); Lachlan Island, Buccaneer Archipelago, 16°38'S, 123°29'E, 14 June 1982, *K.F. Kenneally* 8319 (CANB, PERTH); Steep Island of Raft Point at entrance to Doubtful Bay, 16°04'S, 124°28'E, 18 May 1988, *K.F. Kenneally* 9682 (CANB); Middle Springs, 18 km NW of Kununurra, 15°38'S, 128°40'E, 8 Mar. 1963, *M. Lazarides* 6799 (DNA, CANB, NSW, PERTH); Anjo Peninsula separating Napier Broome Bay & Vansittart Bay, *c.* 3.5 km SSW Sharp Point, 13°57'S, 126°31'E, 31 May 1984, *J.H. Willis s.n.* (BRI, CBG, MEL, NSW, PERTH); Kalumburu Mission, 14°17'S, 126°38'E, 7 Aug. 1970, *T.O. Wolfe & M. Martin* 227 (CANB).

Distribution. Restricted to the Kimberley Region and the adjacent islands, Western Australia, and from few collections from the lower Victoria River, the Northern Territory. Probably more widespread in the central Kimberley region than present collections suggest. (Figure 1)

Habitat. Found growing on sand, sandstone, quartzite and, rarely limestone.

Phenology. Flowering material has been collected from January to September, and fruiting material from March to September.

Conservation status. Common, widespread and under no immediate threat. Found in several reserves.

Etymology. This taxon was named in honour of Wilson who first sent specimens to Mueller.

Typification. Of the three specimens cited by Bentham (1863) when describing *B. artemisiifolia* var. *wilsonii*, the collection 'Vansittart's Bay, *Alan Cunningham* 432, 1819' housed at PERTH is in the best

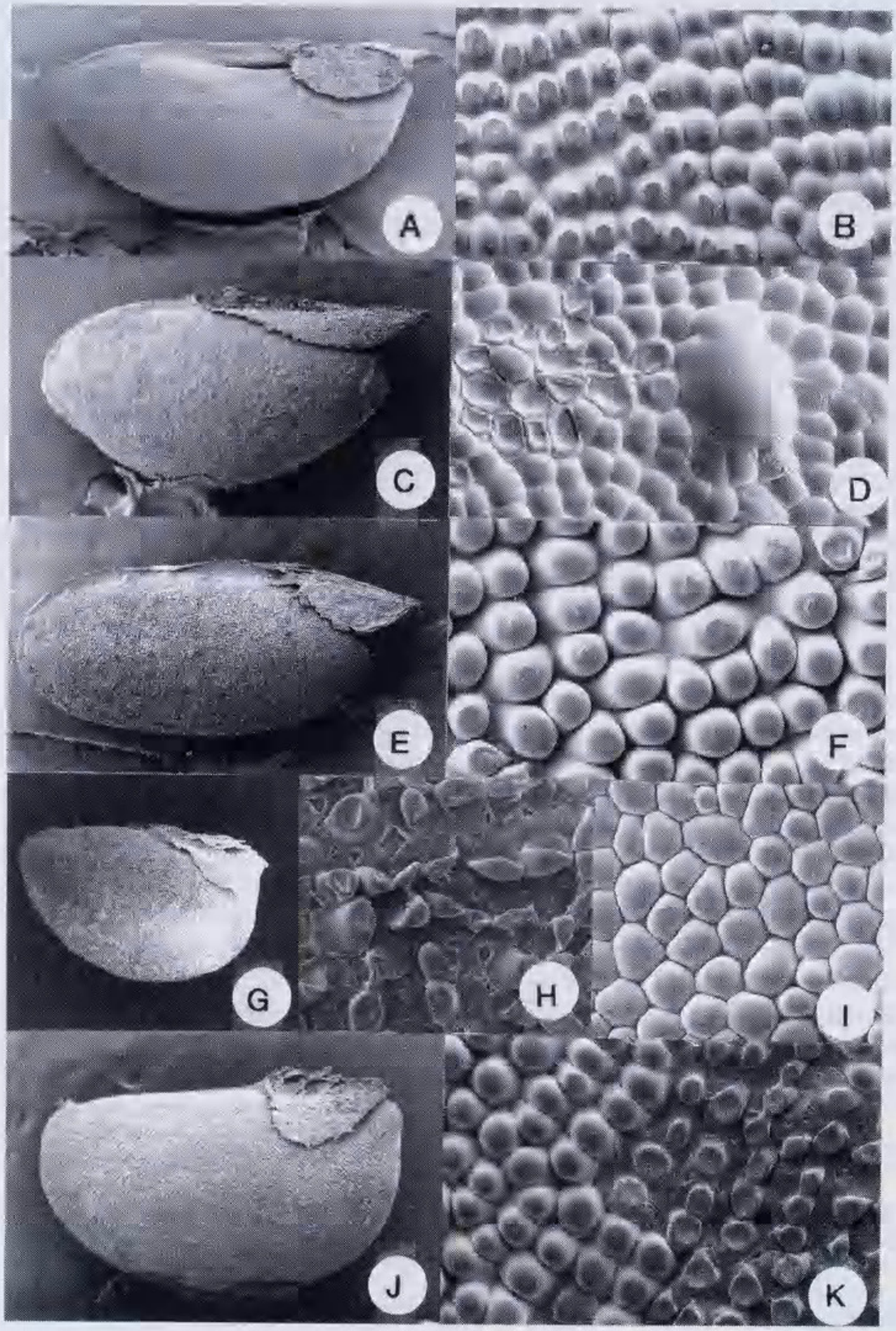

Figure 9. Scanning electron micrographs of seed surfaces. A,B - *B. lanuginosa* (*Chappill* 4783, MEL). C,D - *B. pauciflora* (*Symon* 7037, PERTH). E,F - *B. filicifolia* (*Fryxell* 4735 *et al.*, CANB). G-I - *B. rupicola* (G,H, *Craven* 6646, CANB; I, *Brennan* 2356, MEL). J,K - *B. lanceolata* (*Duretto* 446 *et al.*, MEL). Scales: x14 (A,C,E), x17 (G,J), x250 (B,D,H,I,K) and x300 (F).

condition and is chosen as the lectotype. It is of interest to note that Mueller annotated the K sheet of the Wilson collection from Victoria River as '*Boronia Wilsoni n. sp.*' suggesting that he thought it was distinct enough to warrant specific status. This collection is not chosen as the lectotype, though in good condition, as it is small and appears to be a plant with juvenile foliage.

Affinities. Closely related to *B. lanuginosa* from which it can be distinguished by the wider and usually shorter pinnae, longer anthopodia and usually smaller flowers.

Notes. Most collections from Drysdale River National Park (*George* 13548 [CANB 255846], *Kenneally* 3025, 3075, 4455) and a collection from Kalumburu (*Wolf & Martin* 227) are far less hirsute than other collections. These collections have what is presumed to be juvenile foliage. It is of note that George lodged two specimens of his number 13548 at CANB: the other, CANB 255847, has foliage with a dense indumentum like coastal plants adding some credence that *B. wilsonii* displays an ontogenetic sequence in indumentum density like *B. lanuginosa*.

The Western Australian species referred to as *B. lanuginosa* by Green (1985), Hnatiuk (1990) and Wheeler (1992) is probably *B. wilsonii*.

3. Boronia decumbens Duretto, *sp. nov.*

A *B. lanuginosa* Endl. habitu decumbenti, indumento sparso ad modicum, pilis stellatis paucis, et foliis sessilibus differt.

Typus: c. 70 km north-east of Pine Creek, El Sharana Rd, Northern Territory, 13°33'S, 132°18'E, 5 March 1985, *C. Dunlop* 6752 *& G. Wightman* (*holo:* CANB 363098; *iso:* DNA, MEL, NSW).

Decumbent, much branched *subshrub* to 10 cm high and 40 cm wide, regrowing from rootstock; with a sparse to moderate simple indumentum. *Multiangular stellate hairs* rare, sessile, with 2-6 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, white to faintly yellow, to 0.1 mm long. *Simple hairs* 0.5-2 mm long, reflexed (Figure 11A). *Branches* terete to slightly quadrangular, decurrencies absent, not obviously glandular (Figure 10B), hairs distributed evenly and becoming glabrous with age, little or no cork development. *Leaves* opposite decussate, imparipinnate, (3)5-7 pinnae, not becoming unifoliolate with age, sessile, 6-20 mm long, 8-25 mm wide; lamina discolourous, paler beneath, dorsiventral, palisade mesophyll usually tightly packed, not obviously glandular, scattered nonsecretory glands in mesophyll, epicuticular waxes absent; margins entire, flat to slightly recurved; midribs of leaflets and rachis segments sometimes impressed adaxially, not or slightly raised abaxially with tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening; pinnae sessile, opposite, linear to narrowly elliptic, tip acute, attenuate; midribs of leaflets and rachis segments not or slightly raised abaxially, not impressed adaxially; terminal pinnae 6-12 mm long, 0.5-1 mm wide, midvein straight, larger than preceding lateral pinnae; lateral pinnae 4-11 mm long, 0.5-1 mm wide; rachis segments winged, triangular, distal end wider, 2-8 mm long, 0.5-1 mm wide. *Inflorescence* 1-flowered; peduncle absent; prophylls linear, minute to minutely unifoliolate, 0.5-2 mm long, persistent; metaxyphylls minute to 1 mm long, persistent; anthopodium 1-4 mm long. *Flowers* white to pink (Figure 10C). *Sepals* longer and wider than petals, deltoid, acute, 4-6 mm long, 1.5-3 mm wide, enlarging to 5.5-8 mm long and 2-4 mm wide with fruit; adaxial surface with a moderate simple indumentum and becoming glabrous towards the base; abaxial surface with a sparse simple indumentum. *Petals* abaxial midrib not or slightly raised at base, 3-5 mm long, 1-2 mm wide, enlarging to 4-5.5 mm long with mature fruit; adaxial surface with a sparse to moderate simple indumentum,

becoming glabrous towards base; abaxial surface with a sparse to moderate simple indumentum. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5 mm long, distal 0.5-1 mm prominently glandular; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum minute or large and erect, glabrous (Figure 10D,E). *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style glabrous; stigma rounded, not or scarcely wider than style. *Cocci* with a sparse to moderate simple and stellate indumentum, 5-6 mm long, 2-2.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black, uniform in colour, 4.5-5 mm long, 2 mm wide, elaiosome yellow-white; surface at magnification as with *B. lanuginosa.* (see Figures 9A,B). (Figure 10A-E)

Other specimens examined. NORTHERN TERRITORY; DARWIN & GULF DISTRICT: Pine Creek-Oenpelli road, 4 miles [6.4 km] E of Mary River, 15 Aug. 1968, *N. Byrnes* 786 (AD, DNA, PERTH); 48 miles [77 km] NE of Pine Creek on El Sharana road, 6 Jan. 1972, *N. Byrnes* 2473 (BRI, CANB, DNA); *c.* 5 miles [8 km] E of Mary River on Oenpelli-Pine Creek road, 14 May 1968, *R.C. Carolin* 6774 (PERTH); Moline Rockhole area, Kakadu Highway, 13°35'S, 132°15'E, 19 Mar. 1987, *M.J. Clark* 835 (DNA); Kakadu Highway near Jabiru turnoff, 13°35'S, 132°15'E, 19 Mar. 1987, *M.J. Clark* 1090 (DNA); Kakadu National Park, 13°34'S, 132°17'E, 20 Nov. 1991, *C.R. Dunlop* 8896 *& C. Wilson* (DNA, MEL); N of Waterfall Creek turnoff on Pine Creek-Oenpelli road, Kakadu National Park, 13°33'S, 132°17'E, 18 June 1993, *M.F. Duretto* 473-5, *J. Chappill & G. Howell* (MFD473 - MEL; MFD474 - CANB, DNA, MEL; MFD475 - DNA, MEL); E of Pine Creek-Oenpelli road towards Waterfall Creek, Kakadu National Park, 13°32'S, 132°17'E, 18 June 1993, *M.F. Duretto* 482, *J. Chappill & G. Howell* (MEL); Mary River Ranger Station, 13°33'S, 132°16'E, 1 July 1993, *M.F. Duretto* 548B-550, *J. Chappill & G. Howell* (MFD548B-549 - DNA, CANB, MEL; MFD550 - MEL); 41 miles [66 km] from Pine Creek to UDP Falls, 13°35'S, 131°43'E, July 1973, *C.H. Gittens* 2682 (DNA, NSW); *c.* 35 miles [56 km] NNE of Pine Creek township, 13°34'S, 132°16'E, 13 Mar. 1965, *M. Lazarides & Adams* 211 (CANB, DNA, MELU, NSW); Kombolgie Creek, Fern Gully, Fern Creek, 13°34'S, 132°18'E, Apr. 1993, *G.J. Leach* 3407 (BRI, PERTH); Kakadu National Park, 3 km SW of Mary River Ranger Station, 13°24'S, 132°05'E, 17 Apr. 1990, *A.V. Slee & L.A. Craven* 2494 (AD, CANB).

