KANUNNAH

Research Journal of the
Tasmanian Museum and Art Gallery

VOLUME 1 (2005)

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Ka-nunnah – 'Thylacine'

The oldest fossils of thylacines are Late Oligocene to Middle Miocene in age (20–25 Million B.P.) and are from the Riversleigh deposits in north-western Queensland (Vickers-Rich et al. 1991). It is speculated that competition with introduced dingoes in mainland Australia may have caused their extinction in mainland Australia during the last 5000 years. The most recent remains of thylacines in mainland Australia were dated at just over 3000 years old (Archer 1974).

The Thylacine *(Thylacinus cynocephalus)* in Tasmania coexisted with Aboriginal people for millennia. The arrival of Europeans in Tasmania resulted, in just over a hundred years, in the extinction of thylacines from their last refuge. The demise of the Thylacine resulted in the extinction of an entire lineage of marsupials from the planet.

To the Aboriginal people of Tasmania the thylacine was called many things due to its wide spread distribution in the State. Tribes from the areas of Mount Royal, Bruny Island, Recherche Bay, and the south of Tasmania referred to the Tiger as 'Ka-nunnah' or 'Laoonana', while tribes from Oyster Bay to Pittwater called it 'Langunta' and the North-west and Western Tribes called it 'Loarinnah' (Milligan 1859). Famous Tasmanian Aboriginal chief Mannalargenna from the East Coast of Tasmania called the thylacine Cab-berr-one-nen-er, while Truganinni and Worrady, (Bruny Island) called it Can-nen-ner.

The Thylacine is the state logo for Tasmania. The title of the Journal 'Kanunnah' commemorates the Tasmanian Aboriginal word used by tribes from southern Tasmania for the thylacine.

Archer M. (1974) New information about the Quaternary distribution of the thylacine (Marsupialia: Thylacinidae) in Australia. *Journal and Proceedings of the Royal Society of Western Australia* 57: 43–50.

Milligan J. (1859) Vocabulary of dialects of Aboriginal Tribes of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 3(2): 239–282.

Vickers-Rich P., Monaghan J.M., Baird R.F., and Rich T.M. (1991) Vertebrate Palaeontology of Australasia. (Monash University Publications Committee: Melbourne).

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Publication Date: 30 June 2005

KANUNNAH

The Research Journal of the Tasmanian Museum and Art Gallery

The Tasmanian Museum and Art Gallery is a combined Museum, Art Gallery and State Herbarium. It has the broadest collection range of any single institution in Australia and these collections span the arts, sciences, history and technology. The Tasmanian Museum and Art Gallery's role is to collect, conserve and interpret material evidence on the State's natural history and cultural heritage.

Kanunnah is a peer-reviewed journal published by the Tasmanian Museum and Art Gallery in Hobart, Tasmania. Its aim is to disseminate research in all areas of study undertaken by the Tasmanian Museum and Art Gallery. These areas include the life sciences, culture, history and the arts. Papers on any of these research areas will be considered, but papers dealing with Tasmanian, southern Australian and sub-Antarctic issues will be particularly welcome.

Short communications and reviews are also welcome. Researchers based outside the institution are encouraged to submit manuscripts for publication to the journal, although they must be relevant to the Museum's primary areas of study.

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Website: http://www.tmag.tas.gov.au/AboutUs/Journal.html

Cover illustration: Bumblebee *(Bombus terrestris)* Queen *del.* Mike Tobias

Kanunnah 1: 1–125 June 2005

Managing Editor: Andrew C. Rozefelds
Computer Layout and Design: Lexi Clark
Printer: Focal Printing
ISSN1832-536X

Tasmania
TASMANIAN MUSEUM
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The Tasmanian Museum and Art Gallery would like to acknowledge the assistance of the Clarence City Council in publishing the inaugural issue of *Kanunnah*.

KANUNNAH

Volume 1 (2005)

CONTENTS

A REVISION OF THE SPECIES OF *VITTADINIA* (ASTERACEAE) IN TASMANIA

Alan M. Gray and Andrew C. Rozefelds

Gray, A. M. and Rozefelds, A. C. 2005. A revision of the species of *Vittadinia* (Asteraceae) in Tasmania. *Kanunnah* 1: 1–16. ISSN1832-536X. Five species of *Vittadinia* are recognised from Tasmania. A new species *Vittadinia burbidgeae* A.M.Gray & Rozefelds is proposed. This species is similar to *V. muelleri*, but differs from it in the absence of strigose hairs on the leaves, the appearance of the alveolae on the receptacle, and in the vestiture of the cypsela. The morphology, distribution and conservation status of each species is examined. A key to the species in Tasmania is included and their conservation status under the *Tasmanian Threatened Species Protection Act* 1995 is briefly discussed. *Vittadinia megacephala* is considered to have been recorded in error from the State.

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KEY WORDS: *Vittadinia*, Asteraceae, Tasmania, New Holland Daisy, conservation status, rare, endangered.

Native grasslands are amongst the most endangered plant communities in Tasmania. The New Holland Daisies *(Vittadinia)* are largely restricted to grassland communities in the State, and all species in this genus are considered rare or endangered under the *Tasmanian Threatened Species Protection Act* 1995. Burbidge (1982) recognised 29 species of *Vittadinia,* and showed that it was essentially an Australian genus, with one species each in New Zealand and New Caledonia. In all species of *Vittadinia* the embryo occupies an apical position in the cypsela, and does not completely fill the cypsela, and this morphological character distinguishes it from other closely related taxa in the Astereae (Lowrey et al. 2001).

Bentham (1867) provided the first assessment of the number of species in the State and recorded a single *Vittadinia* species, *V. australis* A.Rich. and the variety *megacephala* F.Muell. ex Benth. from Tasmania. Rodway (1907) recognised only *V. australis* from the State. *Vittadinia australis* is considered to be a New Zealand species (Black 1929) and the name was applied by Bentham (1867) and Rodway (1903) to the Australian species in error. Curtis (1963) referred the Tasmanian material to *Vittadinia triloba*

(Gaud.) DC., and she recognised two varieties, var. *lanuginosa* J.M.Black and var. *megacephala* F.Muell. as occurring in the State. Black (1929) raised var. *megacephala* to specific status, but Curtis (1963) treated it as having varietal status in the *Student's Flora of Tasmania*. The most recent study of *Vittadinia* was undertaken by Burbidge (1982), as part of the revision of the genus for Australia. She recognised four species from Tasmania which included *V. cuneata* DC., *V. megacephala* (F.Muell. ex Benth.) J.M.Black, *V. muelleri* N.T.Burb. and *V. gracilis* (Hook.f.) N.T.Burb. Recently an additional taxon, *V. australasica* (Turcz.) N.T.Burb. var. *oricola* N.T.Burb., which was thought to be extinct in Tasmania, was collected by Richard Schahinger from the west coast of Tasmania (Buchanan 1999). Also two distinct forms of *Vittadinia muelleri* have been recognised by the authors as occurring in the State. The status of *Vittadinia megacephala* in Tasmania was also unclear, because although Burbidge (1982) recorded the species from the State, there are no supporting collections held in the Tasmanian Herbarium (HO). Because of the various problems identified above, a taxonomic revision of the Tasmanian material of *Vittadinia* was undertaken.

In this paper the morphology, distribution, ecology and conservation status of the five species of *Vittadinia* in Tasmania are discussed, and a key to the genus in the State is provided. Comparative material of *Vittadinia megacephala* and *V. australasica* from mainland Australia was also included in the study (see Appendix). The nomenclature and classification generally follows Burbidge (1982) unless otherwise stated, and the Tasmanian biogeographical regions are those of Orchard (1988).

FIG. 1. Photograph of grassland communities near the Township Lagoon Saltpan at Tunbridge in mid-eastern Tasmania. Both *Vittadinia burbidgeae* sp. nov. and *V. cuneata* occur in this region. Photo Hans and Annie Wapstra.

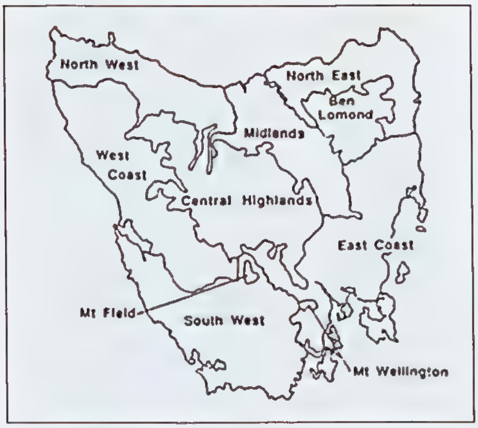


FIG. 2. Geographical regions of Tasmania, based upon Orchard (1988).

Burbidge (1982) recognised that cypselas, and in particular the distribution of hairs on the cypselas, provided important taxonomic characters in identifying species. In our study cypselas were examined with a scanning electron microscope, the specimens being airdried and placed onto aluminium stubs with tape. They were sputter coated with gold and examined with a Philips Electroscan Environmental Scanning Electron Microscope 2020, under high vacuum operated at 10–15 kV. The types of hairs on the leaves and stems were also found to provide useful taxonomic characters. A hand lens is needed to recognise the different indumentum and cypsela characters.

Key to the Tasmanian species of *Vittadinia*

1. Cypsela with marginal ribs covered with hairs, conspicuous glandular hairs present on facial ribs; plants appearing grey or greyish-green................................2

Cypsela with marginal ribs glabrous (except near basal tuft), conspicuous glandular hairs absent from facial ribs; plants distinctly green................................3

2. Indumentum of woolly, white-cottony hairs, usually covering younger stems and often on leaves..................*Vittadinia gracilis*

Indumentum of straight or slightly curved hairs, spreading or appressed, stiff-ish hairs..........*Vittadinia cuneata* var. *cuneata*

3. Plants lacking strigose hairs on leaves or stems.........................*Vittadinia burbidgeae*

Plants with sparse strigose hairs on stems and leaves...................................4

4. Leaves broadly oblanceolate-spathulate, scarcely conduplicate with or without a pair of lateral teeth/lobes in upper third, both surfaces with sparse strigose hairs; cypsela with all facial ribs continued to base, lower portion largely lacking twin hairs (except basal tuft). Plants only known from near Temma in north west Tasmania.....*Vittadinia australasica* var. *oricola*

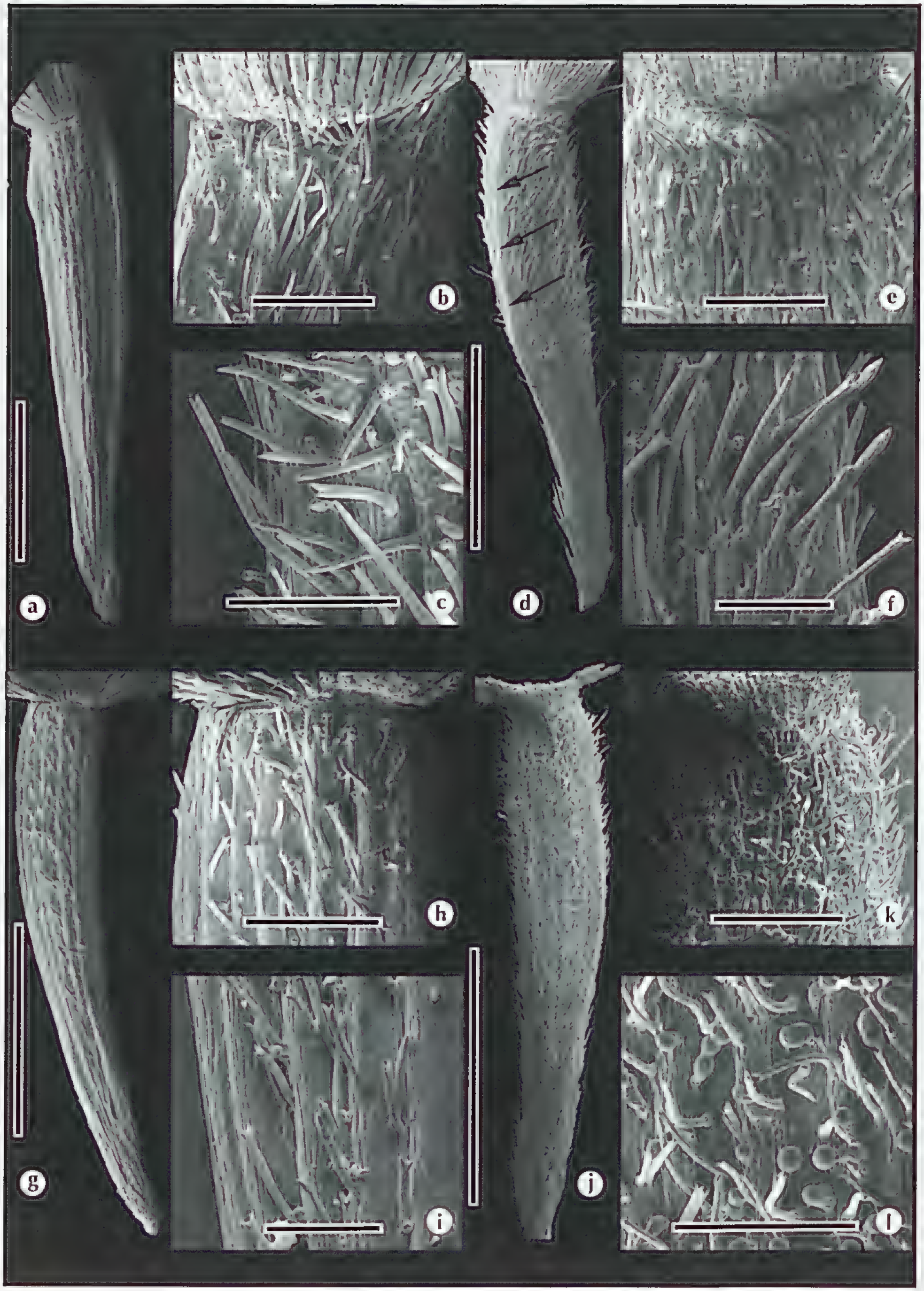
Leaves narrowly oblanceolate-ovate, mostly conduplicate with a pair of teeth/lobes toward upper third of blade, sparse, stout, strigose hairs on the margins and abaxial surface and midvein, adaxial surface hairless or with very sparse hairs near the apex and on the lateral lobes; cypselas with facial ribs coalescent in lower portion, lower portion with conspicuous twin hairs. Plants known from south eastern Tasmania.............*V. muelleri*

Systematics

Vittadinia australasica var. *oricola* N.T. Burb. (Fig. 3a–c)

Vittadinia australasica (Turcz.) N.T.Burb. var. *oricola* N.T.Burb. *Brunonia* 5:44 (1982). **Type:** Portland, Bridgewater Lakes area, SW Victoria, *A.C.Beauglehole 548*, xi. 1945, CANB269721 n.v., Isotype: MEL n.v.

Stout *herb* with woody perennating rootstock, stems ascending to decumbent 15–30 cm long. Young stems minutely ridged; vestiture of fairly dense strigose, septate hairs interspersed with fewer, much smaller, crisped, glandular hairs,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older stems usually naked. *Leaves* alternate 1–4 cm long, spathulate-oblanceolate, irregularly and distantly toothed toward the apex, rarely lobed or entire, apex acute, minutely apiculate or rounded; base attenuated and often amplexicaul; adaxial surface with scattered curved strigose hairs; abaxial surface with main vein rather more densely hairy; both surfaces with minute crisped glandular hairs; margins densely hairy. *Peduncles* 2–5 cm long, elongating during anthesis and bearing 2–3 small, distant linear bracteoles; vestiture as for the branchlets. *Capitula* solitary on each peduncle; phyllaries 3–9 mm long in 2–3 rows, green or with pale blue/purple keel, narrow elliptical, apex acute, margins hyaline, entire or minutely ciliolate near the base; outer surface hairy, particularly along the keel, inner surface glabrous. *Ray florets* in 2 (–3) rows, pistillate, floral tube very slender, ligules bluish to mauve, spreading, apex entire or minutely 3-lobed. *Disk florets* hermaphrodite, inflated in the upper portion, 5-lobed; stigmas papillose. *Receptacle* flat to slightly convex, alveolate, the rims surrounding the alveolae irregularly 4–5 lobed, the lobes fimbriate/ciliate. *Cypsela* 4–5 mm long, narrow cuneate, slightly curved, flattened, constricted just below the apex; marginal ribs thickened, without hairs or with few very sparse twin hairs at the apex and very sparse minute collapsed glandular hairs; facial ribs continuous, the central rib rather more prominent and usually glabrous or with a few hairs at the apex; subordinate ribs and the grooves between with scattered short, twin hairs; basal twin hairs few, short, appressed. *Pappus bristles* numerous, 5–8 mm long, minutely barbellate.

COMMON NAME

Coastal New Holland Daisy

SELECTED SPECIMENS EXAMINED

Tasmania: West Coast: South of Temma, 41°14'S 144°42'E, *R.Schahinger s.n.,* 10. i. 2001 (HO510623); Western Australia: Blackwood River (MEL1004335); Boxer Island, Recherche Archipelago, *J.H.Willis s.n.,* 8. xi. 1950 (MEL). Victoria: South-West Study area, 10 km N of Nelson PO, 20 km WSW. of Dartmoor PO, *A.C.Beauglehole 57791,* 19. ii. 1978 (MEL648159).

REMARKS

Burbidge (1982) recognised var. *oricola* as a subspecies of *V. australasica* and suggested that it may be of hybrid origin. The Tasmanian populations of this taxon do not occur with any other species, so there is no evidence of hybridisation, and it is morphologically distinct and geographically disjunct from the other Tasmanian species (Fig. 4a). For these reasons, at least in Tasmania, the taxon might warrant recognition at species rank. Walsh (1999) however

←**FIG. 3.** *Vittadinia australasica* var. *oricola* (HO510623) **a**, cypsela, note conspicuous longitudinal ridges on lateral faces and absence of hairs on marginal ribs; **b**, detail of cypsela below the pappus; **c**, detail of twin hairs and a few scattered collapsed gland-tipped hairs, *V. muelleri* (HO50221); **d**, cypsela, longitudinal ridges on lateral faces obscured by hairs, note that the marginal rib (arrowed) lacks twin hairs but the orientation of the cypsela makes this somewhat difficult to see; **e**, detail of cypsela below the pappus; **f**, detail of twin hairs and a few scattered collapsed gland-tipped hairs. *V. burbidgeae* (HO105937); **g**, cypsela, note conspicuous longitudinal ridges on lateral faces and absence of hairs on marginal ribs; **h**, detail of cypsela below the pappus, note the relatively few hairs present; **i**, detail of twin hairs and a few collapsed gland-tipped hairs, *V. gracilis* (HO108473); **j**, cypsela, longitudinal ridges on lateral faces obscured by hairs, note the hairs on the marginal ribs; **k**, detail of cypsela below the pappus; **l**, detail of twin hairs and conspicuous gland-tipped hairs. Scale bars: a, d, g, j = 2 cm; b, c, e, h, i, k, l = 200 *μm;* f = 50 *μm.*

FIG. 4. Distribution maps of *Vittadinia* species in Tasmania based upon Tasmanian Herbarium (HO) records. **a**, *V. australasica* var. *oricola* (square, arrowed) and *V. burbidgeae* (circles); **b**, *V. muelleri*; **c**, *V. gracilis*; **d**, *V. cuneata* var. *cuneata*.

noted that var. *oricola* intergrades with var. *australasica* in south west Victoria and it is for this reason that we maintain it as a variety of *V. australasica*.

DISTRIBUTION AND ECOLOGY

In Tasmania *V. australasica* var. *oricola is* only known from Temma on the north west coast of Tasmania and occurs on stabilised calcareous sand dunes (R. Schahinger pers. comm.) (Fig. 4a). The vegetation at the Temma site was described as grassy herbfield with scattered shrubs. A specimen held by National Herbarium of Victoria (MEL1004345), ex. Herb. Sonder, has been determined by N.T.Burbidge as *V. australasica* var. *oricola*. The Sonder label gives the locality as V.D.L. [Van Diemens Land = Tasmania] and no further locality details are given. On mainland Australia the species occurs in Victoria, Western Australia and South Australia (Burbidge 1982, Walsh 1999).

FLOWERING PERIOD

January

CONSERVATION STATUS

In Tasmania, the species is only known from a single locality on the west coast and is appropriately listed as endangered under the *Tasmanian Threatened Species Protection Act* 1995.

Vittadinia muelleri
N.T.Burb. (Fig. 3 d–f, 3b)

Vittadinia muelleri N.T.Burb. *Proc. Linn. Soc. New South Wales* 93: 440 (1969). **Type:** Rockbank adjoining Black Mtn Station, Wulgulmerang, NE Gippsland, Victoria, alt. 2800 feet [c. 850 m], *J.H.Willis s.n.* 27. xi. 1962, holotype MEL30013, n.v., *fide* Burbidge (1982: 45).

A wiry *herb* with a stout woody rootstock, stems erect-ascending, 15–20 (–25) cm long. Younger stems prominently ridged, the ridges with very sparsely scattered strigose, septate hairs with more numerous, minute glandular hairs throughout. *Leaves* alternate 1–5 cm long, spathulate-narrowly oblanceolate, often conduplicate, irregularly 1–4 (–5) toothed or lobed toward the apex, rarely entire, apex acute or minutely apiculate; base attenuated, rarely amplexicaul; adaxial surface sometimes with scattered curved strigose hairs along the main vein, mostly at or near the apex and on the teeth; abaxial surface with sparse curved strigose hairs particularly along the prominent main vein; both surfaces with minute crisped glandular hairs; margins conspicuously and evenly strigose. *Peduncles* 3–8 cm long, and bearing 3–4 distant linear bracteoles; vestiture as for the branchlets. *Capitula* solitary on each peduncle; phyllaries 2–6 mm long in 2–3 rows, green, obscurely keeled, narrow elliptical-oblanceolate, margins hyaline, entire or with distant cilia; apex blunt, ciliolate-fimbriate; both surfaces glabrous. *Ray florets* in 2 (–3) rows, pistillate, floral tube very slender, ligules bluish to mauve, spreading, apex entire or minutely 3-lobed. *Disk florets* hermaphrodite, inflated in the upper portion, 5-lobed; stigmas papillose. *Receptacle* flat to slightly convex, pitted/alveolate, the rims surrounding the alveolae irregularly 4–5 lobed, minutely ciliolate or occasionally entire. *Cypsela* 2–4 mm long, narrow cuneate, slightly curved, flattened, scarcely constricted at the apex; marginal ribs not thickened, bare except for some hairs at the apex; facial ribs inconspicuous ± copiously invested with stout twin hairs, and very sparse minute collapsed glandular hairs; basal twin hairs long, dense, appressed. *Pappus bristles* numerous, 3–6 mm long, minutely barbellate.

COMMON NAME

Narrow Leaf New Holland Daisy

SELECTED SPECIMENS EXAMINED

Tasmania: East Coast: Broadmarsh Road, 42°40'50'S 147°10'14'E, *A.M.Buchanan 15335*, 17. xi. 1998 (HO329369); Mt Nelson, 42°54'S 147°19'E, *E.Rodway s.n.*, 5. xi. 1933 (HO65802); opposite Bagdad Primary School, Midland Highway, 42°38'S 147°13'E, *A.J.North s.n.*, 28. xi. 1994 (HO323113); Queens Domain, Hobart, 42°52'S 147°19'E, *J.Hickie s.n.* 18. xi. 1992, (HO400385); Near Brighton, 42°42'S 147°13'E, *B.Farrell s.n.*, 23. v. 2001 (HO513767); Queensland: Bunya Mountains National Park, Edge of Big Falls, *R.&R.Belcher 807*, 29. xi. 1867 (MEL2096342); New South Wales: Near Maryland, at the border of New South Wales, *E.Hickey s.n.*, xi. 1884 (MEL1004855); NW slopes, Northern Tablelands, Mt Kaputar National Park, Sawn Rocks, 30°08'S 150°09'E, *K.Watanabe 14*, 26. ix. 1992 (MEL2014777); Australian Capital Territory: Stirling Park, Yarralumla, 35°18'S 149°06'E, *R.Coveny 11490* & *P.Hind* 18. i. 1983 (MEL296425); Victoria: Laverton Airbase (old), 37°52'09'S 144°44'38'E, *A.C.Cochrane 230*, 9. x. 1998 (MEL2052370); Herring Island, 37°50'00'S 145°00'05'E, *D.E.Albrecht 3256*, 19. xi. 1985 (MEL1560683); Crown Land divided by Newry-Boisdale Road, *B.Thompson 105*, 22. iv. 1982 (MEL621960); Diamond Creek, about 2 km SW of Post Office, on Aqueduct Reserve, adjacent to Aqueduct

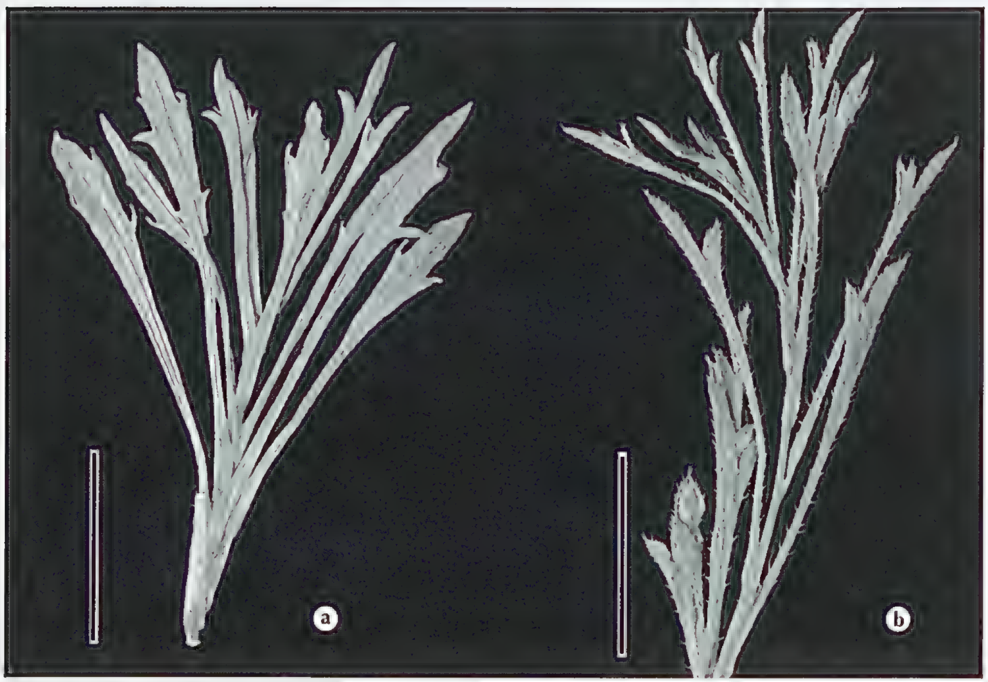

FIG. 5. Leaf morphology of *Vittadinia muelleri* and *V. burbidgeae*. **a,** *Vittadinia burbidgeae* also has minute glandular hairs but lacks the conspicuous strigose hairs (HO142314); **b,** *Vittadinia muelleri* leaves have evenly spaced strigose hairs and minute glandular hairs (HO400385). Scale bars = 1 cm.

Rd, 37°42'00'S 145°08'05'E, *R.J.Adair 1396* 22. xi. 1981 (MEL296889); Omeo Highway, between Bindi Rd Junction and Junction of Old Gap Rd, *A.C.Beauglehole 36929*, 21. ii. 1979 (MEL1584787).

DISTRIBUTION AND ECOLOGY

In Tasmania, the species is restricted to the East Coast region and has only been collected from south eastern Tasmania (Fig. 4b). Like all of the other *Vittadinia* species it has been collected primarily from grassland communities. It also occurs in Victoria, Queensland and New South Wales (Walsh 1999).

FLOWERING PERIOD

Mainly November–December, rarely February, March and May

CONSERVATION STATUS

Previous assessments of the conservation status of *V. muelleri* had included material of *V. burbidgeae* sp. nov. in a broadly defined taxon. Recognition of the new species requires a reassessment of the conservation status of *V. muelleri* in Tasmania. There are relatively few collections known of this species so the current listing of *V. muelleri* as rare under the *Threatened Species Protection Act* 1995 in Tasmania would appear to still be appropriate. Ongoing threats to the species are likely to arise from the loss of suitable habitat through urban development in southern Tasmania and through grazing and agriculture in the rest of the State.

Vittadinia burbidgeae A.M. Gray & Rozefelds sp. nov. (Fig. 3g–l, 5a, 7c)

Ab *Vittadinia muelleri* N.T.Burb. foliis et caulibus pilis strigosis carentibus, cypselis sparsim pilosis praesentim distaliter, differt.

Type: Bridgewater, W. side of road, top of hill, 42°43'S 147°14'E, *D.I.Morris 86346*, 14. ix. 1988, holotype HO142314, isotypes MEL!, CANB!.

A wiry *herb* with a stout woody rootstock, stems erect-ascending, 15–20 (–25) cm long. Younger stems prominently ridged, the ridges with numerous, minute glandular hairs throughout. *Leaves* alternate 1–5 cm long, spathulate–narrowly oblanceolate, often conduplicate, irregularly 1–4 toothed or lobed toward the apex, rarely entire, apex acute or minutely apiculate; base attenuated, rarely amplexicaul; both leaf surfaces appearing glabrous but with minute crisped glandular hairs; margins glabrous. *Peduncles* 3–8 cm long, solitary, terminal and bearing 3–4 distant linear bracteoles; vestiture as for the branchlets. *Capitula* solitary on each peduncle; phyllaries 2–6 mm long in 2–3 rows, green, obscurely keeled, narrow elliptical-oblanceolate, margins hyaline, entire or with distant cilia; apex blunt, ciliolate-fimbriate; both surfaces glabrous. *Ray florets* in 2 (–3) rows, pistillate, floral tube very slender, ligules bluish to mauve, spreading, apex entire or minutely 3-lobed. *Disk florets* hermaphrodite, inflated in the upper portion, 5-lobed; stigmas papillose. *Receptacle* flat to slightly convex, pitted/alveolate, the rims surrounding the alveolae irregularly 4–5 lobed, minutely ciliolate or occasionally entire. *Cypsela* 2–4 mm long, narrow cuneate, slightly curved, flattened, scarcely constricted at the apex; marginal ribs not thickened, bare except for some twin hairs at the apex; facial ribs inconspicuous ± copiously invested with stout twin hairs, and very sparse minute collapsed glandular hairs; basal twin hairs long, dense, appressed. *Pappus bristles* numerous, 3–6 mm long, minutely barbellate.

COMMON NAME

Smooth New Holland Daisy

SELECTED SPECIMENS EXAMINED

Tasmania: East Coast: Mt Nelson, 42°55'S 147°20'E, *C.E.Lord s.n.,* i. 1930 (HO15188); Crow Hill, 42°16'S 147°33'E, *D.Ziegeler 134,* 23. x. 1995 (HO314558); Mona Vale halfway to Tunbridge, 42°07'S 147°26'E, *W.M.Curtis s.n.,* 4. i. 1960 (HO15180); Hamilton Plains, 42°34'S 146°51'E, *A.M.Buchanan 13682,* 15. iii. 1994 (HO410030); Avoca, 41°47'S 147°43'E, *A.Simson 2193,* 18. x. 1881 (HO507722); Midlands: Midland Highway, 1 km N of Perth, 41°33'S 147°10'E, *R.J.Fensham s.n.*, 26. xii. 1984 (HO108427).

REMARKS

Vegetative features of this species are similar to *V. muelleri* and both species have leaves with minute crisped glandular hairs (Fig. 5a). This species was regarded as *V. muelleri* in the past, but it differs from that species in the absence of septate hairs on the leaves and stem. Examination of mainland Australian collections shows that septate hairs are consistently present, but the frequency of hairs can vary. In *V. burbidgeae* the ribs of the cypselas are considerably less hairy, particularly toward the apex, than in *V. muelleri* (cf. Fig. 3d, 1g). The twin hairs arising from the sides of, and between the facial ribs, are usually sparser than in *V. muelleri,* particularly in the distal region. The appearance of the receptacle also differs in these two species. In *V. burbidgeae* the involucral alveolae usually lack the minute ciliolate hairs of *V. muelleri.*

ETYMOLOGY

This species has been named in honour of the late Nancy T. Burbidge (1912–1977), a botanist at the then Herbarium Australiense, CSIRO, Canberra. Burbidge was working on a revision of the genus *Vittadinia* at the time of her death.

DISTRIBUTION AND ECOLOGY

This species is endemic in Tasmania and has been collected from drier areas of the East Coast and Midlands regions (Fig. 4a). A number of specimens collected were from shallow doleritic soils.

FLOWERING PERIOD

September–January, rarely March

CONSERVATION STATUS

The herbarium collections currently known demonstrate a wide but fragmented distribution which would suggest that *V. burbidgeae* requires listing under the *Threatened Species Protection Act* 1995 in Tasmania. Based upon the existing data a conservation status of rare is considered appropriate. Ongoing threats to the species are likely to arise from the loss of suitable habitat through grazing and agriculture.

Vittadinia cuneata

DC. var. ***cuneata*** (Fig. 6a–d, 7d, e)

Vittadinia cuneata DC. *Prod.* 5: 281 (1836). **Type:** Aster – dry barren tracts Lachlan River interior of N.S.W., *Allan Cunningham 22,* 26. April 1817, lectotype here selected G n.v.; Dry barren hills, depot, Lachlan River, western interior N.S. Wales, *Allan Cunningham 327,* 26. Apl. [sic] 1817, putative isolectotype K!, *fide* Burbidge (1982: 49).

NOMENCLATURAL NOTES

Burbidge (1982) recognised two syntypes that were both collected by Allan Cunningham from the Lachlan River area, but did not formally recognise a lectotype. Following on from Burbidge's (1982) suggestion, specimen b. is herein selected as the lectotype.

A small, erect *undershrub* 15–40 cm high, seasonal branches arising from a slender, woody, perennating rootstock and from the previous season's branches, soft and herbaceous at first but becoming woody, clothed with sparse, septate strigose hairs with minute glandular hairs between. *Leaves* alternate, 0.5–2.5 cm long, often appearing clustered due to developing on short lateral branches; erect to sub-erect with the distal portion often recurved, oblanceolate to spathulate; base often slightly broadened but scarcely stem-clasping; apex sub-acute to blunt; blade inrolled to conduplicate especially in the broader upper portion; entire or with 2 short triangular lobes just below the apex; adaxial surface glabrous or with a few curved strigose hairs and minute glandular hairs; abaxial surface clothed with moderately dense curved septate strigose hairs; both surfaces with scattered minute glandular hairs; margin with curved strigose hairs. *Peduncles* striate 2–3.5 cm long, lengthening only slightly following anthesis, leaves few and becoming smaller and bract-like toward the apex; vestiture as for the branchlets. *Capitula* solitary, or 2–3 together, at the apex of the branchlets; phyllaries 3–5 (–8) mm long in 2–3 rows; narrow-elliptical, imbricate, margins hyaline, pale, central portion keeled, green; outer surface with hairs as on the stems and leaves. *Ray florets* in 2 (–3) rows, pistillate, floral tube very slender, ligules bluish to mauve,

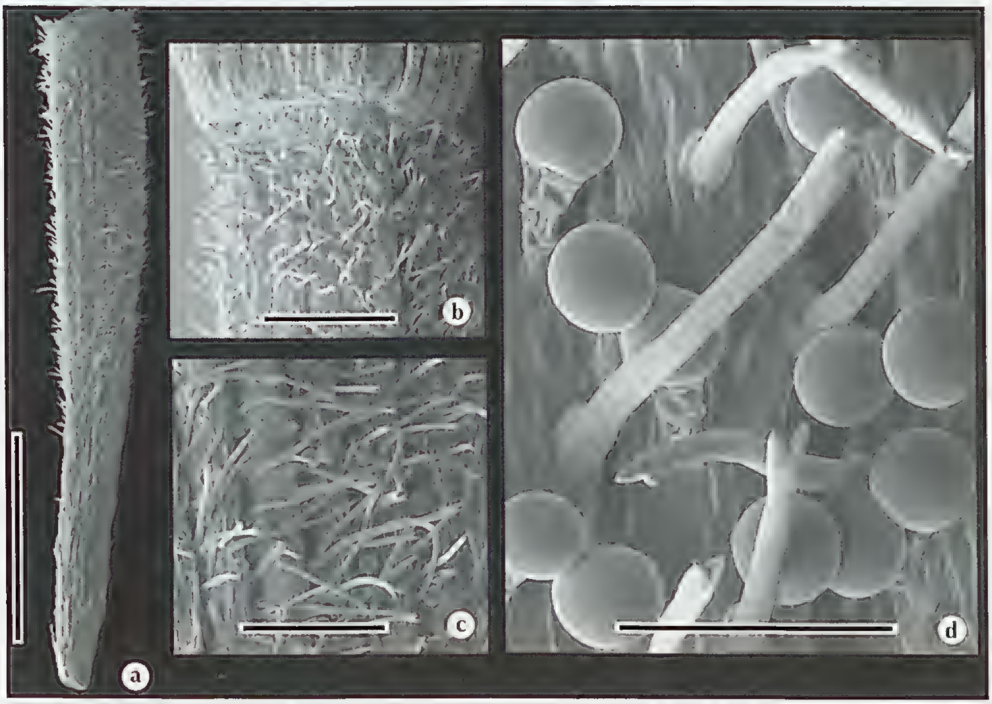

FIG. 6. *V. cuneata* var. *cuneata* (HO95411) **a**, cypsela, longitudinal ridges on lateral faces obscured by hairs and note the hairs on the marginal ribs; **b**, detail of cypsela below the pappus; **c**, detail of twin hairs and conspicuous gland-tipped hairs; **d**, detail of gland-tipped hairs. Scale bars: a = 2 cm, b, c, = 200 μm, d = 100 μm.

FIG. 7. Habit photographs of *Vittadinia* species. **a,b** *V. gracilis* from Township Lagoon, Tunbridge, Tasmania; **a**, note the characteristic grey-green foliage; **b**, detail of heads and leaves; **c**, *V. burbidgeae* from Ross, Tasmania, note green foliage and absence of large hairs from leaves; **d**, **e**, *V. cuneata* var. *cuneata* from Tunbridge, Tasmania; **d**, note appearance of the involucral bracts on older flowering heads; **e**, detail of single flowering head and fine indumentum on stem. Photographs Hans and Annie Wapstra.

spreading, apex entire or minutely 3-lobed. *Disk florets* hermaphrodite, inflated in the upper portion, 5-lobed; stigmas papillose. *Receptacle* convex, pitted/alveolate, the rims surrounding the alveolae irregularly 4–5 lobed entire, undulate. *Cypsela* 3–5 mm long, narrow obovate-cuneate, some slightly curved, flattened but the faces convex, not or only slightly constricted below the apex; marginal ribs scarcely thickened, margins hairy, spreading on the upper part, closely appressed below; facial ribs 5–7, these and the grooves between with spreading and appressed twin hairs and conspicuous smaller glandular hairs interspersed between; basal twin hairs a little longer, closely appressed. *Pappus bristles* numerous, 3–6 mm long, minutely barbellate.

COMMON NAME

Fuzzy New Holland Daisy

SELECTED SPECIMENS EXAMINED

Tasmania: East Coast: Tasman Highway near Lake Leake Junction, 42°03'S 148°03'E, on roadside, *A.M.Buchanan 13354*, 3. iv. 1993 (HO409907); Brighton, 42°42'S 147°15'E, *A.Simson 390*, xii. 1876 (HO512469); 3 km E of Hamilton, 42°33'S 146°52'E, *A.M.Buchanan 12684*, 2. xii. 1992 (HO410140); Fingal, 41°39'S 147°59'E, *A.Simson 1171*, 20. iv. 1878 (HO507720); Midlands: Township Lagoon, Tunbridge, 42°09'S 147°25'E, etc. *A.Moscal 3899a*, 9. xi. 1983 (HO87771); New South Wales: Booligal, Lachlan River, *A.Bell s.n.*, ix. 1887 (MEL1004577); Wellington Road, Dripstone, *J.H.Willis s.n.*, 12. v. 1969 (MEL1004420); Victoria: On the Yarrawonga–Benalla Road, 4 miles (*c.* 6 km) from Hume Highway, *T.B.Muir 1758*, 2. xi. 1960 (MEL1004380); East Gippsland, upper Genoa River, Coopracambra State Park, *A.C. Beauglehole 35021*, 30. xi. 1970 (MEL1584801); Grampians Crown Land, 7 km WSW of Brimpaen, *A.C.Beauglehole 76685*, 21. iv. 1984 (MEL298135).

REMARKS

The Tasmanian material was referred to *forma cuneata* by Burbidge (1982).

DISTRIBUTION AND ECOLOGY

In Tasmania, the species is largely restricted to drier parts of the East Coast and the southern Midlands regions (Fig. 4d) and most commonly occurs in native grassland and has been collected occasionally from *Eucalyptus amygdalina* woodland. The species is also widespread in southern mainland states of Australia.

FLOWERING PERIOD

October–December, March–April

CONSERVATION STATUS

Listed as rare under the *Tasmanian Threatened Species Protection Act* 1995.

Vittadinia gracilis
(Hook.f.) N.T.Burb. (Fig. 3j–l)

Basionym: *Eurybiopsis gracilis* J.D.Hook. *Hooker's J. Bot. Kew Gard. Misc.* 6: 110 (1847).

Type: New Norfolk, *Gunn s.n.*, 11. xi. 1839, 695/1842, lectotype K!, *fide* Burbidge (1982: 54).

A small diffuse *undershrub* 15–40 cm high, branches arising from a persistent woody rootstock, older branches woody, the current season's branchlets ± herbaceous, and soft, clothed with dense, greyish-white, appressed cottony hairs. *Leaves* 1–2.5 (–4) cm long, alternate, sub-erect to recurved particularly nearer the apex, narrow oblanceolate, base stem clasping, apex rounded to sub-acute, blade ± inrolled to conduplicate, entire to distantly crenate, occasionally 2-lobed just below the apex; both leaf surfaces with dense greyish-white, appressed cottony hairs and scattered minute glandular hairs; margins with cottony hairs. *Peduncles* 3–5 cm long, solitary, leafy, lengthening following anthesis, upper leaves smaller, bract-like and appressed to the stem. *Capitula* solitary, phyllaries 5–10 mm long in 2–3 rows, imbricate, green with paler hyaline margins, narrow elliptical, apex acute; outer surface finely cottony hairy. *Ray florets* in 2(–3) rows, pistillate, floral tube very slender, ligules mauve to lilac-purple, spreading, apex shallowly 3-lobed. *Disk florets* hermaphrodite, somewhat inflated toward the apex, 5-lobed; stigmas papillose especially near the apex. *Receptacle* flat or slightly convex, pitted/alveolate, the rims surrounding the alveolae irregularly 4–5 lobed, the lobes entire, ± undulate. *Cypsela* 3.5–5 mm long, narrow obovate-cuneate, slightly curved, flattened, constricted below the apex; marginal ribs appearing thickened due to the close proximity of the facial ribs, margins hairy, the twin hairs appressed; facial ribs 5–7, clothed with appressed twin hairs similar to those on the margins and with conspicuous smaller glandular hairs interspersed between, basal twin hairs a little longer, closely appressed. *Pappus bristles* numerous, 3–6 mm long, minutely barbellate.

