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The *Opuntiae* of the Big Bend Region of Texas

Margery Anthony

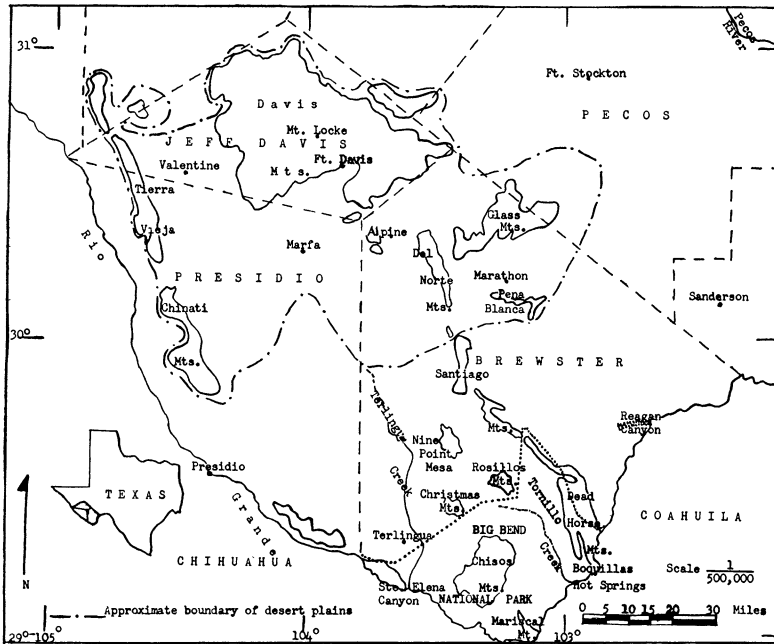
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More than 900 members of the genus *Opuntia* (Tournefort) Miller had been named before 1919 when Britton & Rose, by reducing many of the names to synonymy, recognized about 250 valid species. This reduction in number of recognized species was the result of withdrawing some entities to previously unrecognized genera, recognizing the capacity for great variation within species, and redefining descriptions based upon sterile material. Because they are less highly specialized in their modifications than most other genera of Cactaceae the *Opuntiae* respond more readily to the sharply fluctuating environmental conditions of xerophytic habitats and thus produce many variants. The group has been neglected in field studies because of the painful glochids which make these plants difficult to handle; many otherwise useful and representative collections of desert plants lack *Opuntia* almost entirely.

Opuntiae are the most numerous and most conspicuous components of the rich cactus flora of the Big Bend Region, an area formed by a great curve of the Rio Grande several hundred miles southeast of El Paso (Map 1). Marked physiographic diversity has produced a variety of habitats with a corresponding development of many different populations of *Opuntia*. It is my purpose, by analysis of these natural populations, to 1) determine the significance of vegetative features with respect to the taxonomy of the group, 2) construct a key for identification of each entity, and 3) discuss the significant features of the species. Each entity is fully described in the thesis (Anthony, 1949). Ecological relationships of these cacti are discussed elsewhere (Anthony, 1954).

A total of thirty-one species, hybrids and varieties of *Opuntia* in the Big Bend Region is recognized in this paper. Field observations and collections were made from February to June in 1947, and from March to October in 1948. The dried collection is in the Herbarium of the University of Michigan. Duplicate specimens were grown at the Botanical Gardens of the University of Michigan from 1947 to 1949 in order to test the constancy and value in classification of vegetative characteristics under uniform conditions of heat, humidity and moisture.

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Map 1.—Big Bend region and surrounding area.

sity of Michigan, Missouri Botanical Garden, New York Botanical Garden, University of Texas and Smithsonian Institution. Collection data for specimens from these herbaria are cited in the thesis.

HISTORICAL CONSIDERATIONS

The most important early scientific exploration of Trans-Pecos Texas was conducted by the United States and Mexican Boundary Commission Survey (Engelmann, 1859) in 1851-53. Extensive notes and collections were made by C. C. Parry, C. Wright, J. M. Bigelow, G. Thurber, and A. Schott, who sent much valuable living, as well as dried, material to George Engelmann for subsequent identification and publication. *Opuntiae* of the Big Bend have also been collected by V. Bailey, W. L. Bray, B. Mackensen, C. R. Orcutt, H. C. Cutler, L. C. Hinckley, and B. H. Warnock. Specimens from neighboring Chihuahua have been collected by E. A. Mearns, E. Palmer, J. N. Rose, and E. Stearns.

Engelmann (1849, 1856, 1859) was the first to describe many of the Big Bend cacti but his information was necessarily limited to the often incomplete collections of the earliest botanical explorers. *Opuntiae* from the Big Bend Region were little represented in the work of D. Griffiths (1908) who, by drawing fine distinctions, described a number of new species; many of these are now reduced in the literature to synonyms or are maintained only as varieties. Most of the Texas species are discussed in the monumental work of Britton & Rose (1919). Their descriptions are brief, with inconsistent choice of charac-

teristics, too narrow ranges of measurement, and obsolete distributional data. "Texas Cacti" by Schultz and Runyon (1930) is largely adapted from Britton & Rose. Some information on the range of various species was obtained from Benson (1940), Boissevain and Davidson (1940), and Tidestrom and Kittell (1941). Bravo (1937) and Ochoterena (1922) have contributed valuable data on the Mexican cacti, many of which occur also in the United States.

Sperry and Warnock (1941) have compiled the most authoritative listing of plant species, including many of the cacti, in Brewster County. A useful key to the plants of the Big Bend National Park (McDougall and Sperry, 1951) has little discussion of the Cactaceae and no key to them.

BRIEF DESCRIPTION OF THE REGION

The study area encompasses Jeff Davis, Presidio and Brewster counties, although the latter, in which are found the Big Bend National Park and greatest topographic diversity, received the most detailed consideration. Physiographically the Big Bend Region includes igneous and sedimentary rocks; shallow to deep and clayey to sandy soils; xerophytic to mesophytic environments; flood plain, desert, arid grassland, encinal and montane habitats occupied by at least thirty-five distinct plant associations (Denyes, 1951). It is a meeting ground for faunal and floral forms of four adjacent biotic provinces.

High desert mountains and mesas, with abrupt increases in altitude, cause sharp changes in vegetative types and associated cacti, as well as producing well-defined races and disjunct distributions through isolation effect (Map I).

CHARACTERISTICS OF TAXONOMIC VALUE

The following features of Opuntiae show enough constancy to be of taxonomic value, despite considerable modification under adverse climatic and edaphic conditions: habit of growth (prostrate, ascending, or arborescent); roots (tuberous or fibrous); joints (cylindrical or flat); distance between areoles on joints; form and color of spines; shape of style; fruits (dry or fleshy, naked or spiny); umbilicus (v-shaped or saucer-shaped); size of seed, and nature of the aril (beaked or beakless, wide or narrow). Skeletons of *Cylindropuntia* joints show characteristic shapes of gaps in the dictyostele, ranging from long and narrow in *O. davisii* to short, ovate gaps in *O. kleimiae*. Number of spines per areole varies considerably among individuals but some species are characteristically more spiny than others. Bristles, which are intermediate in size between spines and glochids and are borne deflexed from the base of the areole, are typically present in some of the species, typically absent in others.

CHARACTERISTICS SUBJECT TO VARIATION WITHIN SPECIES

Within species greatest variation is expressed in: size of joints and leaves; proportion of spiniferous to naked areoles on joint; number of spines per areole; and length of individual spines. A smaller range of variations occurs in: presence or absence of trunk; amount of glaucous covering of joints; and size and shape of ovary and fruit. These variations may be caused by local differences in water supply, altitude, soil or exposure to sun. Plants growing

in dense shade are often so modified, bearing elongate joints and areoles further apart with fewer spines than is typical, that they can only be identified after experience in growing them under uniform conditions.

Seeds of *O. tortispina* and *O. tunicata* occasionally have double embryos so that two seedlings grow up side by side. One is always larger, greener and more apt to survive. Even if the larger one is early removed at ground level, the weaker pinkish seedling does not succeed. A very low percentage of tricotyledonous seedlings was observed among seeds germinated at the Botanical Gardens. The two cotyledons of a seedling are usually unequal; depending upon the species the cotyledons are long and thin, or short and thick, and with obtuse or acute tips. However, these differences are not great enough to constitute specific characteristics.

Stomata on joints are difficult to observe because of numerous calcium oxylate crystals in the hypodermis. Stomata from cotyledons and leaves of various species show no significant differences in spacing. Length of stomata ranges from an average of 20.9 μ in *O. imbricata* to 43.2 μ in *O. tenuispina*. The rest of the species fall into a graded series between these two averages. Most of the *Cylindropuntiae* of the study area have somewhat smaller stomata than the *Platyopuntiae*.

Some of the *Opuntiae* in the Big Bend Region seem inherently more variable than others. Among the *Cylindropuntiae* only populations of *O. grahamii* x *schottii* show variability, as would be expected in any hybrid individuals since they tend to resemble one or the other parent. Even the two varieties, *O. leptocaulis* var. *brevispina* and *O. imbricata* var. *argentea*, are very distinct from the typical forms. Among *Platyopuntiae* greatest variation is evident in populations of *O. engelmannii*, *O. lindheimeri*, *O. phaeacantha* and *O. tortispina* as is reflected in their lengthy synonymy. The fact that the morphological plasticity of these species produces many local races adapted to diverse habitats may explain their wider distribution through the Big Bend Region, with the exception of *O. lindheimeri* which here reaches the western edge of its range.

The following hybrids were found in the area: *O. grahamii* x *schottii*, *O. kleimiae* x *leptocaulis*, and *O. engelmannii* x *phaeacantha*. The latter hybrid *Platyopuntiae* is the only one that forms fertile fruits but the two hybrid *Cylindropuntiae* reproduce prolifically by fragmentation. Parental species of each hybrid overlap in their flowering periods, are present in the same locality with the hybrids, and the hybrids show intermediate characteristics.

Evolutionary implications of variation within species and of hybridization were discussed in an article on the ecology of these cacti.

KEY TO THE OPUNTIAE OF THE BIG BEND REGION

Since many species of *Opuntia* bloom sporadically the majority of plants have only vegetative characteristics as a clue to identity. Furthermore, reproductive organs of closely related species, such as in the *O. engelmannii*—*O. phaeacantha* complex and the *O. grahamii*—*O. schottii* complex, are variable enough that clear-cut distinctions based upon these alone would be difficult to observe in the field without long experience. Herbarium specimens of flowers and fruits are also difficult to distinguish because of the great distor-

tion of the succulent tissue in drying. For these reasons the key stresses habit and other vegetative features which are more readily recognized in the field.

Species are numbered to follow the sequence of relationship used by Britton & Rose (1919). Discussion of each entity emphasizes points not covered by those authors. Complete descriptions of new forms are included here to facilitate future reference but their original publication occurred with the microfilming of the thesis in 1951.

- 1a. Joints cylindricalCYLINDROPUNTIA 2a
 1b. Joints flattened to form "pads"PLATYOPUNTIA 12a
 2a. Branches ascending, joints linear-oblong, spines sheathed 3a
 2b. Branches prostrate, only terminal joints ascending, joints clavate, tubercles broad, spines scabrous, without sheaths except when very young 10a
 3a. Plant a low clump, shrub or tree, joints mostly more than 16 mm in diameter, tubercles strong, laterally compressed 4a
 3b. Plant a twiggy shrub, ultimate joints less than 16 mm in diameter, readily detached, of two distinct kinds; some long, others always short and relatively spineless, tubercles weak or absent 7a
 4a. Shrubs or trees with definite, erect trunk 5a
 4b. Low clump to 5 dm high with many short erect branches, ultimate joints mostly 2.5 cm in diameter (dwarf forms noticeably smaller), tubercles about 30 mm long, 3 mm wide, 12 mm high, spines yellow with whitish sheaths, flower yellow. (figs. 8 & 9)8. *O. tunicata*
 5a. Tall shrubs to trees, ultimate joints 1.5-4 cm in diameter, flower magenta 6a
 5b. Small shrubs, up to 7.5 dm high, ultimate joints .6-2 cm in diameter, typically wrinkled, tubercles about 25 mm long, 7 mm wide, 7 mm high, spines yellow or rufous, with yellow sheaths, flower yellow. (fig. 3)..... 5. *O. davisii*
 6a. To 45 dm in height, tubercles 30 mm long and 8 mm high or more, central spines yellow or reddish brown, with dull white sheaths. (fig. 6)6. *O. imbricata*
 6b. To 12 dm in height, tubercles only 20 mm long and 5 mm high, spines silver with silver sheaths. (fig. 7)..... *O. imbricata* var. *argentea*
 7a. Ultimate joints 6-15 mm in diameter, short ones mostly 5-7 cm long, arising at acute angles and curving gradually upwards, surface somewhat tuberculate, flower rose or pinkish, 2.5-4 cm long 8a
 7b. Ultimate joints 5-6 mm in diameter, short ones mostly 2-4 cm long, arising mostly at right angles and curving sharply upwards, surface not tuberculate, flower lemon yellow, about 2.2 cm long 9a
 8a. Ultimate joints usually more than 8 mm in diameter, short joints mostly 7 cm long, flower dull rose, about 4 cm long. (fig. 2)3. *O. kleiniae*
 8b. Ultimate joints usually less than 8 mm in diameter, short joints mostly 5 cm long, flower pinkish brown, 2.5-3 cm long. (figs. 1 & 4) 4. *O. kleiniae* x *leptocaulis*
 9a. Spines 3-5 cm long, with conspicuous persistent sheaths1. *O. leptocaulis*
 9b. Spines .8-2.8 cm long, with fugacious sheaths. (fig. 1)
2. *O. leptocaulis* var. *brevispina*
 10a. Spines acicular, mostly terete, only a few flattened, leaves longsubulate, joints 4.5-7 cm long, tubercles weak. (fig. 12)10. *O. grahamii*
 10b. Spines subulate, mostly flattened, leaves short subulate 11a
 11a. Joints 2.5-9 cm long, strongly tuberculate, spines 1.5-2 mm wide. (fig. 12).....
 9. *O. schottii*
 11b. Joints 2.5-6.3 cm long, tubercles only moderately developed, spines .5-1.3 mm wide (fig. 13) 11. *O. grahamii* x *schottii*
 12a. Plant a large bush, usually more than 3 dm high and 10 dm wide, surface of

