# Agave turneri (Agavaceae), a new species from northeastern Baja California, Mexico

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# *Agave turneri* (Agavaceae), a new species from northeastern Baja California, Mexico

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**Abstract**. **Agave turneri**, a new species of Agave from the Sierras Cucapá and El Mayor in northeastern Baja California, Mexico, is a medium-sized species that does not produce offsets, has a relatively short and narrow panicle, and has a distinctive flower structure. The closest relatives to this new species are *Agave moranii*, which occurs approximately 200 km to the south of the type locality, and *A. deserti* var. *simplex*, which occurs in Arizona and California. This new species is a narrow endemic restricted to specific granodiorite and tonalite habitats in a hyperarid environment. *Agave turneri* appears to be a critically endangered owing to its habitat preference for specific types of granite in the Sierra Cucapá, threats due to prolonged drought and global change, and its close proximity to the Mexicali metropolitan area.

**Key Words:** *Agave*, Agavaceae, Baja California, hyperarid desert, endemic.

**Resumen**. Se describe una nueva especie de agave, **Agave turneri**. La planta es de tamaño mediano, no produce hijuelos y su inflorescencia es relativamente corta y angosta. Sus parientes más cercanos son *Agave moranii*, que está presente a unos 200 km hacia el sur de la localidad tipo y *A. deserti* var. *simplex*, que se distribuye en Arizona y California. La especie es endémica y restringida al noreste de Baja California, México, donde ocurre sobre granodiorita y tonalita de hábitats hiperáridos en las Sierras Cucapá y El Mayor. *Agave turneri* parece estar en un estatus de conservación de peligro de extinción, debido a su ámbito y hábitat tan restringidos, las sequías prolongadas y el cambio global, y por su cercanía al área metropolitana de Mexicali.

As part of a larger project on landscape change and biogeography of Baja California, we scaled the lower slopes of the Sierra El Mayor, southwest of Mexicali (Fig. 1). We were searching for camera stations occupied by E. A. Goldman on his epic trip with E. W. Nelson in 1905–1906 (Nelson, 1922). In April 1905, on their first foray onto the peninsula, Goldman climbed the east slope of Cerro El Mayor (Fig. 1), securing photographs of the Colorado River delta (e.g., Nelson, 1922, plate 23) as well as views of the peak of this small range. Although Goldman photographed numerous endemic agaves of Baja California, he either did not notice or failed to recognize the significance of a medium-sized, solitary *Agave* in the Sierra El Mayor. This is somewhat surprising because Nelson and Goldman collected many of the type specimens of *Agave* from Baja California (Gentry, 1978). Kniffen (1932), however, observed plants he thought were *Agave consociata* Trel. (= *A. deserti* Engelm.) in the Sierra Cucapá and speculated that their restricted distribution and absence at the base of the range might indicate either extirpation by human use or climatic restrictions.

A total of 15 species of *Agave* are known from the Baja California peninsula or nearby islands (Gentry, 1978), with only a few other members of this genus present in adjacent areas of California and Arizona (Gentry, 1982; Reveal & Hodgson, 2002; Navarro-Quezada et al., 2003). A total of four species

