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CHROMOSOME NUMBERS IN SOME CACTI OF WESTERN NORTH AMERICA—VIII

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Abstract: Chromosome numbers are determined for 514 individuals belonging to 119 taxa within Cactaceae. Nineteen taxa have chromosome numbers reported for the first time. Based on geographic, morphological, and cytological data, three new nomenclatural combinations are made: *Cylindropuntia* ×*cardenche* (Griffiths) Pinkava & M. A. Baker, *Cylindropuntia imbricata* (Haworth) F.M.Knuth var *spinitecta* (Griffiths) M.A.Baker, and *Echinocereus bonkerae* Thornber & Bonker ssp *apachensis* (W.Blum & Rutow) A.D.Zimmerman. Four species are here newly published as interspecific hybrids based, in part, on several character states intermediate of their respective sympatric putative parents: *Cylindropuntia* ×*cardenche* (Griffiths) Pinkava & M.A.Baker (pro. sp) comb. nov., *Cylindropuntia* ×*pallida* (Rose) F.M.Knuth (pro. sp), *Opuntia* ×*charlestonensis* Clokey (pro. sp), and *Opuntia streptacantha* Lemaire × *O. tomentosa* Salm-Dyck.

The family Cactaceae comprises approximately 1800 species (Parfitt and Gibson 2003), the taxonomy of which is complicated by apomixis, hybridization, and polyploidy (Pinkava 2002). Chromosome numbers in Cactaceae are nearly always a multiple of eleven. Ploidy levels are often correlated with morphological and geographic distribution, and are crucial to the evolution and systematics of the family. The most important aspect of polyploidy in Cactaceae is that it creates a genetic barrier (sexual reproductive isolation) that often leads to speciation (Baker 2003, 2006; Baker and Pinkava 1987, 1999; Parfitt 1987, Pinkava and others 2001; Powell and Weedin 2001).

Aneuploidy appears to be of little importance in cactus evolution considering that nearly all chromosomes determinations have been euploid. Of the thousands of counts determined for Cactaceae, only 16 taxa have been reported as aneuploid. Individuals of 14 of these taxa have since been reported as euploid by other researchers. Nine of the 14 aneuploid counts were reported in the 1930s when techniques for determining chromosome numbers may not have been as reliable as they are today. These aneuploid counts have not been repeated. This information suggests that these early aneuploid chromosome determinations may have been in error. Two remaining reports of aneuploidy not yet recounted are *Echinocactus apricus* Arechavaleta ($2n = 38$) by Takagi (1938) and *Deamia testudo* (Karwinski) Britton & Rose ($2n = 24$) by Bhattacharyya (1970).

Additional chromosome counts continue to shed light on speciation, geographic migrations and distributions, and understanding relationships among and within taxa. For taxa having multiple ploidy levels, ecological or geographic patterns often do not come to light until several to many chromosome determinations are made. In this paper, we will begin to address the geographic distributions of some of these chromosome races.

Materials and Methods

Flower buds were collected in developmental series from plants growing in native habitats or placed in cultivation (mostly at Southwest Botanical Research, Chino Valley, Arizona or Desert Botanical Garden, Phoenix, Arizona). The senior author has developed a method whereby many of the buds were selected by extracting anthers with fine-tipped forceps and previewing meiosis under 100× magnification. Closed forceps were gently pushed through the layers of developing tepals, pried open, and re-closed over anthers. The procedure, which was easily done with a field microscope, allowed for the collection of a min-

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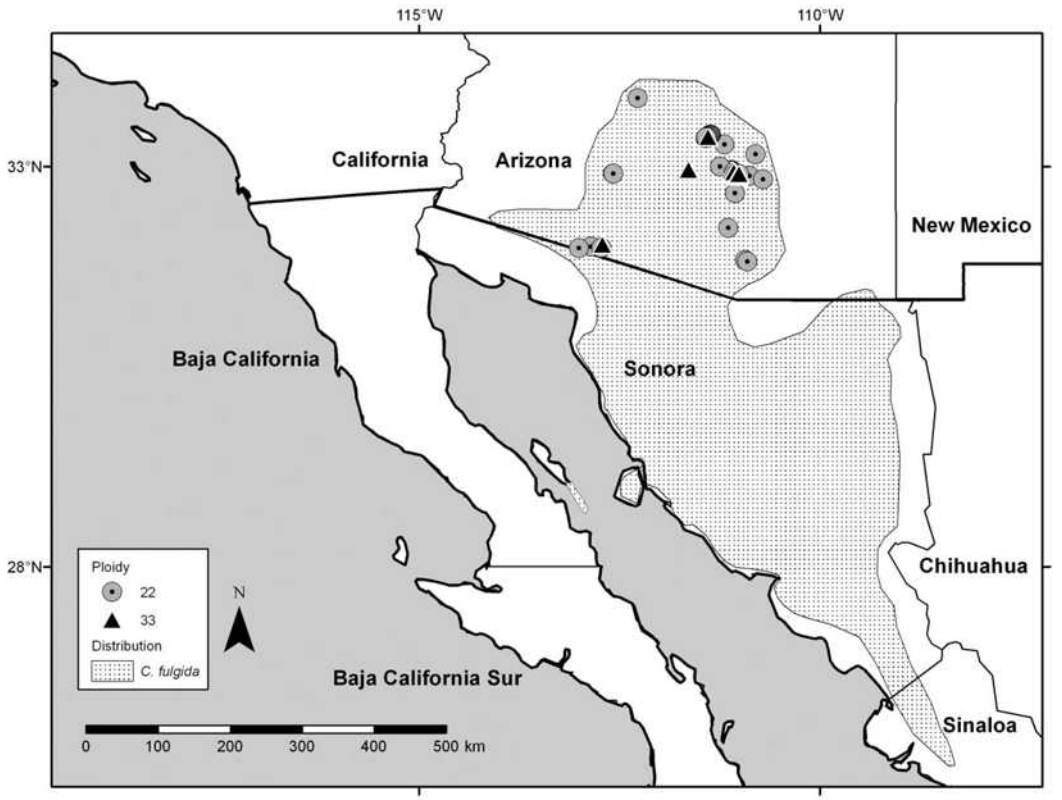

Figure 1. Distribution of chromosome determinations for individuals of *Cylindropuntia fulgid*a (Data from Baker and Pinkava 1999; Pinkava and others 1973, 1985, 1992a, 1992b, 1998; Pinkava and Parfitt 1982).

imal number of buds and assured a high rate of success. Alternatively, severed young buds were previewed by cutting them in half, and if too early, were wrapped in a moist paper towel, placed in a petri dish, and reviewed from time to time until meiosis was observed. Buds were killed and fixed in chloroform, 95% ethanol, and glacial acetic acid (3:3:1 or 0:3:1) for at least 24 hours, transferred to 70% ethanol, and refrigerated. In general, best results were obtained from buds transferred to 70% ethanol within 48 hours. Anthers were squashed in acetocarmine and mounted in Hoyer's medium (Beeks 1955). Most squashes were done using a metal vise. Voucher specimens (Appendix 1) are deposited in ASU unless otherwise stated. Most specimens included duplicates that will be distributed to various herbaria.

Morphological measurements, as necessary for identification and taxonomic review, were taken from both live and herbarium material. Herbarium material included specimens from ARIZ, ASC, ASU, BRY, DES, MICH, MO, NY, NMC, RENO, RM, RSA, SRSC, UNLV, UNM, US, UT, and UTEP.

Results

Chromosome counts are reported for 514 individuals representative of 119 taxa from 12 genera of native cacti mostly from western United States and northern Mexico. First-time chromosome counts (Appendix 1) are determined for 19 taxa: five species, three infraspecific taxa, and ten interspecific hybrids. The chromosome counts for the remaining taxa are all in agreement with previously published reports.

First-time counts are reported for the following: *Coryphantha alversonii*, *Cylindropuntia* ×*cardenche*, *C. imbricata* var *spinitecta*, *C. leptocaulis* × *C. versicolor*, *C.* ×*pallida*, *C. santamaria*, *Echinocereus bonkerae* ssp *apachensis*, *E. lindsayi*, *Nopalea guatemalensis*, *N. hondurensis*, *Opuntia aurea* × *O. phaeacantha*, *O. aurea* × *O. pinkavae*, *O. aurea* × *O. polyacantha*, *O.* ×*charlestonensis*, *O.* ×*columbiana*, *O. comonduensis*, *O. macrorhiza* × *phaeacantha*, *O. polyacantha var hystricina*, and *O. streptacantha* × *O. tomentosa*. The pentaploid count of one individual of *Opuntia engelmannii* var *linguiformis* differs from earlier counts of hexaploid in-

dividuals (Yuasa and others 1973, Weedin and Powell 1978, Pinkava and Parfitt 1982).

Discussion

In this eight-part series (Pinkava and McLeod 1971; Pinkava and Parfitt 1982; Pinkava and others 1973, 1977, 1985, 1992a, 1998, and this paper), chromosome numbers have been determined for 1632 individuals of 229 taxa (including 35 interspecific hybrids and two intergeneric hybrids) in 22 genera of cacti.

Euploidy continues to overwhelmingly dominate the karyotype within Cactaceae. No aneuploid individuals were detected from any of the 514 individuals examined (1632 individuals for our eight-part series) and, except for those of odd-polyploids, no aneuploid gametes were recorded.

Cytological, morphological, and geographical data indicate the need for nomenclatural changes for the following:

***Cylindropuntia* ×*cardenche* (Griffiths) Pinkava & M. A. Baker (pro. sp) comb. et status nov.** (*C. imbricata* (Haworth) F.M.Knuth × *C. kleiniae* (A.P.De Candolle) F.M.Knuth. Basionym: *Opuntia cardenche* Griffiths, *Rep Mo Bot Gard* 19: 259, pl. 21 (in part). 1908. The newly assigned status of this species as hybrid or nothospecies is based on individuals possessing intermediate morphological character states with respect to the putative parents, and the isolated occurrences of individuals. The tetraploid genome of both individuals reported here probably arose from the union of reduced gametes from tetraploid *C. kleiniae* and unreduced gametes of diploid *C. imbricata*. At least one individual of similar morphology, *MAB 12816* [ASU], occurs near Cuatro Cienegas, Coahuila. All three populations occur sympatrically with those of *C. imbricata* var *imbricata* (Haworth) F.M.Knuth. At this time, there are not enough data to determine whether *C.* ×*cardenche* represents a conglomeration of spontaneous hybrids or a widespread but rare microspecies.

***Cylindropuntia imbricata* (Haworth) F. M. Knuth var *spinitecta* (Griffiths) M. A. Baker, comb. nov.** Basionym: *Opuntia spinotecta* Griffiths, *Proc Biol Soc Wash* 27: 24. 1914 (corrected to *O. spinitecta* by Crook and Mottram 2003). This variety differs from the typical in having fewer central spines per areole (3–6, mostly 4), generally bearing at least some fusiform tuber-like roots, lower and narrower stem tubercles, and eco-geographical segregation, occurring at higher elevations (1560+ m) along part of the mutual boundary between the states of Durango and Zacatecas, Mexico. The placement of *O. spinitecta* as a variety within *C. imbricata* is based on their identical chromosome number, degree of overlap in morphological states, and the occasional presence of tuberous roots in *C. imbricata*. The authors are aware that *C. imbricata* populations south of the Chihuahuan Desert possess morphological characteristics that differ dramatically from those of populations in the Great Plains. Further studies are needed, however, in order to determine where best to determine additional taxonomic lines.

***Cylindropuntia* ×*pallida* (Rose) F. M. Knuth (pro. sp) et status nov.** (*C. imbricata* (Haworth) F.M.Knuth × *C. tunicata* (Lehman) F.M.Knuth). Basionym: *Opuntia pallida* Rose, *Smiths Misc Coll* 50: 507. 1908. Individuals possessing morphological states intermediate between those of *C. imbricata* and *C. tunicata* are frequent. The frequency of *C.* ×*pallida* individuals, including those with morphological states favoring one or the other parent, suggests that backcrossing is frequent. The combinations *Opuntia* ×*pallida* (Comision Nacional de Áreas Naturales Protegidas 2003) and *Cylindropuntia* ×*pallida* (Díez and Hernández 1999) have been listed by previous authors without explanation.

***Opuntia* ×*charlestonensis* Clokey, pro. sp et status nov.** (*O. polyacantha* Haworth var *erinacea* (Engelmann & J.M.Bigelow) B.D.Parfitt × *O. phaeacantha* Engelmann). Basionym: *Opuntia charlestonensis* Clokey, *Madroño* 7: 71, pl. 4, fig ca. 1943. Individuals of both putative parents occur sympatrically with those of *O.* ×*charlestonensis* near type locality, where buds were collected for chromosome determinations. An individual of *O. phaeacantha* from Kyle Canyon was recorded as $n = 33$, which is typical for the species, and an individual of *O. polyacantha* var *erinacea* from Kyle Canyon was recorded as $n = 22$, typical for the variety (Pinkava and others 1973, 1985; Pinkava and Parfitt 1982). In light of these data, the pentaploid genome of *O.* ×*charlestonensis* probably resulted from the union of normal reduced gametes from the putative parents. The morphological characteristics of *O.* ×*charlestonensis* tend to align more with those of *O. phaeacantha*, which would be expected with the latter's greater contribution of chromosomes.

***Opuntia streptacantha* Lemaire × *O. tomentosa* Salm-Dyck.** This interspecific hybrid is intermediate morphologically to its putative parents in length and shape of stems segments, trunk diameter, flower color, number of stigma lobes, and the color and shape of

fruits. It is similar to *O. tomentosa* (the spiny morph of central Mexico, not the spineless or nearly spineless commonly grown morph of cultivation) in having a pubescent epidermis, though not as long, and yellow glochids (not red-brown). It is similar to *O. streptacantha* in having stigma lobes pale green (not white). It differs from both arborescent parents in being shrubby, often leaning, to 2 m tall, not to 6–5 m tall.

Individuals of *Opuntia streptacantha* × *O. tomentosa* and both putative parents were collected by M Baker in the same habitat and locality in Hidalgo, Mexico, from where the hybrid and *O. tomentosa* were counted as octoploids (n = 44, in this paper); *O. streptacantha* was not counted here but has been reported as n = 44 in San Luis Potosí (Pinkava & Parfitt 1982).

***Echinocereus bonkerae* ssp *apachensis* (Blum & Rutow) A. Zimmerman, comb. nov.** Basionym: *Echinocereus apachensis* Blum & Rutow, *Echinocereus* (monograph), p 101 (100–103 [text], 106–107 [figs], 86 [map], 460 [seed]. 1998. Type: Arizona, Maricopa Co., Apache Trail, near Fish Creek, 18 Feb 1929 *McKelvey 735* (Holotype US 1532949), *non vidi*.

