THE IDENTIFICATION AND DISTRIBUTION OF *GLYCINE LATROBEANA* (MEISSN.) BENTH. IN TASMANIA

by A.J.J. Lynch

(with two tables and one text-figure)

LYNCH, A.J.J., 1994 (30:vi): The identification and distribution of *Glycine latrobeana* (Meissn.) Benth. in Tasmania. *Pap. Proc. R. Soc. Tasm.* 128: 17-20. https://doi.org/10.26749/rstpp.128.17 ISSN 0080-4703. Department of Geography and Environmental Studies, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001 (formerly of Parks and Wildlife Service, Department of Environment and Land Management, Hobart).

Glycine latrobeana has commonly been confused in Tasmania with other *Glycine* species and also with *Desmodium gunnii*. This paper details the known distribution and habitat characteristics of *G. latrobeana* and presents a key to the species of *Glycine* extant in Tasmania.
Key Words: Fabaceae, Glycine, Tasmania.

INTRODUCTION

Three species of *Glycine* occur in Tasmania: *G. clandestina* J.Wendl., *G. latrobeana* (Meissn.) Benth. and *G. microphylla* (Benth.) Tind. These species are all small, perennial, trifoliolate herbs, which may become trailing or twining if protected from grazing. Like many leguminous plants, they are palatable, and the species are restricted to dry sclerophyll woodlands where the populations are usually grazed by native herbivores. Consequently, wild plants tend to be small, comprising only a few short stems (up to 0.1 m length). In Tasmania, the three *Glycine* species can adopt similar habits, even if not intensively grazed, making identification difficult.

Glycine latrobeana has commonly been confused in Tasmania with the other *Glycine* species and also with *Desmodium gunnii.* Similar confusion within the *Glycine* genus has been noted in South Australia (Davies 1986). In Tasmania, this confusion has arisen from identifications based on growth habit as described in Curtis & Morris (1975). These authors recognised only *G. clandestina* and *G. latrobeana* as present in Tasmania, and did not describe the variability inherent in *G. clandestina.* In addition, confusion has arisen temporarily from the results of cytological studies by CSIRO. These factors have resulted in the misidentification of *Glycine* species in surveys, especially the grasslands survey (Kirkpatrick *et al.* 1988), and in the literature (Duncan & Harris 1983, Kirkpatrick *et al.* 1991). As a result, the extent of *G. latrobeana* in Tasmania has been overestimated. This paper details the known distribution and habitat characteristics of *G. latrobeana,* and presents a new key for distinguishing between species of *Glycine* extant in Tasmania. Nomenclature of plant species follows Buchanan *et al.* (1989), except for *Desmodium gunnii* (syn. *Desmodium varians* var. *gunnii*) which follows Hacker (1990).

IDENTIFICATION

The morphology of *G. latrobeana* was described in a revision of the genus and its immediate allies (Hermann 1962). Field identification of *Glycine* species is difficult because they are usually grazed, because they lack flowering or fruiting characters for much of the year, and also because of their ability to reproduce via both chasmogamous and cleistogamous inflorescences. *G. tabacina* has also been thought to occur in Tasmania, but has not been positively identified (J. Grace & A. Brown, pers. comm.). The following section on identification is based on Tindale (1987), Jessop & Toelken (1986), J. Grace & A. Brown (pers. comm.) and personal observations.

A key to the four species of *Glycine* is presented in table 1, based on the stem, stipel, leaf and seed morphology. Additional characters distinguishing *G. latrobeana* from *G. clandestina* are that the former has trailing rather than twining stems, that it may spread rhizomatously, and also that it has orbicular to obovate leaflets rather than digitately trifoliolate leaflets (however, this characteristic is highly variable in Tasmanian specimens of *G. clandestina,* which may also have orbicular leaflets, especially when stems are young).

The chasmogamous flowers of the *Glycine* species are small, either purple or pink pea-flowers ascending in racemes from the axils of the upper leaves on long peduncles. Cleistogamous flowers are often solitary, frequently in the lower axils, and on very short peduncles. These flowers do not open but self-fertilise. The inflorescence of *G. latrobeana* is more compact than *G. clandestina,* being crowded near the ends of the peduncles rather than spread along the upper half. The pods of *G. latrobeana* are about 20–25 mm by 5 mm and contain 3–5 cylindrical-shaped seeds, whereas the pods of *G. clandestina* are c. 12–30 mm by 3–4 mm and contain 4–8 seeds (Weber 1986).

Desmodium gunnii is similar in appearance to *G. latrobeana* but is distinguishable by its hairless stems and lobed pod.

DISTRIBUTION

Glycine latrobeana is an uncommon species which usually occurs in the open grasslands of southeastern Australia (Mt. Lofty Ranges and southeastern region of South Australia, throughout Victoria except for the northwestern quarter, the far eastern section and the districts of Shepparton and Albury; Davies 1986).

Records in Tasmania older than 25 years (fig. 1) placed the species in the northwest at Circular Head (1836, 1837), and in the midlands (Folly Lagoon near Ross 1964) extending

TABLE 1
Key to Tasmanian *Glycine* Species*

1.	Stems non-stoloniferous. Leaves digitately trifoliolate, the 3 leaflets equally petiolulate and subsessile (i.e. all petiolules equal lengths). Veins of leaflets coarsely reticulate within the larger areolae. Stipels of the median petiolule absent or minute.	2
1.	Stems stoloniferous with adventitious roots at the nodes of above-ground stems. Growth habit prostrate and/or twining. Leaves pinnately trifoliolate, the terminal leaflet inserted on a short but distinct petiolule, lateral leaflets subsessile. Stipels always present on the median petiolule. Seeds of chasmogamous legumes 3–6, perisperm granular or smooth. Veins of the leaflets very finely reticulate within the larger areolae.	3
2.	Stems elongate, growth habit twining, with shoots all from the crown. Stipels absent on the median petiolule. Stipules oblong to lanceolate. Seeds of chasmogamous legumes 9–12, with a brown-coloured, rough surface. Seeds c. 1.5 × 1–1.2 mm	*G. clandestina*
2.	Stems short, erect, decumbent or ascending, growth habit trailing and spreading rhizomatously. Petiolules densely covered with antrorse to reflexed hairs, obscuring stipels which are minute and caducous. Stipules suborbicular to broadly ovate or reniform, as wide as long or wider, and wrapping around stem. Seeds of chasmogamous legumes 3–5, with a dark-brown, smooth to muriculate surface. Seeds c. 2–2.75 × 1.75–2.25 mm	*G. latrobeana*
3.	Leaves weakly pinnately trifoliolate. Growth habit twining. Seeds 1.5–2.2 × 1–2 mm, perisperm smooth	*G. microphylla*
3.	Leaves strongly pinnately trifoliolate. Growth habit trailing. Distinct, long stipules. Seeds 2–2.5 mm × 1.8–2.5 mm, perisperm smooth or in some forms granular. Not recorded from Tasmania	*G. tabacina*

*Adapted from Tindale 1987, Jessop & Toelken 1986 and J. Grace & A. Brown (pers. comm.)

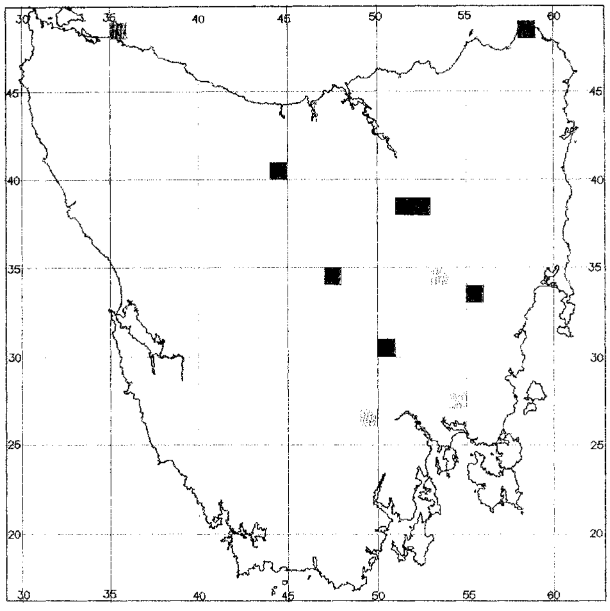

FIG. 1 — Distribution of Glycine latrobeana *in Tasmania: recently recorded populations (dark shading), records older than 25 years (paler shading).*

south to Runnymede (1848) and the Derwent Valley (Plenty 1839). None of these records has been verified recently. The current Tasmanian distribution of the species (fig. 1) appears to be in the midlands: from north of Epping Forest (Powranna Road 1991), at Stockers Bottom (1981), and at Pig Farm Hill in the Bothwell area (1982); on the central plateau, at two sites along the Ouse River (1980, 1984); and at two near-coastal sites at Cape Portland, in the far northeast of the state (1983, 1991). Specimens of *G. latrobeana* from Pig Farm Hill and the upper Ouse River were identified by CSIRO Plant Industry researchers Dr A. Brown and Dr J. Grace from field collections by Dr M. Brown and F. Duncan. Two other sites without supporting specimens have also been recorded for *G. latrobeana:* Hummocky Hills in the midlands (M. Cameron, pers. comm. 1992) and Dogs Head Hill, north of Mole Creek in northern Tasmania (Duncan 1989).