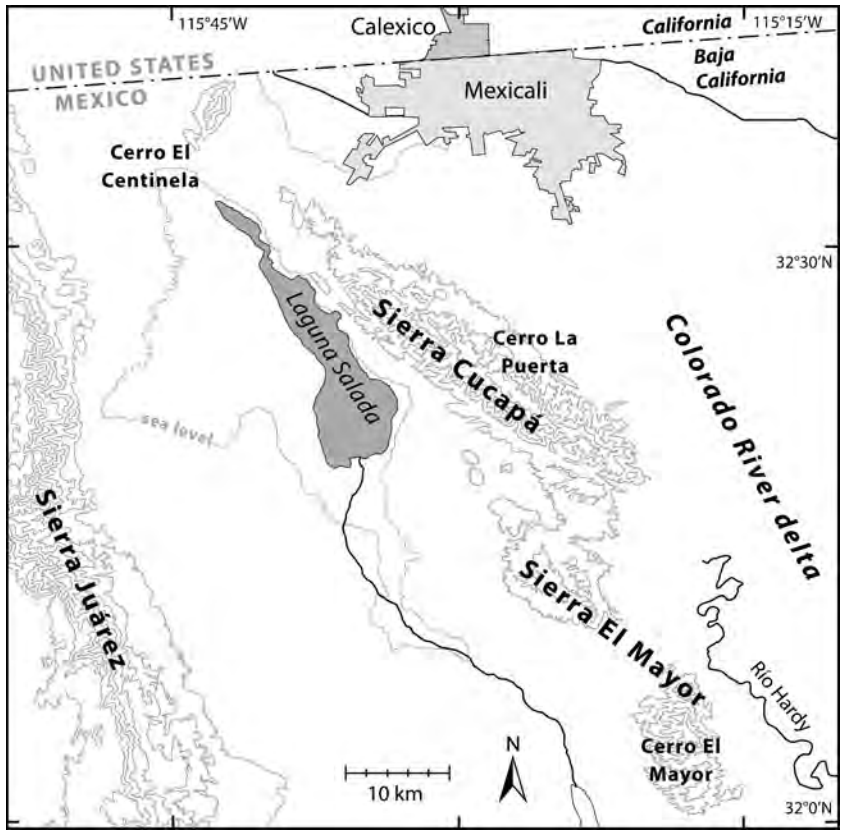


**Fig. 1.** Map of northeastern Baja California showing the Sierra Cucapá and the Sierra el Mayor, habitat of *Agave turneri*.

with three varieties and one hybrid occur within 200 km of the Sierra Cucapá. To the southwest and west, these include *Agave deserti* Engelm. var. *deserti*, *A. deserti* var. *pringlei* (Gentry) W. C. Hodgs. & Reveal (Hodgson, 2001), and *A. shawii* Engelm. ssp. *shawii* (Gentry, 1982). *Agave moranii* Gentry occurs 200 km to the south at the southern end of the Sierra San Pedro Martír. *A. deserti* var. *simplex* (Gentry) W. C. Hodgson & Reveal and *A.x ajoensis* W. C. Hodgs. (Hodgson, 2001) occur in Arizona to the northeast of the Sierra Cucapá. Finally, *A. schottii* Engelm. occurs a little farther than 200 km to the northeast of the Sierra Cucapá.

The *Agave* in the Sierra Cucapá and Sierra El Mayor, for which we propose the epithet *turneri*, is clearly distinct from any other species of *Agave* within 200 km if only its size and solitary habit are considered. We describe this species and its habitat and place the species in the context of the Deserticolae group (Gentry, 1982) with affinities to *A. moranii* and *A. deserti* var. *simplex*. Finally, we propose that this species should be considered as critically endangered due to the indirect effects of urban growth and climate change.

**Agave turneri** R. H. Webb & J. M. Salazar-Ceseña, **sp. nov.** Type: Mexico. Baja California: Sierra Cucapá, 25 km southwest of Mexicali, 6 Mar 2009, *M. Salazar 3740* (holotype: MEXU). (Figs. 2, 3)

*Agave turneri* sp. nov. *A. deserti* var. *simplici* atque *A. moranii* similis sed ab ambabus foliis inferme tantum canaliculatis et filamentis subaequaliter insertis differt. Ab *A. moranii* panicula breviore 2–4 m tantum (nec 4–5 m) longa etiam differt. Ab *A. deserti* var. *simplici* ramulis paniculae lateralibus longioribus 20–30 cm longis (nec 5–15 cm tantum longis) etiam differt.