Distribution. Endemic to Kakadu National Park, north of the Mary River in an area around the Mary River Ranger Station and the Waterfall Creek turnoff on the Pine Creek-Oenpelli Road, in the Northern Territory. (Figure 12)

Habitat. Grows on deep sand or sandstone in eucalypt open woodland. Tolerates annual fires and many plants consist of a large number of small stems growing from a robust rootstock.

Phenology. Flowering material has been collected from November to August and fruiting material from March to August.

Conservation Status. A conservation code of 2RC+ is appropriate. Surveys are required to ascertain the full extent of this species as all known populations are near roads.

Etymology. The epithet alludes to the characteristic decumbent habit of this species.

Affinities. Most closely related to *B. tolerans* and *B. jucunda* from which it can be distinguished by the decumbent habit and few (if any) stellate hairs. These features and the sessile leaves also distinguish this species from *B. lanuginosa.*

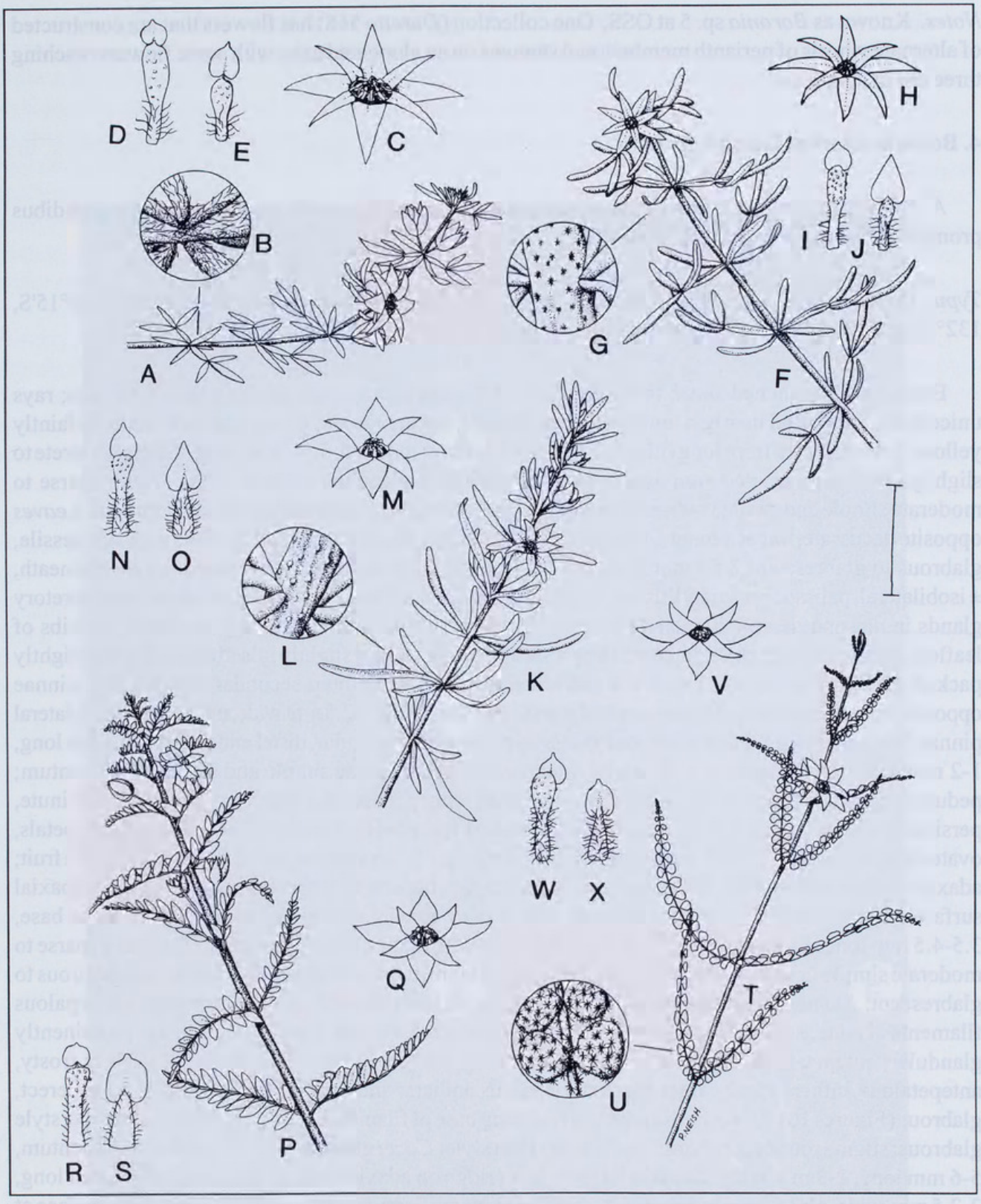

Figure 10. A-E - *B. decumbens* A - flowering branchlet; B - branchlet detail (A,B, holotype, *Dunlop* 6752, CANB); C - flower; D - abaxial view of antesepalous stamen; E - abaxial view of antepetalous stamen (C-E, *Duretto* 474, MEL). F-J - *B. tolerans* F - flowering branchlet; G - branchlet detail; H - flower; I - abaxial view of antesepalous stamen; J - abaxial view of antepetalous stamen (F-J, *holotype*, *Duretto* 516 *et al.*, MEL). K-O - *B. jucunda* K - flowering branchlet; L - branchlet detail (K,L, *holotype, Chesterfield* 214, MEL); M - flower; N - abaxial view of antesepalous stamen; O - abaxial view of antepetalous stamen (M-O, *Duretto* 509, MEL). P-S - *B. kalumburuensis* P, flowering branchlet; Q - flower; R - abaxial view of antesepalous stamen; S - abaxial view of antepetalous stamen (P-S, *holotype*, *Edwards* LAC9247, CANB). T-X - *B. minutipinna* T - flowering branchlet; U - leaf detail, adaxial surface; V - flower; W - abaxial view of antesepalous stamen; X - abaxial view of antepetalous stamen (T-X, *isotype, Cowie* 1911, MEL). Scale bars: 16 mm (A, F, K, P, T), 8 mm (C, H, M, Q, V) and 2 mm (D-E, I-J, N-O, R-S, W-X). This figure was prepared by Peter Neish for inclusion in "Flora of Australia" Vol. 26 (in prep.) and is reproduced here with the permission of the artist and ABRS.

Notes. Known as *Boronia* sp. 5 at OSS. One collection (*Duretto* 548) has flowers that are constructed of alternate whorls of perianth members and stamens on an elongated axis, with some flowers reaching three cm in length.

4. Boronia tolerans Duretto, *sp. nov.*

A *B. lanuginosa* Endl. indumento sparso et foliis sessilibus, a *B. jucunda* Duretto glandibus prominentibus in caulibus destitutis differt.

Typus: On track to and near Biddlecombe Cascades, Nitmiluk National Park, Northern Territory, 14°15'S, 132°26'E, 28 June 1993, *M.F. Duretto* 516, *J. Chappill & G. Howell* (*holo:* MEL; *iso:* DNA).

Erect, much branched *shrub* to 50 cm high. *Multiangular stellate hairs* sessile, 4-12 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, white to faintly yellow, 0.05-0.25(0.5) mm long (Figure 11B). *Simple hairs* reflexed, 0.5-1 mm long. *Branches* terete to slightly quadrangular, decurrencies absent, not obviously glandular (Figure 10G), with a sparse to moderate simple and stellate indumentum, hair distribution even, little or no cork development. *Leaves* opposite decussate, imparipinnate, with (1-3)5-7(9) pinnae, not becoming unifoliolate with age, sessile, glabrous to glabrescent, 7-50 mm long, 8-17 mm wide; lamina slightly discolourous, paler beneath, ± isobilateral, palisade mesophyll usually tightly packed, not obviously glandular, scattered nonsecretory glands in mesophyll, epicuticular waxes absent; margins entire, flat to slightly recurved; midribs of leaflets and rachis segments sometimes impressed adaxially, not or slightly raised abaxially with tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening; pinnae opposite, linear to narrowly elliptic; terminal pinnae, 8-25 mm long, 1-2.5 mm wide, midvein straight; lateral pinnae 5-16 mm long, 1-2 mm wide; rachis segments winged, triangular, distal end wider, 2-10 mm long, 1-2 mm wide. *Inflorescence* 1-flowered, glabrous or with a sparse simple and stellate indumentum; peduncle absent; prophylls linear, minute, to 0.5 mm long, persistent; metaxyphylls absent or minute, persistent; anthopodium 1-2 mm long. *Flowers* white (Figure 10H). *Sepals* longer and wider than petals, ovate-deltoid, acute, 4-5 mm long, 1.5 mm wide, enlarging to 5.5-6 mm long and 2-2.5 mm wide with fruit; adaxial surface with a moderate and minute indumentum, becoming glabrous towards the base; abaxial surface glabrous or with a sparse indumentum. *Petals* abaxial midrib not or slightly raised at base, 3.5-4.5 mm long, 1 mm wide, enlarging to 5 mm long with mature fruit; adaxial surface with a sparse to moderate simple or stellate indumentum, becoming glabrous towards base; abaxial surface glabrous to glabrescent. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5 mm long, distal 0.5 mm prominently glandular; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not or slightly frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum minute to large, erect, glabrous (Figures 10I-J). *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style glabrous; stigma rounded, not or scarcely wider than style. *Cocci* glabrous or with a sparse indumentum, 5-6 mm long, 2-3 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black, 4-4.5 mm long, 2-2.5 mm wide, elaiosome yellow-white; surface at magnification tuberculate to colliculate; surface at magnification as with *B. lanuginosa.* (see Figure 9A,B). (Figure 10F-J)

Other specimens examined. NORTHERN TERRITORY; DARWIN & GULF DISTRICT: On track to & near Biddlecombe Cascades, Nitmiluk National Park, 14°16'S, 132°26'E, 28 June 1993, *M.F. Duretto* 517-21, *J. Chappill & G. Howell* (MEL); Biddlecombe cascades, Katherine Gorge National Park, 16 June 1981, *S. King* (DNA); 3 km E of Biddlecombe cascades, Katherine Gorge National Park, 20 June 1981, *S. King* (DNA).