The diploid chromosome number indicates that the well-known Fish Creek phenotype of *Echinocereus* is not part of the widespread tetraploid *E. engelmannii*. *Echinocereus bonkerae* ssp *apachensis* differs from typical *E. bonkerae* in spininess (mostly its spectacularly greater central spine length). Intermediate spine forms (highly variable) are seen in the Sierra Ancha (including one of the chromosome vouchers cited herein), the Mazatzal Mountains, and in the mountains between Globe and Superior. Subspecies *apachensis* is relatively xeromorphic (tall, seriously spiny plants at the lower altitudinal limits of the species). Nominate subspecies *bonkerae* grows as compact clumps of shorter stems having short spines, in chaparral and windswept grasslands at mostly higher altitudes. Blum and others (1998: 101) claim differences in color of style and filaments, but these are too variable. A slight difference in reported testa cell shape likewise appears inconsistent. Both subspecies of this relictual diploid species, endemic to central Arizona, are marginally sympatric with the widespread tetraploid species, *E. engelmannii* sensu lato. Subspecies *apachensis* is widely mislabeled with the epithet "*boyce-thompsonii*" apparently beginning with misidentifications by Lyman Benson. The real *boyce-thompsonii* is a synonym of *E. engelmannii* ssp *fasciculatus*.

Cytogeography of certain autopolyploid races in *Cylindropuntia*

With the addition of our present data, we are beginning to see some coarse resolution in the geographic distribution of chromosome races within certain species. Maps providing locations of vouchered chromosome determinations and approximate geographic distributions for *Cylindropuntia bigelovii*, *C. cholla*, *C. fulgida*, *C. leptocaulis*, *C. ramosissima*, and *C. whipplei* are presented in figures 1–6. Individuals mapped are all considered to be diploids or their respective autopolyploids. Sources for overall geographic distributions include herbarium material, Pinkava (1999, 2003), and Turner and others (1995).

The taxa are discussed in terms of various stages of autopolyploid evolution. Although they represent a certain degree of progression, certain stages may not be applicable to all species.

Cylindropuntia fulgida

Distributions of diploid and triploid races of *Cylindropuntia fulgida* (Fig 1) show no geographic separation. All known triploid individuals occur sympatrically with diploid individuals. The occurrence of at least four geographically scattered locations for triploid individuals, of at least two triploid morphological forms within *C. fulgida*, and of another triploid form as a hybrid with *C. spinosior* (Baker and Pinkava 1987), indicate that the production of unreduced gametes has occurred repeatedly within the species. Although not indicated on the map, thus far chromosome determinations have been n = 11 for all individuals referred to as *C. fulgida* var *mammillata* (Schott ex Engelmann) Coulter.

The distribution of chromosome races within *C. fulgida* represents the first stage in autopolyploid speciation, in which spontaneous triploid individuals occur within the distribution of diploid individuals. This first example simply involves the union of a reduced with an unreduced gamete and there are no marginal effects and no apparent advantages to polyploidy.

Cylindropuntia bigelovii and *C. ciribe*

The distribution of individuals within the two chromosomal races of *Cylindropuntia bigelovii* bears some correlation with geography (Fig 2). Triploid populations span southern

and central Arizona, southern California, and the northern portion of the Baja California peninsula. Diploid populations occur at the eastern edge, at the northernmost extremity (Grand Canyon), and at the southernmost extent of its geographic range (Baja California and Baja California Sur). Thus far, no correlations between chromosome race and morphology have been reported for *C. bigelovii*. Pinkava (2002) hypothesizes that these peripheral diploid populations may be derived from triploids bearing 1*x* gametes. Assuming random segregation of chromosomes during metaphase I, 3*x* = 33 mother cells would produce a pair of 2*x* and a pair of 1*x* meiotic products (daughter cells) in one of every 2^{10} or 1024 attempts. Although the origin of diploid populations from triploid populations is hypothetically possible, direct evidence is lacking. Populations of the very closely related *C. ciribe* (2*n* = 22) have a limited geographic distribution in Baja California Sur (Fig 2). As with the chromosome races within *C. bigelovii*, there is little evidence to indicate whether *C. bigelovii* or *C. ciribe* are genetically closest to ancestral populations.

The distribution of chromosome races within *C. bigelovii* represents the second stage in autopolyploid speciation, in which triploid individuals have either invaded new habitats or have out-competed their diploid counterparts. This second example may only be available to apomictic species, since sexual reproduction in odd-ploidy is severely crippled. The primary genetic advantages triploids may have over diploids are increased heterozygosity and higher levels of genetic and genomic diversity (Soltis and Soltis 2000).

Cylindropuntia cholla

Populations of *Cylindropuntia cholla* occur throughout the Baja California peninsula. Chromosome determinations for most individuals have been diploid (2*n* = 22), with one triploid (2*n* = 33) individual at the northern extent of the range and one tetraploid (2*n* = 44)

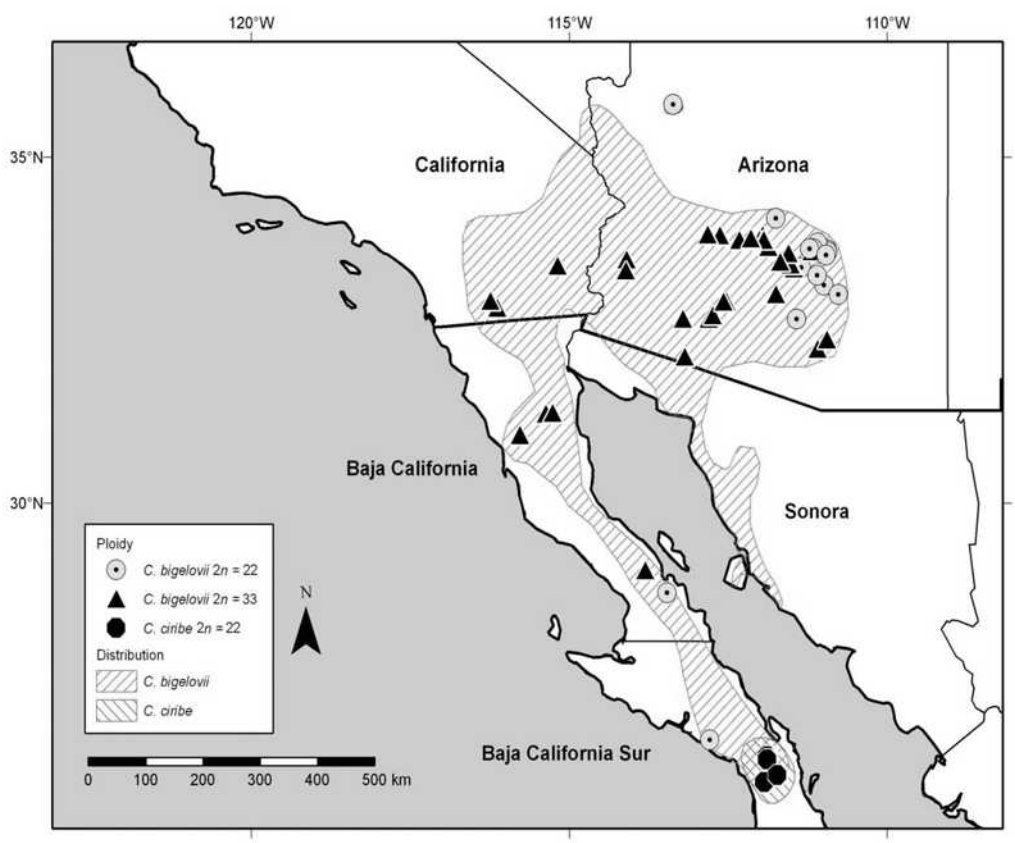

Figure 2. Distribution of chromosome determinations for individuals of *Cylindropuntia bigelovi*i and the closely related C. *ciribe*. (Data from Baker and Pinkava 1999; Pinkava and others 1985, 1992b, 1998; Pinkava and Parfitt 1982; Pinkava and McLeod 1971).

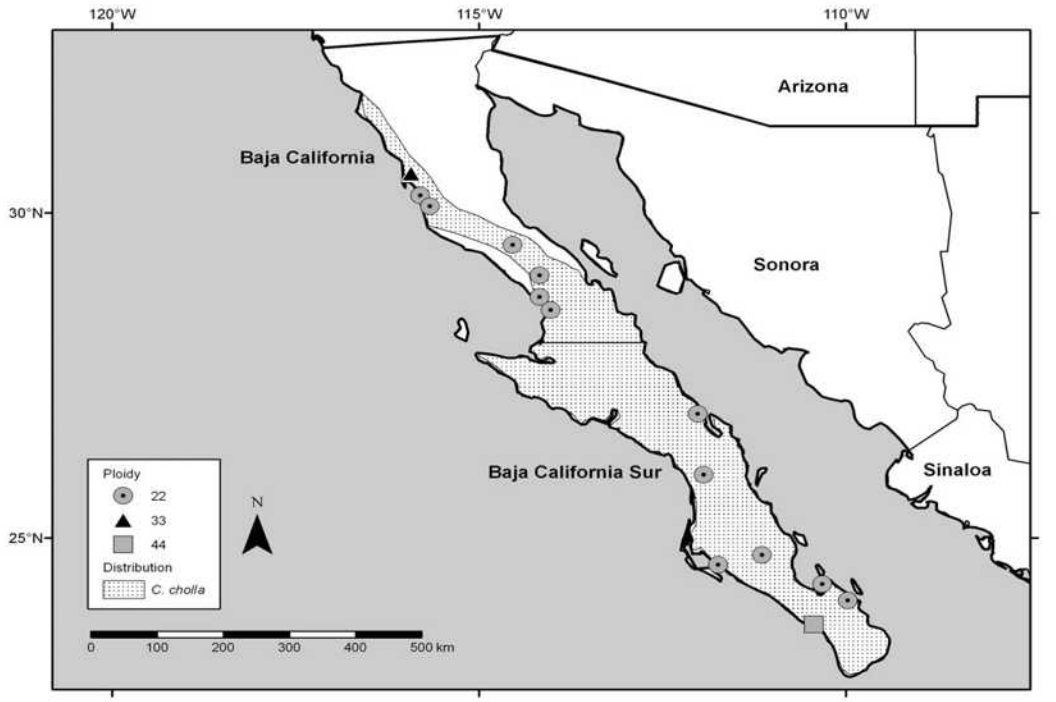

Figure 3. Distribution of chromosome determinations for individuals of *Cylindropuntia chol*la (Data from Pinkava and others 1992a, 1998; Pinkava and Parfitt 1982).

population at the southernmost extent of the range (Fig 3). The occurrence of polyploidy at the both ends of the species range suggests that polyploid individuals are better adapted with respect to invading new habitats.

The distribution of chromosome races within *C. cholla* represents a third stage in autopolyploid speciation, in which tetraploid individuals occur. The formation of tetraploidy is more complex than that of triploidy because the former involves the union of two unreduced diploid gametes or the union of an unreduced triploid gamete with a reduced diploid gamete. Unlike triploid individuals, diploid individuals generally have the advantage of fertile gametes.

Cylindropuntia ramosissima

Known diploid individuals of *Cylindropuntia ramosissima* are widespread, and tetraploid individuals have been recorded only from a geographic cluster in Maricopa and Pinal counties, Arizona**,** at the southeastern edge of the overall range of the species (Fig 4). Although this may be yet another example of a polyploid race invading new habitats, no correlations have been found between chromosome races in *C. ramosissima* and either plant morphology or habitat type.

The distribution of chromosome races within *C. ramosissima* represents a fourth stage in autopolyploid speciation, in which tetraploid individuals appear to be invading new habitats. Note that triploid individuals in non-apomictic species, such as *C. ramosissima*, would be rare, because they have no or severely restricted means of reproducing.

Cylindropuntia leptocaulis

Large gaps occur in the geographic distribution of *Cylindropuntia leptocaulis* (Fig 5) where there have been no published chromosome number determinations. Where determinations have been made, sample size has been too low to correlate chromosome number with morphology. Thus far, records of tetraploid ($2n = 44$) individuals of *C. leptocaulis* are confined to the Chihuahuan Desert and may be another example of the invasion of new habitats by polyploid individuals. Powell and Weedin (2001) suggest that morphological differences between tetraploid and diploid races of the Trans-Pecos *C. leptocaulis* warrant recognition of two separate taxa. They also suggest that certain tetraploid races of the closely related *C. kleiniae* should be segregated taxonomically. Individuals of *C. kleiniae* are morphologically intermediate between those of *C. leptocaulis* and *C. imbricata*, and occur in the area of sympatry for the two latter species.

Based on this evidence, certain populations of *C. kleiniae* may represent spontaneous hybrids of recent origin, others of more distant origin, and others phylogenetic intermediates between those of *C. leptocaulis* and *C. imbricata*. In any case, available data are not sufficient to fully explain evolution and taxonomy within *C. leptocaulis* and *C. kleiniae*.

The distribution of chromosome races within *C. leptocaulis* represents a further developed stage four of autopolyploid speciation, in which tetraploid individuals have a larger geographic distribution.

Cylindropuntia whipplei

Diploid populations of *Cylindropuntia whipplei* occur in its eastern portion of its geographic range and in its westernmost portion north of the Colorado River. Tetraploid populations occur in the westernmost portion of its range, south of the Colorado River, with the exception of at least two populations just north of the river. In this fourth example of polyploid populations occupying fringe habitats, there is some correlation between chromosome race and morphology. Individuals of the tetraploid race, for which the name *C. whipplei* var *enodis* (Peebles) Backeberg has been applied, are more depauperate, with fewer spines, and bear less tuberculate fruits with thicker pericarpel walls than those of the diploid race. In addition, populations of the tetraploid occur generally within desert grassland, while those of the diploid occur at higher elevations in mixed grassland or within various woodlands. The distributions of the two chromosomal races overlap near Grand Canyon Caverns at the type locality of *Opuntia hualpaensis*. Based on the type photo and description, we place *O. hualpaensis* as a synonym of *C. whipplei* var *enodis*.

The distribution of chromosome races within *C. whipplei* represents an advanced stage four of autopolyploid speciation, in which tetraploid populations have taxonomic significance. Chromosome number is now correlated, not only with geology, but with ecology and morphology as well. These types of correlations are well-documented in other vascular plant species (Levin 2001; Stebbins 1950, 1980).

The maps of chromosome races indicate that there are varying degrees of correlations among ploidy, geographic distribution, habitat, and overall morphology among infraspecific populations. The duration of genetic isolation between or among chromosome races undoubtedly plays an important role in speciation processes. In any case, as additional pieces are gathered, the understanding of evolutionary processes in Cactaceae will become clearer.

