

A multivariate study of morphological characters for *Echinocactus
horizonthalonius* and *E. texensis* (Cactaceae).

First draft report

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ABSTRACT

A biosystematic study is underway primarily to ascertain the taxonomic validity of *E. horizonthalonius* var. *nicholii*, which is listed as endangered by the USFWS. The present taxonomic status of the variety is tenuous and there is marked disagreement among authors of classical taxonomic treatments. In order to test the hypothesis that individuals of *E. horizonthalonius* var. *nicholii* are morphologically unique from those of the typical variety, a multivariate study is being done to compare the degree of morphological variation among stem characters within populations to that among populations of *E. horizonthalonius* throughout its known range. *Echinocactus texensis* is being used for outgroup comparison. Stem characters were chosen for this analysis because they represent the only diagnostic characters used by proponents of *E. horizonthalonius* var. *nicholii*. Thus far, a single population of *E. horizonthalonius* var. *nicholii*, six populations of *E. horizonthalonius* var. *horizonthalonius*, and three populations of *E. texensis* have been measured. Further attempts are being made to measure two additional populations of *E. horizonthalonius* var. *horizonthalonius*, access to which have been thus far denied by property owners.

INTRODUCTION

A biosystematic study is underway using multivariate analyses of stem characters within *Echinocactus horzonthalonius* Lemaire and *E. texensis* Hopffer. The primary objective of the study is to ascertain the taxonomic validity of *E. horzonthalonius* var. *nicholii*. *Echinocactus texensis* was chosen as an outgroup because although it represents the closest ally to *E. horzonthalonius*, there have no reports hybridization between the two species (Powell and Weedin 2004) and chloroplast DNA data suggest that the two species are not closely related (Wallace, 1995).

Echinocactus horzonthalonius is a small barrel cactus that occurs primarily throughout the Chihuahuan Desert and was not known from the Sonoran Desert until 1918 when Forrest Shreve collected an individual from Pima County, Arizona. In 1969, the Arizona populations were named by L. Benson as *E. horzonthalonius* var. *nicholii* after A. A. Nichol, who studied the populations in the 1930's. Sonoran Desert populations identified as *E. horzonthalonius* var. *nicholii* have recently been found in Sonora, Mexico (Aguilar et al 2000, Yatskievych, G. and Ficher 1983). In his latest treatment, Benson (1982) differentiates *E. horzonthalonius* var. *nicholii* from the typical variety as individuals merely being taller and darker. Both height and darkness of the stems are dubious characters since height is age-related and darkness is often ecologically related and difficult to quantify. According to Zimmerman and Parfitt (2003), morphology of individuals within Sonoran Desert populations are similar to those in New Mexico and extreme western Texas much greater morphologic diversity occurs within populations of *E. horzonthalonius* farther east and south. Similarly, Powell and Weedin (2004) do not recognize *E. horzonthalonius* var. *nicholii* as a valid taxon stating that individuals resembling the Benson's original description occur in Big Bend National Park and that such plants in Texas appear to be merely older individuals in harsh desert habitats. They further suggest, however, that there are distinctive groups of populations within the Chihuahuan Desert that should be validly named. In contrast to the opinions of Zimmerman and Parfitt, and Powell and Weedin, Anderson (2001) does recognize *E. horzonthalonius* var. *nicholii* on the basis of Benson's diagnosis of the taxon. Anderson maintains that stem clustering is unique to individuals of *E. horzonthalonius* var. *nicholii* and that there is a significant difference in maximum height between individuals of the two varieties. The diversity of professional opinions combined with the paucity of available scientific data on *E. horzonthalonius* emphasizes the need for biosystematic work on the species. This need is further amplified by the fact that *E. horzonthalonius* var. *nicholii* is designated as an Endangered species pursuant to the Endangered Species Act of 1973 (50 CFR 17.12; P.L. 93-205, 87 Stat. 884; 16 U.S.C. 1531-1540) (USFWS 1986).