- joints glabrous or pubescent 13a
- 12b. Plant a small bush, usually less than 3 dm high and 10 dm wide, surface of joints glabrous 31a
- 13a. Surface of joints glabrous, spines typically present 14a
- 13b. Surface of joints pubescent, spines never present, branches mostly ascending, joints relatively thick 30a
- 14a. Mature spines predominantly orange, yellow or white 15a
- 14b. Mature spines predominantly red to brown or darker colors 22a
- 15a. Mature spines predominantly white 16a
- 15b. Mature spines predominantly yellow or shades of orange 18a
- 16a. Young joints not wrinkled, longer spines flattened, only slightly twisted, young spines mostly white or black with dark bases 17a
- 16b. Young joints often wrinkled, longer spines terete, much twisted, young spines burnt yellow (fig. 11) 14. *O. tortispina*
- 17a. Branches mostly ascending, joints short-obovate to orbicular, young spines white with dark bases, mature spines 3-5.6 cm long, fruit large, pyriform 24. *O. engelmannii*
- 17b. Branches spreading, slightly ascending, joints long-obovate with attenuate bases, young spines black, mature spines 5.5-7.3 cm long (fig. 28) 25. *O. engelmannii* var. *wootonii*
- 18a. Branches all ascending, to 25 dm in height, joints with elongate cow-tongue shape, spines acicular, bristles absent, flower yellow (fig. 5) 27. *O. linguiformis*
- 18b. Branches spreading or gradually ascending, joints obovate to orbicular, spines subulate 19a
- 19a. Spines elliptic to flat in cross-section, only slightly twisted 20a
- 19b. Spines terete, much twisted (fig. 11) 14. *O. tortispina*
- 20a. Marked contrast between young white spines, mature yellow spines and old black spines, bristles often present. (fig. 18) 21. *O. azurea*
- 20b. No marked contrast, young spines mostly yellow, mature spines yellow to orange-red, old spines becoming gray to black, bristles absent 21a
- 21a. Areoles circular, elevated and conspicuous, spines little curved, fruit large, pyriform, to 7 cm long (fig. 29) 28. *O. lindheimeri*
- 21b. Areoles long-elliptic, not conspicuous, spines mostly curved downward, fruit globular, to 4.5 cm long (figs. 26 & 29) 29. *O. lindheimeri* var. *chisosensis*
- 22a. Spines subulate 23a
- 22b. Spines acicular, mostly from upper or marginal areoles 27a
- 23a. Branches ascending abruptly to form a tall bush, joints somewhat tuberculate, 2-4 rufous spines and 2 conspicuous bristles in an areole, ovary and fruit spiny (figs. 22, 23 & 24). 23. *O. spinosibacca*
- 23b. Branches spreading or ascending gradually, joints not tuberculate 24a
- 24a. Areoles distant, fruit naked 25a
- 24b. Areoles closely-set, fruit spiny, joints mostly orbicular, spines dark reddish brown with yellow tips (fig. 16) 15. *O. strigil*
- 25a. Areoles elevated, spines somewhat flattened, not annulately marked 26a
- 25b. Areoles not elevated, spines mostly terete, often annulately marked, young spines rufous and white, flower usually less than 6.5 cm long, seeds to 7 mm in diameter (fig. 25) 22. *O. phaeacantha*
- 26a. Young spines white, mature spines white to reddish brown, fruit large, pyriform, to 6.5 cm long 24. *O. engelmannii*
- 26b. Young and mature spines reddish brown to black, fruit variable (fig. 27) 26. *O. engelmannii* x *phaeacantha*
- 27a. Branches spreading and ascending, joints mostly orbicular or short-obovate 28a

- 27b. Branches mostly spreading, joints obovate 29a
- 28a. Joints 6-12 mm thick, spines 1-10 per areole, some flattened, mostly spreading downwards, not annulately marked. (fig. 19) 17. *O. setispina*
- 28b. Joints mostly less than 6 mm thick, spines mostly 2-3 per areole, terete, spreading upwards, annulately marked. 19. *O. macrocentra*
- 29a. Branches spreading, a few ascending vertically, joints less than 15 cm long, areoles less than 20 mm apart (fig. 21) 20. *O. macrocentra* var. *minor*
- 29b. Branches spreading, joints more than 15 cm long, areoles more than 25 mm apart (fig. 20) 18. *O. tenuispina*
- 30a. Areoles mostly about 16 mm apart, joints long obovate, outer perianth segments broad-lanceolate and not swirled (fig. 14) 12. *O. rufida*
- 30b. Areoles mostly about 12 mm apart, joints short obovate to short elliptic, outer perianth segments narrow lanceolate and swirled (fig. 15). 13. *O. rufida* var. *tortiflora*
- 31a. Branches creeping, only terminal joints ascending, roots fibrous, joints obovate to elliptic, areoles closely-set, spines acicular, from all but lowermost areoles, fruit spiny and dry 32a
- 31b. Plant inconspicuous; branches, with only 2-3 joints, ascending, to 2.5 dm in height; roots tuberous, with milky juice; flower rose-red; fruit naked, pale purple (fig. 17) 16. *O. pottsii*
- 32a. Joints obovate with somewhat tuberculate surface, hairs absent (fig. 32)..... 31. *O. polyacantha*
- 32b. Joints long-elliptic, not tuberculate, long hairs conspicuous in lowermost areoles of older joints (fig. 31) 30. *O. trichophora*

1 OPUNTIA LEPTOCAULIS DC. Mém. Mus. Hist. Nat. Paris 17:118. 1828.

Distribution: GENERAL.—Arizona, New Mexico, Texas, southern Oklahoma and the northern states of Mexico (Chihuahua, Coahuila, Hidalgo, San Luis Potosi, Sonora and Tamaulipas). LOCAL.—Grassland and desert associations of Brewster, Presidio and Jeff Davis counties, at altitudes from 1900 to 5000 feet.

This species is aptly named for its pencil-thin joints. Of wide-spread occurrence throughout the Big Bend Region the plants vary in form from low bushes with numerous primary stems to erect, almost arborescent bushes producing only one or two primary stems which in turn give rise to secondary branches about 8 cm above the ground.

The majority of the readily-detached ultimate joints are spineless and about 3 cm long. The remainder are more variable in length (from 3 to 9.5 cm long). In contrast to *O. kleimiae*, *O. leptocaulis* has more of the very short joints which usually arise at right angles. These, and the longer joints, curve up sharply, unlike the gradually upward-curving ultimate joints of *O. kleimiae*. There are rarely more than two joints at a node. Stems of this species are yellow-green in color with purple blotches below the areoles; those of *O. kleimiae* are gray-green with a purple tinge around the areoles or over the entire ventral surface. Diseased joints of *O. leptocaulis* proliferate prodigiously, producing a "witches' broom" effect.

Flowers arise along the terminal halves of longer joints, are inconspicuous, and in contrast to those of other Opuntiae, do not open until late afternoon, closing late at night. The blooming period extends from the middle of June to as late as September. Fruits often remain on the plant a year or longer, are spineless, and capable of proliferation. Each fruit bears a few seeds which have a narrow beakless aril. The vascular gaps in the skeletal

lattice are relatively small, mostly short and oval with much thick wood between.

Many varieties have been described, but the only evident variant in the Big Bend Region is var. *brevispina*. The species is reported by Britton & Rose (1919) to hybridize with *O. imbricata*. I found no such hybrids, although the two species occur together frequently and their flowering periods overlap. A hybrid between *O. leptocaulis* and *O. kleiniae* was collected and is described below.

2 *OPUNTIA LEPTOCAULIS* var. *BREVISPINA* Engelm. in
Proc. Amer. Acad. 3:309. 1856

This short-spined variety of the well-defined species occurs commonly throughout the southwest and has long been recognized by taxonomists. It is characterized by shorter spines (6-28 mm long) which lack sheaths or have closely-fitting fugacious sheaths and fewer of the long ultimate joints (fig. 1). Spines often spread downward instead of at right angles as in the typical form. It sometimes occurs with the typical *O. leptocaulis* which negates the possibility of its being only an edaphic form.

3 *OPUNTIA KLEINIAE* DC. Mém. Mus. Hist. Nat. Paris 17:118. 1828

Distribution: GENERAL.—Southern New Mexico, western Texas, Coahuila, Sonora and states in central Mexico. *LOCAL.*—Infrequent along creek bottomlands in the Davis Mountains and in arroyos on desert flats, also along the Rio Grande from Presidio to Pecos River, at altitudes from 1900 to 4800 feet.

The specific epithet emphasizes the resemblance to members of the genus *Kleinia*, a succulent composite endemic to Africa.

These large profusely-branched bushes are difficult to discern at a distance, since they are usually growing with other tall shrubs. Three or more main branches arise from the base of the plant, whereas *O. leptocaulis* typically has only one or two main trunks (fig. 2). There are two types of ultimate joints in *O. kleiniae* as is also characteristic of *O. leptocaulis* and *O. leptocaulis* x *kleiniae*. The majority of the joints are short (in *O. kleiniae* about 7 cm long, and spineless); the others are highly variable in length (in *O. Kleiniae* from 8 to 25 cm long). Both types of ultimate joints in *O. kleiniae* arise at angles somewhat less than 90° to the main branch and curve gradually upward. As many as four verticillate branches may arise at a node. Joints are readily detached and spines are strongly barbed. There are usually 2-9 spines in an areole.

The flowering period lasts from late May to late August, with dull rose flowers borne in profusion. Mature fruits develop within two months. Under adverse conditions, or if detached while still green, these fruits readily proliferate, producing shoots and roots, and may serve for vegetative reproduction. Seeds are relatively large (to 5 mm in diameter) with a narrow and beaked aril. Seedlings are frequently found in thickets of these bushes. The skeletal pattern is characterized by oval gaps which are relatively short and wide.

4 *Opuntia kleiniae* x *leptocaulis* hybr. nov.

Erecta, usque ad 15 dm alta; articulis plerisque 5 cm longis, 8 mm diametro, paulum tuberculatis; areolis elevatis 2 mm; spina 1, paululum deflexa, spinis setosis absen-

tibus; floribus 3.2 cm longis, 1.5 cm latis, magnitudine intermediis inter parentes, interioribus segmentibus fuscis-rubellis; fructibus 1.4-1.8 cm longis, 1 cm latis; seminibus 4 mm diametro. Specimen typicum secus rivulum dictum "Musquiz Creek," prope montem "Mitre Peak," Jeff Davis Co., Texas, siccatum conservatum est sub numero 513 in Herb. Univ. Mich. et vivum sub numero 19215 in Hort. Mich.

Plant a densely-branched bush to 15 dm high with crown about 20 dm across; trunk to 5 cm in diameter; branches ascending; roots fibrous; joints intermediate between parents in size, ascending at acute angles, more like *O. Kleiniae* in appearance, short joints mostly 5-7 cm long, to 8 mm in diameter, slightly tuberculate with protuberances to 2 mm high, glaucous, gray green; leaves subulate, short mucronate, 3-7 mm long, 1.5 mm wide, green; areoles distant, about 12 mm apart, bearing glands, obovate, to 4.5 mm long and 3 mm wide, becoming larger and elevated in age; wool abundant, yellow or tan; spines 1 per areole, from uppermost areoles, stout, at right angles to stem or directed slightly downward, short joints spineless, young and mature spines white or purplish-brown with yellow tips, sheath white with long orange-tip, persistent, finally becoming gray and shaggy in age; bristles 2-4, caducous; glochids inconspicuous in small dense tufts in upper end of areoles, bright orange with yellow bases, to 15 mm long in older areoles; flower intermediate between parents in size, about 3.2 cm long, and 1.5 cm across with perianth segments in 4 whorls, outer segments short-oblong, mucronate, not recurved, inner segments pale pinkish brown with darker trace, broadly spatulate, mucronate, to 1.3 cm long and 8 mm wide; filaments greenish white below, pink above, 5 mm long, anthers yellow; style white below, pink above, bulbous above base, long and thin, to 12 mm in length, stigma lobes 4, creamy yellow, 2.5 mm long; ovary long conic with tapering base, to 2 cm long and 1 cm in diameter, with distant areoles bearing minute, subulate leaves, tawny wool, dense tufts of reddish-orange glochids; lacking bristles and spines; fruit small, drying to orange, narrowly obconic, with attenuate base, mostly sterile, to 1.8 cm long and 1 cm in diameter when mature, with minute areoles, short reddish-orange glochids, spines lacking; umbilicus v-shaped, 5 mm deep; seeds yellow, beakless, faintly notched at hilum, large, 4 mm in diameter, to 2 mm thick, aril 0.5 mm wide.

Type locality: With *Acacia* and *Prosopis* in thickets along bottomland of Musquiz Creek, south of Davis Mountains and east of Rt. 118, Jeff Davis County, Texas, at 4400 ft. altitude.

