

DOCUMENTED CHROMOSOME NUMBERS 1993:1. CHROMOSOME NUMBER REPORTS IN COMPOSITAE WITH EMPHASIS ON TRIBE ASTEREAEE OF THE SOUTHWESTERN UNITED STATES AND MEXICO

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ABSTRACT

A total of 78 counts for 64 taxa of Compositae are presented. Of these, five are for previously uncounted taxa: *Grindelia camporum* var. *bracteosa* ($n = 12$), *G. confusa* ($n = 6$), *Isocoma tenuisecta* ($n = 6_{II}$, 12_{II}), *Conoclinium betonicifolium* ($n = 10_{II}$), and *Gnaphalium schraderi* ($n = 14_{II}$). Three counts are reports of previously unreported ploidy levels for the taxa they represent. Two counts are of interest because they conflict with earlier reports: *Geissolepis suaedaefolia* ($n = 9_{II}$) and *Vanceleva stylosa* ($2n = 12$).

RESUMEN

Se presentan un total de 78 recuentos para 64 taxa de Asteraceae. De estos, cinco pertenecen a taxa que no habían sido recontados previamente: *Grindelia camporum* var. *bracteosa* ($n = 12$), *G. confusa* ($n = 6$), *Isocoma tenuisecta* ($n = 6_{II}$, 12_{II}), *Conoclinium betonicifolium* ($n = 10_{II}$), y *Gnaphalium schraderi* ($n = 14_{II}$). Tres recuentos ofrecen niveles de ploidía no citados previamente para los taxa afectados. Dos recuentos son de interés porque están en contradicción con recuentos previos: *Geissolepis suaedaefolia* ($n = 9_{II}$) y *Vanceleva stylosa* ($2n = 12$).

In this paper, we report 78 chromosome counts for 64 taxa of Compositae representing the tribes Astereae, Eupatorieae, Heliantheae, Inuleae and Tageteae. The chromosome numbers of five of these taxa were previously unknown, and three of our counts appear to be reports of additional ploidy levels for taxa reported earlier. The numbers obtained for two species in this study differ from the single previous reports in each case; these are discussed below.

As observed by Ralston et al. (1989), it is becoming increasingly difficult to discover whether or not newly obtained chromosome counts previously have been reported. However, to the best of our knowledge (all standard plant chromosome number indices and the computerized BIOSIS® database have been searched) the counts reported here as new are new, and the others are in agreement with the information in various reference works. Conversion of the data contained in the several printed indices into a machine-readable and -searchable database is much to be desired. As was noted by Strother (1972), biosystematic studies are enhanced by knowledge of variation in chromosome number within and between

taxa, but the flood of such information is becoming increasingly difficult to encompass without computer assistance.

METHODS AND MATERIALS

Voucher specimens for all counts are deposited at COLO, KANU, RM or TEX, as noted in Table 1. Chromosome squashes, if prepared by the standard acetocarmine technique, were made from buds field-collected into 3:1 EtOH:acetic acid and subsequently stored at minus 20°C in 70% EtOH. Buds for squashes made using the FLP method of Jackson (1973) were collected into 3:1 EtOH:propionic acid; subsequent storage was similar. Permanent reference slides were made in all cases and are on file at KANU; those of acetocarmine squashes were preserved in Hoyer's medium, and those of FLP squashes in Canada balsam diluted with propionic acid (Jackson 1973). All collections are those of MAL; counts were made by JL and MAL. Micrographs (Fig. 1) were made on an Olympus compound microscope at a magnification of $\times 1000$ (phase-contrast, oil immersion) using 4 $\times$ 5 Polaroid P/N55 film.

DISCUSSION

Astereae—Most of the counts for the 41 taxa of this tribe (Table 1) are consistent with the present state of knowledge about the base chromosome numbers of the genera. *Grindelia camporum* var. *bracteosa* ($n = 12_{II}$), *G. confusa* ($n = 6_{II}$), and *Isocoma tenuisecta* ($n = 6_{II}$, 12_{II}) were uncounted prior to this study.