Small differences in chromosome length, chiasma frequencies, and nature of chromosome satellites, do not appear to play important roles in speciation within *Cylindropuntia*, at least in comparison to euploidy. Frequent and nearly universal hybridization within the genus commonly results in fertile offspring (Pinkava 2002). Since interspecific chromosome morphology is generally a weak genetic barrier, intraspecific chromosome morphology is likely to be even weaker. Although differences in cytotypes have been correlated with morphology in populations of certain Cactaceae (Cid and Palomino 1996, Das and others 1997, 1998a, 1998b), is it not known whether such differences have led to genetic isolation or are simply a result of genetic isolation, geographic isolation, or otherwise.

Chromosome determinations and associated cytological observations continue to be important tools for understanding evolutionary processes, geography, and taxonomy within Cactaceae. Larger sample sizes with respect to chromosome determinations, as well as associated morphological and habitat data, are needed for most, if not all, polyploid taxa.

Acknowledgments

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Appendix 1. Chromosome numbers determined for certain cacti of western North America. Voucher specimens are on deposit at ASU unless otherwise noted. Symbols: * = first chromosome count for taxon, ** = new chromosome count for taxon. Because of the variable number of chromosomes in meiotic daughter cells, odd polyploid counts are denoted by the diploid number of chromosomes divided by two, for instance, triploid = 33/2, pentaploid = 55/2. Note: some taxonomic corrections and addenda to earlier published chromosome reports are presented at the end of this table. Collector names' abbreviations: *MAB* = Marc Baker, *BDP* = Bruce Parfitt, *CC* = Charlotte Christy, *DJF* = Dave Ferguson; *DJP* = Donald Pinkava, *CH* = Cheryl Hampsten; *JPR* = Jon Rebman, *KR* = Kathy Roberts, *RJ* = Robert Johnson; *RR* = Rafael Routson, *TW* = Theresa Wright, *ADZ* = Allan D Zimmerman. Chromosome counts were determined by the collector of the numbered specimen unless marked in [brackets] enclosing initials of an author of this paper.

Subfamily Opuntioideae

Cylindropuntia acanthocarpa (Engelmann & J.M.Bigelow) F.M.Knuth var *acanthocarpa*.

n = 11. **USA, Arizona**, Mohave Co.: 35.180° N 113.485° W, Cactus Pass, just N of I-40, **original type locality of *Opuntia acanthocarpa*** Engelmann & J.M.Bigelow, *MAB 11131* (intermediate to var *thornberi*); Yavapai Co.: 34.468° N 112.892° W, 6 km NNW of Hillside, *MAB 10361*.

Cylindropuntia acanthocarpa var *coloradensis* (L.D.Benson) Pinkava.

n = 11. **USA, California**, Imperial Co.: NW of Yuma, AZ, N of Cargo Muchacho Mtns, *JPR 4942 & CC*; San Bernardino Co.: 35.473° N 115.233° W, just south of Hwy 164, 29 km west of Searchlight, *MAB 11615*.

Cylindropuntia acanthocarpa var *major* (Engelmann) Pinkava

n = 11. **USA, Arizona**, Pinal Co.: 33.010° N 111.746° W, ca. 8 mi N of Casa Grande, *MAB 8109*; 32.993° N 111.248° W, 12 km ESE of Florence, *MAB 4214*.

Cylindropuntia acanthocarpa var *thornberi* (Thornber & Bonker) Backeberg.

n = 11. **USA, Arizona**, Mohave Co.: 35.197° N 113.477° W, 48 km E of Kingman, vicinity of Cactus Pass, **original type locality of *Opuntia acanthocarpa*** Engelmann & J.M.Bigelow, *MAB 11813*; Pinal Co.: 33.165° N 110.952° W, above Susie D. Gulch, 15 km N of Kearny, *MAB 11233*; Yavapai Co.: 34.206° N 112.155° *W*, 600 m NW of Bumblebee, **lectotype locality for *Opuntia thornberi*** Thornber & Bonker, *MAB 16147*.

Cylindropuntia alcahes (F.A.C.Weber) F.M.Knuth var *alcahes*.

n = 11. **Mexico, Baja California**: 29°21.0′ N 114°19.8′ W, 2 km SE of Laguna Chapala, 6 km SE of Chapala, *MAB 15174 & RJ*; 29°23.1′ N 114°20.0′ W, 3 km SE of Chapala, *MAB 15169 & RJ*; 29°35.6′ N 114°23.5′ W, Arroyo La Turquesa, *MAB 15166 & RJ*; 114 km S of San Quintín on Hwy 1 & just S of the turn to Misión San Fernando, *JPR* 1724 & Davis (SD). **Baja California Sur**: 27°36.4′ N 113°01.6′ W, Sierra San Francisco, 1.4 km NW of San Francisco, *MAB 15179 & RJ*; 27°30.7′ N 113°08.1′ W, 15 km SW of San Francisco and 16 km due E of Hwy 1, *MAB 15187 & RJ*; 27°35.6′ N 113°00.8′ W, 0.5 km S of San Francisco, *MAB 15184*, *15196 & RJ*; 27°34.3′ N 113°04.5′ W, Sierra San Francisco, Mesa La Caguama, *MAB 15192*, *15193*.

Cylindropuntia alcahes (F.A.C.Weber) F.M.Knuth var nov. B (See Pinkava and others 1998).

n = 11. **Mexico, Baja California**: ca. 3 mi S of Punta Baja, W of El Rosario and 1.5 mi inland from the ocean, *JPR 941 & Marsh* (SD).

Cylindropuntia bigelovii (Engelmann) F.M.Knuth.

n = 11. **USA, Arizona**, Mohave Co.: 35.757° N 113.359° W, 500 m SSE of confluence of Peach Springs Canyon and Diamond Creek, *MAB 15216*, *15217*; Pinal Co.: 33°08.5′ N 110°59.3′ W, along E side of Hwy 177, 20 km SSE of Superior, *Baker 13923 & Trudeau*, *16634* (population vouchers); Yavapai Co.: 34.110° N 111.751° W, 45 km SW of Payson, Tangle Creek, 5 km NW of Verde River, *MAB 8819*.

n = 33/2. **USA, Arizona**, Maricopa Co.: 33.797° N 112.320° W, 30 km NNW of Glendale, Hieroglyphic Mtns, *MAB 13733 & Weissman*; 33.877° N 112.821° W, 14 km SW of Wickenberg, *MAB 15255*; 32.706° N 112.741° W, 25 km S of Gila Bend, *MAB 15254*; 32.656° N 112.799° W, Sauceda Mtns, 30 km SSW of Gila Bend, *MAB 15235*; Pima Co.: 32.110° N 113.181° W, Cabeza Prieta Wildlife Refuge, Cholla Pass, **lectotype locality for *Opuntia bigelovii*** Engelmann, *MAB 13839*. **California**, San Diego Co.: 32.815° N 116.128° W, 15 km WNW of Ocotillo, 0.5 km ESE of Sweeney Pass, *MAB 12783*; 32°51′ N 116°15′ W, Anza-Borrego Desert State Park, *JPR 3026 & Simpson*. **Mexico, Baja California**: 31°17.9′ N 115°15.4′ W, NW of San Felipe, 30 km SW of Crucero de Valle de la Trinidad, *MAB 15213 & M. Trushell*.

Cylindropuntia calmalliana (Coulter) F.M.Knuth.

n = 33. **Mexico, Baja California Sur**: 27°26.5′ N 113°15.9′ W, SE of Guerrero Negro, 0.5 km E of Hwy 1, 1.5 km SSW of Loma la Criba, *MAB 15190 & RJ*; 27°46.5′ N 113°34.4′ W, S side of Hwy 1, Desierto el Vizcaino, *MAB 15203 & RJ*.

**Cylindropuntia* ×*cardenche* (Griffiths) Pinkava & M.A.Baker [*C. imbricata* × *C. kleiniae*].

n = 22. **Mexico, San Luis Potosí:** 22°06.6′ N 100°56.0′ W, SE side of San Luis Potosí, 2 km NNE of El Aguaje, **type locality for *Opuntia cardenche*** D.Griffiths, *MAB 12379*. **Coahuila**: 25°28′ N 103°25′ W, just S of Torreón, 5 km NE of La Perla, near **type locality for *Opuntia recondita*** D.Griffiths, *MAB 12822*.

Cylindropuntia cholla (F.A.C.Weber) F.M.Knuth.

n = 11. **Mexico, Baja California Sur**: 26°81′ N 112°72′ W, W of Múlege, *JPR 5184*.

Cylindropuntia ×*congesta* (Griffiths) Pinkava [*C. acanthocarpa* × *C. whipplei*].

n = 11. **USA, Arizona**, Yavapai Co.: 34.435° N 112.914° W, 2 km N of Hillside, *MAB 10863*.

Cylindropuntia davisii (Engelmann & J.M.Bigelow) F. M. Knuth.

n = 22 **USA, New Mexico**, Chaves Co.: 33.605° N 104.305° W, 30 km NE of Roswell, *MAB 10892.4*.

Cylindropuntia echinocarpa (Engelmann & J.M.Bigelow) F.M.Knuth.

n = 11. **USA, Arizona**, Maricopa Co.: 33°01.96′ N 113°18.45′ W, Agua Caliente Mtns, *MAB 15316*; Mohave Co.: 36.993° N 113.898° W, 12 km NNE of Littlefield, *MAB 13983* & *Walker*; Yavapai Co.: 34.090° N 113.007° W, 11 km SW of Congress, *MAB 11272 & TW*; 36.919° N 113.239° W, along Antelope Trail Road, east side of Clayhole Wash, *MAB 16717.2*. **California**, Inyo Co.: 35°54.4′ N 116°00.8′ W, 20 km ENE of Tecopa, E slope of Nopal Range, *MAB 16151*; San Bernardino Co.: 34°50′17″ N 114°59′04″ W, 2 km W of Homer, *MAB 13838*, **lectotype locality for O. echinocarpa** Engelmann & J.M.Bigelow; 35.471° N 115.233° *W*, just S of Hwy 164, ca. 5 mi W of Nevada state line, *MAB 11614*; 34.250° N 116.500° W, Bighorn Mtns, 1.5 km north of Black Lava Butte, *MAB 16693*. **Nevada**, Clark Co.: 36°03.1′ N 115°24.5′ W, Just NW of town Blue Diamond, *MAB 13670 & Sawasaki*.

Cylindropuntia ×*fosbergii* (C.B.Wolf) Rebman, Baker & Pinkava [*C. bigelovii* × *C. echinocarpa*].

n = 33/2. **USA, California**, San Diego Co.: 32°54′12″ N 116°13′57′ W, Canebrake between Ocotillo and Scissors Crossing, *JPR 4958 and others.*

Cylindropuntia ganderi (C.B.Wolf) Rebman & Pinkava var nov. A (See Pinkava and others 1998).

n = 11. **Mexico, Baja California**: 29°46′39″ N 114°46′56′ W, Cataviña boulder fields, *JPR 4986*.

Cylindropuntia ganderi var *ganderi*.

n = 11. **USA, California**, San Diego Co.: 32°75′ N 116°72′ W, between Jacumba and Inkopah, *JPR 5284*; 32°51′ N 116°15′ W, Anza-Borrego Desert State Park, Tarote Canyon, *JPR 3025 & Simpson*; 32.876° N 116.202° W, 25 km WNW of Ocotillo, Carrizo Valley, Old Stage Trail, *MAB 12790*; 32.859° N 116.207° W, 24 km NW of Ocotillo, Carrizo Valley, just N of Bow Willow Creek, *MAB 12787*; 33.133° N 116.308° W, 16 km W of Ocotillo Wells, Vallecito Mtns, just W of the Narrows, *MAB 12792*.

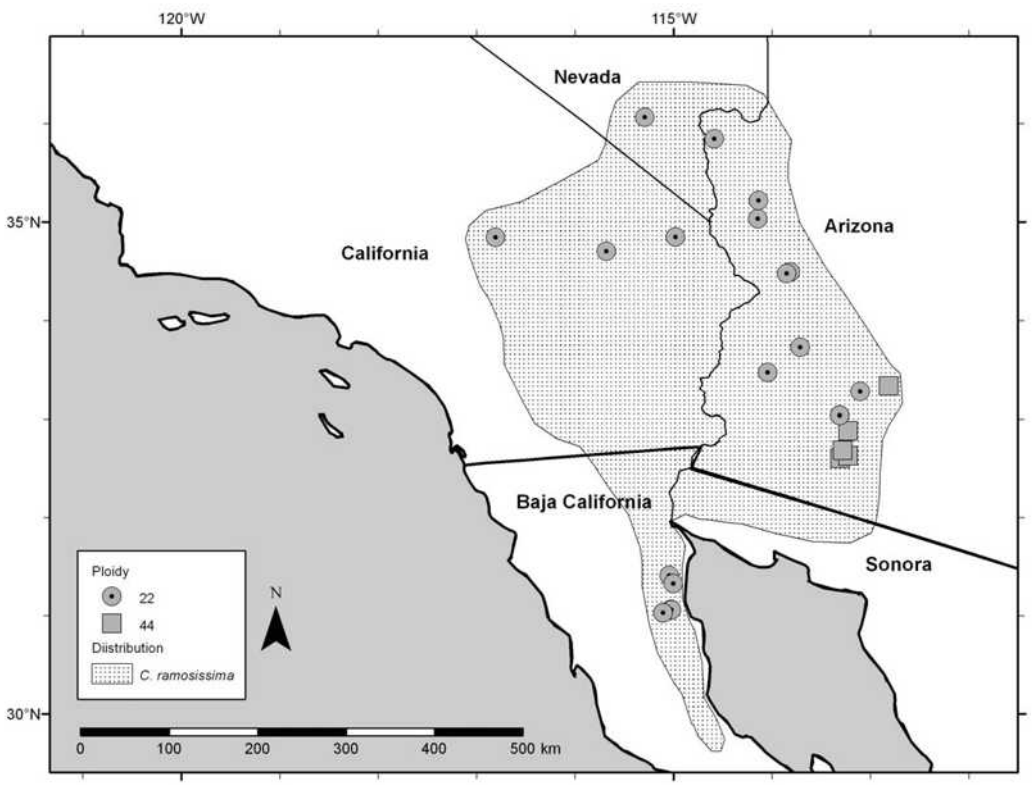

Figure 4. Distribution of chromosome determinations for individuals of *Cylindropuntia ramosissim*a (data from Pinkava and others 1973, 1985, 1992a, 1998).

Cylindropuntia imbricata (Haworth) F.M.Knuth var *argentea* (Anthony) Backeberg.

n = 11. **Texas**, Brewster Co.: 29°06′ N 103°11′ W, N end of Mariscal Mtn., *MAB 12803*; 29°03′ N 103°07′ W, 1 km W of Solis, **type locality for *Opuntia imbricata* var *argentea* Anthony**, *MAB 12804*.