Approximately 60 *Glycine* plants were observed on private land on the Powranna Road at the northern end of Epping Forest, midlands Tasmania, in 1991. The site was very small (10 m × 5 m). It was located on a gentle slope above a poorly drained area of cleared native pasture and sedges, at an altitude of 170 m. This site faced southeast and was situated on sandy loam on dolerite, amidst a *Eucalyptus pauciflora* and *E. viminalis* open woodland with a moderately dense, shrubby understorey. The understorey was dominated by *Acacia dealbata* and *Pteridium esculentum.* The ground layer was grassy, dominated by *Themeda triandra, Poa sieberiana, Ehrharta stipoides, Stipa* sp., *Danthonia* sp. and *Aira caryophyllaea,* and also with *Lissanthe strigosa, Astroloma humifusum, Centaurium erythraea, Hypochoeris glabra, Plantago varia, Goodenia lanata, Brunonia australis* and *Pimelea humilis.* The area was grazed by sheep, and also subject to woodcutting and frequent firing. The ground species were under considerable grazing pressure, with little regeneration observed of *Brunonia australis* and none of *Glycine latrobeana* (A. Pyrke, pers. comm.). The weed gorse, *Ulex europaeus,* occurs near the site. *G. latrobeana* has also been reported to occur five kilometres to the southwest, at Hummocky Hills (M. Cameron, pers. comm.).

Two *Glycine* species have been collected in the Stockers Bottom locality. *G. clandestina* was identified from one site (A. Brown & J. Grace, pers. comm.), while one kilometre east, *G. latrobeana* has been collected. The *G. latrobeana* site was located on an undulating plateau at 420 m altitude on Triassic sediments. The community was localised and composed of a *Eucalyptus viminalis–E. dalrympleana* open forest marginal to a *E. ovata–E. pauciflora–E. rodwayi* frost hollow. The site had a high fire frequency, reflected in the heathy grassland understorey, which was dominated by the shrubs *Acacia dealbata, Lissanthe strigosa, Acrotriche serrulata* and *Astroloma humifusum,* the grasses *Microlaena stipoides, Danthonia* sp. and *Poa rodwayi,* and the herbs *Viola* spp., *Pimelea humilis, Acaena echinata, Plantago varia* and *Bossiaea prostrata.* The site had been selectively logged and was grazed.

The site at Pig Farm Hill in the Bothwell district was also located on private land. The site was on the moderately sloping, northern aspect of a broad knoll at an altitude of 660 m. The local rock-type was Jurassic dolerite, and the soils shallow. The vegetation community was a *Eucalyptus rubida* and *E. dalrympleana* woodland with a shrubby understorey, primarily of *Acacia dealbata* and regenerating *E. rubida.* The ground cover consisted of moderately dense *Lomandra longifolia,* with *Lissanthe montana,* and a dense cover of the grasses *Poa labillardieri, P. rodwayi* and *Danthonia* sp. The herbs *Pimelea humilis, Dichondra repens, Lagenifera stipitata, Geranium potentilloides* and *Senecio minimus* were also present. This site had a frequent firing regime and was grazed by sheep.

Glycine latrobeana has been collected from a high altitude site (900 m) on the upper Ouse River, Miena district (1984). This site was a flat to undulating site on the top of a broad ridge above the river, near the Monpeelyata Canal. It comprised *Eucalyptus pauciflora* woodland over a mid-dense, low shrub layer of *Cyathodes parvifolia, Leucopogon hookeri* and *Lomatia tinctoria,* and a predominantly grassy ground cover of *Poa gunnii, Elymus scabrus, Danthonia penicillata, Deyeuxia quadriseta* and *Dichelachne rara.* The following herbs also contributed cover: *Plantago paradoxa, Acaena novae-zelandiae, A. echinata, Geranium sessiliflorum* and *Glycine clandestina.* The local geology was dolerite, and the site was fired at reasonably frequent intervals.

Closer to the Ouse River and near Remarkable Rock, *G. latrobeana* has been collected in flower and fruit (1980). This site was located in small meadows above the river at an altitude of 850 m.

Two collections of this species have been made close to sea level at Cape Portland, in the far northeast of Tasmania. The first site was located on the neck of the Cape Portland headland (1983). *Glycine* was, however, extremely rare. It was located in pasture dominated by *Zoysia, Trifolium, Cerastium, Plantago* and *Lomandra.* The second site (1991) was located 4 km farther south, at Petal Point. *G. latrobeana* was localised and growing in sandy soil on a grassy flat.

One record exists of *G. latrobeana* at Dogs Head Hill, north of Mole Creek, on limestone at about 350 m elevation (Duncan 1989). This population was not relocated in late January 1992, although *G. microphylla* and *D. gunnii* were collected. *G. latrobeana* may still be present at the site, since these two *Glycine* species are in coexistence on the Upper Ouse River; it was described as common on the north-facing lower and mid-slopes amidst grassy *Eucalyptus amygdalina* woodland (Duncan 1989). These slopes were frequently fired. The low-to-medium understorey was dense and included *Acacia dealbata, A. melanoxylon, Pultenaea juniperina, Lomatia tinctoria, Bossiaea riparia* and *Acrotriche serrulata.* The ground layer was also dense, comprising *Pteridium esculentum, Lomandra longifolia, Lepidosperma laterale, Dianella* sp. and the grasses *Elymus scabrus, Danthonia pilosa, Themeda australis, Poa* sp., *Ehrharta stipoides, Dichelachne rara* and *Deyeuxia quadriseta.*

The preferred habitat of *G. latrobeana* appears to be on well-drained and insolated sites with a dolerite substrate or sandy soils, usually on flats or gentle slopes of plains, ridgelines, or valleys (table 2). The sites vary from near sea level to 900 m altitude, but tend to be in dry sclerophyll, shrubby woodland, often with a dense grass component of the ground layer, and dominated by *Eucalyptus viminalis, E. pauciflora* or *E. dalrympleana.* The species may also occur in grasslands. Some overstorey cover appears to be required in the midlands populations, so a balance must be achieved between regeneration of canopy species with maintenance of an open shrubby to grassy understorey.

Its regeneration ecology appears to be typical of dry sclerophyll species. The species produces hard seeds, which may join the soil-stored seed bank and germinate after mild to hot fires. *G. latrobeana* may also resprout, a characteristic enhanced by its thickened tap-root. This tap-root enables the species to lie "dormant" through winter, and reshoot, flower and fruit in late spring to early summer. The timing of grazing is, therefore, very important to the survival of this species. Although the seed persists in the soil, spring–summer grazing over many years combined with frequent firing will deplete the seed bank and the capacity of the species to persist. The seed has a high viability and probable longevity but is not known to be easily or commonly dispersed. The sites are usually very localised, and most are subject to frequent firing and grazing. All sites are, therefore, important to the survival of the genetic diversity of this species in Tasmania.

CONSERVATION STATUS OF *GLYCINE LATROBEANA*

Glycine latrobeana was listed nationally as rare (3RCa), with a distribution over more than 100 km, and considered adequately reserved (Briggs & Leigh 1988). More populations have been found in Victoria (J. Grace, pers. comm.), but the species is still considered nationally to be vulnerable (ANZECC 1993). In Tasmania, there are seven populations recently recorded, two of which need to have specimens collected for the Tasmanian Herbarium. There are also two other sites which need to be confirmed. The sites are widespread but extremely restricted, usually over areas tens of metres across. They also tend to contain less than 60 plants at a site. The species is unreserved and should be upgraded from rare (r3 – Kirkpatrick *et al.* 1991) to vulnerable at both the state and national levels (Vuv – Lynch 1993).

ACKNOWLEDGEMENTS

The assistance of Phil Barker, Tony Brown, Alex Buchanan, Fred Duncan, Jim Grace, Colin Reed and Mary Tindale was appreciated. Comments on the draft manuscript by Jamie Kirkpatrick, Stephen Harris, Mick Brown and an anonymous referee were also appreciated. This research was funded under a grant from the Endangered Species Programme, Australian National Parks and Wildlife Service to the Parks and Wildlife Service, Tasmania.

TABLE 2
Summary of habitat records and conservation information for *Glycine latrobeana*

Recent records:	7 (– 9) extant sites	
Habit:	Small, perennial trifoliolate herb, trails across ground if protected from grazing	
Population size:	< 500	
Regeneration:	Type:	Presumed from soil-stored seed, not observed
Habitat:	Landform:	(Flat ridgetops) — gentle slopes of plains, ridgelines, valleys
	Altitude:	Near sea level–900 m
	Aspect:	North to southeast
	Slope:	Gentle (usually < 10°)
	Community:	Dry sclerophyll shrubby to grassy woodland (*Eucalyptus viminalis, E. pauciflora, E. dalrympleana*), may be in pasture
Fire response:	May resprout; significant seed germination of *G. clandestina* after moderate intensity burns (Auld & O'Connell 1991)	
Conservation status:	Recommended:	Vuv
	Current:	(V – ANZECC 1993; r3 – Kirkpatrick *et al.* 1991; 3RCa – Briggs & Leigh 1988)
Comment:	Unreserved	
	Herbarium specimen not collected from site at Dogs Head Hill, Mole Creek (proposed reserve), and population may actually have been *G. microphylla*	

REFERENCES

ANZECC, 1993: Proposed list of threatened Australian flora. Unpubl. rep.for Australian and New Zealand Environment and Conservation Council (ANZECC) by ANZECC Endangered Flora Network.