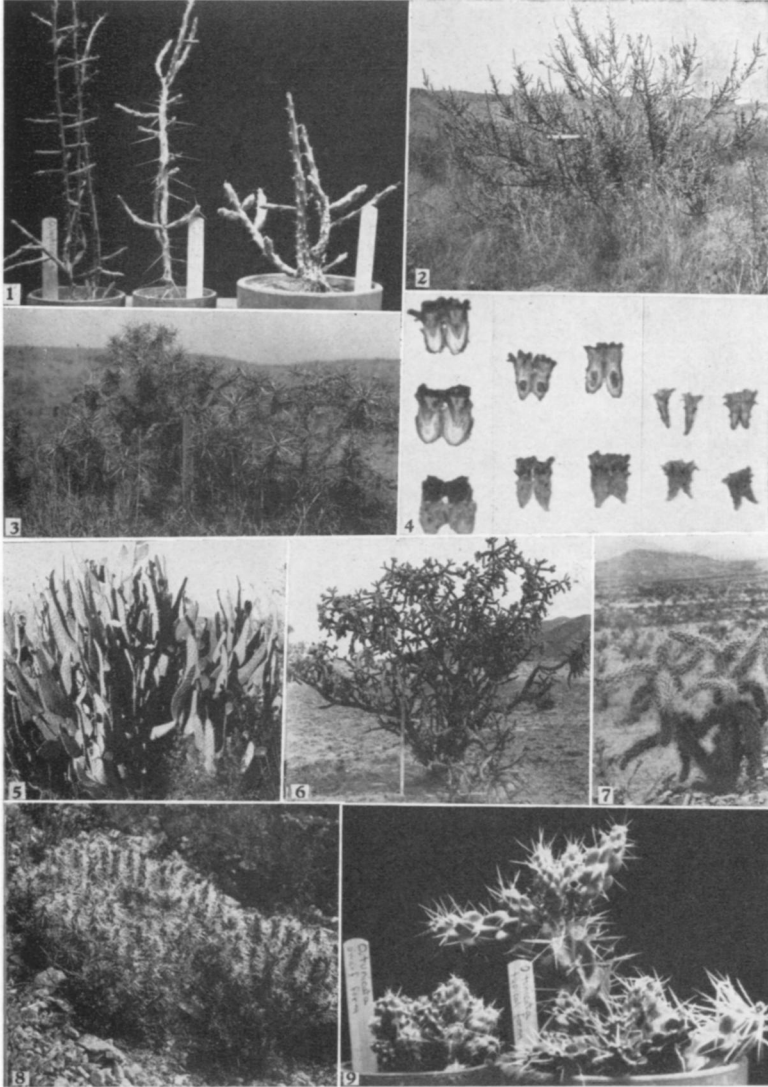
Distribution: Found only at type locality.

In most respects these hybrid plants resemble *Opuntia kleiniae* more closely than *O. leptocaulis* (figs. 1 and 4) but size of the entire plant is somewhat smaller; the short joints characteristically curve up more sharply; tubercles are less evident and bear smaller areoles; areoles usually have only one long spine, pointing downward; mature plants lack bristles; and seedlings have more slender cotyledons.

Flowering coincides with that of the parents, both of which bloom from June to August. Young fruits were collected in late September.

Both parents were locally abundant at the locale of this hybrid. The smaller stature of the hybrid may arise from some disparity in chromosome numbers of the parents. The peculiar color of the flowers may conceivably be interpreted as a purely visual effect of the inheritance of yellow pigment in certain cells (probably sub-epidermal) from one parent and purple (probably in epidermal cells) from the other parent, the combined effect being brownish.

Collections.—JEFF DAVIS Co.: (Type specimen) infrequent with *Acacia* and *Prosopis* in thickets along bottomland of Musquiz Creek, east of Mitre Peak, along Rt. 118, 4400 ft., June 4, 1948, No. 513; Aug. 24, 1948, No. 1044; Sept. 22, 1948, No. 1377 (a and b).



Figs. 1-9.—1. l. to r.) *O. leptocaulis* var. *brevispina*, *O. kleiniae* x *leptocaulis* and *O. kleiniae*. All have produced some new growth under cultivation; 2. *O. kleiniae* with fruits, in catclaw thicket with short grass along Musquiz Creek; 3. *O. davisii* in fruit, with grassland vegetation south of Marathon; 4. Flowers of the hybrid (center) are intermediate in size and color between those of *O. kleiniae* (left) and *O. leptocaulis* (right); 5. *O. linguiformis* in abandoned Mexican garden along Tornillo Creek, Big Bend National Park; 6. *O. imbricata* in bloom, with short grass association east of Alpine; 7. Young plant of *O. imbricata* var. *argentea*; north end of Mariscal Mountain; 8. *O. tunicata* with flowers and immature fruits; 9. Dwarf form of *O. tunicata* (left) with joints about 1/3 the size of those of the typical form (right).

5 *OPUNTIA DAVISII* Engelman and Bigelow, Pac. R.R. Rep. 4:49. 1856

Distribution: GENERAL.—Western Texas, eastern New Mexico, southwestern Colorado, and southwestern Oklahoma. LOCAL.—Grassland plains of northern Presidio and Brewster counties, at altitudes of 4400-5000 feet.

Engelmann and Bigelow (1856) named this *Opuntia* in honor of Jefferson Davis, the Secretary of War under whom the scientifically valuable Pacific railway surveys were made.

The erect shrub stands out at some distance with its straw-colored, loosely-sheathed spines completely obscuring the stems (fig. 3). The untidy appearance of the plants is due to the great abundance of spines from closely set areoles. The trunk is woody and densely-branched with several verticillate, easily-detached joints at each node. Spines are of two sorts, 5-7 are longer, subulate, reddish brown with persistent sheaths; 2-4 radially deflexed from the outer margin of the areole are shorter, acicular, all yellow or straw-colored, and without sheaths. Hester (1939) described a plant from this region otherwise resembling *Opuntia davisii* but with tuberous roots.

The flowering period is short, a few weeks in late June and early July. One to three seeds may be found in a fruit although many of the fruits are sterile. The seeds are about 3.5 mm in diameter with a thin beaked aril. The large vascular gaps on old stems are long, narrow and actually-pointed.

Individuals occur singly or as many as ten may be scattered locally. In the Big Bend Region the species is restricted to arid grassland associations, particularly in broad wash areas.

6 *OPUNTIA IMBRICATA* (Haworth) DC. Prodr. Sys. Nat. Reg. Veg. 3:471.1828

Distribution: GENERAL.—Central to southeastern Colorado, Oklahoma, Texas, New Mexico, Arizona, and the high plains of Mexico. Reported from Utah (Rydberg, 1917) and from Kansas. LOCAL.—Woodland, grassland and desert associations in Brewster, Presidio, and Jeff Davis counties, at altitudes from 2700 to 6200 feet.

The specific epithet refers to the sublobular tubercles which overlap on the stem. The sturdy trunk reaches a height of one or more dm before it divides into at least three primary branches. At each node two to six verticillate secondary branches arise, usually at right angles and curving upwards. One of these generally continues growth to form new nodes (fig. 6). Each areole bears 6-14 reddish-brown, central spines and 3-10 shorter, gray, radial spines.

Along washes and other runoff areas plants may be relatively spineless or bearing very short spines and the joints are often more turgid with broader tubercles. The surface is lighter green with a less glaucous covering.

Flowering is prolific over a period from the end of April to as late as the end of July with the peak in May; two to six flowers are borne in a cluster near the tips of ultimate joints. Fruits ripen within two to three months but are long-persistent on the plant so that two years' crop may be present at once. Occasionally these fruits undergo vegetative reversion and develop into joints with the locule imbedded in the upper part. Seeds are smooth, with a narrow slightly beaked aril. Seedlings are surprisingly abundant considering how seldom one sees seedlings of other cactus species. Undoubtedly

their prolific production allows greater chance for some surviving. Skeletons of branches are distinguished by a pattern of long and wide vascular gaps.

7 *Opuntia imbricata* var. *argentea* var. nov.

Similis formae typicae sed articulus crassioribus quam in forma typica; spinis vaginisque argenteis. Specimen typicum ex monte dicto "Mariscal Mountain, Big Bend National Park, Texas" siccatum conservatum est sub numero 280 in Herb. Univ. Mich. et vivum conservatum est sub numero 18830 in Hort. Mich.

Plant a small, erect shrub, to 12 dm high, with crown to about 10 dm. across; trunk up to 7.5 cm in diameter; branches many, spreading to erect; roots fibrous; joints relatively large, to 20 cm long, 1.5-4 cm in diameter; tubercles 2 cm long, 5-12 mm wide and 5 mm high, heavily glaucous, silvery green; leaves long-subulate, apiculate, 10-17 mm long, 1.5 mm wide; areoles closely set, to 20 mm apart, long-oval, 5-7 mm long, 3-4 mm wide; wool abundant, pale yellow, gray in age; spines 11-21, from all except lowermost areoles, subulate, elliptic in cross-section, young spines white or pink with greenish base, older spines silvery with pinkish bases and silvery white sheaths, finally becoming gray, 6-14 central spines longer, to 2 cm long, spreading, 5-7 radial spines shorter, to 1.8 cm long, spreading deflexed; bristles indistinguishable; glochids inconspicuous in compact row along upper margin of areole, white with green bases when young, pale yellow in older areoles; scarcely 1 mm long; flower about 5 cm long, and to 5 cm across, with perianth segments in 4 whorls, outer segments pink with olive trace, apiculate, oblong, inner segments reddish-purple, broadly spatulate, apiculate, to 2.5 cm long and 1.4 cm wide; filaments magenta, 9 mm long; style bulbous just above base, to 18 mm long, stigma lobes 7-9, 5 mm long; ovary short conic, truncate, about 1.5 cm long, and 1.5 cm wide, with large, closely set areoles, uppermost ones bearing small subulate leaves, abundant tawny wool, few minute white glochids and 1-2 long white bristles; fruits and seeds unknown.

Type locality: Mariscal Mountain, Big Bend National Park, Brewster County, Texas.

Distribution: Around Mariscal Mountain only, observed on northern and eastern slopes, eastern pediment, and west of Solis Ranch in *Prosopis* thickets of Rio Grande Plain, Big Bend National Park, at altitudes from 2000 to 2400 feet.

This variety differs from the typical *O. imbricata* in its lower stature, smaller tubercles so that the areoles are closer together, and spines which are silvery throughout, hence the varietal epithet. Appearance in the field is chubby in comparison with the typical form (fig. 7). Flowers open early in April. Mature fruits were not obtained.

A specimen, transplanted from the type locality at 2300 feet to Victor Pierce Ranch in the Glass Mountains at 4300 feet, survived the unusually cold winter (minimum temperature of 0°F) of 1947-48, and was growing vigorously when re-collected. This adaptability augers well for future spreading and establishment beyond the present small range of distribution.

A living specimen at the Botanical Gardens has produced a number of new joints which are more abundant, arise at more acute angles, and are spinier than joints of the typical *O. imbricata* growing in the same greenhouse.

Collections.—BREWSTER CO.: Locally abund. with *Larrea-Agave*, 2000 feet, on pediment 4 mi. east of Mariscal Mt., Big Bend National Park, April 7, 1947, No. 23; rare, with *Prosopis* on sandy wash along Rio Grande near Solis Ranch house, Big Bend Nat. Park, April 28, 1948, No. 276; (type specimen) abundant with *Agave lechuguilla*, 2500 ft., on northern slope of Mariscal Mt., Big Bend Nat. Park, Apr. 29, 1948, No. 280; with *Bouteloua-Juniperus* association in transplant plot on Victor Pierce Ranch in Glass Mts., limestone soil, 4300 ft., (Orig. from pediment e. of Mariscal Mt., Apr. 7, 1947), Sept. 12, 1948, No. 1163.

8 *OPUNTIA TUNICATA* (Lehman) Link and Otto, in Pfeiffer
Enum. Cact. 170. 1837

Distribution: GENERAL.—Oriente, Cuba; Mesa Central and Highlands of central Mexico; Ecuador; Peru; Chile; locally in Glass Mountains, Big Bend Region of Texas. *LOCAL*.—In an area of about one-half square mile on the southeastern slope of an outlier of the Glass Mountains, in southwestern Pecos County, Texas. First known scientific observation of this locality was by Dr. B. H. Warnock, Department of Biology, Sul Ross State Teachers College, who very kindly brought it to my attention.

The specific epithet from "tunicatus" L. refers to the sheaths which clothe the spines. The sheen of these papery-white sheaths, which almost obscure the stem in their abundance, strikes the eye with patches of reflected light, even at some distance. The plants grow in low-spreading clumps to 3.5 dm high and 7.1 dm across, with an accumulated debris of dead branches among the green ones. Myriads of ants are attracted by glandular secretions from the living areoles.

A thick, woody, half-buried stem, which may attain a length of 30 cm, creeps along the ground sending up branches. Clumps are composed of about 50-60 main stems which are erect, to 20 cm in height and 5 cm in width, and bear ultimate joints to 9 cm long and 2.5 cm in diameter (fig. 8). Joints are very readily detached and root wherever they fall. The whitish yellow spines are of several lengths; one up to 5.2 cm long, 2-4 shorter, and 1-2 much shorter, only reaching 3 cm in length. Two thin bristles reaching 8 mm in length are frequently found accompanying spines and glochids in the areoles.

As many as seven flowers may be borne in a cluster toward the tips of ultimate joints. The perianth segments are loosely arranged in three whorls. In 1948, the flowering period extended from about June 24 to early July, and fruits matured in two months. The obconic fruit is often sterile and may proliferate, especially if detached. Seeds when present average 3.2 mm in diameter with a thin aril. Of 15 seeds planted at the Botanical Gardens, only one germinated and it happened to have a double embryo.