Cylindropuntia imbricata var *imbricata*.

n = 11. **Mexico, Chihuahua**: 27°26.6′ N 104°54.8′ W, NW of Jimènes, 500 m E of Arroyo Flòrido, *MAB 12389*. **Coahuila**: 25°52.5′ N 100°57.5′ W, Perros Bravos, *MAB 12829*. **Hidalgo**: 20°04′ N 99°20′ W, 1 km N of Tula de Allende, **type locality for *Opuntia rosea*** (A.P.De Candolle) F.M.Knuth, *MAB 12838*; 27°03′ N 101°56′ W, NE of Cuatro Cienegas, 11 km W of Lamadrid, *MAB 12810*. **Zacatecas**: 24°28′ N 101°22.5′ W, SE of Concepción del Oro, *MAB 12835*; 24°41′ N 101°46.5′ W, just SW of Cedros, **type locality for *Opuntia lloydii*** Rose, *MAB 12832*. **USA, New Mexico**, Chaves Co.: 32°58.1′ N 104°09.5′ W, 27 km ENE of Artesia, 20 km ESE of town of Lake Arthur, *MAB 15851*; Eddy Co.: 32.318° N 104.809° W, 750 m north of Rawhide Canyon, 54 km WSW of Carlsbad, *MAB 16705.1* & *I. Trushell*; McKinley Co.: 35.650° N 108.053° W, 2 km SW of Prewitt, *MAB 11733 & Hevron*; Sandoval Co.: 35°39′ N 106°52′ W, W of Peñasco Canyon, 1.4 km N of Los Pinos Arroyo, *MAB 13552.2*.

**Cylindropuntia imbricata* var *spinitecta* (Griffiths) M.A.Baker.

n = 11. **Mexico, Durango**: 24°32.1′ N, 103°58.9′ W, 2.5 km SW of Luis Moya, just NE of Las Campanas, 1950 m, *MAB 12387*. **Zacatecas**: 23°39.1′ N, 103°35.4′ W, E of the city Durango, 5 km ENE of Sombrerete, *MAB 12381*.

Cylindropuntia ×*kelvinensis* (V.E.Grant & K.A.Grant) P.V.Heath [*C. fulgida* × *C. spinosior*].

n = 11. **USA, Arizona**, Pima Co.: 32.220° N 111.330° W, 1 km ENE of Cocoraque Butte, *MAB 15310 and others*; Pinal Co.: 33.0835° N 110.9817° W, 2.6 km SW of Kelvin, MAB 4638 & DJP.

Cylindropuntia kleiniae (A.P.de Candolle) F.M.Knuth.

n = 22. **Mexico, Coahuila**: 25°52.5′ N 100°57.5′ W, just SW of Perros Bravos, *MAB 12827*. **San Luis Potosí**: 22°06.8′ N 100°56.2′ W, El Aguaje, SE side of San Luis Potos*í*, *MAB 12378*; 23°57.5′ N 101°00′ W, NW of Matehuala, *MAB 12837*.

Cylindropuntia leptocaulis (A.P.de Candolle) F.M.Knuth.

n = 11. **USA, Arizona**, Maricopa Co.: 32°46.6′ N 112°50.8′ W, 22 km SW of Gila Bend, *MAB 15283*; 33°46.97′ N 112°01.1′ W, Paradise Valley, *MAB 16503.1*, *16503.2*; Yavapai Co.: 34.408°N 112.705°*W*, 25 km SE of Prescott, *MAB 12397*; **New Mexico**, Chaves Co.: 32°59.94′ N 104°35.16′ W, 44 km S of Roswell, *Baker 15871*; Eddy Co.: 32°53.9′ N 104°14.3′ W, 16 km ENE of Artesia, 1 km west of Dog Canyon, *MAB 15858* & *RR*.

n = 22. **USA, New Mexico**, Eddy Co.: 32°48.1′ N 104°17.1′ W, 12 km SE of Artesia, Logan Draw, *MAB 15855* & *RR*.

Cylindropuntia leptocaulis × *C. spinosior* (Engelmann) F.M.Knuth.

n = 11. **USA, Arizona**, Cochise Co.: 31.368° N 109.145° W, 9 km west of the New Mexican border, 3.9 km north of the Mexican border, *MAB 16466.1*, *16466.2 and others* (possible backcross to *C. spinosior*); Graham Co.: 32.854° N 110.355° W, 2 km N of Klondyke, *MAB 11648 & TW*; Pima Co.: 31.963° N 110.673° W, 2 km west of Davidson Canyon, 10 km south of Vail, *MAB 16455*.

**Cylindropuntia leptocaulis* × *C. versicolor* (Engelmann) F.M.Knuth or *C. acanthocarpa*.

n = 11. **USA, Arizona**, Pima Co.: 32°26.3′ N 110°58.5′ W, 2 km W of Big Wash, *MAB 11289*. **Mexico, Sonora**: 30°37′ N 110°57′ W, E of Magdalena, *MAB 10367 and others*

Cylindropuntia leptocaulis × *C. whipplei*.

n = 11. **USA, Arizona**, Yavapai Co.: 34°53.9′ N 112°5.2′ W, 12 km NNW of Clarkdale, *MAB 9801 & TW*; 34.693° N 111.838° W, 7 km SE of Cornville, *MAB 13335 & Byrd*.

Cylindropuntia munzii (C.B.Wolf) Backeberg.

n = 11. **Mexico, Baja California**, 31°15′42″ N 115°18′50″ W, E of San Matias, *JPR 4970 & CC*.

Cylindropuntia ×*neoarbuscula* (Griffiths) F.M.Knuth. [*C. arbuscula* (Engelmann) F.M.Knuth × *C. spinosior*].

n = 55/2. **USA, Arizona**, Pima Co.: 31.902° N 110.886° W, 10 km SE of Sahuarita, *MAB and others 10481*, *10483*.

**Cylindropuntia* ×*pallida* (Rose) F.M.Knuth,[*C. imbricata* var *imbricata* × *C. tunicata*].

n = 22. **Mexico, Hidalgo**: 20°04′ N 99°20′ W, 1 km N of Tula de Allende, **type locality for *Opuntia pallida*** Rose, *MAB 12839*.

Cylindropuntia prolifera (Engelmann) F.M.Knuth.

n = 33/2. **Mexico, Baja California**: 32°05′16′ N 116°52′22″ W, La Misión, *JPR 5119*.

Cylindropuntia ramosissima (Engelmann) F.M.Knuth.

n = 11. **Mexico, Baja California**: 31°03.6′ N 115°01.3′ W, W of San Felipe, *MAB 12901*, *12902 & RJ*; 31°01′ N 115°05′ W, E of San Felipe, *MAB 12905 & RJ*; 31°19′12″ N 115°13′04″ W, W of El Crucero, E of Sierra San Felipe, *JPR 5291 & Villareal*. **USA, Arizona**, Maricopa Co.: 33°01.96′ N 113°18.45′ W, 6 km NNE of Agua Caliente, *MAB 15317*; Mohave Co.: 35.035° N 114.138° W, 18 km SW of Kingman, *MAB 12953*. **California**, San Bernardino Co.: 38.842° N 116.801° W, N end of Newberry Mtns, *MAB 12956*; 34.702° N 115.678° W, along road to Amboy, *MAB 12955*; 34.838° N 114.975° W, W of Flattop Mtn., *MAB 12954*. **Nevada**, Clark Co.: 36°16.76′ N 115°25.91′ W, 10 km WNW of the summit of Lone Mtn. *MAB 15486* & *RR*.

n = 22. USA, **Arizona**, Maricopa Co.: 32°40.9′ N 113° W, 22 km SSW of Sentinel, *MAB 15302*; 32°35.9′ N 113°18.2′ W, 30 km S of Sentinel, *MAB 15289*, *15290*; 32°37.6′ N 113°13.2′ W, Childs Valley, 26 km S of Sentinel, *MAB 15300*.

Cylindropuntia sanfelipensis (Rebman) Rebman.

n = 33. **Mexico, Baja California**, 31°15′42″ N 115°18′50′ W, E of San Matias, *JPR and others 4969*; 31°18.8′ N 115°12.9′ W, NW of San Felipe, *MAB 15206 & M. Trushell*.

**Cylindropuntia santamaria* (E.M.Baxter) Rebman.

n = 11. **Mexico, Baja California Sur**, 24°39′18″ N 112°08′56′ W, Isla Magdalena, just N of town Magdalena, *JPR 4831*.

Cylindropuntia spinosior (Engelmann) F.M.Knuth.

n = 11. **USA, Arizona**, Pima Co.: 32.439°110.971 W°, 1.5 km W of Big Wash, *MAB 11285 & RJ*; 32°04.3′ N 110°36.4′ W, Rincon Mtns, Posta Quemada Canyon, *MAB 16554*; Pinal Co.: 33°20.3′ N 111°02.5′ W, 3 km N of Oak Flat, 7 km NE of Superior, *MAB 12186*; Yavapai Co.: 34.362° N 112.672° W, 11 km NNE of town of Peeples Valley, *MAB 7041*. **New Mexico**, Grant Co.: 32.798° N 108.189° W, Arenas Valley, E of Silver City, *MAB 11449 & TW*.

Cylindropuntia tesajo (Engelmann) F.M.Knuth.

n = 11. **Mexico, Baja California**: 28°43′15″ N 114°05′00″ W, 0.5 km SE of Santo Dominguito along road to Rosalillita, *Baker 8696* & *RJ*.

Cylindropuntia ×*tetracantha* (Toumey) F.M.Knuth [*C. acanthocarpa* × *C. leptocaulis*].

n = 11. **USA Arizona**, Gila Co.: 33.427° N 111.016° W, 24 km WNW of Globe, *MAB 13700 & RJ*; Pinal Co.:

32°34′21″N 111W 45′15”, SW corner of Sawtooth Mtns, *MAB 15122*.

Cylindropuntia tunicata (Lehman) F.M.Knuth.

n = 22. **Mexico, San Luis Potosí**: 22°06′N 100°46′W, 2 km WNW of Santo Domingo, ESE of city of San Luis Potosí, *MAB 12847*.

Cylindropuntia versicolor (Engelmann ex J.M.Coulter) F.M.Knuth.

n = 11. **USA, Arizona**, Pima Co.: 32.207° N 111.002° W, S slope of Tumamoc Hill, Tucson, *MAB 8261*, *8362*, *8263 & Van* Devender; 32.237° N 111.057° W, E side of Tucson Mtns, *MAB 8250*, *8251*, *8253*, *8254*, *8255*, *8256*, *8257*, *8259* and others; 32.352° N 110.973° W, N end of Tucson, *MAB 8139*; 32.236° N 111.058° W, E slope of the Tucson Mtns, *MAB 8136*; 32.230° N 111.327° W, ENE of Cocoraque Butte, *MAB 15309* and others.

Cylindropuntia ×*viridiflora* (Britton & Rose) F.M.Knuth [*C. imbricata* × *C. whipplei*].

n = 11. **USA, New Mexico**, McKinley Co.: 35.650° N 108.053° W, 2 km SW of Prewitt, *MAB 11734 & Hevron* (apparent backcross to *C. imbricata*), *MAB 11732 & Hevron* (apparent backcross to *C. whipplei*); 35.348° N 108.011° *W*, N of I-40, E of exit 63, *MAB 14281*.

Cylindropuntia whipplei (Engelmann & J.M.Bigelow) F.M.Knuth var *enodis* (Peebles) Backeberg.

n = 22. **USA, Arizona**, Coconino Co.: 35°31.9′N 113°14.2′W, just WNW of Grand Canyon Caverns, **type population of *Opuntia hualpaensis*** Hester, *MAB 16179.1*, *16179.2*; Mohave Co.: 035.4287° N 114.2824° W, SW base of Cerbat Mtns, *MAB 12961*; 35.149° N 113.904° W, Hualapai Mtns 0.3 mi W of D. W. Ranch, *MAB 11617*; 35°23′03″N 113°39′42″W, SW of Valentine, *MAB 15390.1*, *15390.2*, *15390.3*; 35°47′10″N 114°15′04″W, White Hills, above White Elephant Wash, *MAB 15368*; 35°54.0′N 114°01.6′W, above and W of Grapevine Wash, *MAB 16152.1*, *16152.2*; 35°18.89′N 114°24.57′W, Black Mtns, 35 km NW of Kingman, *MAB 15362*, *15363*, *15364*; 35°20.59′N 114°23.80′W, Black Mtns, 35 km NW of Kingman, *MAB 15366*; 35°45.0′N 114°10.7′W, White Hills, 4.5 km NNE of Filaree Tank, *MAB 15371*; 35°11.6′N 113°54.3’; W 1.3 km SE of summit of Rattlesnake Hill, **type locality for *Opuntia whipplei* var *enodis*** Peebles, *MAB 15360*, *15361*, *13672*; 35°46.40′N 114°14.05′W, 10 km SE of Senator Mtn., *MAB 15370*; 36°29′53″N 113°26′46″W, Little Hurricane Rim, 4.4 km NNW of Poverty Knoll, *MAB 16712.1*, *16712.2* (DES), *16712.3*, *16712.4* (RSA), *16712.5*; 36.670° N 113.495° W, south base of Poverty Mountain, just north of Parashant Canyon, *MAB 16713.1*, *16713.2*, *16713.4* (MO), *16713.5*, *16713.6* (ASC).

Cylindropuntia whipplei (Engelmann & J.M.Bigelow) F.M.Knuth var *whipplei*.

n = 11. **USA, Arizona**, Apache Co.: 34.290° N 109.810° W, W of St. Johns & NE of Show Low, *JPR 2998* (SD); Coconino Co.: 35°31.9′N 113°14.2′W, just WNW of Grand Canyon Caverns, **sympatric with type population for synonym *Opuntia hualpaensis*** Hester, *MAB 16178.1*; 36°3.5′N 112°41.5′W, 51 km WNW of Tusayon, *MAB 11544*.1 *& TW*; 35°15′52″N 111°00′31″W, Canyon Diablo, *MAB 14055*, *14055.1*; Mohave Co.: 36.795° N 113.281° W, along Navajo Trail, just west of Dutchman Draw, *MAB 16654.1*, *16715.1*, *16715.2*, *16715.3* (DES), *16715.4* (UNLV); Navajo Co.: 36°35.4′N 110°28.3′W, Long House Valley, 2.8 mi NE of jctn. Hwys 160 and 564, 25 km SW of Kayenta, *MAB 11718*; 35°55′N 110°27′W, Second Mesa, *MAB 13588*; Yavapai Co.: 34.722° N 112.158° W, 5 km SW of Jerome, *Baker 9973*; 34°50′24″N 113°00′37″W, Scratch Canyon, NW of Prescott, *TW 93–181 & MAB* [MAB]; 35.019° N 112.805° W, 35 km SSE of Seligman, *MAB 11811*; 34.985° N 112.798° W, 39 km south of Seligman, *MAB 11810*; 34.984° N 112.877° W, N side of Juniper Mesa, *MAB 9918 & TW*; 35°13.3′N 112°33.5′W, Rte. 66, 7 km W of Ash Fork, *MAB 15145*; 34.967° N 112.510° W, 3 km east of Williamson Valley Road, *MAB 16721.1*. **Nevada**, Clark Co.: 36°41.9′N 115°06.6′W, Sheep Range, 9 km NE of Hayford Peak, *MAB 15925.4*. **New Mexico**, McKinley Co.: 35.072° N 108.767° W, Cheama Canyon, 12 km east of Zuni, *MAB 16670.4*, *16670.9* & *RR*, **near type locality of *Opuntia whipplei*** Engelmann & J.M.Bigelow.