Individuals of *Echinocactus horzonthalonius* are a pale gray-green to bright gray-blue cactus with generally solitary stems to 20cm in diameter and 45cm tall, although most individuals are 10-15cm in diameter and less than 25cm tall. The stems are somewhat flat-topped when young and become more cylindrical with age. The stem surface is divided into 7-9 very broad, rounded

ribs that are oriented vertically to helically curving around stem. Occasionally individuals are clustered, either by seedlings occurring close together or by branching. Branching is often induced when the apical meristem is damaged. There are 5-10 generally pink to tan stout spines, which are strongly annulate-ridged, subulate and more or less flattened. Unlike most cacti, the central and radial spines are very distinct from one another. The large bright rose-pink to magenta flowers are mostly 5-7cm broad and born among long dense hairs of the areole. The pink to red fruits are spheric to ovoid-spheric and up to 3cm long. The seeds are up to 3mm long, black or gray, angular or slightly wrinkled, and spheric to obovoid. All chromosome reports thus far for the species have been $2n = 22$ (Powell and Weedin 2004). Flowers generally appear between April and July depending upon the timing and amount of precipitation (Powell and Weedin 2004). In some years, perhaps 20% of individuals produce flowers repeatedly in response to adequate rainfall during the summer and perhaps in early fall, for up to three additional times during the year (Worthington, 1986). Depending on moisture patterns, populations have been known to flower synchronously from almost one edge of the Chihuahuan Desert to the other (Powell and Weedin 2004).

Chihuahuan Desert populations of *Echinocactus horizonthalonius* are common and between 750 and 1675m elevation of a variety of topographic forms and on substrates of both igneous and sedimentary origin, most commonly on limestone and gypsum soils. Populations have been recorded in southeastern New Mexico to east of the Trans-Pecos mostly in Val Verde County, Texas, and south through the Chihuahuan Desert to San Luis Potosí, possibly even farther south (Powell and Weedin 2004).

Arizona populations of *Echinocactus horizonthalonius* var. *nicholii* occur in *Parkinsonia microphylla* scrub with *Ambrosia deltoidea*, *Carnegiea gigantea*, *Cylindropuntia acanthocarpa*, *Encelia farinosa*, *Fouquieria splendens*, *Krameria grayi*, and *Opuntia phaeacantha*. Individuals occur between 750 and 1250m elevation exclusively on limestone substrates of dissected alluvial fans, inclined terraces and saddles between ridges (Butterwick 1985, Phillips et al. 1979). These substrates include the Pennsylvanian-aged Harquilla Limestone, the Permian Earp Formation, the Permian Concha Limestone and the Mississippian Escambrosa Limestone (Butterwick 1985; McClymonds 1957, 1959). Populations are recorded from southwestern Pinal County (Benson 1982) and Pima County in the Abbey Waterman and Silver Bell Mountains. Individuals in Sonora are very sparsely distributed on a few limestone ridgetops (Yatskievych and Fischer 1984). Exact locality data is not available.

Populations of the outgroup, *Echinocactus texensis*, occur from 0-1000m from southeastern New Mexico to southwestern Oklahoma, then south though much of Texas into northern Chihuahua and southward east of the Sierra Madre Oriental into Nuevo León and Tamaulipas.

TAXONOMIC DOCUMENTATION

Echinocactus horizonthalonius Lemaire 1839 var. ***horizonthalonius***

Common names: bisnagre, bisnaga de dulce, bisnaga meloncillo, blue barrel cactus, blue barrel, devil's head, devilshead, devil's-head cactus, eagle-claw cactus, eaglesclaw cactus, eagle's-claw, eagle claw, eagle claws, horse maimer, mancacaballo, mancamula, manca mula, melon cactus, tepenexcomitl, Turk's-cap cactus, Turk's-head cactus, viznaga meloncillo.