A dwarf form, scattered abundantly around the larger, typical plants, is distinguished by its miniature size (mostly 7 cm high) and shorter, more bristle-like spines (fig. 9). The creeping stem is 10 cm long, 1.5 cm wide, and there is a short erect trunk. Joints are short-obovate and clavate, about 3.5 cm long and 1 cm wide. Areoles measure up to 2.5 cm long and contain 1-2 spines, 2.4 cm long or less, and 2-4 bristles, strongly deflexed, to 5 mm long. Neither flowers nor fruits were found on dwarf plants. These dwarf forms develop from detached, proliferating, terminal joints and fruits, and from natural seeding. The larger typical form seems to arise from detached main branches. Further research with living material will be carried out to determine the complete origin of both forms and significance of their relationship.

9 *OPUNTIA GRAHAMII* Engelm., Rep. U.S. & Mex.
Bound. Surv. II, Pt. 1, p. 55. 1859

Distribution: GENERAL.—Southern New Mexico, western Texas, and adjacent parts of Chihuahua in Mexico. *LOCAL*.—Desert associations in southern Brewster and Presidio counties, at altitudes from 1900 to 3400 feet.

As head of the scientific corps of the United States and Mexican Boundary Commission, Colonel James D. Graham was responsible for much of the botanical material sent to Engelmann, who gratefully named this cactus in his honor.

This prostrate, clump-forming species is much more common in the Big Bend Region than the closely related *O. schottii*. Each main branch in the clump usually produces three, linearly arranged, joints; these give rise to secondary branches which are curved and ascending toward the tips. As branches creep along the ground, fibrous roots develop from basal areoles of each joint. Tuberos roots are generally found near the center of the clump where the roots are older and better established. The "tubers" of *O. grahamii* are smaller and less abundant than those of *O. schottii*. The oldest joints are apparently always infected with fungus and tend to disintegrate, or it may be that the older parts of the plant die naturally, and that fungus infection is secondary. In either event many small independent plants become established around a central mass of dead and dying stems. Terminal joints also break off easily to form new individuals. Clumps are often found around the bases of creosote bushes; either fragments blow and lodge there, or they are less disturbed and therefore have a better chance to develop under such conditions. The mounds, with a tangle of creeping branches, are nuclei of deposition for wind-carried debris and soil particles so the oldest joints are usually covered by soil and the mound grows upward as well as outward (fig. 10). There are usually 4-6 spreading, dull red, central spines and 2-6 shorter, deflexed, white, radial spines in each areole on the upper half of the joint. Young spines occasionally have evanescent white sheaths.

Few, but conspicuously large, flowers are formed, usually in March and early April although Engelmann (1859) gives the flowering period as June; it may vary with the rains. Flowers are often as long as the joints themselves. By September, a few mature dry bristly fruits are found, but most of them are sterile. The large seeds (5 mm in diameter) have a narrow beaked aril.

10 *OPUNTIA SCHOTTII* Engelmann, Rep. U.S. & Mex. Bound.
Surv. II, Pt. I., p. 54. 1859

Distribution: GENERAL.—Southern and western Texas, and northern Mexico. LOCAL.—Desert associations in southern Brewster and Presidio counties, at altitudes from 1500 to 3800 feet.

Arthur Schott was another active botanical collector with the United States and Mexican Boundary Survey of 1851-1853 and sent many species of cacti to Engelmann.

In its most typical form, this species is easily distinguished from *O. grahamii* by stronger and broadly-flattened spines, larger and relatively longer joints, and more prominent and elongate tubercles (fig. 12). There are usually 2-5 longer, spreading, grayish-brown, central spines; 1-4 shorter spines below these; and 5-8 short, deflexed, white, radial spines, in areoles on the upper two-thirds of the joint. Mounds are of the same general formation as those of *O. grahamii* but are larger. Joints have a very spiny appearance and readily become attached to passing animals.

Flowers are even rarer than those of *O. grahamii*; the species seems to be

losing its ability to reproduce sexually while becoming highly successful with asexual means of propagation. Flowers, sometimes as long as the joints, may be found from the middle of April to early May. Fruits which mature about a month after flowering, are dry, shrunken, abundantly armed with bristles, and often sterile. Rarely a fruit may metamorphose directly into a joint. Seeds are similar to those of *O. grahamii*.

11 *Opuntia grahamii* x *schottii* hybr. nov.

Prostrata; articulis 5-6.3 cm longis, 1.5-2.5 cm latis, grandioribus quam in *O. grahamii*, eis *O. schottii* fere aequalibus; tuberculis magnis, angustioribus quam in *O. grahamii*; spinis 3-9; subcompressis; floribus flavis, segmentis perianthii exterioribus longis, angustis. Specimen typicum ex loco dicto "Hot Springs, Big Bend National Park, Texas" siccatum conservatum est sub numero 856 in Herb. Univ. Mich. et vivum conservatum est sub 19605 in Hort. Mich.

Plant forming low mound about 10 cm high and 6 dm in diameter; trunk absent; branches creeping, ascending at tips; roots mostly fibrous, occasionally with several tubers to 10 cm long and 1 cm wide; joints clavate or short obovate, 5-6.3 cm long, 1.5-2.3 cm wide; tubercles broad, to 8 mm long, 4-5 mm wide, and 5-7 mm high, glaucous, apple green, purplish on tubercles; leaves short-subulate, apiculate, to 7 mm long and 2 mm wide, purplish-green; areoles 10-15 mm apart, circular, large, to 4 mm in diameter; wool abundant, white; spines 1-10, from all but lowermost areoles, scabrous, subulate, flat above, convex below, with bulbous bases, young spines white with pinkish bases and pale yellow tips, older spines purplish-brown with white edges, 3-4 spines longer, to 4.6 cm long, spreading, 1-5 spines shorter, to 1.9 cm in length, spreading, 2-4 radial spines even shorter, to 1.7 cm long, terete, deflexed, white; bristles indistinguishable; glochids conspicuous, pale yellow when young, white to gray and up to 12 mm long and spine-like in older areoles; flower about 7 cm long and 5 cm across with perianth segments in 4-5 whorls, outer segments long lanceolate to narrow conic, green tipped with pink, inner segments bright yellow, spatulate, apiculate, slightly fimbriate, to 2.8 cm long and 1.8 cm wide; filaments red, 8 mm long; style creamy, narrow, to 25 mm long, stigma lobes 5, green, 5 mm long; ovary thin-obconic to 4.5 cm long, and 1.1 cm in diameter, with large areoles, bearing subulate leaves, abundant white wool, numerous white glochids and several white bristles near rim of ovary; immature fruit as in *O. schottii* with areoles bearing abundant white glochids and many long white bristles; umbilicus v-shaped, 10 mm. deep.

Type locality: Sandy upper reaches of Tornillo Creek, northeast of Grapevine Hills, Big Bend National Park, Brewster County, Texas.

Distribution: Desert shrub belt in southern Brewster and Presidio counties, Texas.

Joints of this hybrid are smaller with shorter and finer spines than those of *O. schottii*, but the spines are more flattened and tubercles are stronger than those of *O. grahamii* (fig. 13). Flowers are sparse, a characteristic common to both parents, and appear in April. Distribution of the hybrid forms is approximately the same as that of the parents, throughout southern Brewster and Presidio counties.

Collections: BREWSTER CO.—With Larrea-Agave on limestone ridges, 2 mi. n.e. of Solis Ranch, 1950 ft., Big Bend Nat. Park, Apr. 15, 1947, No. 31b; with Larrea on limestone flat; n. of Hot Springs, 2000 ft., Big Bend Nat. Park, Apr. 18, 1947 No. 37a; in draw n. of Talley Mt., 2600 ft., Big Bend Nat. Park, May 4, 1947, No. 83; (type specimen) with Larrea, on Tornillo Flats, 2800 ft., Big Bend Nat. Park, July 30, 1948, No. 856; with Larrea, e. of Nine-Pt. Mesa, 3200 ft., Aug. 3, 1948, No. 909; with Larrea, 15 mi. n. of Terlingua, along road to Alpine, Sept. 14, 1948, No. 1181; with Larrea-Fouquieria, flats just n. of Ste. Elena Canyon, 2200 ft., Big Bend Nat. Park, Sept. 15, 1948, No. 1246; with Larrea, just s. of Nine-Pt. Mesa, 3400 ft., Sept. 26, 1948, No. 1267; with Dasyliiron-Agave and some Larrea along Dabney-Moody ranch rd. in to Nine-

Pt. Mesa, 3700 ft., Sept. 28, 1948, No. 1283. VAL VERDE Co.—6 mi. w. of Pecos River, Mar. 31, 1948, No. 205.

12 *OPUNTIA RUFIDA* Engelm., Rep. U.S. & Mex. Bound.
Surv. II, Pt. 1, p. 51, 1859

Distribution: GENERAL.—Texas and northern Mexico. LOCAL.—Desert flats south from approximately latitude 30°, in southern Brewster and Presidio counties, characteristically on steep, rocky walls along the river and in canyons, at altitudes from 1600 to 4100 feet.

The specific epithet refers to conspicuous reddish-brown tufts of glochids on the spineless pads. The ascending, somewhat spreading branches form a large bush up to 18 dm high and 15 dm across (fig. 14).

One form of *Opuntia rufida*, which is here named *O. rufida* var. *tortiflora*, has short-obovate to elliptic joints, relatively remote areoles, and outer perianth segments which are swirled in imbrication and twisted sideways in anthesis (fig. 15). In contradistinction, the typical form has obovate to long-obovate joints, areoles not as distant and outer perianth segments not swirled in imbrication nor twisted on the flower.

Flowering of both forms occurs in April. Fruits require a long period to mature and were not observed.

13 *Opuntia rufida* var. *tortiflora* var. nov.

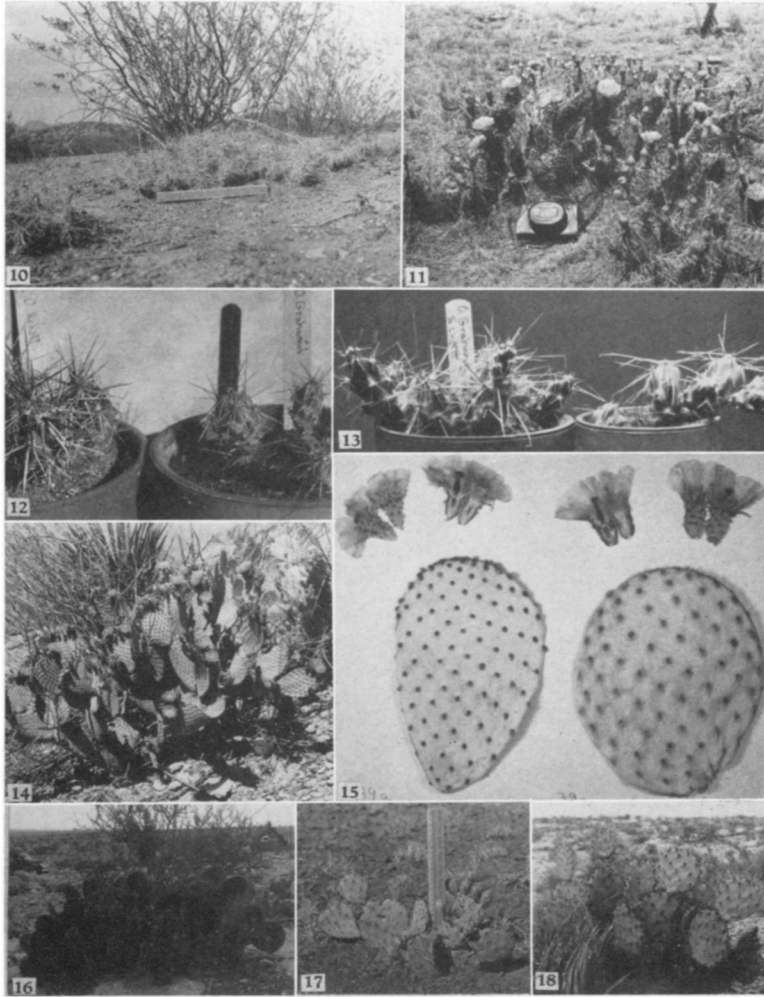
Articulis ellipticis breviter obovoideis; areolis remotis; segmentis perianthii exterioribus tortis. Specimen typicum ex loco dicto "Hot Springs, Big Bend National Park" siccatum conservatum est sub numero 39c, in Herb. Univ. Mich.

Plant large, bushy, 9-18 dm high, 7.5-15 dm wide, occasionally with definite trunk 15 cm high, 10 cm in diameter; branches ascending, somewhat spreading; roots fibrous; joints short-obovate, elliptic to short oval, 13-24 cm long, 10.5-14 cm wide, up to 11 mm thick, pale blue-green to gray-green, purple around areoles; areoles remote, 10-15 mm apart, long elliptic, less elevated and prominent than in type form, to 3 mm long, becoming worm-like in age; wool pale tan, becoming darker; glochids rufous; flower bud with segments swirled in imbrication; flower 3.5 cm long, 5.5 cm across with perianth segments in 4 whorls, outer segments reddish bronze with green trace, long-lanceolate, narrow, twisted, inner segments yellow, fading to pink with tan base; obovate, mucronate, up to 3.5 cm long and 2.3 cm wide; filaments 13 mm long; style yellow, 6 mm in diameter, 23 mm long, stigma lobes 8, green; ovary oblong, up to 2.4 cm long and 1.5 cm in diameter with large, closely set areoles; fruits and seeds not observed.

Collections.—BREWSTER CO.: Big Bend National Park: with *Larrea-Agave* among igneous rocks, south slope of Chilicotal Mt., 4100 ft., Apr. 3, 1947, No. 16; (type specimen) with *Larrea-Agave* on steep limestone slopes n.w. of Hot Springs, 2000 ft., April 18, 1947, No. 39c, (d) and (e); with *Larrea-Agave* on steep n.w. slope of hill e. of Boquillas, 2000 ft., Apr. 11, 1948, No. 237; with *Dasyliroton-Agave* on slopes of brown limestone hills just s. of Dagger Flats, Aug. 2, 1948, No. 899.