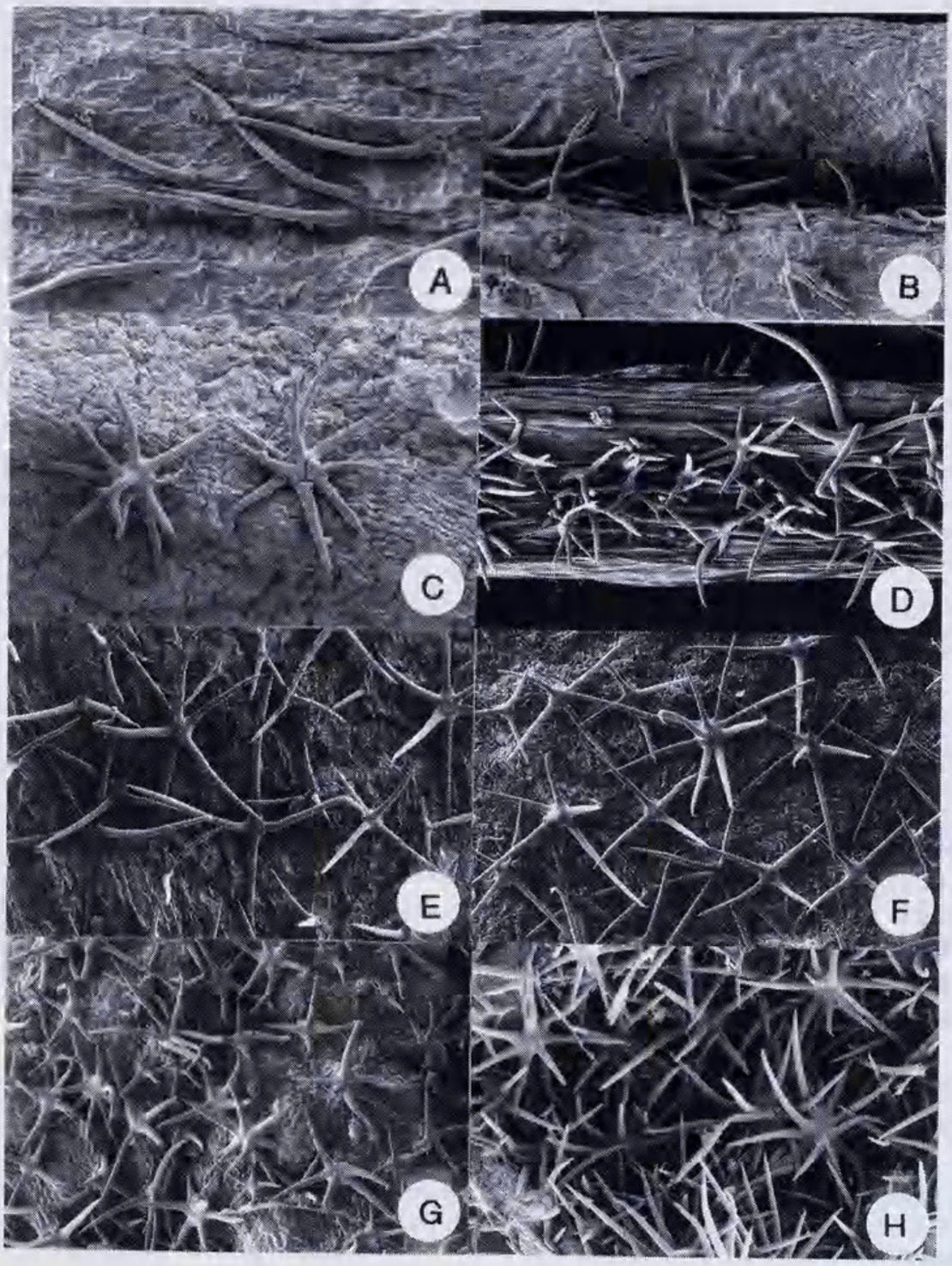

Figure 11. Scanning electron micrographs of hairs on adaxial (A,B, G) or abaxial (C, E,F, H) leaf surfaces, or stem (D). A - *B. decumbens* x55 (*Duretto* 473 *et al.*, MEL). B - *B. tolerans* x55 (*Duretto* 519 *et al.*, MEL). C - *B. jucunda* x130 (*Duretto* 509 *et al.*, MEL). D - *B. pauciflora* x80 (*Craven* 9212 *et al.*, CANB). E - *B. filicifolia* x55 (*Dunlop* 5262, CANB). F - *B. kalumburuensis* x55 (*Fryxell et al.* 4858, MEL). G,H - *B. minutipinna* G - x55, H - x80 (*Cowie* 1991, MEL).

Possible hybrid. Boronia tolerans x B. lanuginosa DARWIN & GULF DISTRICT: On track to & near Biddlecombe Cascades, Nitmiluk National Park, 14°16'S, 132°26'E, 28 June 1993, *M.F. Duretto* 525, 526, (MFD525 - DNA, MEL; MFD526 - MEL).

Distribution. Occurs in a restricted area near Biddlecombe Cascades, Nitmiluk National Park, the Northern Territory. (Figure 12)

Habitat. Found growing on deep sand in a eucalypt woodland on the plateau top.

Phenology. Flowering and fruiting material collected in June.

Conservation status. A code of 2VC+ is appropriate as this species is only known, with certainty, from one small population near a walking track. This population is isolated from, but near, a hybrid swarm between *B. tolerans* and *B. lanuginosa*. *Boronia tolerans* could be in danger of genetic swamping by hybridization and introgression (see Rhymer & Simberloff 1996).

Etymology. The name is derived from the Latin, *tolerans* - tolerant, and is named in recognition of the great mental hardship suffered by Dr Greg Howell on the day this species was collected in the field.

Affinities. Closely related to *B. jucunda* from which it can be distinguished by having up to seven pinnae per leaf, and the smooth stems. Distinguished from *B. lanuginosa* by the sessile, isobilateral leaves with few hairs, and the smaller flowers.

Notes. One of two species in the *B. lanuginosa* species group that have isobilateral leaves, the other being *B. jucunda*.

Possible hybrids between *Boronia tolerans* and *B. lanuginosa* were observed near Biddlecombe Cascades in Nitmiluk National Park. Plants of *B. lanuginosa* (*Duretto* 522-4) and *B. tolerans* (*Duretto* 517-21) were growing beside sandstone outcrops and on nearby sandy flats respectively. Six putative hybrids (*Duretto* 525, 536) were growing in an intermediate habitat of sand with a large number of rocks and had flowers that were variously larger and hairier than those of *B. tolerans,* but smaller than those of *B. lanuginosa.* Flower and leaf morphology is variable in these plants as might be expected in a hybrid population. The leaves of one of the hybrids are dorsiventral with prominently raised abaxial midribs, which is similar to the leaf anatomy of *B. lanuginosa.* (Figure 8)

5. Boronia jucunda Duretto, *sp. nov.*

A *B. lanuginosa* Endl. indumento sparso et foliis sessilibus, isobilateralibus, a *B. tolerans* Duretto caulibus glandulosis manifeste differt.

Typus: Mabel Downs, Winnama Gorge, Kimberley Region, Western Australia, 17°11'S, 128°15'E, 14 May 1984, *E.A. Chesterfield* 214 (*holo*: MEL 1534494; *iso*: CBG 8503155, DNA 56026, NSW 166827, PERTH 1622609).

Illustration. J.R. Wheeler, Fl. Kimb. 669, Figure 206 D1-3 (1992) as *Boronia* sp. A.

Erect, much branched *shrub* to 50 cm high. *Multiangular stellate hairs* sessile, 4-12 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, 0.05-0.1 mm long

(Figure 11C). *Simple hairs* reflexed, 0.5-1 mm long. *Branches* slightly quadrangular, decurrencies absent, glandular (Figure 10L), with a sparse to moderate simple and stellate indumentum, hair distribution even, little or no cork development. *Leaves* opposite decussate, trifoliolate, not becoming unifoliolate with age, sessile, glabrous to glabrescent; pinnae discolourous, paler beneath, ± isobilateral, not obviously glandular, scattered nonsecretory glands in mesophyll, palisade mesophyll usually tightly packed, epicuticular waxes absent, linear to narrowly elliptic; margins entire, flat to slightly recurved; midribs of leaflets and rachis segments not or slightly raised abaxially with tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening, sometimes impressed adaxially; terminal pinnae, 8-42 mm long, 1-3 mm wide, midvein straight; lateral pinnae 6-23 mm long, 1-2 mm wide. *Inflorescence* 1-flowered, glabrous or with a sparse simple and stellate indumentum; peduncle absent to 0.5 mm long, not woody, deciduous with flower; prophylls linear, minute, to 0.5 mm long, persistent; metaxyphylls absent or minute, persistent; anthopodium 0.5-3 mm long. *Flowers* white (Figure 10M). *Sepals* longer and wider than petals, ovate-deltoid, acute, 4-5 mm long, 1.5-2.5 mm wide, enlarging to 5.5-6 mm long and 2-2.5 mm wide with fruit; adaxial surface with a moderate stellate indumentum, becoming glabrous towards the base; abaxial surface glabrous or with a sparse indumentum. *Petals* abaxial midrib not or slightly raised at base, 3.5-4 mm long, 1 mm wide, not enlarging significantly with mature fruit; adaxial surface with a moderate simple or stellate indumentum, becoming glabrous towards base; abaxial surface glabrous or with a sparse simple and stellate indumentum. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5-2 mm long, distal 0.5-1 mm prominently glandular; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum minute to large, erect, glabrous (Figure 10N,O). *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style hirsute at base or for full length; stigma rounded, not or scarcely wider than style. *Cocci* with a sparse indumentum, 5.5-6 mm long, 3-3.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black, usually uniform in colour, rarely mottled, 4.5-5 mm long, 2-3 mm wide, elaiosome yellow-white; surface at magnification tuberculate to colliculate; surface at magnification as with *B. lanuginosa.* (see Figure 9A,B). (Figure 10K-O)

Other specimens examined. WESTERN AUSTRALIA, KIMBERLEY REGION: Escarpment edge, Winnama Gorge, 17°11'S, 128°15'E, 25 June 1993, *M.F. Duretto* 505-9 & *G. Howell* (MFD505 - DNA, MEL, PERTH; MFD506 - MEL; MFD507 & MFD509 - CANB, DNA, MEL, NSW, PERTH; MFD508 - DNA, MEL); Winnama Spring *c.* 17.5 km S of Turkey Creek, 17°11'S, 128°15'E, 15 May 1984, *J.H. Willis* (CBG, MEL, PERTH).

Distribution. Known only from the plateau top near Winnama Gorge, south-east Kimberley Region, Western Australia. (Figure 12)

Habitat. Found in open eucalypt woodland with a heathy/spinifex understorey on quartzite. The population is extensive and plants favour rockier areas away from grass especially along the gorge lip, but not on the gorge slope.

Phenology. Flowering material and fruiting material have been collected in May and June.

Conservation status. Known from a single large population. Winnama Gorge is used for recreation but disturbance is concentrated on the gorge bottom and the species is under no immediate threat. A conservation code of 2R is appropriate. Listed as a Priority 1 category on the Priority Flora List of the Department of Conservation and Land Management of Western Australia.

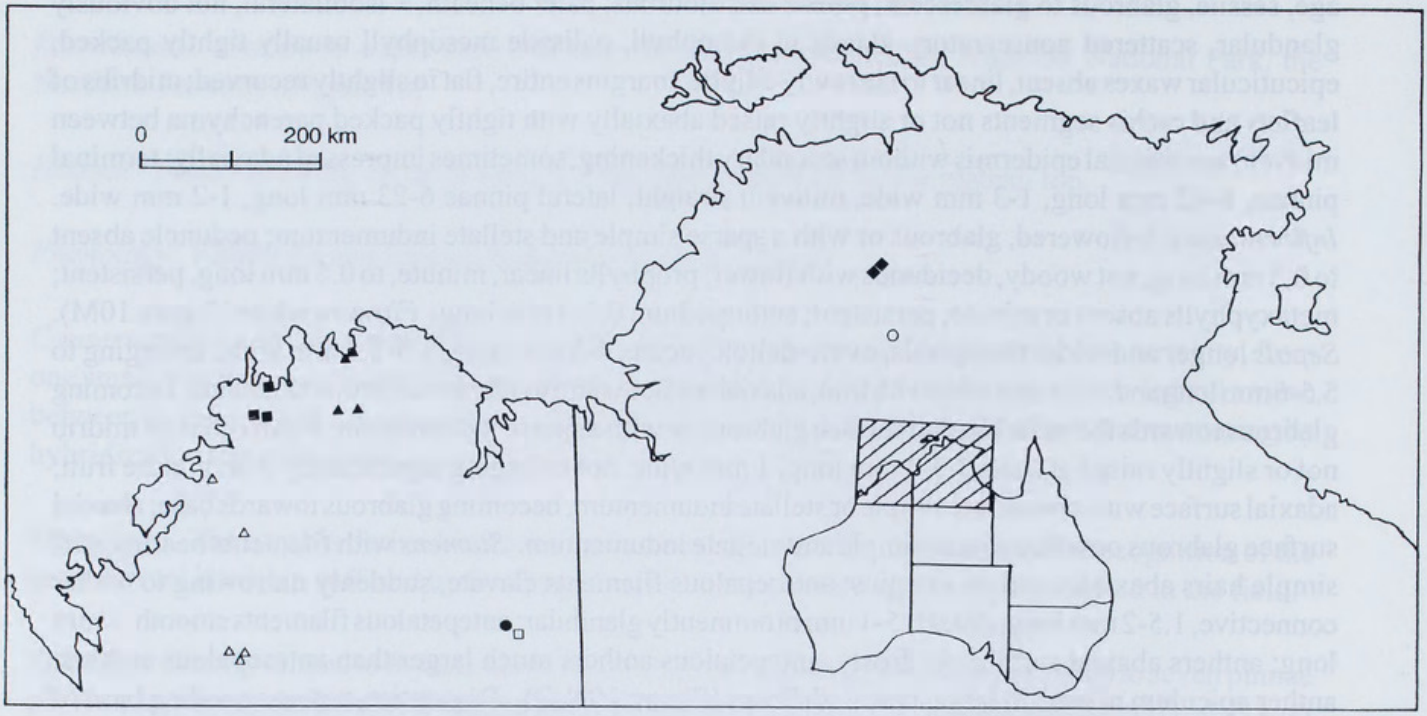

Figure 12. North-western Australia. Distribution of *B. decumbens* (◆); *B. jucunda* (●), *B. filicifolia* (■), *B. kalumburuensis* (▲); *B. minutipinna* (□), *B. pauciflora* (△) and *B. tolerans* (○).