Cylindropuntia wolfii (L.D.Benson) M.A.Baker.

n = 33. **USA, California**, San Diego Co.: 32.814° N 116.128° W, 0.5 km ESE of Sweeney Pass, *MAB 12785*; 32°47′44″N 116°06′22′W, edge of Anza-Borrego Desert State Park, *JPR 4978*.

Grusonia aggeria (Ralston & Hilsenbeck) E.F.Anderson.

n = 11. **Mexico, Chihuahua**: 27°26.6′N 104°54.8′W, 16 km NNW of Torreoncitos, *MAB 12390*; 26°52′N 104°07.5′W, 1 km E of Mercurio, 25 km NE of Escalón, *MAB 15667 & Moscato*.

Grusonia clavata (Engelmann) H.Robinson.

n = 11. **USA, New Mexico**, Sandoval Co.: 35°39′N 106°52′W, 820 m E of Cachana Spring, *MAB 13559 & Himes*.

Grusonia emoryi (Engelmann) Pinkava.

n = 22. **USA, Arizona**, Graham Co.: 32°59.2′N 109°41.5′W, 17 km N of Safford, E of Gila Mtns, *MAB 11333*; 33.149° N 109.996° W, 6 km SW of Gila Pk., 44 km NW of Safford, *MAB 11638*.

Grusonia parishiorum (Orcutt) Pinkava. (Basionym originally published as *O. parishii* Orcutt and corrected to *O. parishiorum* by Crook & Mottram 2001)

n = 11. **USA, Arizona**, Mohave Co.: 35°39.3 N 114°07.5′W, 2 km west of Red Lake, *MAB 15162.2*; Pinal Co.: 32°33.9′N 111°40.9′W, 1 mi SE of Sawtooth Mtns, *MAB 11939*; **California**, San Bernardino Co.: 34°57.2′N 115°07.9′W, Fenner Valley, *MAB 13704*.

Grusonia pulchella (Engelmann) H.Robinson. [*Micropuntia pulchella* (Engelmann) M.P.Griffith, *Corynopuntia pulchella* (Engelmann) F.M.Knuth].

n = 11. **USA, Nevada**, Nye Co.: 38.183° N 117.083° W, NE of Tonopah, 7.7 mi N of Hwy 6, 5 km WNW from Thunder Mtn. summit, *MAB 12958*.

**Nopalea hondurensis* (Standley) R.Puente.

n = 22. **Honduras, Dept. Yoro**: 4 km W of Olanchito (plaza) on road to San José, *ADZ 2626 & Garcia* (DES)[JPR].

Opuntia aurea E.M.Baxter.

n = 33. **USA, Arizona**, Mohave Co.: 1.5 mi S of Colorado City, *BDP 3962 & KR*; W of Cane Beds on road to Lost Spring, *BDP 3968*, *3969*, *3970 & KR*. **Utah**, Kane Co.: 9 mi N of US 89, along Johnson Canyon Rd, *CC 505* [BDP]; 9 mi SE of jctn. US 89 with UT 9, hill just N of U8S, *CC 506* [BDP]; Washington Co.: 37.287° N 113.897° W, Beaver Dam Wash, N of Beaver Dam Mtns, *Silverman 63*, cultivated and re-collected by *MAB 11654* (All individuals with yellow flowers); 37.193° N 112.990° W, near Rockville, *Silverman 36*, cultivated and re-collected by *MAB 11653*; 37.069° N 113.133° W, 18 km SE of Hurricane; *MAB 14093 & Trudeau* (all above individuals with pink to magenta flowers, apparently introgressed with *O. polyacantha*).

**Opuntia aurea* × *O. phaeacantha*.

n = 33. **USA, Arizona**, Mohave Co.: 26 mi E of Hurricane and 29 mi W of Fredonia, road from Colorado City to Mt. Trumbull, *BDP 3629 & KR*; due W of Kane Beds, about 5 mi W of Hwy 389, T41N R7W 22S, 4000 ft, *BDP 3972 & KR*.

**Opuntia aurea* × *O. pinkavae*.

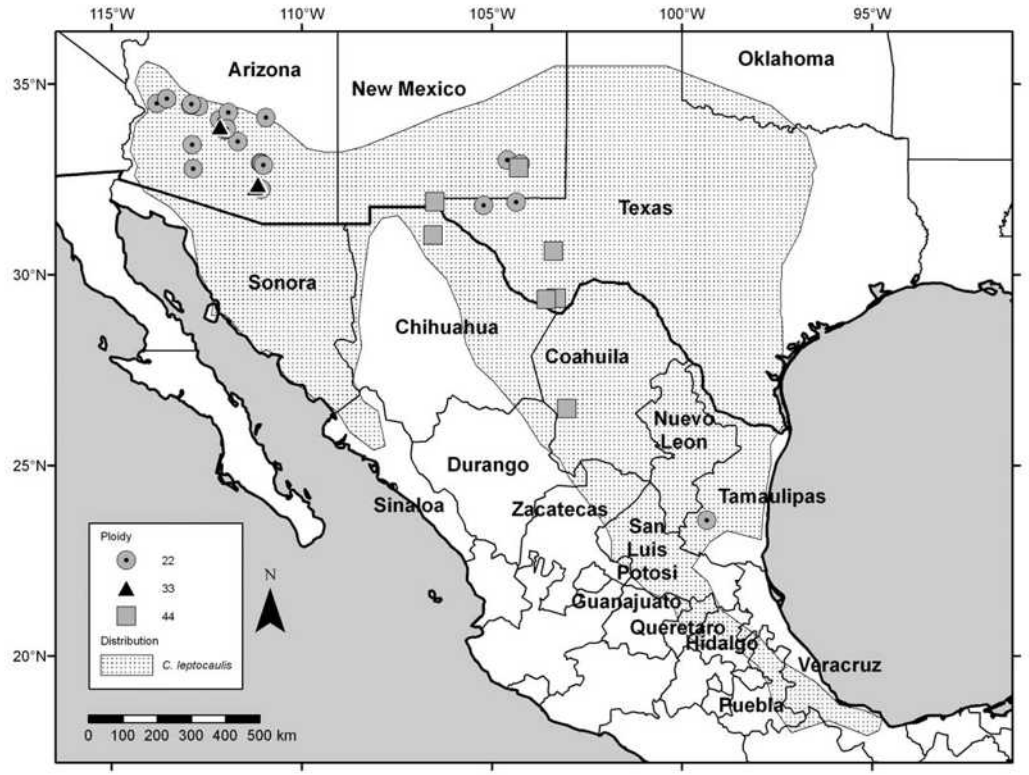

Figure 5. Distribution of chromosome determinations for individuals of *Cylindropuntia leptocaulis* (data from Pinkava and others 1973, 1977, 1985, 1992a, 1998; Powell and Weedin 2001; Ward 84; Weedin and Powell 1978).

n = 77/2. **USA, Arizona**, Mohave Co.: 1.5 mi S of Colorado City, T41N R6W 7S (or 18), 5000 ft, *BDP 3960*, *3961*, *3963*, *3965 & KR*; 26 mi E of Hurricane + 29 mi W of Fredonia, T41N R6W 12S, 5000 ft, *BDP 3624 & KR* (All with pink flowers).

**Opuntia aurea* × *O. polyacantha*.

n = 33. **USA, Utah**, Washington Co.: across from Springdale City Hall, Lion Blvd., 0.3 mi N of Hwy 89, *BDP 3619 & KR* (with magenta flowers).

Opuntia basilaris Engelmann & J.M.Bigelow var *basilaris*.

n = 11. USA, Arizona, Mohave Co.: 35°10.8′ N 113°29.4′ W, just N of Willow Creek, near Cactus Pass, **original type locality for the taxon**, *MAB 11132*; 35.149° N 113.904° W, Hualapai Mtns, 0.3 mi W of D. W. Ranch, *MAB 11618*.

**Opuntia* ×*charlestonensis* Clokey [*O. polyacantha* var *erinacea* × *O. phaeacantha*].

n = 55/2. **USA, Nevada**, Clark Co.: 36.271° N 115.599° *W*, Spring Mtns, Kyle Canyon, **near type locality for the taxon**, *MAB 16566*, 16566.1.

Opuntia chlorotica Engelmann & J.M.Bigelow.

n = 11. **Mexico, Baja California**: S of Hwy 3 between Ensenada and San Matias, just N of El Alamo, *JPR 5313 & Villarreal*. **USA, Arizona,** Yavapai Co.: 34°04.0′ N 113°02.3′ W, 20 km SW of Congress, *MAB 11517.1*; 34°49.5′ N 112°03.5′ W, 6 km N of Clarkdale, *MAB 11880 & Haberle*; 34.787° N 112.141° W, 5 km NNW of Jerome, *MAB 11892 & TW*. **California**, San Diego Co.: between Jacumba and Inkopah, *JPR 5282*.

Opuntia ×*columbiana* Griffiths (*O. fragilis* × *O. polyacantha* var *polyacantha*).

n = 33. **USA, Washington**, Benton Co.: west Richland, *Link 1*, *4*.; W of Richland, *Link 2*. [BDP]

**Opuntia comonduensis* (J.M.Coulter) Britton & Rose.

n = 11. **Mexico, Baja California Sur**: 4.4 mi S of San Gregorio, *JPR 5128*.

Opuntia ×*curvispina* Griffiths. (Originally published as *O. curvospina* Griffiths and corrected to *O. curvispina* by Crook & Mottram 1996)

n = 22. **USA, Arizona**. Mohave Co.: 35.201° N 113.931° *W*, E of Kingman, 1.8 km W of Rattlesnake Hill, *MAB 13630*; 35°45′03″ N 114°12′55″ W, 64 km NNW of Kingman, 13 km SE of Senator Mtn., *MAB 13647.1*.

Opuntia durangensis Britton & Rose.

n = 22. **Mexico, Sonora**: E of Yecora, between Yecora and Maycoba, *JPR 5274* and others.

Opuntia engelmannii Salm-Dyck ex Engelmann var *cuija* Griffiths & Hare.

n = 11. **Mexico, San Luis Potosí**: 21°42′ N 100°39′ W, 8 km WNW of Tierra Nueva, S of San Luis Potosí, *MAB 12843*. **Zacatecas**: 23°39.1′ N 103°35.4′ W, E of city Durango, 5 km ENE of Sombrerete, *MAB 12383*, *12833* aff

Opuntia engelmannii var *engelmannii*.

n = 33. **Mexico, Baja California**: Hwy 3 between Ensenada and San Matias, *JPR 5299*, *5301 & Villarreal*. **USA, Arizona**, Gila Co.: 33.387° N 110.889° *W*, 4 km E of Needle Mtn., *TW 1169.2*; 34.388° N 111.65° W, 13 km W of Strawberry, *MAB 12951*; Pima Co.: 32°26′ N 111°01′ W, just S of Tortolita Mtns, *MAB 13328*, *13332*, *13333 & ADZ*; Yavapai Co.: 34.804° N 112.834° W, 44 km NW of Prescott, MAB 10819; 34.733° N 112.972° W, 50 km NW of Prescott, *MAB 10837*; 34°49.1′ N 112°04.4′ W, 5.5 km

NNW of Clarkdale, *TW 1426*, *1427 & MAB* [MAB]; 34.831° N 112.179° W, 10 km NW of Jerome, *TW 1618.2 & MAB* [MAB]; 34°47.0′ N 112°10.5′ W, N base of Woodchute Mtn., *MAB 10279*; 34°18.2′ N 112°15.5′ W, Turkey Creek, 3.5 km NNW of Battle Flat, *MAB 15039.1*, *15039.2*. **California**, San Diego Co.: between Jacumba and Boulevard, Hwy 80, *JPR 5286*.

***Opuntia engelmannii* var *linguiformis* (D.Griffiths) B.D.Parfitt & Pinkava.

n = 55/2. **USA, Arizona**, Pima Co.: 32°04.3′ N 110°36.4′ W, Rincon Mtns, Posta Quemada Canyon, at old homestead, *MAB 16555*.

Opuntia engelmannii × *O. phaeacantha*.

n = 33. **USA, Arizona**, Pinal Co.: 32°50.2′ N 111°19.4′ W, SE of Florence, *MAB 11146 & TW*; Yavapai Co.: 34°26′ N 112°44′ W, 3.5k NW of Kirkland, **near type locality of *O. arizonica*** Griffiths, *MAB 12768 and others*

Opuntia fragilis (Nuttall) Haworth.

n = 33. **USA, Arizona**, Navajo Co.: 36°18.1′ N 110°10.6′ W, Cliff Spring Valley, *MAB 12666* & *Jodi*.

Opuntia humifusa (Rafinesque) Rafinesque var *humifusa*.

n = 11 **USA, Florida**, Alachua Co.: 2.8 mi SW of jctn. of Hwys 24 and 41 in Archer, *BDP 5166*, *5167*, *5168*, *5169 & CH* [DJP]; Hamilton Co.: 5.5 mi W of Jasper, *BDP 5163 & CH* [DJP]; Marion Co.: 6.5 mi from Salt Spring, *BDP 5173 & CH* [DJP].

Opuntia macrocentra Engelmann.

n = 11. **USA, Texas**, Brewster Co.: 29°27′ N 103°32′ W, S of Alpine, 5 km ESE of Hen Egg Mtn., *MAB 12800*; Hudspeth Co.: 31°10′ N 105°42′ W, 2 km NNE of Esperanza, *MAB 12796*.

n = 22. **USA, New Mexico,** Chaves Co.: 33°18.88′ N 103°51.3′ W, 2.3 km west of the Mescalero Ridge (Caprock), 50 km west of Tatum, *MAB 16457* & *and RR*; Grant Co.: 32.856° N 108.524° W, 25 km WNW of Silver City, above Black Smith Canyon, *MAB 11627* & *and TW*; Hidalgo Co.: 31.860° N 108.425° *W*, Little Hatchet Mtns, 60 km SE of Lordsburg, 2 km NE of Hachita Pk., S end of Howells Ridge, *MAB 16501*.