14 *OPUNTIA TORTISPINA* Engelm., Pac. RR. Rep. 3:41. 1856

Distribution: GENERAL.—South Dakota, Minnesota, Missouri, Nebraska, Kansas, Wisconsin, southeastern Colorado, eastern Arizona, eastern and southeastern New Mexico, Arkansas, and Texas. Established and slowly spreading east of Cincinnati, Ohio (E. T. Wherry, 1922). LOCAL.—Common in grassland and woodland associations in northern Brewster and Presidio counties, also in Jeff Davis County, at altitudes from 3800 to 6700 feet.



Figs. 10-18.—10. *O. schottii* at base of creosote bush, Big Bend National Park; 11. *O. tortispina* in flower (joints less spiny than usual) with grassland vegetation in Del Norte Mountains; 12. Tubercle size as well as number and shape of spines can be compared between *O. schottii* (left) and *O. grahamii* (right); 13. *O. grahamii* x *schottii* with intermediate tubercle size and spine form; 14. *O. rufida* in flower, Big Bend National Park; 15. *O. rufida* var. *tortiflora* (right) contrasted with typical form (left); 16. Note the closely-set areoles of *O. strigil*, east of Ft. Stockton; 17. *O. potsii* in fruit, with short grass association; 18. *O. azurea* with creosote-lechuguilla association, in Big Bend National Park.

The twisted habit of the spines is well emphasized in the name of this species. The typical form is very distinct with spreading, much-branched habit; long obovate joints which are wrinkled when young; new spines of striking burnt-yellow color, long central spines with shorter, deflexed radials; and characteristically rose-purple fruits (fig. 11). Atypical forms of *O. tortispina* are most likely to be confused with *O. phaeacantha*, but can be identified by more closely set areoles and dense tufts of conspicuous orange-red glochids.

Flowers are borne in profusion commencing about mid-May and continuing into mid-July. The abundant fruits ripen in a month and are filled with juicy pulp and abundant seeds, which have a wide beakless aril.

15 *OPUNTIA STRIGIL* Engelman, Rep. U.S. & Mex. Bound.
Surv. II, Pt. 1, p. 47. 1859

Distribution: GENERAL.—West of the Pecos River in Texas. *LOCAL.*—South and east of Ft. Stockton on limestone hills, Pecos County, at altitude from 2600 to 3000 feet.

The meaning of this specific epithet is more obscure than most. The Latin means either "a scraper" (instrument for scraping the skin as after a bath) or "one of a group of undulating flutings in Roman architecture." Perhaps it is a misnomer, meant to be "strigosus" N.L., which, botanically, means "set with stiff bristles."

At a distance the plants look very much like *O. rufida* with densely branched, spreading-ascending habit, short trunk, short-obovate joints, and closely-set but large areoles filled with conspicuous glochids. However, closer inspection shows a very spiny joint, truly one of the most viciously armed species among the *Opuntiae* under consideration here (fig. 16). Old joints may reach a length of 19 cm and a width of 16 cm.

Flowers, borne in abundance along the upper margin of the pads in early April, measure about 6 cm long and 7 cm wide, with perianth markedly longer than ovary. The fimbriate inner segments are pale lemon-yellow, tinged with pink at the base. Mature fruits, dry, and a rose-purple to plum color, were collected early in July. Seeds which have a narrow beakless aril, are very abundant.

This species forms a monotypic Series (*Strigiles*) and with its lack of variability is easily identified by the relatively large, thick joints; red and yellow spines which are mostly deflexed; and small, bristly fruits.

Although *O. strigil* is very abundant west of Pecos River in Terrell County and on limestone ridges south and east of Fort Stockton in Pecos County, it was not found in the three Big Bend counties although similar habitats are available. It is included in this discussion because so little information is elsewhere available for it and because of the problem it presents in range of distribution.

16 *OPUNTIA POTTSII* Salm-Dyck, Cact. Hort. Dyck. 1849. 236. 1850

Distribution: GENERAL.—Southern New Mexico, Trans-Pecos Texas, to central Chihuahua in Mexico. *LOCAL.*—Occasional in grassland associations of Brewster, Jeff Davis and Presidio counties, at altitudes from 3000 to 6000 feet.

This specific epithet honors John Potts, an official in Chihuahua, who sent cacti to Royal Botanic Gardens, Kew between 1842 and 1850.

One of the least conspicuous of the *Platyopuntiae*, *O. pottsii* is strikingly different from any other of the region because of its large, tuberous, milky-juiced roots and orange-red flowers, which appear in the middle of May. Joints are highly variable in form, being orbicular, obovate or sometimes almost triangular in shape. A plant rarely bears more than six to eight joints (fig. 17). There are usually one or two long, twisted, spreading spines and one shorter, deflexed spine from each areole along the upper margins of pads, although some spineless joints are found. Mature fruits, collected from late August to October have a distinctive long-pyriform shape and a glaucous, pink-purple color. Seeds are about 6 mm in diameter with a wide beaked aril.

17 *OPUNTIA SETISPINA* Engelmann in Salm-Dyck,
Cact. Hort. Dyck. 1849. 239. 1850

Distribution: GENERAL.—Western Texas, to western Chihuahua in Mexico. LOCAL.—Grassland associations of northern Brewster County, at altitudes from 2400 to 5000 feet.

The relatively thin, acicular spines explain the name “setis” (L. bristle) “spina” (L. spine).

This grassland and encinal species resembles *O. macrocentra*, but has thicker, usually orbicular, joints, and downward-spreading spines (fig. 19). Some specimens also resemble *O. tenuispina* in having noticeably acicular spines, but the latter has a more creeping habit, usually long-obovate joints, fewer and less flattened spines, and the spines mostly restricted to marginal areoles. Joints of *O. setispina* are often curved, making it difficult to slice them for herbarium specimens, and may reach a size of 25 cm in length and 17 cm in width. Generally 2-4 brown spines are borne in an areole, although there may be as many as ten. Of these, one is long and porrect, two are shorter, twisted and porrect, and one still shorter is always deflexed.

When plants of *O. setispina* are in flower, from the middle of May to the middle of July, one notices particularly the very numerous and minute areoles on the somewhat tuberculate ovaries. Flowers are about 6-7 cm long and 6 cm wide; perianth segments are yellow, grading into rose at the base. Fruits begin to mature by late June; occasionally two and even three fruits will develop fused together although the plant appears otherwise normal. No flowers with this tendency were found. Seeds within these atypical fruits are perfectly normal and well formed with a wide beaked aril.

18 *OPUNTIA TENUISPINA* Engelmann Rep. U.S. & Mex. Bound.
Surv. II., Pt. I., p. 50. 1859

Distribution: GENERAL.—Arizona, Zion National Park in Utah, New Mexico, southwestern Texas, northern Chihuahua in Mexico. LOCAL.—Frequent in desert life belt in southern and eastern Brewster County, frequent in encinal belt of Chisos Mountains and Nine Point Mesa, occasional in grassland belt in northern Brewster County at altitudes from 2200 to 5100 feet.

The species name refers to the slender spines which characterize these plants. The cluster typically consists of one very long spine, sometimes deflexed; 1-2 shorter, twisted spines, spreading-deflexed; and one very short deflexed spine. With a low, spreading habit (fig. 20), long-obovate joints (sometimes 27 cm long and 13 cm wide), spines in upper areoles only, and

usually 1 to 3 terete spines per areole, the species resembles *O. phaeacantha* and can only be well distinguished by thinner joints and fewer spines per joint. Low bushes of *O. engelmannii* also may be confused with *O. tenuispina*, but the former have larger areoles and flatter spines. Flowers, bearing yellow segments with a faint rosy blush at the base, appear in early June but are very sparse so are of little use in field identification. A few mature fruits were collected by early August; the seeds have a wide, slightly beaked aril.

19 *OPUNTIA MACROCENTRA* Engelmann Rep. U.S. & Mex. Bound.
Surv. II, Pt. I, p. 292. 1859

Distribution: GENERAL.—South central and southeastern Arizona, southern New Mexico, western Texas, Chihuahua in Mexico. LOCAL.—Occasional in grasslands and common on desert flats in Brewster and Presidio counties, from 1900 to 4800 feet.

The name "macrocentra" means large central spines, a feature which immediately distinguishes this species in its typical form. Only the uppermost areoles of a joint bear spines; three or four are usually present per areole. There is at least one spine longer than the two intermediate ones; and one, lower in the areole, is very much shorter and deflexed. The species is well segregated from *Opuntia phaeacantha* by thinner and usually orbicular joints, slender leaves, smaller and more closely set areoles, lack of bristles, more acicular spines, and more elongate flowers with narrower outer segments. *O. setispina*, alike in orbicular joints, closely-set areoles, and large flowers, always has thicker joints with spines spreading downward, while *O. macrocentra* has porrect, upward-spreading spines although, in sheltered habitats, individuals are frequently spineless. Young joints are a beautiful reddish- or blue-green. Mature joints have a tendency to become purple, especially during sunny summer months and in dry years; in size they may reach a length of 26 cm and a width of 17 cm. There is also a marked tendency for pads to be twisted.

O. macrocentra is one of the earliest cacti in the region to begin flowering; buds open from April to the middle of May. Flowers may be almost as long as the joints and sometimes the perianth is twice as long as the ovary. Inner perianth segments are pale to dark yellow with rose bases and white tips. The many fertile fruits ripen by early July; seeds are large with a wide, beakless aril.

20 *Opuntia macrocentra* var. *minor* var. *nov.*

Diffusa; paucis ramis erecte ascendentibus; articulis quam in forma typica minoribus breviter obovatis; areolis remotioribus; spinis 2-7, varie divergentibus; floribus fructibusque ignotis. Specimen typicum ex loco dicto "Ruidosa, Presidio Co., Texas" siccatum conservatum est sub numero 1081, in Herb. Univ. Mich. et vivum conservatum est sub numero 19607 in Hort. Mich.

Plant mostly spreading, much branched; some branches vertically ascending; trunk absent; roots fibrous but sometimes with fleshy taproot; joints short obovate, from 6 cm long and 5 cm wide to 10 cm long and 7 cm wide, to 8 mm thick, heavily glaucous, young joints blue-green, older joints glaucous green; leaves subulate, apiculate, 4-6 mm long, 1.5 mm wide, green; areoles 15-20 mm apart, large, ovate to circular, 3-6 mm long, 2-4 mm wide, becoming larger in age; wool tan to gray; spines 2-7 (mostly 3-4), from areoles on upper half of joint, acicular, twisted, angular, young spines rufous below, be-

coming white with orange tips, older spines rufous with orange tips, finally becoming all brown; 1-3 spines longer, mostly 4.5 cm, a few to 6 cm long, spreading, 1-4 spines shorter, mostly 2.5 cm, spreading, 1 spine short, 2.2 cm, always deflexed, rufous below, white toward tip; bristles absent; glochids abundant, conspicuous, bright orange when young, yellow and rufous with yellow bases and to 12 mm long in older areoles; flowers unknown.

Type locality: With *Larrea* on sandy soil 1.4 miles southeast of Ruidosa along road to Presidio, Presidio County.

Distribution: With *Larrea* and *Larrea-Prosopis* associations on sandy flats along the Rio Grande, from 2100-2700 feet, Ruidosa to Presidio, Presidio Co., and north of Santa Elena Canyon in Big Bend Nat. Park, Brewster County.

The spreading branches of this small-jointed and very spiny variety form an extensive clump among the creosote bushes; occasional erect branches, three to four joints long, reach a height of about 3 dm (fig. 21). All spines are rufous, unlike those of the typical *O. macrocentra* with the terminal half paler or white. Tap roots on one plant were definitely fleshy. Neither flowers nor fruits were found.

PRESIDIO CO.: (Type specimen) with *Larrea* on sandy flats, 2700 ft., 1.4 mi. from Ruidosa along road to Presidio, Aug. 26, 1948, No. 1081. BREWSTER CO.: With *Larrea-Prosopis* on sandy soil, 4.8 mi. n. Ste. Elena Canyon, 2200 ft., Big Bend National Park, Sept. 16, 1948, No. 1211.

OPUNTIA sp.

Two plants were found (fig. 30) that closely resembled *O. macrocentra* with a few long spines in each areole along the upper margin of the joints, but spines were yellow rather than dark reddish-brown, areoles were relatively distant rather than closely set and flowers were yellow throughout. These plants therefore suggested hybridization between *O. lindheimeri* and *O. macrocentra*. Continued observation of specimens under cultivation will be necessary to substantiate this hypothesis.

Collections.—BREWSTER CO.: With *Bouteloua-Juniperus* in valley southwest of Old Blue in Glass Mts., on Victor Pierce Ranch, May 19, 1947, No. 125; on low limestone hill with *Pinus-Quercus*, Yates Ranch, Glass Mts., June 3, 1948, No. 506.

21 OPUNTIA AZUREA Rose, Contr. U.S. Nat. Herb. 12:291. 1909

Distribution: GENERAL.—Zacatecas and Durango in Mexico, near Rio Grande in Brewster County, Texas. LOCAL.—Locally abundant with *Larrea-Agave lechuguilla*, on barren limestone ridges one mile northeast of Solis Ranch in the Big Bend National Park, at about 1900 feet.

The specific epithet refers to the blue-green color of the joints. Successive joints of three years' growth show a striking contrast between young creamy-white spines, mature bright yellow spines and the old black spines (fig. 18). In each spine cluster one main spine is longer and porrect, 1-3 are shorter and spreading, and one is very short and points downward. Britton & Rose (1919) describe the spines of these plants as only 2 to 3 cm long and the flowers as fading pink, but in Texas some spines reach a length of 6.3 cm, and flowers fade to white on the second day.