Etymology. The epithet is derived from the Latin, *jucundus* - pleasing, and alludes to the pleasant smell of the leaves when crushed, unlike the leaves of most other members of section *Valvatae*.

Affinities. Closely related to *B. tolerans,* both species being unusual in having isobilateral leaves, but can be distinguished from *B. tolerans* by its trifoliolate leaves and prominently glandular stems. These features, plus its glabrescence, also distinguish this species from *B. lanuginosa, B. wilsonii,* and *B. decumbens.*

Notes. Called *B. ? pauciflora* in Forbes & Kenneally (1986) and Woirnarski (1992), and *B.* sp. A in Wheeler (1992).

6. Boronia pauciflora W. Fitzg., J. Proc. Roy. Soc. W. Austral. 3: 158 (1918). *Type:* Mount Broome, 1000 feet above the base, Western Australia, 17°21'S, 125°23'E, May 1905, *W.V. Fitzgerald* 825 (*lecto* (here designated): PERTH 1099701; *isolecto:* K *n.v.* (slide MEL, PERTH), NSW).

Illustration. J.R. Wheeler, Fl. Kimb. 669, Figure 206 C (1992).

Erect, much branched *shrub* to 60 cm high; glabrescent or with a sparse stellate indumentum throughout. *Multiangular stellate hairs* sessile, with 2-8 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, 0.1-0.2 mm long (Figure 11D). *Branches* quadrangular, decurrencies present, slightly glandular, with a sparse or rarely moderate stellate indumentum, hairs between decurrencies, becoming glabrous with age, little or no cork development.

Leaves opposite decussate, usually simple, juvenile leaves trifoliolate for few nodes; lamina of simple leaves and pinnae elliptic to lanceolate, tip acute, attenuate, discolourous, paler beneath, dorsiventral (fresh material not available), not obviously glandular, scattered nonsecretory glands in mesophyll, glabrescent with few scattered stellate and simple hairs, mainly on midrib, epicuticular waxes absent, trifoliolate leaves sessile, simple leaves petiolate, pinnae petiolate; margins entire, flat; midrib slightly impressed adaxially, raised abaxially, tightly packed parenchyma between midvein and abaxial epidermis with or without secondary thickening; simple leaves and terminal pinnae longer than lateral pinnae, midvein straight, 12-80 mm long, 2-12 mm wide; lateral pinnae 7-13 mm long, 2-4 mm wide; petiole not winged, 0.5-7 mm long; petiolule 1-2 mm long. *Inflorescence* cymose, 1(3)-flowered, glabrous or with a sparse stellate indumentum; peduncle absent; prophylls minute-minutely unifoliolate, to 1 mm long; metaxyphylls absent to 0.5 mm long; anthopodium 4-22 mm long. *Flowers* white to pink. *Sepals c.* same size as petals, ovate-deltoid, acute to acuminate, 2.5-4.5 mm long, 1-2 mm wide, enlarging to 4.5-5 mm long with fruit; adaxial surface with a sparse simple indumentum becoming glabrous towards base; abaxial surface glabrous to glabrescent. *Petals* midvein not raised abaxially, 2-4.5 mm long, 1-1.5 mm wide, scarcely enlarging with mature fruit; adaxial surface with a sparse to moderate stellate indumentum, becoming glabrous towards base; abaxial surface with a sparse stellate indumentum. *Stamens* with filaments bearing stiff simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 2 mm long, distal 1-1.5 mm prominently glandular; antepetalous filaments smooth, 1.5 mm long; anthers abaxial surface not or slightly frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum absent. *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style hirsute for full length; stigma rounded, not or scarcely wider than style. *Cocci* glabrous, 5-6 mm long, 2-2.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black but mottled, 4-4.5 mm long, 2-2.5 mm wide, elaiosome yellow-white; surface at magnification colliculate; collicules smooth, unfused or fused into amorphous units, somtimes collapsed, anticlinal walls ± visible, 10-55 µm across (Figure 9C,D).

Other specimens examined. WESTERN AUSTRALIA; KIMBERLEY REGION: Bold Bluff, King Leopold Ranges, 17°16'S, 125°15'E, 25 May 1971, *N. Byrnes* 2260 (CANB, DNA, PERTH); *c.* 10 km NE of Prince Regent River mouth, 15°26'S, 125°10'E, 27 May 1993, *L.A. Craven* 9212, *J. McD. Stewart & C.L. Brubaker* (CANB, DNA, E, L, MEL, PERTH); Foot of Bold Bluff, July 1967, *C.H. Gittens* 1443 (NSW); Leopold Range, towards base of Bold Bluff, 17°17'S, 125°25'E, 26 May 1971, *D.E. Symon* 7037 (MEL, PERTH); Edkins Range, *c.* 132 km from Mount Elizabeth homestead along the Walcott Inlet track, 16°02'S, 125°28'E, 1 May 1992, *I.R. Telford* 11627 (PERTH).

Distribution. Known from a few collections from the King Leopold Ranges, and two recent collections from the Edkins Range and Prince Regent River areas to the north, western Kimberley Region, Western Australia. (Figure 12)

Habitat. Found in rocky (sandstones and quartzites) areas with spinifex. The specimens collected from the Prince Regent River (*Craven* 9212 *et al.*) were part of regrowth after a spinifex fire the year before (collector's notes). It is of note that all plants were seedlings rather than older plants regrowing from a rootstock.

Phenology. Flowering and fruiting material has been collected between May and July.

Conservation status. Briggs & Leigh (1996) give *B. pauciflora* a conservation code of 3K, which is probably appropriate. Listed as a Priority 3 category on the Priority Flora List of the Department of Conservation and Land Management of Western Australia. Further surveys are required to ascertain the sizes of the three known populations and to determine the taxonomic status of the Prince Regent River population.

Etymology. The epithet is derived from the Latin, *paucus* - few and *flora* - flower, and presumably alludes to the few flowers found on the type material.

Typification. Fitzgerald (1918) cited only one of his own collections when describing *B. pauciflora*. The majority of Fitzgerald's collections are now lodged at BM, E, NSW and PERTH (Short 1990, 1993), and a large portion of his Kimberley material was received by PERTH via the Western Australian Museum (Kenneally 1986). Specimens matching the collection cited by Fitzgerald (1918) have been located at PERTH, K and NSW. As the PERTH specimen is in better condition than the other two seen, and it is unlikely that a better specimen exists elsewhere, it is chosen here as the lectotype.

Affinities. Fitzgerald (1918) thought *B. pauciflora* to be closely related to *B. grandisepala*, probably because both are simple-leaved. Weston *et al.* (1984) also suggested affinities between these two species when they combined them when scoring for their cladistic analysis of *Boronia* and *Boronella* Baill. A more detailed cladistic analysis of *Boronia* section *Valvatae* places this species sister to the *B. filicifolia* species group on a number of leaf, flower and seed characters (Duretto 1995; Duretto & Ladiges in prep.).

Notes. The Prince Regent River material (*Craven* 9212 *et al.*) differs from the King Leopold (type locality) and Edkins Ranges material in having a greater hair density on the branches, longer anthopodia (on average), less acuminate sepals, and less hirsute staminal filaments. Some of the Prince Regent River material has trifoliolate leaves, i.e. specimens lodged at A, CANB and MEL. The trifoliolate leaves are difficult to discern as the leaves are sessile, and the lateral pinnae are much smaller than the terminal pinnae. This variation, along with the disjunct distribution, could be used to support an argument for taxonomic recognition of the northern Prince Regent River population. It would be premature to do so, as the *Craven* 9212 collection from the Prince Regent River area consists of seedlings or young plants. That is, the variation seen may represent an ontogenetic developmental sequence and the plants may be displaying some juvenile features. It is suggested that the population be monitored and sampled over a period of years to determine whether or not the variation is genetic or ontogenetic.

The taxon referred to as *B. ? pauciflora* by Forbes & Kenneally (1986) and Woirnarski (1992) is *B. jucunda* (see above).

7. Boronia filicifolia A. Cunn. ex Benth., Fl. Austral. 1: 311 (1863). *Type:* Montague and York Sounds, N.W. Australia [Western Australia], 1820, *A. Cunningham* 220, third voyage of the "Mermaid" (*lecto* (here designated): K *n.v.* (cibachrome & slide MEL); *isolecto*: BM *n.v.* (slides MEL, PERTH)).

Illustration. J.R. Wheeler, Fl. Kimb. 669, Figure 206 A1, A2 (1992).

Erect, much branched *shrub* to 50 cm high; with a sparse to moderate stellate indumentum. *Multiangular stellate hairs* sessile, with 2-10 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, to 0.25 mm long (Figure 11E). *Branches* quadrangular becoming terete with age, not obviously glandular, decurrencies absent, hairs distributed evenly, becoming glabrous with age, little or no cork development. *Leaves* opposite decussate to subopposite, imparipinnate, (5)15-55 pinnae, not becoming unifoliolate with age, pinnae number gradually increasing along axillary branches, sessile or petiolate, (7-11)30-75 mm long, (3)6-12 mm wide; lamina discolourous, paler beneath, dorsiventral (fresh material not available), not obviously glandular, non-secretory glands scattered in mesophyll, epicuticular waxes absent; margin entire, flat to recurved; midribs of leaflets and rachis segments usually impressed adaxially, raised abaxially, tightly packed parenchyma between midvein and

abaxial epidermis without secondary thickening; pinnae acute, ± petiolate, petiolule 0-1 mm long; terminal pinnae lanceolate, longer than laterals, midvein straight, (1.5)3-8 mm long, 1-5 mm wide; lateral pinnae elliptic to rhombic, sometimes overlapping, opposite or rarely subopposite, 0.5-5(7) mm long, 0.5-3 mm wide; rachis segments winged, triangular, distal end wider, (0.5)2-7 mm long, 0.5-1 mm wide; petiole not winged, 0-2 mm long. *Inflorescence* cymose, 1(3)-flowered; peduncle absent; prophylls minute, persistent; metaxyphylls absent or minute, persistent; anthopodium glabrous or with sparse to moderate stellate indumentum, (2)6-22 mm long. *Flowers* white to pink. *Sepals c.* equal in size to petals, ovate-deltoid, acute, 2-3.5 mm long, 1.5-2 mm wide, not enlarging significantly with fruit; adaxial surface with a moderate stellate indumentum; abaxial surface glabrous or with a sparse stellate indumentum. *Petals* abaxial midrib not or slightly raised at base, 2.5-3.5 mm long, 1-1.5 mm wide, enlarging to 4 mm long with mature fruit; adaxial surface with a dense stellate indumentum, becoming glabrous towards base; abaxial surface glabrous or with a sparse stellate indumentum. *Stamens* with filaments bearing stiff bifid and some simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5 mm long, distal 0.5 mm prominently glandular, most glands bearing a minute stellate hair; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not or slightly frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum absent or present, minute or large and erect, glabrous or bearing few simple erect hairs. *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style hirsute for full length; stigma rounded, not or scarcely wider than style. *Cocci* glabrous to glabrescent, 5 mm long, 2-2.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black but mottled, 4 mm long, 2 mm wide, elaiosome yellow-white; surface at magnification tuberculate; tubercles smooth, unfused, anticlinal walls ± visible 6-55 µm across (Figure 9 E,F).