New ploidy levels are reported for three taxa. Counts for *Erigeron strigosus* and *Isocoma rusbyi* appear to represent tetraploids relative to the previously reported

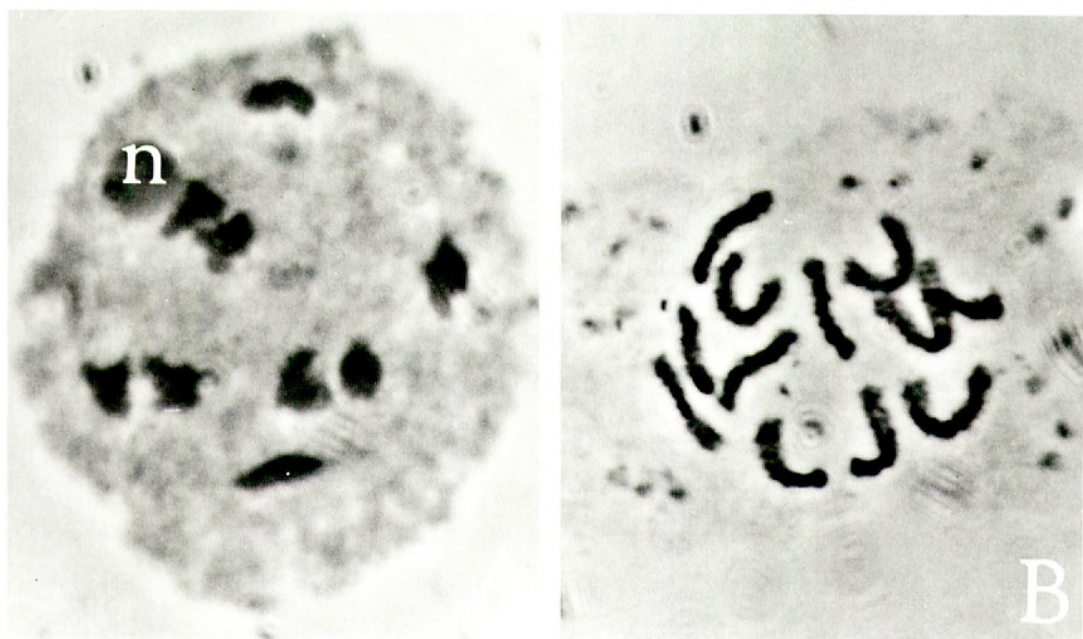


FIG. 1. A. *Geissolepis suaeaeifolia* pollen parent cell showing nine pairs of chromosomes (n = nucleolus). B. *Vancleavea sylvosa* mitotic cell with twelve chromosomes.

Table 1. Chromosome counts for 64 taxa of Compositae. All counts were made from meiosis (usually diplotene) in pollen parent cells except as noted. Collection numbers are those of MAL; vouchers are deposited as indicated by herbarium acronym. * = Taxon previously unreported. ** = Previously unreported ploidy level. *** = Count differs from previous reports. † = Meiosis irregular: most cells had 10 bivalents, a ring of 4, and 4 supernumerary chromosomes.