Opuntia macrorhiza Engelmann.

n = 22. **Mexico, Sonora:** 28°22′33″ N 108°56′24″; W 2 km NW of Yécora on old road to Santa Rosa, Originally collected by *Tom Van Devender 96–116* and others, 13 March 1996, transplanted into cultivation, Chino Valley, Arizona, and re-collected by *MAB 12191*. **USA, Arizona**, Mohave Co.: Hwy 66, 2.5 mi E of jctn. with Moulthan Rd in Truxton, *BDP 5383 & Kohan*; Yavapai Co.: 34.489° N 112.582° W, 12 km SW of Prescott, 400 m SE of the top of Gabarina Hill, *MAB 14868*; 34°46.8′ N 112°26.6′ W, Chino Valley, *MAB 16162*; 34.984° N 112.877° W, 38 km S of Seligman, 3 km NE of Pine Springs, *MAB 9914 & TW*; 34.791° N 112.980° W, Santa Maria Mtns, 54 km NW of Prescott, *MAB 11069 and others* **USA, New Mexico**, Lincoln Co.: 33°37.6′ N 104°57.1′ W, 45 km NW of Roswell, at Cedar Hill, *MAB 15110* & *Woodard*.

**Opuntia macrorhiza* × *O. phaeacantha*.

n = 55/2. **USA, Arizona**, Yavapai Co.: 34°18.8′ N 112°13.0′ W, 4 km NNE of Cleator, *MAB 14888*. Meiosis irregular: some cells forming up to 8 micronuclei; some cells at anaphase I producing 27 chromosomes (two-stranded with unreduced centromeres) plus one chromosome (one-stranded with reduced centromeres to each pole); one cell *n* = ca. 33.

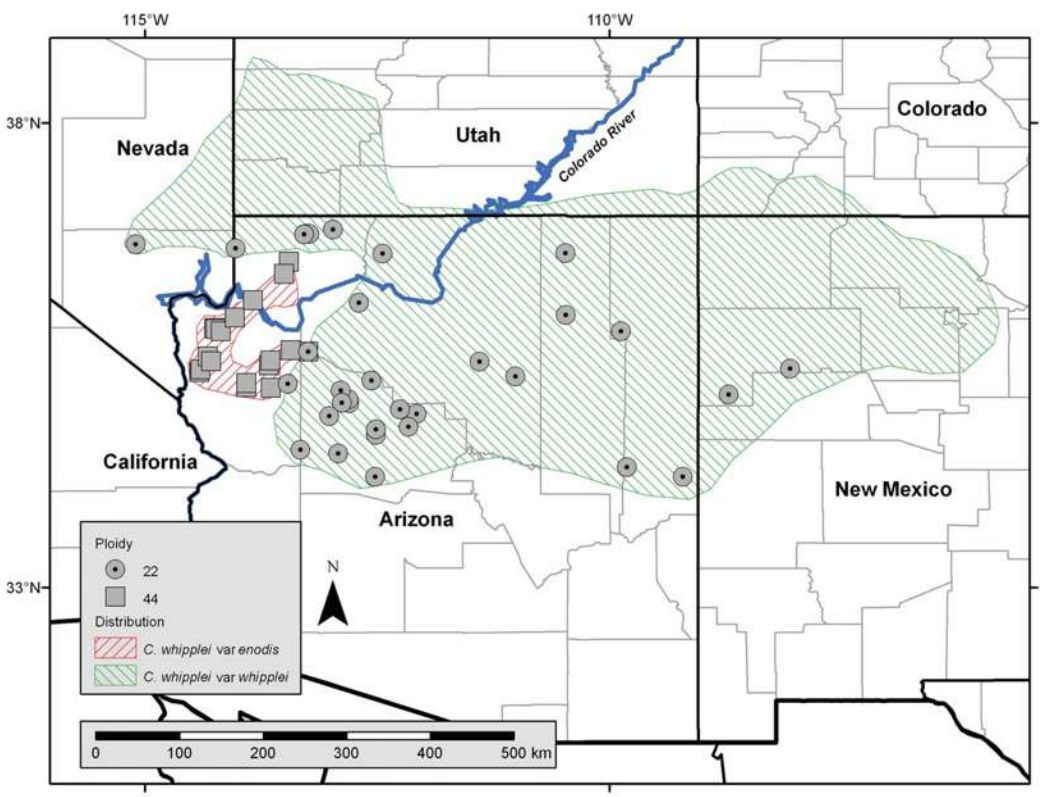

Figure 6. Distribution of chromosome determinations for individuals of *Cylindropuntia whipplei* (data from Pinkava and others 1973, 1992a, 1998; Pinkava and Parfitt 1982).

Opuntia phaeacantha Engelmann *sensu lato*.

n = 33. **Mexico, Baja California**: Hwy 2 between Tecate and Mexicali, *JPR 5287 & Villarreal*. **Sonora**: 3.7 mi S Hwy 16 between Hermosillo and Yecora, *JPR 5268* and others. **USA, Arizona**, Cochise Co.: 1.4 mi NW of Portal, *ADZ 2777*; Gila Co.: 33°42.7′ N 110°32.2′ W, 9 km SSE of Ash Mtn., *MAB 16275*; Pima Co.: 32.440° N 110.968° W, 13 km SSW of Oracle Junction, *MAB 11288* [spineless morphotype *'O. phaeacantha* var *laevis*']; Mohave Co.: 1.5 mi S of Colorado City, *BDP 3959 & KR*; Hidden Hills, 36°24′50N 113°38′26W, *MAB 13658*; Pima Co.: 32°26′ N 111°01′ W, Tucson, just S of Tortolita Mtns, *MAB 13329*, *13330*, *13331 & ADZ*; Santa Cruz Co.: 31°29.7′ N 110°45.5′ W, Flux Canyon, *MAB 15341*; Yavapai Co.: 34°20.9′ N 112°30.3′ W, 11 km SE of Wilhoit, Pole Camp Canyon, *MAB 14987*; 34.844° N 112.462° *W*, 5 km N of Chino Valley, *MAB 12309*; 34°43′ N 112°46′ W, NNE of Prescott, N base of Eagle Pk., *MAB 12399*, unusual form with thick, often elongate stem segments, areoles with a proliferation of glochids, and all or all but one of the spines appressed and pointing nearly straight down; 34°17.0′ N 112°29.4′ W, Bradshaw Mtns, SSW of Prescott, *MAB 15000*; 34.733° N 112.972° W, 50 km NW of Prescott, 3.7 km SW of Connell Mtn. summit, *MAB 10838*; 34.785° N 112.852° W, NW of Prescott, 4.1 km SW of Brushy Mtn., *MAB 11206 & TW*; 34.827° N 112.760° W, NW of Prescott, NW of Johnson Pk., *MAB 11048* & *TW*; 34.792° N 112.162° W, 6 km NW of Jerome, *TW 1718 & MAB* [MAB]; 34.984° N 112.877° W, 38 km S of Seligman, N side of Juniper Mesa, *MAB 9915 & TW*; NW corner of Jctn. Hwys 93 and 71, *DJP 3949* (*n* = ca. 33). **Nevada**, **Clark Co.**: 36.276° N 115.580° *W*, Kyle Canyon, *MAB 16569* (coexisting with *O.* ×*charlestonensis*). **New Mexico**, Chaves Co.: 32°58.1′ N 104°09.5′ W, 27 km ENE of Artesia, *MAB 15849*; Grant Co.: 32.856° N 108.524° W, Black Smith Canyon, *MAB 11627.1 & TW*; Sandoval Co.: 35°37′ N 106°42′ W, S of Metita Blanca, *MAB 13571*.

Opuntia pinkavae B.D.Parfitt.

n = 44. **USA, Arizona**, Mohave Co.: Hwy 389, 20.5 mi W of its jctn. with Hwy 89A in Fredonia, *BDP 3958* & *KR*.

Opuntia polyacantha Haworth var *erinacea* (Engelmann & J.M.Bigelow) B.D.Parfitt.

n = 22. **USA, Arizona**, Coconino Co.: 36.086° N 112.683° W, SW of Driftwood Canyon, *MAB 11544 & TW*; Mohave Co.: between Hurricane Cliffs and White Pockets on BLM Rd. 30, *BDP 4624* & *CC*. **Nevada**, Clark Co.: 36°16.3′ N 115°35.0′ W, Kyle Canyon, 5 km south of Angel Peak, *MAB 16590.1* & *Widdowson*; Nye Co.: 38.183° N 117.083° W, NE of Tonopah, 5 km WNW from summit of Thunder Mtn., *MAB 12958.1*.

**Opuntia polyacantha* var *hystricina* (Engelmann & J.M.Bigelow) B.D.Parfitt.

n = 22. **USA, Arizona**, Apache Co.: 7.2 mi WNW of Navajo Hwy 13, *BDP 3550* & *Reeves*; Mohave Co.: E of Hualapai Ind. Res., Hwy 18, 44.2 mi NE of Hwy 66, *BDP 5386*, *5387 & Kohan*.

Opuntia polyacantha var *nicholii* (L.Benson) B.D.Parfitt.

n = 33. **USA, Arizona**, Coconino Co.: 1.9 mi E of Cliff Dwellers Lodge, Hwy 89A, *BDP 4293* & *CC*.

Opuntia polyacantha var *polyacantha*.

n = 11. **USA, Arizona**, Navajo Co.: 36.678° N 110.544° W, 26 km WSW of Kayenta, *MAB 11714*. **New Mexico**, Catron Co., 34°29.6′ N 108°25.0′ W, 16 km NNE of Quemado, *MAB 11427*; Chaves Co.: 33.566° N 103.820° W, 31 km SSW of Kenna, 68 km ENE of Roswell, *MAB 16641.1* & *RR*; McKinley Co.: 35.487° N 108.162° W, 4.5 km SSW of Smith Lake, *MAB 11901*; Cibola-McKinley cos. line: Bluewater State Park overlook, *BDP 3540 & Nelson*; McKinley Co.: 35.506° N 108.154° W, 13 km NNE of Thoreau, *MAB 11898 and others*; Otero Co.: 32.399° N 106.096° W, SE base of Jarilla Mtns, *MAB 13877*, *13877.2 & Himes*; Sandoval Co.: 35°47′ N 106°56′ W, N of Arroyo Veguita Blanca, *MAB 13562*, *13562.1 & Himes*; 35°39′ N 106°52′ W, W of Peñasco Canyon, MAB 13557 & Himes. **Utah**, San Juan Co.: Hwy 95, 10 mi E of jctn. with Hwy 276, *CC 609* [BDP].

n = 22. **USA, Colorado**, Alamosa Co.: near base of Little Bear Pk., *BDP 3653 & KR*; Arapahoe Co.: Aurora, *Weedin 1573* [BDP]; Chaffee Co.: Hwy 285, N edge of Nathrop, **type locality for *O. beacockiae*** Arp **(Originally published as *O. beacockae* Arp and corrected by Crook & Mottram 1998)**, *BDP 3668 & KR*; Fremont Co.: Hwy 9, 5.3 mi N of Hwy 50, then 42 mi s of Hwy 24, *BDP 3663*, *3664*, *3669 & KR*; Hwy 50, 3.1 mi E of Canon City, 1.9 mi E of Four-Mile Crossing, *BDP 3662 & KR*; Huerfano Co.: W of Walsenberg, Hwy 160, 10 mi W of jctn. with I-10, *BDP 5388 & Kohan*; Larimer Co.: Mouth of Elkhorn Canyon, 1.5 mi W of Big Narrows, *Wilken 14969* [BDP]; Poudre Canyon, T8N R70W 4S, *Wilken 14974* [BDP]; Pueblo Co.: Univ. Southern Colorado campus, *BDP 3657 & KR*. **Idaho**, Bingham Co.: 9 mi W of downtown Blackfoot, *BDP 3777*, *3778* & *KR*; Butte Co.: 34.3 mi E of jctn. Hwys 20 and 26/93 at Carey, *BDP 3779 & KR*. **New Mexico**, Guadalupe Co.: Santa Rosa Lake, E side of dam, *DJF 670* [DJP]; Torrance Co.: 2.7 mi W of jctn. Hwys 41 and 55 + 10.9 mi E of old cemetery in Tajique, *BDP 3530 & KR*; Union Co.: Hwy 3325, 3 mi N of Capulin Mtn. National Monument, *Weedin 1568 & Weedin* [BDP]. **Utah**, Weber Co.: 12 mi W of I-15 at Ogden, 1.5 mi E of Little Mtn., *BDP 3776 & KR*. **Wyoming**, RJ Co.: Hwy 190 to Barnham, 5.5 mi W of jctn. with Hwy 191, *G. K. Brown 2966 and others* [BDP].

Opuntia polyacantha var uncertain (few-spined form).

n = 22. **USA, Arizona**, Apache Co.: SE of Tsaile Lake, *BDP 3556*, *3557 & Reeves*; NE of Tsaile, *BDP 3551 & Reeves*. **California**, Mono Co.: French Camp Campground, near Tom's Place, *BDP 3832 & KR*; McGee Creek, near Tom's Place exit, Hwy 395, *BDP 3836 & KR*; **Colorado**, La Plata Co.: Hwy 160, 5.2 mi W of Bayfield, *BDP 3697 & KR*; **Nevada**, White Pine Co.: 20.2 mi W of Ely cemetery, Hwy 50, *BDP 3818 & KR*; **New Mexico**: Colfax Co.: 36°48.4′ N 104°55.38′ W, 2.3 km W of Vermejo River, *MAB 12528.2* & *TW*; San Juan Co.: 0.4 mi S of Animas River on Hwy 555 + 0.6 mi E on County Rd. 2390, *BDP 3696 & KR*; **Utah**, Sevier Co.: 3.9 mi of jctn. Hwys 89 and 4, *BDP 3763 & KR*.

Opuntia pottsii Salm-Dyck.

n = 22. **USA, New Mexico**, Chaves Co.: 33°00.4′ N 104°10.3′ W, 54 km SE of Roswell; 18.5 km SE of Hagerman, *MAB 15835*; 32°58.1′ N 104°09.5′ W, 27 km ENE of Artesia, *MAB 15850*.

Opuntia pycnantha Engelmann.

n = 11. **Mexico, Baja California Sur**: Isla Santa Margarita; in canyon on N side of Cerro Margarita, *JPR 4829 & N. Roberts*.

