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<td>Chromosome number determinations in the Australian Astereae (Asteraceae)</td>
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<td>Author(s)</td>
<td>Watanabe, Kuniaki / Short, P.S. / Denda, Tetsuo / Suzuki, Y / Ito, Motomi / Yahara, Tetsukazu / Kosuge, Keiko</td>
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PDF issue: 2018-12-11
Chromosome number determinations in the Australian Astereae (Asteraceae)

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²National Herbarium of Victoria, Birdwood Avenue, South Yarra, 3141, Victoria, Australia.
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⁴Department of Biology, Faculty of Science, Kyushu University, Fukuoka 812, Japan.

ABSTRACT
Chromosome number determinations from 200 populations attributed to 99 species or infraspecific taxa of ten genera are presented in Table I. They include the first substantiated reports for Brachyscome glandulosa (2n = 36), B. muellerioides (n = 3), B. obovata (2n = 18), B. petrophila (2n = 18), B. tatei (n = 9), Erodiophyllum elderi (2n = 16), Minuria gardneri (n = 9), M. integerrima (n = 18), Olearia astrotricha (n = 9), O. ferresii (n = 9), O. imbricata (n = 9), O. puheacea (n = 9), O. ramulosa (n = 9), O. xerophila (n = 9), Vittadinia cuneata (n = 9), V. gracilis (n = 9), V. muelleri (n = 9), V. pterochaeta (n = 9), V. pulchella (n = 9) and V. sulcata (n = 9). Polyploidy is reported for the first time in Brachyscome dissectifolia, B. cardiocarpa, Calotis allthemoides and in the Olearia phlogopappa complex. Remaining counts support previously reported determinations and add to the knowledge of chromosome number distribution within taxa. Some taxonomic problems are briefly discussed. It is concluded that chromosomal variation in Australian Astereae is similar to that found in North America.

Introduction
In a recent census of Australian vascular plants 831 native species of Asteraceae were listed under c. 130 genera (Hnatiuk 1990). About 330 formally recognised species belong to the tribe Astereae, and most are currently distributed amongst four genera, i.e. Olearia Moench (c. 130), Brachyscome Cass. (c. 70), Vittadinia A.Rich. (29) and Calotis R.Br. (c. 28). The remaining genera here considered to belong to the Astereae are Achnophora F.Muell. (1), Camptacra N.T.Burb (2), Celmisia Cass. (c. 10), Centipedo Lour. (5), Ceratogyne Turcz. (1), Dichrocephala DC. (1), Dichromochlamys Dunlop (1), Dimorphochaoma F.Muell. & Tate (1), Elachanthus F.Muell. (2), Erigeron L. (c. 10), Erodiophyllum F.Muell. (2), Eurybiopsis DC. (1), Isotopis Turcz. (1), Ixiochlamys F.Muell. & Sond. (4), Kippistia F.Muell. (1), Minuria DC. (10 or 11), Lagenifera Cass. (4) and Solenogyne Cass. (3).

Chromosome number surveys have been primarily restricted to just two genera, i.e. Brachyscome (Smith-White et al. 1970, Carter 1978, Watanabe & Short 1992) and Calotis (Stace 1978, 1982). In this paper we report further chromosome number determinations for both of these genera as well as new determinations for native species of Erodiophyllum, Lagenifera, Minuria, Olearia, Solenogyne and Vittadinia, briefly examine previous reports, and comment on some associated taxonomic problems.

A number of species of Astereae belonging to Aster L., Bellis L., Conyza Less., Erigeron L. and Solidago L. are naturalised in Australia but with the exception of Erigeron karvinskianus they have not been examined.

Materials and methods
Chromosome counts were obtained from either floral bud material fixed in the field, or from root tips obtained from seedlings grown from fruit of known provenance. For the
<table>
<thead>
<tr>
<th>Species &amp; locality</th>
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</table>
| **B. nivalis** F.Muell.  
Club Lake, Mt Kosciusko N.P., N.S.W., 5 Feb. 1993, *Short 4005* | 11II | 22 |
| **B. nodosa** P.S.Short & K.Watan.  
Bracket Creek, Qld, 29 Sept. 1992, *Watanabe 19* | 3II |
| 15.5 km E of Inglewood, Qld, 29 Sept. 1992, *Watanabe 20* | 3II |
| 2 km E of Inglewood, Qld, 29 Sept. 1992, *Watanabe 24* | 3II |
| 69 km N of Coonabarabran, N.S.W., 25 Sept. 1992, *Watanabe 8* | 3II |
| **B. nova-anglica** G.L.R.Davis  
Girraween N.P., Qld, 29 Jan. 1993, *Watanabe 79* | 7II | 14 |
| 26.5 km SE of Wongwibinda, N.S.W., 31 Jan. 1993, *Short 3978* | 7II | 14 |
| **B. aff. nova-anglica (A)**  
3 km S of Glen Aplin, Qld, 30 Jan. 1993, *Short 3969* | 5II | 10 |
| **B. aff. nova-anglica (B)**  
| **B. obovata** G.L.R.Davis  
Daners Gap, Mt Kosciusko N.P. N.S.W., 4 Feb. 1993, *Short 3993* | 18 |
| Blue Lake to Charlotte Pass  
Mt Kosciusko N.P., N.S.W., 5 Feb. 1993, *Short 3997* | 18 |
| **B. oncocarpa** Diels  
100 km N of Galena Bridge on NW Coastal Hwy, W.A., 6 Oct. 1993, *Short 4084* | 18 |
### TABLE 1. CONTINUED