Taxon	Gametic chromosome number	Voucher (repository)
ASTEREAE		
<i>Aphanostephus ramosissimus</i> DC. var. <i>humilis</i> (Benth.) Turner & Birdsong	4 _{II}	Mexico: San Luis Potosi: 2.3 mi N of Las Tablas, 2914 (TEX)
<i>Aphanostephus skirrhobasis</i> Trel.	3 _{II}	Texas: Bastrop Co.: 6 mi SE of Bastrop, 3239 (KANU)
<i>Croptilon hookerianum</i> House var. <i>graniticum</i> (E. B. Smith) E. B. Smith	7 _{II}	Texas: Burnet Co.: Inks Lake State Park, 3233 (KANU)
<i>Ericameria arborescens</i> E. Greene	9 _{II}	California: Contra Costa Co.: Univ. of California Botanic Garden, 3260 (KANU)
<i>Erigeron delphinifolius</i> Willd.	9 _{II}	Mexico: Durango: 26.5 km N of El Piño, 2733 (TEX)
** <i>Erigeron strigosus</i> E. Greene	18 _{II}	Mexico: Chihuahua: 11.1 km S of La Junta, 2501 (TEX)
*** <i>Geissolepis suaedaefolia</i> Robinson	9 _{II}	Mexico: San Luis Potosi: 0.7 mi N of Las Tablas, 2911 (TEX)
<i>Grindelia camporum</i> E. Greene var. <i>camporum</i>	6 _{II}	California: Kern Co.: jct. of IH5 and CA hwy 46, 3097 (KANU); Los Angeles Co.: Elizabeth Lake Rd. 0.25 mi E of Green Valley Rd., 3094 (KANU); Fresno Co.: Tranquillity, along Fresno River, 3100 (KANU)
<i>Grindelia camporum</i> E. Greene var. <i>camporum</i>	12 _{II}	California: San Luis Obispo Co.: jct. of US101 and CA hwy 58, 3098 (KANU); Merced Co.: CA hwy 165 at San Joaquin River, 3102 (KANU); Santa Clara Co.: Pacheco Pass, E of San Felipe, 3103 (KANU); Contra Costa Co.: Pinole, along San Pablo Blvd., 3104 (KANU)
* <i>Grindelia camporum</i> E. Greene var. <i>bracteosa</i> (J. Howell) M. A. Lane	12 _{II}	California: Los Angeles Co.: seaward edge of Pepperdine Univ. campus, 3092 (KANU); San Benito Co.: Parkfield grade, 2.2 mi from CA hwy 198, 3251 (KANU)
* <i>Grindelia confusa</i> Steyerl.	6 _{II}	Mexico: Durango: 23.2 km W of Guadalupe Victoria on hwy 40, 2276 (TEX); 12.3 km W of Guadalupe Victoria on hwy 40, 2273 (TEX)
<i>Grindelia camporum</i> E. Greene × <i>G. stricta</i> DC. var. <i>angustifolia</i> (A. Gray) M. A. Lane	12 _{II}	California: Solano Co.: CA hwy 37, W of CA hwy 29 and NE of Napa R. bridge, 3105 (KANU)
<i>Grindelia hirsutula</i> Hook. & Arn. var. <i>ballii</i> (Stey.) M. A. Lane	6 _{II}	California: San Diego Co.: 2.7 mi E of Julian, 3088 (KANU)
† <i>Grindelia hirsutula</i> Hook. & Arn. var. <i>davyi</i> (Jepson) M. A. Lane	10 _{II} + R4 + 4B	California: Madera Co.: Nippanawasee, along CA hwy 49, 3101 (KANU)

Table 1. (continued)

Taxon	Gametic chromosome number	Voucher (repository)
<i>Grindelia hirsutula</i> Hook. & Arn. var. <i>davyi</i> (Jepson) M. A. Lane	12 _{II}	California: Colusa Co.: 4.5 mi E of College City, 3107 (KANU); 2 mi E of Colusa on CA hwy 20, 3108 (KANU)
<i>Grindelia squarrosa</i> (Pursh) Dunal var. <i>serrulata</i> (Rydberg) Steyerf.	6 _{II}	Colorado: Moffatt Co.: Dinosaur Nat. Mon., Deerlodge CG on Yampa R., 2933 (COLO)
<i>Grindelia stricta</i> DC. var. <i>angustifolia</i> (A. Gray) M. A. Lane	12 _{II}	California: Solano Co.: CA hwy 37, Napa R. bridge, 3106 (KANU)
<i>Grindelia stricta</i> DC. var. <i>platyphylla</i> (E. Greene) M. A. Lane $\times$ <i>G. nana</i> Nutt.?	12 _{II}	California: Humboldt Co.: Humboldt Redwoods St. Park, Mattole Rd., 3136 (KANU)
<i>Grindelia stricta</i> DC. var. <i>stricta</i>	12 _{II}	Washington: Clallam Co.: Sequim, 3145 (KANU)
<i>Gutierrezia microcephala</i> DC.	16 _{II}	Mexico: Nuevo Leon: 38 km E of Saltillo on hwy 40, 2583 (TEX)
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	4 _{II}	California: San Diego Co.: 2.7 mi E of Julian, 3089 (KANU)
<i>Haplopappus gracilis</i> (Nutt.) A. Gray	2 _{II}	Colorado: Archuleta Co.: ca. 20 mi W of Pagosa Springs, hwy 160, 2976 (COLO); New Mexico: Doña Ana Co.: 25.1 mi NE of Deming, hwy 26, 3078 (KANU)
<i>Heterotheca grandiflora</i> Nutt.	9 _{II}	California: San Diego Co.: CA hwy 94 at Otay Lakes Rd., 3085 (KANU)
<i>Heterotheca subaxillaris</i> Britton & Rusby	9 _{II}	Florida: Escambia Co.: Pensacola, 3241, 3242 (KANU)
<i>Isocoma acradenia</i> (E. Greene) E. Greene var. <i>eremophila</i> (E. Greene) Nesom	12 _{II}	California: San Diego Co.: 7.9 mi E of Julian, 3090 (KANU)
<i>Isocoma bartwegii</i> (A. Gray) E. Greene	6 _{II}	Mexico: San Luis Potosi: 23 km E of San Luis Potosi, 2925 (TEX)
** <i>Isocoma menziesii</i> (Hook. & Arn.) Nesom var. <i>menziesii</i>	6 _{II}	California: San Diego Co.: Marron Valley Rd., 5.4 mi S of CA hwy 94, 3087 (KANU)
	12 _{II}	California: San Diego Co.: Marron Valley Rd., 5.1 mi S of CA hwy 94, 3086 (KANU)
<i>Isocoma menziesii</i> (Hook. & Arn.) Nesom var. <i>vernonioides</i> (Nutt.) Nesom	12 _{II}	California: San Benito Co.: 5 mi S of var. Panoche Rd. on New Idria Rd., 3254 (KANU)
<i>Isocoma pluriflora</i> (Torrey & A. Gray) E. Greene	12 _{II}	New Mexico: Valencia Co.: jct. of IH25 and NM hwy 6, 3075 (KANU); Texas: Hudspeth Co.: 10 mi E of El Paso on IH10, 3079 (KANU)
** <i>Isocoma rusbyi</i> E. Greene	12 _{II}	Arizona: Gila Co.: jct. IH10 and Riggs Rd., 3082 (KANU)
* <i>Isocoma tenuisecta</i> E. Greene	6 _{II}	New Mexico: Hidalgo Co.: 15 mi E of AZ state line on IH10, 3081 (KANU)

