Chromosome numbers in some cacti of western North America—III.1

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PINKAVA, D. J., L. A. MCGILL, T. REEVES (Dept. Bot. and Microbiol., Arizona State Univ., Tempe, 85281), and M. G. McLEOD (Dept. of Biol. Sci., California Polytechnic State Univ., San Luis Obispo, 93407). Chromosome numbers in some cacti of western North America—III. Bull. Torr. Bot. Club 104: 105-110. 1977.—Documented meiotic chromosome numbers are reported for 42 taxa in 36 species of 9 Cactaceae genera of southwestern United States and northern Mexico. First counts for 17 taxa belonging to 15 species are reported, including first counts for 3 genera (Machaerocereus, Rathbunia and Sclerocactus). Diploid and polyploid taxa, including one triploid, were observed, all consistent with the base number, x = 13.

This report is the third in a series of studies (cf. Pinkava & McLeod, 1971; Pinkava et al. 1973) that attempt to solve certain taxonomic problems in cacti. Polyploidy plays an important evolutionary role in Cactaceae, particularly in the tribe Opuntiae. As reported in our series thus far, 19 of 39 taxa (48.7%) of the Opuntiae and 5 of 38 taxa (13.2%) of the Cacteae are polyploid. Two taxa are represented by both diploid and polyploid individuals.

Materials and methods. Flower buds were collected in developmental series from plants growing in their native habitats. Buds were killed and fixed in chloroform, ethanol, and glacial acetic acid ([6 or 4]: 8:1 v/v), transferred to 70% ethanol and refrigerated. Anthers were squashed in aceticarnine and mounted in Hoyer's medium according to the method of Beeks (1955). Voucher specimens are deposited in ASU. Nomenclature follows that of Benson (1969a, b, c), Britton and Rose (1919-1923), and Shreve and Wiggins (1964).

Results and discussion. Chromosome counts (Table 1) were made for 54 individuals belonging to 42 taxa of 36 species in 9 genera. Counts for 17 taxa belonging to 15 species are first reports, including first counts for 3 genera (Machaerocereus, Rathbunia, and Sclerocactus).

Newly counted in our series of studies are 25 taxa (including one count different from that previously reported for the species, Opuntia leptacantha) which are illustrated (Figs. 1-26). Of this group, only 7 taxa had been published previously and all are consistent with our findings: O. fragilis (Bowden, 1945), O. kleiniae var. tetrocantha (Fischer, 1962), O. microdasys (Katagiri, 1952, 1953), O. polyacantha (Stockwell, 1935), O. rufida (Katagiri, 1952, 1953), Ferocactus rostii Britt. & Rose (= P. acanthodes var. acanthodes) (Stockwell, 1935), and Mammillaria microcarpa (Remski, 1954). Individuals of O. polyacantha are also reported as diploids (n = 11) by Matsura and Suto (1935) and as hexaploids (n = 33) by Stockwell, 1935. Opuntia leptocantha is reported here as n = 11 in the Sonoran Desert and as n = 22 (Conde, 1975; Fischer, 1962; Pinkava et al., 1973) in the Chihuahuan Desert. Careful study may reveal that more than one taxon is involved, as in the two varieties of O. kleiniae: diploid var. tetrocantha in the Sonoran Desert and tet-