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<td><strong>B. papillosa</strong> G.L.R.Davis</td>
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<td>6 Oct. 1992, <em>Watanabe</em> 73</td>
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<td></td>
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<td>Muggabah Creek, 14 km N of Booligal,</td>
<td>8</td>
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<td>N.S.W., 6 Oct. 1992, <em>Watanabe</em> 75</td>
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<td><strong>B. perpusilla</strong> (Steetz) J.M.Black</td>
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<td>Totadgin Rock, W.A., 3 Oct. 1993,</td>
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<td><em>Watanabe</em> 115</td>
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<td><em>Watanabe</em> 160</td>
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<td><strong>B. petrophila</strong> G.L.R.Davis</td>
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<td>Angler’s Rest, Vict.</td>
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<td>Unvouchered colln, Feb. 1993</td>
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<td>W edge of Lake King, W.A.,</td>
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<td><strong>B. readeri</strong> G.L.R.Davis</td>
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<td>10</td>
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<td>Ulupna Island, Vict.,</td>
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<td>23 Sept. 1992, <em>Watanabe</em> 4</td>
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<td><strong>B. rigidula</strong> (DC.) G.L.R.Davis</td>
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<td>Lake Omeo, c. 0.4 km S of intersection</td>
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<td>of Blowhard road and Lake Omeo road,</td>
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<td>3.5 km NW of Backwater, N.S.W.,</td>
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<td>30 Jan. 1993, <em>Short</em> 3972</td>
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<td>Buckety Plains, Bogong N.P., Vict.,</td>
<td>9II</td>
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<td><strong>B. smithwhitei</strong> P.S.Short &amp; K.Watan.</td>
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<td>28.7 km S of Ivanhoe, N.S.W.,</td>
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<td>1.4 km W of Menindee, N.S.W., 22 Oct. 1993, Watanabe 210</td>
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<td>Sawyers Hill, Kosciusko N.P., N.S.W., 3 Feb. 1993, Short 3985</td>
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<td>Daners Gap, Kosciusko N.P., N.S.W., 4 Feb. 1993, Short 3994</td>
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<td>Club Lake, Kosciusko N.P., N.S.W., 5 Feb. 1993, Short 4003</td>
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<td>Cathcart to Rocky Hall, N.S.W., 6 Feb. 1993, Short 4011</td>
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<td><strong>B. stolonifera</strong> G.L.R. Davis</td>
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<td><strong>B. stuartii</strong> Benth.</td>
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<td>Girraween N.P., Qld, 29 Jan. 1993, Watanabe 81</td>
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<td>11 km from Deepwater towards Tenterfield, N.S.W., 29 Jan. 1993, Short 3964</td>
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<td><strong>B. tatei</strong> J.M. Black</td>
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<td>42.5 km E of Border Village, S.A., 18 Oct. 1993, Watanabe 184</td>
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<td><strong>B. tenuiscapa</strong> Hook.f.</td>
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<td>var. <strong>pubescens</strong> (Benth.) G.L.R. Davis</td>
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<td>3.5 km NW of Backwater, N.S.W., 30 Jan. 1993, Short 3975</td>
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<td>aff. var. <strong>tenuiscapa</strong></td>
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<td>3.5 km NE of Mt Reynard, Snowy Plains, Vict., Walsh s.n., Cultivated RBG, Accession No. 905484</td>
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<td><strong>B. trachycarpa</strong> F.Muell.</td>
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<td>Ceduna, S.A., 12 Sept. 1990, Short 3781</td>
<td>18 + 0-2Bs</td>
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<td><strong>B. sp. aff. trachycarpa</strong> F.Muell.</td>
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<td>25 km W of Dalby, N.S.W., 30 Sept. 1992, Watanabe 31</td>
<td>27I or 11I</td>
<td>+ 0-9II + 1s</td>
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<td><strong>Brachyscome sp.</strong></td>
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<td><strong>Calotis</strong> R.Br.</td>
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<td><strong>C. cuneata</strong> (F.Muell. ex Benth.) G.L.R.Davis <em>var. cuneata</em></td>
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<td>25 km W of Dalby, N.S.W., 30 Sept. 1992, <em>Watanabe 32</em></td>
<td>16II</td>
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<td><strong>C. cuneifolia</strong> R.Br.</td>
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<td>17 km SW of Dubbo, N.S.W., 24 Sept. 1992, <em>Watanabe 5</em></td>
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<td>16</td>
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<td>15.5 km E of Inglewood, Qld, 29 Sept. 1992, <em>Watanabe 23</em></td>
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<td>25 km W of Dalby, N.S.W., 30 Sept. 1992, <em>Watanabe 34</em></td>
<td>16II</td>
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<td><strong>C. cymbacantha</strong> F.Muell. (*Tilpa, N.S.W., 2 Oct. 1992, <em>Watanabe 48</em>)</td>
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<td><strong>C. dentex</strong> R.Br.</td>
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<td>3 km S of Glen Alpin, Qld, 30 Jan. 1993, <em>Short 3967</em></td>
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<td><strong>C. erinacea</strong> Steetz</td>
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<td>15 km SW of Kimba, S.A., 21 Sept. 1982, <em>Short 1766</em></td>
<td>12II + 1IV</td>
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<td><strong>C. lappulacea</strong> Benth.</td>
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<td>15.5 km E of Inglewood, Qld, 29 Sept. 1992, <em>Watanabe 21</em></td>
<td>14II</td>
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<td><strong>C. aff. lappulacea</strong></td>
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<td>15.5 km E of Inglewood, Qld, 29 Sept. 1992, <em>Watanabe 22</em></td>
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<td><strong>C. multicaulis</strong> (Turcz.) Druce</td>
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<td><strong>C. plumulifera</strong> F.Muell.</td>
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<td>5II + BII</td>
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<td>45 km SE of Broken Hill, N.S.W., 6 Oct. 1992, <em>Watanabe 66</em></td>
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<td>28.7 km S of Ivanhoe, N.S.W., 23 Oct. 1993, <em>Watanabe 213</em></td>
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<td>Sawpit Creek, Kosciusko N.P., N.S.W., 4 Feb. 1993, <em>Short 3995</em></td>
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<td><em>C. scapigera</em> Hook. Louth, N.S.W., 2 Oct. 1992, <em>Watanabe 42</em></td>
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<td>6 km NE of Jerilderie, N.S.W., 26 Jan. 1993, <em>Short 3933</em></td>
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<td><em>Erigeron</em> L. <em>E. karvinskianus</em> DC. 4 km N of Mt Slide, Vict., March 1991, <em>H.Manson s.n.</em>, (MEL 1592608)</td>
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<td><em>L. stipitata</em> (Labill.) Druce Mt Kaputar N.P., N.S.W. 28 Jan. 1993 <em>Short 3952</em></td>
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<td><strong>Minuria DC.</strong></td>
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<td><em>M. cunninghamii</em> (DC.) Benth.</td>
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<td><em>M. integerrima</em> (DC.) Benth.</td>
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<td>18II</td>
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<td>28 km W of Condamine, N.S.W., 30 Sept. 1992, <em>Watanabe 35</em></td>
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<td><em>O. astrotricha</em> (F.Muell.) F.Muell. ex Benth.</td>
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<td><em>O. ferresii</em> (F.Muell.) F.Muell. ex Benth.</td>
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<tr>
<td><strong>O. imbricata</strong> (Turcz.) Benth.</td>
<td>9II</td>
<td></td>
</tr>
<tr>
<td>10 km SE of Ravensthorpe, W.A., 3 Sept. 1986, <em>Short 2662</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O. phlogopappa</strong> (Labill.) DC. complex</td>
<td>18II</td>
<td></td>
</tr>
<tr>
<td>Falls Creek, Vict., 2 March 1987 <em>Short 3035</em></td>
<td></td>
<td></td>
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<td><strong>O. pimelio;des</strong> (DC.) Benth.</td>
<td>9II</td>
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<td>53.5 km E of ‘Nallan’, W.A., 1986, <em>Lander 1391</em></td>
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<tr>
<td><strong>O. plucheacea</strong> Lander</td>
<td>9II</td>
<td></td>
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<tr>
<td>Kennedy Range, W.A., 20 Aug. 1986, <em>Short 2535</em></td>
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<tr>
<td><strong>O. rullulosa</strong> (Labill.) Benth. complex</td>
<td>9II</td>
<td></td>
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<td>Golton Gorge, Grampians, Vict. 11 Sept. 1986, <em>RBG 86/1735</em></td>
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<td><strong>O. rudis</strong> (Benth.) Benth.</td>
<td>9II</td>
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<tr>
<td>19 km SW of Three Springs, W.A., 9 Sept. 1986, <em>Short 2795</em></td>
<td></td>
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<td>10 km S of Mt Hope, N.S.W., 16 Sept. 1987, <em>Short 3078</em></td>
<td></td>
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<td>17 km N of Patchewollock, Vict., 25 Aug. 1988, <em>Short 3174</em></td>
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<td><strong>O. stuartii</strong> (F.Muell.) Benth.</td>
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<td></td>
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<td>Kennedy Range, W.A., 20 Aug. 1986 <em>Short 2538</em></td>
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<td><strong>O. xerophila</strong> (F.Muell.) Benth.</td>
<td>9II</td>
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<tr>
<td>Dales Gorge, W.A., 30 Aug. 1995, <em>Short 4275</em></td>
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<tr>
<td><strong>Olearia sp.</strong></td>
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<td><strong>Solenogyne Cass.</strong></td>
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<tr>
<td><strong>S. dominii</strong> L.G.Adams</td>
<td>18</td>
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TABLE 1. CONTINUED