Echinocactus horizonthalonius Lemaire, Cact. Gen, Sp. Nov. 19. 1839

Synonyms:

Echinocactus equitans Scheidw. Bull. Acad. Sci. Brux. 6 (1): 88. 1839

E. horizontalis Hort, ex Forster, Handb. Cacteenk. 327, • 1846, pro syn.

E. laticostatus Engelm. U.S. Senate Rept. Expl. & Surv. R. R. Route Pacific Ocean. Botany 4: 32. 1857, nom, nov, (without data)

Echinocactus horizonthalonius Lemaire var. *centrispinus* Engelm. Proc. Amer. Acad. 3: 276. 1857 (preprint, 1856); in Emory, Rept. U.S. & Mex. Bound. Surv. 2: Cactaceae 26. pl. 21; 22_, f. 1-5. 1859. "...The Pecos to El Paso, and north to Dona Ana; Wislizenus, Wright, Bigelow, Parry." The Engelmann collection includes the following: 1 sheet, without locality, Wright in 1851-52; 1 sheet with packets, as follows: "Echinocactus No. 6., Chs. Wright. 1851"; "Stony hills near Frontera, Chs. Wright, Apr. 27, 1852"; Frontera, on stony hills, Chs. Wright, July, 1851," Mo.

E. horizonthalonius Lemaire var. *laticostatus* Schmoll, Catalog 1947.

E. horizonthalonius Lemaire var. *equitans* Schmoll, Catalog 1947. "Descriptio nonnullarum Cactacearum quae domino Galeotti in finibus Potosi, Guanaxato, et aliis, regni Mexicani invenientur a M. J. Scheidweiler.

Echinocactus horizonthalonius f. *curvispinus* (Salm-Dyck) Schelle -- Handbuch der Kakteenkultur 146. 1907 (GCI)

Echinocactus horizonthalonius f. *curvispinus* (Salm-Dyck) Schelle, Cactaeae in Horto Dyckensi Cultae 146 (1849), 1850

Echinocactus horizonthalonius var. *curvispinus* Salm-Dyck -- Cactaeae Horto Dyckensi Cultae Anno 1849, Secundum tribus et genera digestae, additis adnotationibus botanicis characateribusque specierum in enumeratione

diagnostica cactearum Doct. Pfeifferi non descriptarum. p. 146. 1850 (GCI)
[Qk475 .F210 S24]

E. horizonthalonius var. *moelleri* "Haage Jr.," ex Weniger, *nom, nud.*; without Latin diagnosis, type specimen, or page reference to a previous publication (no publication by Haage, f_., in the Gray Herbarium Card Catalogue). "...Franklin and Guadalupe mountains [Texas] west into Arizona."

Homalocephala horizonthalonius Weniger, *Cacti S. W.* 69. 1970, *nom, nud.* (Art. 33) and illegitimate (not accepted by its author)

Meyeroactus horizonthalonius (Lem.) Doweld in *Succulenta*, 75(6): 271 (1996):.

Echinocactus horizonthalonius var. *subikii* Stanik & Drab 1998

Note: Varieties of recognized by Weniger (1984) as occurring in the Trans-Pecos, *E. horizonthalonius* var. *curvispinus* Salm-Dyck and *E. horizonthalonius* var. *moelleri* "Haage Jr.," are not excepted by Powell and Weedin (2004). The type specimen was of *E. horizonthalonius* was sent to Europe by the Galeotti, who had collected it from central Mexico, possibly in San Luis Potosí. According to Powell and Weedin (2004), individuals within these populations are very different morphological from those in the Trans-Pecos.

Echinocactus horizonthalonius Lemaire var. ***nicholii*** L. Benson, *Cacti Ariz.* ed. 3. 23, 175. 1969. "Arizona in Pima County, several miles southwest of Silver Bell, Silver Bell Mountains, 2,800 feet elevation, Arizona Desert, Lyman Benson 16663, July 3, 1966," Pom 311314.