Superficially the species resembles *O. lindheimeri* in spreading and ascending habit and orbicular to short obovate joints with yellow spines, but it

differs in having more closely set areoles, occasional bristles, marked contrast in spine color and yellow flowers with red centers similar to those of *O. macrocentra*. Flowering period lasts from early to late April. Mature fruits were not available.

Plants were found only in a small colony at this one station.

22 *OPUNTIA PHAEACANTHA* Engelm. in Gray, Mem.
Amer. Acad. 4:52. 1849

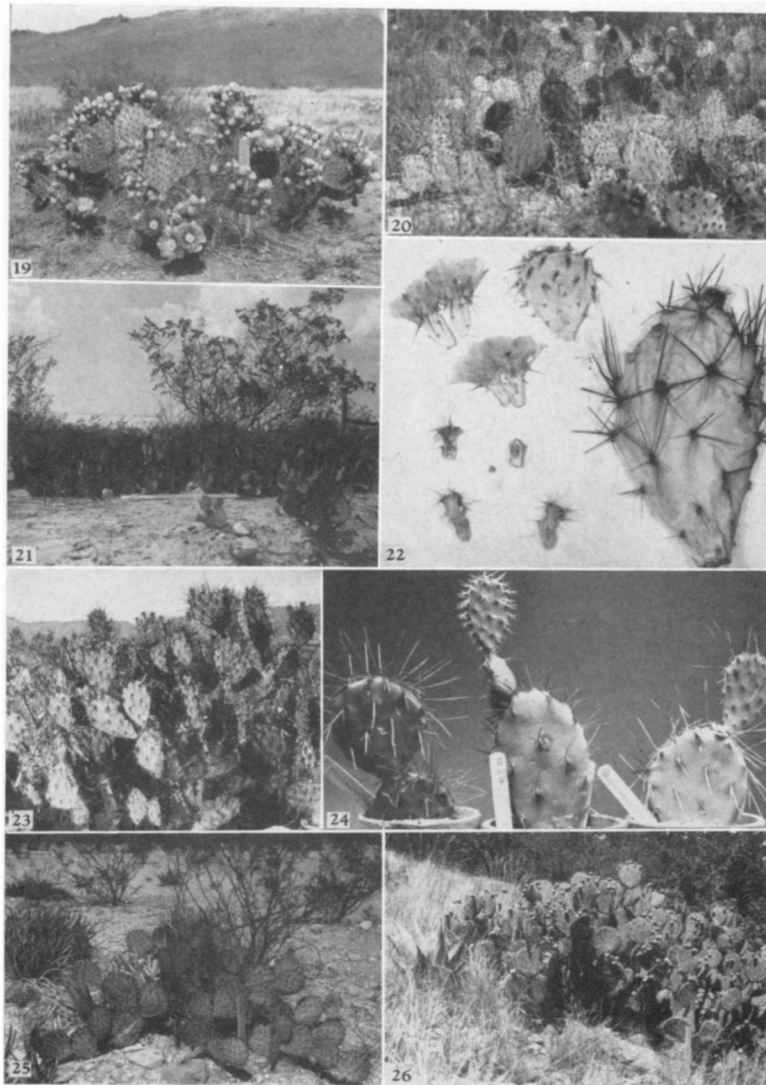
Distribution: GENERAL.—California, southern Utah, Arizona, southeastern and western Colorado, New Mexico, western Texas, and in Chihuahua, Mexico. LOCAL.—In desert shrub, arid grassland and encinal belts of Brewster, Jeff Davis and Presidio counties at altitudes from 1600 to 5500 feet.

“Phae” (Gr. brown) and “acantha” (Gr. spine) constitutes an apt name for this reddish brown-spined common species of the southwest.

Usually a low, spreading bush, but extremely variable in most characteristics, *Opuntia phaeacantha* is one of the most difficult species in the Big Bend to identify with certainty. Flowers and fruits are too sparse to be of much help either. After study in the field, many distinct forms of the species can be recognized, each differing in subtle variations of habit, spine number, and spine arrangement, but intergrading to defy definition. Under cultivation many of these differences become less evident. Therefore, the group is here broadly defined, ranging from spreading plants with a few spines in the marginal areoles, to larger, more ascending bushes reaching 15 dm in height (with a short thick trunk) and with very spiny joints (fig. 25). Occasional joints reach 30 cm in length and 19 cm in width but average joints measure 10 to 22 cm long and 9 to 15 cm wide. Thickness of joints on different individuals varies from 7 mm, which is relatively thin for the *Opuntiae*, to 15 mm, which is relatively thick. Bristles are consistently present in some forms and absent in others. Three to four spines constitute a cluster, although there may be as many as ten in an areole. One to four are long, others are shorter and spreading, one is much shorter and deflexed. Although the color pattern is similar to that in *O. macrocentra*, flowers of *O. phaeacantha* are characteristically shorter with a stouter ovary. Other differences in floral structure include a short thick style, usually bulbous at the base rather than above it; stigma lobes short and heavy instead of long and thin; outer perianth segments broadly conic; perianth no longer than ovary and frequently shorter; areoles distant on the ovary; and flowers fading to a pale tan color, rather than pink as in *O. macrocentra*. Flowers are sparse and open from early April to early July. Mature fruits with abundant seeds were collected from the middle of July on. Seeds have a very wide beakless aril.

23 *Opuntia spinosibacca* sp. nov.

Robusta, diffusa, plerumque erecta; ramis adscendentibus; radicibus fibrosis; saepe basi caule sublignoso teretique; articulis planis, longi-obovatis, basi attenuatis, superficie paullum tuberculatis, glaucis, viridibus, ad areolas purpureis; areolis ellipticis, remotis, magnis, fulvilanosis et seta colore flavida vel rufida gerentibus, plerisque armatis; spinis 2-5, validis, teretibus, superioribus ascendentibus divergentibus, inaequalibus, junioribus albidis, rufescentibus, aetate griseinigris; aliis inferioribus lateralibus 1 vel 2 setosis, deflexis, griseis, longis, conspicuis; infima brevi, deflexa; pallida floribus 5.5 cm longis, 5 cm latis,



Figs. 19-26.—19. *O. setispina* in flower, with short grass association, east of Alpine; 20. *O. tenuispina*, west of Sanderson; 21. *O. macrocentra* var. *minor*, with creosote bush on sandy soil along Rio Grande River; 22. *O. spinosibacca* in Big Bend National Park. Note spiny ovary and fruits; 23. *O. spinosibacca*—note tubercles on joints; 24. Fruit of *O. spinosibacca* (center) proliferating to form new joint, pads of the closely related *O. phaeacantha* to left and right); 25. *O. phaeacantha* on desert flats with creosote bush, east of Santiago Mountains; 26. *O. lindheimeri* var. *chisosensis* with pinyon-oak-juniper association in Chisos Mountains.

flavis, intus rubellis, segmentis perianthii 5-seriatis, exterioribus obovatis, longe-apiculatis, interioribus spatulatis; filamentis flavis; stylo flavo, stigmatibus lobis 7, flavidi-viridibus; ovario obconico, areolis magnis, remotis, setis flavidirufis, superioribus areolis 1-3 spinas validas albas, basi rufas, gerentibus; bacca immatura succosa, matura sicca, etuberculata, longe oblonga, prolifera, areolis superioribus 1-4 spinas validas et albas gerentibus; seminibus magnis, 6 mm diametro, commissura lineari distincta, late marginatis. Specimen typicum ex loco dicto "Boquillas, Big Bend National Park, Brewster County, Texas," siccatum conservatum est sub numero 236 in Herb. Univ. Mich. et vivum conservatum est sub numero 19109 in Hort. Mich.

Plant a tall, massive bush, to 15 dm high, and 18 dm wide; trunk sometimes present, to 6 dm high, 18 cm in diameter; branches ascending, slightly spreading; roots fibrous; joints obovate to long ovate with attenuate base, 10-24 cm long, 7.5-11 cm wide, 7-12 mm thick, heavily glaucous, green with purple around areoles; texture dry, granular; leaves long subulate, mucronate, green to pink with bronze tips; areoles elevated on small protuberances, relatively distant, 30-40 mm apart, oval, large, to 6 mm in length and 3 mm in width; wool tawny or gray; spines 2-5, from all but lowermost areoles, subulate, mostly elliptic in cross-section, slightly twisted, young spines white with rufous bases, older spines reddish orange to dark reddish-brown with paler tips, finally becoming gray in age, 1-4 spines 3.5-7 cm long, porrect, spreading, 1 spine from base of areole, only to 2 cm long, much deflexed, gray; bristles 2, deflexed from base of areole, rufous or gray, to 1.2 cm long; glochids in upper margin of areole, yellow to rufous, 4-7 mm long; flower about 5.5 cm long and 5 cm across with perianth segments in 5 whorls, outer segments with yellow margins, pinkish-green trace, obovate, long-apiculate, inner segments yellow with red base, long obovate, apiculate, to 2.5 cm long and 1.8 cm wide; filaments yellow, to 11 mm long, anthers white or yellow; style white or yellow, bulbous above base, 18 mm long, stigma lobes 7, yellowish-green, 4 mm long; ovary tuberculate, obconic with tapering base, reaching 3 cm in length and 1.5 cm in diameter, with relatively large and distant areoles, uppermost ones bearing subulate, apiculate leaves, dense tan wool, numerous yellow to rufous glochids and 1-3 subulate spines, rufous below, white above; fruit becoming dry, shrunken, tuberculate, capable of proliferation or transformation into joint, long-oblong, with truncate base, to 3.5 cm long and 1.5 cm in diameter when mature, glaucous, pale purple with distant areoles, long yellow or orange glochids, areoles on upper half with 1-4 rufous and white subulate spines; umbilicus v-shaped, 10 mm deep; flesh dry, granular, cream colored; seeds few per fruit, large, rough (noticeable angle between body of seed and aril) yellow with green embryo, beakless, deeply notched at hilum, reaching 6 mm in diameter, 2 mm in thickness, aril 1-1.5 mm wide.

Type locality: On slopes of limestone hill just west of ranger's quarters, Boquillas, Big Bend National Park, Brewster County, Texas.

Distribution: Locally abundant around Boquillas, especially on rocky slopes from Boquillas west half way to Hot Springs, in Larrea-Agave association on limestone formations.

The species name is given to emphasize the very distinctive spiny fruits. The most striking features are markedly ascending branches, reaching 15 dm in height; protuberances elevating each areole on the joint; spiny ovaries; and tuberculate, dry, and spiny fruits (figs. 22 and 23).

In the key by Britton & Rose (1919) these characteristics bring it into the series Phaeacanthae near *O. angustata* and *O. phaeacantha*. *O. angustata* differs in having shorter, more or less white spines, and no mention of tuberculate joints or dry tuberculate fruits. *O. phaeacantha* agrees in having somewhat conspicuous bristles, reddish spines and similar flowers, but differs in its more spreading habit, short-obovate to orbicular non-tuberculate joints, and juicy, non-tuberculate, naked fruit.

Flowering period extends from April to about the middle of May, with fruits maturing a month after the flowers. Fruits are mostly sterile and readily

proliferous (fig. 24). A few seedlings with very long (to 6.5 cm) white to reddish brown spines were found near the parent plants.

Collections.—Big Bend National Park, BREWSTER CO.: Locally abundant with *Larrea Agave*, and *Jatropha spathulata*, at 2250 ft., on rocky limestone slopes e. of rangers' headquarters at Boquillas, Apr. 17, 1947, No. 36; Apr. 11, 1948, (type specimen) No. 236, No. 238, No. 241, No. 243:

24 *OPUNTIA ENGELMANNII* Salm-Dyck in Engelm.,
Bost. Jour. Nat. Hist. 6:207. 1850

Distribution: GENERAL.—Southeastern Arizona, southern New Mexico, western Texas, and Mexico, in Chihuahua, Durango, Nuevo Leon and Sonora. LOCAL.—Grassland and desert associations throughout Brewster, Jeff Davis and Presidio counties, at altitudes from 2100 to 6700 feet.

This large and well-known prickly pear is deservedly named after one of the earliest and greatest authorities on cacti, (particularly those from the Trans-Pecos region), Dr. George Engelmann, who worked on the many specimens sent to him by early biologists with the government surveys.

This species is the least restricted and most abundant cactus in the Big Bend area. It usually occurs as a massive bush with short thick trunk, and large heavy pads, although low spreading forms are encountered. Joints, especially on plants in the Chisos Basin of the Big Bend National Park, have a tendency to expand in three planes—a possible reversion to cylindrical form. This tendency was also evinced on one specimen of *O. macrocentra* and one of *O. lindheimeri* (fig. 29). Joints are extremely variable in shape, ranging from elliptic through long-obovate or orbicular, to reniform, and in size from 10.5 to 45 cm long, 10.5 to 33 cm wide, and 6-40 mm thick. Spines may be entirely lacking, or present only in a few areoles, or present in all but the lowermost areoles. Typically in each cluster there are 2-3 long, and 1-3 shorter, flattened, somewhat deflexed spines; 1-2 deflexed bristles are often present also.

Flowering is prolific from late April in the desert belt to late July in the arid grassland belt. Flower color ranges from clear yellow and yellow heavily streaked with orange, to yellow segments with rose bases; stigma lobes are yellow to green. Mature, almost naked, fruits are formed by the middle of May and are eaten by many animals. Seeds are relatively small with a narrow beakless aril. Seedlings are easily identified in the field by the hairy bases. Hairs are also present in lowermost areoles of the first young pads and in areoles on trunks of mature plants.