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<td><strong>Vittadinia A.Rich.</strong></td>
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<td><em>V. cuneata</em> DC. var. <em>hirsuta</em> N.T.Burb.</td>
<td>9II</td>
<td>18</td>
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<tr>
<td>4 km NE of Milmerran, Qld, 29 Sept. 1992, Watanabe 26</td>
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<td><em>V. gracilis</em> (Hook.f.) N.T.Burb.</td>
<td>9II</td>
<td></td>
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<tr>
<td>2 km W of Hines Hill, W.A., 23 Oct. 1995, Short 4450</td>
<td></td>
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<td>Ulupna Island, Vict., 25 Jan. 1993, Short 3925</td>
<td>9II</td>
<td></td>
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<tr>
<td><em>V. muelleri</em> N.T.Burb.</td>
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<td></td>
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<tr>
<td>44 km NE of Narrabri, N.S.W., 26 Sept. 1992, Watanabe 14</td>
<td></td>
<td></td>
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<td><em>V. pterochaeta</em> (F.Mueil. ex Benth.) J.M.Black</td>
<td>9II</td>
<td></td>
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<tr>
<td>24 km NE of Wirrealfa, S.A., 3 Oct. 1992, Watanabe 57</td>
<td></td>
<td></td>
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<tr>
<td><em>V. pustulata</em> N.T.Burb.</td>
<td>9II</td>
<td></td>
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<tr>
<td>28 km W of Condamine, N.S.W., 30 Sept. 1992, Watanabe 36</td>
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<tr>
<td><em>V. sulcata</em> N.T.Burb.</td>
<td>9II</td>
<td></td>
</tr>
<tr>
<td>c. 10 km S. of Wild Dog Glen, S.A., 20 Oct. 1993, Watanabe 190</td>
<td></td>
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</table>

**BRACHYSCOME**

As in Watanabe & Short (1992) our references to species and species complexes in Tables I & II are largely the concepts of Davis (1948, 1949, 1955, 1959) and Smith-White *et al.* (1970) although the concept of ‘superspecies’ is not used. As we are primarily concerned here with the presentation of new chromosome number determinations and with reviewing chromosome numbers in the Australian Astereae, further comments on species or generic delimitation are here kept to a minimum. Such problems will be the subject of future papers and will follow after the completion of detailed anatomical, morphological, cytological and macromolecular studies.