AULD, T.D. & O'CONNELL, M.A., 1991: Predicting patterns of post-fire germination in 35 eastern Australian Fabaceae. *Aust. J. Ecol.* 16: 53–70.

BRIGGS, J.D. & LEIGH, J.H., 1988: *RARE OR THREATENED AUSTRALIAN PLANTS. Aust. Nat. Pks & Wildl. Serv. Spec. Publ.* 14.

BUCHANAN, A. M., MCGEARY-BROWN, A. & ORCHARD, A.E., 1989: *A CENSUS OF THE VASCULAR PLANTS OF TASMANIA. Tasm. Herb. Occ. Publ.* 2.

CURTIS, W.M. & MORRIS, D.I., 1975: *THE STUDENT'S FLORA OF TASMANIA. PART 1.* Second edn, Government Printer, Tasmania.

DAVIES, R.J.-P., 1986: *THREATENED PLANT SPECIES OF THE MOUNT LOFTY RANGES AND KANGAROO ISLAND REGIONS OF SOUTH AUSTRALIA.* Conservation Council of South Australia, Adelaide.

DUNCAN, F., 1989: Vegetation of proposed Dogs Head Hill Forest Reserve. Unpubl. rep. Tasm. For. Commn, Hobart.

DUNCAN, F. & HARRIS, S., 1983: A botanical survey in the Colonels Hills, an area of dry sclerophyll bushland near Tooms Lake. *Tasm. Nat.* 75: 5–16.

HACKER, J.B., 1990: *A GUIDE TO HERBACEOUS AND SHRUB LEGUMES OF QUEENSLAND.* University of Queensland Press, Brisbane.

HERMANN, F.J., 1962: A revision of the genus *Glycine* and its immediate allies. *U.S. Dep. Agric. Tech. Bull.* 1268: 1–79.

JESSOP, J.P. & TOELKEN, H.R. (Eds), 1986: *FLORA OF SOUTH AUSTRALIA. PART II. LEGUMINOSAE–RUBIACEAE.* South Australian Government Printing Division, Adelaide and the Flora and Fauna of South Australia Handbook Committee.

KIRKPATRICK, J., GILFEDDER, L. & FENSHAM, R., 1988: *CITY PARKS AND CEMETERIES — TASMANIA'S REMNANT GRASSLANDS AND GRASSY WOODLANDS.* Tasmanian Conservation Trust, Hobart.

KIRKPATRICK, J.B., GILFEDDER, L., HICKIE, J. & HARRIS, S., 1991: Reservation and conservations status of Tasmanian native higher plants. *Wildl. Div. Sci. Rep.* 91/2. Dep. Pks, Wildl. & Heritage, Tasm.

LYNCH, A.J.J., 1993: Conservation biology and management of 16 rare or threatened Fabaceae species in Tasmania. *Aust. Nat. Pks & Wildl. Serv., Endangered Species Programme, Project No.* 4. Pks & Wildl. Serv., Hobart.

TINDALE, M.D., 1987: Taxonomic notes on three Australian and Norfolk Island species of *Glycine* Willd. (Fabaceae: Phaseolae) including the choice of a neotype for *G. clandestina* Wendl. *Brunonia* 9: 179–191.

WEBER, J.Z., 1986: Subfamily 3 — Papilionoideae. *In* Jessop, J.P. & Toelken, H.R. (Eds): *FLORA OF SOUTH AUSTRALIA. PART II. LEGUMINOSAE–RUBIACEAE.* South Australian Government Printing Division, Adelaide & the Flora and Fauna of South Australia Handbooks Committee: 569–709.

(accepted 3 August 1993)

Selected Glossary

(adapted from Curtis & Morris 1975)

areolae:	spaces, usually angular, marked out on a surface by ridges or cracks
caducous:	falling at an early stage or prematurely
chasmogamous:	of flowers which are cross-pollinated
cleistogamous:	of flowers which are self-fertilised
petiolule:	the stalk of a leaflet
stipel:	one of a pair of outgrowths that may occur at the base of a leaflet stalk, i.e. stipule of a leaflet
trifoliolate:	having a compound leaf or leaves each with three leaflets

VARIATION IN *EUCALYPTUS BARBERI* L. JOHNSON & BLAXELL

by A.C. McEntee, B.M. Potts and J.B. Reid

(with three tables and four text-figures)

McENTEE, A.C., POTTS, B.M. & REID, J.B., 1994 (30:vi): Variation in *Eucalyptus barberi* L. Johnson & Blaxell. *Pap. Proc. R. Soc. Tasm.* 128: 21–30. ISSN 0080–4703. Department of Plant Science, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001.

Phenetic variation within *Eucalyptus barberi* L. Johnson & Blaxell was examined and compared to related Tasmanian species. "Typical" northern populations were morphologically distinct from the more diverse group of populations to the south. This phenetic disjunction did not correspond to the major geographic disjunction in the range of *E. barberi*. Detailed study of two morphologically aberrant populations indicated that they probably arose from *in situ* hybridisation; however, the exact identities of the progenitor species remains unclear. The type locality and several of the "southern" populations, as well as aberrant populations at Meredith Tier and Ponybottom Creek, deserve formal conservation.

Keywords: *Eucalyptus barberi*, genetic variation, hybridisation, rare endemic, conservation, Tasmania.

INTRODUCTION

The past environment of the east coast is less well understood than that of other regions of Tasmania (e.g. southwestern Tasmania, MacPhail & Colhoun 1985). In addition, the Eastern Tiers have received little botanical study until relatively recently (Duncan *et al.* 1981, Kirkparrick 1981). Kirkpatrick & Brown (1984b) suggested that the geographic and habitat patterns of many species on the east coast result from limited radiation from separate glacial refugia. Their study of endemism in Tasmania suggested two centres of endemism on the east coast, implying at least two past glacial refugia (Kirkpatrick & Brown 1984b).

Eucalypts in this region exhibit interesting biogeographic and genetic patterns of uncertain origin. These include unexplained north–south range disjunctions (e.g. *Eucalyptus tenuiramis* – Wiltshire *et al.* 1991), absences from apparently suitable habitats in the northeastern mountains (*E. coccifera, E. urnigera, E. subcrenulata* and *E. johnstonii* – Potts 1990), and the unlikely presence of high-altitude species on low-altitude hills (*E. coccifera* – Shaw *et al.* 1984). In addition, species that are morphologically and ecologically distinct in the southeast appear to converge in both morphology and substrate preference in the east (*E. pulchella, E. amygdalina* and *E. tenuiramis* – Kirkpatrick & Brown 1984b). Other species exhibit marked genetic differentiation between eastern and southeastern populations (e.g. *E. cordata* – Potts 1989), and patches comprising individuals outside the typical phenotypic range of currently described species are regularly encountered (e.g. Potts 1989, Potts & Reid 1985b).

The present study examines population differentiation in the rare Tasmanian endemic *E. barberi*, that is distributed as a series of small, disjunct populations on the east coast of Tasmania (Kirkpatrick 1981, Pryor & Briggs 1981). In addition, several small, variable populations with some affinity to *E. barberi* are examined. *E. barberi* is restricted to the northern slopes of dry, low-altitude, dolerite ridges, most of which are unreserved crown or private land (Duncan 1989). *E. barberi* was first described informally by Barber (1954). It was formally described by Johnson & Blaxell (1972), who considered that it had obvious affinities to *E. ovata, E. camphora* and *E. yarraensis* and therefore placed it in the informal subseries *Ovatinae* (series *Ovatae*, section *Maidenaria*, subgenus *Symphyomyrtus*) of Pryor & Johnson (1971). Ladiges *et al.* (1981, 1984) included one population in phylogenetically oriented studies of juvenile and seedling characters within the series. Chippendale (1988) has since redefined the series *Foveolatae*, which also includes *E. aggregata, E. rodwayi* and *E. brookeriana* (Gray 1979). The affinities of *E. barberi* to other Tasmanian *Foveolatae* species are also examined.

MATERIALS AND METHODS

Sampling

Sites were chosen that encompassed the full geographic range of *E. barberi* (fig. 1, table 1), including the type locality (east Cherry Tree Hill; site 4). Representative samples of the other Tasmanian *Foveolatae* species (*E. brookeriana* A.M. Gray, *E. ovata* Labill. and *E. rodwayi* Baker & Smith) were also included for comparison with *E. barberi.*

Atypical phenotypes with some affinities to *E. barberi* grow at Meredith Tier (sites 10–11) and Ponybottom Creek (sites 12–13). At Meredith Tier, samples were located along a transect (4–8 trees from each of 7 sites) to capture a distinct spatial gradient of atypical phenotypes over about 1 km. Eleven trees were also sampled from an isolated stand, with apparent affinities to *E. barberi*, 1 km away (site 6). There was no evident spatial pattern of phenotypes at Ponybottom Creek. Consequently ten trees were sampled, in each of three subjective classes:

(1) narrow green foliage, resembling *E. barberi* (site 12),
(2) glaucous, broad-leaved phenotypes with apparent affinities to *E. gunnii* or *E. cordata* (site 13), and
(3) phenotypes intermediate between these extremes.