COMMON NAME

Woolly New Holland Daisy

SELECTED SPECIMENS EXAMINED

Tasmania: East Coast: York Plains Road, S side, 42°16'S 147°31'E, *M.Neyland s.n.*, 1. iv. 1993 (HO400368); Queens Domain, Hobart, 42°52'S 147°19'E, *W.M.Curtis s.n.*, x. 1943 (HO65801); Kempton, dry roadside, 42°32'12'S 147°11'51'E, *A.M.Buchanan 15181*, 3. iv. 1998 (HO325028); Midlands: Ross Cemetery, 42°01'S 147°30'E, *R.J.Fensham s.n.*, 14. xii. 1984 (HO315272); South Australia: Along northern boundary of proposed Monarto town-site, between Preamimma and Pallamana *c.* 15 km NW of Murray Bridge, *N.N.Donner 9662*, 27. iv. 1983 (HO112027); Victoria: Ailsa Roadside Reserve, *A.C.Beauglehole 84829*, 6. x. 1986 (HO105157).

REMARKS

Both this species and *V. cuneata* have conspicuous large glandular hairs on the cypselas that do not collapse on drying (Fig. 3j–l, 6a–d). Burbidge (1982) did not record this feature for *V. cuneata*.

DISTRIBUTION AND ECOLOGY

In Tasmania, the species is largely restricted to drier parts of the East Coast and Midlands regions (Fig. 4c), and occurs in *Eucalyptus amygdalina* woodland and native grassland communities. The species is widespread in southern mainland states of Australia.

FLOWERING PERIOD

October–April

CONSERVATION STATUS

Currently listed as rare under the *Tasmanian Threatened Species Protection Act* 1995.

Conclusion

Taxonomic studies are usually the first step in assessing whether species are threatened, and therefore should be listed under the appropriate threatened species legislation. In this particular study the recognition of two segregate species in *V. muelleri* (*sensu* Burbidge 1982) requires an examination of the conservation status of *V. muelleri sens. str.*, and also the new species *V. burbidgeae*. While the available data are extremely limited it would suggest that both species require listing under the *Tasmanian*

Threatened Species Protection Act 1995, due to their limited and fragmented distribution within the State. *Vittadinia australasica* var. *oricola* is restricted to a single locality in north western Tasmania and is currently listed as endangered. All species of *Vittadinia* in Tasmania are typical grassland specialists and have been subjected to loss of suitable habitat throughout their ranges.

Similarly, a reassessment of the conservation status of *V. megacephala,* which is currently listed as extinct in Tasmania, is also required. *Vittadinia megacephala* can be differentiated from the other Tasmanian species by the absence of lateral ridges on the sides of the cypselas. This species was recorded from Tasmania (as a variety of *V. australis*) by Bentham (1867) and he cited a Gunn collection at Kew. Curtis (1963) also records *V. megacephala*, as a variety of *V. triloba,* from the State but she cites no collections and no distributional data for the species. Burbidge (1982), possibly based upon Bentham (1867), alludes to a Gunn collection in Kew (K), although she notes that no Tasmanian material was available for her study. No specimens of this species are lodged in the Tasmanian Herbarium (HO). Checking by Rod Seppelt, while Australian Botanical Liaison Officer in Kew, did not locate any Tasmanian specimens of *V. megacephala* in their collections. Colleagues in other herbaria in Australia (CANB, MEL, NSW) also confirmed that no Tasmanian material of *V. megacephala* is in their collections. Peter Jobson (pers. comm. 2002) indicated that a specimen in NSW from Flinders Island of South Australia (NSW103518, *T.G.B.Osborn s.n.*) may have inadvertently been considered to be from Flinders Island of Tasmania. *Vittadinia megacephala* is currently listed as extinct on the *Threatened Species Protection Act* (1995). As there are no collections of this species known from Tasmania, there is no justification for recording this species from the State, and it is therefore also appropriate to delete this species from the list of extinct species on the *Tasmanian Threatened Species Protection Act* 1995.

Acknowledgements

Rod Seppelt provided information on *Vittadinia* material held at Kew. Richard Schahinger provided information and unpublished reports on the distribution of *Vittadinia australasica* var. *oricola* at Temma. Neville Walsh (MEL) and Peter Jobson (NSW) provided information on collections in these institutions. Alex George kindly prepared the Latin diagnosis.

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Appendix

Additional non-Tasmanian material examined

Vittadinia megacephala (F.Muell. ex Benth.) J.M.Black

South Australia: Worlds End Creek, 33°45'S 139°02'E, *R.J.Bates 35305,* 22. xi. 1995 (MEL2061696); Berri, 34°16'S 140°36'E, *R.Filson 615,* 13. xii. 1958 (MEL1011431); Victoria: Mt Arapiles, SW side, Grampians, *A.C.Beauglehole 29764,* 23. xi. 1968 (MEL2096339); Wyperfeld National Park, Eastern Lookout Nature Drive, *c.* 4 km ESE of Flagstaff Hill, 35°35'29'S 142°06'13'E, *A.M.Lyne* 624 & *B.Hadlow,* 11. xi. 1991 (MEL234354).

Vittadinia australasica (Turcz.) N.T.Burb. var. *australasica*

South Australia: Thistle Island, *J.H.Maiden s.n.,* i. 1907 (MEL1004379); Along the railway line N of Auburn, 34°00'S 138°40'E, *R.J.Bates 29592,* 25. x. 1992 (MEL266286). Victoria: Green Lake Reserve, *c.* 6 miles [*c.* 10 km] S of Sea Lake PO, *A.C.Beauglehole 40518,* 11. x. 1972 (MEL648166); Mt Jess, Pink Lakes State Park, *J.H.Browne 224,* 10. x. 1983 (MEL661095).

Vittadinia australasica (Turcz.) N.T.Burb. var. *oricola* N.T.Burb

Western Australia: Boxer Island, Recherche Archipelago, *J.H.Willis s.n.,* 8. xi. 1950 (MEL1004385); Victoria: South West study area, 10 km N of Nelson PO, *A.C.Beauglehole 57791,* 19. ii. 1978 (MEL648159); Rennick Forest, N of Princes Highway, Far South West, *C.E.Woolcock W1133,* 6. xii. 1976 (MEL677444).

TERRESTRIAL FLATWORMS (PLATYHELMINTHES: TRICLADIDA: TERRICOLA) FROM SUB-ANTARCTIC MACQUARIE ISLAND

Leigh Winsor and Mark Stevens

Winsor, L. and Stevens, M. 2005. Terrestrial flatworms (Platyhelminthes: Tricladida: Terricola) from sub-Antarctic Macquarie Island. *Kanunnah* 1: 17–32. ISSN1832-536X. Two species of terrestrial flatworms are described from Macquarie Island. The genus *Arthurdendyus* is emended, and a new species of *Arthurdendyus* described. A new record, and description of *Kontikia andersoni* is provided. The co-occurrence of *K. andersoni* and new species of *Arthurdendyus* at the Lusitania Bay site, Macquarie Island, strongly suggests both species are introductions from New Zealand. Circumstantial evidence supports the view that *A. vegrandis* is vermivorous and is predating earthworms at the site. *Kontikia andersoni* was observed feeding on a slug.

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KEY WORDS: Terrestrial flatworm, Terricola, planarians, sub-Antarctic, Macquarie Island, introduced species, earthworm predator.

Terrestrial flatworms, also known as land planarians, live in damp soil and similar cryptic habitats, and prey on other soil animals. Species are distinguished by a combination of external features and internal anatomical characters. World wide there are some 880 named species of land planarians in three principal families and the flatworm fauna of Australia is estimated to be in excess of 300 species of which 137 are named (Winsor 1998). The impact of the New Zealand flatworm, *Arthurdendyus triangulatus* (Dendy 1895) on native earthworm populations in Europe has stimulated renewed interest in the terrestrial flatworms, especially in their basic biology, behaviour and ecology (Winsor et al. 1998).

Whilst terrestrial flatworms have long been known from the New Zealand sub-Antarctic islands (Graff 1899; Dendy 1909; Fyfe 1953), it is only recently that they have been found on the Australian sub-Antarctic Macquarie Island (Winsor 2001).

Materials and methods

All specimens were collected in the area of Lusitania Bay, Waterfall Bay, and Green Gorge, Macquarie Island (Fig. 1). The specimens were directly fixed in 70% ethanol, processed to paraffin wax, serially sectioned at 8 µm and stained by the Martius Scarlet Blue (MSB) technique (Winsor 1998). Some data for the Holotype of *Kontikia andersoni* were derived from measurements taken from Fig. 2 in Jones (1981). The positions of body apertures are given in millimetres from the anterior end and mouth, and are also expressed as percentages of the body length. The Cutaneous Muscular Index (CMI) is the thickness of the cutaneous musculature relative to body height (the mc:h index of Froehlich 1955). The Parenchymal Muscular Index (PMI) (Winsor 1983) is similarly calculated. Nomenclature of the adenodactyls follows Winsor (1998). Only principal synonymies are provided. Holotype and Paratype specimens were lodged in the Queen Victoria Museum and Art Gallery, Launceston (QVM); additional recently collected material is held in L. Winsor's reference collection (LW). Photographs on living non-type specimens of both species are provided in Fig. 2 and 3.

FIG. 2. *Arthurdendyus vegrandis* n.sp. Living specimen collected in moss, Lusitania Valley, Lusitania Bay, Macquarie Is. Photo M. Stevens.

FIG. 1. Macquarie Island showing collection sites at Lusitania Bay, Waterfall Bay, and Green Gorge (map after Selkirk et al. 1990).

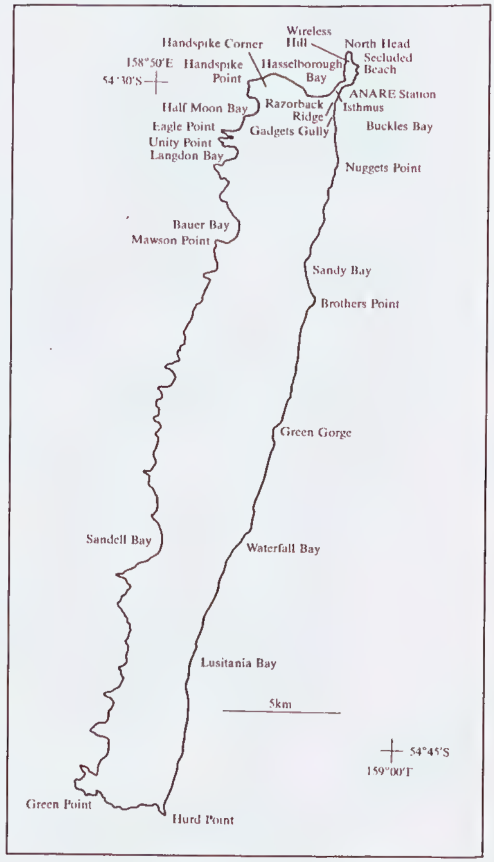

FIG. 3. *Kontikia andersoni.* Living specimen collected in moss, Lusitania Valley, Lusitania Bay, Macquarie Island. Photo M. Stevens.

Systematics

Family Geoplanidae
Subfamily Caenoplaninae
Arthurdendyus Jones and Gerard, 1999 emend

Arthurdendyus Jones and Gerard, 1999; *Arthurdendius* Jones and Gerard; Ogren et al. 1999; *Artioposthia* (in part), Fyfe 1937; Johns 1998; *Geoplana* (in part), Dendy 1895.

ORIGINAL DIAGNOSIS

'Geoplanid land planarians with ovaries lateral to the male copulatory apparatus, adenodactyli (or accessory glands) present. Pharynx "bell-shaped", not cylindrical' (Jones and Gerard 1999).

EMENDED DIAGNOSIS

Caenoplaninae with broad, elongate and strap-like body. With mouth situated posterior to mid body; gonopore closer to mouth than to posterior end. Ciliated creeping sole absent. Anterior adhesive pad or sucker absent. Sensory papillae absent. Eyes pigment cup-type, small, in single row around anterior end, and anterolaterally to posterior. Cutaneous musculature tripartite, strong, with circular, helical muscles, with longitudinal muscles in bundles. CMI 14%. Parenchymal musculature with strong dorsal and ventral transverse muscles, weak to absent longitudinal muscles. Pharynx plicate (collar-form). Pharyngeal musculature with inner epithelium, longitudinal, circular, thin inner layer longitudinal muscles; outer pharyngeal musculature with epithelium, circular, longitudinal, then strong circular muscles. Oesophagus present. Testes, sperm ducts ventral. Testes extend almost entire length of body. Vasa deferentia retiform distally, enter seminal vesicle horizontally, both sides, at multiple points. Penis eversible, without papilla. Male antrum capacious, elongate. Ovaries lateral to male copulatory apparatus, with lateral resorptive bursae situated behind mouth, before gonopore. Ovovitelline ducts unite, form short common duct that enters posterior female genital canal horizontally. Female genital canal horizontal, in-line with female antrum. Female antrum elongate, enters common antrum via ventroposterior atrial wall. Adenodactyls present.

TYPE SPECIES

Geoplana triangulata Dendy, 1895

ETYMOLOGY

'Named in honour of Arthur Dendy for his great contributions to the study of land flatworms. Gender. Male.' (Jones and Gerard 1999). The alteration of the genus name to *Arthurdendius* by Ogren et al. (1999) and subsequently used in their species lists (Kawakatsu et al. 2000, 2001), is an 'unjustified emendation' under Article 33.2.3 (ICZN 1999). The original spelling must be maintained under Article 32.2 (ICZN 1999).

DISTRIBUTION

The genus occurs in New Zealand, and includes *A. albidus* Jones and Gerard, 1999, *A. australis* (Dendy 1895), *A. latissimus* (Dendy 1896), *A. testaceus* (Hutton 1880), and *A. triangulatus* (Dendy 1895). Evidence suggests that it has been introduced to the Australian and New Zealand sub-Antarctic islands. Two species of the genus are introduced in the United Kingdom; one of which is *A. triangulatus*, an agricultural pest and serious threat to earthworms in the United Kingdom and the Faeroe Islands.

SYSTEMIC DISCUSSION

Amendment of the original genus diagnosis is necessary in order to provide comparable treatment of comparative characters (Winsor et al. 1998) and to facilitate differentiation of the genus *Arthurdendyus* from similar taxa. Within the adenodactylate taxa of the Caenoplaninae, the combination of the presence of ovaries posterior to the pharynx at the level of the copulatory organs, the pharynx type, and absence of a creeping sole, chiefly differentiates *Arthurdendyus* from other taxa. *Artioposthia ventropunctata* (Dendy 1892), *A. lucasi* (Dendy 1891), and *A. mariae* (Dendy 1895) have no creeping sole, but have cylindrical pharynges, and prepharyngeal ovaries. The sub-Antarctic species *Artioposthia carnleyi* Fyfe, 1953 has post-pharyngeal ovaries anterior to the copulatory organs, has a creeping sole, cylindrical pharynx, and dorsoventral testes.

Arthurdendyus species have a plicate collar-form pharynx, characterised by the location of the dorsal insertion of the pharynx in the posterior third of the pharyngeal pouch. In bell-form pharynges the dorsal insertion of the pharynx is located in the mid pouch region (Graff 1899).

Arthurdendyus vegrandis n. sp.

MATERIAL EXAMINED

Holotype: Lusitania Creek, Lusitania Bay, Macquarie Island, collected by R.J.Blakemore, 7 January 1998, QVM: 19:3961. Fixed in 70% ethanol; 50 slides of anterior tip, prepharyngeal, and posterior LSS with TS through the region of the gonopore, sectioned at 8 µm, stained by MSB method.
Paratype: immature specimen from Lusitania Creek, Lusitania Bay, Macquarie Island, collected by R.J.Blakemore, 7 January 1998. Fixed in 70% ethanol.
Additional material: five mature specimens found in moss and/or under rocks, Lusitania Valley, Lusitania Bay, and Waterfall Bay (material not examined), Macquarie Island, collected by M.Stevens and R.Edwards, 8 January 2004 and 5 February 2004, LW 1771. Fixed in 70% ethanol.

ETYMOLOGY

The specific epithet *vegrandis* is Latin, meaning not very large, diminutive, alludes to the species being the smallest of the six described *Arthurdendyus* taxa.

EXTERNAL MORPHOLOGY

Both specimens are strap-like, broad, flat, tapering anteriorly and posteriorly, with

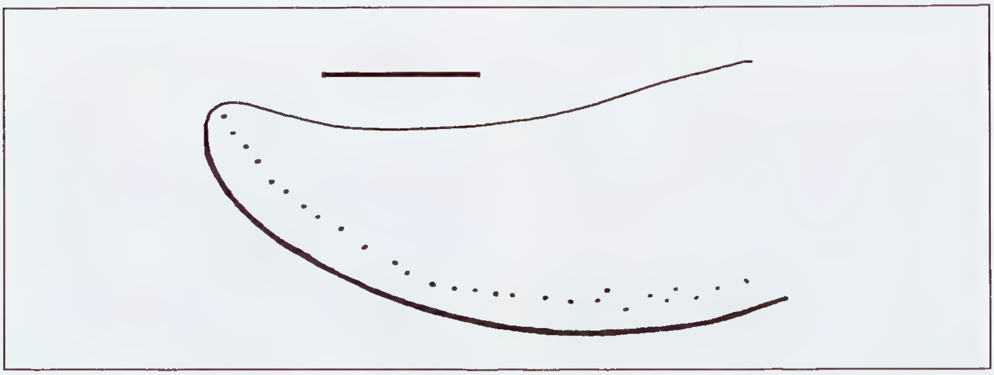

FIG. 4. *Arthurdendyus vegrandis* n.sp. Holotype. Anterior end. Eye pattern. Scale 500 µm.

slightly crenulate margins (a fixation artefact). Dorsal surface is reddish-brown, with narrow white margins extending ventrally and around both ends. Ventral surface is a uniform cream colour. Eyes very small, in single row around the anterior tip and submarginally to posterior. Holotype measured 39 mm long, and 4 mm wide at mouth. Mouth is 23 mm (59%) from anterior tip, and gonopore 6.5 mm (16.6%) behind the mouth. Paratype measured 32 mm long and 3 mm wide at mouth. Mouth is 18.5 mm (57.8%) from anterior tip; gonopore not visible.

HEAD

Specialised adhesive structure and associated musculature absent. Anterior tip richly endowed with erythrophil secretions that may have an adhesive function. Eyes very small, pigment-cup type, approximately 20 µm diameter, in single row skirting anterior tip margin, then submarginally along sides (Fig. 4). Retinal clubs could not be counted. Ciliated pits were not seen – the anterior tip was damaged.

PRE-PHARYNGEAL REGION

Pre-pharyngeal region (Fig. 5A). At this point width is 2580 µm and height 997 µm. Epithelium thickness mostly uniform over whole body, thickest ventrally, with suggestion of adhesive margin characterised by increase in density of rhabditogen, erythrophilic glands marginally. Ciliated creeping sole absent. Rhabdoids rhammite type, 9–10 µm long, most numerous submarginally, sparse dorsally, ventrally. Erythrophil epidermal secretions, finely granular, abundant dorsally, marginally, ventrally. Xanthophil secretions, finely granular, abundant especially dorsally. Cyanophil secretions present dorsally, ventrally. Cutaneous musculature tripartite, with dorsal musculature slightly thicker than ventrally, thinnest dorso- and ventromedially (dorsal 71 µm, ventral 64 µm), thicker dorso- and ventrolaterally (dorsal 85 µm, ventra1 60 µm), and the thickest submarginally (dorsal 99 µm, ventral 78 µm). CMI = 13.5%–17.8%. Parenchymal musculature well developed. Parenchymal longitudinal muscles absent. With strong dorsal and ventral parenchymal transverse muscles, weaker dorsoventral and peri-intestinal muscles.

THE ALIMENTARY SYSTEM

Pharynx plicate (collar-form), dorsal insertion posteriad, ventral insertion anteriad, not strongly muscularised, with oesophagus. Pharyngeal musculature inner infranucleate epithelium, longitudinal, then circular muscles; outer epithelium, circular, then thin layer longitudinal muscles. Oesophagus present, 740 µm long with highly folded infranucleate epithelium, with underlying circular muscle layer considerably thicker than in pharynx proper. Mouth situated approximately two-thirds along the pharyngeal pouch.

REPRODUCTIVE SYSTEM

The copulatory organs (Fig. 5B–D, Fig. 6) comprise a long penis bulb, common antrum into which discharge adenomuralia type adenodactyls, and a horizontal female genital canal.

Testes ventral, loculate, 100–210 µm high, some 85 µm in width and depth, present below and between gut diverticula,

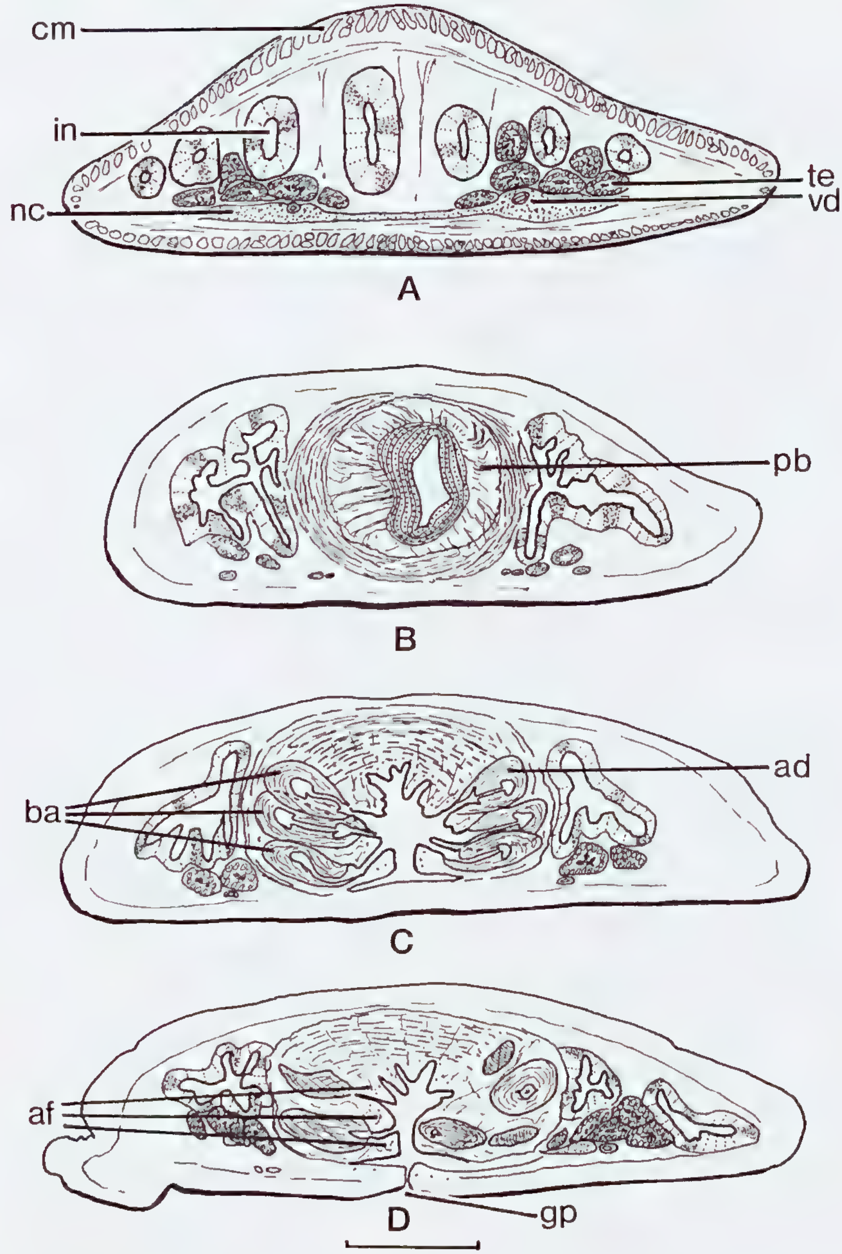

FIG. 5. *Arthurdendyus vegrandis* n.sp. Holotype. **A.** Pre-pharyngeal transverse section; **B.** Penis, transverse section showing basketwork musculature; **C.** Common antrum, transverse section showing batteries of adenodactyls; **D**. Region of gonopore, transverse section. Abbreviations used in figures (see p. 32). Scale A-D 500 µm.

extend from anterior almost to posterior tip. Sperm duct passes from each testis to intermediate duct, then to vasa deferentia immediately below nerve cords, mediad with respect to ovovitelline ducts. Vasa deferentia lined by nucleate ciliated epithelium, pass posteriad just posterior to pharyngeal pouch, then retiform (rete vasa deferentia), then separately enter proximal seminal vesicle at multiple points laterally, then continue alongside and beyond copulatory organs to service posterior testes.

Penis bulb divided into two regions on basis of cytology and secretions: with small seminal vesicle; ejaculatory duct elongate. Penis bulb musculature with inner coat of circular muscles with exterior sheath of cords of strong longitudinal retractor muscles, which together form 'basketwork musculature' (Fig. 5B) described by Fyfe (1937). Penis without papilla, eversible type. Seminal vesicle 400 µm long, lined by low columnar epithelium with lumenal margin heavily charged with fine bright erythrophil granules, epithelium receives secretions from cyanophil, erythrophil, xanthophil penial glands. Ejaculatory duct long, sinuate, 3.6 mm long, lined by columnar epithelium characterised by presence of long-necked gland cells, with terminal tips clearly projecting into lumen. Ejaculatory duct receives coarse erythrophil and amorphous purplish secretions, derived from glands in adjacent parenchyma.

Adenodactyls, 15, Type 1 (see Winsor 1998), arranged in five pairs of batteries facing each other in common antrum (Fig. 5C–D). Each battery comprises three adenodactyls – upper, mid and lower. Adenodactyls with tight circular muscle around bulb, duct, external to which is longitudinal muscle sheath. Reservoir lined by nucleate cuboidal epithelium charged with cyanophil and erythrophil granules derived from glands in adjacent mesenchyme, with erythrophil secretions predominating towards distal reservoir near start of duct. Duct lined by a similar secretory epithelium. Adenodactyls secrete what appears to be a sclerotin substance. Atrial mucosa with tall columnar epithelium heavily charged with bright erythrophil, strongly cyanophil secretions derived from glands in adjacent parenchyma.

Ovaries located on either side of mid penis bulb, slightly embedded in dorsolateral sides of anterior quarter of lateral resorptive bursae; ellipsoidal in shape, 260 µm long, 140 µm high with germ centre in lower anteriad pole. Occlusive cells present where oviducts enter ovaries. Oviducts pass ventrad from ovaries through bursae, recurve, continue posteriorly then unite to form common ovovitelline duct.

Lateral bursae, one each side of penis bulb, sausage-like, 2 mm long, and 160 µm diameter enclosed within very thin muscular tunica. Ovovitelline duct opens into bursa immediately before entering ovary. Bursa with deeply meandering duct lined by highly folded cuboidal epithelium. Bursal epithelium consists of two main cell types: cells with vacuolate pale greyish-blue cytoplasm (phagocytes), and granule cells charged with strongly erythrophil fine granules and coarse clumps (lysocytes). Vitellaria extensive, surround intestinal diverticula.

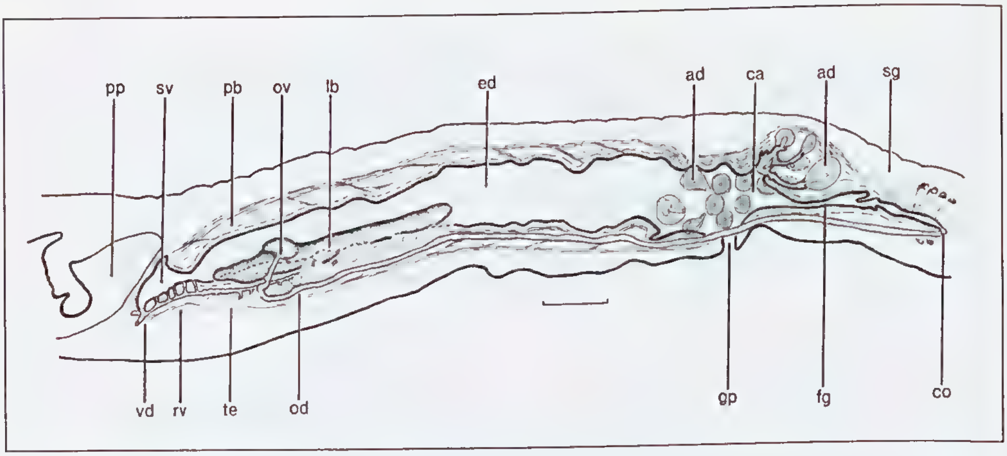

FIG. 6. *Arthurdendyus vegrandis* n.sp. Holotype. Diagram of copulatory organs. Sagittal section. Scale 500 µm.

FIG. 7. *Kontikia andersoni* Anterior end. Eye pattern. Scale 500 µm.

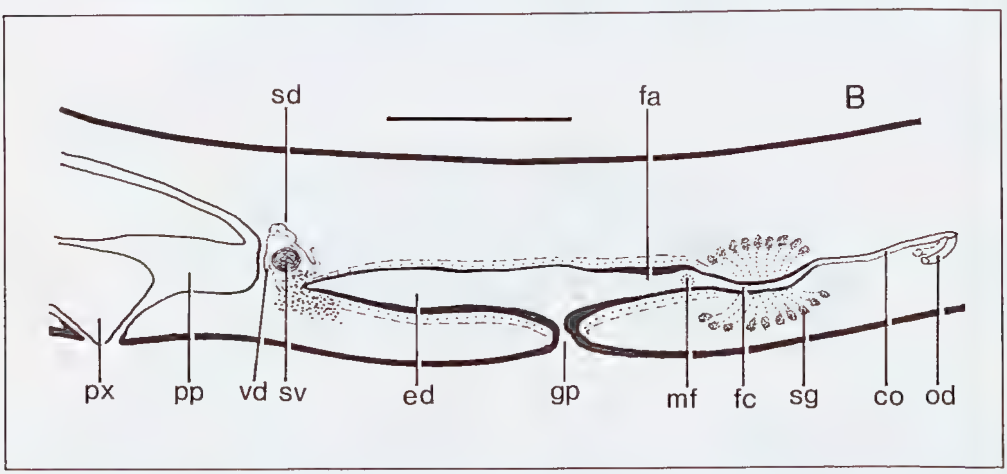

FIG. 8. *Kontikia andersoni* Diagram of copulatory organs. Sagittal section. Scale 500 µm. Abbreviations used in figures (see p. 32).

Female duct sinuoid, almost horizontal, with three regions: common ovovitelline duct 30 µm long with ciliated low cuboidal epithelium, passes directly to proximal genital canal lined by tall non-ciliated columnar epithelium, with pale, almost colourless cytoplasm charged with fine pale purplish granules, and bright erythrophil globules derived from glands dorsal to copulatory organs. Canal narrows sharply, passes directly into distal duct some 1.2 mm long, with muscular flap in roof. Epithelium of distal canal similar to antrum, receives strongly erythrophil globular secretions, but lacks conspicuous bright cyanophil secretions of antrum.

Distal canal expands and opens into common antrum, 880 µm long, with gonopore in mid floor (Fig. 5D). Atrial floor lined by ciliated low cuboidal nucleate pigmented epithelium. Atrial walls with four prominent longitudinal folds on each side (Fig. 5C). Adenodactyls (adenomuralia) in batteries, embedded in atrial walls, discharge secretions into lateral horizontal mucosal creases formed by folds in atrial walls.

SYSTEMATIC DISCUSSION

The morphology, general pattern of markings, and internal anatomy of *A. vegrandis* are very typical of New Zealand *Arthurdendyus* species. The general colour and markings of the species are similar to *A. testacea* (Hutton 1880) and *A. australis* (Dendy 1895). Although the specimen is not fully mature it is possible to differentiate the species from others in the genus as the number of adenodactyls in a particular species is constant and not seasonal (Fyfe 1944, 1956). The species has 15 pairs of adenodactyls and in this character differs from *A. triangulatus* (three pairs) and *A. albidus* Jones and Gerard 1999 (one pair). The arrangement of the multiple adenodactyls in the atrial walls of the species differs from *A. australis* in which a grouping of adenodactyls is present ventral to the mouth of the ejaculatory duct, and multiple small conical (Type I) adenodactyls present 'which project from the sides and two muscular flaps hanging from the roof of the antrum' (Fyfe 1947). The testes are immature with spermatids present in the lumen, and the rete vasa deferentia are not prominent, features consistent with the immaturity of the specimen. The penis is eversible, without distinct papilla; what looks like a papilla in the longitudinal sections is in fact an anteroventral pocket in the wall of the common antrum.

Arthurdendyus vegrandis has similarities with an undescribed species from the mountains north west of Christchurch, New Zealand (P. Johns, pers. comm.). However Johns' species has not been found further south, nor on Stewart Island where boats to Macquarie Island probably docked from time to time (P. Johns to P. Greenslade, pers. comm.). At present Johns' species is considered distinct from *A. vegrandis*.

An interesting feature of *Arthurdendyus* is the presence of lateral bursae. These bursae, all arising from the female genital organs, occur in a number of Australo-Pacific taxa. All lateral bursae have a similar internal structure comprising thin, irregular arborizing folds that may fuse to appear honeycomb-like. Lysocytes and phagocytes are present, and sperm are digested intraluminaly.

Three types of lateral bursae are recognised (Winsor 2003):

1. Lateral bursae embedded in the atrial musculature; the short bursal stalks of which arise at the entrance of the female genital canal in *Australopacifica willeyi* (Busson 1903) which has anterior-facing, inequibilobed, bilateral bursae.
2. Lateral bursae situated either side of the pharynx; the short bursal stalks arise from the ovovitelline ducts. Present in an as yet undescribed *Artioposthia* species (Winsor 2003).
3. Lateral bursae situated at the proximal end of the oviducts and ventrolateral to the ovaries. Present in species of *Arthurdendyus* (*triangulatus*, *vegrandis*) and other sub-Antarctic taxa. The bursae in *A. triangulatus*, *Kontikia marrineri*, *Kontikia ashleyi* and *Artioposthia carnleyi* were previously regarded as 'parovarian tissue' (Fyfe 1937, 1953).

Kontikia C.G.Froehlich, 1955

Kontikia andersoni Jones, 1981

MATERIAL EXAMINED

Voucher specimen: Lusitania Creek Lusitania Bay, Macquarie Island, by R.J.Blakemore, 7 January 1998. QVM: 19:3962. Length 16.0 mm, maximum width 2.5 mm, mouth 11.5 mm from the anterior tip, gonopore 1.3 mm behind the mouth. Fixed in 70% ethanol; 18 slides of anterior tip, prepharyngeal, and posterior LSS with TS through the region of the gonopore, sectioned at 8 µm, stained by MSB method.

Additional material: immature specimens from Lusitania Creek, Lusitania Bay, Macquarie Island, collected by R.J.Blakemore, 7 January 1998, (a) length 16.0 mm, maximum width 2.0 mm, mouth 10.0 mm from the anterior tip; (b) 7.0 mm long; (c) 6.5 mm long. Fixed in 70% ethanol; some 32 specimens, some of which appear to exhibit a gonopore, found in moss and/or under rocks, Lusitania Valley, Lusitania Bay, Waterfall Bay (material not examined), and Green Gorge (material not examined) Macquarie Island, collected by M.Stevens and R.Edwards, 5–6 February 2004, LW 1772. Fixed in 70% ethanol.

EXTERNAL MORPHOLOGY

Body small, thin, ellipsoid to subquadrangulate in cross section. Mouth ventral at about third body quarter (72% of body length), with genital pore very close behind it (80% body length). Living specimens up to 25 mm long and 1.5mm wide. Markings: Dorsolateral ground colour buff with three dark red-brown finely mottled stripes running length of body: a thin median stripe, then paired broader lateral stripes. Mottling present laterally as ill-defined stripe. Ventral surface is cream-white.

HEAD

Anterior adhesive pad or sucker absent. Eyes small, pigment cup-type, with greater depth (23 µm diameter) than width (20 µm diameter), numerous, in a single row around the anterior tip then with slight clustering over 1–2 mm, then continuing in a staggered submarginal line posteriorly (Fig. 7). Sensorial zone pale, ventral, skirts anterior tip and present anterolaterally. Sensory pits ciliated, 5.4 µm diameter, 12.6 µm deep. The pits appear mostly to be simple, though there was a suggestion of a diverticulum observed in a few pits.

PRE-PHARYNGEAL REGION

Dorsal epithelium 12.6 µm thick, ventral epithelium 18 µm thick, ciliated adhesive margin present. Rhabdoids of the rhammite type, 12.6 µm long. Erythrophil, xanthophil secretions abundant dorsolaterally, present also over creeping sole. Cyanophil secretions sparse. Ciliated creeping sole 42% of body width. Cutaneous musculature tripartite, weak, with circular, helical muscles; with longitudinal muscles in bundles. CMI 3.8%. Parenchymal musculature strong, with longitudinal muscles present in a well-defined ring zone (22 µm thick, PMI 4.3%) and ventral plate (45 µm thick, PMI 8.7%). Dorsal, subintestinal and subneural diagonal muscles, and dorsoventral muscles weak.

ALIMENTARY SYSTEM

Pharynx elongate, cylindrical, 214 µm long, with ventral insertion anterior to dorsal insertion. Pharyngeal musculature with inner epithelium, longitudinal, then mixed circular-longitudinal muscles; outer pharyngeal musculature with epithelium, longitudinal, thick layer circular, then longitudinal muscles. With oesophagus, oesophagus-pharynx ratio 25%. Pharyngeal pouch 118 µm long, with mouth 90 mm, 76% of pouch length. Pouch diverticulum absent.

REPRODUCTIVE SYSTEM

Copulatory organs (Fig. 8) lie in posterior body third. Testes are not present. A vas deferens is present just behind the pharyngeal pouch. Here it rises slightly, then expands to form a spermiducal vesicle. Vesicle ellipsoidal, 56 µm diameter, 84 µm long with flattened nucleate non-ciliate epithelium, contains mature sperm. Coiled seminal duct, with amorphous pale cyanophil contents derived from adjacent parenchymal glands appears to enter distal (prostatic) end of ejaculatory duct, possibly through multiple openings in dorsoanterior end. Ejaculatory duct with ciliated, nucleate cuboidal epithelium, underlain by weak longitudinal musculature ventrally, stronger decussate corseting musculature dorsolaterally; circular muscles sparse. Prostatic region approximately 180 µm long, with strong erythrophil and cyanophil secretions passing through roof and walls of distal ejaculatory duct. Mid section of ejaculatory duct 460 µm long, with ciliated, nucleate cuboidal epithelium. Common antrum with thick, rugose columnar epithelium with lumenal margin heavily charged with fine erythrophil granules, with slightly thickened musculature in region of gonopore. Female antrum tapers posteriorly, with strongly erythrophil rugose cuboidal epithelium lining roof and walls.

Ovaries elongate, paired, approximately 220 µm long, 70 µm high, embedded in anterior lateral nerve cords at one-third of the distance between anterior tip and pharyngeal root. Oviducts with tuba at ovary, enter ventrolateral ovarian wall at two points: small foramen to anterior ovary, and larger mid ovarian foramen with occlusive cells. Sperm is present in both oviducts and tubae. From tubae, ovovitelline ducts pass posteriorly along crest of lateral nerve cords to well behind the copulatory organs, incurve, then join to form common ovovitelline duct 400 µm long. Common duct, slightly undulating, enters distal (glandular) region of female genital canal horizontally. Distal genital canal receives shell gland secretions from glands in adjacent parenchyma, and then rises gently to enter female antrum. At this point half of the duct is split by small mucosal flap from left antral wall. Vitellaria are extensive and surround the gut.

PATHOLOGY

A very light parasitic load of gregarine gamonts is present in the gastrodermis.

SYSTEMATIC DISCUSSION

The mainly Indo-Pacific genus *Kontikia* is characterised by the presence of a broad creeping sole, strong parenchymal musculature, ventral testes, and penis papilla. Given the absence of a distinct penis papilla in *K. andersoni*, this species appears to be more closely related to the austral genus *Parakontikia* (penis papilla absent) than *Kontikia* (penis papilla present). However *K. andersoni* exhibits slight anterolateral crowding of the eyes unlike species of *Parakontikia* that have a single row of eyes anterolaterally. This character is shared with sub-Antarctic genera (*Artioposthia carnleyi*; *Kontikia ashleyi*). The stripe pattern exhibited by *K. andersoni* is close to that of *Tasmanoplana tasmaniana*. The latter species is differentiated from *K. andersoni* in having a single row of eyes without anterolateral crowding, broader creeping sole (60%), stronger parenchymal musculature (PMI 11.5–20%), well-formed penis papilla, and viscid gland.

The external appearance, position of the body apertures, and internal anatomy of the Macquarie Island voucher specimen generally accord with the original description of *K. andersoni* from specimens collected in Ireland. The Macquarie Island specimens differ from the Ireland specimens in having a narrower creeping sole (Holotype 50%, voucher 42%), stronger cutaneous musculature (Holotype 1.2%, voucher 3.8%) and stronger parenchymal longitudinal musculature (Holotype PMI 3%, voucher PMI 12.9%). The copulatory organs of the voucher specimen are not as contracted as in the material from Ireland, and the male organs appear immature.

The presence of spermatozoa in the spermiducal vesicle, but absence of testes in the voucher specimen is puzzling. It is difficult to determine whether the specimen is immature, suggested by the absence of testes and poorly differentiated efferent ducts, secretory elements and musculature, or whether other factors have given rise to the incomplete male organs (resorption of the male organs, sterility and arrested development due to parasites, or that the specimen is in the process of a sex change). Similar apparent developmental anomalies have been observed in species of the *Newzealandia moseleyi-graffi-iris* complex (Fyfe 1947; Johns 1993; Winsor pers. obs.). The patent gonopore, presence of sperm in the tubae, and absence of sperm in the antra of the *K. andersoni* voucher specimen indicate that copulation had taken place sometime earlier. Examination of additional mature specimens is necessary to resolve present uncertainties of the anatomy of *K. andersoni* from Macquarie Island.

The taxonomy of *K. andersoni* is complicated. As the species appears to lack a penis papilla it therefore should be transferred to *Parakontikia*. However, externally *K. andersoni* closely resembles *Artioposthia subquadrangulata* variety (b) of Dendy (1895 page 188), one of the three variants of *A. subquadrangulata* described from gardens near Christchurch, Ashburton, Dunedin, and The Bluff, in the South Island of New Zealand (Dendy 1895). *Artioposthia sub-quadrangulata* is as yet an unresolved species complex comprising some eight or more species and a number of genera (Johns 1998). Some members of this complex occur naturally on the New Zealand sub-Antarctic islands, but not the *A. subquadrangulata* variety (b). It is therefore proposed to leave *K. andersoni* in the genus *Kontikia* pending resolution of the *subquadrangulata* complex.

Kontikia andersoni was originally described from specimens found at 'Massereene', in County Antrim, Northern Ireland, on the shore of Loch Neagh. It occurred with *Arthurdendyus triangulatus,* an introduced species from New Zealand, the native European flatworm *Microplana terrestris*, and the terrestrial nemertean *Argonemertes dendyi*, native of south western Australia, but reported as an immigrant to European greenhouses, the Azores and Canary Islands, as well as the British Isles (Moore and Gibson 1981). The country of origin of *K. andersoni* is unknown, but is suspected to be New Zealand.

GENERAL DISCUSSION

The co-occurrence of *K. andersoni* and *Arthurdendyus vegrandis* at the Lusitania Bay site, Macquarie Island, strongly suggests both species are introductions from New Zealand. Lusitania Bay was the site of the first attempt by a scientist, A. Hamilton, to deliberately modify the island's flora by importing a range of tree seeds from southern New Zealand (Selkirk et al. 1990). The bay was also the centre for harvesting oil from seals and penguins for some years and there was much traffic in materials such as firewood, soil and plant products that could harbour flatworms (Cumpston 1968). Recent fieldwork at Macquarie Island by one of us (MS) showed that both species are more widespread and numerous than previously found by R. Blakemore. However the distribution of both species in the Lusitania Bay area is very patchy and often only a single individual was found at any one site.