As currently recognised *Brachyscome* is a genus of more than 80 species and occurs in Australia, New Guinea and New Zealand. Of these, over 70 species are confined to Australia. Davis (1948) recognised two subgenera within *Brachyscome*, i.e. ‘*Eubrachyscome*’ and ‘*Metabrachyscome*’. They are illegitimate names but are frequently adopted in cytological papers (e.g. Smith-White *et al.* 1970).

The majority of species were referred by Davis to ‘subgenus *Eubrachyscome*’ and this group was the subject of cytological investigations by Smith-White *et al.* (1970). They found an array of chromosome numbers in the group and suggested that it represents a reducing series, i.e. $x = 9$ to $x = 2$. It was also noted that most species with $n = 9$ (including polyploids) are mesic, perennial species. In contrast, species of arid regions frequently display an annual habit and this is correlated with lower chromosome numbers. Chromosome number determinations by Watanabe & Short (1992), and in this paper for species not examined by Smith-White *et al.*, are consistent with these observations. Thus *B. goniocarpa* ($n = 4$), *B. gracilis* ($n = 4$), *B. muelleri* ($n = 3$) and *B. muelleroides* ($n = 3$) are all annual species which occur in arid, or seasonally dry areas.
As noted by Carter (1978a), species referred by Davis to ‘subgenus *Metabrachyscome*’ are chromosomally conservative compared to members of ‘*Eubrachyscome*’. All species have *x* = 9, with polyploidy mainly confined to the *B. ciliaris* complex. Many of the species are also annuals confined to arid regions.

The *B. iberidifolia* complex referred to in both Tables is mainly confined to Western Australia and includes *B. bellidioides* and *B. pusilla*. The complex belongs to ‘subgenus *Metabrachyscome*’. There is considerable diversity in collections referred by us to this complex and additional taxa undoubtedly should be recognised.

The chromosome complements of *B. nivalis* (*2n* = 22), *B. radicans* (*2n* = 26), *B. tenuiscapa* aff. var. *tenuiscapa* (*2n* = 28) and *B. stolonifera* (*2n* = 30) are markedly different from those found in most other species, their karyotypes displaying two different sizes of chromosomes. This is in marked contrast to the unimodal karyotypes found in species with *2n* = 18. However, species with chromosome numbers less than *2n* = 18 frequently have bimodal karyotypes, a feature explained by descending aneuploidy caused by reciprocal translocation and loss of centromeric fragments. Species with chromosome numbers greater than *2n* = 18 are perhaps amphidiploids originating as a result of hybridization between taxa with chromosome numbers less than *n* = 9.

Both the array of chromosome numbers and the discrepancies in numbers reported by us with those published by Smith-White *et al.* (1970) for *B. diversifolia*, *B. microcarpa*, *B. multifida* and *B. nova-anglica* may in part be the result of misidentification. However, they primarily reflect the morphological complexity of the taxa concerned. More work is required to clarify the delimitation of the various entities in these complexes and therefore discussion of the significance of chromosome numbers in these taxa is premature.

**CALOTIS**

A genus containing 28 formally recognised species *Calotis* mainly occurs in semi-arid and arid regions of Australia. Stace (1978, 1982) has reported on the cytoevolution of the genus and noted two significant trends, i.e. a reduction from a base of *x* = 8 down to *x* = 4 in the mainly arid zone annuals, and a high degree of polyploidy. Two-thirds of the species were found to be polyploids and this condition was found to be as frequent in low chromosome number annuals as in high chromosome number perennials.

Our data presented in Table I support the observations made by Stace.

**CELMISIA**

*Celmisia* contains about 70 species confined to Australia and New Zealand. They are mainly found in alpine regions and most are endemic to New Zealand, only about ten species occurring in Australia. *Celmisias* are perennial herbs or subshrubs of diverse habit and a cytological survey of 65 species (Hair 1980, Given & Gray 1986) indicates that most are at least 12-ploid, with *n* = 54. Haploid numbers of *n* = 54 and *n* = 108 have been found in Australian species.

**CERATOGYNE**

*Ceratogyne obionoides*, the only member of this genus, is an annual species with *n* = 6 and is found throughout much of arid Australia.

**ERODIOPHYLLUM**

A ditypic genus, *Erodiophyllum* occurs in semi-arid and arid mainland Australia. Both species are perennial herbs with *n* = 8.
TABLE II. SUMMARY OF CHROMOSOME NUMBER DETERMINATIONS IN NATIVE AUSTRALIAN ASTEREAE