Opuntia rufida Engelmann.

n = 11. **Mexico, Coahuila**: 25°30′ N 103°20′ W, SE of Torreón, 2.5 km E of La Perla, *MAB 12820*.

**Opuntia streptacantha* Lemaire × *O. tomentosa*.

n = 44. **Mexico, Hidalgo**: 20.075° N 99.336° W, 1 km N of Tula de Allende, *MAB 12841*.

Opuntia tomentosa Salm-Dyck.

n = 44. **Mexico, Hidalgo**: 20.075° N 99.336° W, 1 km N of Tula de Allende, spiny form, *MAB 12840*.

Subfamily Cactoideae

Carnegiea gigantea (Engelmann) Britton & Rose.

n = 11. **USA, Arizona**, Maricopa Co.: 32°48.2′N 112°27.1′W, Sand Tank Mtns, *MAB 15320*.

**Coryphantha alversonii* (J.M.Coulter) Orcutt.

n = 11. **USA, California**, San Bernardino Co.: 35.155° N 115.223° W, 10 km N of Hackberry Mtn., *MAB 13759 & Pauly*.

Coryphantha chlorantha (Engelmann) Britton & Rose.

n = 11. **USA, Arizona**, Mohave Co.: Just N I-15, 15 km SSW of St. George, Utah, T41N R13W 1S, *Gierisch 5118* [BDP]. **Nevada**, Clark Co.: 36.177° N 115.261°; W 8 km SSE of Lone Mtn., *MAB and others 11366.1*.

Coryphantha robustispina (A.Schott ex Engelmann) Britton & Rose ssp *scheeri* (Lemaire) N.P.Taylor.

n = 11. **USA, Texas**, Pecos Co.: 30°52′N 102°27′W, just south of Big Mesa, 40 km east of Fort Stockton, *MAB 15645.1 and others*

Coryphantha vivipara (Nuttall) Britton & Rose var *arizonica* (Engelmann) W.T.Marshall.

n = 11. **USA. Arizona**, Yavapai Co.: 34°18.0′N 112°29.8′W, Bradshaw Mtns, 1.9 km SSW of Battleship Butte, *MAB 14997*.

Echinocactus texensis Hopffer.

n = 11. **USA, New Mexico**, Eddy Co.: 32°45.2′N 104°14.8′W, 17 km SE of Artesia, *MAB 14286.1 & RR*.

Echinocereus arizonicus Rose ex Orcutt ssp *arizonicus*.

n = 11. **USA, Arizona**; Pinal Co.: Devil's Canyon Picnic Area, E of Superior, *BDP 4836 & CC*; US Hwy 60 at Pinto Creek *BDP 4833 & CC*; T1S R14E 7S, *BDP 4835* & *CC*.

Echinocereus arizonicus ssp *nigrihorridispinus* W.Blum & Rutow.

n = 11. **USA, Arizona**, Cochise Co. SE of Tombstone, T20S R22E 36S, *BDP 4236*, *4237 & CC*; S of Huachuca Mtns, canyon fed by Yaqui Spring, *BDP 4987 & CC*; 31°53.67′N 109°58.29′W, NW of Cochise Pk., *MAB 15394*; Graham Co.: 33.056°N 109.747° *W*, 8.3 km NW of Bryce Mtn., *MAB 11641*; 32.978° N 109.643° W, Gila Mtns, N of Safford, 1.5 km WNW of Bear Spring, *MAB 13949*; Pima Co.: 31°50.92′N 110°45.72W, E side of Hart Butte, *MAB 15503*.

**Echinocereus bonkerae* Thornber & Bonker ssp *apachensis* (W.Blum & Rutow) A.D.Zimmerman.

n = 11. **USA, Arizona**, Gila Co.: 33.038° N 110.730° W, Dripping Springs Mtns, 4 mi NE of Winkleman, *MAB 8117*; Maricopa Co.: 33°32.4′N 111°20.7′W, 2 km SW of Fish Creek, 5 km S of Horse Mesa Dam at Apache Lake, **type locality for *E. apachensis*** W.Blum & Rutow, *MAB 12229*; Pinal Co.: 33.204° N 111.056° W, 11 km SSE of Superior, *MAB 12183*; 33.171° N 110.949° W, 15 km N of Kearny, *MAB and others 11245*, *11246*.

Echinocereus bonkerae ssp *bonkerae*.

n = 11. **USA, Arizona**, Gila Co.: Hwy 288, 3.8 mi NNW of Salome Creek Rd. & 16 mi N of Hwy 88, *BDP 4820*, *4821*, *4825 & CC* [the last intermediate to *E. bonkerae* ssp *apachense*]; Pinal Co.: 6 km SSE of Oracle, Santa Catalina Mtns, *ADZ 2635*; ca. 6 mi SE of Oracle, *ADZ 2807* (*n* = ca. 11); 33.607° N 110.75° W, Oracle, 1300 m E of the jctn of Mt. Lemmon Road and the Oracle loop, N side of Mt. Lemmon, **near lectotype locality for *this taxon*** *MAB 16504.2*.

Echinocereus coccineus Engelmann ssp *coccineus*.

n = 22. **USA, Arizona**, Graham Co.: 32°58.7′N 110°21.5′W, 60 km SE of Globe, south slope of Horse Mountain, *MAB 11647* & *TW*; La Paz County: 34.006°N 113.508° *W*, Harcuvar. Mtns, 20 km N of Wenden, *MAB 13695.1*, *13695.2* & *Byrd*; Mohave Co.: 36.221°N 113.058°; *W* Toroweap, **type locality for *E. triglochidiatus*** Engelmann **var *toroweapensis*** P.C.Fischer, *MAB 13761.2* & *Pauly*; 35°55.3′N 113°54.8′W, N of Seligman, Grapevine Canyon, *MAB 15161.1*; SW of Colorado City, *BDP 4258 & CC*; 35°39.9′N 113°27.0′W, Peach Springs Canyon, *MAB 13926.1*; Pinal Co.: 33.441° N 111.061° W, west fork of Pinto Creek, FS Rd 287(A), *MAB 13777*; Yavapai Co: 34°49.5′N 112°03.8′W, along Verde River across from S. O. B. Canyon, *MAB 13930*; 34.823° N 112.069° *W*, 2 km E of Packard Trail Tank, *MAB 11757*; Pinal Co.: 33°26′30″N 111°03′15″W, 17 km NNE of Superior; Pinto Creek, *MAB 13799* & Ziemmeck; 34.984° N 112.877° W, 38 km south of Seligman, north side of Juniper Mesa, *MAB 9916* & *TW* (seed-producing). **New Mexico**, McKinley Co.: 35.488° N 108.163°; *W* 51 km E of Gallup, *MAB 11899.2*; Mora Co.: 36°02′50″N 105°06′25″W, 3 km S of Cerro Del Amole Pk., *MAB 13816.1*; 35.835° N 104.994° *W*, 1.5 km SW of Wolf Creek along the Santa Fe Trail, **near type locality for this taxon**, *MAB 12575*; Sandoval Co.: 35°39′N 106°52′W, 1.4 km N of Los Pinos Arroyo, *MAB 13546.1 & Himes*. **Utah**, Washington Co.: 37.076° N 113.157° W, 35 km E of St. George, *MAB 14090.1* & Trudeau.

Echinocereus coccineus ssp *paucispinus* (Engelmann) W.Blum, Mich.Lange, & Rutow.

n = 22. **USA, New Mexico**, Eddy Co.: 32.171° N 104.486° *W*, Walnut Canyon, *MAB 13077.1*. **Texas**, Crockett Co.: 30°43.1′N 101°48.1′W, 3.5 km NE of Sheffield, *MAB 16029*; Terrell Co.: 30.058° N 102.235° W, 18 km ESE of Sanderson, *MAB 16614.1* & *RR*.

Echinocereus coccineus ssp *rosei* (Wooton & Standley) W.Blum & Rutow.

n = 22. **USA, New Mexico**, Chaves Co.: 33°03.1′N 104°47.3′W, 40 km SW of Roswell, Crooked Canyon, *MAB 15655.1*, *15655.3*; Doña Ana Co.: 32°21.00′N 106°36.72′W, 15 km E of Las Cruces, *MAB 15565*; 32.002° N 106.524° W, 8 km E of Anthony, *MAB* 13324.1; east Potrillo Mtns, NE side of Mt. Riley, *Worthington 20497* [DJP]; Lincoln Co.: 33°18.5′N 104°56.6′W, 30 km WSW of Roswell, 5 km SW of Horseshoe Bend, *MAB 15656.2*; 33°40.8′N 105°55.0′W, the Malpais, N of Carrizozo, *MAB 14297 & RR*; 33.200° N 105.061° W, 54 km WSW of Roswell, 1.5 km east of Border Hill between Twin Butte and Monuments Canyons, *MAB 16665.1* & *RR*; Otero Co.: 32.398° N 106.096°; *W* 2 km NNW of Orogrande, *MAB 13876*, *13876.2* & *Himes*. **Texas**, Culberson Co.: 31°53′N 104°52′W, summit of Guadalupe Pk., *MAB 13086.1*.

Echinocereus dasyacanthus Engelmann.

n = 22. **USA, New Mexico**, Eddy Co.: 32°45.2′N 104°14.8′W, 17 km SE of Artesia, *MAB 14285.1*, *14285.2*; Otero Co.: 32.398° N 106.096° W, 2 km NNW of Orogrande, *MAB 13875* & *Himes*; **Texas**, Pecos Co.: 30°25′N 102°58′W, Glass Mtns, 2 km S of Marathon Gap, *MAB 12808*.

Echinocereus engelmannii (Engelmann) Lemaire ssp *engelmannii*.

n = 22. **Mexico**, **Baja California**: SW of Ejido Matias, 3 mi S of Mex 3 on road to Mike's Sky Ranch, *JPR and others 2653*; 105 km S of San Quintín, 4.5 mi E of Hwy 1, *JPR 1640 & Delgadillo*; 9 mi S of Mex. 3 on road to Mike's Sky Ranch, *JPR 1093 & Rice*. **USA, California**, San Bernardino Co.: 34.914° N 115.048° W, 1.3 km ESE of Goffs, north end of Piute Mountains, **type locality of *Echinocereus engelmannii* var *howei*** L.D.Benson, *MAB 16689.2*, *16689.4*; 34.475° N 117.124° W, 5 km east of the town of Apple Valley, 300 m north of Deadman Point, **near type locality of *Echinocereus engelmannii* var *armatus*** L.D.Benson, *MAB 16700.1*; San Diego Co.: Anza-Borrego Desert State Park, SW of Torote Canyon, *JPR 3027 & Simpson*. **USA, Arizona**, Coconino Co.: 36.279° N 111.493° W, 5 km SW of the Gap, *MAB 12478***;** 36°41.131′N 111°39.266W, 6 km N

of Bitter Springs, 1.8 km W of Echo Cliffs, *MAB 16532.1*, *16532.3*, *16532.4*; 36°48.5′ N 111°39.24W, N branch of Sevenmile Draw, *MAB 16534.1*, *16534.4*; 36°43.883′ N 112°03.368W, 1.1 km N of House Rock Canyon, *MAB 16535.4*; 35.884° N 111.452° W, 4 km N of Cameron, *MAB 12442 & Hevron*; 11 mi due S of Gray Mtn., *ADZ and others 2821*; La Paz Co.: 34.027° N 113.531° *W*, Butler Valley; *MAB 16468*; Maricopa Co.: 33°43.469′ N 112°14.17′ W, Deer Valley, near **type locality of *E. engelmannii* var *acicularis* L. D. Benson,** *MAB 16465.1*, *16465.2*, Mohave Co.: 35°23′03″ N 113°39′42″ W; W SW of Valentine, *MAB 13643*; 35°19.0′ N 114°23.2′ W, Black Mtns, 2.4 km NNW of Willow Spring, *MAB 15261*; 35.135° N 113.522° W, 1.3 km south of Willow Creek, 2.7 km ENE of Mesquite Thicket Spring, **type locality for *Cereus engelmannii*** Engelmann **var *variegatus*** Engelmann & J.M.Bigelow, *MAB 16644.1*, *16644.2*; Yavapai Co.: 34°20.7′ N 112°13.3′ W, 7 km N of Cleator, *MAB 14566.1*; 34°12.1′ N 112°09.4′ W, 600 m NW of Bumblebee, *MAB 16145.1*, *16145.2*; **Nevada**, Clark Co.: 36.475° N 115.470° W, SW of jctn. of Hwys 95 and 156, 44 km NW of central Las Vegas, *MAB 11956*; 35°31.2′ N 115°03.4′ W, 14 km WNW of Searchlight, *MAB 14311*. **Utah,** Washington Co.: 37°10.353′ N 113°16.3067W, Hurricane Cliffs, 1.6 km E of Hurricane, *MAB 16539.1*, *16539.2*, *16539.4*.

Echinocereus engelmannii ssp *engelmannii* [intermediate to *E. engelmannii* ssp *fasciculatus*].

n = 22. **USA**, **Arizona**; Pinal Co.: 5.5 mi W of Boyce-Thompson Arboretum, *BDP 4206*, *4207*, *4208 & CC*; 4.8 mi W of Boyce-Thompson Arboretum, *BDP 4220 & CC*.