Other specimens examined. WESTERN AUSTRALIA; KIMBERLEY REGION: 6 km W of Mitchell River Falls, 14°49'S, 125°38'E, 29 Apr. 1993, *I. Cowie* 4346 *& C. Brubaker* (CANB, PERTH); Mitchell River, 14°50'S, 125°42'E, 22 Feb. 1980, *C.R. Dunlop* 5262 (CANB, DNA, NSW, PERTH); Along Mitchell River S of Mitchell Plateau, 14°47.57'S, 125°44'E, 10 June 1985, *P.A. Fryxell, L.A. Craven & J. McDStewert* 4735 (CANB, MEL, PERTH); Mitchell River Falls, Mitchell Plateau, 14°49'S, 125°41'E, 17 June 1976, *K.F. Kenneally* 5011 (PERTH); E side of Mindjau Creek, Port Warrender, Admiralty Gulf, 14°40'S, 125°56'E, 16 Jan. 1982, *K.F. Kenneally* 7763 (CANB, PERTH); *ibid,* 22 Jan. 1982, *K.F. Kenneally* 7903 (CANB, PERTH); Porosus Creek above confluence of fresh and salt water, Hunter River, 14°57'S, 125°24'E, 2 June 1992, *K.F. Kenneally* 11191 (PERTH); 300 m upstream of junction of tidal and fresh water interface, 14°59'S, 125°29'E, 10 Apr. 1992, *A.A. Mitchell & T. Willing* 2418 (PERTH).

Distribution. Occurs in the catchment area of the Mitchell River, and in the Port Warrender area, northern Kimberley Region, Western Australia. (Figure 12)

Habitat. Found in heath and open woodland on sandstones and quartzites.

Phenology. Flowering material has been collected from January to June, and fruiting material in June and July.

Conservation status. Briggs & Leigh (1996) gave this species a code of 3K, but a code of 2R is more appropriate. Listed as a Priority 2 category on the Priority Flora List of the Department of Conservation and Land Management of Western Australia.

Etymology. The specific epithet refers to the fern-like foliage of this species.

Typification. Bentham (1863) cited only one Cunningham collection when describing *B. filicifolia*: 'N. Australia. York and Montague Sounds, N.W. Coast.' A Cunningham collection was located at K, 'Montague and York Sound N. W. Australia, *A. Cunningham* 220, Sept. 1820', and another at BM, 'Shores of Montague and York Sounds, *A. Cunningham* 220, 1820'. These can be assumed to be duplicates and the K sheet, being superior, is chosen as the lectotype.

Affinities. Boronia filicifolia can be distinguished from *B. kalumburuensis* by the more numerous pinnae and by the glabrous to glabrescent cocci; and *from B. minutipinna* by the larger and more numerous pinnae, longer anthopodia and fewer hairs on the abaxial leaf surface.

Notes. In addition to the Mitchell River (type) and Kalumburu (*B. kalumburuensis*) variants of *B. filicifolia*, Wheeler (1992) noted a variant from Port Warrender in which the sepals were smaller than the petals. The Port Warrender collection (*Kenneally* 7763) does have smaller sepals (2-2.5 mm) than petals (2.5-3 mm), and also has much narrower pinnae than typical *B. filicifolia*. With more material and research the Port Warrender variant may prove to be distinct.

8. Boronia kalumburuensis Duretto, *sp. nov.*

A *B. filicifolia* A. Cunn. foliis pinnis paucis (15-27), sepalis largioribus (3.5-5 mm longis) et coccis hirsutis differt.

Typus: Outcropping sandstone immediately north of Kalumburu airstrip, Western Australia, 14°17'S, 126°37'E, 22 May 1993, *E.D. Edwards* LAC9247 (*holo*: CANB463023; *iso*: DNA, MEL234516, PERTH).

Erect, much branched *shrub* to 50 cm high; with a sparse to moderate stellate indumentum. *Multiangular stellate hairs* sessile, with 4-10 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, to 0.5 mm long (Figure 11F). *Branches* slightly quadrangular becoming terete with age, decurrencies absent, hairs distributed evenly, becoming glabrous with age, not obviously glandular, little or no cork development. *Leaves* opposite decussate, imparipinnate with 15-27 pinnae, not becoming unifoliolate with age, 8-40 mm long, 4-14 mm wide; lamina discolourous, paler beneath, dorsiventral (fresh material not available), not obviously glandular, non-secretory glands scattered in mesophyll, epicuticular waxes absent; margins entire, flat to recurved; midribs of leaflets and rachis segments usually impressed adaxially, raised abaxially with tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening; pinnae acute, subsessile; terminal pinnae lanceolate, longer than laterals, midvein straight, 3-11 mm long, 1-3 mm wide; lateral pinnae opposite or rarely subopposite, elliptic, 1-9 mm long, 0.5-2.5 mm wide; rachis segments winged, triangular, distal end wider, 0.5-1.5 mm long, 0.5-1.5 mm wide; petiole not winged, 1-2 mm long; juvenile leaves larger than mature leaves, initially glabrous, becoming progressively more hirsute along stem. *Inflorescence* cymose, 1(-3)-flowered; peduncle absent; prophylls to 1 mm long, persistent; metaxyphylls absent or minute, persistent; anthopodium with a sparse to dense stellate indumentum, 7-24 mm long. *Flowers* white to pink (Figure 10Q). *Sepals* longer and wider than petals, ovate-deltoid, acute to acuminate, 3.5-5 mm long, 1.5-2.5 mm wide, enlarging to 5-6 mm long with fruit; adaxial surface with moderate stellate indumentum, sometimes along margins only; abaxial surface with a sparse stellate indumentum. *Petals* abaxial midrib not or slightly raised at base, 2.5-4 mm long, 1-2 mm wide, not enlarging significantly with mature fruit; adaxial surface with a sparse simple and stellate indumentum, becoming glabrous towards base; abaxial surface glabrous or with a sparse stellate indumentum. *Stamens* with filaments bearing stiff stellate and some simple hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5 mm long, distal 0.5-1 mm prominently glandular; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not frosty, antepetalous anthers much larger than

antesepalous anthers; anther apiculum absent or present, minute or large and erect, sometimes with few stiff simple hairs (Figures 10R-S). *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style hirsute at base or for full length; stigma rounded, not or scarcely wider than style. *Cocci* glabrescent or with a sparse stellate indumentum, 5-5.5 mm long, 2-2.5 mm wide. *Seeds* with prominent ridge on adaxial side, shiny, black but mottled, 4.5 mm long, 2.5 mm wide, elaiosome yellow-white; surface at magnification as with *B. filicifolia.* (see Figure 9E,F). (Figure 10P-S)

Other specimens examined. WESTERN AUSTRALIA; KIMBERLEY REGION: 3.6 km by road N of Kalumburu on road to Pago Mission, 14°16'S, 126°37'E, 1 May 1985, *T.E.H. Aplin* 867, *R.J. Cranfield & J.R. Wheeler* (PERTH); 2 km N of Kalumburu, 14°16'S, 126°37'E, 25 May 1993 *I. Cowie & Brubaker,* (CANB, PERTH); Sandstone outcrop adjacent to river, 14°50'S, 126°30'E, 24 July 1984, *S.J. Forbes* 2722 (MEL); *c.* 10 km N of Kalumburu Mission, 14°11'S, 126°40'E, 14 May 1983, *P.A. Fryxell & L.A. Craven* 4131 (CANB, DNA, MEL, PERTH); Theda Station near Homestead on banks of Morgan River, 14°49'S, 126°43'E, 18 June 1985, *P.A. Fryxell, L.A. Craven & J. McDStewert* 4858 (CANB, MEL, PERTH); 4 km N of Kalumburu, 14°17'S, 126°37'E, 24 June 1978, *A.S. George* 15199 (CANB, MEL, NSW, PERTH); Quartzite outcrop between Kalumburu Mission & Longini Landing, 14°16'S, 126°37'E, 26 May 1975, *D.E. Symon* 10184 (AD, CANB, PERTH).

Distribution. Endemic to the Kalumburu area, north Kimberley Region, Western Australia (Figure 12).

Habitat. Grows mainly on sandstones and quartzites.

Phenology. Flowering and fruiting material has been collected from May to July.

Conservation status. The appropriate conservation code for this species is 2RC-. Listed as a Priority 3 category on the Priority Flora List of the Department of Conservation and Land Management of Western Australia.

Etymology. The epithet refers to the major community in the area where this species is found, Kalumburu.

Affinities. Related to *B. filicifolia* and *B. minutipinna* from which it can be distinguished by the smaller number of pinnae and hirsute cocci, and from *B. wilsonii* by the sparse to moderate indumentum, much longer anthopodia, and smaller and less hirsute flowers.

9. Boronia minutipinna Duretto, *sp. nov.*

A *B. filicifolia* A Cunn. ex Benth. foliis pinnis paucioribus (17-35) et minoribus (0.5-2 mm longis), et anthipodiis brevioribus (1-6 mm longis) differt.

Typus: Osmond Plateau, Western Australia, 17°16'S, 128°22'E, 19 July 1991, *I. Cowie* 1991 (*holo*: CANB 412831; *iso*: DNA 59392, MEL 229246, PERTH 1881515).

Erect, much branched *shrub* to 50 cm high; with a moderate to dense stellate indumentum throughout. *Multiangular stellate hairs* sessile, with 6-15 rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, 0.1-0.25(0.5) mm long (Figures 11G,H). *Branches* slightly quadrangular becoming terete with age, decurrencies absent, not obviously glandular, hairs distributed evenly, becoming glabrous with age, little or no cork development. *Leaves* opposite decussate, imparipinnate, 17-35 pinnae, not becoming unifoliolate with age, pinnae number gradually increasing

along axillary branches, sessile, 5-34 mm long, 2-4 mm wide; lamina discolourous, paler beneath, dorsiventral (fresh material not available), not obviously glandular, scattered nonsecretory glands in mesophyll, epicuticular waxes absent; adaxial surface with moderate stellate indumentum (Figures 10U, 11G); abaxial surface with a moderate to dense stellate indumentum (Figure 11H); margins entire, flat to recurved; midribs of leaflets and rachis segments raised abaxially, with tightly packed parenchyma between midvein and abaxial epidermis without secondary thickening; pinnae acute, petiolule *c.* 0.5 mm long; terminal pinnae elliptic, longer than but the same width as laterals, 1-2 mm long, midvein straight, 0.5-1.5 mm wide; lateral pinnae rhombic, overlapping, opposite or rarely subopposite, 0.5-1.5 mm long, 0.5-1.5 mm wide; rachis segments winged, oval shaped, 0.5-12 mm long, 0.5-1.5 mm wide. *Inflorescence* 1-flowered, with a moderate stellate indumentum; peduncle absent; prophylls to 1 mm long, minute, persistent; metaxyphylls absent or minute, persistent; anthopodium 1-6 mm long. *Flowers* white to pink (Figure 10V). *Sepals* longer and wider than petals, deltoid, acute, 3-4 mm long, 1.5-2 mm wide, enlarging to 3.5-5 mm long with fruit; adaxial surface with a sparse simple and stellate indumentum; abaxial surface with a sparse stellate indumentum. *Petals* midrib not raised abaxially, 2.5-3 mm long, 1-1.5 mm wide, enlarging to 4-4.5 mm long with mature fruit; adaxial surface with a moderate to dense stellate indumentum, becoming glabrous towards base; abaxial surface with a sparse to moderate stellate indumentum. *Stamens* with filaments bearing stiff bifid or stellate hairs abaxially and on margins; antesepalous filaments clavate, suddenly narrowing to anther connective, 1.5-2 mm long, distal 0.5 mm prominently glandular; antepetalous filaments smooth, 1 mm long; anthers abaxial surface not frosty, antepetalous anthers much larger than antesepalous anthers; anther apiculum present, minute or large and erect; glabrous (Figures 10W,X). *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; style glabrous or hirsute at base; stigma rounded, not or scarcely wider than style. *Cocci* (mature not seen) with a moderate stellate and simple indumentum, 6 mm long, 2.5 mm wide. *Seed* not seen. (Figure 10T-X)

Specimens seen. Known from the type material only.