<table>
<thead>
<tr>
<th>Species</th>
<th>n</th>
<th>2n</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachyscome Cass.</td>
<td>9,18</td>
<td>18</td>
<td>Stace 1981; Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. aculeata (Labill.) Cass. ex Lessing</td>
<td>0-6Bs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. aff. aculeata (Mt Gingera)</td>
<td>9 + 1B</td>
<td></td>
<td>Stace 1981</td>
</tr>
<tr>
<td>B. aff. aculeata (Halls Gap)</td>
<td>27</td>
<td></td>
<td>Stace 1981</td>
</tr>
<tr>
<td>B. angustifolia A.Cunn.ex DC. var. angustifolia</td>
<td>9</td>
<td></td>
<td>Smith-White et al. 1970</td>
</tr>
<tr>
<td>var. heterophylla (Benth.) G.L.R.Davis</td>
<td>9</td>
<td></td>
<td>Smith-White et al. 1970</td>
</tr>
<tr>
<td>B. sp. aff. angustifolia</td>
<td>5</td>
<td>10</td>
<td>Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. basaltica F.Muell. var. basaltica</td>
<td>8</td>
<td>16</td>
<td>Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
</tr>
<tr>
<td>var. gracilis Benth.</td>
<td>6</td>
<td>12</td>
<td>Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. breviscapis C.R.Carter</td>
<td>4</td>
<td>8</td>
<td>De Jong 1963; Smith-White et al. 1970; Carter 1978a; Watanabe &amp; Short 1992</td>
</tr>
<tr>
<td>B. cardiocarpa F.Muell. ex Benth.</td>
<td>9</td>
<td>36</td>
<td>Smith-White et al. 1970; Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. cheilocarpa F.Muell.</td>
<td>9</td>
<td></td>
<td>Carter 1978a; Watanabe et al. 1996</td>
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<tr>
<td>B. aff. cheilocarpa (A)</td>
<td>18</td>
<td></td>
<td>Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. aff. cheilocarpa (B)</td>
<td>9</td>
<td></td>
<td>Watanabe et al. 1996</td>
</tr>
<tr>
<td>B. chrysoglossa F.Muell.</td>
<td>4</td>
<td>8 + 0-3Bs</td>
<td>mith-White et al. 1970; Watanabe &amp; Short 1992</td>
</tr>
<tr>
<td>B. ciliaris (Labill.) Less. complex</td>
<td>9,18</td>
<td>27,36</td>
<td>De Jong 1963; Smith-White et al. 1970; Carter 1978a; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td></td>
<td>27, 36I</td>
<td>81</td>
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Fig. 1. Mitotic and meiotic chromosomes in Australian Astereae. A - Brachyscome muellerioides $n = 31$ (Watanabe 3). B - B. readeri $n = 51$ (Watanabe 4). C - B. sp. aff. nova-anglica $n = 51$ (Short 3969). D - B. sp. aff. angustifolia $2n = 10$ (Short 3979). E - B. tatei $n = 91$ (Watanabe 184). F - Minuria leptophylla $2n = 18$ (Watanabe 194). G - Vittadina gracilis $n = 91$ (Short 3925). H - Erodiphyllum elderi $2n = 16$ (Short 3779). Scale: 10 µm.
<table>
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<th>Species</th>
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<tr>
<td><em>B. ciliocarpa</em> W.Fitzg.</td>
<td>9</td>
<td>18+</td>
<td>0-2Bs Carter 1978a; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<tr>
<td><em>B. sp. aff. ciliocarpa</em></td>
<td>9</td>
<td></td>
<td>Watanabe et al. 1996</td>
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<tr>
<td><em>B. cuneifolia</em> Tate</td>
<td>9</td>
<td>18</td>
<td>Stace 1981</td>
</tr>
<tr>
<td><em>B. curvicarpa</em> G.L.R.Davis</td>
<td>4</td>
<td>8+</td>
<td>0-5Bs Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<tr>
<td><em>B. debilis</em> Sond.</td>
<td>3</td>
<td>6</td>
<td>Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td><em>B. decipiens</em> Hook.f.</td>
<td>9,27</td>
<td>18,54</td>
<td>Solbrig et al. 1964; Smith-White et al. 1970; Watanabe et al. 1996</td>
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<tr>
<td><em>B. dentata</em> Gaudich.</td>
<td>4,8,12</td>
<td>8,16</td>
<td>24+ 0-4Bs Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td><em>B. dissectifolia</em> G.L.R.Davis</td>
<td>6,12</td>
<td>12,24</td>
<td>Smith-White et al. 1970; Watanabe et al. 1996</td>
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<td><em>B. diversifolia</em> (Hook.) Fischer &amp; C. Meyer var. <em>diversifolia</em></td>
<td>12,16</td>
<td>24,</td>
<td>36+ 0-1B Smith-White et al. 1970; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td><em>B. eriogona</em> (J.M.Black) G.L.R. Davis</td>
<td>4</td>
<td>8</td>
<td>Smith-White et al. 1970, as <em>B. campylocarpa</em> sp. <em>A</em>; Watanabe &amp; Short 1992</td>
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<tr>
<td><em>B. exilis</em> Sond.</td>
<td>9</td>
<td>18</td>
<td>Carter 1978a; Watanabe et al. 1996</td>
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<tr>
<td><em>B. formosa</em> P.S.Short</td>
<td>9</td>
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<td>Short 1988; Watanabe et al. 1996</td>
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<td><em>B. glandulosa</em> (Steetz) Benth.</td>
<td>36</td>
<td></td>
<td>Watanabe et al. 1996</td>
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<td><em>B. goniocarpa</em> Sond. &amp; F.Muell.</td>
<td>4</td>
<td>8</td>
<td>Watanabe et al. 1991; Watanabe &amp; Short 1992</td>
</tr>
<tr>
<td><em>B. gracilis</em> G.L.R. Davis</td>
<td>4</td>
<td>8</td>
<td>Smith-White et al. 1970, as <em>B. diversifolia</em> var. <em>dissecta</em> G.L.R. Davis; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td><em>B. graminea</em> (Labill.) F.Muell.</td>
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<td>18</td>
<td>Smith-White et al. 1970; Watanabe et al. 1996</td>
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<td><em>B. halophila</em> P.S.Short</td>
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<td>18</td>
<td>Short 1988; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
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<td><em>B. iberidifolia</em> Benth.</td>
<td>9 +</td>
<td>18</td>
<td>De Jong 1963; Chouksanova et al. 1968; Gupta 1969; Turner 1970, including specimens referred to <em>B. bellidioides</em>; Carter 1978a; Keighery 1978; Gupta &amp; Gill 1983, 1989; Watanabe et al. 1996</td>
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<td><em>B. latisquamea</em> F.Muell.</td>
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<td>18</td>
<td>Carter 1978a; Watanabe et al. 1996</td>
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<td><em>B. leptocarpa</em> F.Muell.</td>
<td>3</td>
<td>6</td>
<td>Smith-White et al. 1970, probably</td>
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<td>2n</td>
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<td>----------------------------------------------------------------------</td>
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<td></td>
<td>4II + 2I</td>
<td>16</td>
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<td><strong>B. lyrifolia</strong> J.M.Black</td>
<td>9</td>
<td>18</td>
<td>Smith-White <em>et al.</em> 1970 and Carter 1978, as to Parachila collections of B. ciliaris; Watanabe &amp; Short 1992</td>
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<td><strong>B. melanocarpa</strong> Sond. &amp; F.Muell.</td>
<td>6,12</td>
<td>12,30</td>
<td>Smith-White <em>et al.</em> 1970; Watanabe &amp; Short 1992; Watanabe <em>et al.</em> 1996</td>
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<td><strong>B. microcarpa</strong> F.Muell.</td>
<td>6, 10</td>
<td>12</td>
<td>Smith-White <em>et al.</em> 1970; Watanabe <em>et al.</em> 1996</td>
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<td>10II + 4I</td>
<td>12</td>
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<td><strong>B. muelleri</strong> Sond.</td>
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<td>6</td>
<td>Watanabe &amp; Short 1992</td>
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<td><strong>B. muelleroides</strong> G.L.R.Davis</td>
<td>3</td>
<td>6</td>
<td>Watanabe <em>et al.</em> 1996</td>
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<td><strong>B. multicaulis</strong> F.Muell.</td>
<td>9</td>
<td>18</td>
<td>Watanabe &amp; Short 1992, as B. rigidula</td>
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<td><strong>B. aff. multicaulis</strong></td>
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<td>18 + 0-2Bs</td>
<td>Watanabe <em>et al.</em> 1996</td>
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<td><strong>B. multifida</strong> DC. complex</td>
<td>7,9</td>
<td>14,18</td>
<td>Smith-White <em>et al.</em> 1970, including var. dilatata Benth. and var. multifida; Watanabe &amp; Short 1992; Watanabe <em>et al.</em> 1996</td>
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<th>2n</th>
<th>Notes</th>
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<td><em>B. nova-anglica</em> G.L.R.Davis</td>
<td>Smith-White et al. 1970, a count of 3n = 18 is probably erroneous; Watanabe et al. 1996</td>
<td>7</td>
<td>14</td>
<td></td>
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<td>Watanabe et al. 1996</td>
<td>5</td>
<td>10</td>
<td></td>
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<tr>
<td><em>B. aff. nova-anglica (B)</em></td>
<td>Smith-White et al. 1970, as B. nova-anglica; Watanabe et al. 1996</td>
<td>6</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td><em>B. obovata</em> G.L.R.Davis</td>
<td>Watanabe et al. 1996</td>
<td>18</td>
<td></td>
<td></td>
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<tr>
<td><em>B. oncocarpa</em> Diels</td>
<td>Carter 1978a; Watanabe et al. 1996</td>
<td>9</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><em>B. papillosa</em> G.L.R. Davis</td>
<td>Smith-White et al. 1970; Watanabe et al. 1996</td>
<td>4+</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><em>B. perpusilla</em> (Steetz) J.M.Black</td>
<td>Smith-White et al. 1970; Carter 1978a; Watanabe &amp; Short 1992; Watanabe et al. 1996</td>
<td>9</td>
<td>18,36</td>
<td></td>
</tr>
<tr>
<td><em>B. petrophila</em> G.L.R. Davis</td>
<td>Watanabe et al. 1996</td>
<td>18</td>
<td></td>
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**ERIGERON**
Given (1973) and Given & Gray (1986) noted that Australian species of *Erigeron* should be excluded from that genus. Nesom (1994a,b) has subsequently referred most Australian species to three genera, i.e. *Lotasperma* Nesom, *Lagenithrix* Nesom and *Pappochroma* Labill. (syn. *Lagenopappus* Nesom), but has left the placement of *E. conyzoides* F.Muell. unresolved. Cladistic studies (by PSS) in Australian Astereae do not wholly support Nesom’s treatment and will be the subject of a future paper.