Synonyms:

Meyeroactus horizonthalonius subsp. *nicholii* (L. D. Benson) Doweld 1999

Echinocactus horizonthalonius f. *centrispinus* (Engelm.) Schelle, *Die Kakteen* (Schelle) 186. 1926

Echinocactus horizonthalonius subsp. *jarmilae* Halda & Horáček -- *Acta Mus. Richnov.*, Sect. Nat. 7(1): 34. 2000 (GCI)

Echinocactus horizonthalonius Lem. subsp. *nicholii* (L.D.Benson) U.Guzmán -- *Cactaceae Syst. Init.* 16: 17 (11 Oct. 2003).

Echinocactus horizonthalonius var. *obscurispinus* Rud.Mey. -- *Monatsschrift für Kakteenkunde* 21: 181. 1911 (GCI) [QK495.C11 M6] ARIZ

Echinocactus horizonthalonius f. *obscurispinus* (Rud.Mey.) Schelle -- *Kakteen* (Schelle) 186. 1926 (GCI)

Echinocactus horizonthalonius Lem. var. *subikii* Staník & Dráb -- in *Cactaceae etc.*, 8(1): 8-9 (1998);. 1999 (IK); **Cactaceae etc.** - Bratislava (CSSR). Vol.11 No.1, 1991+. A5, quarterly. Continuation of *Kaktusy Sukulenty*, q.v.

Echinocactus horizonthalonius Lem. var. *subikii* Staník & Dráb -- cf. *Repert. Pl. Succ. (I.O.S.)*, 49: 15 (1998 publ. 1999). (IK)

Echinocactus horizonthalonius f. *centrispinus* (Engelm.) Schelle, *Proceedings of the American Academy of Arts and Sciences* 3: 276, 1856

Echinocactus horizonthalonius f. *obscurispinus* (Rud. Meyer) Schelle, *Monatsschrift für Kakteenkunde* 21: 181, 1911

Echinocactus horizonthalonius var. *equitans* Schmoll, *Catalog.*, 1947

Echinocactus horizonthalonius var. *laticostatus* Schmoll, *Catalog.*, 1947

Echinocactus horizonthalonius var. *moelleri* Haage jr.

Echinocactus texensis (outgroup)

Echinocactus texensis Hopffer, *Allg. Otto and Dietr. Gartenz.* 10: 207. 1842.

Synonyms:

Echinocactus texensis Hopffer ex Regel. *Gartenflora* xxxvii (1888):633, t1286

Homalocephala texensis Britton & Rose, *Cactaceae* 3: 181. 1922 "...Aus Samen gezogen, welchen der hiesige KBnigl. botanische Garten 1835 von Texas erhielt...."

Echinocactus lindheimeri Engelm. *Pl. Lindh. I. Bost. Jour. Nat. Hist.* 5: 246. 1845. "...near the Colorado River [Texas]." LECTOTYPE designation: "St. Louis, Cult, from Texas, June, 1845," doubtless collected by F. Lindheimer, Mo. (Benson 1982).

Echinocactus platycephalus Mühlenpfordt, *Allg. Gratenz.* 16:9. 1848. "Aus Mexico".

Echinocactus texensis var. *gourgensii* Cels in Labouret, *Monogr. Cact.* 196. 1853. *nom. nud.*

Homacephala texensis (Hopffer) Britton & Rose var. *gourgensii* Y. Ito, *Cacti* 1952: 108. 1952, *nom. nud.*

Echinocactus courantianus Lemaire ex Labouret, Monogr. Cact. 196. 1853. pro syn., *nom. nud.*

Echinocactus texensis Hopffer f. *longispinus* Schelle, Handb. Kakteenkult. 161. 1907. "Texas" Garden material.

Echinocactus texensis cristata Pirtle, Cactus and Succulent Journal (Amer.) 7:71. f. 1935, *nom. nud.* Labelled photograph.