Nine trees were sampled from the nearest population with affinities to *E. barberi* (Ringrove Razorback, site 9), 1.5 km away. A range of eastern populations of *E. cordata, E. gunnii, E. archeri, E. johnstonii* and *E. subcrenulata* were sampled, including those proximal to the Meredith Tier (sites 10–11) and Ponybottom Creek (sites 12–13) sites, because

TABLE 1
Populations sampled for this study

Species	Sample location	Site code	AMG ref.* East	AMG ref.* North	Alt†. (m)	Popn‡ (min)	Number sampled§ AP	JP	AH	JH
Eucalyptus barberi	Blindburn Hill North	1	6022	53678	220	400	12	22	12	22
	Blindburn Hill South	2	6024	53663	200	30	11	24	11	24
	Cherry Tree Hill West	3	5943	53528	180	40	9	23	9	23
	Cherry Tree Hill East	4	5948	53518	170	60	12	16	12	16
	Brushy Creek	5	5762	53478	440	60	10	18	10	18
	Meredith Tier	6	5770	53297	400	30	11	35	–	–
	Lily Flats (South of)	7	5718	53161	320	60	13	25	13	25
	Ravensdale Hill	8	5713	53079	140	18	9	22	9	22
	Ringrove Razorback	9	5735	52713	160	30	9	21	–	–
Uncertain	Meredith Tier green	10					7	29	7	29
	intermediate	–	5767	53301	440	200	–	–	25	96
	glaucous	11					6	37	6	37
	Ponybottom Ck green	12					10	37	10	37
	intermediate	–	5736	52723	180	60	–	–	13	42
	glaucous	13					10	41	10	41
E. brookeriana	Buckbys Road	14	3633	54602	120	–	4	–	–	–
	Elephant Pass	15	6020	53908	390	–	–	4	–	–
	E. brookeriana type ¶	16	5705	53420	600	–	1	1	–	–
	Rocka Rivulet	17	5700	53205	450	–	2	5	–	–
	Kellevie Plateau	18	5670	52663	340	–	1	5	–	–
Pooled *E. brookeriana*		BR	sites: 14 – 18			–	8	18	–	–
E. ovata	Robbins Road	19	3210	54855	20	–	5	–	–	–
	Bass Highway	20	3990	54575	10	–	6	–	–	–
	W Road	21	5727	52758	40	–	8	13	–	–
	Hobart College	22	5250	52480	280	–	9	15	–	–
Pooled northwest coast *E. ovata*		WO	sites: 19 – 20			–	8	13	–	–
E. rodwayi	Steppes	23	4910	53375	800	–	–	19	–	–
	M Road South	24	5698	53233	580	–	7	12	–	–
E. cordata	Bluestone Tier	25	5652	52932	350	–	10	18	10	18
	Brown Mt	26	5428	52837	710	–	7	13	7	13
	Perpendicular Mt top	27	5933	52766	340	–	–	–	10	–
	Perpendicular Mt low	28	5930	52765	240	–	–	–	10	–
	Square Mt	29	5506	52695	370	–	9	6	9	6
	Hospital Creek	30	5673	52660	240	–	–	–	10	–
	Chimney Pot Hill	31	5225	52476	430	–	–	–	10	–
	Cape Queen Elizabeth	32	5345	52109	100	–	–	–	10	–
E. archeri	Mt Maurice	33	5490	54260	1000	–	–	13	–	13
E. gunnii	Mt Arthur NE	34	5208	54283	500	–	–	–	10	–
	Mt Victoria	35	5687	54228	790	–	–	–	20	–
	Snow Hill	36	5693	53592	950	–	–	–	25	15
	Pensford	37	4837	53487	960	–	–	–	20	–
	M Road North	38	5732	53298	640	–	11	32	11	32
E. johnstonii	Springs, Mt Wellington	39	5190	52490	600	–	–	10	–	–
	Snug Plains	40	5133	52330	600	–	–	5	16	–
E. subcrenulata	Dove Lake	41	4135	53870	960	–	–	12	–	–
	Lake Charles	42	4367	53633	1070	–	–	10	–	–

* Australian Map Grid reference. † Altitude (metres). ‡ Minimum estimate of population size for *E. barberi* populations.
§ Number of individuals sampled for population studies: variation in *E. barberi* and related species (AP = adults, JP = juveniles); aberrant populations at Meredith Tier and Ponybottom Creek, sites 10–13 and intermediates (AH =adults, JH = juveniles).
¶ Seed collected from open pollinated offspring from type specimen of *E. brookeriana*, grown as an ornamental.

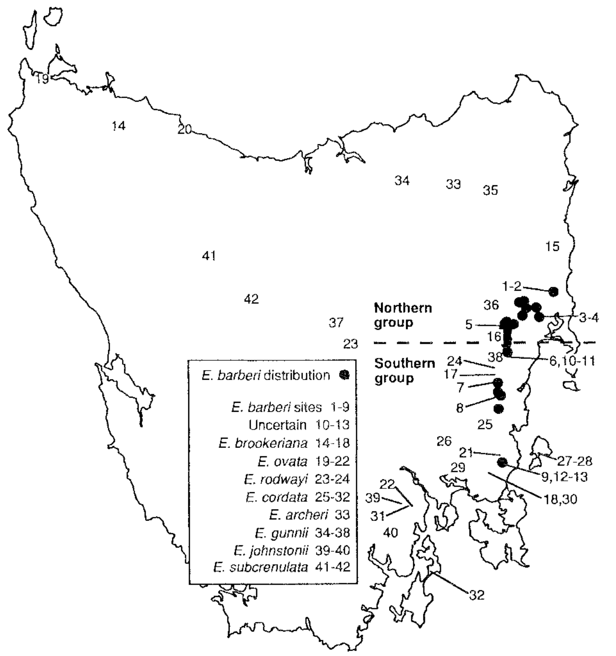

FIG. 1 — The known distribution of Eucalyptus barberi *(• — from Forestry Commission of Tasmania records) and locations of populations of all species sampled for this study (codes). (Location codes are detailed in table 1.) An explanation of "northern" and "southern" groups is given in the discussion.*

some atypical phenotypes showed affinities to these species. Adult data from previous studies were also used for *E. gunnii*, *E. archeri* (Potts & Reid 1985b) and *E. cordata* (Potts 1989). Open-pollinated seed, as well as three typical, mature canopy leaves and capsules, was collected from up to 13 trees, at least two tree-heights apart, from each *E. barberi* population (see table 1, AP).

Progeny trial

Seeds were germinated on a 1:1 vermiculite:gravel mix covered with a surface (20 mm) of vermiculite. At the cotyledonary stage (three weeks) plants were transplanted into black plastic potting bags filled with potting mix. Plants were grown under glasshouse conditions (day 19°–24°C, night 12°–14°C) with the natural photoperiod extended to 18 h by a mixed incandescent and fluorescent light source.

Four seedlings from each of approximately 12 families were used in the progeny trial and were placed in a completely random design. Between 16 and 25 individuals were scored for each typical *E. barberi* population (numbers sampled from each populations are shown in table 1, JP). *E. brookeriana* samples (sites 14–18) were pooled (BR) for the purposes of the analysis. Similarly, northwest coast *E. ovata* populations (sites 19–20) were treated as one population sample (WO).

Morphometric data collection and analysis

The characters scored from adult and juvenile plants are listed in table 2. Capsule and adult leaf characters are the same as those described in Potts & Reid (1985b). Adult data analysis was performed on the means of three replicates from each tree. Seedlings were scored six months after planting. Measurement of the juveniles was based upon characters (table 2) recognised as distinguishing *E. barberi* from other members of the *Foveolatae* (LAML8, LAMW8, LWP8, PETL8, RUG, GLAND, CREN, LATLEN, LATRAT and INTLEN), *E. johnstonii* and *E. subcrenulata* (DIARAT, COLOUR), and *E. cordata* and *E. gunnii* (LOBE8, GLAU, INTRANOD, PETNODE; Chippendale 1988). Juvenile leaf characters were measured from a leaf removed from the eighth node (counting the cotyledonary node as node 0), and stem characters from the eighth internode (below node 8). Categorical multistate characters measured on relative scales were scored by comparison with standards (GLAND, CREN, RUG, GLAU, COLOUR). DIARAT (diameter ratio = widest width/narrowest width at the same height on the stem) represented the rectangularity of the stem. INTLEN (mean internode length) was calculated as the height/ the number of internodes. LATRAT (lateral ratio = number of nodes with laterals/number of nodes) represented the proportion of the plant bearing lateral branches.