No earthworms were found in the area where *A. vegrandis* was first found to be present, though earthworms are abundant elsewhere on the island (R.J.Blakemore pers. comm. to P.Greenslade). This observation, together with the type of pharynx present in this genus, is circumstantial evidence supporting the view that *A. vegrandis* is vermivorous. Against this one of us (MS) observed earthworms coexisting with both *A. vegrandis* and *K. andersoni*. The flatworms were not observed feeding on the earthworms. Other *Arthurdendyus* species, *A. triangulatus* and *A. albidus* have been recorded in the U.K. as introductions. The damaging effect of *A. triangulatus* on native earthworm populations in Europe is well documented (Cannon et al. 1999).

Kontikia andersoni was found at the same site on Macquarie Island as the new *Arthurdendyus* species. Here it possibly feeds mainly on Collembola (Greenslade pers. comm.). In Canterbury, New Zealand, *Artioposthia subquadrangulata* (one of the complex with similar external morphology to *K. andersoni*) has so frequently been found associated with slugs for there to be no foodchain link (Johns 1993). In one instance on Macquarie Island one of us (MS) observed four *K. andersoni* individuals feeding on a single slug at Waterfall Bay.

Further studies on the distribution, taxonomic histology, and ultimately molecular biology are needed to investigate the origin and phylogenetic affinities of these two flatworm species on Macquarie Island. This will involve a multidisciplinary approach involving genetic and ecological data.

Acknowledgements

Penny Greenslade, Paul Sunnucks, Rod Blakemore, and Robert Edwards are thanked for making the flatworms available for study, for information on the collection sites, assistance on Macquarie Island, and for constructive comments on early drafts of this paper. We thank the Australian Antarctic Division who in part supported this work (ASAC project 2397), and are grateful for support of the 56th ANARE 2003/2004 staff and use of the facilities on Macquarie Island. We thank Geoff Copson (Department of Primary Industries, Water and Environment), and Peter Cusick and Noel Carmichael (Department of Tourism, Parks, Heritage and the Arts) for their advice and assistance with permits and access to the sites. Support for the use of equipment, consumables and facilities from Professor R. Pearson, Head of the School of Tropical Biology, James Cook University, is gratefully acknowledged.

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ABBREVIATIONS USED IN FIGURES

ad adenodactyl
af antral folds
ba battery of adenodactyls
ca common antrum
cm cutaneous musculature
co common ovovitelline duct
ed ejaculatory duct
fa female antrum
fg female genital canal
gp gonopore
in intestine
lb lateral bursa
ma male antrum
mf mucosal flap
pb penis bulb
pp pharyngeal pouch
px pharynx
nc nerve cord
oe oesophagus
ov ovary
od ovovitelline duct
rv rete vas deferens
rz ring zone, parenchymal longitudinal muscles
sg shell glands
sv seminal vesicle
te testis
vd vas deferens
vi vitellaria

A FOUR-YEAR ANTIPODEAN ODYSSEY: THE REVEREND WILLIAM WEBB SPICER M.A. IN TASMANIA, 1874–1878

Andrew C. Rozefelds

Rozefelds, A. C. 2005. A Four-Year Antipodean Odyssey: The Reverend William Webb Spicer M. A. in Tasmania, 1874–1878. *Kanunnah* 1: 33–46. ISSN1832-536X. A biographical sketch, focussing on the natural history studies of Reverend W.W. Spicer M.A. is provided. Spicer resided in Tasmania from 1874 to 1878, and during this time he published research papers and a *Handbook of the Plants of Tasmania*. Spicer was responsible for incorporating and curating both Joseph Milligan's and Ronald Campbell Gunn's herbaria into the Tasmanian Museum and Art Gallery [Tasmanian Herbarium (HO)] collections. Spicer's *Handbook of the Flora of Tasmania* provided the stimulus for the subsequent publication of Mueller's *Key to the System of Victorian Plants*.

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KEY WORDS: Spicer, biography, Tasmania, history, Tasmanian Museum and Art Gallery, natural history.

William Webb Spicer was a naturalist and botanist who spent four years of his life in Tasmania. He was born in England in 1820 and was ordained an Anglican priest in 1846 at the Chapel of Farnham Castle, County of Surrey, by the Bishop of Winchester. He was the Rector at Itchen Abbas, Winchester, England for twenty-four years from 1850–1874 (Fig. 1).

During Spicer's time as Rector of Itchen Abbas he oversaw extensive alterations and additions to the Rectory, and supervised the committee responsible for rebuilding part of the church (Claisse and Taylor 1992). The original Norman church building was built in the late eleventh century, and parts of the original Norman stonework, i.e., the chancel arch and in the porch, were included in the new church which was consecrated on 30 May 1863 by the Bishop of Winchester. The original chancel arch and porch were deliberately incorporated into the building to 'give a tone of antiquity'.

Spicer's support of the local community is illustrated by his application for a grant in 1873 from the National Society to build a new school in the area. His application

FIG. 1. The Church of St John the Baptist, note the original Norman walls in the porch and chancel arch. Photo Paul Douglas.

for funding was unsuccessful and the school board had to be established, and was funded from local rates. Also in 1873, he initiated a parish fund to raise money for villagers who lost their homes in a fire, and 73 pounds, 8 shillings were raised (Claisse and Taylor 1992). No details are provided as to why or when Spicer left the Parish. In the history of the church it is suggested that 'Spicer appears to have left the Parish in June 1874' (Claisse and Taylor 1992, p. 16), although the information from Tasmanian sources would indicate that he left the parish somewhat earlier that year.

He completed a M.A. from Christ Church College, Oxford, in 1848 and was familiar with both Latin and German. Spicer's interest in botany, and in particular ferns, is recorded in correspondence to Sir William Hooker, the then Director of Kew.[1] Spicer's letters written between 1856 and 1857 indicate that he had a personal herbarium. He also visited Kew, and Hooker allowed him to choose specimens from his duplicate collection. Spicer's comments in these letters indicate an understanding of species concepts and plant taxonomic methods. In 1869, he translated and edited *The Collection and Preservation of Algae* by J. Nave from the original German text *Anleitung zum Einsammeln, Präpariren und Untersuchen der Pflanzen, mit besondere Rücksicht auf der Kryptogamen* (Stafleu and Cowan 1985). He also wrote articles on some rare insects in Wiltshire (England) (Spicer 1874). His botanical collections are lodged in a number of herbaria in England including Winchester, Oxford, Kew and Liverpool and he was also a Fellow of the Royal Microscopical Society (Desmond 1994).

It is clearly evident from these records from England that Spicer's interests in Natural History were well established before he came to Tasmania. He was also evidently a capable administrator, and contributed to the wellbeing of the local community, and these skills were used to good effect during his time in Tasmania.

Spicer came to Tasmania in 1874 when he was 54 years old. It seems that his reason for coming to Tasmania was his son-in-law, Frederick (or Frederic) John Simson's ill health. Spicer's daughter, Dora Mary Spicer, married Frederick John Simson in 1870 (Simson 1966). Simson (1966, p. 27) recorded that while moving furniture 'a large mirror fell on the back of Frederic's head. As a result of medical advice he and his family worked a farm temporarily in Tasmania for five years where Augustus [Simson, Frederic's brother] joined them'. The juxtaposition of these two sentences is probably unrelated, but patients suffering from poor health, due to either tuberculosis or another respiratory disease, were often encouraged to leave England for what was considered a better climate in Australia. In *The Mercury* of the 31 January 1874, Frederick and Dora Simson with two children and servant were recorded as arriving in Hobart on the *S.S. Southern Cross*, on the previous day. Spicer and his wife, Dorotheae, joined their son-in-law and daughter in their move.[2] They are recorded, in *The Mercury* of the 10 February 1874, as arriving at Low Heads in northern Tasmania on the *S.S. Tamar* on the previous day. *The Records of the Archives of the Anglican Diocese of Tasmania*, Hobart, record that Spicer was not licensed as a priest by the Bishop of Tasmania until the 8 September 1876 (S. Blackler pers. comm. 2003). He was listed, on the passenger lists of the *S.S. Tamar*, as Mr Spicer, which also supports the claim that his coming to Tasmania was for personal, rather than for ecclesiastical duties. Brief accounts have appeared of Spicer's research and studies in Tasmania (Maiden 1909; Orchard 1999). As Orchard (1999) noted, Spicer's *Handbook of the Plants of Tasmania* was the first locally produced flora in Australia. In this paper a more comprehensive account of Spicer's life in Tasmania is provided. In particular, it focuses upon his work on some of the early botanical collections that were the founding collections of the Tasmanian Museum and Art Gallery, and are now currently lodged in the Tasmanian Herbarium. The paper documents his research on Tasmanian natural history, including the publication of the first State Flora, the *Handbook of the Plants of Tasmania*, for Australia. This paper also documents his contribution to the broader Tasmanian community, in particular his association with the Royal Hobart Hospital, and his chairmanship of the Royal Commission into the running of the Hospital.

Botanical Studies and Early Botanical Collections of the Tasmanian Museum and Art Gallery

Spicer arrived in Hobart in 1874, and is listed as a Member, or Fellow, of the Royal Society of Tasmania in the *Report of the Royal Society of Tasmania* for that year, so he quickly immersed himself in the scientific and cultural life of the colony. The Royal Society consisted of learned members of the community and consisted of over 130 members and fellows at this time. Spicer as a member of the Royal Society of Tasmania provided assistance with curating some of the most important botanical collections to be donated to the Society. It is evident from his publications, and from comments in his letters, that he had a good understanding of plant nomenclature and plant systematic concepts. In the Proceedings for July 1875 of the *Papers and Proceedings and Report of the Royal Society of Tasmania*, 1876, Spicer is recorded as donating various Sedums to the Botanical Gardens in Hobart. It is not known whether he was asked, or if he offered to curate the Royal Society's botanical collection. In a letter to the Council of the Royal Society he indicates that he has just completed curating Joseph Milligan's plant collection. He notes in the Proceedings for October 1875 of the *Papers and Proceedings and Report of the Royal Society of Tasmania*, 1876, that:

> they were in a state of disorder, the species being in many cases mingled together, and no care having been taken to keep them under their respective natural categories.

In the same letter, Spicer also notes that:

> the collection consists of 468 species and varieties, comprised in 244 genera and 69 orders (a small proportion this of the whole of our native Flora, which at present known, contains nearly 1000 species, ranged under about 420 genera and 93 orders), but the plants included in it have a special value, having had the advantage of passing under the inspection of Baron von Mueller, and many of them, I believe, having served as types of Hooker to Bentham, in working out the Flora of Tasmania and the Flora Australiensis.

Spicer also explains that:

> In arranging Dr Milligan's plants I have followed the scheme employed by Baron von Mueller and in his 'Census of the Plants in Tasmania, 1875', and to a great extent but not entirely, I have adopted his nomenclature.

Spicer also indicated that at this time the herbarium of the Royal Society of Tasmania, which comprised the founding botanical collections for the Tasmanian Museum and Art Gallery, contained another 2000 specimens, consisting of nearly 30 different collections. In discussing the collections he notes that 'many of these are valuable, while of others it may be said, the wonder is they ever found a lodging here at all!' In the same letter, he also offered to curate these remaining collections. In the Report of the Royal Society for the year 1875 in the *Papers and Proceedings and Report of the Royal Society of Tasmania*, for 1876 the Council of the Royal Society acknowledged Spicer's contribution and indicated that he had provided a:

> most valuable service by naming, arranging, and mounting the various collections of dried plants in the Museum. The European and Tasmanian portions of the Herbarium have already been completed, and Mr Spicer purposes to proceed with the arrangement of the remainder as opportunities offer.

The Tasmanian Museum and Art Gallery's botanical collections at this time comprised approximately 3000 specimens.

Spicer and James Reid Scott (explorer and politician) also took on the labour of arranging, re-papering, and classifying the large collection of Tasmanian plants that were collected by Ronald Campbell Gunn and donated to the Tasmanian Museum and Art Gallery in 1876.[3] The only proviso placed on the donation of the collection was that any duplicate specimens were to be returned to Gunn. No indication is given as to the size of Gunn's collection but there are currently 1300 Gunn specimens in the Tasmanian Herbarium (A.M. Buchanan, pers. comm. 2003). Gunn's collection would have increased the total number of specimens in the Tasmanian Museum and Art Gallery to well over 4000. Gunn's original collection consisted of more specimens but a significant proportion of the Tasmanian Museum and Art Gallery's collection of Gunn's Herbarium was transferred to the National Herbarium of New South Wales in 1904 (Anonymous 2001).

While the Society was successful in obtaining the Milligan and Gunn collections, some other important collections unfortunately went overseas. Spicer was clearly supportive of maintaining scientific collections in the Colony (of Tasmania) and a letter, in the Library of the Royal Botanical Gardens, Melbourne (RB MSS M72), to Australia's foremost botanist, Ferdinand von Mueller, he wrote:

> We have missed getting a good herbarium – W. Archer's. It was sent to England – and Dr Hooker advised us we could have it for 60 Pounds. However the government has refused the money, and the Society cannot afford to [buy] it, it will be sold in England. I am sorry because it was so purely Tasmanian.

Spicer correspondence, from at least November 1876 to February 1878, with Mueller is preserved in the Library of the Royal Botanical Gardens, Melbourne. He also sent specimens to Mueller for identification. Mueller in his essay, 'Contributions to the Phytography of Tasmania', acknowledges Spicer's help in providing information on plants that were naturalised in the colony (Mueller 1877). Spicer's (1878a) paper entitled 'Alien Plants' collated his observations on naturalised plants in the colony, and was published in the *Papers and Proceedings of the Royal*

Society. Information on the introduced flora of Tasmania was also included in his *Handbook of the Plants of Tasmania* which was published in the same year (Spicer 1878b). The significance of these two studies in documenting the naturalised flora in Tasmania in the 1870s is reviewed in Rozefelds and Mackenzie (2005), in this issue of *Kanunnah*. They concluded, from Spicer's research, that over 100 species of plants had became naturalised in Tasmania in the first 70 years since the establishment of the colony. Nearly all the plant species that were recorded by Spicer as being naturalised were annuals or rapidly maturing perennials.

Spicer's *Handbook of the Plants of Tasmania* was the first comprehensive guide published on a state flora in Australia. Spicer's book was reviewed anonymously in *Walsh's Literary Intelligentsia* in April, 1878:

> In all of the 100,000 inhabitants of Tasmania, there are probably not a half-a-dozen men or women who could give an intelligent account of a handful of the plants indigenous to the Colony gathered in hazard; and this arises from no lack of ability or desire to acquire the information, but because such information was up to the present time only to be obtained from costly books, and at a great sacrifice of time... Though modestly called a *Handbook of the Plants of Tasmania*, it is really a key to a much more extended field of botanical research, and those studying it will gain a large insight into the flora of the neighbouring colonies.

The Handbook provided an overview of the flora of the Colony of Tasmania and it also inspired the writing of a handbook on the Victorian Flora. The Reverend Stanley Dobson (President of the Field Naturalists in Victoria) wrote to the Chief Secretary's Office asking the then Minister of Education, the Hon. Prof. Pearson, and others, to support the publication of a handbook of the Victorian flora.[4] Spicer's *Handbook of the Plants of Tasmania* was cited as an appropriate model, and Mueller responded by publishing his *Key to the System of Victorian Plants* in 1887–1888.

Spicer did not undertake any detailed taxonomic studies, although he was familiar with the existing published floras. Correspondence in the Library, Royal Botanical Gardens Melbourne, indicates that he sought help from Mueller with specimens he could not identify, and also to obtain descriptions of species that were not available at the Tasmanian Museum. In his *Handbook of the Plants of Tasmania*, he did however recognise a new species of *Helichrysum* (Spicer 1878b). Mueller named the species *Helichrysum spiceri*, after Spicer, thereby acknowledging his contribution to Tasmanian botany (Mueller 1878). The current name for this species is *Argentipallium spiceri* (F.Muell.) Paul G. Wilson. The single specimen of *Helichrysum spiceri* was discovered by his son-in-law's brother, the naturalist Augustus Simson (Simson 1880), who was a keen botanist, philatelist, and entomologist (Simson 1966).

Spicer donated his Tasmanian botanical specimens to the Royal Society of Tasmania and they were eventually incorporated into the Tasmanian Museum and Art Gallery collections. Over 122 specimens, including both native and introduced species, are currently lodged in the Tasmanian Herbarium. The vast majority of his specimens were from the greater Hobart area and were presumably collected by him. There are a few other specimens attributed to Spicer from Mt Olympus, Circular Head and King Island. It is not known whether he visited these areas, or whether the specimens were given to Spicer by other botanists. Specimens that he sent to Mueller are lodged in the National Herbarium of Victoria (e.g. *Eucalyptus sieberiana* MEL1615667). Orchard (1999) also notes that the Australian collections of Spicer are lodged in Herbaria in Auckland, Edinburgh, Kew, Manchester and Oxford.

Other Natural History Studies in Tasmania

Spicer had broad interests and published a series of natural history papers. These studies were either topics of special interest or more often general topics, as was the pursuit of educated people in the nineteenth century. One of Spicer's more interesting studies was an account of envenomation caused by the spurs of the male platypus (Spicer 1877). The victim was his son-in-law's brother, Augustus Simson. Spicer quotes the description from Mr [Thomas] Stephens (Educationist and Member of the Royal Society) of how the wound was caused, and the effect of the poison. Stephens wrote that the wound was caused by:

> a powerful lateral and inward movement of the hind legs, the spurs being brought together like the points of a pair of callipers... One spur slightly tearing the palm, and the other the back of the hand, making a deep puncture between the knuckles of (I think) the first and second fingers. The pain from this was intense, and almost paralysing. But for the administration of a small dose of brandy, he would have fainted on the spot.

Spicer (1978c) maintained his interest in algae and recorded the fresh water alga *Conferva bombycina* in Tasmania. Spicer also wrote three other papers that were published in *Papers and Proceedings of the Royal Society of Tasmania.* In these natural history papers he discusses the occurrence of the fungal disease ergot in Tasmania (Spicer 1878d), while the other two articles were semi-popular accounts on the interactions between plants and insects entitled 'Plants as insect destroyers' and 'Silk and silk producers' (Spicer 1878e,f).

As a member of the Royal Society, and through his contributions to the *Papers and Proceedings of the Royal Society of Tasmania*, Spicer would have known most of the scientific community in the colony. For example, he wrote to Mueller in 1876 (RMB MSS M72, Library, Royal Botanic Gardens, Melbourne) and commented that 'Our friend Father Woods [J.E. Tenison Woods] has left the Island for Queensland ... He will be a great loss to us here'. Spicer was also honoured by his peers in Tasmania as two new species of gastropods were 'apparently' named after him. While the etymology of the species names is not explained in either paper, it appears that Tenison Woods named the marine gastropod, *Fusus spiceri* after him in 1876. Similarly Petterd named *Helix spiceri* after Spicer in 1879. The current names for these gastropods are *Dolicholatirus spiceri* (Tenison-Woods, 1876) (Liz Turner, pers. comm. 2003) and *Trochoaloma spiceri* (Petterd 1879) (Brian Smith, pers. comm. 2003) respectively.

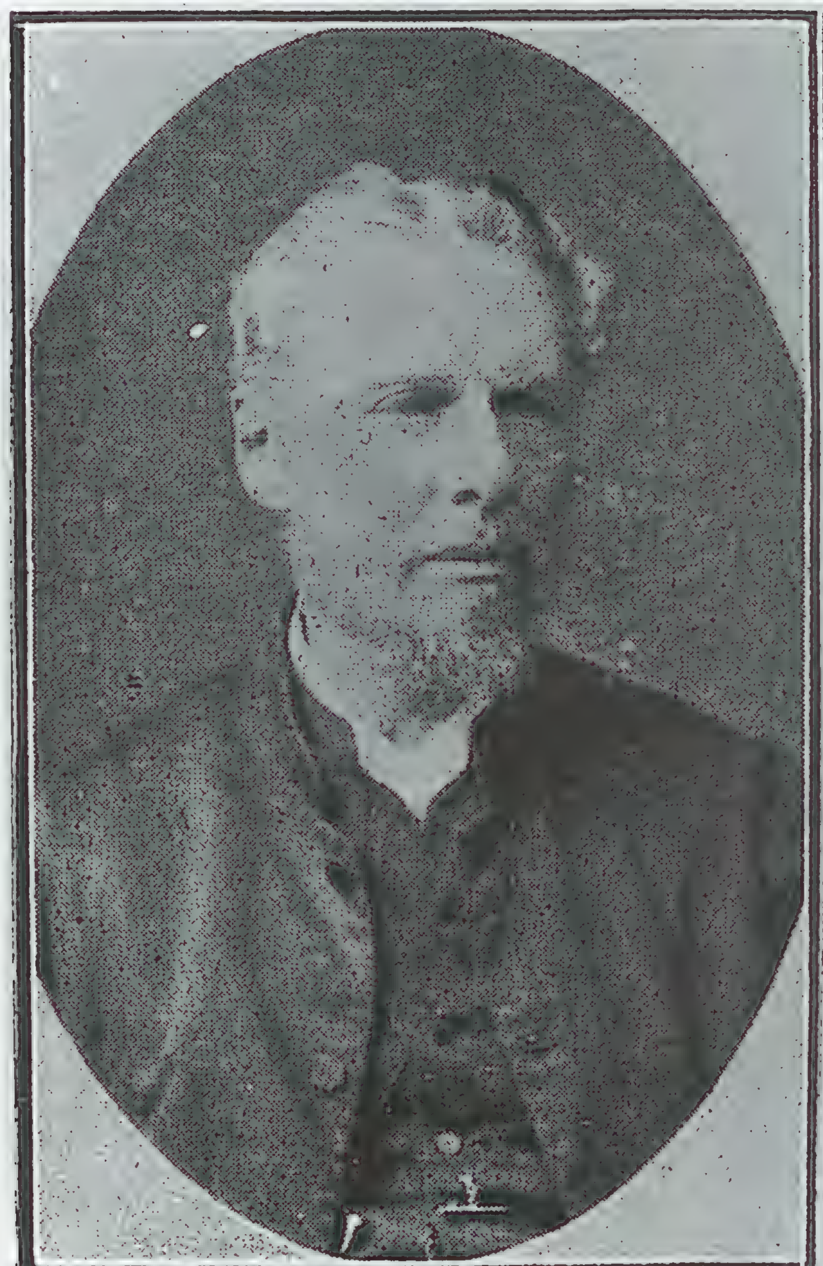

FIG. 2. Photograph of the Reverend W. W. Spicer, *Tasmanian Mail Centenary,* 21 February 1904, p. 19.

Contributions to the Broader Community

Spicer did not confine his activities to science and he supported a range of public institutions and charitable organisations in Tasmania, including the Royal Society of Tasmania. As indicated earlier he was licensed to officiate as a priest on 8 September 1876. *The Church News for the Diocese of Tasmania* for July 1876, p. 486, records some of his writings, including a philosophical essay on 'Sunday-School teaching: Its method and its aim'. In 1877, reprints of this article became available for purchase. He was actively involved in St David's Church Union, and in *The Mercury* of the 24 January 1877, it is noted that he helped set up a Sunday School at St David's Cathedral. *The Mercury* of the 2 February 1877 recorded that he was also a committee member of the Benevolent Society which provided support to the disadvantaged in Hobart.

Spicer read a paper before members of St David's Union, which was published in *The Church News for the Diocese of Tasmania* of the 1 September 1877 on the importance of 'District Visiting' which was a community outreach activity encouraging female members of the parish to proselytise on behalf of the church. *The Church News for the Diocese of Tasmania* of the 2 January 1877 also records that he was responsible for setting up a Penny Saving Bank in Hobart Town. The bank was to help poor people save money and when sufficient funds (e.g. three pounds) had been accumulated the money could then be transferred to a Savings Bank. The Penny Savings Bank was also seen as a means of encouraging greater temperance in the community.

His church duties, and lectures he gave on natural history topics, resulted in his travelling around southern Tasmania. It is recorded in *The Church News for the Diocese of Tasmania* that he preached at the Easter harvest festival at Pontville in 1877, and gave a lecture on the 11 October 1877 at Campbell Town. *The Mercury* of the 15 October 1877, notes that the lecture also included a display of 150 herbarium specimens. It was highly likely that these travels gave Spicer the opportunity to record the distribution of naturalised plants in the colony at that time.

Spicer's chief social contribution to Tasmania lay in his association with the Hobart General Hospital (Fig. 2). On the 14 December 1876, he was elected chairman of the Royal Commission into the running of the Hospital (Anonymous 1877; Rimmer 1981, p. 105). The Commission recommended the replacement of the surgeon superintendent with a board of management (Rimmer 1981). Spicer drew the Chief Secretary's attention to several recommendations of the Royal Commission, which included: the provision of two toilet blocks containing water closets at both ends of the main block; a hot water system so that patients could be bathed at any time of the day; and the repair of subterranean drains to ensure that the sewage was properly carried away from the hospital (Rimmer 1981, p. 117). Rimmer (1981) notes that these recommendations were put into effect immediately by the then Premier, Mr Thomas Reibey.

A provisional board was set up for the Hobart General Hospital with Spicer as the first chairman on the 29 January 1877 (Rimmer 1981, p. 106). In this position, *The Mercury* of the 20 November 1877 records that Spicer wrote to the Colonial Secretary in November 1877 recommending the provision of a hospital ambulance. He resigned from his chairmanship of the board in March 1878, and not March 1877 as indicated by Rimmer, because of ill health (Rimmer 1981, p. 106). Rimmer (1981) in his history of the Hospital, suggests that Spicer's resignation most probably resulted from the Premier's displeasure at his extravagance. Spicer, however, had decided to return to England, and he subsequently died the following year, so it seems more likely that ill health was the major factor in influencing his decision to resign.

During Spicer's brief term of appointment as chairman he foreshadowed the establishment of committees for finance, buildings, medical, and rules for visiting (Rimmer 1981). These committees never materialised and the finance committee undertook the main administration role for the Hospital (Rimmer 1981). This committee also languished following Spicer's resignation (Rimmer 1981).

Return to England

In February 1878, Spicer wrote to Ferdinand von Mueller, saying 'I am going to leave Tasmania and return with my family to the old country [England] once more. We have had enough of colonial life, and want to see our relations again.'[5] *The Tasmanian Mail* of the 30 March 1878 noted that Spicer left Tasmania in March to return to England, via Sydney, 'on the *S.S. Southern Cross*, with Mrs Spicer and misses (3)'.

He was widely applauded for his contributions to the Tasmanian community. The Council of the Royal Society in their Proceedings for April 1878, of the *Papers and Proceedings and Report of the Royal Society of Tasmania*, 1879 thanked Spicer for his efforts noting:

> their sense of loss the Society will sustain by his departure. They feel that their best thanks are due to Mr Spicer, not only for the large amount of special work which he has accomplished with the Museum and the Society, but also for his labours generally in the cause of the natural history of the island.

In the wider community *The Tasmanian Mail* of 30 March 1878 described Spicer as 'a useful and energetic member of the Royal Society of Tasmania, and an able contributor to colonial scientific record'. James Barnard (Government Printer) in *The Tasmanian Mail* of the 23 May 1878, noted the other contributions made by Spicer, including:

> the value of the co-operation rendered by him in the church and parish, as well as in connection with the Penny Bank, the Church Union and other parochial institutions, and... in the management of some of the Charitable Institutions of the town.

He died the following year, on the 28 April 1879, in Notting Hill, London and is buried in Itchen Abbas (Anonymous 1880; Desmond 1994). Spicer's daughter and son-in-law (Dora and Frederick Simson), owing to his wife's difficulties in Tasmania, left the colony in 1879 to return to Havre (France) (Simson 1966). Frederick Simson is buried in the Itchen Abbas cemetery as well (Fig. 3). Descendants of Augustus Simson's family, however, still reside in Australia.

Spicer was an energetic, hard working and independent thinker. This is evident in his views on religious teachings. In a paper to St David's Union recorded in *The Mercury* of the 8 March 1877, he outlined his views on 'Ritualistic Practices'. He expressed his disapproval of both:

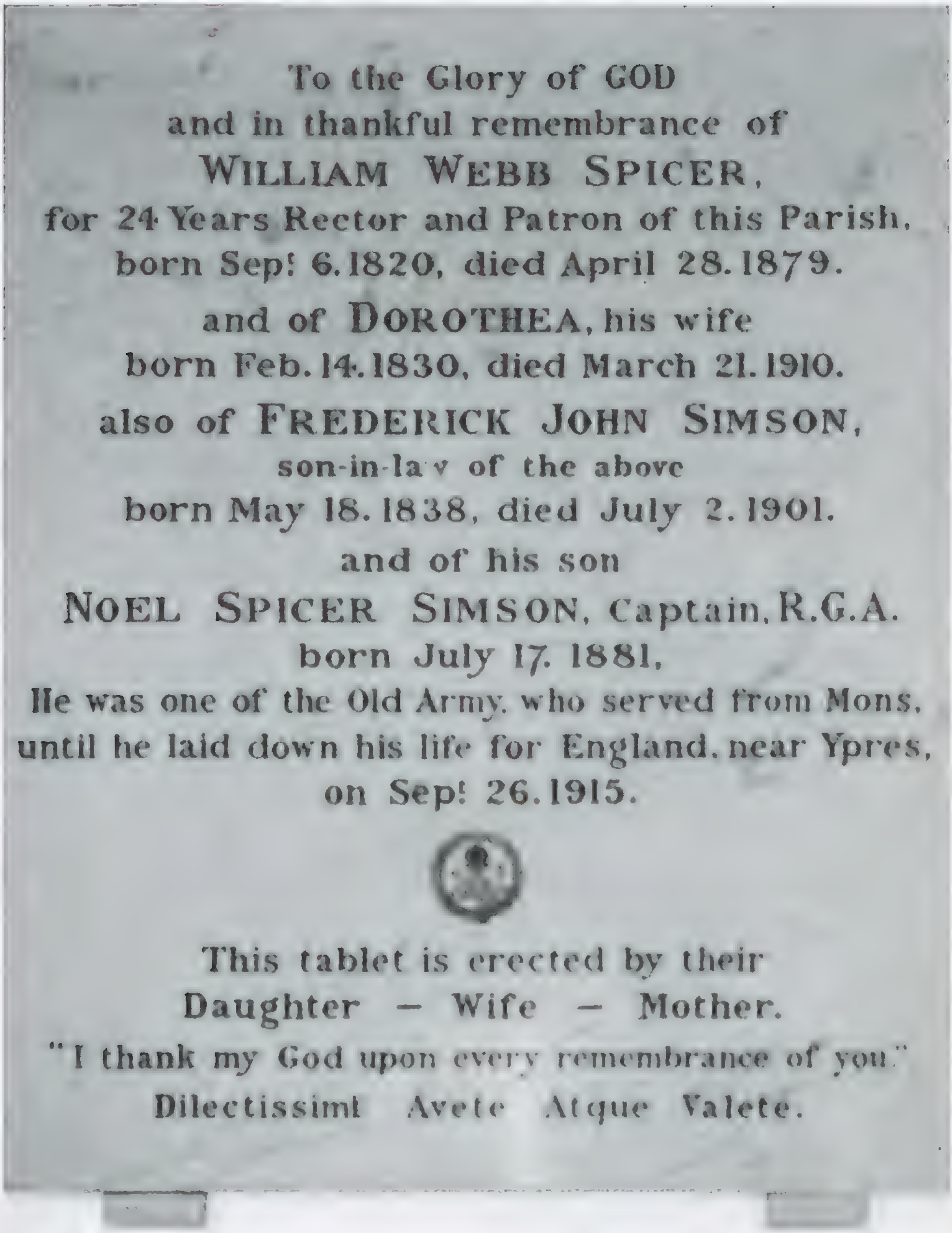

FIG. 3. Memorial to the Spicer family in the Church of St John the Baptist at Itchen Abbas, England. Photograph provided by Paul Douglas.

old style bald worship and the more extreme practices of the ritualist, but advocated a medium between the two, riz., the adoption of a ritual which makes the service pleasing and attractive without becoming a worship of mere outward forms.

As chairman of the Hospital Board he was a strong advocate for improving conditions in the Hobart Hospital. The available evidence suggests that Spicer was straightforward and uncompromising; and was prepared to write to the Editor of *The Mercury* of the 16 April 1877 to correct the public record regarding comments that were erroneously attributed to him. Many early Tasmanian collections, such as William Archer's orchids, were lodged in overseas herbaria. Spicer actively supported the Royal Society of Tasmania and the developing scientific infrastructure in the colony and recognised the importance of retaining significant collections in the colony.

Reverend William Webb Spicer made significant contributions to the natural history of Tasmania, particularly in botany, and during his four years in Tasmania he was also an important figure in Tasmanian life through his community work and philanthropy. Spicer was part of the gentleman-amateur scientific tradition that characterised much of the scientific enterprise undertaken in Tasmania at this time (Hoare 1981). As Gilbert (1982) pointed out the clergy made a more significant contribution to botanical knowledge in Australia during the nineteenth century than any other amateur group.

Spicer was a generalist in his interests, and his published papers included reviews and semi-popular articles, such as 'Plants as insect destroyers' and 'Silk and silk producers', while his 'Alien Plants' paper and *Handbook of the Plants of Tasmania* were significant studies in their own right. The *Handbook of the Plants of Tasmania* was the first state flora published in Australia. The significance of his 'Alien Plants' paper in documenting the weed invasion in Tasmania in the 1870s has only been fully appreciated relatively recently (Rozefelds and Mackenzie 2005). Spicer was also responsible for curating some of the most important botanical collections in Tasmania at that time, namely those of Ronald Campbell Gunn and Joseph Milligan. Spicer was honoured by having two gastropods and one flowering plant from Tasmania named after him. All of these contributions were completed, in a remarkably short period of time from 1874 to 1878, during Spicer's residence in Tasmania.

FOOTNOTES:

1 Directors Correspondence, Kew, Vol. 36, Item 386, 14 January, 1856; Item 549, 17 April 1857; Item 550, 27 April 1857.

2 John A. Simson (the son of Augustus Simson) wrote to Jim Willis, National Herbarium of Victoria, on the 27 May 1954, suggesting that 'My father's brother Fred was married to Rev Spicer's daughter, and that I think was what influenced that family to come to S. Tasmania for a few years'.

3 'Proceedings for May 1876', *Papers and Proceedings and Report of the Royal Society of Tasmania,* 1877, p. 10; *The Mercury*, 31 January 1877; 'Royal Society of Tasmania for the year 1876', *Reports of the Tasmanian House of Assembly,* 1877, Vol 33.

4 Inward registered correspondence, J.S. Dobson to Charles Pearson, 23 March 1887 (H87/3068, unit 272), and J.S. Dobson to Graham Berry, 13 September 1884 (A84/8354, unit 59) VPRS 3992/P, VA475 Chief Secretary's Department, Public Record Office, Victoria.

5 RB MSS M72, Library, Royal Botanical Gardens, Melbourne.

Acknowledgements

Ms Lyn Cave and Dr Stuart Blackler provided help with information on the Spicer's ecclesiastical pursuits. Ms Monika Wells (Mueller Correspondence Project) provided copies of correspondence between Ferdinand von Mueller and W.W. Spicer. Ms Elizabeth Turner and Dr Brian Smith provided advice on the current scientific names for two gastropods. The staff of the State Archives of Tasmania also provided help in accessing information on Spicer's life in Tasmania. Mr Richard Simson provided access to the family history of the Simson Family, *'The Simson Story and Family Trees'* which was written by Ivan Simson in 1966. Comments by Professor Michael Roe, Ms Gillian Winter and Ms Monika Wells on an earlier draft have significantly improved the ms. Ms Jackie Luck also provided help in researching the newspapers of the day. Roberta Cowen (Australian Botanical Liaison Officer, 2003) and staff at Kew and the Natural History Museum, London, provided help with accessing information in these institutions. Photographs and research by Paul Douglas from Salisbury, England, provided information on Spicer's life in England prior to coming to Tasmania.

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PALYNOFLORAS FROM FLINDERS AND CAPE BARREN ISLANDS, TASMANIA

Liliana M. Stoian

Stoian, L. M. 2005. Palynofloras from Flinders and Cape Barren Islands, Tasmania. *Kanunnah* 1:47–60, ISSN1832-536X. Well-preserved palynofloras were re-examined from sedimentary units at Rooks River, Cape Barren Island, and from Tanners Bay, Flinders Island in Tasmania. The palynofloras from Cape Barren Island are time equivalents of the Early–Middle Miocene Upper *Proteacidites tuberculatus* to *Canthiumidites bellus* Zones, while those on Flinders Island are equivalent to the Late Miocene–Early Pliocene *Monotocidites galeatus* Zone. The Miocene Rooks River sample is dominated by pollen of the Proteaceae (17%), *Nothofagidites* spp. (17%), Podocarpaceae (16%) and Casuarinaceae (11%). Dinoflagellate cysts are rare with both marine and fresh water taxa present. This may suggest an estuarine environment near the site. The Late Miocene–Early Pliocene sample from Tanners Bay yielded a quite distinct palynoflora, with *Milfordia* spp. (38%) dominant, and the Casuarinaceae (17%) and Proteaceae (10%) also well represented. *Nothofagidites* spp. and the Podocarpaceae are both rare at this site.

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KEY WORDS: Tasmania, Flinders Island, Cape Barren Island, Tanners Bay, Rooks River, Miocene, Pliocene, *Canthiumidites bellus* Zone, *Monotocidites galeatus* Zone, pollen, spores, palynofloras, dinoflagellate, correlation.

In 1964, Wayne Harris, Senior Palynologist with the South Australia Department of Mines and Energy (now PIRSA), was asked by the Tasmanian Department of Mines, to examine Utah Development Company samples from tin leads in north east Tasmania. Included in this collection were samples from localities on Cape Barren and Flinders Islands. The results of these studies were published in two internal reports (Harris 1965a,b).

With little known about the Tertiary palynology of Tasmania, Harris expanded his study to include additional samples provided by personnel of the University of Tasmania, Tasmanian Museum and Art Gallery, Tasmanian Department of Mines, and the Hydro-Electric Commission. These results were included in a summary internal report about Tasmanian Tertiary and Quaternary microfloras (Harris 1967), which was published a few years before a reference spore-pollen palynological zonation was developed for Australia

(Harris 1971; Stover and Partridge 1973). Most of the age-diagnostic fossil species were not formally described before 1971–1973, and an age like mid Tertiary or Quaternary indicates the limit of refinement at the time.

In response to a recent request by the Tasmanian Museum and Art Gallery for more information on Harris's 1965 results, a re-examination of the original slides was undertaken. This required a search through the palynological slide collections of the Geological Survey Branch, Minerals, Petroleum and Energy Division, PIRSA. Preservation of these slides varies considerably, but most are in good condition. Re-examination of samples from Cape Barren and Flinders Islands provides new information related to the age, spore-pollen zone and environmental settings, and the results are presented below.

Methods and Materials

Three samples have been re-examined, two from Cape Barren Island at Rooks River, and one from Flinders Island in the Tanners Bay area. Preservation and yield of palynomorphs varied from poor to excellent. Counts of between 500 and 1000 palynomorphs were undertaken on samples containing rich palynofloras. The S-752 sample from Rooks River, Cape Barren Island, contained too few palynomorphs for evaluation, so only the presence of species was recorded.

Palynomorphs images have been captured using a Nikon video camera attached to a Zeiss Photomicroscope III. Spore-pollen zonation of Stover and Partridge (1973, 1982) and Macphail (1999) are used for correlation of the palynofloras (Fig. 1). The taxa recorded from the three samples are listed in the Appendix.

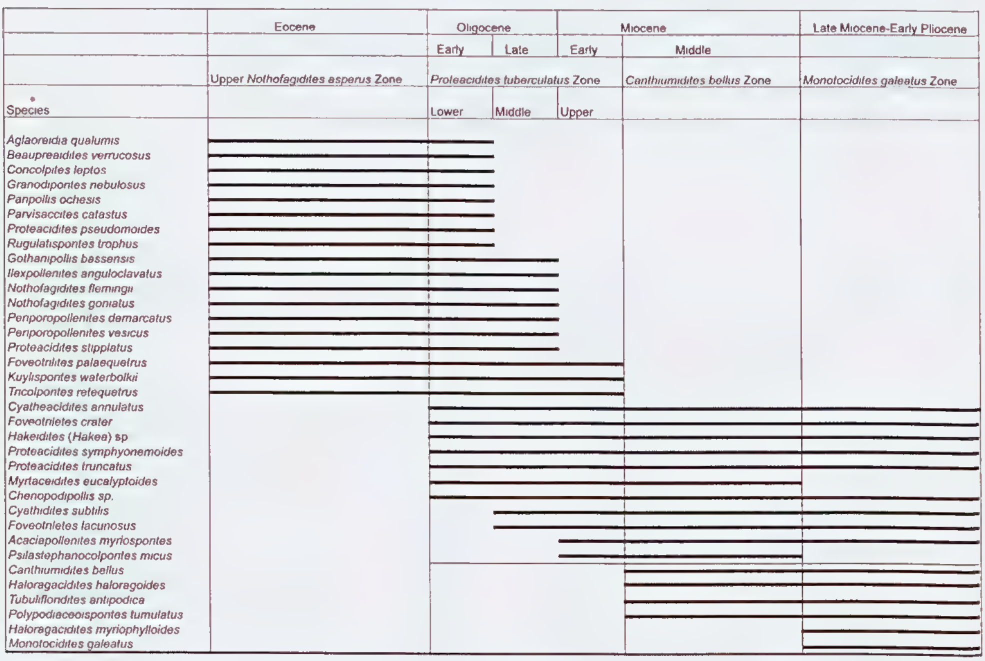

FIG.1. Distribution of selected spore-pollen species within the *Proteacidites* tuberculatus Zone, *Canthiumidites bellus* Zone and *Monotocidites galeatus* Zone (after Stover and Partridge, 1973 and Macphail, 1999, modified).

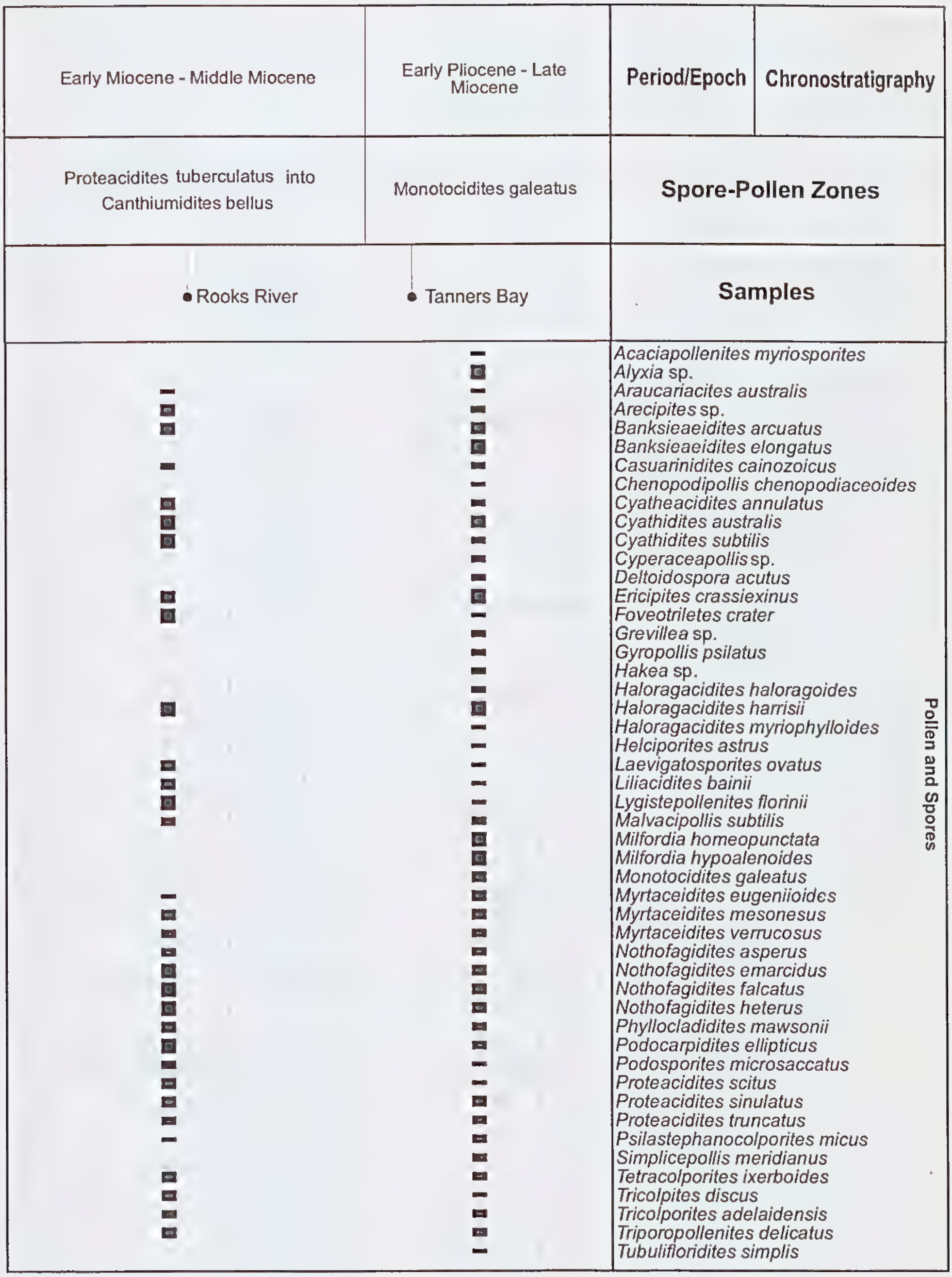

FIG. 2. Semi-quantitative distribution of pollen, spores and dinoflagellate cysts in samples from Flinders and Cape Barren Islands, Tasmania.