Distribution. Known from the Osmond Plateau, south-east Kimberley Region, Western Australia. (Figure 12)

Habitat. Found growing in sand amongst boulders (collector's notes).

Phenology. Flowering and fruiting material was collected in July.

Conservation status. As the species is known only from the type collection a code of 1K is appropriate. Listed as a Priority 2 category on the Priority Flora List of the Department of Conservation and Land Management of Western Australia.

Etymology. The epithet is derived from the Latin, *minutas* - small and *pinnae* - wings and alludes to the small pinnae of the leaves.

Affinities. Closely related to *B. filicifolia* from which it can be distinguished by having smaller and fewer pinnae, the abaxial surface of the leaves having a moderate to dense indumentum, smaller anthopodia, and perianth parts with a sparse indumentum.

10. Boronia rupicola Duretto, *sp. nov.*

A aliis speciebus *Boroniae* sectionis *Valvatarum* (Benth.) Engl. habitu pendulo, floribus parvis flavo-virentibus, et foliis planis differt.

Typus: 18 km south-east of Jabiru, outlier of main Plateau, Northern Territory, 12°48'S, 132°55'E, 30 March 1981, *L.A. Craven* 6646 (*holo*: CANB 338121; *iso*: A, AD, BRI, CANB 338122, DNA *n.v.*, E, L, MEL).

Pendulous *subshrub* to 40 cm long, capable of regrowing from rootstock, glabrous or with a dense stellate indumentum. *Multiangular stellate hairs* mostly sessile but occasionally stalked, with 10-20+ rays; rays firm, straight, smooth, glossy, unfused, unicellular, epidermal in origin, white to faintly yellow, to 0.05(0.1) mm long (Figure 14A-C). *Simple hairs* (mainly on adaxial surface of leaves) erect, 0.01-0.02 mm long (Figure 14A). *Branches* brittle, quadrangular, decurrencies absent, not glandular, hairs distributed evenly, becoming glabrous with age, little or no cork development. *Leaves* opposite decussate, simple, unifoliolate or imparipinnate, 1-7 pinnae, becoming simple with age, 5-15 mm long, 1-4 mm wide; lamina strongly discolourous, paler beneath, dorsiventral, not obviously glandular, scattered nonsecretory glands in mesophyll, palisade mesophyll tightly packed, epicuticular waxes absent; pinnae and simple leaves elliptic to oblanceolate, sessile to subsessile, tip obtuse, base attenuate to obtuse, margin entire and flat; midrib not raised significantly abaxially, tightly packed parenchyma with secondary thickening between midvein and abaxial epidermis; adaxial surface smooth, glabrous or with a sparse indumentum with multiangular stellate hairs and minute erect simple hairs (Figure 14A); abaxial surface glabrous or with a dense indumentum made up of a heterogenous layer of two hair types: a sparse to moderate layer of multiangular hairs (some stalked) and a dense layer of smaller planer stellate hairs (Figure 15B,C); terminal pinnae longer than preceding laterals but shorter than other laterals, midrib straight, 7-10 mm long, 1-3 mm wide; lateral pinnae opposite, 4-10 mm long, 1-3 mm wide; rachis segments winged, oval or triangular with distal end wider, 4-7 long 0.5-1 wide; petiole 1.5-7 mm long. *Inflorescence* cymose, 1(3)-flowered, with a dense stellate indumentum; peduncle terete in cross section, non woody and deciduous with flower, 0.5-1 mm long; prophylls persistent, linear to minutely unifoliolate, 1-6.5 mm long, 0.5-1.5 mm wide, indumentum as leaves; metaxyphylls persistent, minute to 0.5 mm long; anthopodium 0.5-3 mm long. *Flowers* yellow-green (Figure 13C,D). *Sepals* ovate-deltoid, acute to slightly acuminate, much shorter and narrower than petals, 1-1.5 mm long, c. 1 mm wide, not enlarging significantly with fruit; adaxial surface with a sparse simple indumentum, becoming glabrous towards base; abaxial surface with a sparse to dense stellate indumentum. *Petals* midvein slightly raised abaxially, 2-2.5 mm long, 1.5 mm wide, not enlarging significantly with mature fruit; adaxial surface with a sparse simple indumentum, becoming glabrous towards base; abaxial surface with a sparse to dense stellate indumentum. *Stamens* with filaments clavate, tapering to anther connective, with stiff simple hairs abaxially and on margins below glandular tip; antesepalous filaments 1.5 mm long, distal 0.5 mm prominently glandular; antepetalous filaments smooth or slightly glandular distally, 1 mm long; anthers all equal, abaxial surface not frosty; anther apiculum absent or present, glabrous, erect (Figure 13E,F). *Disc* entire, glabrous, not surrounding base of filaments. *Ovary* glabrous; style hirsute at base; stigma rounded, not or scarcely wider than style (Figure 13G). *Cocci* glabrous to moderately hirsute, 3.5 mm long, 2 mm wide (Figure 13D). *Seeds* black or grey, shiny or dull, adaxial side with or without minute ridge, 2-3 mm long, 1-1.5 mm wide; elaiosome yellow-white; testa surface at magnification ± tuberculate; tubercles unicellular, smooth, anticlinal walls ± visible, often collapsed, 6-55 µm across (Figure 9G-I). (Figure 13)

Other specimens examined. NORTHERN TERRITORY; DARWIN & GULF DISTRICT: Baroalba Creek, 31 Mar. 1990, *K. Brennan* 142 (OSS); Tin Camp Creek, 6.5 km WNW of Myra Falls, *c.* 12°27'S, 133°17'E, 17 Apr. 1993, *K. Brennan* 2269 (OSS); 11.5 km ESE of Nabarlek, *c.* 12°20'S, 133°26'E, 13 June 1993, *K. Brennan* 2356 (MEL, OSS); *c.* 17 km SE of Jabiru, 12°47.5'S, 132°57.5'E, *L.A. Craven* 6581 (CANB); Radon Gorge, Mt Brockman, 12°45'S, 132°54'E, 21 Apr. 1980, *C.R. Dunlop* 5455 (DNA, NSW); Tin Can Creek *c.* 20 miles [32 km] S of Nabarlek Mining Camp, 12°28'S, 133°15'E, 30 May 1973, *T.G. Hartley* 13819 (CANB, DNA); Nabarlek, 12°22'S, 133°23'E, 11 July 1989, *Hinz* 565 (DNA); Gulungul Creek, mouth of Radon Gorge, 4 km WSW of Mt Brockman, Kakadu National Park, 12°45'S, 132°55'E, 21 June 1980, *I.R. Telford* 7931 & *J.W. Wrigley* (CBG); 6.5 km SSW of Mt Brockman, Kakadu National Park, 12°48'S, 132°56'E, 23 Apr. 1980, *I.R. Telford* 8058 & *J.W. Wrigley* (CANB, CBG).

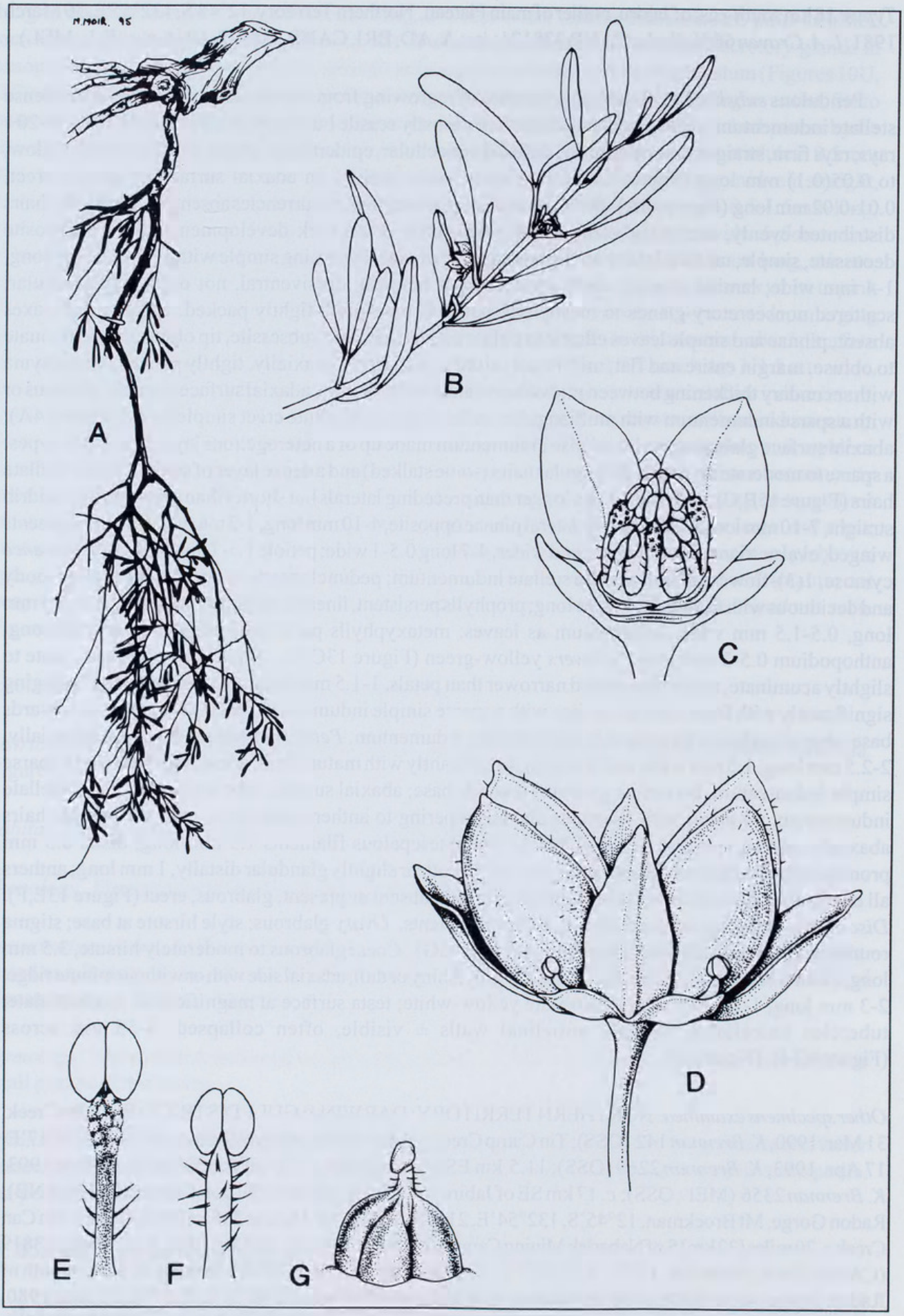

Figure 13. *Boronia rupicola* A - habit (x0.5). B - habit (x3). C - flower, one sepal and two petals removed (x10). D - fruiting flower (x10). E - antesepalous stamen (x20). F - antepetalous stamen (x20). G - gynoecium (x20). Drawn from *L.Craven* 6646 *(isotype*, MEL 338122) (A,B), and *K.Brennan* 2356 (MEL) (C-G). Drawing prepared by Mali Moir.