25 *Opuntia engelmannii* var. *wootonii* (Griffiths) nov. comb.
(*O. wootonii* Griffiths, Rep. Mo. Bot. Gard. 21:171. 1910.)

Plant somewhat ascending, to 6 dm high, spreading to 12 dm wide; trunk absent; branches much subdivided; roots fibrous; joints long-ovate or obovate, occasionally attenuate at both ends, 14.5-25 cm long and 10-15 cm wide, relatively thin, 6-8 mm thick, heavily glaucous; texture granular; areoles distant, 30-40 mm apart, short ovate, large, to 10 mm long and 7 mm wide; wool pale tan; spines 4-7, from areoles on upper 2/3 to 4/5 of joint, subulate, twisted, young spines mostly black with paler tips, older spines pinkish-white with reddish black bases and horny yellow tips, becoming red throughout when wet, finally becoming grayish-black, annulately marked; 1 spine very long, to 7.3 cm usually flattened, prorect or spreading downward, 2-3 spines shorter, to 5.5 cm long, elliptic to flattened, twisted, spreading, 1 spine very short, to 2.3 cm long.

elliptic, deflexed; bristles 0.2, white with yellow or orange tips, reaching 5 mm in length; glochids yellow, orange, or reddish-brown; flower and fruit not observed.

Type locality: Organ Mountains of New Mexico.

Distribution: Scattered in desert shrub vegetation of Tornillo Flats and locally abundant in Christmas Mountains.

From collections made by Prof. E. O. Wooton in the Organ Mountains of New Mexico, Griffiths (1908) described *O. wootonii* as a new species. Britton & Rose (1919) subsequently delegated this name to synonymy under *O. engelmannii*. Unlike the plants in the original description with joints attenuate at both ends, these Texas representatives have mostly obovate joints which are only occasionally attenuate at the base (fig. 28).

In contrast to the typical *O. engelmannii* with its massive habit, mostly orbicular joints, and markedly flattened spines reaching about 5 cm in length, this variety has a more spreading habit, elongate-obovate joints and conspicuous long white spines, reaching 7.3 cm in length and little flattened. Spines have a white bloom which is easily penetrated by water so they darken to red when wetted by rain.

An extensive population is well established on desert plains within the Christmas Mountains. A few scattered specimens were found elsewhere, almost always with creosote-mesquite association, so it is probable that local edaphic conditions of greater moisture have contributed to development of this race.

It may represent a separate evolutionary development along parallel lines to the plant of the Organ Mountains, possibly disjunct and never part of the same population. Nevertheless, one hesitates to give it a distinct name on a chiefly geographic basis. If it is too conservative to consider the Big Bend population as essentially the same as Griffith's *O. wootonii*, the most important matter is to point out the existence of similar evolutionary trends in isolated areas. It will be interesting later to cultivate them side by side and to hybridize them.

Collections.—BREWSTER CO.: With *Prosopis* on sandy clay, 1900 ft., near Solis Ranchhouse along Rio Grande, Big Bend Nat. Park, April 28, 1948, No. 274; with *Larrea-Flourensia* and *Agave lechuguilla*, 3200 ft., in Dagger Flats, Big Bend Nat. Park, Aug. 2, 1948, No. 873; with *Larrea-Prosopis* 12 mi. n. of Terlingua on road to Alpine, Sept. 14, 1948, No. 1182; with *Larrea-Prosopis*, 2900 ft., just n.e. of Terlingua, Sept. 17, 1948, No. 1224; with *Prosopis*, 4.1 miles along road into Christmas Mts., n.e. of Study Butte, Sept. 18, 1948, No. 1231; with *Larrea-Prosopis* on flat valley in Christmas Mts., Sept. 18, 1948, No. 1236; with *Larrea-Prosopis*, near end of road in Christmas Mts., Sept. 18, 1948, No. 1244.

26 *Opuntia engelmannii* x *phaeacantha* hybr. nov.

Magnitudine parentibus similis; areolis remotis, elevatis, plerisque armatis; spinis 2-5, subcompressis, subdeflexis, retrorsum divergentibus, junioribus spinis subnigris, rufescentibus floribus, flavis, intus rubellis, fructibus longis, obovoideis seminibus magnis, late marginatis. Specimen typicum ex montibus dictis "Glass Mountains, Brewster Co., Texas" siccatum conservatum est sub numero 113 in Herb. Univ. Mich. et vivum conservatum est sub numero 18906 in Hort. Mich.

Plant a low spreading bush, attaining a height of 7.5 dm and a width of 18 dm; trunk rarely present; branches only slightly ascending; roots fibrous; joints orbicular, obovate or ovate, 15-45 cm long, 12-40 cm wide, 7-13 mm thick; glaucous, purple around areoles; texture granular; leaves subulate, with curved tip, mucronate, 5-15 mm long, 1-3 mm

wide, green to purplish-pink; areoles relatively distant, 30-45 mm apart, elevated, prominent, oval, elliptic to orbicular, large, 9-10 mm long, 4-7 mm wide; wool abundant, tan or reddish-brown, becoming gray in age; spines 2-5 from areoles on upper 2/3 to 4/5 of joint, especially along edge, subulate, more or less flattened, twisted, sometimes curved, young spines white or reddish-brown, with black bases and orange tips, older spines reddish-brown, or more often black, with orange, or reddish-brown tips, finally becoming gray and 7-8 per areole, 1 spine longer, reaching 5.1 cm in length, terete, porrect, 2 spines shorter, 2.5-3 cm long, spreading, 1 spine very short, 1.7-2.5 cm long, white or gray, flattened, usually deflexed; bristles 0-2, spreading, gray, to 7 mm long; glochids abundant, long, scattered in areole, orange when young, yellow, orange or dark reddish-brown with yellow bases in older areoles, finally becoming gray and 17 mm long; flower reaching 7.5 cm in length and 6 cm across, with perianth segments in 4 whorls, outer segments green with pinkish tip and yellow margins, obcordate, inner segments bright yellow sometimes with pink to red bases, short obcordate, emarginate, slightly fimbriate; filaments mostly green, sometimes yellow or white above, 11-14 mm long, anthers yellow; style white to pinkish, to 5 mm thick just above base and 19 mm long, stigma lobes 6-10, pale green, or yellowish green, 4.5 mm long; ovary long conic, curved, 3-4.5 cm long, 1.5-2.3 cm in diameter, with distant, small areoles bearing a few subulate leaves, yellow or reddish-brown glochids and a few bristles; fruit purple, long obovate, reaching 3.5-5 cm in length and 2.5 cm in diameter, with small, distant areoles bearing few glochids and no spines; umbilicus v-shaped, 5 mm deep; seeds yellow, rough, irregularly-shaped, beakless, deeply notched at hilum, large, 6 mm long, 4.5 mm across, 2 mm thick, aril 1 mm wide.

Type locality: Low limestone hill on Victor Pierce Ranch, just west of Glass Mountains, Brewster County, Texas.

Distribution: Culberson, Pecos, and Val Verde counties, desert shrub, arid grassland and encinal belts in Brewster and Presidio counties at altitudes from 2600 to 4400 feet.

Flowers, fruits and seeds of this hybrid most closely resemble the *O. phaeacantha* parent but the massive habit, orbicular joints, somewhat elevated and distant areoles, and flattened spines suggest *O. Engelmannii* (fig. 27). Young spines are usually darker than those of either parent; perhaps an instance of interacting genetic factors, one derived from each parent.

The hybrid shows little restriction in distribution since the parents are themselves common throughout the region but it is found more frequently in the Glass Mountains and grassland areas of Brewster County than in the desert shrub life belt.

Collections: BREWSTER CO.—With *Juniperus* on low limestone hill, 4400 ft., Victor Pierce Ranch, just w. of Glass Mts., May 13, 1947, No. 112 (type specimen) No. 113; with *Larrea-Agave*, on limestone hill n. of Terlingua, 3000 ft., May 9, 1948, No. 326; with *Juniperus* and grass, in Santiago Mts., 4000 ft., along rd. to Marathon, May 9, 1948, No. 340; with *Bouteloua-Juniperus*, on Sohl Ranch, w. of Del Norte Mts., May 22, 1948, No. 448; in draw with *Juglans rupestris* along rd. from Rt. 67 in to Gilliland Canyon, Glass Mts., June 4, 1948, No. 508; with *Yucca, Agave* and other desert shrubs on slopes of chert cuesta, Pena Blanca Mts., s.e. of Marathon, July 8, 1948, No. 727; with *Larrea-Leucophyllum* along Chalk draw, n. of Nine-Pt. Mesa, Aug. 3, 1948, No. 912; with *Larrea-Flourensia* on flat, 20 mi. n.e. from Reagan Canyon on Bullis Gap rd., Aug. 17, 1948, No. 1012; with *Larrea-Agave* and *Fouquieria*, on north slope, Christmas Mts., Sept. 18, 1948, No. 1241; with *Larrea-O. leptocaulis*, 3400 ft., on sandy flat, s. of Nine-Pt. Mesa, Sept. 26, 1948, No. 1270; CULBERSON CO.—With *Yucca-Agave*, 4½ mi. w. of Van Horn, Aug. 8, 1948, No. 942. PECOS CO.—With *Juniperus* on limestone hill, 15 mi. s. of Ft. Stockton, July 3, 1948, No. 694; with *Bouteloua-Prosopis*, 13½ mi. w. of Sanderson, along Rt. 90, July 9, 1948, No. 744. PRESIDIO CO.—With *Prosopis* on sandy flat, 2600 ft., 8½ mi. s.e. of Ruidosa on rd. to Presidio, Aug. 26, 1948, No. 1083, No. 1084. VAL VERDE CO.—With *Prosopis* on overgrazed rangeland, 31 mi. n.w. of Del Rio, Mar. 31, 1948, No. 201.

27 *OPUNTIA LINGUIFORMIS* Griffiths Rep. Mo. Bot. Gard. 19:270. 1908

Several large bushes of this species have become well established near an abandoned Mexican dwelling about one mile north of the mouth of Tornillo Creek, at an altitude of 1800 feet, in the Big Bend National Park (fig. 5). It seems probable that the plants will eventually become a part of the natural vegetation, at least in the mesquite thicket along the creek. There is also the possibility of spontaneous crossing in course of time which may inaugurate a new population. Since this species has only been recorded as native around San Antonio, Texas, and is not listed by Bravo (1937) in Mexico it is remarkable to find it thriving so far afield. Flower buds were forming early in April but neither flowers nor fruits were obtained.

28 *OPUNTIA LINDHEIMERI* Engelm., Bost. Jour. Nat. Hist. 6:207. 1850

Distribution: GENERAL.—Southwestern Louisiana, reported in southern New Mexico by Tidestrom (1941), southeastern to southwestern Texas, northern Tamaulipas in Mexico. *LOCAL.*—Rare in grasslands of northern Brewster County and in Jeff Davis County, at altitudes from 2700 to about 6000 feet.

This species honors Ferdinand Lindheimer who collected actively in southeastern Texas from 1843 to 1852.

The spreading-ascending bush closely resembles *O. engelmannii*, but is distinguished by circular to elliptic areoles, consistently yellow spines, and lack of bristles in areoles (fig. 29). Joints are of variable shape, degree of spininess, and size but rarely become larger than 33 cm in length and 24.5 cm in width. When present the flattened, curved, reddish-brown to yellow spines appear in clusters with 1-4 longer and spreading downward and 0-2 spines which are lower in the areole, shorter and usually deflexed.

Flowers, appearing from the middle of May to early June, are large (7.5-9 cm long and up to 7 cm wide). Naked fruits ripen within about six weeks and are as prolific, juicy and edible as those of *O. engelmannii*. They may reach a length of 7 cm and 4 cm in diameter.

Many specimens were noted from San Antonio, west to Del Rio and north to Devil's River, but further west toward the Pecos and beyond, *O. lindheimeri* becomes rare and forms less massive bushes.

29 *Opuntia lindheimeri* var. *chisosensis* var. nov.

Robusta; articulis plerisque orbiculatis; areolis obovatis, spinis 1-5 saepe curvatis, paullum compressis; floribus ignotis; fructibus subglobosis, 3.3-4.5 cm longis, 3.5 cm latis; seminibus 5 mm diametro. Specimen typicum ex loco dicto "Basin, Chisos Mountains, Big Bend National Park, Texas" siccatum conservatum est sub numero 810 in Herb. Univ. Mich. et vivum conservatum est sub numero 19606 in Hort. Mich.

Plant a large bush, reaching about 10 dm in height, and 20.5 dm in width; trunk absent; branches spreading and ascending from short, thickened base; roots fibrous; joints usually 6 per branch, mostly orbicular, some short-obovate with attenuate base, 16-29 cm long, 13-22 cm wide, and 6-15 mm thick, heavily glaucous, yellow-green to gray-green; texture mealy; areoles relatively distant, 30-35 mm apart, short oval to circular, 7-8 mm long, 5-6 mm wide, becoming larger and elevated in age; wool abundant, tan; spines 1-5, from areoles on upper 2/3 to all of joint, subulate, elliptic in cross section, often curved, spreading downward, young spines bright yellow with paler tips, older spines all yellow or reddish-orange with yellow bases and yellow tips; 1 spine very long, to 6.7 cm, flattened, 1-4 spines shorter, about 5.5 cm, annulate, curved, spreading; 1 spine very short, to 2 cm, much deflexed; bristles absent; glochids in dense tufts, yellow throughout, to

20 mm long and conspicuous in older areoles; flower not observed; fruit juicy, reddish purple, glaucous, small, short-oblong with truncate base to globose, 3.3-4.5 cm long and 3.5 cm in diameter, with small, inconspicuous, distant areoles bearing only a few yellow glochids; umbilicus saucer-shaped, to 9 mm deep; flesh purple; seeds yellow, beakless, notched at hilum, large, 5 mm long, 4 mm wide, 2 mm thick, aril 1 mm wide.