The pooled within-population residuals for each variable were tested for normality, using the UNIVARIATE procedure of SAS (SAS 1988). The relationship between residuals and fitted values, derived from the one-way GLM analysis (SAS 1988), was inspected in bivariate plots. Where necessary, transformations were used that optimised the normality and homogeneity of variance criteria. Variables and transformations used in the analysis are shown in table 2. Stepwise discriminant analysis (STEPDISC procedure of SAS) found that all variables were significant ($p < 0.05$) in separating populations.

Parametric canonical discriminant analysis was performed using the CANDISC procedure of SAS; this produced discriminant functions, which maximised the separation of populations. Means and standard errors were calculated for each population from the individual scores along the discriminant functions. The relative importance of different characters in differentiating populations, and their direction of variation in the discriminant space, were summarised by plotting vectors, the lengths of which are proportional to the univariate F-values, the directions being determined by the standardised canonical coefficients of the relevant discriminant functions. Populations were also clustered, using average linkage cluster analysis (Sneath & Sokal 1973) based on the matrix of Mahalanobis' distances. Mahalanobis' distances between populations were calculated from the squared Euclidean distance between populations, in the space defined by the first nine discriminant axes (representing 99.3% of adult and 94.9% of juvenile variation for the populations shown in fig. 3). This procedure was applied to adult and juvenile (table 1: AP, JP respectively) *E. barberi* (sites 1–9) and other *Foveolatae* populations (*E. brookeriana* – BR; *E. ovata* – WO, sites 21–22; *E. rodwayi*, sites 23–24), including the green phenotypes resembling *E. barberi* from Meredith Tier (site 10) and Ponybottom Creek (site 12). For comparison with other species, this analysis was repeated, with the addition of samples from populations of *E. johnstonii* (sites 39–40), *E. subcrenulata* (sites 41–42), *E. gunnii-archeri*

TABLE 2
Morphological characters measured for this study

Code	Description	Scale*	Trans.†	Significance‡	
Adult leaf characters				$F_{15,140}$	Pr>F
LL	Lamina length	mm	log	8.42	0.0001
LW	Lamina width	mm	log	13.9	0.0001
LWP	Length to widest point	mm	log	4.73	0.0001
PET	Petiole length	mm	log	8.93	0.0001
Adult capsule characters					
PEDI	Pedicel length	mm	log	9.39	0.0001
PEDU	Peduncle length	mm	log	6.71	0.0001
CAPL	Capsule length	mm	log	19.2	0.0001
MAXW	Capsule max. width	mm	log	13.8	0.0001
PTMW	Length to max. width	mm	log	6.69	0.0001
RIMW	Rim width	mm	square	5.18	0.0001
VPOS	Valve thickness	(1–4)	square	2.92	0.0005
VSIZE	Valve size	(1–4)	log	1.97	0.0212
Juvenile leaf characters				$F_{15,333}$	
LAML8	Lamina length	mm	–	4.85	0.0001
LAMW8	Lamina width	mm	–	13.2	0.0001
LWP8	Length to widest point	mm	–	5.81	0.0001
PETL8	Petiole length	mm	–	1.58	0.0001
LOBE8	Lobe length from leaf base to bottom of lobe	mm	–	7.63	0.0001
GLAND	Gland density on leaf	(1–4)	–	8.27	0.0001
CREN	Crenulation of margin	(1–3)	–	5.51	0.0001
Juvenile stem characters					
RUG	Rugoseness	(1–3)	log	14.7	0.0001
DIARAT	Stem rectangularity	–	–	2.53	0.0014
Juvenile whole plant characters					
INTRANOD	Node 1st intranode	–	–	10.6	0.0001
PETNODE	Node of 1st petiole	–	–	9.32	0.0001
INTLEN	Mean internode length	mm	–	7.04	0.0001
LATLEN	Length longest lateral	mm	–	4.13	0.0001
LATRAT	Lateral ratio	–	–	3.14	0.0001
GLAU	Glaucousness	(0–8)	–	3.12	0.0001
COLOUR	Max. node where anthocyanin occurs on the undersurface of the leaf 0–10 × Depth of colour (0, 1, ... 3)	(0–30)	–	2.15	0.0079

* Numbers in parentheses represent relative scales.
† Transformation used.
‡ Univariate significance of variation in each character between populations in the series *Foveolatae*.

(sites 33, 36, 38), *E. cordata* (sites 25–26, 29), and the most glaucous phenotypes from Meredith Tier (site 11) and Ponybottom Creek (site 13).

For analysis of the Meredith Tier and Ponybottom Creek samples, quadratic discriminant functions were calculated for both adult and juvenile data sets, which maximised the separation between typical populations of *E. barberi* (sites 1–5, 7–8), *E. gunnii* (sites 34–38) and *E. cordata* (sites 25–32). The latter procedure takes into account the differences in variance/covariance structures between species. Mean discriminant scores and 95% confidence intervals for individuals from the reference groups were calculated. Discriminant scores for individuals from Meredith Tier (sites 10–11 and intermediates) and Ponybottom Creek (sites 12-13 and intermediates) were also calculated on the two discriminant functions derived from this analysis.

In order to determine whether an individual falls within the range of variation encompassed by each reference species (*E. barberi, E. gunnii, E. cordata*), the generalised distance of each individual tree from the centroid of each species, and its significance were calculated according to equations 5.1 and 5.2b in Orlóci (1978), using separate variance–covariance matrices for each species (and equal sample sizes). An individual was classified as falling within the range of variation encompassed by a species if the probability of obtaining the observed generalised distance due to chance alone was greater than 0.05 (i.e. the individual falls within the multivariate 95% confidence interval of the species). For each of the three reference species, the proportions of adult individuals in each population that matched the reference species phenotype were calculated, as well as the proportion of individuals whose phenotype did not match

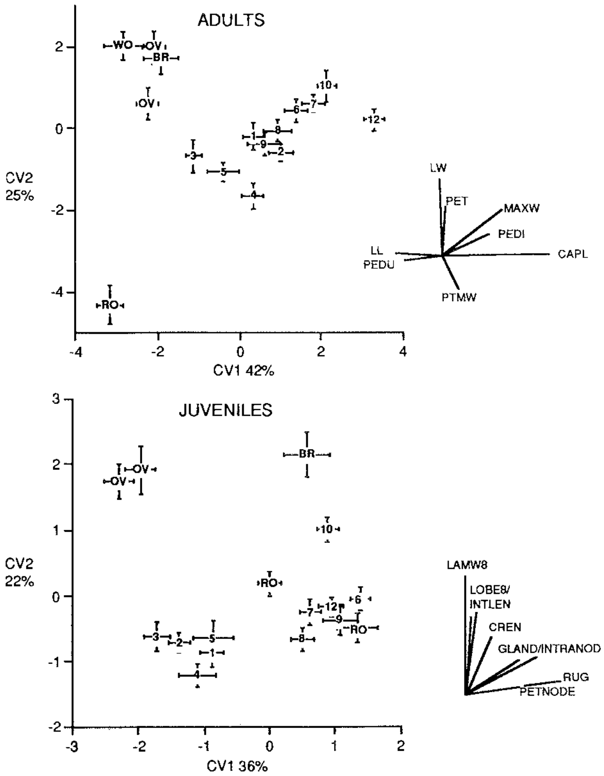

FIG. 2 — Population means and standard errors along the two major discriminant functions (CV1, CV2) derived from the analysis of adult (upper) and juvenile (lower) population samples from northern (sites 1–5) and southern (sites 6–9) populations of Eucalyptus barberi, E. brookeriana *(BR),* E. ovata *(OV, WO),* E. rodwayi *(RO) and green phenotypes resembling* E. barberi *from Meredith Tier (site 10) and Ponybottom Creek (site 12). Vectors represent the direction (derived from the standardised discriminant function coefficients) and magnitude (derived from the univariate F-values) of variation in characters between populations. The percentage of the total variance explained by each discriminant function is indicated. (Location codes detailed in table 1.)*

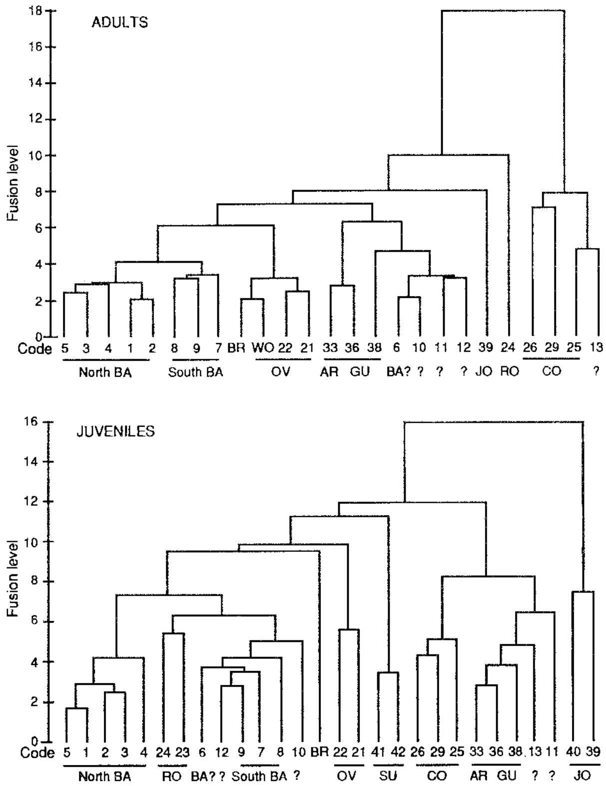

FIG. 3 — Dendrogram from average linkage clustering of adults (upper) and juveniles (lower) from populations of Eucalyptus barberi *(BA),* E. brookeriana *(BR),* E. ovata *(OV),* E. rodwayi *(RO),* E. archeri *(AR),* E. gunnii *(GU),* E. cordata *(CO),* E. johnstonii *(JO),* E. subcrenulata *(SU) and aberrant populations (?). (Location codes detailed in table 1.)*

any of the three species. Where there is phenetic overlap between species, some individuals may fall within the 95% confidence intervals of more than one species; hence, the proportions may sum to more than 100%. In the juveniles, only the proportion that matched the phenotype of *E. barberi* was calculated, since samples sizes of juvenile *E. gunnii* and *E. cordata* were insufficient to represent the species' full phenetic ranges.