Table 1. (continued)

Taxon	Gametic chromosome number	Voucher (repository)
	12 _{II}	Arizona: Cochise Co.: 6 mi S Cochise on Cochise Rd., 3083 (KANU)
<i>Lessingia filaginifolia</i> (Hook. & Arn.) M.A. Lane var. <i>filaginifolia</i>	5 _{II}	California: Contra Costa Co.: Univ. of California Botanic Garden, 3258 (KANU)
<i>Lessingia leptoclada</i> A. Gray	5 _{II}	California: Contra Costa Co.: Univ. of California Botanic Garden, 3256 (KANU)
<i>Lessingia nemaclada</i> E. Greene	5 _{II}	California: San Benito Co.: Parkfield grade, 10.4 mi from CA hwy 198, 3250 (KANU)
<i>Lessingia occidentalis</i> (H.M. Hall) M.A. Lane	5 _{II}	California: San Benito Co.: Parkfield grade, 10.4 mi from CA hwy 198, 3249 (KANU)
<i>Machaeranthera pinnatifida</i> (Hook.) Shinnars var. <i>chihuahuana</i> B. Turner & R.L. Hartman	4 _{II}	Mexico: Nuevo Leon: Estación Mariposa, 2885 (TEX); San Luis Potosi: 23 km E of San Luis Potosi, 2934 (TEX)
<i>Pityopsis aspera</i> (Shuttlew.) Small var. <i>adenolepis</i> (Fern.) Semple & Bowers	18 _{II}	Florida: Escambia Co.: ca. 1 mi W of Pensacola, 3243 (KANU)
<i>Prionopsis ciliata</i> (Nutt.) Nutt.	6 _{II}	Texas: Cooke Co.: US hwy 135 at Red River, 2586 (TEX); New Mexico: Doña Ana Co.: 25.1 mi NE of Deming, hwy 26, 3077 (KANU)
<i>Stenotus armerioides</i> Nutt.	9 _{II}	New Mexico: Taos Co.: Carson NF Tres Piedras RS, 3073 (RM)
<i>Stephanodoria tomentella</i> Robinson & Greenman	6 _{II}	Mexico: San Luis Potosi: Las Tablas, 2920 (COLO)
*** <i>Vanceleva stylosa</i> (Eastw.) E. Greene	2n = 12	Utah: Kane Co.: Glen Canyon NRA, Paria Canyon RS, 3247 (KANU)
<i>Xanthisma texana</i> DC.	4 _{II}	Texas: Calhoun Co: Swan Point, near Seadrift, 2811 (TEX)
EUPATORIEAE		
* <i>Conoclinium betonicifolium</i> (Miller) King & H. Robinson	10 _{II}	Mexico: San Luis Potosi: Las Tablas, 2921 (TEX)
<i>Stevia serrata</i> Cav.	44 _I	Mexico: Mexico: 18.2 km W of Toluca, 2647 (TEX)
HELIANTHEAE		
<i>Acmella radicans</i> (Jacq.) R. K. Jansen var. <i>radicans</i>	39 _{II}	Mexico: Sinaloa: 41 mi E of Mazatlan on hwy 40, 2154 (TEX)
<i>Babia aristata</i> (Rydb.) Turner	10 _{II}	Mexico: San Luis Potosi: 1.3 mi S of Colonia Libertad, 2909 (TEX)
<i>Bidens odorata</i> Cav. var. <i>oaxacensis</i> Ballard	12 _{II}	Mexico: Oaxaca: Cd. Oaxaca, 2103 (TEX)
<i>Cosmos caudatus</i> Kunth	24 _{II}	Mexico: Guerrero: 27 mi S of Chilpancingo on hwy 95, 2132 (TEX)
<i>Cosmos sulphureus</i> Cav.	12 _{II}	Mexico: Guerrero: 27 mi S of Chilpancingo on hwy 95, 2131 (TEX).
<i>Galinsoga parviflora</i> Cav.	16 _{II}	Mexico: Veracruz: 14.5 km W of Mendoza on hwy 150, 2067 (TEX)