The alpine *E. pappochroma* complex (*Lagenithrix* & *Pappochroma* sensu Nesom) seemingly has affinities with the *Olearia-Celmisia* complex (Given & Gray 1986) and could be expected to have a base of $x = 9$.

The count of $2n = 36$ for the introduced *E. karvinskianus* is consistent with those obtained by Montgomery & Yang (1960, as *E. mucronatus* DC.).

**LAGENIFERA & SOLENOGYNE**
Whether or not *Solenogyne* is deserving of generic rank or should be relegated to synonymy under *Lagenifera* has been the subject of debate for some years (Drury 1974, Adams 1979). They are here maintained as separate genera pending further work. All species are perennials and tend to be found in mesic conditions. Our chromosome number determinations, i.e. $n = 9$ and $2n = 18$, are consistent with the observations of previous workers (Smith-White *et al.* 1970, Turner 1970, Adams 1979).

**KIPPSTIA & MINURIA**
Eleven species are currently placed in this genus (Lander & Barry 1980b, Lander 1987b, Short 1991) although one, *M. macrorhiza*, should possibly be reinstated as *Eurybiopsis* (see below). All but one, *M. annua* (Tate) J.M.Black, are apparently perennial herbs or small shrubs although several, including *M. muliseta* P.S.Short may be short lived. We have confirmed earlier reports of $n = 9$ for *M. cunninghamii* and *M. leptophylla* (Turner 1970, Short 1986) and here record the tetraploid condition for *M. integerrima*. The presence of B chromosomes is here reported for the first time in this genus.