RESULTS

The mean scores of the series *Foveolatae* populations on the first two discriminant axes derived from the adult and juvenile data are shown in figure 2. Clusters produced from this analysis proved to be subsets of those produced by the analysis including other species (fig. 3).

E. barberi (sites 1–9) and green samples from Meredith Tier and Ponybottom Creek with apparent affinities to *E. barberi* (sites 10, 12) were well separated from the other *Foveolatae* species (BR, OV, WO, RO) in the discriminant space derived from the analysis of adult morphological traits. However, they were not well differentiated from *E. rodwayi* (RO) in the juvenile analysis (figs 2 & 3). *E. ovata* (OV, WO) was quite distinct from *E. barberi* and *E. rodwayi* (RO) in adult and juvenile morphology. *E. brookeriana* is closer to *E. ovata* in adult morphology, particularly the northwestern samples (WO, fig. 3), but equidistant and distinct from other species in juvenile morphology.

On juvenile morphology, *E. barberi* populations fell into two distinct groups: sites 1–5 and sites 6–9, 10, 12 (fig. 3). These correspond geographically to a northern and a southern group (fig. 1). In the cluster analysis, which incorporates a larger proportion of variation than the ordination, this pattern is also apparent in the adults (fig. 3). Southern populations (sites 6–9, 10, 12) exhibited greater variation in adult than juvenile morphology. In particular, the green samples with apparent affinities to *E. barberi* from Meredith Tier (sites 6, 10) and Ponybottom Creek (site 12) were separated from other southern populations of *E. barberi* (fig. 3). The northern and southern *E. barberi* populations differed in capsule traits (larger, more pedicellate capsules in southern populations), and seedlings from southern populations retained the juvenile foliage longer than northern populations (expressed as higher node of first intranode and petiole; fig. 2).

At Meredith Tier (sites 10–11) and Ponybottom Creek (sites 12–13), phenotypes varied from narrow, green-leaved individuals with seven medium-sized fruit per umbel, typical of *E. barberi,* to individuals with broad, glaucous leaves and three large fruit per umbel, resembling *E. cordata.* The

TABLE 3
Comparison of samples with the phenotypic ranges of three eucalypt species*

Collected as		Code (Site)		Classification† *E. barberi* %	*E. cordata* %	*E. gunnii* %	None test sp. %	n
E. barberi		1	adults	100	0	17	0	12
			juveniles	100	–	–	–	22
		2	adults	100	0	18	0	11
			juveniles	96	–	–	–	24
		3	adults	100	0	0	0	9
			juveniles	100	–	–	–	23
		4	adults	100	0	0	0	12
			juveniles	94	–	–	–	16
		5	adults	100	0	0	0	10
			juveniles	83	–	–	–	18
		6	adults	45	0	27	36	11
			juveniles	63	–	–	–	35
		7	adults	100	0	8	0	13
			juveniles	92	–	–	–	25
		8	adults	100	0	11	0	9
			juveniles	91	–	–	–	22
		9	adults	89	0	11	11	9
			juveniles	86	–	–	–	21
Meredith Tier	green	10	adults	57	0	43	29	7
			juveniles	59	–	–	–	29
	intermediate	–	adults	43	0	30	44	23
			juveniles	27	–	–	–	96
	glaucous	11	adults	13	0	13	88	8
			juveniles	14	–	–	–	37
Ponybottom Ck	green	12	adults	30	0	40	50	10
			juveniles	51	–	–	–	37
	intermediate	–	adults	0	0	0	100	13
			juveniles	45	–	–	–	42
	glaucous	13	adults	0	10	0	90	10
			juveniles	12	–	–	–	41
Summary:								
E. barberi		all	adults	93	0	10	5	96
			juveniles	88	–	–	–	206
E. cordata		all	adults	0	100	0	0	76
			juveniles	0	–	–	–	37
E. gunnii		all	adults	11	0	96	3	76
			juveniles	7	–	–	–	46
Meredith Tier		all	adults	39	0	30	50	38
			juveniles	30	–	–	–	162
Ponybottom Ck		all	adults	9	3	12	82	33
			juveniles	36	–	–	–	120

* The percentage of individuals in each sample which were not significantly different ($p > 0.05$) from *E. barberi*, *E. cordata* and *E. gunnii*, and the percentage matching none of the reference species. The percentage of individuals of the reference species which were not significantly different from the reference groups is shown, for comparison with samples from Meredith Tier and Ponybottom Creek. Dash (–) indicates sample not tested. Due to overlap between reference groups, percentage may not total 100%.
† Based on generalised distance.

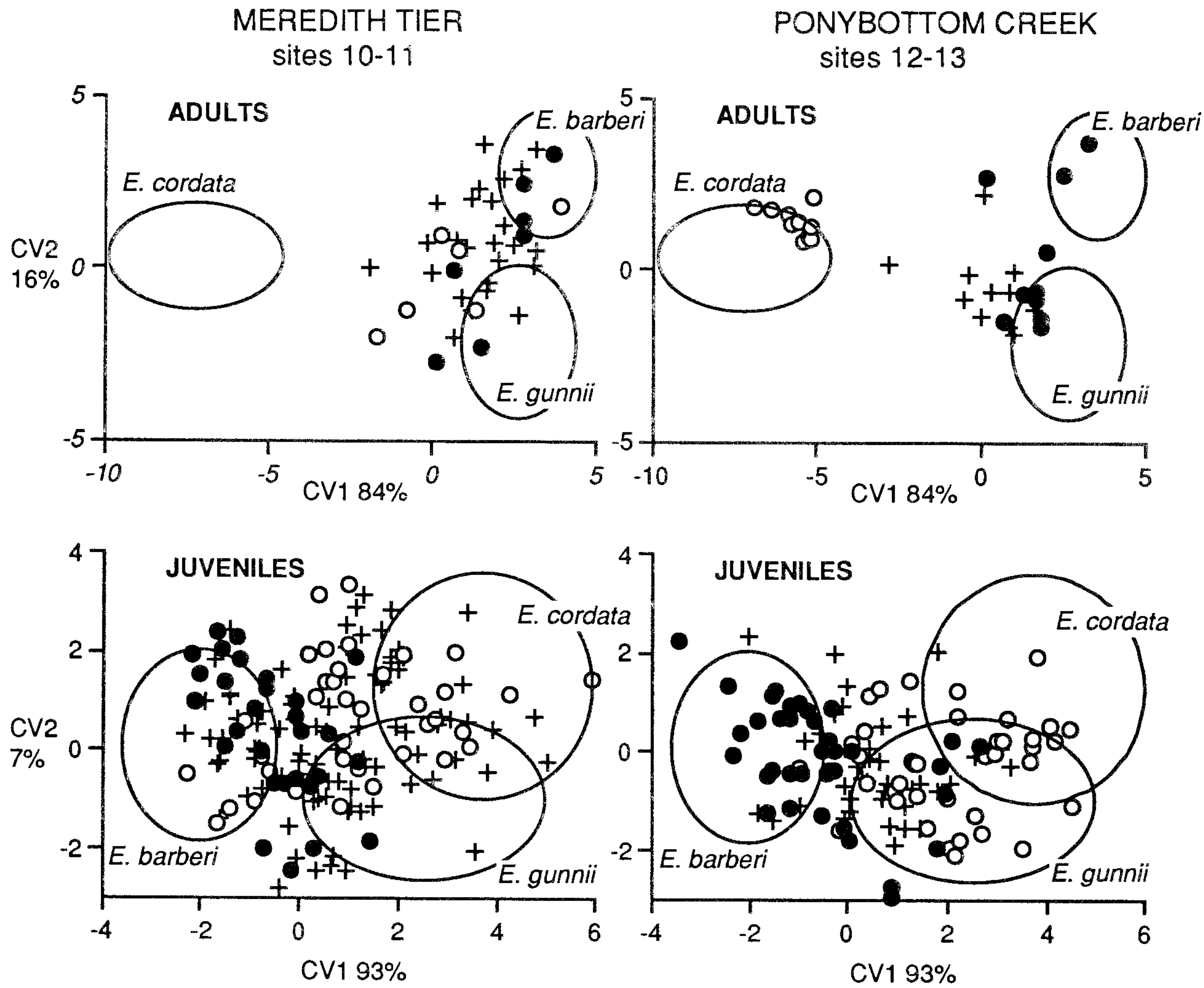

FIG. 4 — Plots of adults (upper) and juveniles (lower) from Meredith Tier (left) and Ponybottom Creek (right) on the axes derived from the discriminant analysis of typical Eucalyptus barberi, E. cordata *and* E. gunnii *samples. The percentage of variance represented by each discriminant function is shown. Ellipses represent the 95% confidence intervals for individuals of the three reference species.* ● *– green adults resembling* E. barberi *(upper), and their juvenile progeny (lower).* O *– glaucous adults and their juvenile progeny.* + *– intermediate adults and their juvenile progeny.*

slightly isolated populations at Meredith Tier (site 6) and Ringrove Razorback (site 9) resembled *E. barberi* in leaf characters, but varied in bud number, from three to seven per umbel. *E. gunnii*, which occurs in the vicinity of the Meredith Tier population, has narrow adult leaves similar to *E. barberi*, but has three small buds per umbel.