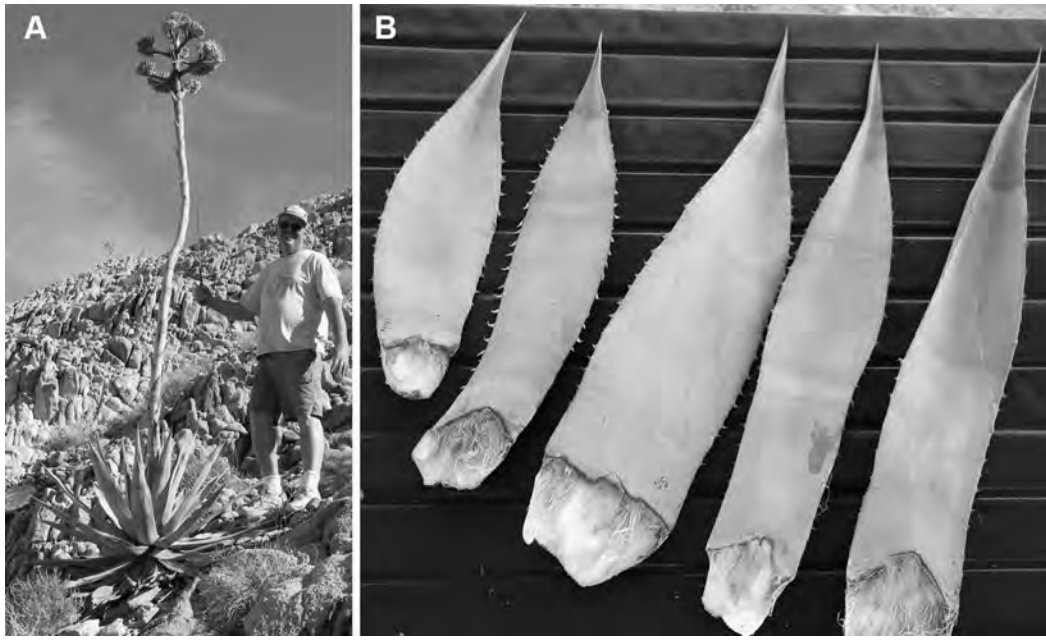


**Fig. 2. A.** *Agave turneri* in the Sierra Cucapá in flower. Individual is 2 m high for scale. **B.** Leaves of 5 individuals of *Agave turneri* showing considerable variability in form but similar straight margins and minimal channeling (guttering) on the adaxial side.

Medium-sized solitary rosette, 80–190 cm wide by 0.4–1.20 m tall, acaulescent, monocarpic; leaves gray-green to blue-glaucous green, lanceolate, 10–40 per rosette, 40–90 cm×6–13 cm, widest about one-quarter from the base, generally not canaliculate (guttered), smooth to scaberulose on the adaxial side and scabridulous to rough on the abaxial side, bearing prominent leaf-margin impressions on both surfaces and occasional darker cross-banding, length: width, 4.0–7.7; margin with a 1–2 mm wide purple, aging to white, band, without undulations (teats); spines easily detached, purple-black turning to white with age, 0.5–0.7 mm long, spaced on average 15 mm along the leaf edge and randomly flexed; leaf apex a terminal spine, 5–6 cm long, proximally channeled on the adaxial side, purple-black; panicle 2–4 m tall ; peduncle 5 cm in diam. with spirally arranged triangular bracts 12–13.5×4.5–6 cm, not banded or variably cross-banded in blue-purple stripes; lateral branches 5–10, in the distal 50–70 cm of the panicle, above the densely bracteate zone, 20–30 cm long, ± capitate, subtended by ± triangular, purple bracts, 50–65 mm wide, bracts spaced 3–6 cm along the peduncle; flowers crowded, pedicels 5–20 mm long, bracteolate; perianth yellow-green to yellow, ± erect, 3.75–5.6 cm long; tepals 18–24×5–9.5 mm, inner and outer tepals subequal, ascending, lanceolate, apex with tufted hairs and beak, inner keeled, outer smooth, both gibbous, tip occasionally red; filaments slender, 2.9–4.1 cm long, subequally inserted, decurrent on perianth tube; anther attachment centric or acentric, anthers 16–20.5 mm prior to dehiscing, 11–12 afterwards, yellow; pollen yellow; ovary 15–29×3–6.5 mm, light glossy green, interior fusiform; ovary neck 3–6×2.5–6 mm, scarcely constricted, sulcate; tube 2–5.5 7–9 mm, crateriform, glabrous; style 15–49 mm, elongating after anthesis, stigma bulbous, rugose, cream-colored, vaguely 3-lobed; capsules beaked, smooth, brown when dry, oblong, 3.6–4.5 cm long, thick-walled, stipitate, up to 60 per branch; seeds black and shiny, 5–8 mm long, compressed, one side flat, one side convex, ±luneate, with a canaliculate, bilateral flange, hilum notch wide, testa rugulate, pustulate, and scarcely puncticulate.