Methods

Localities were chosen to include as wide an area possible within the geographic distributions of the taxa. Populations thought to be unusual morphologically were also sought. Historic data were gathered from previous reports to government agencies, journal articles, and herbarium collections. Herbaria visited included ASU, DBG, ARIZ, UTEP (El Paso, Texas), SRSC (Alpine, Texas), NMC (Las Cruces, New Mexico), and SLPM (San Luis Potosí, Mexico). Information on the Guanajuato site was obtained from the El Charco Del Ingenio Botanical Garden in Miguel de Allende. The following professionals were consulted: Alan Zimmerman (Tucson), Richard Worthington (University of Texas at El Paso), Michael Powell (Sul Ross University), Richard Spellenberg (Las Cruces), Tom Van Devender (Tucson), Ana Lilia Reina (Tucson), and Dave Ferguson (Albuquerque).

Fieldwork to date was conducted 3 May, 18-20 June, and 29 August-9 September 2007. Localities of populations measured are presented in Table 1. Locations of individuals were recorded using a GPS unit with an accuracy of ca. 5m. Data were of the NAD27 CONUS UTM Grid, which is the same used for all but the oldest USGS 7.5' and Mexican 1:50,000 topographic quadrangles. Herbarium vouchers were made for undocumented populations will be deposited at ARIZ and ASU. Some of the vouchers are photographs only. I am still attempting to measure two additional populations of *Echinocactus horizonthalonius* var. *nicholii*, one on the Tohono O'odham Nation and the other in the Sierra Viejo, Sonora, Mexico. During the first trip to Sierra Viejo we failed to locate individuals.

Thus far, approximately 30 individuals of each population were measured. Characters will included stem height, diameter midway and at base, angle of ribs, number of central spines, number of radial spines, length of longest central spine, length of longest radial spine, thickness of thickest central spine, height of tubercle, and basal width of tubercle (Table 2, see also data sheet at end of document). Data has been entered into Excel⁷.

Table 1. List of populations used for the morphological analysis, including locality and ecological data, and voucher designation.				
Site no.	<i>A priori</i> taxon	Locality	Ecological data	Voucher
1	<i>E. horizonthalonius</i> var. <i>nicholii</i>	Arizona, Pima County, Z12 0456435-0457145mE 3577980-3578430mN, N32° 20.37' W110° 27.78'; 735-780 m (2420-2550 feet); Waterman Mountains, ca. 50km NW of Tucson, 1.4km SE of the summit of Waterman Peak. Waterman Peak 7.5' USGS topographic Triangle.	Sparse scrub on associated with limestone outcroppings and associated alluvium with <i>Acacia constricta</i> , <i>Ambrosia deltoidea</i> , <i>Aristida purpurea</i> , <i>Calliandra eriophylla</i> , <i>Carnegiea gigantea</i> , <i>Cylindropuntia acanthocarpa</i> , <i>C. bigelovii</i> , <i>C. fulgida</i> , <i>C. leptocaulis</i> , <i>Dasyochloa pulchella</i> , <i>Echinocereus engelmannii</i> , <i>Encelia farinosa</i> , <i>Eriogonum inflatum</i> , <i>Ferocactus cylindraceus</i> , <i>Fouquieria splendens</i> , <i>Krameria erecta</i> , <i>Larrea tridentata</i> , <i>Mammillaria grahamii</i> , <i>Olneya tesota</i> , <i>Opuntia engelmannii</i> , <i>Parkinsonia microphylla</i> , and <i>Tiquilia canescens</i> .	Parfitt 2788 (ASU)
2	<i>E. horizonthalonius</i> var. <i>horizonthalonius</i>	New Mexico, Doña Ana County, Z13S 03 53 160mE 35 41 970mN (NAD83); N32.006° W106.554°; 1255-1270m (4120-4160ft) elevation; Franklin Mountains, 2.8km WSW of Anthony Gap, 38km SE of Las Cruces. Anthony 7.5' USGS topographic Quadrangle.	<i>Larrea tridentata</i> scrub on limestone hills with <i>Agave lechuguilla</i> , <i>Aloysia wrightii</i> , <i>Bahia absinthifolia</i> , <i>Cylindropuntia leptocaulis</i> , <i>Echinocereus coccineus</i> , <i>Echinocereus dasyacanthus</i> , <i>Fouquieria splendens</i> , <i>Gutierrezia microcephala</i> , <i>Koeberlinia spinosa</i> , <i>Krameria erecta</i> , <i>Muhlenbergia porteri</i> , <i>Opuntia spinosibacca</i> , <i>Parthenium incanum</i> , <i>Thymophylla acerosa</i> , <i>Thymophylla pentachaeta</i> , <i>Tiquilia canescens</i> , <i>Tiquilia greggii</i> , <i>Yucca treculeana</i> , and <i>Zinnia acerosa</i> .	Baker 16593
3	<i>E. horizonthalonius</i> var. <i>horizonthalonius</i>	Texas, Brewster County, Z13 06 84 600mE 32 17 900mN (NAD83); N29.077° W103.104°; 690m (2000ft) elevation; 550m WSW of Boquillas, 500m north of the confluence of Fresno Creek with the Rio Grande River; 1km SE of the summit of Tally Mountain. Solis 7.5' USGS topographic Quadrangle.	Limestone ridges with <i>Acacia neovernicosa</i> , <i>Ariocarpus fissuratus</i> , <i>Bouteloua trifida</i> , <i>Cylindropuntia leptocaulis</i> , <i>Dasyochloa pulchella</i> , <i>Echinocactus horizonthalonius</i> , <i>Echinocereus dasyacanthus</i> , <i>Ephedra trifurca</i> , <i>Glandulicactus uncinatus</i> , <i>Guaiacum angustifolium</i> , <i>Leucophyllum frutescens</i> , <i>Opuntia spinosibacca</i> , <i>Porophyllum gracilis</i> , <i>Prosopis glandulosa</i> , <i>Selaginella lepidophylla</i> , <i>Tiquilia canescens</i> , and <i>Tridens mutica</i> .	Baker 16595.2 (photos only)