Samples from Meredith Tier and Ponybottom Creek were ordinated in the discriminant space differentiating core populations of *E. barberi*, *E. cordata* and *E. gunnii* (fig. 4). Overlap of the juvenile discriminant scores of the reference *E. cordata* and *E. gunnii* populations (fig. 4, ellipses) indicates that these species were less distinct from one another in the juvenile than adult stages. Tests of the significance of the generalised distance between individuals and the centroids of the three reference species are shown in table 3. It is expected, in theory, that 95% of typical species' samples would not differ significantly from the corresponding reference group. In this case, 93–100% of adults of the three species and 88% of *E. barberi* juveniles were correctly classified. There was some overlap in the ranges of *E. barberi* and *E. gunnii* adults, with 8–10% of adults of both species falling within the 95% confidence intervals of the other species.

The pattern observed for the reference populations contrasts markedly with the classification results from the anomalous populations at Meredith Tier and Ponybottom Creek. Most adults from Meredith Tier fell outside the 95% confidence intervals of all three reference species; 50% overall and 88% of the glaucous individuals were outside the confidence intervals of all the reference species (table 3). Those that did match were similar to *E. barberi* and *E. gunnii* in approximately equal proportions (39% and 30% respectively) and, overall, the Meredith Tier population showed similarities to *E. gunnii* in the cluster analysis (fig. 3). The adults from Meredith Tier deviated slightly toward, but were not within the phenotypic range of *E. cordata* (fig. 4). A large proportion of the juveniles from Meredith Tier were also outside the ranges of all three reference species and most were intermediate between the reference species (fig. 4). Cluster analysis of the juveniles placed the green sample from Meredith Tier (site 10) as an outlier to the *E. barberi* populations and the glaucous sample (site 11) closest to *E. gunnii* (fig. 3).

In the full multidimensional space, 82% of the Ponybottom Creek adults were outside the 95% confidence intervals of all three reference species (table 3), with a small proportion of the remainder ascribed to each species. The green individuals (site 12) were divided between *E. barberi* (30%) and *E. gunnii* (40%). Only one individual from the intermediate and glaucous (site 13) samples matched a reference species (*E. cordata*), but the glaucous individuals appeared closest to the *E. cordata* populations in the cluster analysis (fig. 3), and were very close to the adult phenotype of *E. cordata* (fig. 4). A greater proportion of Ponybottom Creek juveniles matched the phenotype of *E. barberi* (36%) compared with the adults (9%, table 3). Most juveniles appeared intermediate between *E. barberi* and *E. gunnii*, but there was overlap with, and deviation toward the phenotypic range of *E. cordata* (fig. 3).

The range of variants observed in the juvenile progeny from both Meredith Tier and Ponybottom Creek (from all phenotypic classes collected) and the intermediate phenotypes of the parents strongly suggested parental heterozygosity rather than simple outcrossing. For example, recombination of leaf shape and glaucousness was very apparent in progeny of one intermediate individual from Meredith Tier.

DISCUSSION

Significant differentiation, in both adult and juvenile characters, was found between most populations of *E. barberi*. A seedling trial clearly indicated that this differentiation has a strong genetic basis. There appeared to be a primary division between a northern group of populations that may be designated "typical" *E. barberi* and other, southern, populations which deviated toward the phenotype of other species (fig. 1). There was no clear clinal or consistent spatial pattern of variation within each group. The "typical" group comprised populations from Cherry Tree Hill (sites 3–4), Brushy Creek (site 5) and the vicinity of Blindburn Creek (sites 1–2, in the Douglas-Apsley National Park). Within this group, phenetic distance was poorly correlated with geographic distance. The southern group comprised *E. barberi* populations from Ravensdale Hill (site 8), 1.5 km south of Lily Flats (site 7) and the green phenotypes resembling *E. barberi* from Meredith Tier (6, 10), Ponybottom Creek (site 12) and Ringrove Razorback (site 9). Some southern populations showed affinities to juvenile *E. rodwayi* but were quite distinct on adult traits. Conversely, several of the southern populations (sites 6, 10, 12) showed affinities toward *E. gunnii* in their adult morphology (fig. 3) but were clearly differentiated from *E. gunnii* and *E. archeri* on juvenile morphology. In most cases, they would also have been differentiated from these species on the basis of the number of buds per inflorescence, which was not included in the analysis (and was greater than the typical three of *E. gunnii* and *E. archeri*). They, therefore, appear to have closest affinities to *E. barberi*.

The high level of population differentiation found within *E. barberi* is typical of the population genetic structure that would be predicted by theory for a species distributed as a series of small disjunct populations (due to factors such as genetic drift – Falconer 1986) and has been observed in other eucalypt species with comparable distribution patterns (e.g. *E. caesia*, *E. pendens* – Moran & Hopper 1987; *E. crucis* – Sampson *et al.* 1988). Prober *et al.* (1990) suggest that such restricted distributions may result from recent divergence (with insufficient time for geographical radiation), barriers to dispersal (e.g. unsuitability of habitat, competition), or contraction of the range of an older species due to environmental factors (e.g. habitat specificity, climatic change). In this case, the degree and pattern of phenetic differentiation between *E. barberi* populations and the large disjunctions in its geographical range support Williams' (1990) contention that *E. barberi* is not a recently diverged species. *E. barberi* appears to be a relic species and has possibly been displaced from intervening sites by competition with more rapidly growing species.

It is only possible to speculate on the cause of differentiation in *E. barberi*. Genetic drift, localised selection, hybridisation and historical factors may all be involved. Kirkpatrick & Brown (1984a, b) and Potts & Reid (1985c) suggested that the present east coast flora may have originated from populations which differentiated in two glacial refugia. Such separation could explain differentiation of the northern and southern populations of *E. barberi*. However, the disjunct distribution of *E. barberi* does not appear to have been caused by insufficient time for radiation, as the major disjunction in the geographical distribution of *E. barberi* does not correspond to the phenetic disjunction (fig. 1). This contrasts with the coincidence of marked genetic differentiation with geographic disjunction in *E. tenuiramis* in the same area (Wiltshire *et al.* 1992). Disjunctions in the geographical distribution of *E. barberi* may not be as extensive as is shown by current records. Paucity of sampling may have occurred, due to the small population sizes (and area), inaccessibility and small size of the trees. There are, for example, unverified reports of other populations west of Triabunna (between sites 12–13 and site 8).

"Confusing intermediacy" (Kirkpatrick & Brown 1984b) is an apt description of the Meredith Tier and Ponybottom Creek populations. At both sites, the pattern of high diversity and intermediacy of parents and progeny, coupled with the high variability within some families, was consistent with a hybrid swarm, several generations old (e.g. Potts & Reid 1985a). The magnitude of the differences between extreme phenotypes was strongly suggestive of hybridisation, as was the distribution of extreme phenotypes at Meredith Tier. Although this may have been produced by disruptive selection from the gene pool of one species, no selective agency of sufficient magnitude was evident, particularly at Ponybottom Creek. At both localities, trees with close affinities to *E. barberi* appeared to be one of the parents. The exact identity of the other parent remains unclear. *E. cordata*, *E. gunnii* and possibly *E. morrisbyi* are the only plausible extant species. *E. morrisbyi* was not included in the progeny trial because of its extremely limited distribution (Wiltshire *et al.* 1990), and the fact that its juveniles would be difficult to distinguish from *E. gunnii* in hybrid combination (e.g. Potts 1989). At both Meredith Tier and Ponybottom Creek, extreme phenotypes did not resemble other members of the *Foveolatae*, and the involvement of *E. johnstonii* or *E. subcrenulata*, which has been reported from near Ponybottom Creek and on the Eastern Tiers (Brown *et al.* 1983), is unlikely, as the juveniles of these taxa are clearly differentiated from those of *E. barberi* and populations at Meredith Tier and Ponybottom Creek (fig. 3).