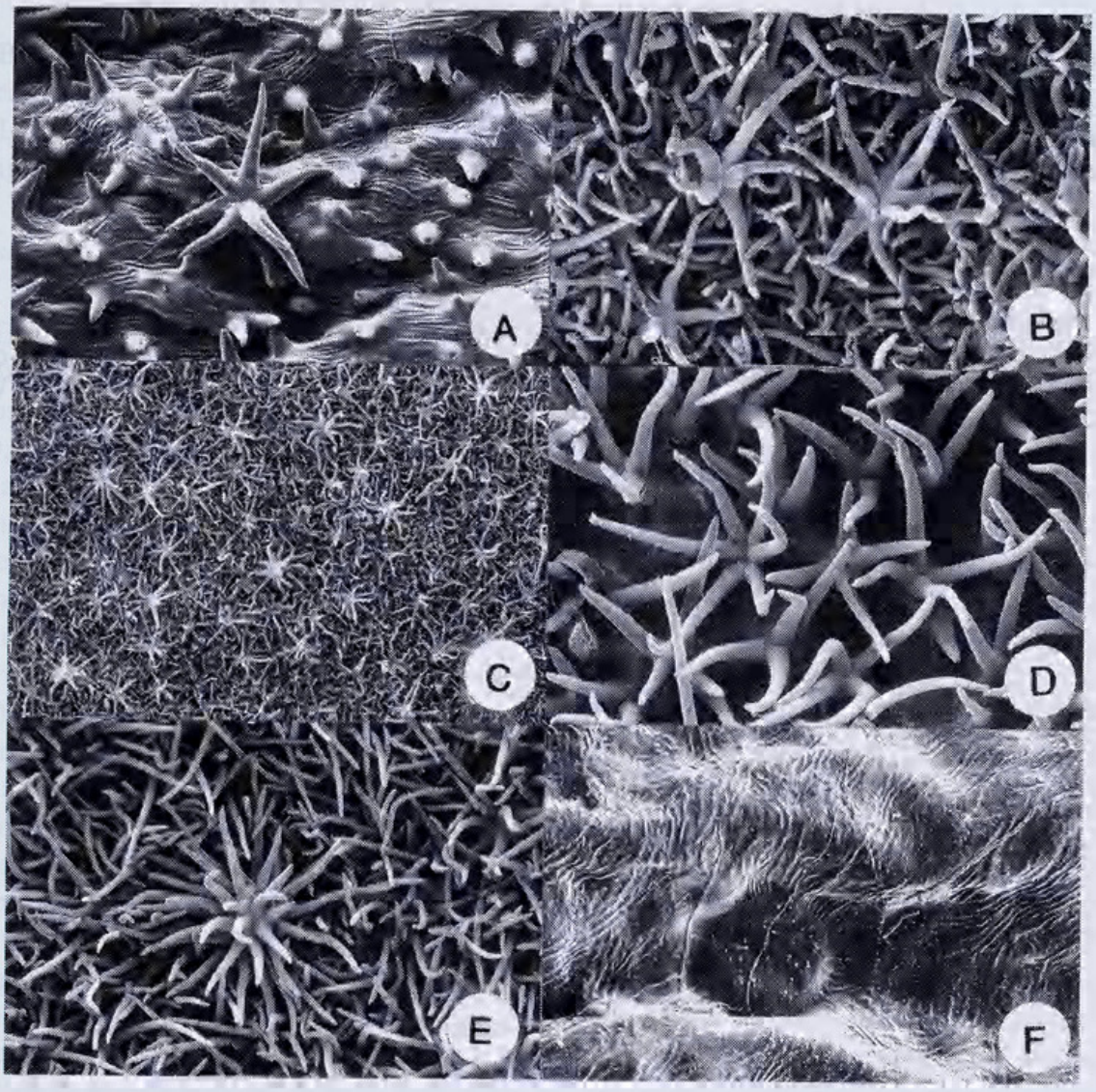

Figure 14. Scanning electron micrographs of leaf surfaces. A-C *B. rupicola*: A - adaxial surface, x250 (*Craven* 6646, CANB); B,C - abaxial leaf surface, B - x250, C - x55 (*Brennan* 2356, MEL). D-F *B. lanceolata*: D - hirsute adaxial surface, x350; E - abaxial surface, x200 (D,E, *Fryxell et al.* 4916, MEL); F - glabrous adaxial surface, x350 (*Weber* 10087, MEL).

Distribution. Known only from the Mt Brockman outlier (Kakadu National Park) and around the Nabarlek mining lease (Arnhem Land), the Northern Territory. (Figure 15A)

Habitat. Pendulous shrub found exclusively on vertical sandstone surfaces.

Phenology. Flowering and fruiting material collected from March to July.

Conservation status. Briggs & Leigh (1996) gave this species a conservation code of 2RC- for both the Nabarlek (their *B. sp. 5*) and Mt Brockman (their *B. sp. 6*) populations: the appropriate code for *B. rupicola* is 2RC-. Neither population is under immediate threat as the species is found in rugged and isolated terrain. Any developments in either area, such as tourism or mining, should be monitored as the habitat of this species is fragile.

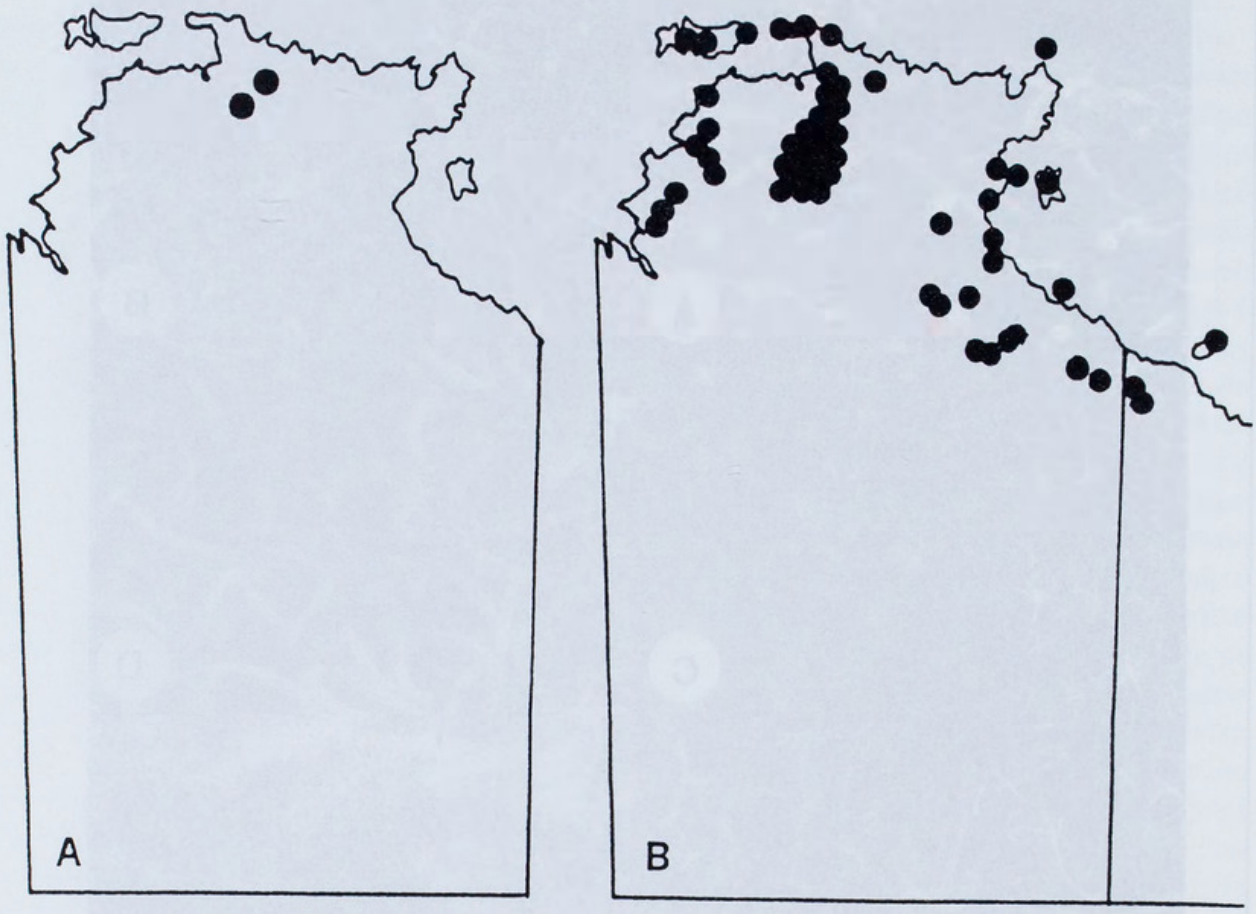

Figure 15. The Northern Territory and north-west Queensland. Distribution of: A - *B. rupicola*; B - *B. lanceolata*.

Etymology. The epithet is derived from the Latin, *rupestris* - rocky and *incola* - inhabitant, and alludes to the specialised habitat of this species.

Affinities. The taxonomic position of this species within section *Valvatae* is unresolved but certainly isolated. Cladistic analysis of section *Valvatae* (Duretto 1995, Duretto & Ladiges in prep.) places this species with the '*B. ledifolia* (Vent.) J.Gay ex DC. group' of Weston (1990). It is one of three species of *Boronia* that colonizes vertical rock faces in the north-west portion of the Arnhem Land plateau. *Boronia rupicola* can be distinguished from these other species by its sepals being much smaller than its petals, pendulous habit and compound leaves (though these are not always present). The last two characters also distinguish it from *B. lanceolata*, the only other species in the region with sepals much smaller than the petals.

Notes. Called *B. sp.* 1 at OSS, A44419 (Nabarlek) and DNA17279 (Radon Gorge) in Leach *et al.* (1992), and *B. sp. 5* (Nabarlek; *T.G. Hartley* 13819) and *B. sp. 6* (Radon Gorge; *C.R. Dunlop* 5455) in Briggs & Leigh (1996). Both glabrous (e.g. *Craven* 6581 and *Hartley* 13819) and hirsute plants (e.g. *Craven* 6646 and *Hinz* 565) have been collected from the Nabarlek and Mt Brockman areas. The two taxa listed by Leach *et al.* (1992) and Briggs & Leigh (1996) are based on glabrous (*viz.* A44419 and *B. sp. 5*) and hirsute (*viz.* DNA17279 and *B. sp. 6*) specimens. Some obviously old plants, e.g. *Craven* 6581 (CANB 338126) are glabrous, and so being glabrous does not appear to be a juvenile condition. Glabrous plants of normally

hirsute taxa of section *Valvatae* do occur (Duretto 1995). Detailed population surveys are required to determine the taxonomic importance, if any, of hair density in this species.

11. Boronia lanceolata F. Muell., Fragm. 1: 66 (1859). *Type*: M'Adam [Macadam] Ranges, [Northern Territory], *F.v.Mueller,* Oct 1855 (*lecto* (here designated): K *n.v.* (cibachrome & slide MEL); *isolecto:* MEL). *Residual syntypes:* Arnhem Land, *F.v.Mueller* (*syn:* K *n.v.* (cibachrome & slide MEL), MEL); Point Efingstone, *F. Mueller* (*syn:* MEL).

Illustration. K. Brennan, Wildfl. Kakadu 34 (1986).

Erect, rarely pendulous, much branched *shrub* to 250(400) cm high, with a moderate to dense stellate indumentum. *Multiangular stellate hairs* sessile, with 10-25+ rays; rays unicellular, epidermal in origin, unfused, firm, straight, not appressed, glossy, smooth, white to faintly yellow, to 0.1 mm long (Figure 14D,E). *Branches* terete, not glandular, little or no cork development, without decurrencies, with a dense stellate indumentum, hair density even around stem, becoming glabrous with age. *Leaves* opposite decussate, rarely subopposite or in whorls of three, simple (juvenile and mature), 8-90 mm long, 3-27 mm wide; lamina strongly discolourous, paler beneath, narrowly elliptic to elliptic-lanceolate, acute, ± slightly mucronate, cuneate to obtuse, dorsiventral, not obviously glandular, scattered nonsecretory glands in mesophyll, palisade mesophyll usually tightly packed, epicuticular waxes absent; margins entire, flat to slightly recurved; adaxial surface glabrous-glabrescent (hairs along midrib only; Figure 14F) or with a dense stellate indumentum (Figure 14D); abaxial surface with a dense indumentum of a heterogenous layer of two hair types: a sparse to moderately dense layer of multiangular stellate hairs, and a dense layer of smaller planer, stellate hairs (Figure 14E); midrib impressed adaxially, raised prominently abaxially, tightly packed parenchyma cells between midvein and abaxial epidermis with secondary thickening; petiole 3-16 mm long; juvenile leaves with a sparse to moderate indumentum, indumentum becoming more dense on progressive nodes, the multiangular stellate hairs appearing before the planer, stellate hairs. *Inflorescence* cymose, often appearing umbellate, 3-7(15)-flowered, with a dense stellate indumentum; peduncle slightly flattened to terete in cross section, non woody and usually deciduous, 0.5-9 mm long; prophylls minutely unifoliolate, persistent, 0.5-6 mm long, to 4 mm wide; metaxyphylls persistent, minute to 0.5 mm long; anthopodium 0.5-5 mm long. *Sepals* shorter and narrower than petals, ovate-deltoid, acuminate, 1-3 mm long, 1-2 mm wide, not enlarging significantly with fruit; adaxial surface glabrous to glabrescent with few stellate hairs near tip; abaxial surface with a dense stellate indumentum. *Petals* abaxial surface with prominently raised midrib, pink or white, 2-5.5 mm long, 1.5-3 mm wide, enlarging to 2.5-7 mm long and 2-4 wide with mature fruit; adaxial surface with a sparse to moderate simple or stellate indumentum, becoming glabrous towards base; abaxial surface with a moderately-dense stellate indumentum, rays of hairs usually firm, glossy and straight. *Stamens* with filaments clavate, tapering to anther connective, glabrous or rarely bearing few stiff simple hairs abaxially or along margins below glandular tip; antesepalous filaments 2-2.5 mm long, distal 0.5 mm prominently glandular; antepetalous filaments slightly to strongly glandular distally, 1-1.5 mm long; anthers all equal, abaxial surface not frosty; anther apiculum absent or rarely minute, glabrous. *Disc* entire, not surrounding base of filaments, glabrous. *Ovary* glabrous; styles glabrous; stigma rounded, not or scarcely wider than style. *Cocci* glabrous with occasional stellate hair along suture, 3-4 mm long, 2-2.5 mm wide. *Seeds* without ridge on adaxial side, shiny but sometimes dull, black or grey, 2-3 mm long, 1.5-2 mm wide, 2-4 mm long, 1.5-2.5 mm wide; elaiosome yellow-white; surface at magnification tuberculate; tubercles unicellular, surface smooth to wrinkled, often collapsed, anticlinal walls ± visible, 6-55 µm across (Figure 9J,K).