Table 1. List of populations used for the morphological analysis, including locality and ecological data, and voucher designation.				
Site no.	<i>A priori</i> taxon	Locality	Ecological data	Voucher
4	<i>E. horizontalonius</i> var. <i>horizontalonius</i>	Mexico, Coahuila, Z14 02 65 225mE 29 03 430mN (NAD83); N27.231° W101.350°; 1135m (3720') elevation; 3km north of Plan de Guadalupe, 90km NNW of Saltillo. Las Coloradas 1:50,000 Cetenal topographic quadrangle.	<i>Larrea tridentata</i> scrub with <i>Agave lechuguilla</i> , <i>Bahia absinthifolia</i> , <i>Cylindropuntia imbricata</i> , <i>C. kleiniae</i> , <i>Dasyochloa pulchella</i> , <i>Euphorbia antisyphilitica</i> , <i>Fouquieria splendens</i> , <i>Jatropha dioica</i> , <i>Lippia graveolens</i> , <i>Lophophora williamsii</i> , <i>Opuntia engelmannii</i> , <i>Opuntia rufida</i> , <i>Parkinsonia texana</i> , <i>Pennisetum ciliare</i> , <i>Thelocactus bicolor</i> , <i>Tiquilia canescens</i> , and <i>Yucca treculeana</i> .	Baker 16612
5	<i>E. horizontalonius</i> var. <i>horizontalonius</i>	Mexico, San Luis Potosí, Z14 03 55 295mE 25 36 075mN (NAD83); N22.928° W100.411°; 1400m (4490') elevation; 97km NNE of San Luis Potosí; 1km ENE of El Entronque, northern tip of Sierra Cuchillo de Enmedio; along Hwy 80, 5km (by road) east of its junction with Hwy 57. Pozas de Santa Ana 1:50,000 Cetenal topographic quadrangle.	<i>Larrea tridentata</i> scrub with <i>Agave scabra</i> , <i>Celtis pallida</i> , <i>Cylindropuntia kleiniae</i> , <i>C. leptocaulis</i> , <i>C. tunicata</i> , <i>Echinocactus platyacanthus</i> , <i>Echinocereus pectinatus</i> , <i>Jatropha dioica</i> , <i>Koeberlinia spinosa</i> , <i>Myrtillocactus geometrizans</i> , <i>Opuntia engelmannii</i> , <i>Prosopis laevigata</i> , <i>Thelocactus bicolor</i> , <i>Tiquilia canescens</i> , and <i>Yucca decipiens</i> .	Baker 16119
6	<i>E. horizontalonius</i> var. <i>horizontalonius</i>	Mexico, Guanajuato, Z14R 03 44 300mE 23 40 880mN (NAD83); N21.163° W100.500°; 2130m (6985') elevation; 15km south of San Luis de la Paz (Mineral de la Pozos), just NE of the Ejido of Espinas Blancas. Mineral de Pozos 1:50,000 Cetenal topographic quadrangle.	Disclimax grassland on rocky volcanic soil with <i>Bouteloua curtipendula</i> , <i>Cathestecum erectum</i> , <i>Coryphantha erecta</i> , <i>Cylindropuntia imbricata</i> , <i>C. tunicata</i> , <i>Dasyochloa pulchella</i> , <i>Erioneuron pilosum</i> , <i>Jatropha dioica</i> , <i>Myrtillocactus geometrizans</i> , <i>Opuntia engelmannii</i> , <i>Opuntia leucotricha</i> , <i>Parthenium incanum</i> , and <i>Yucca filifolia</i>	Baker 16607
7	<i>E. horizontalonius</i> var. <i>horizontalonius</i>	Mexico, Coahuila, Z13 06 30 740mE 29 90 370mN (NAD83); N27.029° W103.682°; 1115m (3655') elevation; 28km south of La Esmeralda; 5km east of Guimbalete, 7km SSE of Cerro el Venado Pelón. Guimbalete 1:50,000 Cetenal topographic quadrangle.	<i>Larrea tridentata</i> scrub with <i>Acacia neovernicosa</i> , <i>Bahia absinthifolia</i> , <i>Coryphantha macromeris</i> , <i>C. poselgeriana</i> , <i>Cylindropuntia leptocaulis</i> , <i>C. imbricata</i> , <i>Echinocereus stramineus</i> , <i>Ferocactus hamatacanthus</i> , <i>Euphorbia antisyphilitica</i> , <i>Flourensia cernua</i> , <i>Fouquieria splendens</i> , <i>Jatropha dioica</i> , <i>Mammillaria heyderi</i> , <i>Opuntia rufida</i> , <i>Parthenium incanum</i> , and <i>Viguiera stenoloba</i> .	Baker 16608