*Kippstia*, a monotypic genus, at one time relegated to synonymy under *Minuria* but reinstated by Lander & Barry (1980a), is seemingly very closely related to the latter genus. *K. suaedifolia* is a small shrub with $n = 9$. 
cultivation of specimens and the preparation of material for chromosome number determinations the procedures of Smith-White et al. (1970) and Watanabe et al. (1975) were followed. Herbarium vouchers have been gathered for all but two species (Brachyscome petrophila and Olearia ramulosa) and a complete set of vouchers is housed at MEL. An incomplete set will be deposited in TI and voucher specimens of non-Victorian populations will be deposited in the major government herbarium (AD, BRI, NSW, PERTH) of the State from which collections were gathered.

Results
Chromosome number determinations from 200 populations attributed to 99 species or infraspecific taxa of ten genera are presented in Table 1. They include the first substantiated reports for Brachyscome glandulosa (2n = 36), B. muelleroides (n = 3), B. obovata (2n = 18), B. petrophila (2n = 18), B. Tatei (n = 9), Erodiophyllum elderi (2n = 16), Minuria gardneri (n = 9), M. integrifolia (n = 18), Olearia astrotricha (n = 9), O. ferresii (n = 9), O. imbricata (n = 9), O. plucheaecae (n = 9), O. ramulosa (n = 9), O. xerophila (n = 9), Vittadinia cuneata (n = 9), V. gracilis (n = 9), V. muelleri (n = 9), V. pterochaeta (n = 9), V. pustulata (n = 9) and V. sulcata (n = 9). Some reports for apparently distinct, but undescribed, taxa such as Calotis aff. lappulacea (n = 8) and B. tenuiscapa aff. var. tenuiscapa (2n = 28) are also presented, as are new determinations for some previously examined taxa, e.g. Brachyscome microcarpa (n = 6, 2n = 12; cf. n = 10 reported by Smith-White et al. 1970). Polyploidy is reported for the first time in Brachyscome dissectifolia, B. cardiorpapa, Calotis anthemoides and in the Olearia phlogopappa complex and B chromosomes are newly reported in Brachyscome ciliocarpa, B. diversifolia, B. iberidifolia, B. trachycarpa, Minuria leptophylla and Olearia pinelioioides.

The meiotic or mitotic chromosomes of some species are displayed in Fig. 1.

The new data is incorporated (by reference to Watanabe et al. 1996) in Table II which summarises known chromosome numbers for taxa of Australian Astereae.

Discussion
As previously pointed out (Watanabe & Short 1992) there are many taxonomic problems within Brachyscome. There are unresolved species complexes, e.g. B. nova-anglica and its allies and the B. ciliaris complex, and generic delimitation is also a problem. The same is true for many of the other genera and the placement of Isotopsis in the Astereae is debatable and perhaps not tenable (Bremer & Anderberg in Bremer 1987, Bruhl & Quinn 1990, Bremer & Humphries 1993). Although there are taxonomic problems it is none the less possible to generally review the state of knowledge of chromosome numbers in the Australian Astereae. An absence of chromosome numbers for some genera, i.e. Achnophora, Camptacra, Dichrocephala, Dichromochlamys, Dimorphocoma and Elachanthes is unfortunate, although between them these genera contain only 12 Australian species.

TABLE 1. NEW CHROMOSOME NUMBER DETERMINATIONS FOR AUSTRALIAN ASTEREAE

<table>
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<tr>
<th>Species &amp; locality</th>
<th>n</th>
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<tr>
<td><strong>Brachyscome</strong>  Cass.</td>
<td></td>
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<tr>
<td>B. aculeata (Labill. ) Less.</td>
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<td>Kosciusko N.P., N.S.W.,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Feb. 1993, Short 3982</td>
<td>911</td>
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<td>Sawpit Creek, Kosciusko N.P.,</td>
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<tr>
<td>N.S.W., 4 Feb. 1993, Short 3996</td>
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OLEARIA
OLEaria consists of about 180 species and occurs in Australia, New Guinea and New Zealand. About 130 species occur in Australia (Lander 1992) and the genus is currently under revision. All species are shrubs and the genus is widespread in alpine, temperate and arid regions of Australia. Few species have been cytologically examined but our data are consistent with the finding for New Zealand species that the base number is $x = 9$. However, most Australian species are diploids, a contrast to the situation in New Zealand where only 12-, 14-, 32- and 48-ploid levels have been recorded (Beuzenberg & Hair 1984). For the first time B chromosomes are also reported for this genus, having been observed by us in *O. pimelioides*.

VITTADINIA, CAMPTACRA & EURYBIOPSIS
Burbidge (1982) revised *Vittadinia* and recognised 29 species, most of which are confined to Australia. She segregated two further genera, describing ditypic *Camptacra* (Lander 1987b) and reinstating monotypic *Eurybiopsis*. Lander (1987a) has subsequently reduced *Eurybiopsis* to synonymy under *Minuria* although more recent work by Wiggins (1990) suggests that the former genus should be maintained.

Chromosome counts are lacking for *Camptacra* and *Eurybiopsis* and until now for all but one species of *Vittadinia*. Chromosome numbers are now known for seven species (Table 11). Of these, three are, or possibly are, annuals. All seven species have $n = 9$. One of these is more or less confined to temperate areas, the others extend from temperate to arid areas.

Base numbers and comparisons
With the exception of *Isoetopsis*, which possibly should be placed in the Gnaphalieae (Bremer & Humphries 1993), ditypic *Erodiophyllum*, monotypic *Ceratogyne*, and the essentially arid-zone genus *Calotis*, all Australian genera for which data are available have one or more species with $n = 9$ or a base number that is a multiple of 9. Therefore, it seems reasonable to conclude that $x = 9$ is the base number for the Australian Astereae, a conclusion that is in keeping with previous findings for the tribe Astereae (Raven et al. 1960, Solbrig et al. 1964, 1969). Following a survey of mainly Northern Hemisphere genera (38 out of 53) and some Southern Hemisphere genera (22 out of 65) Solbrig et al. (1964) also noted that many species with low chromosome numbers ($n = 4$ & 5) belong to mainly annual genera that are concentrated in southwestern North America and that low numbers were probably correlated with dry habitats. As noted above, the same correlations are apparent in annual species of *Brachyscome* 'subgenus *Eubrachyscome*', *Calotis* and *Ceratogyne*. Chromosomal variation in Australian Astereae is clearly similar to that found in North America. In fact, although fewer chromosome number determinations were available to him, Turner (1970) previously suggested this to be the case, not just for the tribe Astereae, but the entire family.