Type locality: Basin of Chisos Mountains, Big Bend National Park, Brewster County, Texas.

Distribution: Encinal belt in Chisos Mountains, Big Bend National Park, Brewster County, Texas, at altitudes from 5200 feet to 6500 feet.

The varietal name is derived from the type locality in the Chisos Mountains. Bushes are compact, usually less than 10 dm high, and colorful with yellow, sometimes red, spines against a glaucous-green background (fig. 26). The red-spined form is about as common as the yellow-spined but does not occur at as high altitudes above the Basin. A profusion of flowers appear in May and the deep red fruits ripen by the middle of July. Areoles are smaller and less elevated, and spines more spreading, than in the typical *O. lindheimeri* (fig. 29). Unlike the large pyriform fruit of the typical form, fruit of this variety is relatively small and almost globose, with very shallow umbilicus and large seeds.

This variety is the most conspicuous and abundant cactus in encinal and montane belts from Upper Green Gulch all through the Basin and up the slopes of the higher peaks of the Chisos Mountains.

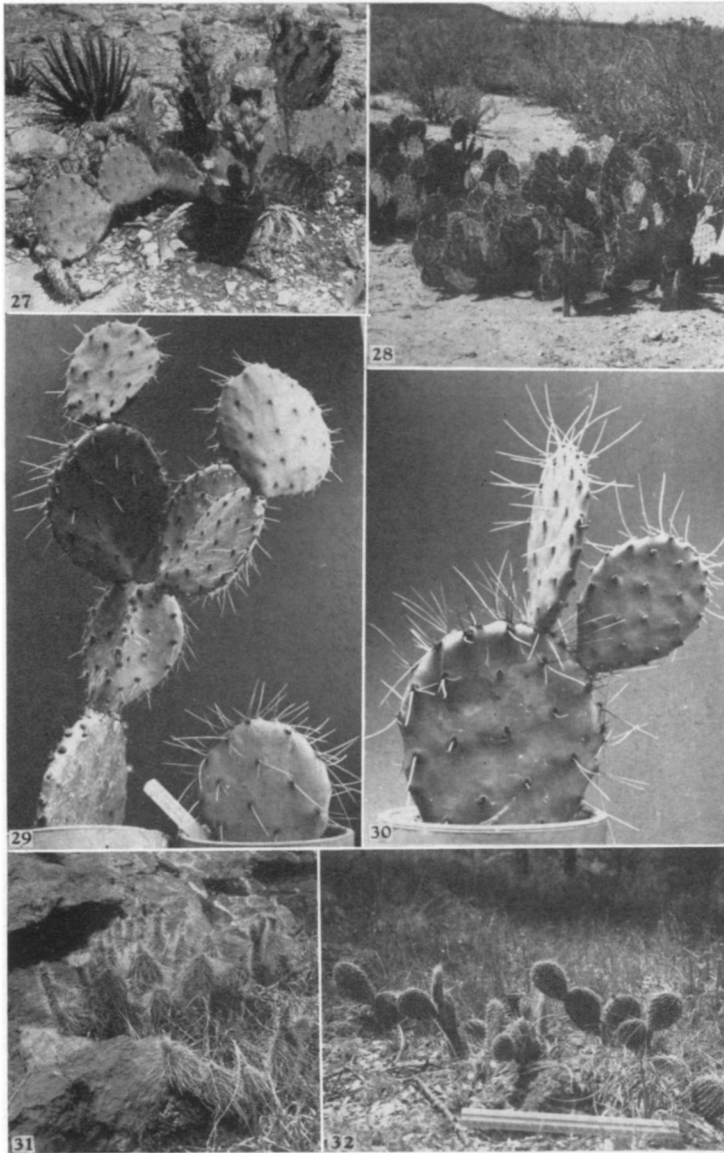
Collections.—Big Bend National Park, BREWSTER CO.—With *Quercus-Pinus* on very sandy soil, 5500 ft., basin of Chisos Mts., April 8 and July 17, 1948, No. 223 (type specimen) No. 810, No. 811, No. 813; with *Pseudotsuga taxifolia* and *Cupressus arizonica* in Upper Juniper Canyon, near Boot Springs, 6500 ft., Chisos Mts., April 18, 1948, No. 253, No. 254; with *Quercus*, *Staphylea*, and grasses, 4400 ft., at Lower Cattail Canyon, evidently washed down from above, May 8, 1948, No. 314; in grassy meadow southwest of Pulliam Peak, 5200 ft., Chisos Mts., July 14, 1948, No. 776; with *Pinus-Quercus*, along Lost Mine Trail, Chisos Mts., July 15, 1948, No. 791, No. 794.

30 *OPUNTIA TRICHOPHORA* (Engelmann) Britton & Rose, Smiths. Misc. Coll. 50:535. 1908

Distribution: GENERAL.—Northeastern Arizona, western Colorado, eastern New Mexico, northern Texas, Oklahoma. LOCAL.—In a grassy swale called "Hidden Valley," in hills south of Lane Ranch buildings, at 4900 feet, southwest of Alpine, Brewster County.

The characteristic of bearing ("phora" Gr.) hairs ("Tricho" Gr.) from lower and older areoles clearly distinguishes this species from its close relative, *O. polyacantha* (figs. 31 and 32). Creeping and ascending branches form a clump about 20 cm high and 10 dm in diameter. The elliptic joints are almost obscured by abundant, long, setiform spines which, curving downward, give the plant a shaggy appearance. Old joints become woody and almost terete, with prominent areoles. All areoles are spiniferous with spines numbering from 8-30 or more in each cluster. All are flattened but 2-6 are longer (3-6.5 cm) and twisted; the remainder are about 2-3 cm long. Spines in lowermost areoles often become especially long and flexible. The few yellow glochids are inconspicuous.

The lemon-yellow flowers, opening early in May, are about 6 cm long and 4-5 cm wide. Fruits were not collected.



Figs. 27-32.—27. Immature plant of *O. engelmannii* x *phaeacantha*; 28. *O. tenuispina* (left), *O. phaeacantha* (center) and *O. engelmannii* var. *wootonii* (right) in creosote-tasajillo association, Big Bend National Park; 29. *O. lindheimeri* var. *chisosensis* (right) has less elevated areoles and more spreading spines than the typical form (left). The tendency for occasional *Opuntia* pads to expand in three directions is seen on the latter; 30. Joints from a possible hybrid, with the long acicular spines in marginal areoles characteristic of *O. macrocentra*, and the yellow spines and remote areoles characteristic of *O. lindheimeri*; 31. *O. trichophora* in flower, with grasses, among igneous rocks, south of Alpine; 32. *O. polyacantha* in a grassy opening in pinyon-oak-juniper association in Davis Mountains.

Previous records had given the most southern, and only Texas station, as El Paso. In the Big Bend the species is very rare, being found only at the locale described above.

31 OPUNTIA POLYCANTHA Haworth, Suppl. Pl. Succ. 82. 1819

Distribution: GENERAL.—Panhandle plains and Davis Mountains of Texas, eastern and northern New Mexico, northern Arizona, southern Utah, throughout Colorado, arid habitats on the plains along the Missouri, northeastern Oklahoma, Nebraska, North Dakota, Montana, Washington, north of the borderline of United States, British Columbia, and Alberta as far north as Peace River. *LOCAL.*—Occasional in montane belt in Davis Mountains, Jeff Davis County.

This species well earns its epithet of "many spines" and is one of the most distinct of the Opuntiae in the Big Bend Region.

The procumbent plant, with terminal joints and some short branches ascending, forms a clump about 2.5 dm high and 9 dm wide. The obovate joints sometimes reach a length of 15 cm, a width of 11 cm and a thickness of 10 mm. Stem surfaces are somewhat tuberculate with diamond to linear-hexagonal shaped elevations up to 2 mm high. One to eight acicular spines are borne in each areole; usually 1 is longer and may be porrect, 2-7 are shorter, spreading and radial (fig. 32).

Distinguished from the closely-related *O. trichophora* by tuberculate surface; fewer spines, more deflexed in appearance; and the absence of any hairs in basal areoles, *O. polyacantha* is equally rare here and likewise occurs in a montane association in the northern part of the area.

Flowers, which may reach a length of 6.4 cm and a width of 4.5 cm begin to appear in late May. Mature fruits, which are dry and bear 1-6 white bristles in each areole, were collected in the latter part of August. Seeds are the largest among these Opuntiae discussed, measuring 7 mm long by 6 mm in diameter, with a broad beaked aril. Several thriving seedlings were found in the forest litter.

O. polyacantha is of sporadic occurrence in Davis Mountains. W. L. Bray in 1902 collected the species in Limpia Canyon above 6000 feet. J. Ferris also found it somewhere in the Davis Mountains in 1925. L. C. Hinckley has collected material "on Mount Livermore" at 8382 feet and "with *Pinus ponderosa* and *Pinus flexilis*" at about 7450 feet. My only collection was from the north slope of Mount Locke at 6780 feet under shade of oak and pine trees on sandy loam.

In general, the species is widely distributed laterally and altitudinally, giving rise to diverse races described under seven varieties, now all in synonymy. This form from Davis Mountains falls in the *albispina* group.

These records from Trans-Pecos Texas mark the most southern known extent of *O. polyacantha*; perhaps the species is migrating south along the higher mountain chains.

SUMMARY

The area studied encompasses Jeff Davis, Presidio and Brewster counties, Texas, with the latter receiving most detailed consideration. Diversity of topography has produced a corresponding variety of habitats with at least thirty-five plant associations and many distinct populations of Opuntiae.

Distinguishing characteristics for species include growth habit, distance between areoles, form and color of spines, presence or absence of bristles, type of fruit, size of seed, and width of aril. Variations of characteristics within species are particularly expressed in number of spiniferous areoles on a joint, number of spines per areole, and length of individual spines. A key to the thirty-one species, varieties and hybrids found in the Big Bend Region precedes discussion of these entities.

Four new varieties are described: *O. imbricata* var. *argentea*, *O. lindheimeri* var. *chisosensis*, *O. macrocentra* var. *minor*, and *O. rufida* var. *tortiflora*. Each of these may be thought of as a potential source of new species. Three new hybrids are presented: *O. engelmannii* x *phaeacantha*, *O. grahamii* x *schottii* and *O. kleiniae* x *leptocaulis*. *O. spinosibacca*, the only known endemic species of Opuntia of the Big Bend Region, is newly described.

An example of disjunct distribution is found in *O. tunicata* which occurs here far from its closest recorded station in Saltillo, Coahuila. Its dwarf and typical forms suggest perpetuation of somatic differentiation in vegetatively reproduced clones.

REFERENCES

- ANTHONY, M. S. 1949—An ecologic and systematic analysis of the genus *Opuntia* Miller in the Big Bend Region of Texas. Univ. Mich. doctoral thesis. (Microfilmed in June, 1951.)
- 1954—Ecology of the *Opuntiae* in the Big Bend Region of Texas. *Ecol.* 35(3).
- BENSON, L. 1940—The cacti of Arizona, Univ. of Ariz. Press, Tucson, Ariz.
- BOISSEVAIN, C. H. AND C. DAVIDSON 1940—Colorado Cacti. Abbey Garden Press, Pasadena, Cal.
- BRAVO, H. 1937—Las cactaceas de Mexico. Imprenta Universitaria, Mex.
- BRITTON, N. L. AND J. N. ROSE 1919—The Cactaceae. Vol. I. Carn. Inst. Wash.
- DENYES, H. A. 1951—Natural terrestrial communities of Brewster County, Texas, and adjoining areas, with special reference to the degree of restriction of certain small mammals to particular communities. Univ. Microfilms Pub. No. 2581. Doct. Dissert. Series. Ann Arbor, Mich.
- ENGELMANN, G. 1849—Cactaceae of plantae Fendlerianae Novi-Mexicanae Mem. Amer. Acad. Arts & Sci. 4(1):49-53.
- 1856—Synopsis of the Cactaceae of the territory of the United States and adjoining regions. *Proc. Amer. Acad. Arts & Sci.* 3:259-311.
- 1859—Cactaceae of the Boundary. Report of the United States and Mexican Boundary Survey II(1):3-78.
- AND J. M. BIGELOW 1856—Description of the Cactaceae collected on route near the thirty-fifth parallel explored by Lt. A. W. Whipple in 1853, 1854. *Rep. Explor. & Surv. for Rr. from Miss. River to Pacific Ocean.* 3:27-58.
- AND A. GRAY 1845—Plantae Lindheimerianae. *Bost. J. Nat. Hist.* 6:195-209.
- GRIFFITHS, D. 1908—Illustrated studies in the genus *Opuntia*. I. *Rep. Mo. Bot. Gard.* 19:259-272. II *Ibid.* 20:81-97. III. *Ibid.* 21:165-174. IV. *Ibid.* 22:25-36.
- HESTER, J. P. 1939—New species of cacti. *Cactus & Succ. J.* 10(10): 179-182.
- MCDougALL, W. B. AND O. E. SPERRY 1951—Plants of Big Bend National Park. U. S. Govt. Print. Office, Wash., D. C.
- OCHOTERNA, I. 1922—Las cactaceas de Mexico, Mexico, D. F.
- SCHULZ, E. D. AND R. RUNYON 1930—Texas cacti. *Proc. Tex. Acad. Sci.* 14.
- SPERRY, O. E. AND B. H. WARNOCK 1941—Plants of Brewster County, Texas. *West Texas Hist. & Sci. Soc. Pub.* 11:16-60.
- TIDESTROM, I. AND SISTER T. KITTELL 1941—A flora of Arizona and New Mexico. Cath. Univ. Amer. Press, Wash., D. C.