Table 1. List of populations used for the morphological analysis, including locality and ecological data, and voucher designation.				
Site no.	<i>A priori</i> taxon	Locality	Ecological data	Voucher
8	<i>E. texensis</i>	New Mexico, Eddy County, Z13 05 58 650mE 36 13 740mN (NAD83); N32.661° W104.375°; 1020 (3340ft) elevation; 1km south of Fourmile Draw, 6km west of the Pecos River, 20km south of the center of Artesia. Lake Mcmillan and Dayton 7.5' USGS topographic Quadrangles.	<i>Scleropogon brevifolius</i> grassland with <i>Coryphantha macromeris</i> , <i>Croton pottsii</i> , <i>Flourensia cernua</i> , <i>Gutierrezia sarothrae</i> , <i>Krameria erecta</i> , <i>Larrea tridentata</i> , <i>Lesquerella fendleri</i> , <i>Opuntia tortispina</i> , <i>Pleuraphis mutica</i> , <i>Prosopis glandulosa</i> , <i>Rhus microphylla</i> , and <i>Yucca glauca</i> .	Baker 16617
9	<i>E. texensis</i>	Texas, Terrell County, Z13 07 66 450mE 32 28 300mN (NAD83); N30.058° W102.235°; 695 (2000ft) elevation; 18km ESE of Sanderson, between Hwy 90 and the railroad tracks, just west of the old Mofeta Railroad stop. Mofeta 7.5' USGS topographic Quadrangle.	<i>Larrea tridentata</i> scrub with <i>Coryphantha macromeris</i> , <i>Cylindropuntia leptocaulis</i> , <i>Echinocactus horizontalonius</i> , <i>Echinocereus coccineus</i> , <i>Flourensia cernua</i> , <i>Koeberlinia spinosa</i> , <i>Lycium berlandieri</i> , <i>Opuntia engelmannii</i> , <i>O. mackenensii</i> , <i>O. strigil</i> , <i>Panicum hallii</i> , <i>Parthenium incanum</i> , <i>Prosopis glandulosa</i> , <i>Tiquilia canescens</i> , <i>Viguiera stenoloba</i> , and <i>Yucca treculeana</i> .	Baker 16596
10	<i>E. texensis</i>	Mexico, Coahuila, Z14 02 76 360mE 30 05 240mN (NAD83); N27.153° W101.257°; 0395m (1295') elevation; just east of Río Monclova, 10km SSW of Primero de Mayo, 5km west of Cuchillo de Arco, 30km ENE of San Bueno Ventura. Primero de Mayo 1:50,000 Cetenal topographic quadrangle.	<i>Larrea tridentata</i> scrub with <i>Bahia absinthifolia</i> , <i>Coryphantha macromeris</i> , <i>Cylindropuntia kleiniae</i> , <i>C. leptocaulis</i> , <i>Echinocereus enneacanthus</i> , <i>Flourensia cernua</i> , <i>Fouquieria splendens</i> , <i>Guaiacum angustifolium</i> , <i>Lycium berlandieri</i> , <i>Mammillaria heyderi</i> , <i>Muhlenbergia porteri</i> , <i>Opuntia engelmannii</i> , <i>Prosopis glandulosa</i> , and <i>Tiquilia canescens</i> .	Baker 16609