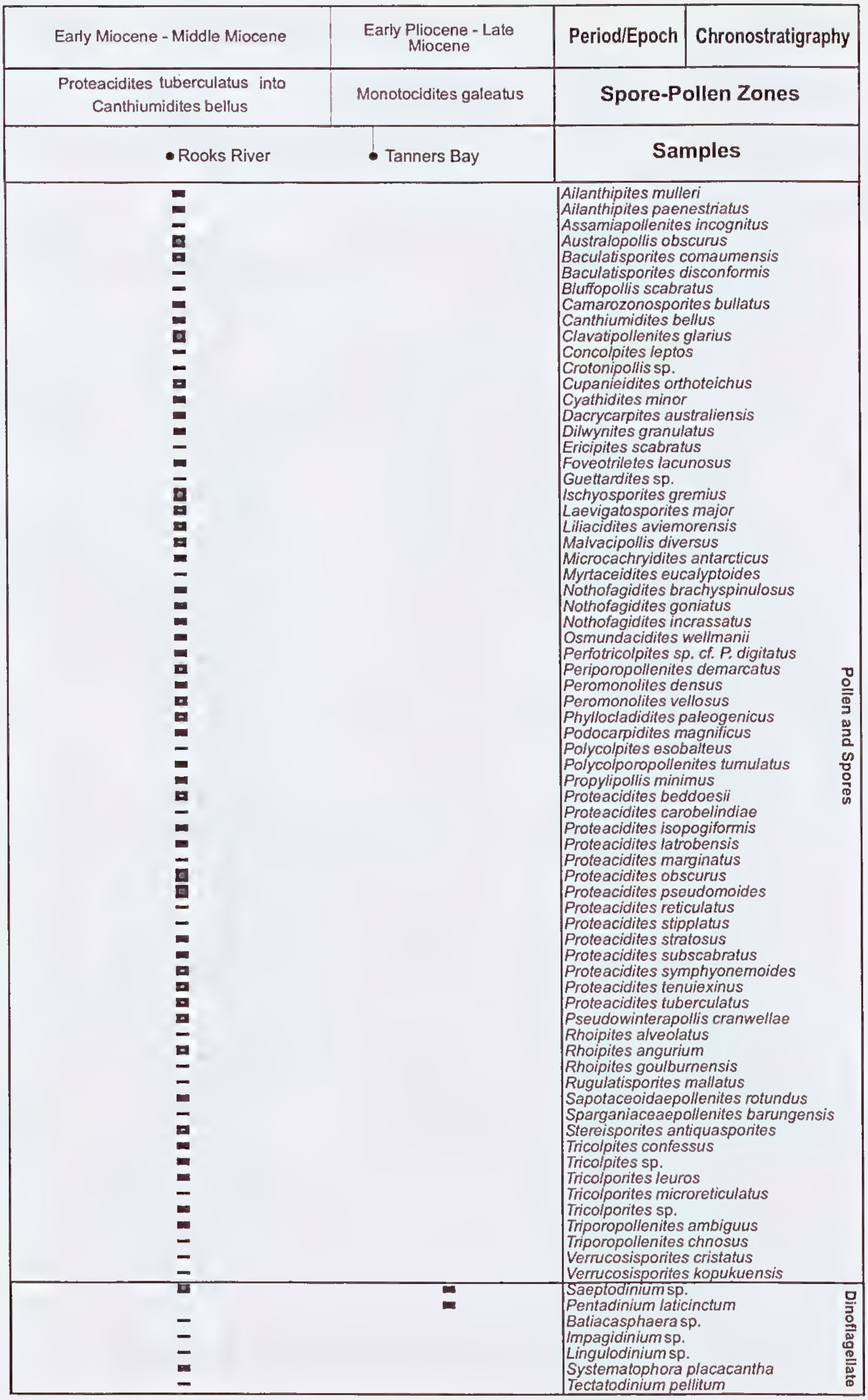

FIG. 2. *(continued)* Semi-quantitative distribution of pollen, spores and dinoflagellate cysts in samples from Flinders and Cape Barren Islands, Tasmania.

Composition of the Palynofloras and Dating

Rooks River, Cape Barren Island

SAMPLE NO. S 752

The preservation of palynoflora is fair, but the yield is poor and few species are present. These include *Nothofagidites* spp. (*N. falcatus, N. heterus* and *N. incrassatus), Gothanipollis bassensis and Cyathidites australis* (Fig. 2). Dinoflagellate cysts are represented by freshwater *Saeptodinium* spp. and the marine taxa, including *Pentadinium laticinctum, Hystrichokolpoma rigaudiae, Tectatodinium pellitum, Apteodinium australiensis, Systematophora placacantha, Heslertonia striata, Spiniferites ramosus and Lingulodinium* sp.

The presence of *Gothanipollis bassensis* would suggest Middle Eocene through Oligocene, Lower *Nothofagidites asperus* Zone into the lower part of the *Proteacidites tuberculatus* Zone (Stover and Partridge 1973, Gippsland Basin). Macphail (1999) extended the range of this taxon to Middle Miocene, *Canthiumidites bellus* Zone (Murray Basin). The absence of other key spore/pollen indicator taxa makes it difficult to assign an age. The dinoflagellate cysts assemblage includes a number of long-range taxa, which are known to occur from Late Eocene in the Eucla Basin (Alley and Beecroft 1993), to Oligocene–Miocene in the Murray Basin, South Australia (Truswell et al. 1985). Dinoflagellate cysts suggest a marine influence.

SAMPLE NO. S 753 (FIGS. 3–6)

Yields are excellent and preservation of palynofloras is good. Pollen dominance is shared between Proteaceae (17.4%), *Nothofagidites* spp. (17.2%), Podocarpaceae (16.7%) and Casuarinaceae (10.5%). Liliaceae (1.9%), Myrtaceae (1.4%) and dinoflagellate cysts (1.4%) are all rare (Fig. 2).

The Proteaceae component includes *Proteacidites obscurus* (8%) with moderate frequencies of *P. pseudomoides* (1.8%) and *Banksieaeidites arcuatus* (1.5%). Other taxa, including *Proteacidites beddoesii, P. reticulatus, P. sinulatus, P. stratosus, P. scitus, P. subscabratus, P. stipplatus, P. symphyonemoides, P. tenuiexinus, P. truncatus, P. tuberculatus and Propylipollis minimus,* are all rare. *Nothofagidites* spp. are represented by *N. emarcidus* (9.6%), *N. falcatus* (3.1%), *N. heterus* (3%) and rare *N. asperus, N. brachyspinulosus, N. goniatus* and *N. incrassatus.*

Podocarpaceae pollen grains are also common with *Podocarpidites ellipticus* (7.7%) and *Lygistepollenites florinii* (6.4%) well represented. *Microcachryidites antarcticus, Dacrycarpites australis, Araucariacites australis, Dilwynites granulatus, Phyllocladidites mawsonii* and *P. palaeogenicus* are rare. The Casuarinaceae is dominated by the species *Haloragacidites harrisii* (10%), with *Casuarinidites cainozoicus* rare.

Spores (14%) are well represented, i.e. *Ischyosporites gremius* (2.7%), *Foveotriletes crater* (2.4%), *Cyathidites australis* (2.4%), *C. subtilis* (1.9%) and rare *Cyatheacidites annulatus, Camarozonosporites bullatus, Baculatisporites comaumensis, Peromonolites vellosus, P. densus* and *Stereisporites antiquasporites.* Other taxa present include *Clavatipollenites glarius* (2.4%), *Australopollis obscurus* (1.8%), Droseraceae (1.6%), *Ericipites crassiexinus* (1.1%), and rare *Ailanthipites paenestriatus, Arecipites* sp., *Canthiumidites bellus, Cupanieidites orthoteichus, Malvacipollis diversus, M. subtilis, Sapotaceoidaepollenites rotundus, Psilastephanocolporites micus, Tetracolporites ixerboides, Tricolpites discus, Tricolporites adelaidensis, T. leuros, T. microreticulatus* and *Triporopollenites chnosus.*

Dinoflagellate cysts (1.4%) are rare with both freshwater and marine taxa present.

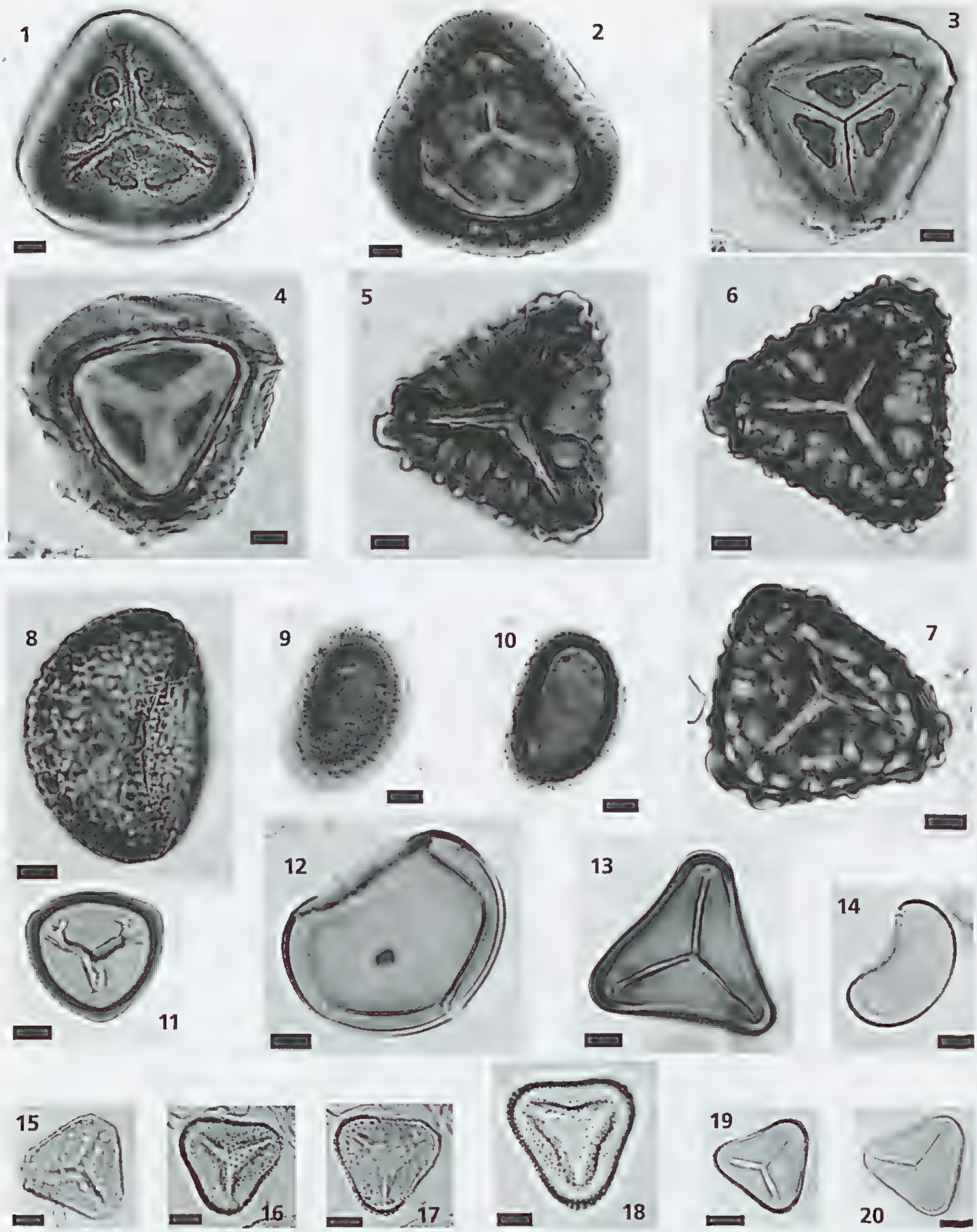

FIG. 3. Photomicrographs from Cape Barren and Flinders Island samples, slides S-753 and S-754. All photomicrographs taken at x 800 magnification (10 µm scale). **1–4** *Cyatheacidites annulatus* Cookson 1947; **5–7** *Ischyosporites* sp. cf. *I. lachlanensis* Martin 1973; **8–10** *Peromonolites densus* Harris 1965; **11** *Stereisporites australis* (Cookson) Krutzsch 1959; **12** *Laevigatosporites major* (Cookson) Krutzsch 1959; **13** *Dictyophyllidites* sp.; **14** *Monolites alveolatus* Couper 1960; **15–17** *Foveotriletes crater* Stover & Partridge 1973; **18** *Foveotriletes lacunosus* Stover & Partridge 1973; **19–20** *Cyathidites subtilis* Stover & Partridge 1973.

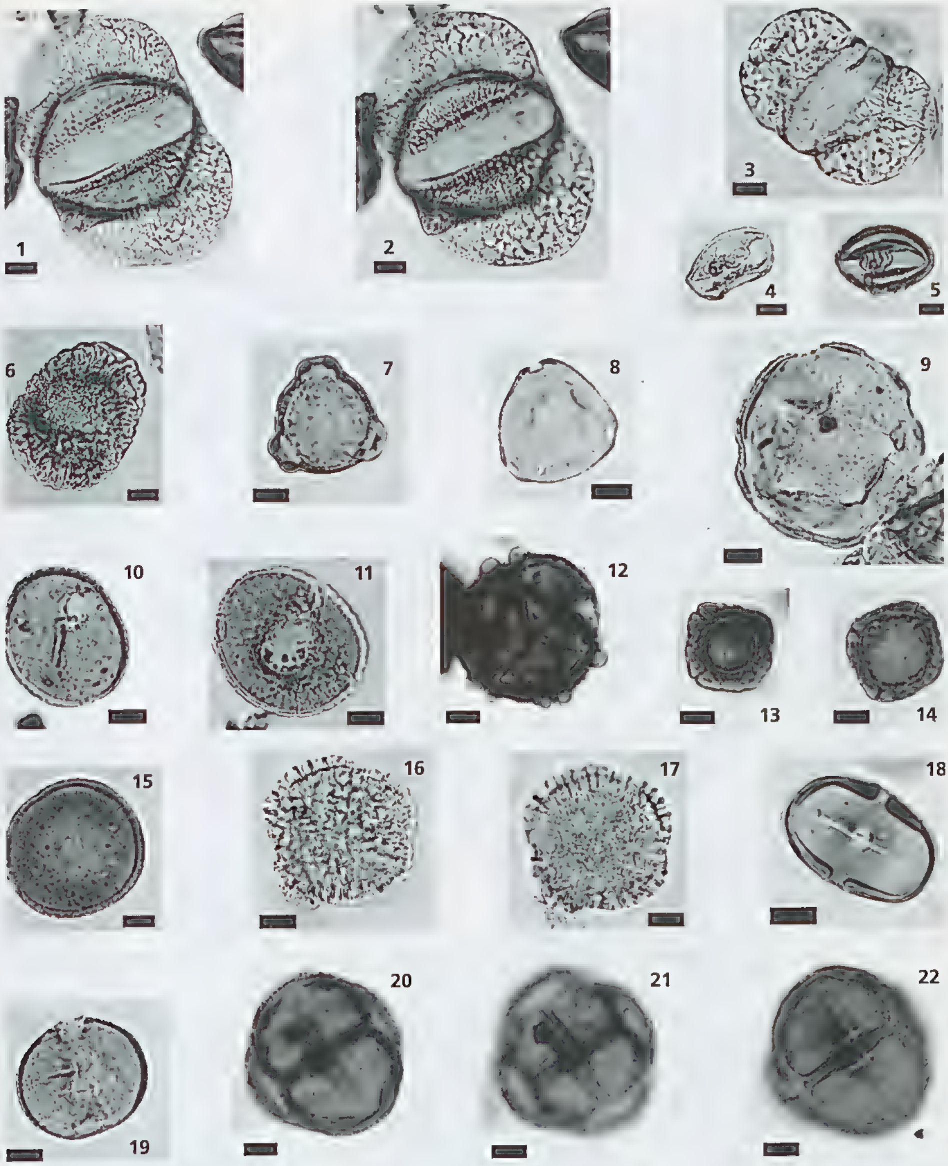

FIG. 4. Photomicrographs of pollen from slides S-753 and S-754. All photomicrographs taken at x 800 magnification (10 μm scale). **1–2** *Podocarpidites* sp. cf. *P. magnificus;* **3** *Podocarpidites ellipticus* Cookson 1950; **4** *Microalatidites paleogenicus* (Cookson & Pike) Mildenhall & Pocknall 1989; **5** *Phyllocladidites mawsonii* Cookson ex Couper 1953; **6** *Lygistepollenites florinii* (Cookson & Pike) Stover & Evans 1973; **7** *Casuarinidites cainozoicus* Cookson & Pike 1954; **8** *Haloragacidites harrisii* (Couper) Harris 1971; **9** *Periporopollenites demarcatus* Stover & Partridge *1973;* **10** *Milfordia homeopunctata* (McIntyre) Stover & Partridge 1973; **11** *Milfordia hypoalenoides* Erdtman 1960; **12** *Bysmapollis emaciatus* Stover & Partridge 1973; **13–14** *Haloragacidites haloragoides* Cookson & Pike 1954; **15** *'Assamiapollenites' incognitus* Pocknall & Mildenhall 1984; **16–17** *Glencopollis ornatus* Pocknall & Mildenhall 1984; **18** *Sapotaceoidaepollenites latizonatus* (McIntyre) Pocknall & Mildenhall 1984; **18** *Stephanocolpites oblatus* Martin 1973; **19** *Sapotaceoidaepollenites rotundus* Harris 1972; **20–22** *Simplicepollis meridianus* Harris 1965.

A few reworked Cretaceous spores are also present, including *Murospora florida, Alisporites grandis* and *Cicatricosisporites* sp. The sample has a mixed age assemblage including species which first/last appear in the Middle *Nothofagidites asperus* Zone, and first appear in the *Proteacidites tuberculatus* and *Canthiumidites bellus* Zones. Most probably the assemblage is Early–Middle Miocene and the palynoflora is assigned to the top of Upper *Proteacidites tuberculatus* Zone into the *Canthiumidites bellus* Zone based on the presence of both *Proteacidites tuberculatus* and *Canthiumidites bellus* in association with reliable indicators of both zones, including *Cyatheacidites annulatus, Cyathidites subtilis, Foveotriletes crater, Foveotriletes lacunosus, Polypodiaceoisporites tumulatus, Proteacidites symphyonemoides, P. stratosus, Triporopollenites chnosus* and *Psilastephanocolporites micus.*

Tanners Bay, Flinders Island
SAMPLE NO. S 754 (FIGS 3–6)

Yield is very good and preservation is adequate to make reliable identifications of palynofloras. The palynofloras are dominated by *Milfordia hypoalenoides* (33%), with the Casuarinaceae (16.6%) also abundant. The Proteaceae (19%), and *Ericipites crassiexinus* (5.8%) are all common, with *Nothofagidites* spp. (5%), *Milfordia homeopunctata* (4.7%), Myrtaceae (4.1%), spores (2.8%), and Podocarpaceae (1.5%) well represented. Dinoflagellate cysts (<1%) are very rare. *Arecipites* sp., *Acaciapollenites myriosporites, A. miocenicus, Haloragacidites haloragoides, Foveotriletes crater, Gyropollis psilatus, Simplicepollis meridianus, Tetracolporites ixerboides, Psilastephanocolporites micus, Cyatheacidites annulatus, Cyathidites subtilis, Tricolpites discus* and *Tricolporites adelaidensis* are all rare.

Harris (1965a) reported that this sample was assignable to the Pliocene, possibly even the Pleistocene, based mainly on the low frequency of *Nothofagidites* spp. and abundance of *Banksieaeidites* spp. Re-examination of the sample shows not only the presence of the above species, but also a significant number of other pollen grains including *Monotocidites galeatus* and *Haloragacidites myriophylloides,* which support a Late Miocene to Early Pliocene age, *Monotocidites galeatus* Zone, (Macphail 1999).

Other taxa, which terminate their range within *Monotocidites galeatus* Zone, include *Psilastephanocolporites micus, Foveotriletes crater, Acaciapollenites myriosporites, A. miocenicus, Hakeidites (Hakea)* sp., *Hakeidites (Grevillea)* sp., *Tubulifloridites simplis, Cyatheacidites annulatus,* and *Cyathidites subtilis,* all of them present in the above sample. This assemblage is therefore different in composition and age from Cape Barren Island samples.

Conclusion

The re-examination of samples from Cape Barren and Flinders Islands, Tasmania, provides more definitive dates with the identification of Miocene and Early Pliocene sediments. The age is based on palynological data only. The presence of *Cyatheacidites annulatus, Cyathidites subtilis, Proteacidites tuberculatus* and *Canthiumidites bellus* with frequent *Foveotriletes crater, F. lacunosus, Psilastephanocolporites micus* and *Acaciapollenites myriosporites* would suggest an age ranging from Early into Middle Miocene.

On Cape Barren Island the palynofloras dominance is shared between Proteaceae (17.4%), *Nothofagidites* spp. (17.2%), Podocarpaceae (16.7%), with Casuarinaceae (10.5%) and spores (14%) also well represented. This would suggest the presence of a mesothermal rainforest, with a diverse subcanopy angiosperm

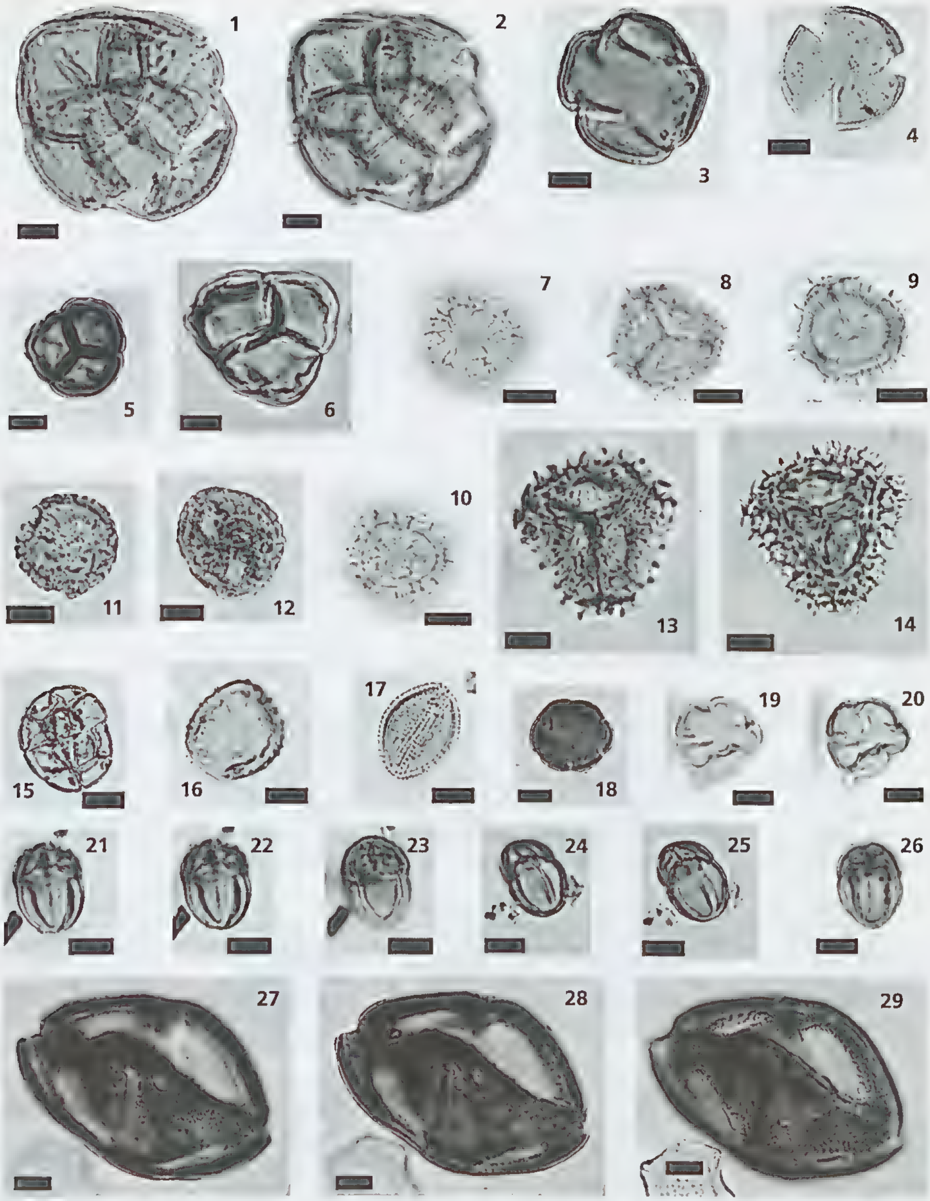

FIG. 5. Photomicrographs of pollen from slides S-753 and S-754. All photomicrographs taken at x800 magnification (10 μm scale). **1–2** *Simplicepollis meridianus* Harris 1965; **3** *Tetracolporites* sp.; **4** *Tricolpites* sp.; **5** *Ericipites* sp.; **6** *Ericipites crassiexinus* Harris 1965; **7–10** *Pseudowinterapollis cranwellae* (Stover & Partridge) Mildenhall & Crosbie 1980; **11** cf. *Guettardidites* Khan 1976; **12** cf. *Clavastephanocolporites meleosus* Martin et al. 1993; **13–14** *Pseudowinterapollis calathus* (Stover & Partridge) Mildenhall & Crosbie 1980; **15** *Acaciapollenites miocenicus* Mildenhall & Pocknall 1989; **16** *Malvacipollis* sp.; **17** *Clavatipollenites glarius* Stover & Partridge 1982; **18** *Stephanocolpites oblatus* Martin 1973; **19–20** *Quintiniapollis* sp.; **21–26** *Monotocidites galeatus* Macphail, Partridge & Truswell 1993; **27–29** *Perfotricolpites* sp.

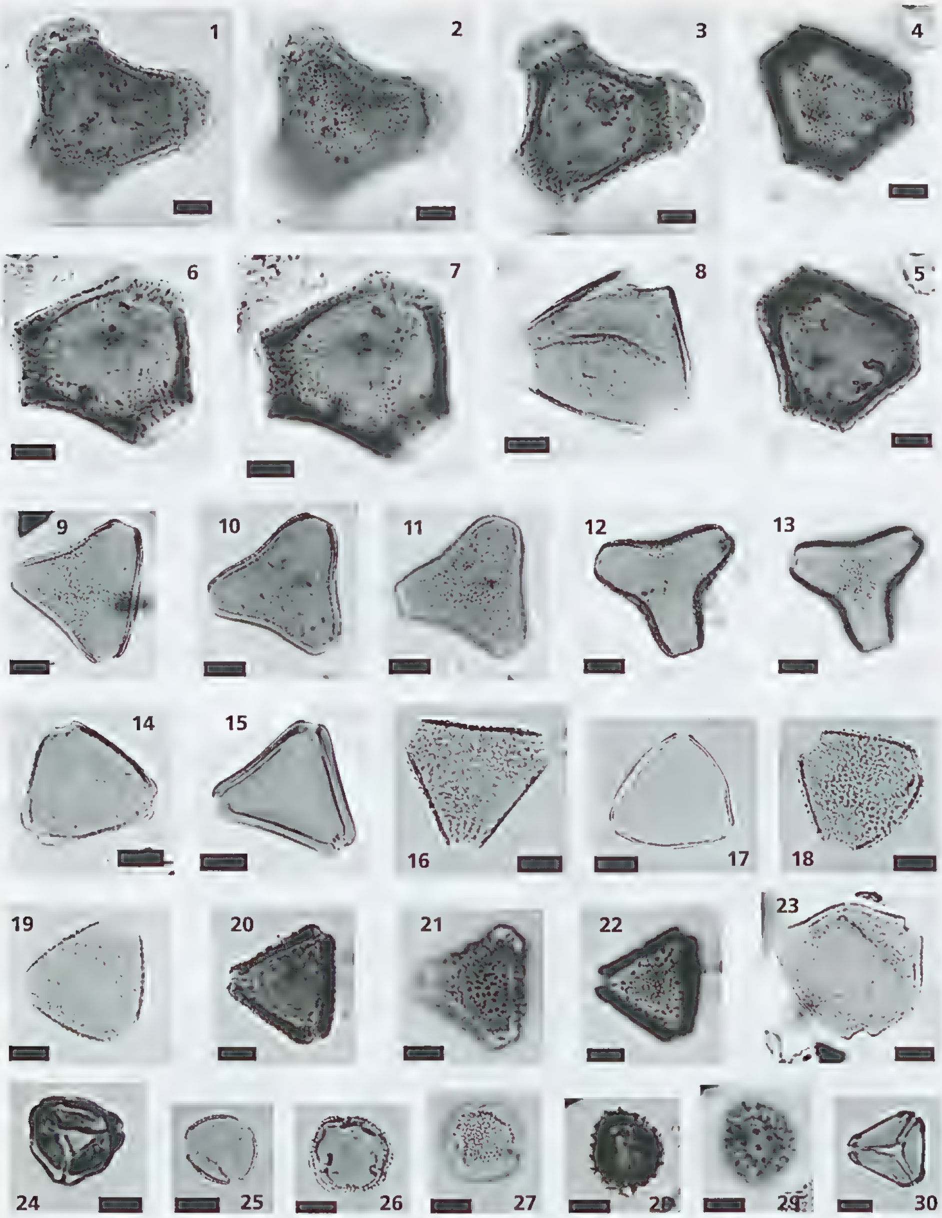

FIG. 6. Photomicrographs of pollen from slides S-753 and S-754. All photomicrographs taken at x800 magnification (10 µm scale). **1–3** *Hakeidites (Hakea)* sp.; **4–7** *Hakeidites (Grevillea)* sp.; **8** cf. *Proteacidites marginatus* Milne & Martin 1998; **9–13** *Proteacidites sinulatus* Dudgeon 1983; **14** *Proteacidites* sp. cf. *Petrophile*; **15** *Proteacidites obscurus* Cookson 1950; **16** *Proteacidites pseudomoides* Stover & Partridge 1973; **17** *Proteacidites* sp. cf. *Stirlingia*; **18–19** *Proteacidites isopogiformis* Couper 1960; **20–22** *Proteacidites* sp. cf. *Agastachys*; **23** *Triporopollenites chnosus* Stover & Partridge 1973; **24** *Myrtaceidites eucalyptoides* Cookson & Pike 1954; **25–27** *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall 1989; **28–29** *Tubulifloridites simplis* Martin 1973; **30** *Myrtaceidites mesonesus* Cookson & Pike 1954.

flora including *Agastachys* type (8%), *Telopea* type, Euphorbiaceae, Sapotaceae, Cupanieae, and *Eucalyptus* type in association with a rich cryptogam flora (mainly Cyatheaceae).

Late Miocene-Early Pliocene palynofloras from Flinders Island are distinctive from other areas of Australia. Some taxa are locally abundant and common, including *Milfordia hypoalenoides* (33%), *Psiladiporites (Alyxia)* sp. (8.8%), *Ericipites crassiexinus* (5.8%) and *Banksieaeidites* spp. (6%). Their level of abundance would suggest the presence of low-nutrient soils and coastal dunes in the vicinity of the site of deposition. High frequencies of herbaceous pollen suggest the presence of low-open sclerophyll vegetation.

To allow comparison with other sites palynologically investigated from Tasmania, further detailed studies are required. A recent review of the Cainozoic Tasmanian fossil sites (Jordan and Hill 2002), provides relevant information related to the relationship between different types of environments and the vegetation, associated with recent and past volcanic activity. Distinct fossil flora assemblages have been recorded from several Mid Tertiary sites in Tasmania including Cethana, Little Rapid River and Lea River (Jordan and Hill 2002). The distinctive palynofloras from Cape Barren and Flinders Islands should not be considered in isolation, but rather as part of the broader picture. It is highly recommended that the remaining Harris slides be re-examined and the results integrated with other palynological studies undertaken by Macphail, Hill, Carpenter, Kershaw, Forsyth, Wells, Jordan, Truswell, Partridge, Stover, and others. This would provide a better understanding of the Tasmanian Miocene–Pliocene vegetation, climate and environmental settings.

Acknowledgements

The author would like to thank Dr Wayne Harris for reviewing the early draft of the manuscript and for providing useful comments. Also many thanks to Dr Andrew Rowett, for useful comments on the text, and to Dr Andrew Rozefelds, for encouraging a review of Harris's samples. The author would like to thank Mr Steve Forsyth and Dr Mike Macphail for their helpful comments and reviews of the manuscript, which was improved considerably. Also many thanks to PIRSA for preserving the original slides and report books in the biostratigraphy collection of the Geological Survey Branch.

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APPENDIX Percentages of spore and pollen species in samples from Cape Barren and Flinders Islands, Tasmania. The plus (+) indicates observed in sample, but not in count. Percentages are based on counts of 500–1000 grains.

	Modern affinity	**S 752**	**S 753**	**S 754**
Spores				
Baculatisporites comaumensis	Osmundaceae		1.0	
Baculatisporites disconformis Stover & Partridge 1973	Osmundaceae		+	
Camarozonosporites bullatus Harris 1965	Lycopodiaceae		+	
Cyatheacidites annulatus Cookson 1947	Lophosoriaceae: *Lophosoria*		0.8	0.5
Cyathidites australis Couper 1953	Pteridophyte	+	2.4	1.1
Cyathidites minor Couper 1953	Pteridophyte		+	
Cyathidites subtilis Stover & Partridge 1973	Cyatheaceae: *Cyathea*		1.9	0.6
Foveotriletes crater Stover & Partridge 1973	Lycopodiaceae: *Lycopodium*		2.4	+
Ischyosporites gremius Stover & Partridge 1973	Dicksoniaceae?		2.7	
Laevigatosporites major (Cookson) Krutzsch 1959	Fern		0.4	
Laevigatosporites ovatus Wilson & Webster 1946	Fern		1.0	+
Osmundacidites wellmanii Couper 1953	Osmundaceaea		+	
Peromonolites densus Harris 1965	Pteridophyte		+	
Peromonolites vellosus Stover & Partrdige 1973	Pteridophyte		0.7	
Polypodiaceoisporites tumulatus Stover & Partridge 1973	Adiantiaceae: *Pteris*		0.4	
Rugulatisporites mallatus Stover & Partridge 1973	Thyrsopteridaceae: *Calochlaena-Culcita*		+	
Stereisporites antiquasporites (Wilson & Webster) Dettmann 1963	Sphagnaceae		0.4	
Total Spores			**15.3**	**2.8**
Angiosperms				
Acaciapollenites myriosporites (Cookson) Mildenhall 1972	Mimosaceae: *Acacia*			+
Ailanthipites mulleri (Kemp) Milne 1988	Anacardiaceae?		+	
Ailanthipites paenestriatus Stover & Partridge 1973, Milne 1988	Anacardiaceae?		+	
Assamiapollenies incognitus Pocknall & Mildenhall 1984	Unknown		+	
Arecipites sp. (Wodehouse) Anderson 1960	?Arecaceae ?Liliaceae		0.9	0.3
Australopollis obscurus (Harris) Krutzch 1966	Callitrichaceae		1.8	
Banksieaeidites arcuatus Stover & Partridge 1973	Proteaceae: Musgraveinae		1.5	1.8
Banksieaeidites elongatus Cookson 1950	Proteaceae: *Banksia/Dryandra*			4.1
Bluffopollis scabratus (Couper) Pocknall & Mildenhall 1984	Strasburgeriaceae: *Strasburgeria*		+	
Canthiumidites bellus (Stover & Partridge) Mildenhall & Pocknall 1989	Rubiaceae: *Randia*		+	
Casuarinidites cainozoicus Cookson & Pike 1954	Casuarinaceae		+	0.9
Chenopodipollis chenopodiaceoides (Martin) Truswell et al. 1985	Amaranthaceae-Chenopodiaceae			+
Clavatipollenites glarius Stover & Partridge 1982	Chloranthaceae: *Ascarina*		2.4	
Concolpites leptos Stover & Partridge 1973	Cunoniaceae: *Gillbeea*-type		+	
Crotonipollis sp.	Euphorbiaceae		+	
Cupanieidites orthoteichus Cookson & Pike 1954	Sapindaceae: *Cupanieae*		0.7	
Droseraceae	Droseraceae		1.6	
Ericipites crassiexinus Harris 1972	Ericales: Ericaceae: Epacridaceae		1.1	5.8
Ericipites scabratus Harris 1965	Ericales: Ericaceae: Epacridaceae		+	
Gothanipollis bassensis Stover & Partridge 1973	Loranthaceae	+		
Gyropollis psilatus Mildenhall & Pocknall 1989	Gyrostemonaceae			0.3
Hakeidites (*Hakea*) sp.	Proteaceae: cf. *Hakea*			0.3
Haloragacidites myriophylloides Cookson & Pike 1954	Haloragaceae: *Myriophyllum*			+
Haloragacidites haloragoides Cookson & Pike 1954	Haloragaceae: *Gonocarpus-Haloragis*			0.5
Haloragacidites harrisii (Couper) Harris 1971	Casuarinaceae		10.3	15.6
Helciporites astrus Stover & Partridge 1973	Unknown			+
Liliacidites aviemorensis McIntyre 1968	Liliaceae		1.0	
Liliacidites bainii Stover & Partridge 1973	Liliaceae		1.0	+
Malvacipollis diversus Harris 1965	Euphorbiaceae: *Austrobuxus*		0.4	
Malvacipollis subtilis Stover & Partridge 1973	Euphorbiaceae: *Micrantheum*-type		0.4	0.3
Milfordia homeopunctata (McIntyre) Stover & Partridge 1973	Restionaceae: *Lyginia*-type			4.7
Milfordia hypoalenoides Erdtman 1960	Restionaceae: *Hypolaena*			33.0
Myrtaceidites eucalyptoides Cookson & Pike 1954	Myrtaceae: *Angophora, Eucalyptus gummifera*-type		+	
Myrtaceidites eugeniioides Cookson & Pike 1954	Myrtaceae: *Eugenia*-type		+	2.0
Myrtaceidites mesonesus Cookson & Pike 1954	Myrtaceae		1.0	1.5
Myrtaceidites verrucosus Stover & Partridge 1973	Myrtaceae: *Austromyrtus*-type		+	0.5
Nothofagidites asperus Romero 1973	Fagaceae: *Nothofagus* subgenus *Lophozonia*		0.4	
Nothofagidites brachyspinulosus (Cookson) Harris 1965	Fagaceae: *Nothofagus* subgenus *Fuscospora*		+	

Nothofagidites emarcidus (Cookson) Harris 1965	Fagaceae: *Nothofagus* subgenus *Brassospora*		9.6	1.3
Nothofagidites falcatus (Cookson) Hekel 1972	Fagaceae: *Nothofagus* subgenus *Brassospora*	+	3.1	2 0
Nothofagidites goniatus (Cookson) Stover & Evans 1973	Fagaceae: Nothofagus subgenus *Lophozonia*		0 4	
Nothofagidites heterus (Cookson) Harris 1965	Fagaceae: *Nothofagus* subgenus *Brassospora*	+	3 0	1.6
Nothofagidites incrassatus (Cookson) Dettmann 1990	Fagaceae: *Nothofagus*	+	+	
Periporopollenites demarcatus Stover & Partridge 1973	Trimeniaceae		0.6	
Polycolpites esobalteus (McIntyre) Poknall & Mildenhall 1984	Polygalaceae		+	
Propylipollis minimus (Couper) Martin & Harris 1974	Proteaceae		0.3	
Proteacidites beddoesii Stover & Partridge 1973	Proteaceae		0.9	
Proteacidites latrobensis (Harris) Martin & Harris 1974	Proteaceae: cf. *Megahertzia*		+	
Proteacidites obscurus Cookson 1950	Proteaceae: *Agastachys*-type		8.0	
Proteacidites pseudomoides Stover & Partridge 1973	Proteaceae: cf. *Lomatia*		1.8	
Proteacidites reticulatus Cookson 1950	Proteaceae		+	
Proteacidites scitus Stover & Partridge 1982	Proteaceae		0.4	+
Proteacidites sinulatus Dudgeon 1983	Proteaceae		0.5	2.2
Proteacidites stipplatus Stover & Partridge 1973	Proteaceae		+	
Proteacidites stratosus Pocknall & Mildenhall 1984	Proteaceae: *Carnarvonia*		0 3	
Proteacidites subscabratus Couper 1960	Proteaceae		+	
Proteacidites symphyonemoides Cookson 1950	Proteaceae: cf. *Symphionema*		0.4	
Proteacidites tenuiexinus Stover & Partridge 1973	Proteaceae		0 5	
Proteacidites truncatus Cookson 1950	Proteaceae: *Isopogon*		+	+
Proteacidites tuberculatus Cookson 1950	Proteaceae		0.4	
Psiladiporites (*Alyxia*) sp.	Apocynaceae: *Alyxia*			8 8
Psilastephanocolporites micus Stover & Partridge 1973	Extinct angiosperm		+	0.3
Rhoipites alveolatus (Couper) Pocknall & Crosbie 1982	Caesalpinaceae? Verbenaceae?		+	
Rhoipites angurium (Stover & Partridge) Pocknall & Mildenhall 1984	Unknown		0 4	
Rhoipites goulburnensis Truswell & Owen 1988	Unknown		+	
Sapotaceoidaepollenites rotundus Harris 1972	Sapotaceae		0.4	
Simplicepollis meridianus Harris 1965	Unknown			0.3
Sparganiaceaepollenites barungensis Harris 1972	Sparganiaceae		+	
Tetracolporites ixerboides Couper 1960	*Ixerba brexioides*		0.7	0.3
Tricolpites confesus Stover & Partridge 1973	Unknown		+	
Tricolpites discus Harris in Harris & Kemp 1977	Unknown		0.9	+
Tricolpites sp. Harris in Harris & Kemp 1977	Unknown		+	
Tricolporites adelaidensis Stover & Partridge 1982	Meliaceae? : *Dysoxylum*?		0.4	0 5
Tricolporites leuros Stover & Partridge 1973	Unknown		+	
Tricolporites microreticulatus Harris 1965	Unknown		+	
Tricolporites sp.	Unknown		0.3	
Triporopollenites ambiguus Stover & Partridge 1973	Proteaceae: cf. *Telopea*		0.3	
Triporopollenites chnosus Stover & Partridge 1973	Proteaceae?		+	
Triporopollenites delicatus Stover & Partridge 1982	Proteaceae: cf. *Lomatia*		1.4	0.3
Total Angiosperms			**66.9**	**94.6**

Gymnosperms				
Araucariacites australis Cookson 1947	Araucariaceae: *Araucaria*-type		+	+
Dacrycarpites australiensis Cookson & Pike 1954	Podocarpaceae: *Dacrycarpus*		+	
Dilwynites granulatus Harris 1965	Araucariaceae: *Wollemia*-type		+	
Lygistepollenites florinii (Cookson & Pike) Stover & Evans 1973	Podocarpaceae: *Dacrydium*		6 4	+
Microcachryidites antarcticus Cookson 1947	Podocarpaceae: *Microcachrys*		+	
Phyllocladidites mawsonii Cookson ex Couper 1953	Podocarpaceae: *Lagarostrobus franklinii*-type		1.2	0.3
Phyllocladidites paleogenicus (Cookson) Harris 1965	Podocarpaceae		0.5	
Podocarpidites ellipticus Cookson 1947	Podocarpaceae		7.7	0.7
Podosporites microsaccatus Couper 1960	Podocarpaceae		+	+
Total Gymnosperms			**16.6**	**1.7**

Dinoflagellate cysts				
Apteodinium australiense		+		
Batiacasphaera sp.			+	
Heslertonia striata		+		
Hystrichokolpoma rigaudae		+		
Impagidinium sp.		+	+	
Lingulodinium sp.		+	+	
Pentadinium laticinctum		+		0 3
Saeptodinium sp.		+	0.7	0.3
Spiniferites ramosus		+		
Systematophora placacantha		+	+	
Tectatodinium pellitum			+	
Total Dinoflagellate cysts			**1.2**	**0.7**

Reworked				
Alisporites grandis			+	
Cicatricosisporites sp.			+	
cf *Murospora florida*			+	

A REAPPRAISAL OF THE EARLY HISTORY OF THE WEED INVASION IN TASMANIA UP TO THE 1870s

Andrew C. Rozefelds and Ray MacKenzie

Rozefelds, A.C. and MacKenzie, R. (2005) A reappraisal of the early history of the weed invasion in Tasmania up to the 1870s. *Kanunnah* 1:61–90. ISSN1832-536X. A critical re-examination of Spicer's publications on 'Alien Plants' and his *Handbook of the Plants of Tasmania* suggests that 107 species, in 83 genera, had became naturalised in the first 70 years of settlement of Tasmania. A taxonomically arranged census of these species is provided. The major weed families represented were Poaceae (20.6%), Asteraceae (19.6%), Fabaceae (9.7%), Brassicaceae (7.5%) and Caryophyllaceae (6.5%). These families include many agricultural and ruderal weeds that are predominantly of European origin (90%). The early weed invasion in Tasmania was characterised by species that were annuals and rapidly maturing perennials. Compared with current trends, woody plants were under represented in the naturalised flora in the 1870s. The intentional introduction of many species into Tasmania, some of which eventually became established as weeds, can be related directly to acclimatisation policies that encouraged the introduction of 'useful' plants into the State at this time. Of the 50 non-indigenous species that were identified as having an uncertain status, i.e. not yet naturalised in the 1870s, over 95% are now recognised as naturalised in the State. It is reasonable to extrapolate from this observation that many species that are currently considered 'sparingly established' will become naturalised in Tasmania over time.