Table 1. (continued)

Taxon	Gametic chromosome number	Voucher (repository)
<i>Melampodium divaricatum</i> (Rich) DC.	12 _{II}	Mexico: Oaxaca: Cd. Oaxaca, 2105 (TEX)
<i>Melampodium microcephalum</i> Less.	12 _{II}	Mexico: Sinaloa: 41 mi E of Mazatlan on hwy 40, 2153 (TEX)
<i>Parthenium confertum</i> A. Gray var. <i>microcephalum</i> Rollins	17 _{II}	Mexico: Nuevo Leon: Estación Mariposa, 2886 (TEX)
<i>Sigesbeckia hartmanii</i> B. Turner	15 _{III}	Mexico: Michoacan: 16 km S of Quiroga, 2435 (TEX)
<i>Simsia lagascaeformis</i> DC.	17 _{II}	Mexico: Oaxaca: Cd. Oaxaca, 2104 (TEX)
<i>Tridax coronopifolia</i> (Kunth) Hemsley	27 _{II}	Mexico: Mexico: 6.2 km E of rd. to Tula on hwy 51D, 2400 (TEX)
<i>Viguiera potosina</i> Blake	17 _{II}	Mexico: San Luis Potosi: Las Tablas, 2919 (TEX)
<i>Zaluzania parthenioides</i> (DC.) Rzedowski	18 _{II}	Mexico: San Luis Potosi: 1.3 mi S of Colonia Libertad, 2908 (TEX)
<i>Zinnia baageana</i> Regal	12 _{II}	Mexico: Michoacan: 52.6 km W of Morelia, 2408 (TEX)
<i>Zinnia peruviana</i> (L.) L.	12 _{II}	Mexico: Zacatecas: 19.3 km toward Tlaltenango from Jalpa, 2447 (TEX)
INULEAE		
* <i>Gnaphalium schraderi</i> DC.	14 _{II}	Mexico: Oaxaca: 48 mi NW of Cd. Oaxaca on hwy 190, 2108 (TEX)
Tageteae		
<i>Nicolletia trifida</i> Rydb.	10 _{II}	Mexico: Baja California Sur: 22.8 km N of Loreto on hwy 1, 2365 (TEX)
<i>Tagetes lucida</i> Cav.	11 _{II}	Mexico: Michoacan: 52.6 km W of Morelia, 2407 (TEX)
<i>Thymophylla setifolia</i> (Lag.) Strother var. <i>setifolia</i>	13 _{II}	Mexico: Puebla: 13 mi SW of jct. hwy 150D and 28, 2085 (TEX)

diploids (Keil et al. 1988; Solbrig et al. 1964). We obtained a diploid count of $n = 6_{II}$ for *Isocoma menziesii* var. *menziesii*, although the previous count (Pinkava & Keil 1977) and one of ours were tetraploid.

The count obtained here for *Geissolepis suaedaefolia*, $n = 9_{II}$, differs from that reported by Ralston et al. (1989). Those authors reported $n = 8_{III}$, and discussed the distinctiveness of *Geissolepis* (a monotypic genus) among American Astereae. They suggested that it perhaps resembles *Astranthium* and *Aphanostephus* in receptacle and achenial trichome characters, and in chromosome number, assuming that the $n = 8$ represented a tetraploid on a base of $x = 4$ (present in both *Astranthium* and *Aphanostephus*). However, the squashes we observed clearly revealed nine pairs of chromosomes at diplotene and diakinesis (Fig. 1A). With respect to this count, it is interesting that *Dichaetophora campestris* has $n = 3_{II}$ (Turner & Ellison 1960; Watson 1973) or $n = 6_{II}$ (Sundberg et al. 1986), and that it shares the peculiar hooked achenial hairs of *Geissolepis*, among other features.