The unusual characteristics of the latter populations may have resulted from hybridisation between atypical populations of the species suggested. Such small, atypical populations of both *E. cordata* (Potts 1989) and *E. gunnii* (Potts & Reid 1985b) are numerous on the east coast and are still being found (e.g. *E. cordata* near Wielangta Hill, between site 12–13 and site 8). However, it remains to be ascertained whether the variation found at Meredith Tier and Ponybottom Creek and the deviation of these populations from typical *E. barberi* are due to past introgression or reflect genetic variation within *E. barberi* at these localities. Molecular techniques may best be able to resolve the identity of these populations.

Conservation status

At present one, albeit relatively large population of *E. barberi* is securely reserved, in the Douglas-Apsley National Park (sites 1–2). Another of the northern populations (Brushy Creek, site 5) is in the proposed Bluemans Creek state reserve (Williams 1989). Other populations, including the type locality (site 4), are unreserved. The type locality also contains other rare species (*Spyridium microphyllum, Helichrysum lycopodioides, Melaleuca pustulata, Cyathodes pendulosa* and *Gahnia graminifolia* – Duncan & Duncan 1984) and has been previously recommended for reservation (Duncan & Brown 1985).

There is a need to extend conservation measures to encompass the full range of variability in this species. In particular, the type locality, representatives of the southern phenetic group (e.g. "south of Lily flats" – site 7; "Ravensdale Hill" – site 8) and outlying populations such as Meredith Tier (sites 6, 10–11), Ringrove Razorback (site 9) and Ponybottom Creek (site 12-13) should be formally reserved. The latter populations are also of scientific interest. *E. barberi* populations are generally small, particularly the southern populations (table 1), which would argue for reservation of multiple representatives of each of the major phenetic groups.

ACKNOWLEDGEMENTS

Thanks to Fred Duncan and Kristen Williams for providing location information for *E. barberi* (from records of the Forestry Commission, Tasmania), and Rob Wiltshire for helpful comments on the manuscript.

REFERENCES

BARBER, H.N., 1954: A sterile eucalypt. *Pap. Proc. R. Soc. Tasm.* 88: 285–287.

BROWN, M.J., KIRKPATRICK, J.B. & MOSCAL, A., 1983: *AN ATLAS OF TASMANIA'S ENDEMIC FLORA.* Tasmanian Conservation Trust, Tasmania.

CHIPPENDALE, G.M., 1988: *FLORA OF AUSTRALIA, VOL. 19. EUCALYPTUS, ANGOPHORA* (MYRTACEAE). Australian Government Publishing Service, Canberra.

DUNCAN, F., 1989: Systematic affinities, hybridisation and clinal variation within Tasmanian eucalypts. *Tasforests* 2: 13–24.

DUNCAN, F. & BROWN, M.J., 1985: Dry schlerophyll vegetation in Tasmania. Extent and conservation status of the communities. *Wildlife Div. Tech. Rep.* 85/1. National Parks and Wildlife Service, Tasmania.

DUNCAN, F. & DUNCAN, D., 1984: A dry sclerophyll woodland mosaic: vegetation of Cherry Tree Hill, near Cranbrook, Tasmania. *Rec. Queen Vic. Mus.* 85: 1–15.

DUNCAN, F., HARRIS, S. & BROWN, M.J., 1981: A descriptive account of the forests near Rocka Rivulet, Eastern Tiers. *Tasm. Nat.* 67: 4–11.

FALCONER, D.S., 1986: *INTRODUCTION TO QUANTITATIVE GENETICS.* John Wiley and Sons, New York.

GRAY, A.M., 1979: A new species of *Eucalyptus* from Tasmania. *Aust. For. Res.* 9: 111–118.

JOHNSON, L. & BLAXELL, D., 1972: New taxa and combinations in *Eucalyptus* I. *Contrib. NSW Nat. Herb.* 4: 284–290.

KIRKPATRICK, J.B., 1981: A transect study of forests and woodlands on dolerite in the Eastern Tiers, Tasmania. *Vegetatio* 44: 155–163.

KIRKPATRICK, J.B. & BROWN, M.J., 1984a: A numerical analysis of Tasmanian higher plant endemism. *Bot. J. Linn. Soc.* 88: 165–183.

KIRKPATRICK, J.B. & BROWN, M.J., 1984b: The palaeogeographic significance of local endemism in Tasmanian higher plants. *Search* 15: 112–113.

LADIGES, P.Y., GRAY, A.M. & BROOKER, M.I.H., 1981: Pattern of geographic variation, based on seedling morphology, in *Eucalyptus ovata* Labill. and *E. brookeriana* A. M. Gray and comparisons with some other *Eucalyptus* species. *Aust. J. Bot.* 29: 593–603.

LADIGES, P.Y., DALE, M.B., ROSS, D.R. & SHIELDS, K.G., 1984: Seedling characters and phylogenetic relationships in the informal series *Ovatae* of *Eucalyptus*, subgenus *Symphyomyrtus. Aust. J. Bot.* 32: 1–13.

MACPHAIL, M.K. & COLHOUN, E.A., 1985: Late last glacial vegetation, climates and fire activity in southwest Tasmania. *Search* 16: 43–45.

MORAN, G.F. & HOPPER, S.D., 1987: Conservation of the genetic resources of rare and widespread eucalypts in remnant vegetation. *In* Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M. (Eds): *NATURE CONSERVATION: THE ROLE OF REMNANTS OF NATIVE VEGETATION.* Surrey Beatty and Sons, Chipping Norton: 151–162.

ORLÓCI, L., 1978: *MULTIVARIATE ANALYSIS IN VEGETATION RESEARCH.* Dr W. Junk, The Hague.

POTTS, B.M., 1989: Population variation and conservation status of a rare Tasmanian endemic, *Eucalyptus cordata. Res. rep.* 4. Tasmanian Forest Research Council Inc.

POTTS, B.M., 1990: The response of eucalypt populations to a changing environment. *Tasforests* 2: 179–193.

POTTS, B.M. & REID, J.B., 1985a: Analysis of a hybrid swarm between *Eucalyptus risdonii* Hook.f. and *E. amygdalina* Labill. *Aust. J. Bot.* 33: 543–562.

POTTS, B.M. & REID, J.B., 1985b: Variation in the *Eucalyptus gunnii-archeri* complex. I. Variation in the adult phenotype. *Aust. J. Bot.* 33: 337–359.

POTTS, B.M. & REID, J.B., 1985c: Variation in the *Eucalyptus gunnii-archeri* complex. II. The origin of variation. *Aust. J. Bot.* 33: 519–541.

PROBER, S.M., TOMPKINS, C., MORAN, G.F. & BELL, J.C., 1990: The conservation genetics of *Eucalyptus paliformis* L. Johnson et Blaxell and *E. parvifolia* Cambage, two rare species from south-eastern Australia. *Aust. J. Bot.* 38: 79–95.

PRYOR, L.D. & BRIGGS, J.D., 1981: *AUSTRALIAN ENDANGERED SPECIES: EUCALYPTS.* Australian National Parks and Wildlife Service, Canberra.

PRYOR, L.D. & JOHNSON, L.A.S., 1971: *A CLASSIFICATION OF THE EUCALYPTS.* Australian National University Press, Canberra.

SAMPSON, J.F., HOPPER, S.D. & JAMES, S.H., 1988: Genetic diversity and the conservation of *Eucalyptus crucis* Maiden. *Aust. J. Bot.* 36: 447–460.

SAS, 1988: *SAS/STAT™ USER'S GUIDE RELEASE 6.03 EDITION.* SAS Institute, Cary, NC.

SHAW, M.J., POTTS, B.M. & REID, J.B., 1984: Variation within and between *Eucalyptus nitida* Hook. f. and *E. coccifera* Hook. f. *Aust. J. Bot.* 32: 641–654.

SNEATH, P.H.A. & SOKAL, R.R., 1973: *NUMERICAL TAXONOMY.* W.H. Freeman and Co., San Francisco.

WILLIAMS, K., 1989: *DRY SCLEROPHYLL FOREST IN TASMANIA. RECOMMENDED AREAS FOR PROTECTION.* A Report to the Working Group for Forest Conservation. Tasmanian Forestry Commission, Hobart.

WILLIAMS, K., 1990: Environmental modelling of Tasmanian plant species. Unpubl. BSc Hons thesis, Univ. Tasm.

WILTSHIRE, R., POTTS, B.M. & REID, J.B., 1990: Phenetic affinities, variability and conservation status of a rare Tasmanian endemic, *Eucalyptus morrisbyi* R. G. Brett. *In* Banks, M.R., Smith, S.J., Orchard, A.E. & Kantvilas, G. (Eds): *ASPECTS OF TASMANIAN BOTANY — A TRIBUTE TO WINIFRED CURTIS.* Royal Society of Tasmania, Hobart: 213–229.

WILTSHIRE, R.J.E., POTTS, B.M. & REID, J.B., 1991: A paedomorphocline in *Eucalyptus*: Natural variation in the *E. risdonii*/*E. tenuiramis* complex. *Aust. J. Bot.* 39: 545–566.

WILTSHIRE, R.J.E., POTTS, B.M. & REID, J.B., 1992: A paedomorphocline in *Eucalyptus*. II: Variation in seedling morphology in the *E. risdonii*/*E. tenuiramis* complex. *Aust. J. Bot.* 40: 789–805.

(accepted 17 November 1993)