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KEY WORDS: Tasmania, weed, Spicer, history, naturalised plant.

The earliest recorded attempts to intentionally introduce plants to Tasmania were by the early English and French navigators who visited the island. Captain James Cook visited Adventure Bay, Bruny Island, in January 1777, and his crew planted potatoes, kidney beans, peach and apricot kernels (Ellis 1782), which apparently did not survive. In May 1792, Admiral Bruny d'Entrecasteaux's crew planted European plants, including cabbages, potatoes, sorrel and other plants at Adventure Bay (Plomley and Piard-Bernier 1993). In January 1793, the botanist La Billadière on the vessel *Le Recherche* reported that only a few plants were still surviving, and all were in poor condition (La Billardière 1800). This attempt to introduce plants to Tasmania was also apparently unsuccessful. The arrival of Europeans in Tasmania, and the establishment of the first settlement at Hobart Town (Hobart) in 1804 brought intensive farming practices, animal husbandry, and an associated influx of new plants, which included crops, ornamentals, and also many weeds.

The first overview of the naturalised flora of Tasmania was compiled by Reverend W. W. Spicer. Spicer lived in Tasmania from 1874 to 1878 (Rozefelds 2005). Spicer's contributions to the study of the Tasmanian flora have been largely overlooked by subsequent workers, and his achievements are all the more notable when it is recognised that he resided in Tasmania for less than five years (Rozefelds 2005). Spicer was clearly familiar with both the native and introduced flora in Tasmania, and had access to the herbarium collections that existed in the State at that time (Rozefelds 2005). He was also in correspondence with the foremost botanist in Australia, at that time, Ferdinand von Mueller in Melbourne. Mueller (1877) included Spicer's notes, on introduced plants, in his paper 'Contributions to the Phytography of Tasmania'. These notes were to form the basis for Spicers 'Alien Plants' paper that was presented to the Royal Society of Tasmania in 1877 and published in the *Papers and Proceedings of the Royal Society of Tasmania* in 1878 (Spicer 1878a). *A Handbook of the Plants of Tasmania* was also published in the same year (Spicer 1878b). Spicer's two publications therefore provide a unique insight into which plants had become naturalised in the first 70 years of European settlement in Tasmania.

The 'Alien Plants' paper drew upon Spicer's own observations, herbarium collections, and also those reports published by Hooker, Mueller and others. Spicer (1878a, p. 62) defined an alien plant as 'such species as have been introduced either by accident or design, and which have maintained their ground more or less firmly in their adopted land... [and] has either now, or from its first introduction, ceased to depend upon man, and has set up on its own account'. His definition would appear to be synonymous with the contemporary term 'naturalised'. Spicer's 'Alien Plants' paper is significant because it is the first attempt by a botanist living in Tasmania to provide a synopsis of the naturalised flora of the State.

These two publications are the primary sources of information for this article which provides an overview of the species that were naturalised in Tasmania at that time. Spicer's publications, however, are inconsistent in the species that he lists as naturalised and this paper attempts to resolve some of these inconsistencies. The aim of this paper is therefore to provide a list of species that were probably naturalised in Tasmania by the 1870s. This revised list of weeds is assessed as to whether they were likely to be intentional or accidental introductions, and as to their distribution at that time. Some of the difficulties in interpreting historical and anecdotal records are also discussed, and the importance of herbarium collections in confirming the identity of some material is demonstrated. The revised 1870's census of species is compared with the naturalised flora currently known in the State (Rozefelds et al. 1999) in terms of the number of weeds species/genera, the major weed families represented, and the habits and geographical origins of weeds in the 1870s. A brief overview of this paper was presented at the 12th Australian Weeds Conference in Hobart in 1999 (Rozefelds and MacKenzie 1999).

Scope and Planning of Study

Terminology used throughout this paper generally follows that of Rozefelds et al. (1999). The term 'weed' is used for any exotic, non-Tasmanian plant that has been introduced into Tasmania, either deliberately, or accidentally, and has been naturalised in one or more localities. The species recorded from Spicer's publications are listed alphabetically in the Appendix, and the nomenclature follows that used by Spicer. Spicer's names have been brought up to date by referring to a number of literature sources, including Bentham (1863–1878), Buchanan (1999), Curtis (1963, 1967), and Curtis and Morris (1975, 1994). The current species name and nomenclature is based primarily upon Buchanan (1999), Shepherd et al. (2001) and Groves et al. (2003). Common names have also changed since Spicer's time. The common names used in the ms are from Shepherd et al. (2001) and are the current names used for these species (Appendix). It was also possible to confirm the accuracy of Spicer's identifications as 75 specimens of naturalised plants collected by Spicer are lodged in the Tasmanian Herbarium (HO). There is limited locality information for most of these herbarium specimens, and it is unclear whether some of the specimens collected from the Royal Society Gardens were from naturalised or cultivated plants.

In the absence of herbarium specimens it is not possible to confirm whether plants were correctly identified although in most cases it is possible to reconcile Spicer's identifications with taxa that are currently recognised in the Tasmanian flora. Other additional literature sources, including Backhouse (1835), Harvey (1855), Hooker (1853–59), Bentham (1863–1878), the journal of Baron Charles von Hügel (Clark 1994) and articles published in *The Tasmanian Journal of Science* (1842–1849) and *Papers and Proceedings of the Royal Society of Tasmania* (1851–1878), were consulted to determine if some species had been recorded from Tasmania previously. Literature citations to particular species are cited in Appendix, although some records are imprecise. Baron Charles von Hügel writes in his journal in January 1834 that 'In Hobart Town itself European weeds have replaced everything else, and thistle, plantain [*Plantago*], and yellow chicory [*Cichorium?*] are as rampant here as anywhere in Europe' (Clark 1994). Harvey (1855 p. 227) similarly notes that 'thistles are fast going ahead, all through Van Diemens Land [Tasmania] ... hundreds of acres given over to them'. Neither Hügel nor Harvey identifies which species of thistles were present.

In the 'Alien Plants' paper Spicer notes that 28 species were scarcely, or only sparingly, established (Appendix). In *A Handbook of the Plants of Tasmania* the native and weed taxa that were then known from Tasmania are listed along with, in some cases, limited distribution data (Spicer 1878b). Spicer (1878a, p. 148) also lists 58 species that he considered were not yet naturalised. Spicer's two publications differ as to whether some species should be considered naturalised. Spicer (1878b, p. 148) lists over 50 species and notes that 'the following plants have been introduced into the colony [of Tasmania], but are not yet sufficiently established' to be considered part of the flora (Appendix). Many of these species were, however,

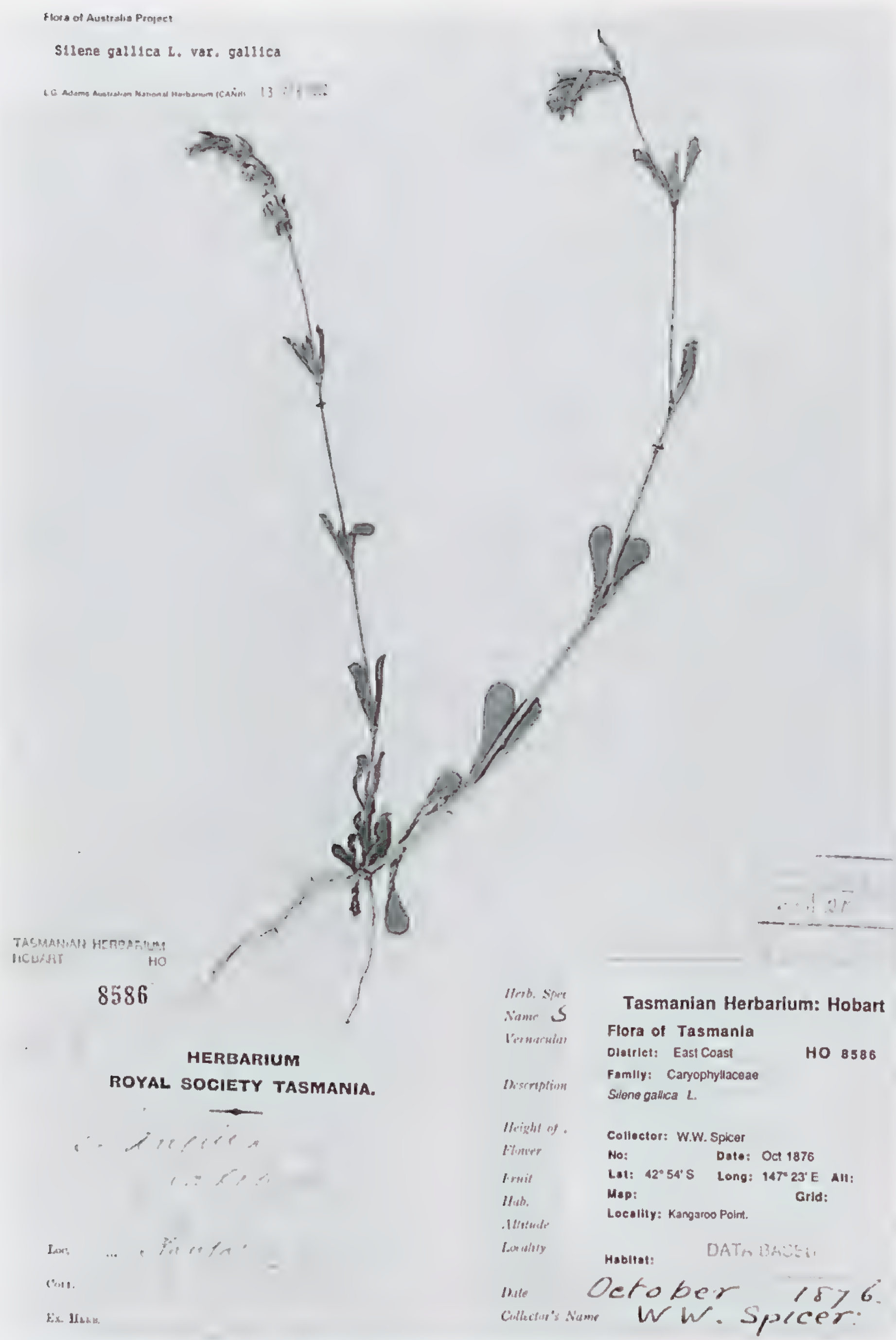

FIG.1. Specimen of *Silene gallica* L. collected by Spicer in 1876. Note the original label in Spicer's characteristic handwriting, and also that the specimen was originally identified as *S. anglica* L.

listed in his 'Alien Plants' paper (Spicer 1878a) as being 'scarcely or only sparingly established'. Similarly, some of the taxa that are listed as 'scarcely naturalised' in Spicer (1878a), are listed as established in the Handbook (Spicer 1878b). Because of these discrepancies in the two Spicer publications, deciding whether some species were established in the State at this time is problematic.

We have concluded, therefore, that those species that are listed in both publications were probably naturalised at that time, e.g. *Foeniculum vulgare* (fennel) (Appendix). Those species that were recorded as naturalised in one of the Spicer publications and identified in supporting literature (e.g. *Anthemis nobilis* (chamomile) Harvey 1855; *Torilis nodosa* (knotted parsley) Mueller 1877) are also considered to be naturalised (Appendix). Species, such as *Conium maculatum* (hemlock), which were listed in only one of Spicer's publications are considered to have an uncertain status (Appendix). Those species whose taxonomic affinities have not been clearly identified, e.g. *Leontodon autumnalis,* are noted as affinities uncertain (Appendix). This taxonomically arranged list of species (Appendix) is used for comparison with the currently recognised introduced flora. Taking these various exceptions into account, it is possible, based upon Spicer's publications, to produce a revised list of species in Tasmania that were probably naturalised by the late 1870s (Table 1). Species whose status is uncertain or that have not been clearly identified have been deleted from Table 1.

Reappraisal of Spicer's List of Naturalised Plants

Scrutiny of Spicer's lists identified a few errors and inconsistencies, and re-examination of his collections in the Tasmanian Herbarium (HO) has also shown that some of Spicer's (1878a) identifications are not consistent with the current names for these taxa (Appendix). This is particularly the case for some of the grasses. Specimens identified as *Lepturus filiformis incurvatus* by Spicer (1878a) included material of *Parapholis incurva* (slender barbgrass) and *Hainardia cylindrica* (common barbgrass). Material referred to as *Bromus racemosus* and *Bromus mollis* by Spicer (1878a) is currently identified as *Bromus hordeaceus* (soft brome), and similarly specimens identified as *Bromus sterilis* are now identified as *Bromus diandrus* (great brome). Also there are other minor inconsistencies; Spicer (1878a) referred to *Silene anglica* in the 'Alien Plants' paper and *Silene gallica* in the 'Handbook', which is its current name (Fig. 1). Spicer (1878b) recorded *Malva rotundifolia,* the latter is usually considered a synonym of *Malva neglecta.* Spicer's specimen (HO12987), however, is referable to another species of *Malva, Malva nicaeensis* (mallow-of-nice).

Spicer's 'Alien Plants' paper (1878a) was based primarily upon his observations, although he listed 21 species that were recorded by other researchers. These additional records including *Arnoseris pusilla, Crepis japonica, Leontodon autumnalis, Ranunculus hirsutus* and *Urtica dioica* are not currently recorded as occurring in the State. The absence of supporting herbarium vouchers would suggest that these records were in error. In a few cases it has not been possible to resolve to which species he referred and attempting to interpret literature records, in the absence of vouchered collections, demonstrates some of the limitations of anecdotal data sets. Another problem is that voucher

Table 1. Revised census of the non-indigenous flora in Tasmania in the 1870s based upon Spicer's publications and Tasmanian Herbarium records. Species whose status is uncertain or that cannot be identified with certainty are not included in the list.

Census of Introduced Plants in Tasmania in the late 1870s
DICOTYLEDONAE
APIACEAE
Foeniculum vulgare Mill.
Scandix pecten-veneris L.
Torilis nodosa (L.) Gaertn.
ASTERACEAE
Arctotheca calendula (L.) Levyns
Bellis perennis L.
Calendula arvense L.
Calendula officinalis L.
Centaurea calcitrapa L.
Centaurea melitensis L.
Chamaemelum nobile (L.) All.
Cirsium arvense (L.) Scop.
Cirsium vulgare (Savi) Ten.
Cotula coronopifolia L.
Hypochaeris glabra L.
Hypochaeris radicata L.
Leontodon taraxacoides(Vill.) Mérat
Onopordum acanthium L.
Senecio vulgaris L.
Silybum marianum (L.) Gaertn.
Sonchus oleraceus L.
Taraxacum officinale Weber ex F.H.Wigg. sp. agg.
Tragopogon porrifolius L.
Vellereophyton dealbatum (Thunb.) Hillard & B.L.Burtt
Xanthium spinosum L.
BORAGINACEAE
Buglossoides arvensis (L.) I.M.Johnston
Echium plantagineum L.
BRASSICACEAE
Brassica napus L.
Capsella bursa-pastoris (L.) Medik.
Coronopus didymus(L.) Smith
Coronopus squamatus (Forsk.) Asch.
Lepidium campestre (L.) R.Br.
Rorippa nasturtium-aquaticum (L.) Hayek
Sinapis arvensis L.
Sisymbrium officinale (L.) Scop.
CARYOPHYLLACEAE
Agrostemma githago L.
Cerastium glomeratum Thuill.
Polycarpon tetraphyllum (L.) L.
Sagina apetala Ard.
Silene gallica L.
Spergula arvensis L.
Stellaria media (L.) Vill.
CHENOPODIACEAE
Chenopodium album L.
Chenopodium glaucum L.
Chenopodium murale L.
CONVOLVULACEAE
Convolvulus arvensis L.
DIPSACACEAE
Scabiosa atropurpurea L.
EUPHORBIACEAE
Euphorbia helioscopia L.
Euphorbia lathyris L.
Euphorbia peplus L.
FABACEAE
Medicago arabica (L.) Huds.
Medicago lupulina L.
Medicago polymorpha L.
Melilotus indicus (L.) All.
Trifolium campestre Schreb.

Trifolium dubium Sibth.
Trifolium pratense L.
Trifolium repens L.
Trifolium tomentosum L.
Ulex europaeus L.
FUMARIACEAE
Fumaria muralis Sond. ex W.D.J.Koch
GERANIACEAE
Erodium cicutarium (L.) L'Hérit.
LAMIACEAE
Marrubium vulgare L.
Stachys arvensis (L.) L.
MALVACEAE
Malva nicaeensis All.
Malva sylvestris L.
PLANTAGINACEAE
Plantago coronopus L.
Plantago lanceolata L.
Plantago major L.
POLYGONACEAE
Acetosella vulgaris Fourr.
Fallopia convolvulus (L.) A.Löve
Polygonum aviculare L.
Rumex crispus L.
PRIMULACEAE
Anagallis arvensis L.
RANUNCULACEAE
Ranunculus muricatus L.
ROSACEAE
Aphanes arvensis L.
Rosa rubiginosa L.
Rubus fruticosus L. sp. agg.
Sanguisorba minor Scop .

RUBIACEAE
Sherardia arvensis L.
SCROPHULARIACEAE
Cymbalaria muralis P. Gaertn., B.Mey. & Scherb.
Veronica peregrina L.
Veronica persica Poir.
SOLANACEAE
Solanum nigrum L.
URTICACEAE
Urtica urens L.
MONOCOTYLEDONAE
HYDROCHARITACEAE
Elodea canadensis Michx.
POACEAE
Agrostis stolonifera L.
Aira caryophyllea L.
Alopecurus pratensis L.
Anthoxanthum odoratum L.
Briza maxima L.
Briza minor L.
Bromus diandrus Roth.
Bromus hordeaceus L.
Bromus wildenowii Kunth
Dactylis glomerata L.
Elymus repens (L.) Gould
Hainardia cylindrica (Willd.) Greuter
Holcus lanatus L.
Hordeum murinum L.
Lolium perenne L.
Lolium temulentum L.
Parapholis incurva (L.) C.E.Hubb.
Parapholis strigosa (Dumort)C.E.Hubb.
Phalaris minor Retz.
Poa annua L.
Polypogon monspeliensis (L.) Desf.
Vulpia bromoides (L.) Gray

specimens of early naturalised Tasmanian species may occur in other state herbaria but we are unaware of these. 'Australia's Virtual Herbarium' project should serve to highlight these in the future.

Other taxa that Spicer (1878a) listed as being sparingly naturalised, e.g. *Aquilegia vulgaris* (columbine) and *Nigella damascena* (fennel flower), while occurring in the State as cultivated plants are not currently considered naturalised (Rozefelds et al. 1999). Also, as our knowledge of the Tasmanian Flora has improved, some of the naturalised plants listed by Spicer (1878a) are now recognised as indigenous or cosmopolitan species, e.g. *Hibiscus trionum* (bladder ketmia) and *Picris angustifolia* (hawkweed). In contrast, *Cotula coronopifolia* (water buttons) was considered by Spicer (1878b) to be a native, however, it is now recognised as introduced from South Africa (Lazarides et al. 1997). *Cardamine hirsuta* (common bittercress) is also introduced but was considered a native species by Spicer (1878b). There are also some taxa, e.g. *Rubus idaeus* (raspberry) which are not currently recognised in the State Flora.

Intentional and Accidental Introductions

As Spicer (1878a) indicated, many species were intentional introductions. He wrote (1878a p. 64), 'It is scarcely necessary to say that most, if not all, the useful grasses and clovers owe their introduction, to a spirit of improvement, and not by accident'. Spicer (1878a) cited the following as useful introductions; agricultural grasses *Bromus* spp. (bromes), *Festuca* spp. (fescues), *Dactylis glomerata* (cocksfoot), *Lolium perenne* (perennial ryegrass), *Holcus lanatus* (yorkshire fog) and the white and red clovers (*Trifolium repens* and *Trifolium pratense* respectively). Other intentional introductions include those species that were introduced as food/beverage/medicinal/herbal plants, ornamentals or for other agrarian purposes. Morgan (1992, p. 99) notes that 'By 1833 the cultivation of virtually all European vegetables had been attempted in Van Diemens Land [Tasmania]'. Hügel's diary in 1834 similarly records that the Botanical Gardens included 'all kinds of European fruits and vegetables in prime condition' (Clark 1994, p. 102). Food and beverage plants that Spicer (1878a) listed as naturalised included *Daucus carota* (carrot), *Chamaemelum nobile* (chamomile), *Cichorium intybus* (chicory), *Foeniculum vulgare* (fennel), *Mentha spicata* (spearmint) and *Rubus fruticosus* sp. agg. (blackberries). Some of these species also had medicinal and herbal uses, e.g. *Conium maculatum* (hemlock), *Cichorium intybus* (chicory), *Hyoscyamus albus* (white henbane), *Mentha spicata* (spearmint), *Papaver somniferum* (opium poppies) and *Taraxacum officinale* sp. agg. (dandelion) (Morgan 1992, Low 2001). Plants were also introduced for use as windbreaks and hedgerows, e.g. *Ulex europaeus* (gorse), *Rosa rubiginosa* (sweetbriar) and *Crataegus monogyna* (hawthorn) (Harvey 1855).

From 1857 onwards there are regular records in the *Papers and Proceedings of the Royal Society of Tasmania* of plants being introduced into the Gardens of the Society, later to become the Royal Tasmanian Botanical Gardens, through extensive seed exchanges then operating. Spicer (1878a) records that *Diplotaxis tenuifolia* (sand rocket), *Nothoscordum gracile* (false onion weed) and *Oxalis pes-caprae* (soursob) were originally brought as seed to the gardens of the Royal Society. Plants that were likely to have been introduced as ornamentals include *Calendula officinalis* (garden marigold), *Cytisus scoparius* (broom), *Dipsacus fullonum* (wild teazel), *Eschscholzia californica* (californian poppy), *Hedera helix* (english ivy), *Leucanthemum vulgare* (ox-eyed daisy), *Nothoscordum gracile* (false onion weed), *Spartium junceum* (spanish broom), and *Vinca major* (blue periwinkle).

A large number of taxa are also considered to be accidental introductions. Backhouse (1835, p. 103) notes that *Polygonum aviculare* (wireweed) was naturalised by the 1830s, 'having been introduced among the seed wheat'. As Spicer (1878a, p. 64) comments, 'Every bushel of corn that has been at any time imported from England was almost sure to contain the seed of the common spurge [*Spergula arvensis*] provided that it has been grown on sandy soils'. *Spergula arvensis* (corn spurrey) was considered naturalised in the State by the 1830s (Backhouse 1845). Hügel's diary, January 1834, records plantains (presumably introduced species of *Plantago*) and thistles as well established in Hobart Town (Clark 1994). A report in *The Tasmanian Journal of Science* records that the nettles were common around the stockyards of the colony (Anonymous 1846). Spicer (1878a, p. 64) notes that 'every pet canary, that arrives in the island, conveys in its food-tin the germs of the pretty canary grass [*Phalaris canariensis*], which abounds on our rubbish tips and roadsides'. Mueller (1877, p. 39) noted that *Lolium temulentum* (darnel) was occurring in corn fields. Accidental introductions also probably occurred with ornamentals, e.g. Hobler in Morgan (1992) wrote in his diary, 'observed the *Celtis occidentalis* or nettle tree making its appearance, and a curious plant rising in the bed sown with mixed seed from the bottom of the box can't imagine what it can be'.

Species that produce abundant small seeds, and occur with agricultural crops, were likely to have come in as seed contaminants and these include many rapidly maturing plants (Appendix). Likely species are members of the Asteraceae: e.g. *Conyza canadensis* (canadian flea-bane), *Vellereophyton dealbatum* (white cudweed); Brassicaceae: *Capsella bursa-pastoris* (shepherd's purse); Caryophyllaceae: *Polycarpon tetraphyllum* (four-leaf allseed), *Stellaria media* (chickweed); Fumariaceae: *Fumaria* spp. (fumitories); Plantaginaceae: *Plantago* spp. (plantains); Poaceae: *Poa annua* (annual poa); Resedaceae: *Reseda* spp. (mignonette), and Urticaceae: *Urtica urens* (stinging nettle).

Distribution of Weeds by the 1870s

Information on the distribution of introduced taxa is extremely limited and is derived primarily from Spicer (1878b), other anecdotal literature sources, e.g. Mueller (1877), and locality information from herbarium records (Appendix). Baron Charles von Hügel's observations are significant because they suggest that by the 1830s in Hobart Town, European plants were well established and had already replaced much of the existing native flora. Spicer was based in Hobart Town and most of his collections in the Tasmanian Herbarium are from southern Tasmania. Much of the material collected is from the greater Hobart area, which today includes the suburbs of New Town, Kangaroo Point [= Bellerive], and Sandy Bay (Appendix). Information on the distribution of naturalised plants in the rest of the State is very patchy.

Spicer (1878a) notes that many species are common and some were quite well established, e.g. *Rubus fruticosus* sp. agg. (blackberries) and *Ulex europaeus* (gorse), by the 1870s. Spicer (1878b) attempted to quantify in general terms, the degree of establishment of some of these species, and he considered that approximately 50% of the species were abundant or common, including *Arctotheca calendula* (cape weed), *Capsella bursa-pastoris* (shepherd's purse), *Cirsium* spp. (thistles), *Cotula coronopifolia* (water buttons), *Euphorbia helioscopia* (sun spurge), *Fumaria muralis* (wall fumitory), *Hypochaeris radicata* (flatweed), *Plantago lanceolata* (ribwort), *Polygonum aviculare* (wireweed), *Rosa rubiginosa* (sweetbriar), *Scandix pecten-veneris* (shepherd's neddle), *Senecio vulgaris* (common groundsel), *Silene gallica* (french catchfly), *Silybum marianum* (variegated thistle), *Sinapis arvensis* (charlock) and *Taraxacum officinale* sp. agg. (dandelion).

In some cases quite detailed information is available on a few species. *Elodea canadensis* (elodea) was first recorded from Tasmania in 1862, when specimens were discovered in the reservoir which supplied the basin in the Franklin Gardens, Hobart Town (Mueller 1877). By the 1870s it had been recorded from the Bagdad Rivulet and Jordan River (Spicer 1878a). *Torilis nodosa* (knotted parsley) and *Trifolium tomentosum* (woolly clover) were both recorded as being restricted to Circular Head in the 1870s (Mueller 1877; Spicer 1878a).

Comparison with Current Weed Flora

Reassessment of Spicer's lists gives a revised estimate of species that were naturalised in Tasmania by the late 1870s. In total, 107 species in 83 genera became naturalised in the first 70 years of settlement. After nearly 200 years, the current census of the naturalised flora lists over 740 naturalised species in 382 genera (Rozefelds et al. 1999) (Fig. 2). In addition to the 106 species considered naturalised in the late 1870s, another 50 species were of uncertain status. This difficulty of deciding when to allocate 'naturalised' status to a non-indigenous species is an ongoing problem (Rozefelds et al. 1999; Richardson et al. 2000). Of the above 50 species, all but two, *Aquilegia* sp. (columbine) and *Nigella* sp. (fennel flower) are currently considered naturalised in Tasmania. *Hyoscyamus albus* (white henbane) is known from a single specimen, collected by Spicer in 1875, and as it has not been recollected it should be deleted from the current State census. However, exotic species are often poorly represented in herbaria so it may be naturalised.

The major weed families in the late 1870s based upon the number of species, and as a percentage of the introduced flora, were Poaceae (22 species, 20.6%), Asteraceae (21 species, 19.6%), Fabaceae (10 species, 9.3%), Brassicaceae (8 species, 7.6%) and Caryophyllaceae (7 species, 6.5%) and these are the predominant weed families in the State today (Rozefelds et al. 1999) (Fig. 3). They are in nearly every case, except Fabaceae, more commonly represented in the flora of the 1870s, than in the current flora (Fig. 4). Other families, represented by more than a single species, include the Apiaceae, Boraginaceae, Chenopodiaceae, Euphorbiaceae, Malvaceae, Plantaginaceae, Polygonaceae, and Scrophulariaceae, all of which include species that are rapid-maturers. The early invasion of exotic plants in Tasmania was characterised by the introduction of many rapidly maturing herbaceous weeds.

The only three woody plants considered naturalised in the 1870s were *Rubus fruticosus* sp. agg. (blackberries) and *Rosa rubiginosa* (sweetbriar) in the family Rosaceae, and *Ulex europaeus* (gorse) (Fabaceae). Polya (1981) in Morgan (1992) claims that a mile [1.6 km] of hedgerow required the planting of between 8000 and 10500 plants. It is not surprising that hedgerow species, e.g. *Ulex europaeus* and *Rosa rubiginosa* had become naturalised by this time. Harvey noted that by 1855, *Rosa rubiginosa* was completely naturalised, and in places forms impenetrable thickets (Harvey 1855, p. 227). Woody plants represented less than 3% of the entire naturalised flora in the 1870s. Currently woody plants, as exemplified by woody shrubs and trees from the Fabaceae, Rosaceae, Rutaceae, Rubiaceae, Salicaceae, etc., represent over 6% of the entire naturalised flora in the State (Rozefelds et al. 1999).

In the first 70 years of settlement, approximately 90% of the non-indigenous flora that had become established was of European origin. Rozefelds et al. (1999) pointed out that the distribution of many of these species also extends into either northern Africa and/or western Asia. It seemed reasonable, however, to assume that the taxa are of European origin as this was the most likely source of seed. The provenance of some species, e.g. *Acetosella vulgaris* (sheep sorrel), *Capsella bursa-pastoris* (shepherd's purse), *Chenopodium album* (fathen) and *Medicago*

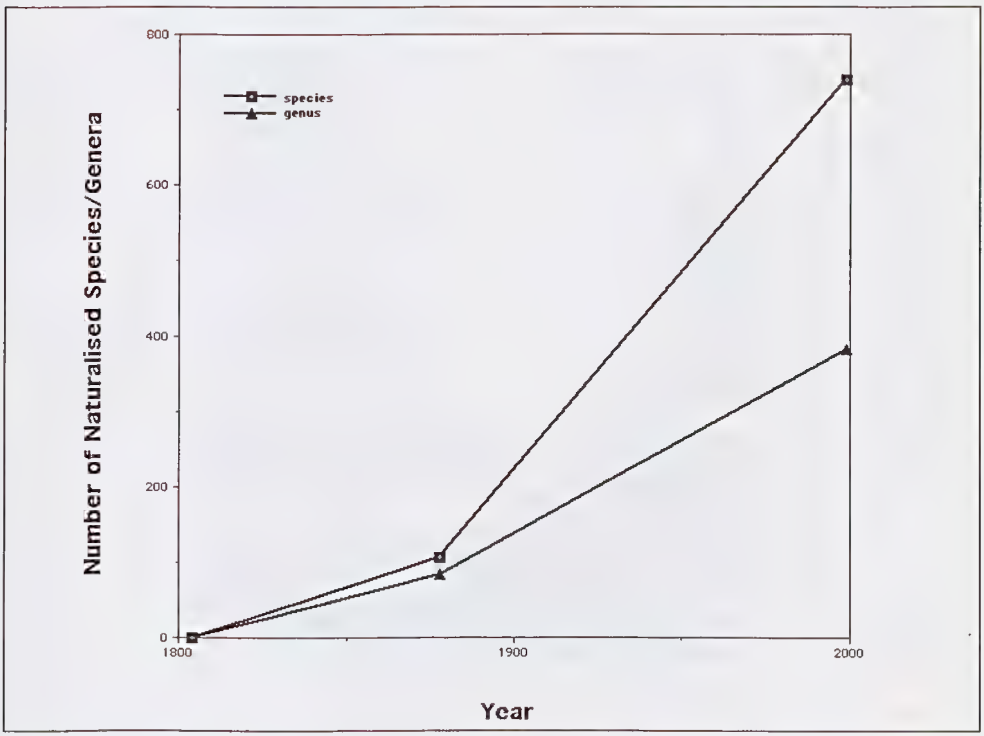

FIG. 2. Changes in the numbers of naturalised species and genera in Tasmania from first settlement to 1999.

polymorpha (burr medic) is unclear as they have a widespread and temperate distribution. Non-European species that were naturalised in Tasmania in the 1870s include *Elodea canadensis* (elodea), *Veronica peregrina* (wandering speedwell) and *Xanthium spinosum* (bathurst burr) (North and South America) and *Arctotheca calendula* (cape weed), *Vellereophyton dealbatum* (white cudweed) and *Cotula coronopifolia* (water buttons) (southern Africa). There has been a proportionally larger number of introductions from other geographical regions to the States Flora in more recent times. Examination of the geographical origins of species considered introduced since 1970 (Rozefelds et al. 1999), indicates that the proportion of European species naturalised in the last 25 years in Tasmania had decreased to approximately 50%. The non-European species naturalised since the 1970s are predominantly from Africa, the Americas, the Australian mainland, Asia and New Zealand (Rozefelds et al. 1999).

Discussion

The early botanical reports and publications of Backhouse (1835), Hooker (1853–59) and Bentham (1863–1878) and others provide records of some naturalised species, but they do not provide an overview of the naturalised flora in the State. While difficulties exist in interpreting some of the records compiled by Spicer, his studies provide the first detailed overview of the naturalised flora of Tasmania. Spicer's

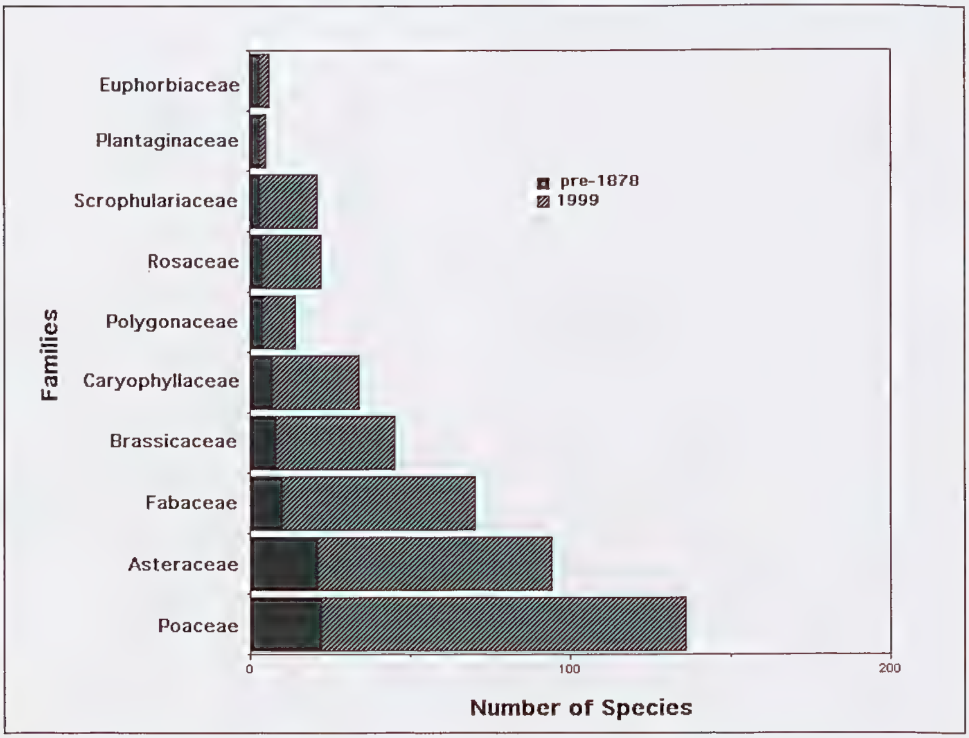

FIG. 3. Comparison of number of species in major weed families in 1878 and in 1999.

studies also provide a temporal framework in which to study the rate at which non-indigenous species were naturalised in the State.

Spicer's publications demonstrate a number of interesting points that are significant in understanding the history of naturalised plants in Tasmania. The species that had become naturalised in the Colony include both accidental and intentional introductions that were predominantly European in origin. Most of the species are annuals and rapidly maturing perennials, and includes many common agricultural and ruderal weeds. Spicer (1878a) provides information on the possible mechanisms for introduction for some species, e.g. *Polygonum aviculare* (wireweed) and *Spergularia arvensis* (corn spurrey). Many of the other species probably came in as contaminants in seed lots, soil, fodder and farming equipment, or on livestock. We can confidently conclude from Spicer's study that over 100 species, in 83 genera, were naturalised in Tasmania by the late 1870s, just 70 years after the first European settlement. Rapidly maturing herbaceous species therefore became established quickly while woody species are poorly represented.

The underlying reason for the rapid uptake of new species in Tasmania is due, in part, to the attempts to introduce any and all 'useful' plants into the State. Morgan (1992) indicates that by 1838, a vast number of flowering plants, both native and introduced, were available to

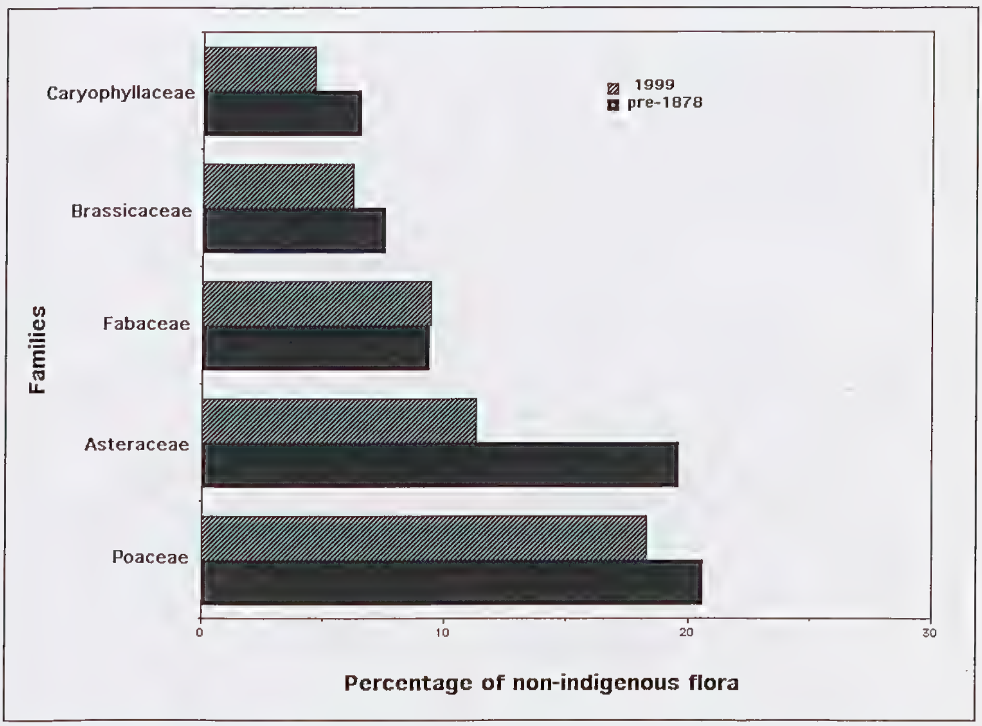

FIG. 4. Comparison of the major weed families recorded from Tasmania in 1878, and in 1999; as a percentage of the non-indigenous flora in the State.

gardeners. Daniel Bunce wrote in *Practical Gardening* that over 140 species of flowering plants were available in the winter month of July (Morgan 1992). Spicer (1878a, p. 64) notes that many species 'owe their introduction, to a spirit of improvement'. The *Rules and objects of the Tasmanian Acclimatisation Society* (Anonymous 1862a), state that 'The objects of the Society shall be the introduction, acclimatisation and domestication of all innocuous quadrupeds, birds, fishes, insects, and vegetables, whether useful or ornamental'. The *Annual Report of the Acclimatisation Society of New South Wales* (Anonymous 1862b) 'notes with satisfaction the multiplication of kindred Societies in Tasmania, Auckland [New Zealand], Adelaide [South Australia] and Queensland'. It seems highly likely, therefore, that the general trends identified for Tasmania, will apply to all other states in Australia that have a temperate climate, New Zealand and probably most of the European colonies that were established in temperate regions of the Southern Hemisphere.