1 Field work supported in part by National Science Foundation grant DES 7601417 to Dr. Thomas H. Nash III, Department of Botany and Microbiology, Arizona State University.
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<table>
<thead>
<tr>
<th>Species</th>
<th>Chromosome Counts</th>
<th>Location Details</th>
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<tr>
<td><em>Opuntia basilaris</em> Engelm. &amp; Bigel. var. basilaris</td>
<td>n = 11</td>
<td>California: Kern Co.: 1.5 mi NE of Caliente store, <em>MoLead 1828</em>; San Bernardino Co.: Ca. 1.5 mi SW of Parker Dam, <em>Reese 538</em>.</td>
</tr>
<tr>
<td><em>Opuntia brachyacantha</em> (Griffiths) Murr.</td>
<td>n = 11</td>
<td>California: San Bernardino Co.: 5 mi W of Rte. 1-15 along Rte. 188, <em>MoLead 1823, 1824</em> (Fig. 1), 1825.</td>
</tr>
<tr>
<td><em>Opuntia brachyacantha</em> (Coult.) Toumey</td>
<td>n = 11</td>
<td>California: Kern Co.: 1.5 mi NE of Caliente store, <em>MoLead 1824</em> (Fig. 2).</td>
</tr>
<tr>
<td><em>Opuntia brandegeei</em> (Coult.) Brandegee</td>
<td>n = 11</td>
<td>Mexico: Coahuila: Rte. 40, 1.6 mi W of Pails, <em>McGill, Reeves, Nash &amp; Pinkava P10569</em> (Fig. 4).</td>
</tr>
<tr>
<td><em>Opuntia fragilis</em> Nutt.</td>
<td>n = 33</td>
<td>Arizona: Coconino Co.: Flagstaff, NW corner of Cedar Rd. and Paradise Dr., <em>Brown &amp; Brown RKB36</em> (Fig. 5).</td>
</tr>
<tr>
<td><em>Opuntia kleinitzii DC</em>, var. <em>tetragonantha</em> (Toumey) Marshall</td>
<td>n = 11</td>
<td>Mexico: Sinaloa: 0.8 mi from Tesoro, Rte. 15, <em>Pinkava, et al. P12919</em> (Fig. 6).</td>
</tr>
<tr>
<td><em>Opuntia leptacantha</em> DC.</td>
<td>n = 11</td>
<td>Arizona: Maricopa Co.: Cave Creek, <em>Smith 1047</em> (Fig. 7).</td>
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<tr>
<td><em>Opuntia macrohiza</em> Engelm. var. <em>macrohiza</em></td>
<td>n = 22</td>
<td>Arizona: Coconino Co.: Flagstaff, NW corner of Cedar Rd. and Paradise Dr., <em>Brown &amp; Brown RKB36</em>.</td>
</tr>
<tr>
<td><em>Opuntia microdasys</em> (Lemm.) Fleischer</td>
<td>n = 11</td>
<td>Mexico: Coahuila: ca. 63 mi S of Monclova, Rte. 57, <em>Pinkava 10538</em> (Fig. 8). Red-fleshed form.</td>
</tr>
<tr>
<td><em>Opuntia nicholii</em> L. Benson</td>
<td>n = 33</td>
<td>Arizona: Coconino Co.: Lee’s Ferry, <em>Nash &amp; Nash 92</em> (Fig. 9); 1 mi N of jctn. Rtes. 89 &amp; 99A, <em>MoLead M418</em>.</td>
</tr>
<tr>
<td><em>Opuntia parryi</em> Engelm. var. <em>parryi</em></td>
<td>n = 11</td>
<td>Baja California: just E of El Condor, Rte. 2, <em>McGill, Nash &amp; Pinkava P9298</em> (Fig. 10).</td>
</tr>
<tr>
<td><em>Opuntia polyanthma</em> Haw. var. <em>polyanthama</em></td>
<td>2n = 26 + 2x</td>
<td>Colorado: Fremont Co.: 5 mi, <em>Royal Gorge, Keil 10700</em> (Fig. 11).</td>
</tr>
<tr>
<td><em>Opuntia rafaela</em> Engelm.</td>
<td>n = 11</td>
<td>Mexico: Coahuila: Cuatro Ciénegas basin, <em>Sierra de San Marcos, Pinkava 10536</em> (Fig. 12).</td>
</tr>
<tr>
<td><em>Opuntia stenopetala</em> Engelm.</td>
<td>n = 11</td>
<td>Mexico: San Luis Potosi: 18 mi ESE of El Huizache, Rte. 80, <em>McGill, Brown &amp; Pinkava P9677</em> (Fig. 13).</td>
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<tr>
<td><em>Opuntia versicolor</em> Engelm.</td>
<td>n = 11</td>
<td>Arizona: Pima Co.: along Tanque Verde Rd., 9.1 mi E of jctn. Catalina Hwy., <em>Lehlo, Hensel &amp; Pinkava P10577</em> (Fig. 14).</td>
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Table I—(Continued)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Location</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Cereus ochal Oroweit (= Myrtillocactus ochal [Oroweit] Britt. &amp; Rose)</td>
<td>MEXICO: Baja California, Rte. 1, ca. 19.3 mi S of San Vicente, McGill, Nash, &amp; Pinkava P90414.</td>
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<tr>
<td>Cereus emoryi Engelm. (= Bergerocactus emoryi [Engelm.] Britt. &amp; Rose)</td>