Echinocereus engelmannii ssp *fasciculatus* (Engelmann ex S. Watson) W. Blum & Mich. Lange [includes *E. boyce-thompsonii* Orcutt and *E. rectispinus* Peebles var *robustus* Peebles].

n = 22. **USA, Arizona**, Cochise Co.: 32.311° N 109.073° W, 2 km NE of Roostercomb, *MAB 11650 & TW*; Gila Co.: 33.666° N 111.219° W, 600 m N of Buckhorn Spring; Tonto Basin, *MAB 8282*; Coconino Co. 35°31.9′ N 113°14.3′ W, WNW of Grand Canyon Caverns, *MAB 16177.1*, *16177.2*; Graham Co.: 32°52.0′ N 109°31.1′ W, SE-facing slope below Earven Flat at N side of the Gila River Floodplain, **neotype locality for *Mammillaria fasciculata*** Engelmann, *MAB and others 16180.1*, *16180.2*; 32°58.4′ N 109°40.4′ W, near Hackberry Spring, *MAB and others 11327*; 32°40′ N 110°16′ W, 4.2 km NNE of Kennedy Pk., *MAB 13413*; Maricopa Co.: 33°32.4′ N 111°20.7′ W, Apache Trail, 2 km SW of Fish Creek, *MAB 12230*; 33°32.0′ N 111°27.2′ W, 1 km SW of Canyon Lake, *MAB 12189*; 33.530° N 111.402° W, 19 km NE of Apache Junction, along the Apache Trail, *MAB 12231*; Pima Co.: 32°04.3′ N 110°36.4′ W, Rincon Mtns, 20 km SE of edge of Tucson, *MAB 16134*, *MAB 16529.1*, *16529.2*; 32°02.6′ N 111°01.6′ W, Santa Cruz Valley, 20 km SSW of Tucson, *MAB 16372.1*; Pinal Co.: 33°16.9′ N 111°0.93′ W, 400 m NE of confluence Queen Creek and Silver King Wash, **near original type locality for *E. boyce-thompsonii*** Orcutt, *MAB 16449.2*, *16449.3*; native to Boyce Thompson Southwestern Arboretum, near Superior, "magna ridge area," *Omar 1* [BDP]; 33.281° N 111.094° W, just S of Superior, *MAB 8141*; 32°35.7′ N 110°43.7′ W, Ray Spring Hill, along Mt. Lemmon Road, 4 km E of Oracle, *MAB 16273.1*, *16273.2*, *16273.4*; 32°31.5′ N 110°42.2′ W, Nugget Canyon, along Mt. Lemmon Road, *MAB 16272.1*; Yavapai Co.: 34°46′24″ N 112°12′41″ W, 4 km NW of Woodchute Mtn. summit, *MAB 13872.1* & *D. Trudeau*; 34.620° N 111.872° W, 6.5 km NNW of Camp Verde, *MAB 12966*, *12966.1*; 34.858° N 112.210° W, 15 mi ENE of Chino Valley, *MAB 9059.1*, *9059.2*; 35.038° N 112.533° W, 20 km S of Ash Fork, *MAB 11477 & TW*; 34.934° N 112.467° W, south of Ash Fork, 7 km SW of Rock Butte, MAB 11612 & TW; 34.666° N 112.925° W, ENE of Loco Pool Spring, *MAB 11196*; 34°57.1′ N 112°07.2′ W, 22 km NNW of Clarkdale, *MAB 10329*; 34.803° N 112.186° W, 9 km NW of Jerome, *TW 1434 & MAB* [MAB]; 34°48.6′ N 112°09.2′ W, E of Horseshoe Canyon, *MAB 12042 & Mohr*; 34.871° N 112.168° W, 14 km NNW of Jerome, *MAB 12073 & RR*; 34°24.5′ N 112°42.3′ W, 1 km S of Kirkland, *MAB 12396.1*; 34°40.5′ N 111° W, 14 km ENE of McGuireville, *TW 1812.1 & MAB* [MAB]; 34.997° N 112.265° W, 31 km NW of Clarkdale, MC Canyon, *MAB 11291.1*.

Echinocereus enneacanthus Engelmann ssp *brevispinus* (W.O.Moore) N.P.Taylor.

n = 11. **USA, Texas,** Val Verde Co.: 29°48′ N 101°27′ W, ESE of Langtry, *MAB 12851*.

Echinocereus enneacanthus Engelmann ssp *enneacanthus*.

n = 11. **Mexico**, **Chihuahua**, 27.443° N 104.913° W, NW of Jimenes, *MAB 12388*.

Echinocereus fendleri (Engelmann) F.A.Haage (northern race).

n = 11. **USA, Arizona**, Apache Co.: 34.109° N 109.076° W, 19 km ESE of Springerville, *MAB 11431.1* & *TW*; Navajo Co.: 35°47.5′ N 110°07.3′ W, NE of Jeddito, *MAB 12654*; 35°59′ N 110°03.5′ W, E end of Low Mtn.; SE of Piñon, *MAB 12659*; Greenlee Co.: Hwy 78, 9 mi W of New Mexico state line, *D. A. Zimmerman s.n. & M. A. Zimmerman*, vouchered from hort. as *ADZ 3558* [ADZ]; Yavapai Co.: 34.778° N 112.202° W, NW base of Woodchute Mtn., *MAB 9101*; 34°49.3′ N 112°56.1′ W, 600 m S of Camp Wood Mtn., *MAB and others 10534*. **New Mexico**, Grant Co.: 32.856° N 108.524° W, 1 mi NNE of Mangas Springs, *MAB 11628* & *TW*; Chaves Co.: 33.806° N 104.434° *W*, 1.2 km E of Hobbs Canyon, *MAB 16462*; Sandoval Co.: 35°39′ N 106°52′ W, 1.4 km N of Los Pinos Arroyo, *MAB 13544*; Santa Fe Co.: 35°37.2′ N 106°01.2′ W, 17.2 km E of Tortilla Pk., *MAB 16244*.

Echinocereus fendleri (southern race).

n = 11. **USA, Arizona**, Cochise Co.: 31.368° N 109.145° *W*, 38 km E of Douglas, *MAB 16467.1*, *16467.2*. **New Mexico**, Hidalgo Co.: 31.860° N 108.425° *W*, Little Hatchet Mtns, 60 km SE of Lordsburg, *MAB 16500.1* & *Hunkins*; Big Hatchet Mtns, Chaney Canyon, [*McIntosh 2370*] recollected from cultivation *ADZ s.n*.

**Echinocereus lindsayi* Meyrán.

n = 11. **Mexico, Baja California**: S of Cataviña, *Ezcurra* s.n. [JPR], 1 May 1999 [SD 143383]

Echinocereus maritimus K.Schumann.

n = 11. **Mexico, Baja California**: 30.435° N 116.024° W, 1 km S of Volcán Sureste, *Baker 14034*.

Echinocereus mojavensis (Engelmann & J.M.Bigelow) Rümpler.

n = 11. **USA, Arizona**, Coconino Co.: 34°35′35″ N 110°47′25″ W, 48 km S of Winslow; Chevelon Crossing, *MAB 13792*, *13793*; 8.5 mi E of Jacob Lake, Rte0.89A, *BDP 4269 & CC*; 30 mi S of Winslow, *ADZ 2771*; Navajo Co.: 35°47′ N 110°14′ W 5.5 km SW of Keams Canyon, *MAB 13794*; 36°40.6′ N 110°32.1′ W, SW end of Fir Canyon, *MAB 11716.1*. **New Mexico**, San Juan Co.: 36°48.3′ N 108°30.0′ W, 30 km NW of Farmington, *MAB 12421 and others* **Nevada**, Clark Co.: 36°43.9′ N 115°07.1′ W, Sheep Range, Peek-a-boo Canyon, *MAB 15928*.

Echinocereus reichenbachii (Walpers) Haage var *albertii* L.D.Benson.

n = 11. **USA**, **Texas**, La Salle Co.: 10 mi SE of Artesia Wells, on Brown Ranch, *Jan Brown s.n.* [DJP]

Echinocereus reichenbachii var *reichenbachii*.

n = 11. **USA**, **New Mexico**, Eddy Co.: 32°20.23′ N 103°55.73′ W, 30 km ESE of Carlsbad, *MAB 15646.1*.

Echinocereus santaritensis W.Blum & Rutow.

n = 22. **USA, Arizona**, Cochise Co.: 31.783° N 109.301° W, 700 m ENE of Rucker Lake, *MAB 13635.1* & *Lieber*; 31°55′ N 109°15′ W, Turkey Park, Chiricahua Mtns, *MAB 13478.1*; Pima Co.: 32°23′05″ N 110°41′40″ W along Old Mt. Lemmon Rd., *MAB 13806* & *Ziemmeck*; Santa Cruz Co.: 31°28.35′ N 110°44.80′ W, Flux Canyon, east of Patagonia, *MAB 15337*. **New Mexico**, Catron Co.: 33.230° N 108.732° W, 5 km WNW of Haystack Mtn., *MAB 11631*.

Echinocereus viridiflorus Engelmann ssp *cylindricus* (Engelmann) N.P.Taylor.

n = 11. **USA, New Mexico,** Eddy Co.: 32°14.8′ N 104°45.4′ W, 53 km WSW of Carlsbad, 1.5 km NW of Last Chance Spring, *MAB 13370*; Lincoln Co.: 33°49.5′ N 105°40.6′ W, Jicarilla Mtns, 27 km NE of Carrizozo, *MAB 16183*, *16185*; 33°47.1′ N 105°42.6′ W, Jicarilla Mtns, 21 km NNE of Carrizozo, *MAB 16190*; Otero Co.: 32.412° N 106.093° W, 4 km N of Orogrande, *MAB 13878* & *Himes*.

Echinocereus viridiflorus Engelmann ssp *viridiflorus*.

n = 11. **USA, New Mexico**, Colfax Co.: 36°46.5′ N 104°51.1′ W, along Vermejo River, *MAB 12495 & TW*.

Echinocereus yavapaiensis M.A.Baker.

n = 33. **USA, Arizona,** Yavapai Co.: 34.211° N 112.757° *W*, Weaver Mtns, 1 km SW of Yarnell, *MAB 12356*, *12357*, *12358*, *12392*, *12481*, *12482*; 34.203° N 112.753° *W*, 2 km SSW of Yarnell, *MAB 12338*; 34°20.7′ N 112°13.3′ W, 7 km N of Cleator, **near type locality for this taxon**, *MAB 14565.1*; 34°24.1′ N 112°32.2′ W, Bradshaw Mtns, 5 km SE of Wilhoit, *MAB 14571.1*; 33°57′41″ N 112°31′20″ W, Wickenburg Mountains, *MAB 13865.2* & *Fine*.

Echinomastus erectocentrus (J. M. Coulter) L. D. Benson var *erectocentrus*.

n = 11. **USA, Arizona**, Pima Co.: 32°00.88′ N 110°35.55′ W, Pantano Rd., 12.3 km ESE of Vail, near the **lectotype locality for *Echinocactus erectocentrus*** Coulter, *MAB 15556.3*; Pima Co. and Pinal Co.: 32°13.5′ N 110°04.9′ W, Allen Flat, SW bajada of Winchester Mtns, 23 km W of Willcox, 35 km NE of Benson, *MAB 16119*.

Echinomastus intertextus (Engelmann) Britton & Rose var *dasyacanthus* (Engelmann) Backeberg.

n = 11. **USA, New Mexico**, Doña Ana Co.: 32.002° N 106.524°1 kmW SE of Anthony Gap, *MAB 13323.1*.

Echinomastus intertextus (Engelmann) Britton & Rose var *intertextus*.

n = 11. **USA, Arizona**, Cochise Co.: N of E entrance to Coronado National Memorial, S end Huachuca Mtns, *BDP 4646 & CC*.

Echinomastus johnsonii (Engelmann) E.M.Baxter.

n = 11. **USA, Arizona**, La Paz Co.: 34.034° N 113.549° W, Butler Valley, 5 km NW of Dripping Springs, **neotype locality for *E. arizonicus*** Hester, *MAB 13692 & Byrd*.

Ferocactus cylindraceus (Engelmann) Orcutt.

n = 11. **USA, California**, San Diego Co.: Anza-Borrego Desert State Park, Jacumba Jim Canyon off Carrizo Canyon, 5.1 miles from Hwy 2S, *JPR 3817* (SD).

Glandulicactus uncinatus (Galeotti ex Pfeiffer) Backeberg var *wrightii* (Engelmann) Backeberg.

n = 11. **USA, New Mexico**, Eddy Co.: 32.171° N 104.487° W, spur of Walnut Canyon, *MAB 13079*; 32°06.8′ N 104°33.5′ W, mouth of Slaughter Canyon, *MAB 14118*. **Texas**, Brewster Co.: 29°27′ N 103°32′ W, S of Alpine, 5 mi ESE of Hen Egg Mtn., *MAB 12799*.

Mammillaria dioica K.Brandegee.

n = 33. **Mexico, Baja California**: 5 mi N of Cataviña boulder fields, *JPR 5011*. **USA, California**, San Diego Co.: Anza-Borrego Desert State Park; NW of Ocotillo along south Indian Gorge Pass Road, *JPR 3828 & Salywon* (SD).

Mammillaria heyderi Mühlenpfordt var *heyderi*.

n = 11. **USA, Texas**, Webb Co.: N of Laredo, I-35, 12 mi N of Río Grande, *ADZ 2726*.

Mammillaria meiacantha Engelmann.

n = 11. **USA, New Mexico**, Mora Co.: 35.835° N 104.994° W, 1.5 km SW of Wolf Creek, *MAB 12577*.

Corrections and Additions

Cylindropuntia delgadilloana J.Rebman & Pinkava, *J Ariz-Nev Acad Sci* 33: 154–156, replaces "*Opuntia* (subgenus *Cylindropuntia*) sp. nov. A." (D. J. Pinkava, and others, 1998. Haseltonia 6: 37).

Cylindropuntia whipplei (Engelmann & J.M.Bigelow) F.M.Knuth var *enodis* (Peebles) Backeberg is the correct name for plants with tetraploid (*n* = 22) counts as "*O. whipplei* var *whipplei*" reported by Pinkava and Parfitt (1982) from Arizona, Mohave Co.: *BDP 2547* (ASU); and as "*O. whipplei*" by Pinkava and others (1998) from Arizona, Mohave Co.: *MAB 4974-A & N. Trushell*, *N. Trushell and others 84–6*, and *N. Trushell 82–206*, *82–208 & MAB*.

Cylindropuntia leptocaulis × *C. thurberi* (Engelmann) F.M.Knuth is the correct identification for specimen erroneously published as "*Opuntia kleiniae* DC. var *tetracantha* (Toumey) Marshall" in Pinkava and others (1977), *n* = 11, from Mexico, Sinaloa, *DJP and others P12919*.

Grusonia aggeria (Ralston & Hilsenbeck) E.F.Anderson is the correct identification (Ralston & Hilsenbeck 1989) for specimen erroneously published as "*Opuntia schottii* Engelmann var *schottii*" in Pinkava and others (1985), *n* = 11, from Texas, Brewster Co., *Worthington 9714*.

Echinocereus engelmannii ssp *fasciculatus* is the correct identification for the following specimens erroneously published as "*Echinocereus fasciculatus* (Engelmann ex B.D.Jackson) L.D.Benson var *bonkerae* (Thornber & Bonker) L.D.Benson," *n* = 22, by Pinkava & Parfitt (1982) from Arizona, Pima Co., *DJP and others 10960* (ASU, DES); and by Pinkava and others (1985) from Arizona, Pima Co.: *DJP and others 11040*(ASU).

Echinocereus fendleri ssp *fendleri* is the correct identification for specimens erroneously published as *Echinocereus fendleri* var *rectispinus* by Pinkava and others (1998) from Grant Co., New Mexico.

**Nopalea guatemalensis* Rose [not *Opuntia guatemalensis* Britton & Rose] is the correct identification for specimen erroneously published as "*Opuntia eichlamii* Rose" by Pinkava and others, 1976, *n* = 11, from Guatemala, Dept. El Progresso, *Keil 9422*. *Opuntia eichlamii* remains uncounted.