This policy of acclimatisation in Tasmania is also evidenced by the large numbers of exotic plants that were being introduced into the Botanical Gardens in these early years of settlement. The first superintendent of the Royal Tasmanian Botanical Gardens introduced over 250 species in 60 genera to the gardens in the 1840s (Hurburgh 1986). A number of species that are listed by Spicer in 1878, had been recorded in a 1857 catalogue of plants in the Royal Society Gardens. The exotic species that were being grown in Tasmania by 1857 included agricultural grasses, *Alopecurus geniculatus* (marsh foxtail), *Anthoxanthum odoratum* (sweet vernal grass), *Bromus racemosus* (soft brome), *Dactylis glomerata* (cocksfoot), *Festuca* (fescue), *Holcus lanatus* (yorkshire fog) and *Lolium perenne* (perennial ryegrass); herbaceous plants *Conium maculatum* (hemlock), *Marrubium vulgare* (horehound), *Mentha spicata* (spearmint) and vines e.g. *Hedera helix* (english ivy) and blackberries, i.e. *Rubus fruticosus* sp. agg. (blackberries) (Hurburgh 1986). The *Papers and Proceedings of the Royal Society of Tasmania* for 1857–1878 record species that were being cultivated in the Society's gardens. Although these species were obviously being grown in Tasmania from the 1850s onwards, it is unclear when they first became naturalised in the State. These plants came from overseas, and from intra and interstate. Botanical gardens and nurseries are recognised as an important source of introduced plants (Myers and Bazely 2003).

The intention of many settlers was to replicate life in England by having the same range of plants available for agricultural and ornamental purposes. Staples (2002) pointed out that the Tasmanian landscape is distinct from that of England, and farming practices evolved rapidly to meet the new conditions. Introduced plant species now account for approximately one-third of the known Tasmanian flora. The vegetation, particularly in urbanised, pastoral and agricultural regions of the State, is now a mosaic of introduced and native species.

There is little published information to suggest that there was recognition of the threat posed by new introductions to the State. Harvey (1855), for example, noted the spread of thistles, *Rubus* (blackberries) and *Rosa rubiginosa* (sweetbriar) in Tasmania. It was only in the early 1870s with the *Act to prevent the spread of the Californian Thistle [Carduus arvensis] 18th October, 1870*, and *An Act to extend the Operation of the The Californian Thistle Act 21st December, 1871* that the weed threat posed by new introductions was formally recognised in

Tasmania. Spicer (1878a, p. 65) was aware of the threats posed by some introductions, e.g. *Rosa rubiginosa* (sweetbriar), *Cirsium arvense* (californian thistle), *Cirsium vulgare* (spear thistle) and *Silybum marianum* (variegated thistle) and 'a host of lesser plagues, such as the stinging nettle [*Urtica urens*], and sheep sorrel [*Acetosella vulgaris*], all of which better had remained at home'. He also recognised the potential threat posed by species, e.g. *Arctotheca calendula* (cape weed), *Xanthium spinosum* (bathurst burr) and *Elodea canadensis* (elodea), noting that 'they are harmless enough; but I much fear the day will come when the colony will have bitter cause to regret their importation'.

When Spicer (1878a,b) undertook his studies, he clearly found it difficult to determine whether some taxa should be considered naturalised. Rozefelds et al. (1999) and Richardson et al. (2000) have expressed similar concerns, and discussed some of the difficulties in making this decision. One of the most significant insights from Spicer's study is that of the 50 exotic species that were considered of an uncertain status (Appendix), i.e. not yet established in the late 1870s, over 95% are now recognised as naturalised in the State (Rozefelds et al. 1999). If we extrapolate from Spicer's work to the present day it is reasonable to predict that most of those species currently considered 'sparingly naturalised', or 'adventives' will become naturalised in the State. We conclude from this that the seed for the next wave of weed invasions in Tasmania has, unfortunately, already been sown.

Acknowledgements

We thank the Tasmaniana Library, State Library of Tasmania for access to early literature. Carolyn Weiller and Dennis Morris have provided advice and assistance with interpreting some of the grass records. Alison Alexander kindly commented on an earlier version of the manuscript.

This paper is dedicated to the co-author, Ray MacKenzie (deceased November 2002), who helped undertake the research for this paper.

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Taxa recorded by Spicer	Current Species Name	Common Name [1]	'Alien Plants'	Handbook	Literature Sources and Tasmanian Herbarium Records	Distribution 1870s and Comments
APIACEAE						
Caucalis infesta Curt.	*Torilis nodosa* (L.) Gaertn.	knotted parsley	+	-	-	Naturalised locally
Caucalis nodosa Scop.	*Torilis nodosa* (L.) Gaertn.	knotted parsley	+	Not naturalised	Spicer (1878a, p. 69) 'restricted to Circular Head';'copiously naturalised' (Mueller 1877, p. 33)	Naturalised locally
Conium maculatum L.	*Conium maculatum* L.	hemlock	+	Not naturalised	Royal Society Gardens (HO23422)	Status uncertain
Daucus carota L. (incl. *D. carota proliferum L*)	*Daucus carota* L.	carrot	+	-	New Town (HO23434)	Status uncertain
Foeniculum vulgare Gaertn.	*Foeniculum vulgare* Miller	fennel	+	+	Abundant at Sandy Bay (Mueller 1877, p. 33)	Common (Spicer 1878b)
Pastinaca sativa L.	*Pastinaca sativa* L.	parsnip	Scarcely	Not naturalised	-	Not currently listed as naturalised (Rozefelds et al. 1999)
Scandix pecten veneris L.	*Scandix pecten-veneris* L.	shepherd's needle	+	+	-	Abundant (Spicer 1878b)
APOCYNACEAE						
Vinca major L.	*Vinca major* L.	blue periwinkle	+	Not naturalised	Hobart (HO3513)	Status uncertain
ARALIACEAE						
Hedera helix L.	*Hedera helix* L.	english ivy	Scarcely	Not naturalised	-	Status uncertain
ASTERACEAE						
Achillea millefolium L.	*Achillea millefolium* L.	yarrow	Scarcely	Not naturalised	-	Status uncertain
Anthemis nobilis L.	*Chamaemelum nobile* (L.) All.	chamomile	+	Not naturalised	(Harvey 1855, p. 227) 'Chamomile covers the fields and paddocks' about Georgetown.	Naturalised

Appendix. List of taxa recorded by Spicer (1878a,b) with their scientific names. The nomenclature for each species in Column 1 is from Spicer's publications. The current scientific names for these taxa is in Column 2, and the current common name for these plants is from Shepherd et al. (2001). Species recorded by Spicer in the 'Alien Plants' paper or in the Handbook are indicated by '+'. Distribution and comments refers to whether the species was considered naturalised, or its weed status was uncertain, and the degree of establishment, i.e. common, abundant, is also included where information exists.

Appendix. *(continued)*

Arnoseris pusilla Gaertn.	?	-	+	+	-	Affinities uncertain
Bellis perennis L.	*Bellis perennis* L.	english daisy	Scarcely	+	Hooker (1859) notes it is only known from old gardens; Hobart (Spicer 1878b); New Town (Mueller 1877, p. 33)	Naturalised
Calendula arvensis L.	*Calendula arvensis* L.	field marigold	+	+	Hobart, New Town (Spicer 1878b)	Naturalised
Calendula officinalis L.	*Calendula officinalis* L.	garden marigold	+	+	Hobart, New Town (Spicer 1878b)	Naturalised
Carduus arvensis L.	*Cirsium arvense* (L.) Scop.	californian or perennial thistle	+	+	New Town (Mueller 1877, p. 34)	Abundant (Spicer 1878b)
Carduus lanceolatus	*Cirsium vulgare* (Savi) Ten.	scotch or spear thistle	+	+	Naturalised (Hooker 1859)	Abundant (Spicer 1878b)
Carduus pratensis L.	?	marsh thistle	+	-	-	Affinities uncertain
Centaurea calcitrapa L.	*Centaurea calcitrapa* L.	star thistle	+	Not naturalised	Recorded in Tasmania – Herb F.Mueller (Bentham 1867)	Naturalised
Centaurea melitensis L.	*Centaurea melitensis* L.	maltese cockspur	+	+	Abundant in various parts of Tasmania (Bentham 1867); Hobart, Tamar Heads (Spicer 1878b)	Naturalised
Chrysanthemum leucanthemum L.	*Leucanthemum vulgare* Lam.	ox-eyed daisy	+	Not naturalised	-	Status uncertain
Cichorium intybus L.	*Cichorium intybus* L.	chicory	Scarcely	Not naturalised	Recorded as established in Hobart in 1834 by Hügel (Clark 1994)	Status uncertain
Cotula coronopifolia L.	*Cotula coronopifolia* L.	water buttons	-	+	-	Abundant (Spicer 1878b); considered a native by Spicer (1878b)
Crepis japonica (L.) Benth.	*Crepis* sp.	hawksbeard	-	Not naturalised	-	Affinities uncertain
Crepis virens L.	*Crepis capillaris* (L.) Wallr.	smooth hawksbeard	Scarcely	-	-	Status uncertain
Cryptostemma calendulaceum Br.	*Arctotheca calendula* (L.) Levyns	cape weed	+	+	-	Abundant (Spicer 1878b)
Erigeron canadensis L.	*Conyza canadensis* (L.) Cronquist	canadian fleabane	+	-	-	Status uncertain
Gnaphalium candidissimum Lam.	*Vellereophyton dealbatum* (Thunb.) Hillard & B.L.Burtt	white cudweed	+	+	Kangaroo Point [Bellerive] (HO11031); Hobart, New Town (Spicer 1878b)	Naturalised; Mueller (1877, p. 34) notes 'That this is the first knowledge which we possess of this pretty species having strayed out of its native home, South Africa'

Appendix. *(continued)*

Hypochaeris glabra L.	*Hypochaeris glabra* L.	smooth cat's ear	+	+	Naturalised (Hooker 1859); reported from Tasmania by Gunn, Flinders Island by Milligan (Bentham 1867)	Common (Spicer 1878b)
Hypochaeris radicata L.	*Hypochaeris radicata* L.	flatweed	+	+	-	Abundant (Spicer 1878b)
Leontodon autumnalis L.	*Leontodon* sp.	hawkbit	+	Not naturalised	-	Affinities uncertain
Leontodon hirtus L.	*Leontodon taraxacoides* (Vill.) Mérat	rough hawkbit	+	+	-	Common (Spicer 1878b)
Leontodon hispidus L.	*Leontodon* sp	hawkbit	+	-	-	Affinities uncertain
Matricaria inodora L.	*Tripleurospermum perforatum* (Mérat) Lainz	scentless mayweed	+	-	-	Status uncertain
Onopordum acanthium L.	*Onopordum acanthium* L.	scotch or cotton thistle	+	Not naturalised	Naturalised (Hooker 1859); New Town (HO14504)	Naturalised
Picris hieracioides L.	*Picris angustifolia* DC	hawkweed	+	+	-	Currently considered a native species (Buchanan 1999)
Senecio vulgaris L.	*Senecio vulgaris* L.	common groundsel	+	+	-	Abundant (Spicer 1878b)
Silybum marianum Gaertn.	*Silybum marianum* (L.) Gaertn.	variegated thistle	+	+	-	Abundant (Spicer 1878b)
Sonchus oleraceus L.	*Sonchus oleraceus* L.	common sowthistle	+	+	Reported from Port Dalrymple [Tamar River] by R Brown, common near the sea and the north coast, Hooker (Bentham 1867)	Common (Spicer 1878b)
Tanacetum vulgare L.	*Tanacetum vulgare* L.	common tansy	Scarcely	Not naturalised	-	Status uncertain
Taraxacum officinale Wigg.	*Taraxacum officinale* Weber ex F.H.Wigg. sp. agg.	dandelion	+	+	-	Abundant (Spicer 1878b)
Tragopogon porrifolius L.	*Tragopogon porrifolius* L.	salsify	+	+	Hobart, Sandy Bay (Spicer 1878b)	Naturalised
Xanthium spinosum L.	*Xanthium spinosum* L.	bathurst burr	+	+	Spicer (1878a, p. 64) 'first seen near Melbourne 1857, and in New Zealand 1863. It must have reached Tasmania .... at a later date'; Launceston, Hobart (Spicer 1878b)	Naturalised

Appendix. *(continued)*

BORAGINACEAE						-
Borago officinalis L.	*Borago officinalis* L.	borage	Scarcely	Not naturalised	-	Status uncertain
Echium violaceum L.	*Echium plantagineum* L.	paterson's curse	+	Not naturalised	Reported in Tasmania (Bentham 1867)	Naturalised
Lithospermum arvense L.	*Buglossoides arvensis* (L.) I.M.Johnst.	cotton gromwell, ironweed	+	+	Established in several localities in Tasmania (Bentham 1869); New Town (HO105899, HO7852)	Common (Spicer 1878b)
BRASSICACEAE						
Brassica napus L.	*Brassica napus* L.	rape	+	Not naturalised	Naturalised (Hooker 1859)	Naturalised
Brassica sinapistrum Boiss.	*Sinapis arvensis* L.	charlock	+	+	Naturalised (Hooker 1859)	Abundant (Spicer 1878b)
Capsella bursa pastoris Mnch.	*Capsella bursa-pastoris* (L.) Medik.	shepherd's purse	+	+	Naturalised (Hooker 1859)	Abundant (Spicer 1878b)
Cardamine hirsuta L.	*Cardamine hirsuta* L.	common bitterweed	-	+	-	Abundant (Spicer 1878b)
Diplotaxis tenuifolia D.C.	*Diplotaxis tenuifolia* (L.) DC.	sand rocket	Scarcely	Not naturalised	Spicer (1878a, p. 64) 'originally brought as seeds to the Royal Society Garden'.	Status uncertain
Lepidium campestre Br.	*Lepidium campestre* (L.) R.Br.	field wort	+	+	'Acanthe', Lenah Valley (HO104496)	Common (Spicer 1878b)
Lepidium sativum L.	*Lepidium sativum* L.	garden cress	Scarcely	Not naturalised	-	Status uncertain
Nasturtium officinale Br.	*Nasturtium officinale* R.Br.	water cress	+	+	New Town Creek (HO15773)	Abundant (Spicer 1878b)
Raphanus raphanistrum L.	*Raphanus raphanistrum* L.	wild radish	Scarcely	Not naturalised	-	Status uncertain
Senebiera coronopus Poir.	*Coronopus squamatus* (Forssk.) Asch.	swinecress	+	+	Hobart (Spicer 1878b)	Well established (Mueller 1877)
Senebiera didyma Pers.	*Coronopus didymus* (L.) Smith	lesser swinecress	+	+	Naturalised (Hooker 1859); Hobart (Spicer 1878b)	Naturalised
Sisymbrium officinale L.	*Sisymbrium officinale* (L.) Scop.	hedge mustard	+	+	-	Common (Spicer 1878b)
CARYOPHYLLACEAE						
Arenaria serpillifolia L.	*Arenaria serpyllifolia* L.	thyme-leaf sandwort	+	Not naturalised	-	Status uncertain
Cerastium glomeratum Thu.	*Cerastium glomeratum* Thuill.	mouse-eared chickweed	+	+	New Town (Mueller 1877)	Common (Spicer 1878b)
Githago segetum Desf.	*Agrostemma githago* L.	corn cockle	+	+	New Town (HO8460)	Naturalised

Appendix. *(continued)*

Gypsophila tubulosa Boiss.	*Gypsophila tubulosa* (Jaub. & Spauch) Boiss.	chalkwort	+	Not naturalised	-	Status uncertain
Polycarpon tetraphyllum L.	*Polycarpon tetraphyllum* (L.) L.	four-leaf allseed	+	+	Hobart (HO8500), Circular Head (Mueller 1877)	Common (Spicer 1878b)
Sagina apetala L.	*Sagina apetala* Ard.	annual pearl wort	+	-	Winton, Brighton (HO8525), Kings Island (Mueller 1877)	Naturalised
Sagina procumbens L.	*Sagina procumbens* L.	spreading pearlwort	-	+	-	Status uncertain
Silene anglica L. (incl. *Silene anglica quinquevaluera* L.)	*Silene gallica* L.	french catch fly	+	+	Naturalised (Hooker 1859); Kangaroo Point [Bellerive] (HO8586)	Abundant (Spicer 1878b)
Spergula arvensis L.	*Spergula arvensis* L.	corn spurrey	+	+	Backhouse (1835, p. 109) 'it has completely naturalised itself in the gardens of Van Diemen's Land [Tasmania]'; New Town (HO8632)	Common in sandy places (Spicer 1878b)
Stellaria media L.	*Stellaria media* (L.) Vill.	chickweed	+	+	-	Abundant (Spicer 1878)
CHENOPODIACEAE					-	
Chenopodium album L.	*Chenopodium album* L.	fathen	+	+	New Town (HO9382)	Common (Spicer 1878b)
Chenopodium glaucum L.	*Chenopodium glaucum* L.	glaucous goosefoot	+	+	Common near the sea coast, Hooker, Port Dalrymple [Tamar River] Brown, (Bentham 1870)	Common on East Coast (Spicer 1878b)
Chenopodium murale L.	*Chenopodium murale* L.	narrow-leaf goosefoot	+	+	Kents Group, George Town (Spicer 1878b)	Naturalised
CONVOLVULACEAE					.	
Convolvulus arvensis L.	*Convolvulus arvensis* L.	field bindweed	+	+	Hobart (Spicer 1878b)	Naturalised
DIPSACACEAE						
Dipsacus silvestris L.	*Dipsacus fullonum* L.	wild teazel	+	Not naturalised	-	Status uncertain

Appendix. *(continued)*

Scabiosa atropurpurea L.	*Scabiosa atropurpurea* L.	pincushion	+	+	Sandy Bay (Spicer 1878b)	Status naturalised; *Scabiosa atropurpurea phoenicea* and *S. atropurpurea albiflora* of Spicer (1878), were considered as two colour varieties by Curtis (1963)
EUPHORBIACEAE						
Euphorbia helioscopia L.	*Euphorbia helioscopia* L.	sun spurge	+	+	New Town (HO6287)	Abundant (Spicer 1878b)
Euphorbia lathyris L.	*Euphorbia lathyris* L.	caper spurge	+	-	Banks of the Derwent, Hobart (HO6292)	Naturalised
Euphorbia peplus L.	*Euphorbia peplus* L.	petty spurge	+	+	New Town (HO106047)	Abundant (Spicer 1878b)
FABACEAE						
Lupinus arboreus Sims	*Lupinus arboreus* Sims	tree lupin	-	Not naturalised	-	Status uncertain
Medicago denticulata Willd.	*Medicago polymorpha* L.	burr medic	+	+	Hobart, Banks of the River Derwent (HO11199); New Town (Spicer 1878b)	Naturalised
Medicago lupulina L.	*Medicago lupulina* L.	black medic	+	+	Sandy Bay (HO11183), Hobart, New Town (Spicer 1878b)	Naturalised
Medicago maculata Sibth.	*Medicago arabica* (L.) Huds.	tree medic	+	+	Hobart (Spicer 1878b)	Naturalised
Medicago sativa L.	*Medicago sativa* L.	lucerne	+	Not naturalised	New Town (HO11214)	Status uncertain
Melilotus parviflora Desf.	*Melilotus indicus* (L.) All.	bokharn clover	+	+	Hobart, Sandy Bay (1878b)	Naturalised
Onobrychis sativa Lam.	*Onobrychis viciifolia* Scop.	sainfoin	Scarcely	Not naturalised	-	Status uncertain
Sarothamnus scoparius Koch.	*Cytisus scoparius* (L.) Link	broom	Scarcely	Not naturalised	-	Status uncertain
Spartium junceum L.	*Spartium junceum* L.	spanish broom	Scarcely	Not naturalised	-	Status uncertain
Trifolium minus L.	*Trifolium dubium* Sibth.	suckling clover	+	+	Common in Tasmania (Bentham 1863); New Town (HO12204)	Common (Spicer 1878b)
Trifolium pratense L.	*Trifolium pratense* L.	red clover	+		Naturalised (Hooker, 1859)	Naturalised
Trifolium procumbens L.	*Trifolium campestre* Schreb.	hop clover	+	+	Elwick (HO12192)	Common (Spicer 1878b)

Appendix. *(continued)*

Trifolium repens L. (includes *T. repens roseum* L.)	*Trifolium repens* L.	white clover	+	+	-	Abundant (Spicer 1878b)
Trifolium tomentosum L.	*Trifolium tomentosum* L.	woolly clover	+	+	-	Restricted to Circular Head (Spicer 1878a, p. 65)
Ulex europaeus L.	*Ulex europaeus* L.	gorse or furze	+	+	Harvey (1855, p. 227) 'common furze is also spreading but not so rapidly in the Western Country'. Hooker (1859) noted that Backhouse recorded it as naturalised around Hobart	Common (Spicer 1878b, Mueller 1877)
Vicia sativa L. (incl. *V. sativa angustifolia* Roth.)	*Vicia sativa* L.	common vetch	+	Not naturalised	-	Status uncertain
FUMARIACEAE						
Fumaria officinalis L.	*Fumaria muralis* Sond. ex W.D.J.Koch	wall fumitory	+	+	New Town (HO104485); incorrect identification	Abundant (Spicer 1878b)
GERANIACEAE						
Erodium cicutarium L.	*Erodium cicutarium* (L.) L'Hérit.	common storksbill	+	+	New Town (HO6665)	Naturalised (Hooker, 1859); Abundant (Spicer 1878b)
LAMIACEAE						
Dracocephalum canariense L.		balm of gilead	-	Not naturalised	-	Affinities uncertain
Marrubium vulgare L.	*Marrubium vulgare* L.	horehound	+	+	Harvey (1855, p. 227) 'it is everywhere by the roadsides'; Hobart, New Town (HO7240)	Abundant (Spicer 1878b)
Mentha viridus L.	*Mentha spicata* L.	spearmint	+	Not naturalised	-	Status uncertain
Stachys arvensis L.	*Stachys arvensis* (L.)L.	stagger weed	+	+	New Town (HO104712), Royal Society Gardens (HO7388); Hobart (Spicer 1878b)	Naturalised

Appendix. *(continued)*

MALVACEAE						
Hibiscus vesicarius Cav.	?*Hibiscus trionum* L.	bladder ketmia	Scarcely	Not naturalised	-	Currently considered a native cosmopolitan species (Lazarides et al. 1997) but introduced in Tasmania (Buchanan 1999)
Lavatera hispida Desf.	*Lavatera* sp.	-	+	Not naturalised	-	Possibly native species; Spicer (1878, p. 65) 'restricted to Bass Strait Islands'
Malva rotundifolia L.	*Malva nicaeensis* All.	mallow-of-nice	+	+	New Town (HO12987); Naturalised (Hooker 1859)	Common (Spicer 1878b)
Malva silvestris L.	*Malva sylvestris* L.	tall mallow	+	+	Naturalised (Hooker 1859)	Common (Spicer 1878b)
OXALIDACEAE						
Oxalis cernua L.	*Oxalis pes-caprae* L.	soursob	+	Not naturalised	Spicer (1878a, p. 64) 'brought as seeds to garden of Royal Society'; Royal Society Gardens (HO19254)	Status uncertain
PAPAVERACEAE						
Eschscholtzia [sic] *californica* Cham. in Nees	*Eschscholzia californica* Cham.	californian poppy	-	Not naturalised	-	Status uncertain
Papaver aculeatum Thunb.	*Papaver aculeatum* Thunb.	bristle poppy	-	+	King Island (Spicer 1878b)	Status uncertain
Papaver dubium L.	*Papaver dubium* L.	long-headed poppy	Scarcely	Not naturalised	-	Status uncertain
Papaver somniferum L.	*Papaver somniferum* L.	opium poppy	Scarcely	Not naturalised	-	Status uncertain
PLANTAGINACEAE						
Plantago coronopus L.	*Plantago coronopus* L.	buck's horn plantain	+	+	Naturalised (Hooker 1859) and Bentham (1870); Brighton (HO19471), George Town, Bridgewater (Spicer 1878b)	Naturalised
Plantago lagopus L.	*Plantago major* L.	greater plantain	scarcely	Not naturalised	Naturalised (Hooker, 1859); Kangaroo Point [Bellerive] (HO19476); incorrect identification	Naturalised

Appendix. *(continued)*

Plantago lanceolata L.	*Plantago lanceolata* L.	ribwort	+	+	Kangaroo Point [Bellerive] (HO19496)	Abundant (Spicer 1878b)
Plantago major L.	*Plantago major* L.	greater plantain	+	+	Port Cygnet (HO19505), Hobart (HO19503)	Naturalised
POLYGONACEAE						
Polygonum aviculare L.	*Polygonum aviculare* L.	wireweed	+	+	Backhouse (1835, p. 103) 'naturalised throughout the Colony having been introduced among the seed wheat'	Abundant (Spicer 1878b)
Polygonum convolvulus L.	*Fallopia convolvulus* (L.) A.Löve	black bindweed	+	Not naturalised	Naturalised (Hooker, 1859)	Naturalised
Rumex acetosella L.	*Acetosella vulgaris* Fourr.	sheep sorrel	+	+		Abundant (Spicer 1878b)
Rumex crispus L.	*Rumex crispus* L.	curled dock	+	+	New Town (HO19852)	Abundant (Spicer 1878b)
PRIMULACEAE						
Anagallis arvensis L.	*Anagallis arvensis* L.	scarlet pimpernel	+	+	-	Abundant (Spicer 1878b)
Anagallis arvensis spp. *coerulea* Lam.	*Anagallis arvensis* L. (blue flowered form)	blue pimpernel	+	-	-	Status uncertain
RANUNCULACEAE						
Aquilegia vulgaris L.	*Aquilegia* sp.	columbine	Scarcely	Not naturalised	-	Not currently naturalised (Rozefelds et al. 1998)
Nigella damascena L.	*Nigella* sp.	fennel flower	Scarcely	Not naturalised	-	Not currently naturalised (Rozefelds et al. 1998)
Ranunculus hirsutus L.	*Ranunculus* sp.	buttercup	+	+	Southport (Spicer 1878b)	Affinities uncertain
Ranunculus muricatus L.	*Ranunculus muricatus* L.	sharp-fruited buttercup	Scarcely	Not naturalised	New Town in wet ditch on road to Risdon Ferry (Mueller 1877)	Naturalised
RESEDACEAE						
Reseda luteola L.	*Reseda luteola* L.	wild mignonette	+	Not naturalised	Roadside Brighton (HO21175)	Status uncertain
Reseda ramosissima Willd.	*Reseda lutea* L.	cut-leaf mignonette	+	Not naturalised	Banks of the Derwent River, Hobart (HO21171)	Status uncertain

Appendix. *(continued)*

ROSACEAE						
Alchemilla arvensis L.	*Aphanes arvensis* L.	parsley piert	+	+	-	Naturalised
Crataegus oxyacantha L.	*Crataegus monogyna* Jacq.	hawthorn	-	Not naturalised	-	Status uncertain
Poterium sanguisorba L.	*Sanguisorba minor* Scop.	small burnet	+	+	Hobart, Lake St Clair (Spicer 1878b)	Naturalised
Prunus communis Huds.	*Prunus* sp.	-	-	Not naturalised	-	Status uncertain
Rosa rubiginosa L.	*Rosa rubiginosa* L.	sweet briar	+	+	Harvey (1855, p. 227) 'originally introduced as a hedge plant, is completely naturalised, and in places forms impenetrable thickets'; Winton, Brighton (HO21521)	Abundant (Spicer 1878b)
Rubus fruticosus L.	*Rubus fruticosus* L. sp. agg.	blackberry	+	+	-	Spicer (1878a, p. 67) notes that it 'abounds on the Northern Coast and in the Ringarooma District; it is spreading widely in the country about the Huon'
Rubus idaeus L.	*Rubus* sp. (¿*idaeus* L.)	¿raspberry	-	Not naturalised	-	Present taxonomy of this genus is unclear
RUBIACEAE						
Sherardia arvensis L.	*Sherardia arvensis* L.	field madder	+	+	Naturalised (Hooker, 1859)	Rare (Spicer 1878b)
Linaria cymbalaria Mill.	*Cymbalaria muralis* P. Gaertn., B.Mey. & Scherb.	ivy-lead toadflax	+	+	New Town (HO104731), Hobart (Spicer 1878b)	Naturalised
Verbascum thapsus L.	*Verbascum thapsus* L.	great mullein	+	Not naturalised	-	Status uncertain
Veronica agrestis L.	*Veronica persica* Poir. in Lam.	creeping speedwell	+	+	New Town (HO22404), Hobart (Spicer 1878b)	Naturalised
Veronica hederaefolia L.	*Veronica persica* Poir. in Lam.	creeping speedwell	+	+	New Norfolk (HO22402)	Naturalised
Veronica peregrina L.	*Veronica peregrina* L.	wandering speedwell	+	Not naturalised	South Esk River, C. Stuart in Bentham (1867); Hobart, New Norfolk, Gould's Country (Spicer 1878b)	Naturalised

Appendix. *(continued)*

SOLANACEAE						
Hyoscyamus niger L.	*Hyoscyamus albus* L.	white henbane	Scarcely	Not naturalised	Hobart (HO22470)	Represented by a single specimen collected by Spicer – not currently naturalised
Solanum marginatum L.	*Solanum marginatum* L.f.	white-edged nightshade	Scarcely	Not naturalised	Royal Society Gardens (HO22490)	Status uncertain
Solanum nigrum L.	*Solanum nigrum* L.	blackberry nightshade	-	+	-	Common (Spicer 1878b)
URTICACEAE						
Urtica dioica L.	uncertain	stinging nettle	+	-	-	Not currently recorded from Tasmania; probable misidentification of native species *U. incisa*
Urtica urens L.	*Urtica urens* L.	dwarf nettle	+	+	Recorded from the State in 1846; Common near buildings in various parts of the State (Bentham 1873); Schomberg (1879) claims that this species was naturalised in Tasmania by 1840; and that the South Australian plants are derived from Tasmania; New Town (HO23594)	Abundant (Spicer 1878b)
VALERIANACEAE						
Centranthus ruber D.C.	*Centranthus ruber* (L.) DC.	red valerian	Scarcely	Not naturalised		Status uncertain
MONOCOTYLEDONAE						
HYDROCHARITACEAE	*Elodea canadensis* Michx.	elodea	+	+	Spicer (1878a, p. 64) 'seems not to have been noticed before 1862'; Hobart, Jordan River (Spicer 1878b); Bagdad Rivulet (HO325150)	Naturalised; Mueller (1877, p. 35) notes that introduced in about 1862, when specimens discovered in the reservoir, supplying the basin in the Franklin Gardens, Hobart Town

Appendix. *(continued)*

LILIACEAE s.lat.						
Asparagus officinalis L.	*Asparagus officinalis* L.	asparagus	+	-	New Town (HO28538)	Status uncertain
Nothoscordum fragrans Knth.	*Nothoscordum gracile* (Aiton) Stearn	false onion weed	+	Not naturalised	Spicer (1878, p. 64) 'brought as seed to gardens of Royal Society'; Royal Society Garden (HO23800)	Status uncertain
POACEAE						
Agrostis canina L.	*Agrostis* sp.	-	-	Not naturalised		Affinities uncertain
Agrostis vulgaris With.	*Agrostis stolonifera* L.	browntop bent	+	+	'Acanthe' Lenah Valley (HO128202); incorrect identification	Common (Spicer 1878b)
Aira caryophyllea L.	*Aira caryophyllea* L.	silvery hairgrass	+	+	Swanport, Story (Bentham 1878); Hobart, Kangaroo Point [Bellerive] (HO128235); Mount Tor (Mueller 1877, p. 39)	Naturalised
Alopecurus geniculatus L.	*Alopecurus geniculatus* L.	marsh foxtail	+	-	'Formosa' near Cressy (Bentham 1878)	Status uncertain
Alopecurus pratensis L.	*Alopecurus pratensis* L.	meadow foxtail	+	+	Hobart (HO128244)	Naturalised
Anthoxanthum odoratum L. (incl. *Anthoxanthum odoratum* L. *gracile*)	*Anthoxanthum odoratum* L.	sweet vernal grass	+	+	Kangaroo Point [Bellerive] (HO128258); New Town (Mueller 1877, p. 39)	Common (Spicer 1878b)
Arrhenatherum avenaceum Pal.	*Arrhenatherum elatius* (L.) P.Beauv. ex J. & C.Presl.	bulbous oat grass	+	-	Banks of the Derwent River (HO128263); incorrect identification	Status uncertain
Avena sativa L.	*Avena fatua* L.	oat	Scarcely	-	Roadside, New Town (HO72923)	Status uncertain
Briza maxima L.	*Briza maxima* L.	quaking grass	+	+	Hobart (HO128273), Kangaroo Point [Bellerive] (HO128274)	Naturalised; Mueller (1877, p. 39) notes that it 'has become one of the commonest weeds round Hobart Town'
Briza minor L.	*Briza minor* L.	shivery quaking grass	+	+	Hobart, New Town (HO128281, HO128280), King Island	Naturalised
Bromus mollis L.	*Bromus hordeaceus* L.	soft brome	+	+	Near Hobart (HO128313)	Common (Spicer 1878b)
Bromus racemosus L.	*Bromus hordeaceus* L.	soft brome	+	+	Hobart, New Town (HO128309)	Common (Spicer 1878b)
Bromus sterilis L.	*Bromus diandrus* Roth.	great brome	+	+	Near Hobart (HO128300)	Common (Spicer 1878b)

Appendix. *(continued)*

Bromus unioloides Hmbt.	*Bromus willdenowii* Kunth[2]	prairie grass	+	+	Spicer (1878a) 'seeds of Prairie Grass were brought to Tasmania in 1865'; Hobart, Brighton, New Town (HO128293), King Island; incorrect identification	Naturalised
Cynodon dactylon Pers.	*Cynodon dactylon* (L.) Pers.	couch	Scarcely	Not naturalised	Hobart (HO128323)	Status uncertain
Dactylis glomerata L.	*Dactylis glomerata* L.	cocksfoot	+	+	New Town (HO128143)	Common (Spicer 1878b)
Festuca myurus L.	*Vulpia bromoides* (L.) Gray	squirrel-tailed fescue	+	+	Hobart (HO128164); incorrect identification	Abundant (Spicer 1878b)
Festuca ovina L.	*Festuca* sp.	fescue	+	+	'Formosa' near Cressy and Swanport (Bentham 1878)	Common (Spicer 1878b)
Festuca pratensis Huds.	*Poa nemoralis* L.	-	+	-	Banks of the Derwent River (HO128513); incorrect identification	Status uncertain
Holcus lanatus L.	*Holcus lanatus* L.	yorkshire fog	+	+	Abundantly naturalised in Tasmania (Bentham 1878); near Hobart (HO128462)	Common (Spicer 1878b)
Hordeum murinum L.	*Hordeum murinum* L.	wall barley grass	+	+	Well established in Tasmania (Bentham 1878); Hobart (HO128463), Launceston, Don, Hobart (Spicer 1878b)	Abundant (Mueller 1877, p. 39)
Hordeum pratense Huds.	*Hordeum* sp.	-	+	Not naturalised	Few specimens in Tasmania (Bentham 1878)	Affinities uncertain
Lepturus filiformis Trin.	*Parapholis strigosa* (Dumort.) C.E.Hubb.	slender barbgrass	+	+	Hobart, Brighton, Sandy Bay (Spicer 1878b)	Naturalised
Lepturus filiformis Trin. ssp. *incurvatus* Trin.	*Hainardia cylindrica* (Willd.) Greuter & *Parapholis incurva* (L.) C.E.Hubb.	common barbgrass and coast barbgrass	+	-	Hobart (HO55638); Hobart (HO55639)	Spicer's sheet included two species
Lolium perenne L. (incl. *L. perenne* ssp. *aristatum* L. & *L. perenne* ssp. *ramosum* L.)	*Lolium perenne* L.	perennial ryegrass	+	+	Naturalised (Hooker 1859) and Bentham (1878); Sandy Bay (HO35712); Kangaroo Point [Bellerive] (HO35711)	Common (Spicer 1878b)
Lolium temulentum L.	*Lolium temulentum* L.	carnel	+	+	Naturalised in Tasmania (Bentham 1878); New Town (HO35727); Hobart, Kents Group (Mueller 1877)	Naturalised; in corn fields (Mueller 1877, p. 39)

Table 1. *(continued)*

Phalaris canariensis L.	*Phalaris minor* Retz.	lesser canary grass	+	+	New Town (HO16276); incorrect identification	Common (Spicer 1878b)
Piptatherum thomasi Pal.	*Piptatherum miliaceum* (L.) Coss.	rice millet	Scarcely	Not naturalised	Royal Society Gardens (HO128489)	Status uncertain
Poa annua L.	*Poa annua* L.	annual poa	+	+	Common in Tasmania (Bentham 1878), Hobart (HO128491)	Abundant (Spicer 1878b)
Polypogon littoralis Smith	X *Agropogon littoralis* (Sm.) C.E.Hubb.	perennial beardgrass	-	Not naturalised		Status uncertain
Polypogon monspeliensis Desf.	*Polypogon monspeliensis* (L.) Desf.	annual beardgrass	+	+	Launceston, Southport and Swanport (Bentham 1878); New Town (HO128558)	Common (Spicer 1878b)
Triticum repens L.	*Elymus repens* (L.) Gould	quack grass	+	+	New Town	Naturalised

1 Common names largely from Shepherd et al. (2001)
2 Some authors consider this species to be *Bromus catharticus* Vahl

XYLOCARYON LOCKII F.MUELL. (PROTEACEAE) FRUITS FROM THE CENOZOIC OF SOUTH EASTERN AUSTRALIA

Andrew C. Rozefelds, Mary E. Dettmann and H. Trevor Clifford

Rozefelds, A.C., Dettmann, M.E. and Clifford, H.T. 2005. *Xylocaryon lockii* F.Muell. (Proteaceae) fruits from the Cenozoic of south eastern Australia. *Kanunnah* 1:91–102, ISSN1832-536X. The fossil fruit *Xylocaryon lockii* F.Muell. is recorded from two localities in Eastern Australia. A specimen from the deep leads (buried placer deposits) at Nintingbool in Victoria is designated as the neotype for the species. A fragmentary specimen is also recorded from tin-bearing sediments near Mt Killiecrankie on Flinders Island. The unusual internal longitudinal ridging in the *Xylocaryon* fruit and similar fruit wall structure support a close relationship to extant *Eidothea* (Proteaceae).

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KEY WORDS: *Eidothea*, Proteaceae, *Xylocaryon*, fossil fruit, Tertiary, Tasmania.

The fossil fruit, *Xylocaryon lockii* was described by Mueller (1883) from Nintingbool, near Haddon, Ballarat area, in Victoria (Fig. 1). It was collected from deep leads (buried placer deposits) that were mined for alluvial gold in the mid–late 1800s. Mueller's description of *Xylocaryon lockii* was based upon two specimens. He described the fruit as large, globular, unilocular, with prominent thick woody walls and characteristic internal longitudinal ribs that project into the locule. The fruit was described as 1.5 inches (c. 3.8 cm) in diameter, and enclosed a single seed with a smooth testa.

The phylogenetic relationships and placement of *Xylocaryon* have been unclear. Mueller (1883) initially suggested that *Xylocaryon* should be placed in the Olacineae [= Olacaceae] probably because in this family the fruits are often one-seeded drupes with two–five locules at the base but one locule above. That is, they are incompletely uniloculate with longitudinal partitions reaching up from the base (Cronquist 1981). Duigan (1950) was uncertain as to the affinities of *Xylocaryon lockii* and considered it a species *incertae sedis*. Its affinities remained unclear until Douglas and Hyland (1999) described *Eidothea*, from north eastern Queensland. The similarity in fruit morphology in *Eidothea* and *Xylocaryon* was brought to their attention

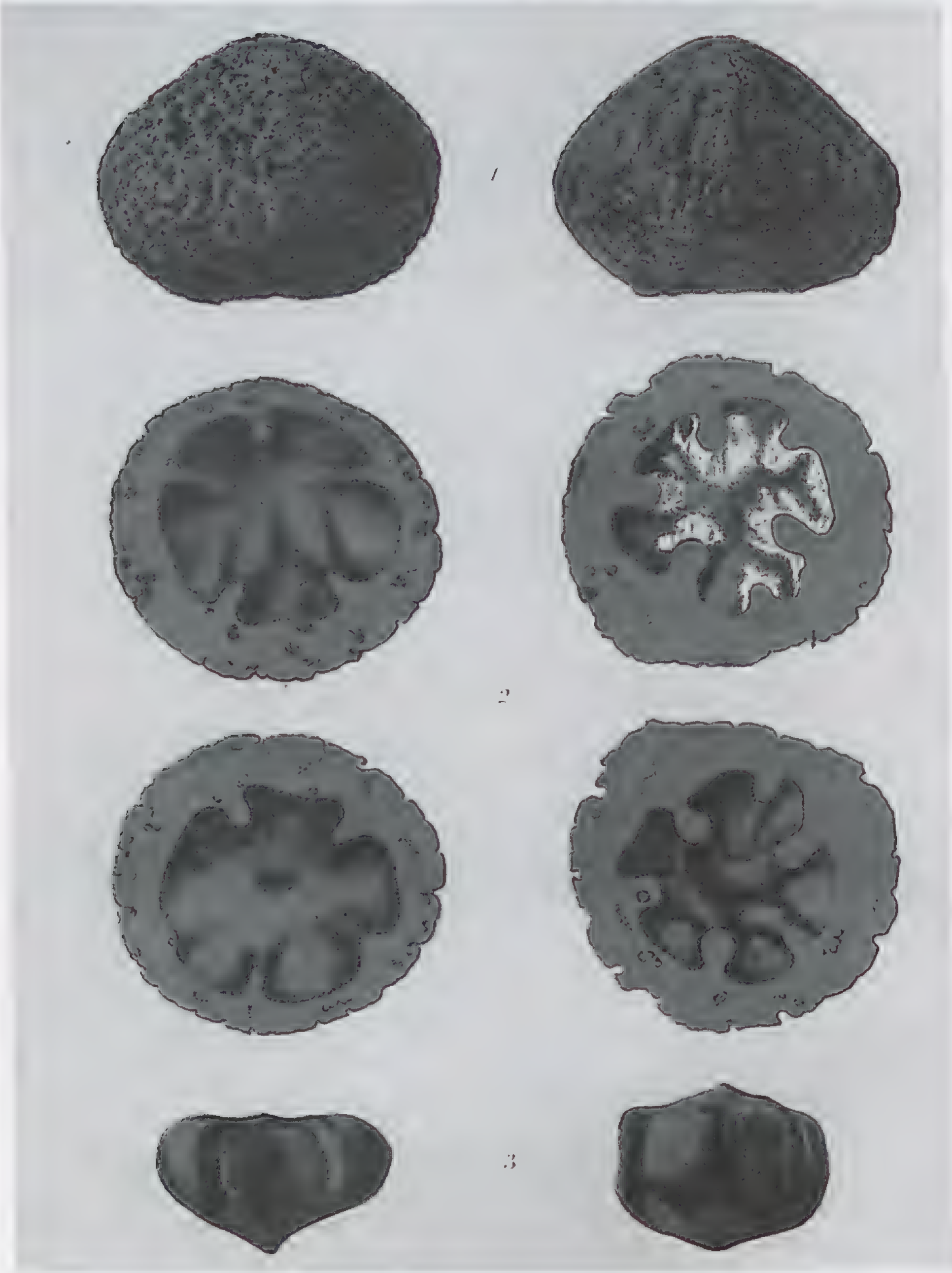

FIG. 1. Copy of illustration of plate xi, *Xylocaryon lockii* from Mueller (1873). All figures x0.85

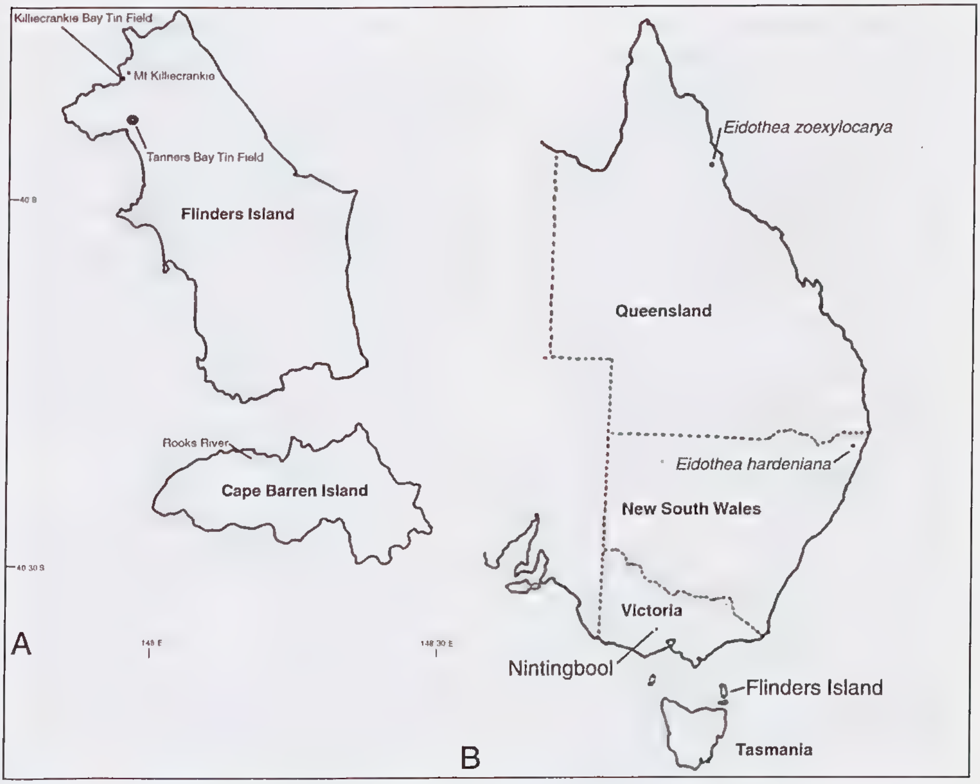

FIG. 2. A. Map showing locations of the tin bearing leases in the Killiecrankie area of Flinders Island; **B.** Map showing the distribution of extant *Eidothea* species in Eastern Australia and also the fossil localities cited in the text.

by the senior author. In recognition of the similarity in fruit morphology, the extant species was named *Eidothea zoexylocarya*, 'living *xylocaryon*' thereby suggesting an affinity between these two genera. Fossil material of *Xylocaryon* was, however, not re-examined in detail, and the comparisons with *Eidothea* were based largely upon the description and figures in Mueller's paper.