<td>MEXICO: Baja California, Rte. 1, 16 mi S of San Vicente, McGill &amp; Pinkava P90585; Rte. 1, 3.3 mi N of El Rosario, McGill &amp; Pinkava P90087.</td>
<td></td>
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<tr>
<td>Cereus pedica-aborigineus Engelm. (= Pachycereus pedica-aborigineus [Engelm.] Britt. &amp; Rose)</td>
<td>MEXICO: Sonora, Rte. 15, 37 mi N of Sonora-Sinaloa line, Pinkava, et al., 12795 (Fig. 15).</td>
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<tr>
<td><em>Machaerocereus gommei</em> (Engelm.) Britt. &amp; Rose</td>
<td>MEXICO: Baja California, turnoff from Rte 1, ca. 30 mi S of Calama, McGill, Nash, &amp; Pinkava P90057 (Fig. 16).</td>
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<tr>
<td><em>Nopalea alamosensis</em> (Coult.) Britt. &amp; Rose</td>
<td>MEXICO: Sonora, 27.3 mi SE of Guaymas, Rte 15, Reese &amp; Lehto L18500 (Fig. 17).</td>
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</tr>
<tr>
<td><em>Echinocereus polyphus</em> Engelm. &amp; Bigel.</td>
<td>NEVADA: Nye Co.: Specer Mts., Nevada Test Site, Nash 180 (Fig. 18).</td>
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<tr>
<td><em>Echinocereus engelmannii</em> var. <em>acutispinus</em> L. Benson</td>
<td>ARIZONA: Maricopa Co.: Usery Mil. region NE of Phoenix, Woodhouse s.n.</td>
<td></td>
</tr>
<tr>
<td><em>Echinocereus maritimus</em> (Jones) Schumann</td>
<td>MEXICO: Baja California, Rte. 1, ca. 19 mi S of San Vicente, Moulin &amp; McGill P0501 (Fig. 19).</td>
<td></td>
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<tr>
<td><em>Echinocereus triglochidiatus</em> Engelm. var. <em>gonyacanthus</em> (Engelm. &amp; Bigel.) Boivin</td>
<td>COLORADO: Fremont Co.: N rim, Royal Gorge, Keil 10989 (Fig. 20).</td>
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<tr>
<td><em>Echinocereus viridiflorus</em> Engelm. var. <em>wallisii</em> (Engelm.) Engelm. ex Humbler in Fawcett</td>
<td>TEXAS: Jeff Davis Co.: ca. 3 mi S of Ft. Davis, Rte 118, Pinkava P10906 (Fig. 21).</td>
<td></td>
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<tr>
<td><em>Echinocereus viridiflorus</em> Engelm. var. <em>viridiflorus</em></td>
<td>COLORADO: El Paso Co.: S of Colorado Springs, Rte 115, Keil 10985 (Fig. 22).</td>
<td></td>
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<tr>
<td>Ferocactus acanthodes (Lemaire) Britt. &amp; Rose var. <em>acanthodes</em></td>
<td>CALIFORNIA: Riverside Co.: 0.5 mi W of Whitewater, Pinkava &amp; Reese R392 (Fig. 23).</td>
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<td>Ferocactus acanthodes (Lemaire) Britt. &amp; Rose var. <em>lecontei</em> (Engelm.) Lindsay</td>
<td>ARIZONA: Maricopa Co.: Cave Creek, Smith 1032, 1728.</td>
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<tr>
<td>Ferocactus graeciz Gats var. <em>graeciz</em></td>
<td>MEXICO: Baja California: NE edge of Laguna Chupala, Huewel &amp; Reese R402; Rte. 1, ca. 23 mi S of El Rosario, Pinkava &amp; Reese R407; Arroyo de El Rosario S of El Rosario, Pinkava &amp; Reese R426.</td>
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</tr>
<tr>
<td><em>Ferocactus pringlei</em> (Coulter) Britt. &amp; Rose</td>
<td>MEXICO: Nuevo Leon: 6.7 mi E of jtn. Rte, 57 at San Roberto, Pinkava P10551 (Fig. 24).</td>
<td></td>
</tr>
<tr>
<td><em>Ferocactus viridescens</em> (Nutt. in T. &amp; G.) Britt. &amp; Rose</td>
<td>MEXICO: Baja California: Rte. 23, Punta Banda, Pinkava &amp; Reese R419.</td>
<td></td>
</tr>
<tr>
<td><strong>Selenovia whipplei</strong> (Engelm. &amp; Bigel.) Britt. &amp; Rose var. <em>intermedium</em> (Peabody) L. Benson</td>
<td>NEW MEXICO: San Juan Co.: Large Canyon, Wynhoff 279 (Fig. 25).</td>
<td></td>
</tr>
<tr>
<td><em>Mammillaria microcarpa</em> Engelm.</td>
<td>ARIZONA: Maricopa Co.: Cave Creek, just S of city limits, Reese 398, 399 (Fig. 26).</td>
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</tbody>
</table>