Specimens examined (selected from c. 200 collections). NORTHERN TERITORY; DARWIN & GULF DISTRICT: Channel Island, Darwin Harbour, 12°34'S, 130°52'E, 3 Feb. 1972, *N. Byrnes* 2376 (DNA);

Sandstone plateau near Glyde River, Macarthur River area, 16°27'S, 136°10'E, 29 May 1976, *L.A. Craven* 3910 (CANB, DNA); Deaf Adder Gorge, 22 Apr. 1980, *C.R. Dunlop* 5475 (CBG, DNA); Bloomfield Springs, Mary River, Kakadu National Park, 15 Sep. 1987, *C.R. Dunlop* 7084 & *Wightman* (DNA); Just before Koongarra saddle, on track to mine site, Kakadu National Park, 12°50.73 S, 132°51.40'E, 16 June 1993, *M.F. Duretto* 446, *J. Chappill & G. Howell* (BRI, DNA, MEL); Saddle/ridge above side creek, just downstream & W of plunge pool, Barramundi Gorge, Kakadu National Park, 13°19.15'S, 132°26.13'E, 18 June 1993, *M.F. Duretto* 463, *J. Chappill & G. Howell* (MEL); Ikoymarrawa Lookout, *c.* 9 km W of Mary River crossing on Jabiru road, Kakadu National Park, 13°34.61 S, 132°15.34'E, 29 June 1993, *M.F. Duretto* 533-7, *J. Chappill & G. Howell* (MFD533-535, 537 - MEL; MFD536 - DNA, MEL); E end of Melville Island, 1.5 km N of Soldier Point, 11°28'S, 131°32'E, 25 June 1985, *P.A. Fryxell, L.A. Craven & J. McD.Stewart* 4916 (CANB, DNA, MEL); Cox River Station, 15°50'S, 134°43'E, 9 July 1977, *T.S. Henshall* 1678 (CANB); 16 km S of Twin Falls, 13°28'S, 132°46.5'E, 5471-592109, 24 May 1980, *M. Lazarides* 8960 (CANB, DNA, NSW); Wilgran Island, English Company Islands, 11°45'S, 136°37'E, 24 July 1992, *G.J. Leach* 3072 (CANB); Butterfly Gorge, Katherine Gorge, 14°19'S, 132°28'E, 4 Aug. 1983, *D.J. Nelson* 2645 (DNA); Adjacent to Round Jungle, Kakadu National Park, 13°18'S, 132°38'E, 30 Apr. 1987, *J. Russell-Smith* 2158 & *D. Lucas* (CANB, DNA); Deaf Adder Gorge, 13°07'S, 132°56'E, 22 Apr. 1980, *I.R. Telford* 7999 & *J.W. Wrigley* (CBG, DNA, NSW); Ngarradj Warde Jobkeng, SW of Cahills Crossing, East Alligator River, 12°27'S, 132°56'E, 18 Apr. 1983, *H.S. Thompson* 286 (AD, CBG, MEL); Moline Rock Holes, 9 km NE of Mary River on Pine Creek-El Sharana road, 13°32'S, 132°12'E, 8 May 1983, *K.L. Wilson* 5217 (DNA, NSW).
VICTORIA RIVER DISTRICT: Vicinity of Woolaning Homestead, 13°06'S, 130°40'E, *L.A. Craven & C. Dunlop* 6686 (CANB, DNA); Candy Rock Range, *c.* 23 km ESE of Daly River police station, 13°50'S, 130°54'E, 23 June 1985, *P.A. Fryxell, L.A. Craven & J. McD.Stewart* 4897 (CANB).
QUEENSLAND; BURKE DISTRICT: Amphitheatre, *c.* 27 km N of Musselbrook Mining Camp, 18°21'S, 138°09'E, 12 June 1995, *J.R. Clarkson* 10483 (MEL); 3 miles [4.8 km] W of Westmoreland Station, 17°20'S, 138°13'E, 5 June 1948, *R.A. Perry* 1351 (BRI, CANB, DNA); Appel Channel, Mornington Island, Wellesly Islands, Gulf of Carpentaria, 16°29'S, 139°34'E, June 1963, *N.B. Tindale & P. Aiken* (AD).

Distribution. Found from Mornington Island and Westmoreland, north-west Queensland, to the Macadam Ranges and the Tiwi Islands, the Northern Territory, including the nearby islands in the Gulf of Carpentaria and off Arnhem Land. (Figure 15B)

Habitat. A denizen of the sandstone monsoon forest, woodland and heath communities (Brennan 1986; pers. obs.).

Phenology. Flowering and fruiting material has been collected from May to February.

Conservation status. Widespread, well represented in conservation reserves (though not in far western or far eastern Northern Territory, or in Queensland), and not under immediate threat.

Etymology. The specific epithet refers to the lanceolate leaves (Bailey 1883).

Typification. Mueller (1859) did not cite any specimens when he described *B. lanceolata* and it can be assumed that the description was based on material he had collected on Gregory's 1855-56 expedition to northern Australia. Bentham (1863) cites three specimens of *B. lanceolata* (*viz.:* Islands of Gulf of Carpentaria, *R. Brown*; Port Essington, *Armstrong & Leichardt*; Stoney places in Arnhem Land and Carpentaria, *F. Mueller*). Specimens matching some of these localities have been located at K and MEL. Of these, Mueller would have definitely seen only his own collection before 1859, and so only this specimen can be confidently called a syntype. In addition, other Mueller collections (Point Effington,

F. Mueller [MEL]; M'Adam Range, Oct 1855, *F. Muell.* [K, MEL]) have been located. This material had obviously been seen by Mueller before the description of *B. lanceolata* and so are also syntypes. As the M'Adam Range (now called Macadam Range) specimen lodged at K is in the best condition, it is chosen as lectotype.

Affinities. Boronia lanceolata is not easily confused with any other species over its range, being more closely related to presently undescribed species from central Queensland. It can be distinguished from other Northern Territory and north-western Queensland species by the sepals being significantly smaller than the petals, and by the simple leaves having a prominently raised midrib on the abaxial surface. It is distinguished from other large, simple-leaved members of *Boronia* section *Valvatae* (eastern Queensland, New South Wales and Victoria) by the small flowers and glabrous to glabrescent staminal filaments.

Notes. Boronia lanceolata is the most common and widespread *Boronia* in the Northern Territory and north-west Queensland. It is a variable taxon; leaves range from small to very large, and from broadly lanceolate-elliptic to narrowly elliptic, and the flowers, fruit and seed also show significant variation in size. Some collections from between Twin Falls and Moline Rock Hole, Kakadu National Park, (e.g. *Duretto* 533-7 *et al.*, *Wilson* 5217) have very narrow, but long leaves. Other collections in this area (e.g. from Barramundi Gorge and UDP Falls) have the more 'typical' elliptic or lanceolate leaf. Moderately narrow-leaved specimens have also been collected from Melville Island (*Fensham* 126 & 244), Darwin (*Byrnes* 2376), Round Jungle (*Russell-Smith* 2158 & *D. Lucas*), Twin Falls (*Lazarides* 8960), Bloomfield Springs (*Dunlop* 7084 & *Wightman*), and Katherine Gorge (*Nelson* 2645). The very narrow-leaved variant and a very large-leafed variant (north-west Arnhem Land plateau) represent extreme conditions between which there is a continuous grade and so no taxonomic limits could be placed confidently on any of these 'forms'. Plants are usually erect but two collections from Deaf Adder Gorge (*Telford* 7999 & *Wrigley* and *Dunlop* 5475) are from pendulous plants (collectors' notes). These plants also have small flowers, but are otherwise very similar to typical *B. lanceolata.*

Leaves of the majority of plants have a glabrous adaxial surface (Figure 14F), but the leaves of a significant percentage of plants have a dense indumentum on the adaxial surface (Figure 14D). Mueller labelled some of these specimens at MEL as '*Boronia velutina*' (an unpublished name used on several specimens including the K specimen 'Arnhem Land, F.v.Mueller') and is probably referring to this phenomenon. The glabrous and hirsute forms are broadly sympatric, but rarely occur in the same population (pers. obs.), though both 'forms' co-exist in the Barramundi Gorge population (*Duretto* 463, 469-472). Scanning electron microscopy of adaxial leaf surfaces revealed that as the epidermis is continuous and unbroken on the glabrous adaxial surface, the glabrous nature of some of these leaves is not due to deciduous hairs (Figure 14F). This feature does not appear to be of any taxonomic significance.

The almost bewildering variety found within *B. lanceolata* may be owing to the diverse environments and communities this taxon inhabits. Unlike the other boronias of the Northern Territory, *B. lanceolata* inhabits a wide variety of communities, from wattle scrub and heath in exposed areas of the plateau surface, to monsoon forests in sheltered gorges. It is also mesic, while the other taxa are more sclerophyllous. It is interesting to note that most of the morphological variation is found within Kakadu National Park between the Mt Brockman/Deaf Adder Gorge area and Katherine Gorge, Nitmiluk National Park, an area that is also problematic in populations of *B. grandisepala* (Duretto 1995; Duretto & Ladiges 1997) and *B. lanuginosa* (see above). *Boronia lanceolata* may have undergone some incipient speciation during the last glacial period when the area was much drier, and populations probably more isolated. Further studies, involving extensive collecting in these areas and utilising data from sources

such as oils, flavonoids and isoenzymes, as well as morphology, are needed to ascertain whether this variation has any taxonomic significance.

Occasionally the leaves of *B. lanceolata* are arranged in whorls of three instead of the normal condition in *Boronia*, opposite and decussate (e.g. *Dunlop* 4712, *Fensham* 869). This is not unusual in plants with opposite decussate leaves (A.N. Drinnan pers. com.) and has also been observed in other boronias, such as *B. rosmarinifolia* A. Cunn. ex Endl. (Duretto 1995). Usually the secondary branches have the normal opposite decussate condition.

Bailey (1899) referred a north Queensland specimen, 'Cave Creek, WE Armit (FvM.)', to *B. lanceolata*. Collections from this locality have been located at MEL (in Mueller's herbarium) and can be confidently assigned to *B. bowmanii* F.Muell. (these specimens are annotated as *B. lanceolata* var. *pinnata*, an unpublished name). Hnatiuk (1990) states that *B. lanceolata* has been collected in the North Kennedy and Cook Districts of Queensland. The Cook District record is probably referring to Bailey (1899). The North Kennedy record may be due to one or two undescribed species of *Boronia* from the humid Wet Tropics (both with large, simple leaves which will be described in a later paper) that have been incorrectly assigned to *B. lanceolata*.

Some novel alkaloids have been isolated from *B. lanceolata* by Ahson *et al.* (1993) and shown to be similar to those of *B. ternata* Endl., the only other member of *Valvatae* sampled.

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