There has been no detailed study of *Xylocaryon* since it was described. When examining the palaeobotanical collections in the Museum Victoria, one of us (ACR) identified three specimens of *Xylocaryon lockii*. Herein the surviving material of *Xylocaryon* is redescribed. The specimen from Flinders Island is a new record for the species from south eastern Australia. The ages of the Flinders Island and Nintingbool specimens are discussed and the probable phylogenetic affinities of *Xylocaryon* are assessed. Many of the fossil fruits, from the deep leads in Victoria and New South Wales, are infiltrated with pyrites which on exposure to air oxidizes resulting in their destruction (pyrites disease). Because of this risk of loss due to pyrites disease, a detailed description and photographs of the material is provided to ensure that the morphology of the surviving material is recorded.

Methods and Materials

The fossil fruits are all from Museum of Victoria collections while the extant fruits of *Eidothea zoexylocarya* A.Douglas & B.Hyland and *E. hardeniana* P.Weston & R.Kooyman were provided by CSIRO Herbarium, Atherton and Peter Weston (NSW) & Robert Kooyman respectively. Fragments of fossil cuticle of *Xylocaryon lockii* F.Muell. were cleared in an aqueous 10% solution of chromium trioxide and stained with safranin O. The cuticle of extant *Eidothea zoexylocarya* was bleached in dilute sodium hypochlorite and stained with safranin O. The cuticles were examined using an Olympus BH2 microscope and photographed on T Max film.

Localities and Age

Xylocaryon fruits have been collected from two localities in south eastern Australia. The age of the Nintingbool deposits, and the other deep leads in the Ballarat area, is uncertain. A minimum mid-Miocene age has been proposed based upon the co-occurrence of fossil fruit taxa from different localities in south eastern Australia and the assumption that these macrofloras are broadly contemporaneous (Rozefelds and Christophel 2002). Dettmann and Clifford (2001, 2002) argue that the sediments may be as old as the Oligocene.

The locality details and stratigraphic information for the Flinders Island specimen is limited. The specimen from Flinders Island was presented by Dr C.S. Sutton (a medical practitioner and keen field naturalist) to the Museum of Victoria on 2 December 1912. How Sutton came by the specimen is not known and it could have been collected years before it came into his possession. The label for the specimen indicates that it was obtained from the tin-bearing gravels at Mt Killiecrankie, and was therefore probably collected during tin mining in this area. Tin mining commenced in the 1880s at two localities in the north western corner of Flinders Island, Killiecrankie Bay and also from near Tanners Bay (Blake 1935) (Fig. 2). Two short-term mining leases operated in the Killiecrankie Bay from 1882 to 1884 (Greg Dickens pers. comm. 2003). The Tanners Bay Tin Field was mined, spasmodically, over a much longer period (Blake 1935, 1947; Jack 1966; Keid 1949) during which time the specimen was collected. The fossil may therefore have come from Tanners Bay rather than Killiecrankie Bay.

As the locality is uncertain the age of the specimen cannot be determined with confidence. The only stratigraphic information recorded for NMVP207687 was that it was collected from tin drift resting on granite. The tin at the Tanners Bay Tin Field occurred in a palaeostream (Deep Lead) and Blake (1935, p. 68) notes it was 'concentrated in the lower layers in conjunction with lignitic wood and pyrite'. It seems likely, therefore, that the fossil fruit was associated with the other organic fragments in the tin-bearing gravels.

These Tertiary non-marine beds lie unconformably on the granitic basement of the island, and Sutherland and Kershaw (1971) suggested a probable Miocene to Early Tertiary age for these deposits. Sediments collected at a depth of 3.3 metres from above basalts at the Tanners Bay Tin Field were dated as Pliocene–Pleistocene by Harris (1965) but a re-examination by Stoian (2005) suggested an early Pliocene age for the palynoflora.

An alkali basalt flow from northern Flinders Island has a Neogene age of

20.0 +/-2.7 Ma. (Sutherland et al. 2002). The basalt flows in this area, are poorly exposed, but elsewhere on Flinders Island i.e. in the Ranga–Whitemark area the alkali basalts overlie deep leads (Sutherland and Kershaw 1971). It would seem likely that the tin-bearing deep leads in the Tanners Bay area are contemporaneous with those of the Ranga–Whitemark area and therefore have a minimum Early Miocene age. A Late Oligocene – Early Miocene age seems likely for the Killiecrankie specimen.

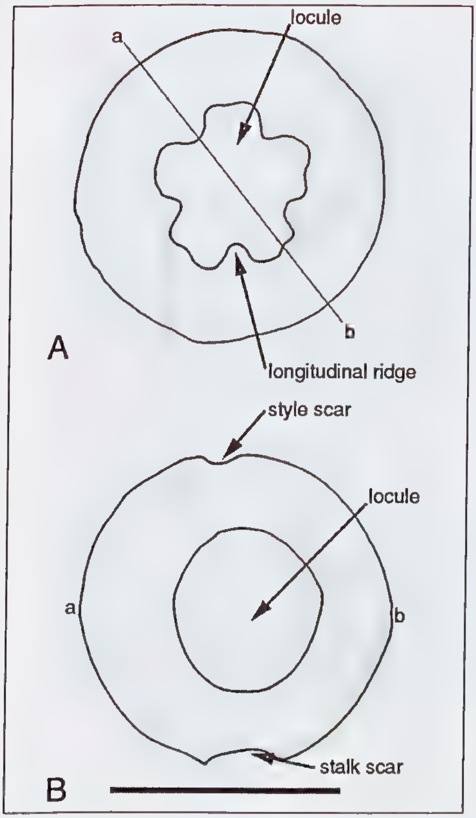

FIG. 3. A.B. Gross morphology of *Xylocaryon lockii* as seen in section (diagrammatic). **A.** Transverse section; **B.** Longitudinal section along plane a–b of Fig. A. (NMVP53980). Scale bar = 5 cm.

Systematic Palaeobotany

Family Proteaceae R.Brown

Xylocaryon (F.Muell. 1883) emend.

Emended diagnosis: Large, globular–subglobular, drupaceous fruit, unilocular, endocarp with 5–7 internal longitudinal ribs, outer wall of fruit consists of sclerified fibrous cells, with areas of thickened fibres occurring throughout the fruit wall and in the longitudinal ribs. Seed coat epidermal cuticle consists of fibriform cells.

Xylocaryon lockii F.Muell.
(Figs 3A, B, 4A, B, 5B, 6A–C, 7A, B)

1883 *Xylocaryon lockii* F.Muell. p. 3, plate X1.

Neotype: NMVP53980, Nintingbool Deep Leads, Victoria. Coll. J. Lynch. (designated herein).

Remarks on Type Material: Mueller (1883) indicated that two specimens were collected from Nintingbool, Victoria. Two specimens are currently known from Nintingbool, one of which (NMVP53950) is in fragments. The only complete specimen (NMVP53980) is much larger than Mueller's original illustration, and so it is not one of the original specimens used by Mueller in preparing his original description. As no other complete surviving fruits are known, this specimen is therefore designated the neotype (Fig. 4A, B).

Additional Material: Victoria: NMVP53950, Nintingbool Deep Leads, Ballarat, Victoria. Coll. J. Lynch (in fragments); Tasmania: NMVP207687, Mt Killiecrankie, Flinders Island, Pres. C.S. Sutton, 2 December 1912, tin drift resting on granite.

DESCRIPTION

Large near globular–subglobular, unilocular drupaceous fruit, endocarp c. 5–7 cm long, c. 4–7 cm wide. Outer surface irregular, with a rough external appearance with a few scattered pores. Fruit wall thick woody,

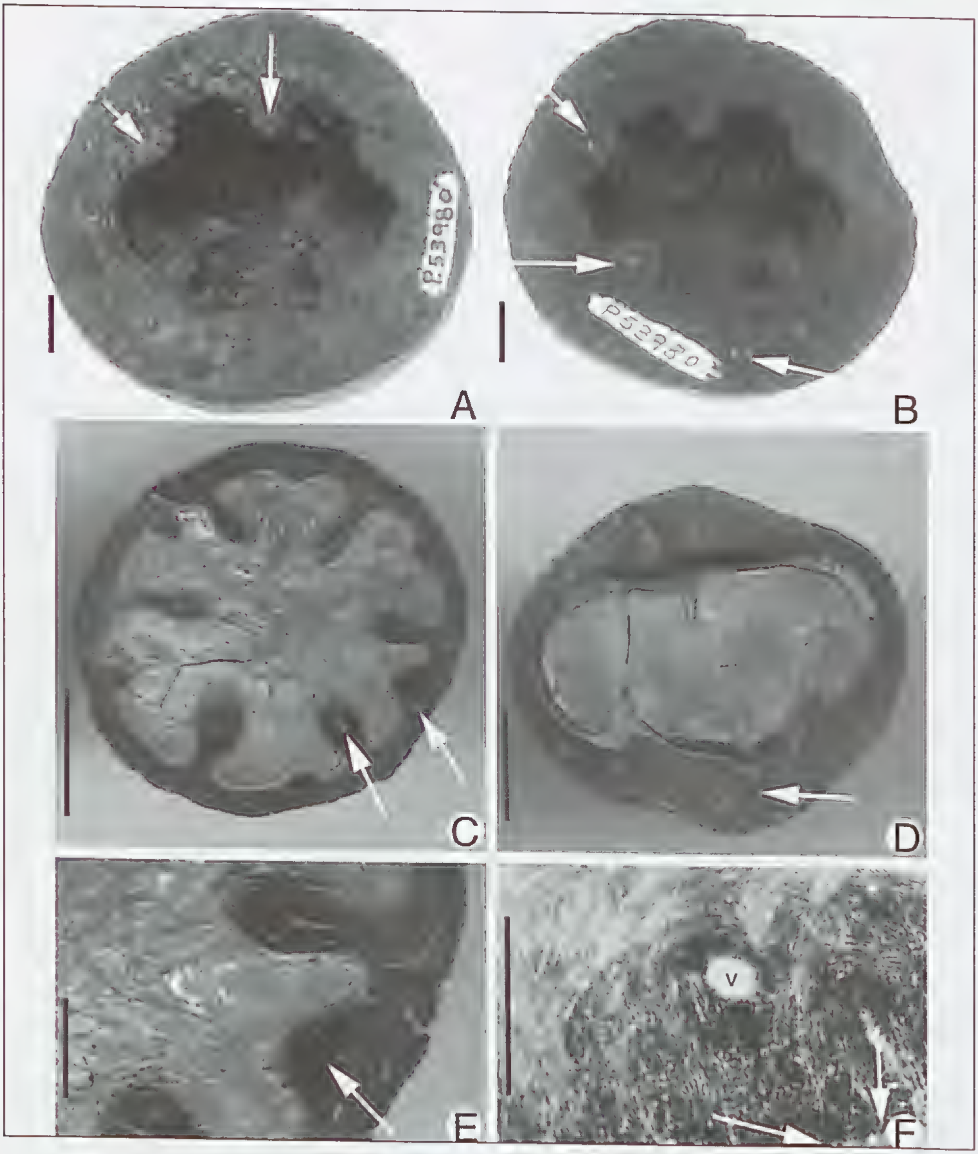

FIG. 4. *Xylocaryon lockii* and *Eidothea zoexylocarya* fruit stones. **A.B.** *Xylocaryon lockii* from Nintingbool, Victoria, cross section of fruit showing internal structure and position of vascular traces (arrowed) (NMVP53980); **C–F.** *Eidothea zoexylocarya* from Mt Bartle Frere (*B.Gray 6035*); **C.** Transverse cross section of fruit showing internal structure, arrows indicate position of vascular traces; **D.** Longitudinal section with arrow showing the position of the micropyle; **E.** Detail of fruit wall of *E. zoexylocarya* with arrow showing the position of dark dense areas in the longitudinal ribs; **F.** Detail of fruit showing the fibrous structure, v = vascular trace, white arrows indicate outside of fruit wall. Scale bars A–B = 1 cm, C = 1.25 cm, D = 1 cm, E = 4 mm, F = 1.2 mm.

11–15 mm in width with 5–6 conspicuous internal longitudinal ribs, in which are embedded longitudinal scattered vascular bundles; ribs in transverse section 5–8 mm high, 6–8 mm wide, with rounded crests that project into the locule of the fruit (Fig. 4A, B, 6B). Outer zone of endocarp consists of radially oriented sclerified fibrous cells, while the inner zone has tangentially arranged sclerified fibrous cells (Fig. 6B). Areas of thickened fibres occur scattered throughout the fruit wall and form the longitudinal ribs, usually with conspicuous vascular bundles. Locule 3.8–4.2 cm in diameter, seed coat consists of epidermal cuticle with fibriform cells, cells 150 µm long, 10–14 µm wide (Fig. 7A, B).

AGE

Nintingbool deposits is a minimum mid–Miocene (Rozefelds and Christophel 2002), and may be Oligocene–early Miocene (Dettmann and Clifford 2001). The Killiecrankie specimen is thought to be of Late Oligocene – late Early Miocene.

REMARKS

The neotype from Nintingbool has been coated in wax or resin that has probably helped conserve the specimen from deterioration. It is little altered by preservation and the woody structure of the fruit is still evident. The Killiecrankie fruit from Flinders Island is less than a quarter complete and the diameter of the fruit is estimated to be at least 4 cm. The fruit is 'charcoalified' and the original woody structure is not well preserved. The outer surface is irregular, while the inner broken surface shows three of the internal longitudinal ribs which are characteristic of this species (Fig. 5A–C). The specimen from Killiecrankie shows all the characteristic features of pyrites disease.

Discussion

The systematic relationships of *Xylocaryon* are currently thought to lie with the family Proteaceae, and in particular with the extant genus *Eidothea*. The fruit morphology, and in particular the internal longitudinal ribs in *Xylocaryon* are reminiscent of the fruits of the extant genus *Eidothea* (Douglas and Hyland 1995). Two species of *Eidothea* are known, *E. zoexylocarya* A.W.Douglas & B.Hyland, from north eastern Queensland and *E. hardeniana* P.Weston & R.Kooyman from north eastern New South Wales (Weston & Kooyman 2002).

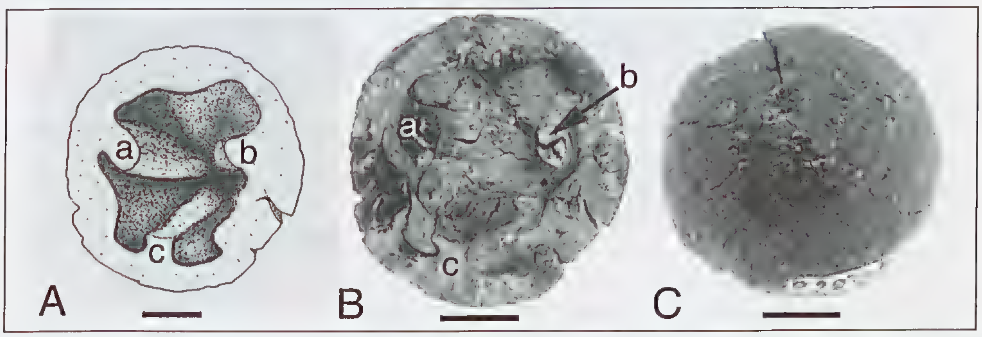

FIG. 5. Partial fruit of *Xylocaryon lockii* F.Muell. from Mt Killiecrankie, Flinders Island, Tasmania, (NMVP207687). **A.** Line drawing of transverse section, a, b, c, indicate the position of the longitudinal ribs; **B.** Photograph of transverse section of fruit showing the position of the longitudinal ribs identified in Fig. A; **C.** External appearance of fruit stone. Scale bar A–C = 1 cm; Fig. A *del.* A. C. Rozefelds.

Eidothea was considered by Douglas and Hyland (1995a) to be sufficiently different from all other Proteaceae genera to warrant placement in a separate subfamily. However, Weston and Kooyman (2002) have argued on the basis of phylogenetic evidence derived from chloroplast DNA sequence data (Hoot and Douglas 1998), that *Eidothea* fits within the subfamily Proteoideae.

Weston and Kooyman (2002) noted that the internal longitudinal woody ribs on the inner surface of the endocarp are characteristic of both *Eidothea* species. They identified this character as an apomorphy for the genus within the Proteoideae thereby suggesting that the internal longitudinal ribs on the inner surface of the endocarp is an important taxonomic character, and implies a close relationship between *Xylocaryon* and *Eidothea*. Both *Eidothea* and *Xylocaryon* possess vasculature in the fruit walls and in the woody longitudinal ribs that extend into the locule cavity of the fruit (Fig. 4A–F). In both genera the outer wall consists of a ground mass of radially or tangentially arranged lignified fibres (Fig. 6B–F). The outer zone of the endocarp has radially arranged fibres while in the inner zone the fibres are more tangentially arranged. Interspersed in this ground mass are 'dense' areas, which consist of clumps of vertically aligned dense fibres and these areas are invariably vascularised (Fig. 4C, E). The longitudinal ribs in the fruits are always formed by these dense areas of fibre cells. The endocarp walls in both *Xylocaryon* and *Eidothea* also have smaller obliquely-aligned vascular structures.

In cross section the two genera differ in the thickness of the fruit wall and in the appearance of the internal ribs. Cross sections of the *Eidothea* fruit show that the woody wall is relatively narrow, 2–4 mm in thickness, and the internal ribs vary from semi-circular to clavate in transverse section, with the clavate ribs tapering from bases towards the locule (Fig. 4C–F). There are 5–6 internal ribs in all *X. lockii* and *E. zoexylocarya* fruits examined but in *E. hardeniana* the number vary from 5–7. The seed coat sometimes tapers into a thin bi-layered extension that extends into the seed cavity (Fig. 6A). In the neotype of *Xylocaryon* and Mueller's pl. xi, fig 1–3 (Fig. 1) the fruit walls are much thicker, 11–15 mm in width, and in cross section the ribs are rounded, semi-circular in outline, and do not taper basally (Fig. 4A, B). However in Mueller's specimens (pl xi, figs 1–3, RHS) the ribs are clavate in section.

The preserved seed cuticle of *Xylocaryon lockii* is morphologically comparable to the cuticle surrounding the embryo of *Eidothea* (Fig. 7A–B). Both possess filiform cells. In seeds of extant *Eidothea* the cuticle occurs between the inner integuments and the nucellus. Overlying tissues of the seed coat include incompletely preserved lignitic and parenchyma cells.

The floras of the Ballarat (including Nintingbool) deep leads include rainforest taxa e.g. *Elaeocarpus* (Rozefelds and Christophel 2002; Dettmann and Clifford 2000). As indicated above the age of this locality is imprecisely known. The age of the Flinders Island specimen is thought to be Late Oligocene–early Miocene in age. The Oligocene–Miocene vegetation in south eastern Australia was dominated by rainforest communities. The Oligocene vegetation at Pioneer in north eastern Tasmania was interpreted by Hill and Macphail (1983) as closed temperate rainforest similar to that of the offshore Gippsland Basins (Stover and Partridge 1973; Stover and Evans 1973). Evidence from other localities in northern Tasmania, e.g., the Brandy Creek (Beaconsfield) deep leads, which are also likely to be Oligocene/ Miocene in age (S.M. Forsyth pers comm. 1989), also include rainforest elements,

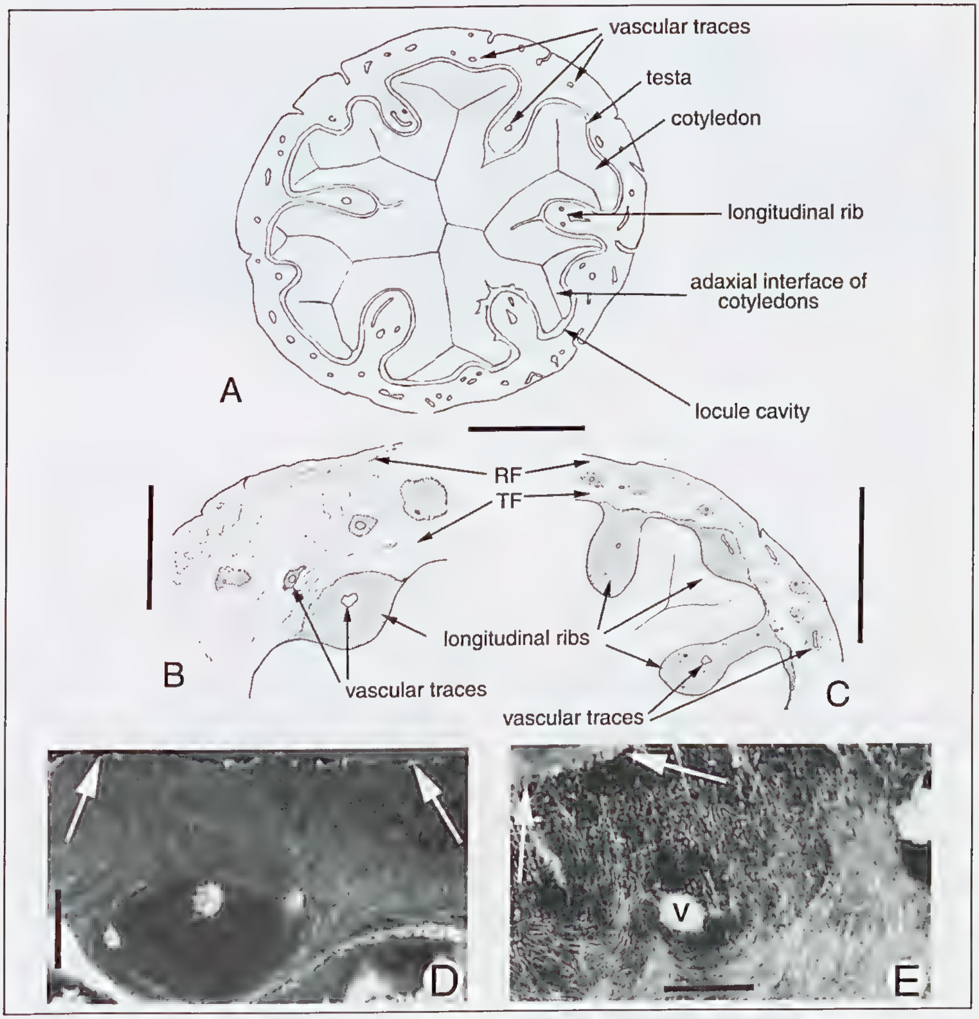

FIG. 6 Transverse section of the fruit morphology in *Eidothea* and *Xylocaryon*. **A.** Transverse section of endocarp and embryo of *Eidothea zoexylocarya* showing the internal structure; **B.** Wall structure in *Xylocaryon lockii* from Nintingbool, Victoria, (NMVP53980), cross section of neotype, showing typical internal structure with the prominent longitudinal ribs and vascular bundles, the darkly stippled areas are the hard stone cells and the radial fibres tend to be more obvious in the outer parts of the fruit wall; **C.** Wall structure in *E. zoexylocarya* (*B.Gray 6035*), the cross section shows the typical internal structure with the prominent longitudinal ribs and vascular bundles, radial fibres tend to occur in the outer part of the fruit wall while tangential fibres are more evident in the middle parts of the wall; **D. E.** Wall structure of *E. zoexylocarya*; **D.** The wall consists of radial and tangential fibres and the longitudinal rib is the darkly stained dense area, arrows indicate the outer fruit surface; **E.** Detail of wall structure showing the radial arrangement of fibres in the outer fruit wall and the loosely tangential arrangement of fibres in the middle fruit wall, arrows indicate the outer fruit surface, v = vascular trace. Scale bar A = 1 cm; B–C = 5 mm; D = 1 mm, E = 0.5 mm. Fig. A *del.* H.T. Clifford; B,C, *del.* A.C. Rozefelds.

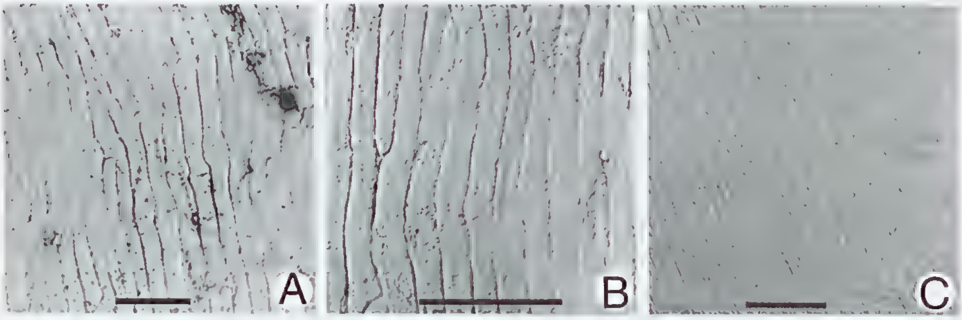

FIG. 7. Epidermal seed cuticle in *Xylocaryon lockii* and *Eidothea zoexylocarya;* **A. B.** *Xylocaryon lockii* (NMVP53980) epidermal seed cuticle showing the fibriform cells; **C.** *Eidothea zoexylocarya* showing the epidermal seed cuticle. Scale bar A–C = 100 μm.

e.g. *Elaeocarpus*, with links to mesic rainforest communities of northern Australia (Rozefelds and Christophel 2002). Study of fossil fruits shows that *Elaeocarpus mackayi* F.Muell. was widely distributed in south eastern mainland Australia at that time (Dettmann and Clifford 2001; Rozefelds and Christophel 2002).

The information available on the palynofloras of this age on the Furneaux Island Group is limited. A pollen florule from the Lower Tertiary units at Rooks River on Cape Barren Island is dominated by *Nothofagidites,* Proteaceae and Podocarpaceae pollen suggesting a rainforest assemblage (Harris 1965). Stoian (2005) suggested an Early to Middle Miocene age for this palynoflora. Based upon the ecology of its closest relatives, (both *Eidothea* species are rainforest taxa) it is probable that *Xylocaryon* was also likely to be associated with rainforest communities. The pollen flora at Tanners Bay Tin Field studied by Harris (1965) occurs about 3.3 m above basalt, and therefore comes from a different stratigraphic horizon to that of the fossil fruit. The palynoflora at this site is different from that on Cape Barren Island and is dominated by *Milfordia* spp. (Restionaceae), Proteaceae, Casuarinaceae and some *Nothofagadities* pollen which Stoian (2005) interpreted as indicating that the area consisted of low nutrient soils and swamps with coastal dunes in the vicinity. Clearly, further research and more detailed study of the stratigraphy and palynofloras of these sedimentary units are needed to adequately understand the vegetation history of these islands.

Acknowledgements

Dermot Henry (Museum Victoria) kindly provided a loan of these specimens for study. The specimens of *Eidothea zoexylocarya* studied were provided by Bernard Hyland (CSIRO Herbarium, Atherton) and those of *E. hardeniana* by Robert Kooyman and Peter Weston (National Herbarium of New South Wales). Greg Dickens and Carol Bacon (Mineral Resources Tasmania) provided access to unpublished reports in Mineral Resources Tasmania. Liliana Stoian (South Australian Department of Mines) provided a copy of Harris's unpublished report, and also re-examined the original slides and provided a revised palynoflora of these sites. The photographs used in this paper were provided by the authors and Simon Cuthbert.

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Comparative Modern Fruit Material examined

Eidothea zoexylocarya

A.Douglas & B.Hyland.

Queensland: Mt Bartle Frere, 17°23'S 147°0'E, rainforest, altitude 1300 m, *B. Gray 6035*, 23 iii 1995 (QRS12123); Mt Bartle Frere, 17°23'S 145°48'E, *B. Gray 6042* (QRS12128).

Eidothea hardeniana

P.Weston & R.Kooyman

New South Wales: Nightcap Range National Park, *R.M. Kooyman s.n.* 25 iii 2003.

THE DISTRIBUTION AND SPREAD OF THE BUMBLEBEE *BOMBUS TERRESTRIS* (L.) IN TASMANIA SINCE INTRODUCTION IN 1992, WITH NOTES ON FOOD PLANTS

Kaye Hergstrom, Roger Buttermore, Ann Hopkins, and Verity Brown

Hergstrom, K., Buttermore, R., Hopkins, A. and Brown, V. 2005. The distribution and spread of the bumblebee *Bombus terrestris* (L.) in Tasmania since introduction in 1992, with notes on food plants. *Kanunnah* 1: 103–125, ISSN1832-536X. A public survey was undertaken to determine the spread of the large earth bumblebee *Bombus terrestris* (L.) across Tasmania since its arrival in 1992. *Bombus terrestris* was sighted more often in the wetter parts of the State, and in urban and rural (irrigated) areas. Using sightings of more than one bee as an indicator of establishment, the results suggest that bumblebees were more commonly established in urban (46%) and rural (39%) areas, than in remote bush (8%) and urban bush (3%). All of the 25 remote bush locations, where more than one bumblebee was recorded, were from the high rainfall belt of the western half of the State. The first sightings of bumblebees in adjacent townships in North West Tasmania often occurred within a short time span in January, or in March/April, indicating that their spread may be associated with migration flights, as have been recorded in Europe. As in European surveys, there was a distinct cyclical pattern for bumblebee observations, commensurate with winter hibernation. For example, 60.4% of 1022 bumblebee sightings occurred in summer, with 27.5% in autumn, 1.5% in winter, and 10.6% in spring. Bumblebees in Tasmania are highly polylectic and were recorded feeding on 198 different plant species. Most of these plants were introduced and only 10.9% of the 1022 sightings of bumblebees were on native Australian plants.

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KEY WORDS: *Bombus terrestris*, bumblebee, bumble bee, Tasmania, spread, distribution, food plants.

The world fauna of bumblebees (Tribe Bombini: Apoidea: Hymenoptera), of about 300 species, is centred in the northern temperate zone (O'Toole and Raw 1991; Prys-Jones and Corbet 1991). There are no naturally occurring species of the Tribe Bombini in Australia (O'Toole and Raw 1991; Prys-Jones and Corbet 1991; Cardale 1993) and attempts to introduce *Bombus terrestris* into New South Wales, Tasmania, and Victoria in 1891–2, 1909, and the 1930s were unsuccessful (Buttermore 1997).

In the past decade, two species of *Bombus*, *B. vosnesenskii* and *B. terrestris audax*, have been collected in Australia. One live *B. vosnesenskii* was collected from Buderim, South East Queensland in 1999 (Planck 1999). No specimens have been collected since that date and so it appears that this species has not become established in Australia (James Planck pers. comm., April 2003). In 1992, a specimen of a second bumblebee species *Bombus terrestris audax* (L.) was collected in an inner-city park in Hobart, Tasmania (Semmens et al. 1993). It is not known whether this introduction was accidental or deliberate. The source of the introduction is believed to be New Zealand, where four bumblebee species, including *B. terrestris audax*, were successfully introduced from England between 1885 and 1906, for the pollination of red clover (Donovan 1980). It became apparent after a year that this exotic bee species had become established in the Hobart area in Tasmania (Fig. 1), and because of high numbers, and the cryptic nature of nesting sites, would be impossible to eradicate.

Since 1992, a number of papers have assessed the spread of *B. terrestris* in Tasmania (Semmens 1995; Buttermore 1997; Stout and Goulson 2000; Hingston et al. 2002). Pomeroy et al. (1997) and Buttermore et al. (1998) assessed whether the strain of *B. terrestris* in Tasmania was genetically variable enough to be commercially reared for agricultural purposes. Other researchers have expressed concern that this exotic bee species was a threat to Australian ecosystems and native pollinators (Hingston 1997; Hingston and McQuillan 1998).

In England and in Holland, public surveys have provided useful information on the distribution of bumblebees in their urban, rural and native environments (Williams 1986; Fussell and Corbet 1992; Marbus-Hotho 1995; Van Iperen and Aptroot 1995; Kwak 1996). In Tasmania, we sought the public's assistance in tracking the spread of *Bombus terrestris*, towards the aim of providing new data to help predict the long-term impact of bumblebees, and also to document which plants they forage on. This is especially relevant, because as of May 2004, *B. terrestris* is not established on mainland Australia, and additional information is needed to determine the impact of bumblebees on the native biota in Australia.

Methods

A state-wide census and floral preference survey was launched by the Tasmanian Museum and Art Gallery in January 2000. Twenty thousand copies of an information sheet/survey form, which was entitled 'Have you seen any bumblebees?' were distributed around the State (Fig. 2). The information sheet included life-sized colour images of bumblebee castes, honeybee workers, several examples of native bees, a hoverfly and a European wasp (Fig. 3). It also included information about the biology of *Bombus terrestris*, and a survey form, asking the date, location, weather conditions, habitat type (urban, rural or bush), and a description of any plant species visited. The survey period extended from January 2000

FIG. 1. Map of Tasmania showing many of the localities mentioned in the text.

to May 2002 and participants were asked to record the numbers of bumblebees seen per unit of time, and whether they had seen any in national parks. The form had a return address, phone and email details for contacting the researchers. The distribution of bumblebees in each season was plotted on maps of Tasmania.

We particularly targeted visitors and workers in wilderness and other bush areas to determine the extent of bumblebee populations in these areas. Three hundred copies of the public survey were hand-delivered to officers in charge of ten national parks, in January 2000 (Appendix 1). Copies of the Survey form were also sent out to the officers in three additional parks. Further copies were sent out as required in 2001 and 2002. The staff at the national parks were requested to display the survey forms in their information centres, and/or regularly provide surveys to bushwalkers, tourists, and parks and wildlife employees. Copies were also sent to all Tasmanian Landcare groups, the Tasmanian Weed Alert Network, 240 Volunteer Fire Brigades, and members of the public upon request.

To promote the survey, in January 2000 and 2001, local newspapers in Launceston and Hobart ran articles on bumblebees. Many people, from mainly the south east and the north west of the State responded to the articles by reporting sightings of bumblebees. Additionally, four ABC radio programs encouraged people to report further sightings. In 2001 and 2002, a check was made on the establishment of bumblebees from areas where they had been previously reported, by contacting members of the public that had recorded bumblebees from their gardens. They were also asked to confirm when they first saw bumblebees in their area (= first time sighting).

Results

Throughout the survey period from January 2000 to May 2002, 613 people reported 1022 bumblebee sightings. Observations indicated that bumblebees are common in

Public Survey on bumblebees

If you have seen a bumblebee in Tasmania, please complete the following details and return to Tasmanian Museum and Art Gallery either by post, fax or email as listed on back of this leaflet.

Have you seen a bumblebee?

Where:

When:

Time of day:

Weather conditions:

Would you describe the area where you saw it as:

URBAN ☐ RURAL ☐

NATIVE BUSH (away from houses) ☐

NATIVE BUSH (in urban areas) ☐

Was the bumblebee:

FLYING ☐

FEEDING ON A FLOWERING PLANT ☐

CARRYING POLLEN ON ITS HIND LEGS ☐

Can you name the plant:

(If you don't know, please enclose a sample of the plant to help identify it)

GPO Box 1164M, Hobart Tas 7001

Tel. (03) 6211 4123/6211 4122

Fax (03) 6211 4112

Email khergstrom@tmag.tas.gov.au

dbuttermore@tmag.tas.gov.au

In one minute, how many bumblebees did you see in the area:

Were there other insects observed at the same time:

(Please look at the drawings of pollinating species on this pamphlet)

If so, how many:

HONEYBEES .... NATIVE BEES

BEETLES FLIES

Have you seen any bumblebees in National Parks:

Where:

When:

Other comments:

CONTACT NAME:

ADDRESS:

PHONE NO:

Have you seen any bumblebees in Tasmania?

What is this survey about?

The Tasmanian Museum and Art Gallery (TMAG) is conducting a survey to find out how far *B. terrestris* has spread across the State and on what flowering plants it is collecting pollen and/or nectar. We would also like to compare numbers to other insects present on flowering plants and find out if bumblebees are becoming established in areas where they might be environmentally harmful.

FIG. 2. The bumblebee survey form *Have you seen any bumblebees in Tasmania?*

summer (60.4%), less common in autumn (27.5%), rare in winter (1.5%), and starting to increase in spring (10.6%). Although observational effort from tourists fluctuated according to seasons and holiday periods, peak tourist visitation in summer coincided with when bumblebees have previously been observed to be most numerous (Buttermore 1997; Hingston 1997). Observational effort from people sighting bumblebees on their own properties, or rangers patrolling areas remained largely non-seasonal.

In the summer of 1997–8, bumblebees were sighted at only six locations, all in the southern half of the State (Fig. 4A). Completed surveys were sent in by local and interstate visitors to national parks, and by members of the general public. By the summer of 1999–2000, there were many sightings reported over a wide area in the south of the State, and several sightings in the north and west of the State (Fig. 4C). The first year of the survey (2000) alerted us to the occurrence of bumblebees in the following areas for the first time: Tasman Peninsula, South Arm, some East Coast towns, the Lake St Clair area, and the Smithton and the Sheffield areas (Fig. 1, 4C).

By the summer of 2001–2, bumblebees were becoming a common sight in the south, north and west of the State, with a scattering of sightings across north central Tasmania (Fig. 4D). Only limited sightings were recorded from the Launceston area, the north east of the State, and along

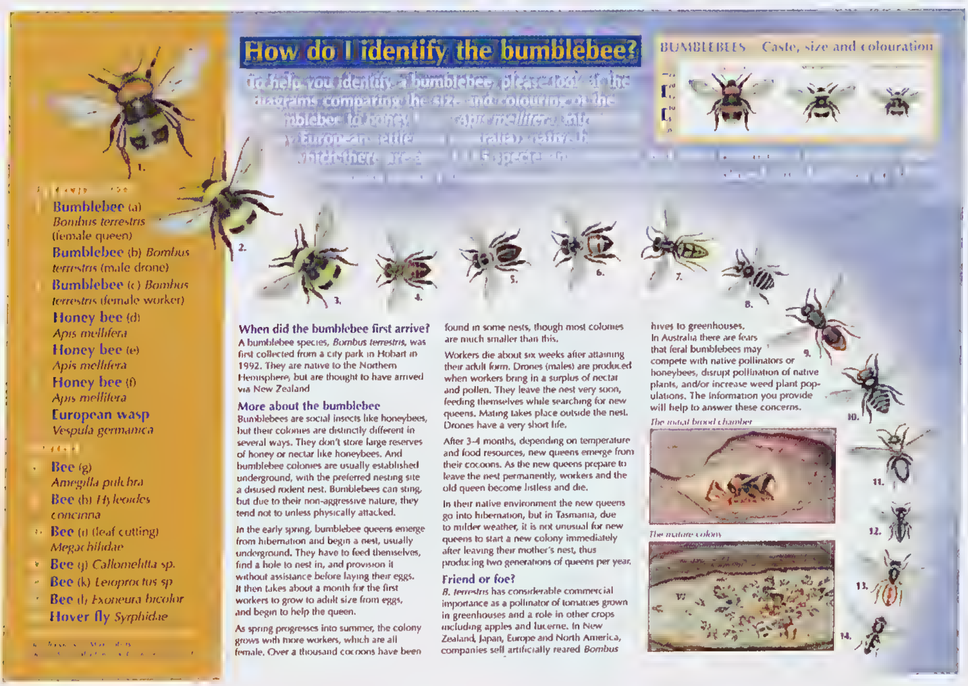

FIG. 3. The bumblebee survey form *Have you seen any bumblebees in Tasmania?*

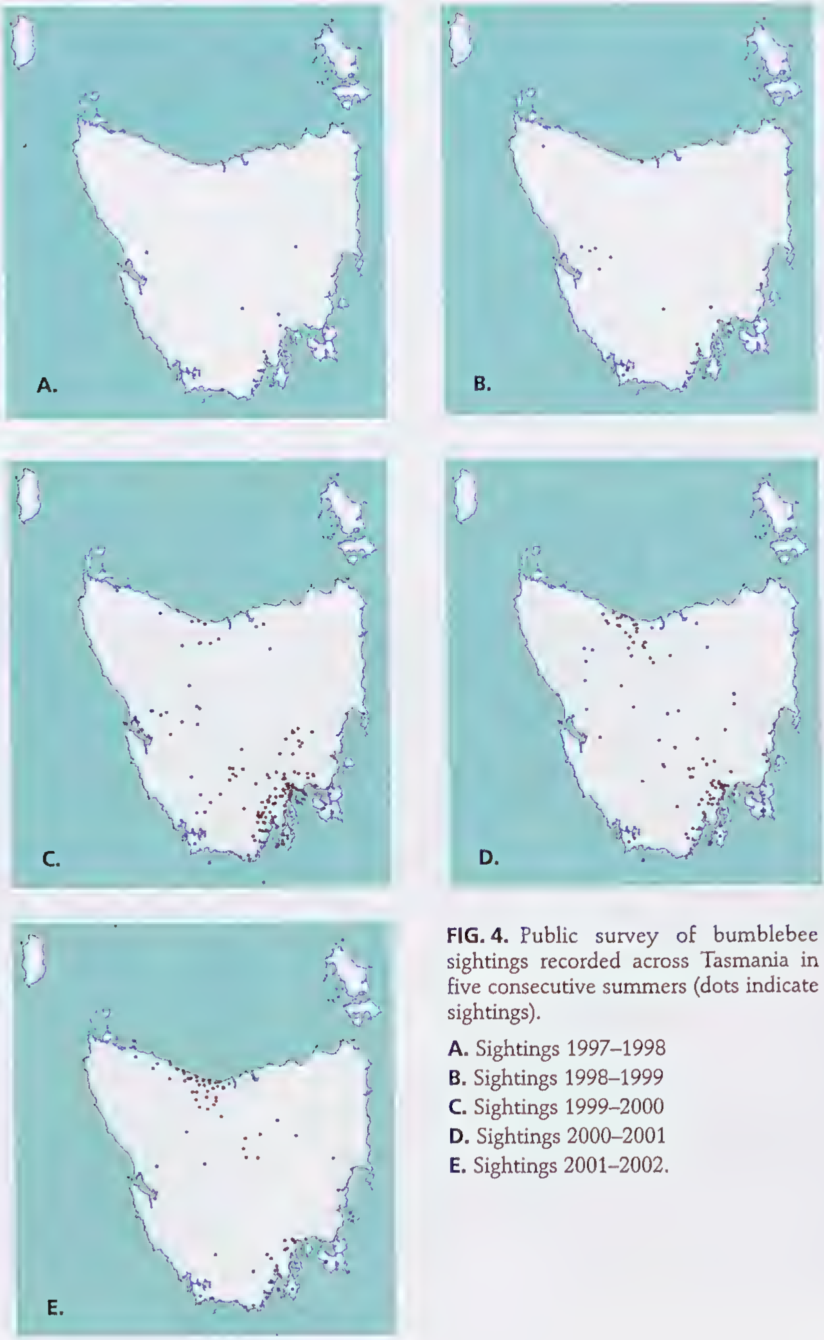

FIG. 4. Public survey of bumblebee sightings recorded across Tasmania in five consecutive summers (dots indicate sightings).