Acknowledgement
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References


Revised paper received 20 April 1995; last update 24 November 1995.
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<td>6 km from Cathcart toward Rocky Hall, 9 Feb. 1993, N.S.W., Short 4010</td>
<td>9II</td>
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<td>Bundara R. crossing on Omeo to Tallangatta road, Vict., 9 Feb. 1993, Short 4018</td>
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**B.** sp. aff. *angustifolia* A. Cunn. ex DC.
Mt Kaputar N.P., N.S.W., 28 Jan. 1993, *Short 3944*

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<tr>
<td>Polblue Picnic Site, Barrington Tops State Forest, N.S.W., 1 Feb. 1993, <em>Short 3981</em></td>
<td>5II</td>
<td>10</td>
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**B. basaltica** F.Muell.
var. *basaltica*
4 km NE of Millmerran, Qld, 29 Sept. 1992, *Watanabe 25*

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<td>var. <em>gracilis</em> Benth.  14 km N of Booligal, N.S.W., 6 Sept. 1992, <em>Watanabe 76</em></td>
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**B. cardiocarpa** F.Muell. ex Benth.
Digby to Strathdownie road, Vict., 3 Sept. 1990, *Short 3919*

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**B. cheilocarpa** F.Muell.
94 km N of Galena Bridge on NW Coastal Hwy, W.A., 6 Oct. 1993, *Short 4083*

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<td>1 km W of NW Coastal Hwy along road to Blowholes, W.A., 7 Oct. 1993, <em>Short 4097</em></td>
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**B. aff. cheilocarpa (A)**
Pt Quobba, W.A., 7 Oct. 1993, *Short 4091*
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<td><strong>B. ciliaris</strong> (Labill.) Less. complex</td>
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<td>4 km NE of Millmerran, Qld, 29 Sept. 1992, <em>Watanabe 27</em></td>
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<td>63 km W of Balladonia, W.A., 1 Oct. 1993, <em>Watanabe 103</em></td>
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<td>41 km E of Quilpie, Qld, 17 Aug. 1989, <em>Short 3607</em></td>
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<td><strong>B. curvicarpa</strong> G.L.R. Davis</td>
<td>4II + BI</td>
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<td>59.5 km SW of Bourke, N.S.W., 2 Oct. 1992, <em>Watanabe 41</em></td>
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<td><strong>B. decipiens</strong> Hook.f.</td>
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<td>Sawyers Hill, Kosciusko N.P. N.S.W., 3 Feb. 1993, <em>Short 3986</em></td>
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<td><strong>B. dentata</strong> Gaudich.</td>
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<td>4II + BI</td>
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<td>Dalby, N.S.W., 30 Sept. 1992, <em>Watanabe 29</em></td>
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<td>44 km SW of Louth, N.S.W., 2 Oct. 1992, <em>Watanabe 46</em></td>
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<td>80 km SE of Broken Hill, N.S.W., 6 Oct. 1992, <em>Watanabe 70</em></td>
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<td>3 Oct. 1992, <em>Watanabe 53</em></td>
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<td>c. 43 km SE of Broken Hill, N.S.W., 22 Oct. 1993, Watanabe 203</td>
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<td>20 km E of Elmore, Vict., 7 Oct. 1992, Watanabe 77</td>
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<td>B. diversifolia (Hook.) Fischer &amp; Meyer</td>
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<td>B. gracilis G.L.R. Davis</td>
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<td>Green Cape Lighthouse, N.S.W. 7 Feb. 1993, Short 4015</td>
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<td>B. halophila P.S.Short</td>
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<td>13 km N of Carnamah, W.A., 5 Oct. 1993, Short 4072</td>
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<td>Yellowdine, W.A., 2 Oct. 1993, Watanabe 113</td>
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<td>Lake Wallanbin, W.A., 11 Oct. 1993, Watanabe 164</td>
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<td>Pt Quobba, W.A., 7 Oct. 1993, Short 4090</td>
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<td><strong>B. melanocarpa</strong> Sond. &amp; F.Muell</td>
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<th>n</th>
<th>2n</th>
</tr>
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<tbody>
<tr>
<td><strong>B. microcarpa</strong> F.Muell.</td>
<td></td>
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<tr>
<td>6 km S of Boonoo Boonoo, N.S.W., 30 Jan. 1993, <em>Short 3970</em></td>
<td>6II</td>
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<tr>
<th>Species &amp; locality</th>
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<tr>
<td><strong>B. muelleroides</strong> G.L.R.Davis</td>
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<table>
<thead>
<tr>
<th>Species &amp; locality</th>
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<tr>
<td><strong>B. aff. multicaulis</strong> F.Muell.</td>
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<tr>
<td>8 km W of Kiandra, N.S.W., 3 Feb. 1993, <em>Short 3988</em></td>
<td>9II</td>
<td>18 + 0-2Bs</td>
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<thead>
<tr>
<th>Species &amp; locality</th>
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<th>2n</th>
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<tbody>
<tr>
<td><strong>B. multifida</strong> DC. complex</td>
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<tr>
<td>3 km S of Glen Alpin, Qld, 30 Jan. 1993, <em>Short 3965</em></td>
<td>7II</td>
<td></td>
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<tr>
<td>Nr Clover Flat along Big River Fire Track, Vict., 9 Feb. 1993, <em>Short 4021</em></td>
<td>9II</td>
<td>18</td>
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