Nesom (pers. comm.) suggests that *D. campestris* would be better placed as a species of *Astranthium* derived via dysploid reduction from $x = 4$. A cpDNA analysis of these and other genera suggested to be related (e.g. *Chaetopappa*, *Leucelene*, *Egletes*, etc.) by Shinnars (1946) is warranted.

Solbrig et al. (1964) reported a count of $n = 9_{II}$ (which was, according to a footnote, "calculated from somatic counts") for *Vancleavea stylosa*. Given the morphological resemblance of this taxon to *Petradoria* and *Hesperodoria* (= *Haplopappus* sect. *Hesperodoria*), this count did not seem out of place. However, phylogenetic analysis of chloroplast DNA restriction site mutations (Lane & Jansen 1990; Lane, unpubl. data) place this taxon within a clade having $x = 6$. Our count of $2n = 12$, and careful observation of technical characters such as disk corolla shape and style-branch appendages support the indication that *Vancleavea* may be a member of the " $x = 6$ group" of Astereae (Hartman & Lane 1991; Lane 1983), perhaps near *Xylorhiza* and/or *Pyrrocoma*, rather than of the " $x = 9$ group." Additional phylogenetic analyses currently underway may clarify this point.

Eupatorieae—The count of $n = 10_{II}$ for *Conoclinium betonicifolium* is new but unremarkable within the genus.

Heliantheae—All sixteen counts obtained for members of this tribe confirm previous reports.

Inuleae—*Gnaphalium schraderi* is here reported for the first time as $n = 14_{III}$, which is consonant with the known base chromosome number of that genus.

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REFERENCES

- HARTMAN, R.L. & M.A. LANE. An intergeneric hybrid in the $x = 6$ group of Astereae (Asteraceae). *Sida* 14:321-329.
- JACKSON, R.C. 1973. Chromosomal evolution in *Haplopappus gracilis*: a centric transposition race. *Evolution* 27:243-256.
- KEIL, D.J., M.A. LUCKOW and D.J. PINKAVA. 1988. Chromosome studies in Asteraceae from the United States, Mexico, the West Indies, and South America. *Amer. J. Bot.* 75:652-668.
- LANE, M.A. 1983. Taxonomy of *Xanthocephalum* Willd. (Compositae: Astereae). *Syst. Bot.* 8:305-316.
- LANE, M.A. & R.K. JANSEN. 1990. Chloroplast DNA restriction site evidence for relationships of genera of Astereae (Compositae). *Amer. J. Bot.* 77(6, part 2 [abstracts]):143.

- PINKAVA, D. J. & D. J. KEIL. 1977. Chromosome counts of Compositae from the United States and Mexico. *Amer. J. Bot.* 64:680–686.
- RALSTON, B. G., G. NESOM and B. L. TURNER. 1989. Documented plant chromosome numbers 1989: 1. Chromosome numbers in Mexican Asteraceae with special reference to the tribe Tageteae. *Sida* 13:359–368.
- SHINNERS, L. H. 1946. The genus *Dichaetophora* A. Gray and its relationships. *Wrightia* 1:90–94.
- SOLBRIG, O. T., L. C. ANDERSON, D. W. KYHOS, P. H. RAVEN & L. RÜDENBERG. 1964. Chromosome numbers in Compositae. V. Astereae. II. *Amer. J. Bot.* 51:513–519.
- STROTHER, J. L. 1972. Chromosome studies in western North American Compositae. *Amer. J. Bot.* 59:242–247.
- SUNDBERG, S., C. P. COWAN & B. L. TURNER. 1986. Chromosome counts of Latin American Compositae. *Amer. J. Bot.* 73:33–38.
- TURNER, B. L. & W. L. ELLISON. 1960. Chromosome numbers in the Compositae. I. Meiotic chromosome counts for 25 species of Texas Compositae including 6 new generic reports. *Texas J. Sci.* 12:146–151.
- WATSON, T. J., JR. 1973. Chromosome numbers in Compositae from the southwestern United States. *Southw. Naturalist* 18:117–124.



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