A. Sightings 1997–1998
B. Sightings 1998–1999
C. Sightings 1999–2000
D. Sightings 2000–2001
E. Sightings 2001–2002.

the eastern seaboard (Fig. 4D). By 2002, *B. terrestris* had become established around Port Arthur and Nubeena on the Tasman Peninsula, and around Strahan, Roseberry and Queenstown on the West Coast, and had been seen at sixty-eight new locations in North West Tasmania (Fig. 4E). Sightings along the East Coast towns were few, with no sightings in North East Tasmania from 2000 to 2002, and there were also no sightings from the sparsely populated north west corner of the State (Fig. 4E).

First ever records of sightings in 68 townships in North West Tasmania indicate a period of rapid expansion from 1999 to 2002 (Fig. 4). Looking at the phenology of the spread in North West Tasmania: the first recorded sighting was from Ulverstone in November 1999. Five other towns reported first ever sightings within the first half of January 2000; four of these towns were west of Ulverstone (Burnie 25 km, Wynyard 40 km, Irishtown 90 km, Forth 8 km) and one town, Wilmot, 25 km south of Ulverstone. There are also distinct peaks in number of sightings in January, as well as in April in 2000 and 2002, and March in 2001. These data would suggest that spread of *B. terrestris* in the North West is occurring at the end of the bivoltine nest cycles, when new queens leave nests to look for a suitable habitat in which to overwinter, or to start a colony. These data are largely commensurate with westward migration and/or dispersal flights from Ulverstone (Fig. 4).

Examination of the observations from the survey indicate that most of the records are from roads and highways in the State (Fig. 5A). Whether bumblebees are randomly distributed across the State or are favouring these roadside verge communities, possibly because of the availability of introduced food plants, is unknown.

Variable Success of Establishment Across Tasmania

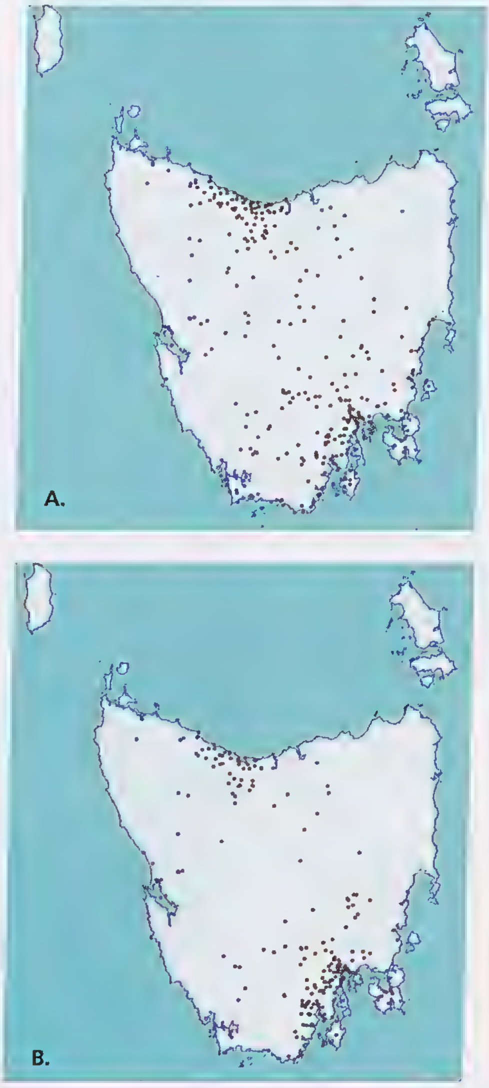

FIG. 5. A. Map showing the record of single sightings of bumblebees. **B.** Map showing sightings of more than one bumblebee per locality.

The data would suggest variation in the ability of bumblebees to establish successfully in Tasmania. Fig. 5 shows a comparison between records where only one bumblebee was observed (this would include recently arrived migrant queens); and records where more than one bumblebee was observed (mostly sites where bumblebees had become established); and average annual rainfall across the State (Australian Bureau of Meteorology 2002). The comparison between Figs. 5A and 5B suggests that a single observation of a bumblebee in an area does not necessarily imply that bumblebees have become established. This was especially the case on the drier East Coast of Tasmania, where bumblebees have not become established.

The average annual rainfall map of Tasmania (Australian Bureau of Meteorology 2002) can be divided roughly into three zones; dry (less than 900 mm rainfall/year), intermediate (900 to 1800 mm/year) and wet (1800 to >3200 mm/year) rainfall zones (Fig. 6). Comparison between the rainfall map (Fig. 6) and the places where more than one bumblebee was observed (Fig. 5B) indicates that *B. terrestris* establishment is more likely in wetter areas of the State. Only 14.5% of all sightings occurred in the dry zone, 40.5% in the intermediate, and 45.5% in the wet. Of the sightings in dry zones, none were in bushland, and 85.7% were in urban and rural gardens, where extra watering and the planting of flowering plants is more likely

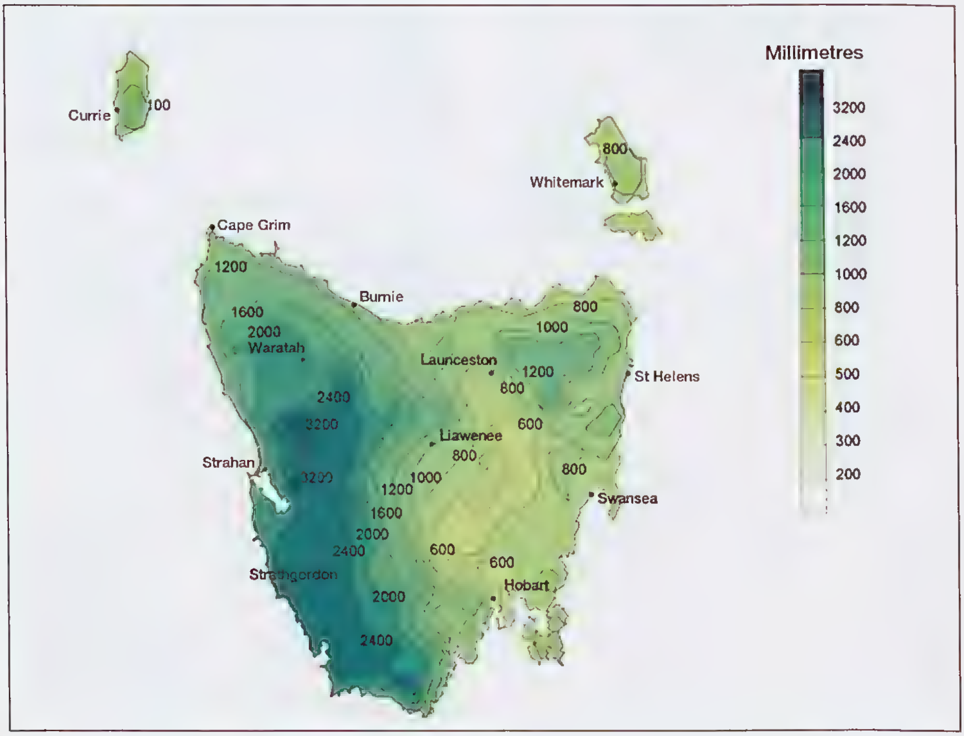

FIG. 6. Average annual rainfall map for Tasmania. (Provided by Bureau of Meteorology, Commonwealth of Australia)

to provide adequate nectar resources for a species like *B. terrestris* that doesn't store much nectar (Alford 1975).

Most sightings, of more than one bumblebee, were from urban (46%) and rural (39%) areas. Bush (3%) and urban bush (3%) only accounted for 7% of sightings, despite the survey form being distributed to national parks to encourage records from sparsely populated areas of the State. Four percent of sightings were from non-specified or other sites. In urban areas the large numbers of potential food plants probably account for the higher proportion of sightings (Appendix 2).

The 31 sightings of more than one bumblebee at remote bush locations were from 25 different locations. Eighteen of these locations were from the South West National Park, three from Bruny Island National Park, two from Tahune National Park, one from Mt Field National Parkand one from the Arthurs Lake (Central Highlands). All 25 locations are in the high rainfall belt (Fig. 5B, 6). Numbers of nests observed in different area types were: 19 urban nests, seven in rural areas, one in remote bush (at Melaleuca, in South West Tasmania under sphagnum moss), and one in urban bush (Zig-zag Trail, Mt Wellington). After a decade, *B. terrestris* does not appear to have become established in Tasmania's second largest city Launceston, as only four sightings have been recorded from there. The availability of suitable nesting sites and/or overwintering sites may also be a determining factor on whether bumblebees can become established in different regions of the State.

One per cent of bumblebee sightings by the public were not on land, with one bumblebee seen 28 km offshore, heading from the Tasman Peninsula to Bruny Island in a direct line. Also there was an additional record of two bumblebees hitching a ride on a Parks and Wildlife boat to Pedra Branca, a small rocky island largely devoid of vegetation. There was also anecdotal evidence of people shifting colonies across the State to Nubeena (Tasman Peninsula) and Triabunna (East Coast).

Feeding Activities within Tasmania

Bumblebees were recorded foraging on 200 plant species (Appendix 2). Of the 1028 sightings of bumblebees on plants across Tasmania, 89.1% were on exotic plants, and 10.9% were on native plants. By far the most visited plant was lavender *Lavandula* spp. (120 sightings). The Lamiaceae, which includes *Lavandula*, accounted for 16.8% of all sightings, and was the most popular family visited by bumblebees. Of the seventy-two plant families recorded as attracting bumblebees, twelve were families native to Australia.

Anecdotal comments from the public suggested that pollination by bumblebees may be inducing changes in the seed set of some plants. These comments were not substantiated, but it was suggested that there was an increase in the seed set of orange nasturtiums over yellow nasturtiums. It was also suggested that cross-pollination of snapdragons by bumblebees have produced a new coloured variety. Similarly, the suggestion was given that pollination of rhododendrons by bumblebees is resulting in early flower droop, and an increase in seed set of some bean crops and blueberries. It was also suggested that bumblebees were responsible for a dramatic reduction in seed set, and therefore seed yield of one broad bean crop due to nectar robbing.

Discussion

Comparison with past surveys

Several previous papers have examined the spread of *B. terrestris* across Tasmania (Semmens 1995; Buttermore 1997; Stout and Goulson 2000; Hingston et al. 2002). Semmens (1995) reported that since 1992, bumblebees had spread throughout much of Hobart, including the Eastern Shore of the city. Bumblebees had also been sighted outside of Hobart at Collinsvale, and in the Channel area, and at Franklin and Cygnet in the Huon Valley. Our survey provided only limited anecdotal information about the early spread of bumblebees in Tasmania.

Stout and Goulson (2000) toured Tasmania in January 1999, recording where they saw bumblebees and mapping their distribution in the State. Bumblebees were sighted as far south as Catamaran (85 km south of Hobart), west to Maydena (55 km), north-west to Ouse (65 km), north to Oatlands (60 km) and north-east to Midway Point (20 km). The authors noted that most bumblebees were observed in gardens, urban parks and pastoral areas. Our records from that same summer (Fig. 4C) indicate their spread or migration into the Queenstown area on the West Coast of Tasmania had also occurred, possibly after Stout and Goulson's monitoring had ceased. For establishment to occur in drier areas of the State, such as north and east of Hobart, we would agree with Stout and Goulson (2000) that most individuals are confined to gardens, urban parks, rural gardens, and flowering crops. These are sites where rainfall is often augmented by watering.

Hingston et al. (2002) collated observations of *B. terrestris* in native vegetation by 63 people between December 1999 and April 2001, along with unpublished records made prior to this period. They recorded 94 sightings of bumblebees in native vegetation, of which 38 were highlighted to indicate more than one bumblebee seen in a day, or a bumblebee was observed carrying pollen; these being used as indicators of colony establishment. Macdonald (2001) took the presence of males or workers as evidence of breeding (successful nest establishment), though he acknowledged that foraging workers do not necessarily represent the successful production of reproductives. Hingston et al. (2002) interpreted their data as providing convincing evidence that *Bombus terrestris* had established colonies in six national parks in southern and western Tasmania, including four of the five national parks in the World Heritage Area.

We used sightings of more than one bumblebee as an indication that a nest may be established in an area. Our records indicate a similar distribution range in native bushland to those of Hingston et al. (2002) (Fig. 5B). In our survey, of the 25 remote bush locations where more than one bumblebee was sighted, 18 were located in the South West National Park. Hingston et al. (2002), did not try to compare the numbers of *B. terrestris* observed between different climatic conditions, vegetation types, altitudes, distances from gardens, species of plants and months of the year, because search effort levels varied at different sites. Our survey similarly focussed on the broad scale distribution of bumblebees in Tasmania. Our survey records that bumblebees were often sighted in urban (46%) and rural (39%) areas than in remote or urban bush.

Is the spread of *B. terrestris* just general expansion, or is mass migration occurring as well?

Mass migrations of insects, including bumblebees, are known to occur in the Northern Hemisphere. There are records of bumblebee species, including *B. terrestris,* taking part in mass migration flights with other insects in the United Kingdom during fair, warm weather in the 1940s and 1950s. Danreuther (1946) 'recorded migration flights in Scotland in 1945 at Macrihanish Bay (Kintyre), when butterflies and bumblebees coming across 23 miles [7 km] of sea from Islay, flying SSE, the latter flying the faster and up to 60 feet [20 metres]'. Owen (1956) recorded that 'On 4 September 1955, a spectacular southward movement of insects down the coast about a mile north of Spurn Point, East Yorkshire. ... Almost all the insects taking part in the movement were syrphids, ... There were also some bumblebees *Bombus* sp. passing at a rate of one a minute, ... Mr G.H. Ainsworth ... informs me that in previous years, in late August, similar movements have been noted.' Birkett (1956) recorded a migration exclusively of bumblebees flying along the coast for four hours in a southerly direction at Silecroft, West Cumberland coast, England. Philp (1957) watched *Bombus terrestris* and *B. lapidarius* (in proportion 9:1) queen bumblebees passing north at an average of one per minute for four hours at Sandwich Bay, Kent, in April 1956. The flight was direct and fast, between one and two feet above the ground and no other species of insects were noticed taking part in this movement.

Other occurrences of mixed species migrations that included bumblebees have been reported from France. These include a seaward migration at Trouville (Lane 1955), a mass migration 1 km from the Isle of Chausey travelling in the direction of Bayeux, which is about 50 miles from where they were seen (Muspratt 1951), and between Trouville and Deauville in 1956 (Rothschild 1956). Research from Finland indicates that bumblebees and wasps congregate along the southern coast and the migrations occur yearly on warm days in May and June (Mikkola 1978, 1984). Mikkola (1984) claims that part of the flight takes the insects across the 80-km-wide Gulf of Finland to Estonia. The top frequencies of spring migrations observed in the years 1975–77 were 23 000/hr on an 800 m front for *Vespula* and 900/hr for *Bombus.* The most common bumblebee species were *B. lucorum* and *B. lapidarius.* All the migrants were queens. The insects oriented against the wind, and the coastline acted as a leading line, concentrating the migrants on a narrow front. The longest flights recorded were over 150 km (Mikkola 1978). From 1992 to 1998, MacDonald (2001) noted the arrival to the Scottish District of Highland of *B. terrestris* queens in spring (between April and July) and again in autumn (between September and October). As no workers or males were observed, to indicate successful colony establishment, he assumed they had dispersed from the south.

Edwards (1980) was not certain 'whether these unusual occurrences were true migratory flights, or whether they were "eruptions" caused by shortage of nest sites following what may have been exceptionally productive years'. In Finland, several species of bumblebees (*Bombus)* and wasps (*Vespula* and *Dolichovespula*) have been observed to undertake spectacular spring migrations together (Mikkola 1978, 1984; Vepsalainen and Savolainen 2000).

Observations by Vepsalainen and Savolainen (2000) in Finland lead them to support Mikkola's theory that this migration was a yearly event. They suggested that mass migrations can constitute an overall adaptive behaviour independent of year-specific, local ecological conditions, and predicted that these migrations were driven by vole cyclicity: voles being European rodents that are both providers of nesting sites, and predators of bumblebees (Vepsalainen and Savolainen 2000).

Despite these records of migration flights, it has been pointed out by Macfarlane and Gurr (1995) that 'In Europe, straits over 10 km wide act as a barrier to bumblebees, restricting colonisation and gene flow. Four subspecies each of *B. terrestris* and *B. lucorum* have developed in populations when separated by straits of 10 km (Elbe/Corsica), 12 km (Italy/Sardinia), 16 km (Spain/North Africa) and 32 km (Great Britain/Europe). Nevertheless, bumblebees do venture across the ocean and *B. terrestris* queens have been collected from European lightships at sea; three times more queens reached 10 km from shore compared to 30 km (Haesler 1974)'. Macfarlane and Griffin (pers. comm.) found that deliberate releases to new sites in New Zealand and Chile may require 100–150 queens in a season to guarantee establishment if sites are not particularly favourable. MacFarlane and Gurr (1995) suggest that limited numbers of *B. terrestris* may have flown to the largest and most remote islands of New Zealand, but may have failed to colonise due to lack of numbers.

Evidence of mass migration of *B. terrestris* in Tasmania at the moment is solely based on the phenology of expansion into new localities (towns) in North West Tasmania. In three consecutive seasons we recorded a rapid expansion of territory within a space of three weeks in January. In the first year of expansion in North West Tasmania only one township, Ulverstone, had a (later) confirmed establishment in Spring 1999, but in the first three weeks of January 2000, there appeared to be a westward expansion of territory up to 90 km from Ulverstone. In the three years of the survey bumblebees successfully expanded their range into new localities in North West Tasmania (five new localities in 2000, 12 in 2001 and an additional 12 in 2002). In the Tasmanian context it is reasonable to predict that bumblebees will continue to rapidly expand their range throughout the state wherever suitable environmental conditions occur.

Floral Records and Bumblebees Feeding Habits in Tasmania

All of the existing reports indicate that bumblebees are generalists and will forage on a wide range of plants. Semmens (1996 and 1998) listed 216 plant species (20 natives and 196 introduced species) visited by *Bombus terrestris* in Tasmania, and concluded that the impact of bumblebees will be low because they are mainly visiting introduced species. Our records from the public survey would concur, in that foraging effort by bumblebees was predominantly (about 90%) focused on introduced plants (Appendix 2); but this does not preclude the possibility of an impact on some native plants and the pollination guilds associated with these plants.

Our public survey indicates that the most attractive native Australian plants to *B. terrestris* were *Banksia* spp. (13 sightings), *Eucalyptus* spp. (13), leatherwood (*Eucryphia lucida)* (10), bottlebrushes (*Callistemon* spp.) (10), *Grevillea* spp. (9), tea tree (*Leptospermum* spp.) (4), pigface (*Disphyma australe)* (3), and common heath (*Epacris impressa)* (3) (Appendix 2). Hingston et al. (2002) from December 1999 to 2001 recorded bumblebees visiting *Banksia marginata*, *Leptospermum* spp., *Eucalyptus* spp., *Eucryphia* spp., *Bursaria spinosa*, and epacrids, *Pentachondra involucrata* and *Epacris impressa*.

Weed plants noted as attractive to *B. terrestris* in bushland by Hingston et al. (2002) were blackberry (*Rubus fruticosus* sp. agg.), American sea rocket (*Cakile edentula*), white clover (*Trifolium repens*), trefoil (*Lotus* spp.) and scotch thistle. Our survey also records bumblebees foraging commonly on blackberries (15 sightings), clover (12), trefoil (12), scotch thistle (10), and dandelions (6). As in the case of introduced garden plants and native plants, the weed species found to be most attractive to *B. terrestris* tend to be common species with an abundant supply of flowers that are mostly nectar providing.

All of the common Australian plants and introduced plants that are most attractive to *B. terrestris,* have large clusters of flowers, as opposed to plants with few or single flowers. European research indicates that *B. terrestris* has a preference for large patches of flowers (Klinkhamer et al. 1989; Sowig 1989; Goulson et al. 1998; Stout et al. 1998). Lunau et al. (1996) studied the innate colour preferences of inexperienced *B. terrestris*, and found that if the corolla colour was constant but its background colour varied, the relative attractiveness of the corolla increased with its colour difference to the background.

Floral Preferences of *B. terrestris* in Europe and New Zealand

The Dutch bumblebee surveys held in 1994 and 1995 found *B. terrestris* to be the most common bumblebee species in Holland (Van Iperen and Aptroot 1995). In natural areas (meadows, dunes, woods and heathland) in Holland, the most attractive plants to *B. terrestris* in order (from most to least) were comfrey (*Symphytum officinale)*, raspberries (*Rubus* spp.), trefoil (*Lotus* spp.), clover (*Trifolium* spp.), and poppies (*Papaver* spp.) (Kwak and Tieleman 1995). All of these species except raspberries are drought sensitive (Bodkin 1986).

In public surveys of bumblebee populations in England conducted in 1987 and 1988, the *B. terrestris* group of bumblebee species was the most abundant bumblebee group sighted (Fussell and Corbet 1992). Plant species commonly accessed by this group in England, and by *B. terrestris* in Australia included: cotoneaster (*Cotoneaster* spp); blackberry *(Rubus fruticosus* sp. agg.); rhododendron, (*Rhododendron* spp.); foxgloves (*Digitalis purpurea*); lavender (*Lavandula* spp.); and fuchsias (*Fuchsia* spp.) (Fussell and Corbet 1992). Differences in floral choice by *B. terrestris* in different countries is likely to be related to relative abundance of different plant species in each country. In England, in contrast to Tasmania however, *Bombus terrestris* was not recorded in significant numbers on trefoil (*Lotus* spp.), and other species of bumblebees, i.e. *B. lapidarius, B. ruderatus, Psithyrus rupestris, P. campestris* were often recorded on lavender (Fussell and Corbet 1992). It seems likely that competition between bumblebee species in Europe may influence feeding preferences. The absence of other bumblebee species from Tasmania would suggest that competition for food plants is not occurring.

Important introduced food sources for *B. terrestris* in New Zealand include: tree lucerne, stone and berry crops, dandelion, pussy willow, brassicas, clovers, kiwifruit, St Johns wort, vipers bugloss, russell lupins, broom, blackberry and thistles (Macfarlane unpublished). Tree lucerne and broom appear to be of little importance to *B. terrestris* in Tasmania due to a later emergence of queens (K. Hergstrom, pers. obs.). *Bombus terrestris* in New Zealand also forages on introduced Australian plant species, i.e. *Grevillea rosmarinifolia*, *Dryandra formosa,* gums (*Eucalyptus* spp.), and to a lesser extent *Banksia* species (Macfarlane unpublished data).

Bombus terrestris is the most common bumblebee species in New Zealand (Macfarlane and Gurr 1995). Donovan and Macfarlane (1984) reported *B. terrestris* visiting 400 introduced and 19 native plants. Macfarlane, in an unpublished report based on 36 515 bumblebee sightings from 1969 to 1990, recorded bumblebees visited over 300 introduced species of flowering plants and 53 species of native plant species. He noted seasonal variation in the abundance of different *Bombus* species, with the numbers of the short-tongued *B. terrestris* declined gradually from mid spring to mid summer, while the numbers of the long-tongued *B. ruderatus* and *B. hortorum* increased. This was not the case in Tasmania as numbers of sightings of *B. terrestris* reached their peak in mid January.

Implications of Survey of *B. terrestris* in Tasmania

Another species of social Hymenoptera, the honeybee *(Apis mellifera),* was introduced into Australia in the 1920s (Paton 1997). Studies by Paton (1993, 1996, 1997) and New (1997) found that honeybees often reach high densities in Australian native bushland, and can sometimes alter, for better or worse, the long-term viability of the native biota. Unfortunately the opportunity to track the spread of honeybees in Australia from the 1820s did not occur and therefore the possibility of using this information to predict the long-term environmental impacts of honeybees was missed. The introduction of *B. terrestris* to Tasmania does, however, provide the opportunity to document the spread of another species of social Hymenoptera in Australia.

The survey in Tasmania showed that bumblebees rapidly expanded their range into new areas. Studies overseas, similarly showed that bumblebees can expand their range rapidly, and in Scotland between 1976 and 2000, *B. terrestris* extended its range 98 km northwards (Macdonald 2001). This expansion of territory coincided with a 15% increase in precipitation, and migrations were concentrated in areas with large towns (Macdonald 2001).

Sightings of bumblebees in Tasmania have come from most parts of the State, with the exception of the north eastern half and the north western corner of the State. Based upon the evidence of *B. terrestris* being sighted from the coast to high on mountains, and across Tasmania's entire range of annual rainfall, Hingston et al. (2002) suggested, that neither of these abiotic factors was limiting the range of *B. terrestris* in Tasmania. Our record of observations (see Fig. 1) would agree that bumblebees may migrate across the entire State, but we suggest that the ability of bumblebees to successfully colonise all regions of the State is variable, and may, in part, be rainfall dependant. Nevertheless, the public survey does suggest that the area of long-term establishment in Tasmania will be broad.

Hingston et al. (2002) also speculated on the potential for *B. terrestris* to increase seed production in weed species in Australia. Introduced plants, which includes some weed species, have been noted to be attractive to *B. terrestris* in all surveys discussed (Appendix 2). The example that Hingston et al. (2002) cited was foxglove *Digitalis purpurea* which is a serious weed in New Zealand. *Bombus terrestris* is unlikely, however, to have a significant impact on seed set in foxgloves because of their relatively short tongue length. The average tongue length of *B. terrestris* workers is 7.85+/–0.57 mm (Kwak 1994), and it has been estimated that it would take a 10 mm tongue to successfully pollinate foxgloves (Brodie 1996). In New Zealand, the longer tongued *B. hortorum* (L.), with an average tongue length of 12.42+/–0.96 mm for workers (Kwak 1994), strongly prefers *Digitalis purpurea* (Macfarlane and Gurr 1995). In Tasmania, *Digitalis purpurea* has been a weed for several decades in the North East of the State near Scottsdale, despite the lack of bumblebee species. This would suggest that other pollinators such as nectar-feeding birds or other insects are pollinating this plant in Tasmania. Anecdotal reports were provided by the public of the effect of feeding, and consequent pollination, by *B. terrestris.* Detailed studies are needed to determine the impact of bumblebees on seed set and therefore seed production of both native and introduced species in the State. The impact of bumblebees on different plant species, and on the insect pollination guilds associated with different plants, is not assessed in this paper.

Given the migrating ability of *B. terrestris* observed in Europe (MacDonald 2001; Danreuther 1946; Owen 1956; Lane 1955; Muspratt 1951; Rothschild 1956; Birkett 1956; Philp 1957) and the observations of perhaps similar migratory flights in Tasmania it is reasonable to speculate that bumblebees will spread across the entire State. The available literature is somewhat contradictory about the ability of bumblebees to cross ocean and sea barriers. Based upon observations from New Zealand, that large numbers of queens are required to successfully colonise new areas (MacFarlane and Gurr 1995), it is considered unlikely that they would be able to island hop, along the chain of islands across Bass Strait, to mainland Australia. The relatively low annual rainfall of most of the Bass Strait islands, (i.e. less than 1200 mm/annum), would also appear not to provide ideal environmental conditions for bumblebees, particularly as bumblebees are still rare in North East Tasmania. The prevailing westerly wind direction in Bass Strait may also reduce the likelihood of bumblebees successfully crossing to mainland Australia. As there is already anecdotal evidence of colonies being moved around the State, human-mediated trafficking is considered the most likely mechanism for bumblebees to reach mainland Australia. If introduced to the mainland, *B. terrestris* is likely to become widely distributed in higher rainfall and urban areas in south eastern Australia.

The introduction and spread of *Bombus terrestris* to mainland Australia has been listed as a potentially threatening process under the *State of Victoria's Flora and Fauna Guarantee Act* 1988 (Lefoe 2002). Prys-Jones and Corbet (1991) pointed out that arguments in favor of introducing a species to a new area, i.e. such as the perceived benefits of improved greenhouse crop pollination (Dogterom et al. 1998), and heightened pollination of field crops as in New Zealand (Donovan and Macfarlane 1984), should be carefully balanced against the possible adverse environmental effects of the introduction on the native flora and fauna.

Acknowledgements

We thank Horticulture Australia for sponsoring the project, and Alex Buchanan for identifying plant species. Thanks to two referees and the editor of the journal for suggestions to improve this paper. Support with dissemination of the public survey was provided by: The Department of Primary Industries, Water and the Environment; Parks and Wildlife Service; Landcare groups, Tasmania; and the Tasmania Fire Service. We would also like to thank the members of the Bumblebee Steering Committee: Mike Driessen, Anthony Brandsema, Mike Schwartz, Les Baxter, and Marilyn Steiner, and attendees at the National Workshop on Bumblebees for their advice and support. Finally the authors would like to thank those members of the public who volunteered information towards the public survey on the distribution of bumblebees in Tasmania.

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Appendix 1: List of National Parks that the bumblebee survey was distributed to in January 2000.

North East Tasmania
Freycinet National Park
Mount William National Park

North West Tasmania
Rocky Cape National Park

Western Tasmania
Cradle Mountain–Lake St Clair National Park
Franklin–Gordon Wild Rivers National Park

Southern Tasmania
Mount Field National Park

South East Tasmania
Bruny Island National Park
Hartz Mt National Park
Maria Island National Park
South West National Park

Appendix 2: Observations of Bumblebees on different plant species in Tasmania.

Species	Sightings (No.)	Common Name	Family	Introduced (I) /Native (N)
Lavandula spp.	120	Lavender	Lamiaceae	I
Rosa spp.	42	Rose	Rosaceae	I
Fuchsia spp.	40	Fuchsia	Onagraceae	I
Agapanthus sp.	30	African Lily	Liliaceae	I
Dahlia variabilis	25	Dahlia	Asteraceae	I
Penstemon sp.	21	Penstemon	Scrophulariaceae	I
Rhododendron spp.	20	Rhododendron	Ericaceae	I
Antirrhinum majus	19	Snapdragons	Scophulariaceae	I
Tropaeolum majus	16	Nasturtium	Tropaeolaceae	I
Rubus fruticosus sp. agg.	15	Blackberries	Rosaceae	I
Geranium gracile	13	Geranium	Geraniaceae	I
Eucalyptus spp.	13	Gum trees	Myrtaceae	N
Banksia spp.	13	Banksia	Proteaceae	N
Trifolium spp.	12	Clover	Fabaceae	I
Salvia uliginosa	12	Bog sage	Lamiaceae	I
Salvia officinalis	12	Sage	Lamiaceae	I
Lotus uliginosus	11	Greater Trefoil	Fabaceae	I
Geranium maculatum	11	Chinese lantern	Geraniaceae	I
Aquilegia vulgaris	11	Granny's bonnet	Ranunculaceae	I
Hebe sp.	11	Hebe	Scophulariaceae	I
Onopordum acanthum	10	Thistle	Asteraceae	I
Lonicera spp.	10	Honeysuckle	Caprifoliaceae	I
Eucryphia lucida	10	Leatherwood	Cunoniaceae	N
Phaseolus multiflorus	10	Scarlet runner beans	Fabaceae	I
Callistemon spp.	10	Bottlebrush	Myrtaceae	N
Digitalis purpurea	10	Foxgloves	Scophulariaceae	I
Abelia spp.	9	Abelia	Caprifoliaceae	I
Plantago media	9	Lambs ear	Plantaginaceae	I
Grevillea spp.	9	Grevillea	Proteaceae	N
Bellis perennis	8	Daisies	Asteraceae	I
Buddleia alternifolia	8	Buddleia	Buddleiaceae	I
Lupinus spp.	8	Lupins	Fabaceae	I
Althea rosea	8	Hollyhocks	Malvaceae	I
Papaver spp.	8	Poppies	Papaveraceae	I
Hydrangea arborescens	8	Hydrangea	Saxifragaceae	I
Alstroemeria spp.	7	Alstroemeria	Amaryllidaceae	I
Cosmos atrosanguineus	7	Cosmos	Asteraceae	I
Taraxacum officinale	6	Dandelion	Asteraceae	I
Cheiranthus mutabilis	6	Wallflowers	Brassicaceae	I
Lathyrus odoratus	6	Sweet peas	Fabaceae	I
Cytisus palmensis	6	Tree lucerne	Fabaceae	I
Abutilon globosum	6	Golden dollar plant	Malvaceae	I
Borago officinalis	5	Borage	Boraginaceae	I
Brassica oleracea	5	Cabbages	Brassicaceae	I
Campanula medium	5	Canterbury Bells	Campanulaceae	I
Vicia faba	5	Broad beans	Fabaceae	I
Nepeta faassenii	5	Catmint	Lamiaceae	I
Delphinium spp.	5	Delphinium	Ranunculaceae	I
Lycopersicon esculentum	5	Tomato	Solonaceae	I
Calendula officinalis	4	Marigold	Asteraceae	I
Helianthus spp.	4	Sunflowers	Asteraceae	I
Thistles	4	Thistles	Asteraceae	I
Scabiosa graminifolia	4	Scabiosa	Dipsacaceae	I
Montbretia sp.	4	Montbretia	Iridaceae	I

Phaseolus vulgaris	4	Climbing beans	Fabaceae	I
Lilium spp.	4	Lily	Liliaceae	I
Leptospermum spp.	4	Tea tree	Myrtaceae	N
Cotoneaster spp.	4	Cotoneaster	Rosaceae	I
Citrus limon	4	Lemon tree	Rutaceae	I
Lycium ferocissimum	4	African Boxthorn	Solonaceae	I
Disphyma australe	3	Pigface	Aizoaceae	N
Allium cepa	3	Onions	Alliaceae	I
Centaurea cyanis	3	Cornflower	Asteraceae	I
Chrysanthemum leucanthenum	3	Sun daisies	Asteraceae	I
Cucurbita maxima	3	Pumpkin	Cucurbitaceae	I
Epacris impressa	3	Common Heath	Epacridaceae	N
Erica spp.	3	Heath	Ericaceae	I
Rhododendron spp.	3	Azalea spp	Ericaceae	I
Cytisus scoparius	3	Broome	Fabaceae	I
Pisum sativum	3	Peas	Fabaceae	I
Pelargonium spp.	3	Pelargonium	Geraniaceae	I
Gladiolus communis	3	Gladioli	Iridaceae	I
Marjorana hortensis	3	Marjoram	Lamiaceae	I
Monardo didyma	3	Bergamot	Lamiaceae	I
Salvia microphylla	3	Salvia	Lamiaceae	I
Thymus vulgaris	3	Thyme	Lamiaceae	I
Salvia elegans	3	Pineapple sage	Lamiaceae	I
Lobelia erinus	3	Lobelia	Lobeliaceae	I
Rubus sp.	3	Boysenberry	Rosaceae	I
Petunia spp.	3	Petunia	Solonaceae	I
Viola spp.	3	Pansies	Violaceae	I
Parthenocissus quinquefolia	3	Creeper	Vitaceae	I
Acanthus mollis	2	Bears Breech	Acanthaceae	I
Eranthemum puthellum	2	Blue sage	Acanthaceae	I
Zephyranthes candida	2	Peruvian lily	Amaryllidaceae	I
Eryngium maritimum	2	Sea holly	Apiaceae	I
Hedera helix	2	Ivy	Araliaceae	I
Senecio glomeratus	2	Fireweed	Asteraceae	I
Bellis sp.	2	Easter daisy	Asteraceae	I
Chrysanthemum parthenium	2	Feverfew	Asteraceae	I
Raphanus raphanistrum	2	Wild radish	Brassicaceae	I
Dianthus spp.	2	Carnations	Caryophyllaceae	I
Sedum spathulifolium	2	Sedum	Crassulaceae	I
Cucurbita pepo	2	Zucchini	Cucurbitaceae	I
Hibbertia scandens	2	Climbing guinea-flower	Dilleniaceae	I
Schizolobium parhyba	2	Jacaranda	Fabaceae	I
Trifolium fragiferum	2	Strawberry clover	Fabaceae	I
Hypericum spp.	2	Hypericum	Guttiferae	I
Westringia brevifolia	2	Westringia	Lamiaceae	N
Agastache foeniculum	2	Anise	Lamiaceae	I
Fritillaria meleagris	2	Daffodil	Liliaceae	I
Kunzea ambigua	2	Kunzea	Myrtaceae	N
Passiflora sp.	2	Passionfruit vine	Passifloraceae	I
Bursaria spinosa	2	Native box	Pittosporaceae	N
Limonium macrophyllum	2	Statice	Plumbaginaceae	I
Cymbopogon nardus	2	Lemon balm	Poaceae	I
Hakea laurina	2	Pincushion Hakea	Proteaceae	N
Anemone nemorosa	2	Windflowers	Ranunculaceae	I
Ranunculus plebius	2	Buttercup	Ranunculaceae	I
Malus pumila	2	Apples	Rosaceae	I
Rubus spp.	2	Raspberries	Rosaceae	I

Escallonia spp.	2	Escallonia	Escalloniaceae	I
Sphagnum sp.	2	Sphagnum moss	Spagnaceae	N
Pimelea nivea	2	Riceflower	Thymelaeaceae	N
Tropaeolum tuberosum	2	Peruvian nasturtium	Tropaeolaceae	I
Allium ascalonicum	1	Shallots	Alliaceae	I
Galanthus byzantinus	1	Death's flower	Amaryllidaceae	I
Carum petroselinium	1	Parsley	Apiaceae	I
Beaumontia terdoniana	1	Trumpet creeper	Apocynaceae	I
Mandevilla splendens	1	Trumpet flower	Apocynaceae	I
Ammobium sp.	1	Ammobium	Asteraceae	N
Olearia phlogopappa	1	daisy bush	Asteraceae	N
Brachyscome augustifolia	1	Native daisies	Asteraceae	N
Echinacea augustifolia	1	Purple cone flower	Asteraceae	I
Lactuca sativa	1	Lettuce	Asteraceae	I
Senecio jacoboea	1	Ragwort	Asteraceae	I
Venidium fastuosum	1	Venidium	Asteraceae	I
Begonia spp.	1	Begonia	Begoniaceae	I
Cerinthe spp.	1	Honey wort	Boraginaceae	I
Echium candicans	1	Pride of Madiera	Boraginaceae	I
Myosotis palustris	1	Forget me nots	Boraginaceae	I
Brassica oleracea	1	Broccoli	Brassicaceae	I
Cardamine pratensis	1	Naked ladies	Brassicaceae	I
Matthiola incana	1	Stock	Brassicaceae	I
Wahlenbergia stricta	1	Bluebell	Campanulaceae	N
Humulus lupulus	1	Hops	Cannabaceae	I
Helianthemum sp.	1	Sun bush	Cistaceae	I
Ipomoea pandusata	1	Potato vine	Convolvulaceae	I
Cupressus macrocarpa	1	Monterey cypress	Cupressaceae	I
Kennnedia prostrata	1	Native creeper	Fabaceae	N
Laburnum anagyroides	1	Golden chain	Fabaceae	I
Lotus majus	1	Birdsfoot trefoil	Fabaceae	I
Lupinus sp.	1	Dwarf lupin	Fabaceae	I
Medicago sativa	1	Lucerne	Fabaceae	I
Vicia sativa	1	Bean	Fabaceae	I
Vicia cracca	1	Vetch	Fabaceae	I
Goodenia ovata	1	Goodenia	Goodeniaceae	N
Paspalum sp.	1	Paspalum	Poaceae	I
Hypericum perforatum	1	St John's wort	Guttiferae	I
Nigella sativa	1	Love in a mist	Helleboraceae	I
Leonotis leonurus	1	Lion's Ear	Lamiaceae	I
Mentha sp.	1	Mint	Lamiaceae	I
Nepeta cataria	1	Catnip	Lamiaceae	I
Ocimum basilicum .	1	Basil	Lamiaceae	I
Salvia patens	1	Cambridge blue	Lamiaceae	I
Atherosperma moschatum	1	Sassafras tree	Lauraceae	N
Acacia longifolia subsp. *sophorae*	1	Boobyalla	Mimosaceae	N
Acacia sp.	1	Native wattle	Mimosaceae	N
Wistaria spp.	1	Wisteria	Fabaceae	I
Blandfordia spp.	1	Blandfordia	Liliaceae	N
Kniphofia uvaria	1	Red-hot Pokers	Liliaceae	I
Magnolia spp.	1	Magnolia	Magnoliaceae	I
Lavatera plebeia	1	Australian hollyhocks	Malvaceae	N
Gravesia sp.	1	Gravesia	Melastomataceae	I
Tibouchina urvilleana	1	Lasiandra	Melastomataceae	I
Melaleuca gibbosa	1	Paperbark	Myrtaceae	N
Syzygium coolminianum	1	Blue Lilly Pilly	Myrtaceae	N

Acmena hemilampra	1	Lilly Pilly	Myrtaceae	N
Jasminum officinale	1	Jasmine	Oleaceae	I
Oxalis incarnata	1	Oxalis	Oxalidaceae	I
Paeonia spp.	1	Peony	Paeoniaceae	I
Plantago lanceolata	1	Plantain	Plantaginaceae	I
Native grasses	1	Native grasses	Poaceae	N
Portulaca grandiflora	1	Portulaca	Portulacaceae	I
Anenome blanda	1	Anenome	Ranunculaceae	I
Reseda lutea	1	Mignonette weed	Resedaceae	I
Ceanothus cyaneus	1	Californian lilac	Rhamnaceae	I
Chaenomeles speciosus	1	Japonica creeper	Rosaceae	I
Fragaria vesca	1	Strawberries	Rosaceae	I
Pyrus communus	1	Pears	Rosaceae	I
Manettia biocolor	1	Manettia		I
Correa alba	1	White correa	Rutaceae	N
Citrus aurantifolia	1	Lime tree	Rutaceae	I
Populus tacamahaca	1	Tacamahac tree		I
Bauera sp.	1	Bauera	Cunoniaceae	N
Ribes americanum	1	Black currant	Saxifragaceae	I
Ribes rubrum	1	Currants	Saxifragaceae	I
Alonsoa spp.	1	Alonsoa	Scophulariaceae	I
Verbascum sp.	1	Verbascum	Scophulariaceae	I
Camellia japonica	1	Camellia	Theaceae	I
Typha orientalis	1	Bullrush	Typhaceae	I
Lantana salviifolia	1	Lantana	Verbenaceae	I
Viola spp.	1	Violas	Violaceae	I
Vitis vinifera	1	Grapevine	Vitaceae	I
Hedychium gardnerianum	1	Wild ginger	Zingiberaceae	I

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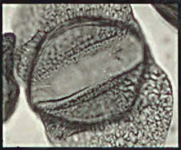

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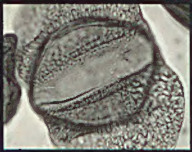


Palaeobotany


Zoology

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