* First report of chromosome count for this taxon.
** First report of chromosome count for this genus.
† Chromosome count different from that previously reported for the species.
tests. No tetraploid individuals of *O. basilaris* are known.

Cytological observations provide insights as to origins and relationships of polyploid taxa. Odd-ploid interspecific hybrids have been recorded: *Cereus cockeal* \((2n = 22) \times C. emoryi* \((4n = 44)\) yielding a sterile hybrid \((3n = 33)\) (Pinkava *et al.*, 1966).

**Figs. 1–26.** Camera lucida drawings of meiotic chromosomes of cacti. Voucher specimens are cited in Table 1. Spacing of chromosome groups adjusted in Figs. 3, 12, 13. **Fig. 1.** *Opuntia basilaris* var. *brachygalada*, metaphase I, \(n = 11\). **Fig. 2.** *O. basilaris* var. *treleasa*, metaphase I, \(n = 11\). **Fig. 3.** *O. basilaris* var. *trelesae*, anaphase I, \(3n = 33\) (triploid). **Fig. 4.** *O. bradiana*, metaphase I, \(n = 11\).
Fig. 5. *O. fragilis*, telophase I, n = 33. Fig. 6. *O. kleiniae* var. *tetragonantha*, diakinesis, n = 11. Fig. 7. *O. leptocanna*, diakinesis, n = 11. Fig. 8. *O. et. microdasys*, prophase II, n = 11. Fig. 9. *O. nicholii*, metaphase I, n = 33. Fig. 10. *O. parryi* var. *parryi*, telophase I, n = 11. Fig. 11. *O. polyacantha* var. *polyacantha*, metaphase I, 2n = 20 + 1p. Fig. 12. *O. rapidus*, telophase I, n = 11. Fig. 13. *O. stenopetala*, telophase II, n = 11. Fig. 14. *O. versicolor*, metaphase I, n = 11. Fig. 15. *Cereus poecilobius*, telophase I, n = 11. Fig. 16. *Mammillaria gemmosus*, metaphase I, n = 11. Fig. 17. *Rallibrounia alamosensis*, metaphase I, n = 11. Fig. 18. *Echinocactus polycephalus*, amphaphase I, n = 11. Fig. 19. *Echinocactus maritimus*, diakinesis, n = 11. Fig. 20. *E. triglochidiatus* var. *gonocanthus*, metaphase I, n = 11. Fig. 21. *E. viridiflorus* var. *cylindricus*, diakinesis, n = 11. Fig. 22. *E. viridiflorus* var. *viridiflorus*, metaphase I, n = 11. Fig. 23. *Ferocactus acanthodes* var. *acanthodes*, diakinesis, n = 11. Fig. 24. *F. pringlei*, telophase I, n = 11. Fig. 25. *Sclerocactus whipplei* var. *intermedius*, telophase II, n = 11. Fig. 26. *Mammillaria microcarpa*, metaphase I, n = 11.
1973); and Opuntia ficus-indica (8n = 88) × O. phaeacantha var. major (6n = 66) yielding a hybrid (7n = 77) with irregular meiosis (McLeod 1975). An even-ploid interspecific hybrid was postulated for a cross between O. chlorotica (2n = 22) and O. phaeacantha var. major (6n = 66), yielding apparently O. curvospina (4n = 44), though more evidence is needed in this case to confirm the putative parents (Pinkava et al., 1973). Additional triploid taxa from Baja California and San Luis Potosí, Mexico, are still under investigation.

Literature Cited


Fischers, P. 1962. Taxonomic relationships of Opuntia ble FOLLOWING PAGE