Table 2. Explanation of characters used in the morphological analysis of <i>E. horizonthalonius</i> .	
Character	Explanation
Stem height from soil level	
Rib number	
Rib angle	Angle of the a single rib with respect to the central stem axis, a straight rib, having an angle of 0.
Stem diameter midway	
Stem diameter base	
The following characters are measured three time for each individual. Spine measurements are made on first fully mature spines clusters as determined by size and color of spines	
Rib height	Maximum height of rib excluding spines an pubescence
Rib width near stem apex	Distance from sinus to sinus along a rib at the edge of the wooly apex of the stem
Rib width maximum	Maximum distance from sinus to sinus along a rib, generally toward base of stem
Length between areoles	Maximum distance between three areoles divided by two
Central spine number	The number of spines whose bases are centrally inserted within the areole
Radial spine number	The number of spines whose bases are inserted at the edge of the areole
Lower Central spine length	The length of the lower central spine measured along its curvature
Lower Central spine angle	The angle formed between the surface the rib and the basal portion of the spine

Table 2. Explanation of characters used in the morphological analysis of <i>E. horizonthalonius</i> .	
Character	Explanation
Lower Central spine curvature	The greatest perpendicular distance between the surface of the lower central spine (generally near the midpoint) and an imaginary line between the spine's base and apex
Lower Central spine annuli per cm	Number of annuli within 1 cm as measured at the spine midpoint
Upper Central spine length	The length of the longest upper central spine
Upper Central spine angle	
Upper Central spine curvature	
Radial spine length	The length of the longest radial spine
Radial spine angle	
Radial spine curvature	
Lower Central spine width	The lateral thickness (generally the greater of the two) of the lower central spine as measured near its midpoint
Lower Central spine dorso-ventral thickness	The dorso-ventral thickness of the lower central spine as measured near its midpoint
Upper Central spine width	
Radial spine lateral width	

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