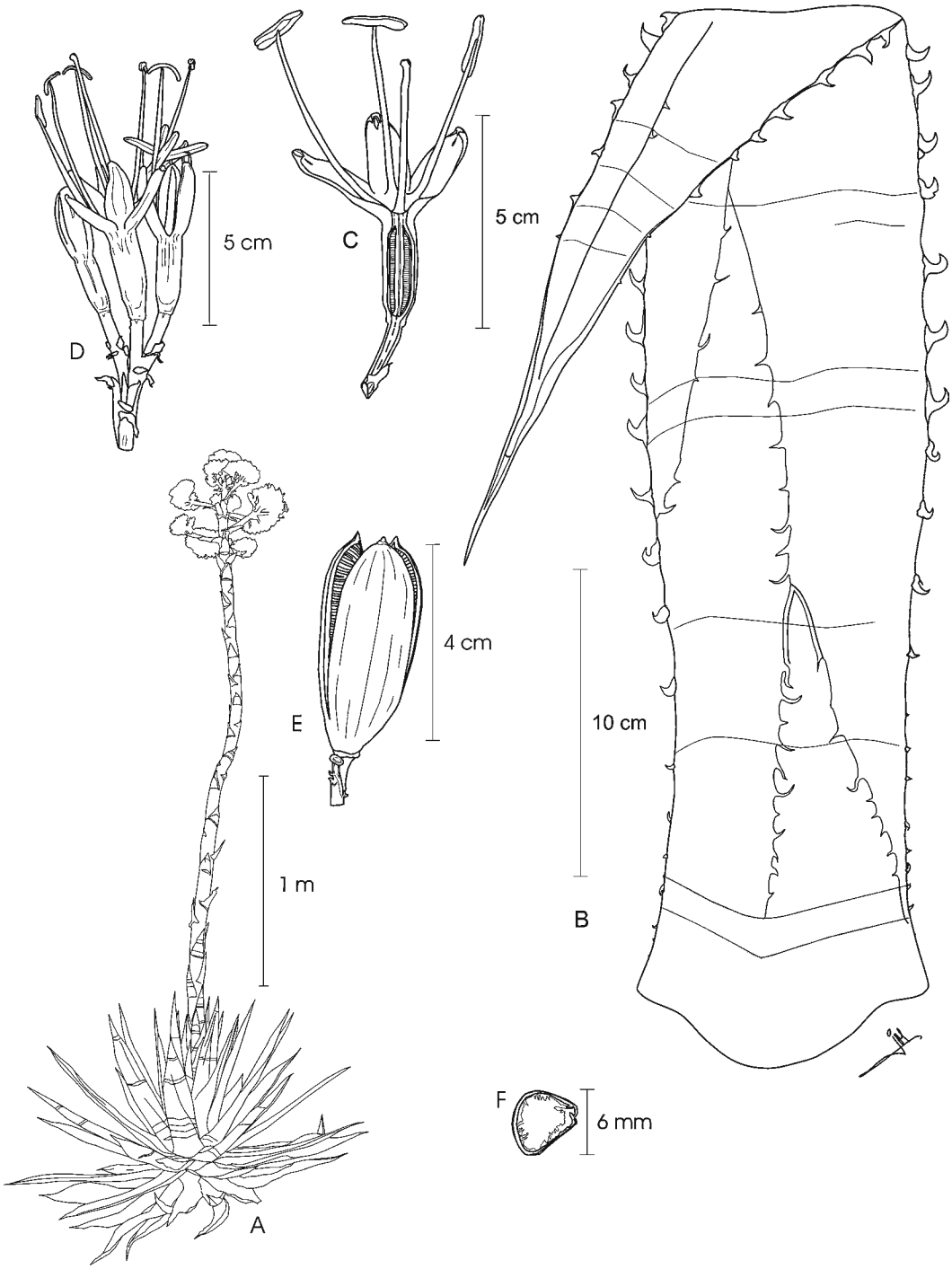


**Fig. 3.** *Agave turneri*. **A.** Habit. **B.** Leaf showing leaf impressions and cross banding. **C.** Flower section. **D.** Flower cluster. **E.** Seed capsule. **F.** Seed. Drawings are a composite of the holotype (leaf) and additional specimens (*Salazar 3742*, ARIZ; *Salazar 3739*, BCMEX; *Salazar 3743*, DES; *Salazar 3741*, SD).

*Distribution*.—This species appears to be restricted to monzogranite and adjacent colluvial slopes in the Sierras Cucapá and El Mayor, Baja California, Mexico (Fig. 1).

*Phenology*.—Flowers have been observed on lateral branches from February–April and in August. Inflorescences without peduncles were ca. 2 m tall in October 2008, then persisted with little change through January 2009 before flowering in early March 2009.

*Ecology*.—We found eight localities of *Agave turneri* in the Sierra Cucapá and Sierra El Mayor, all on the eastern side of the ranges. The Sierra Cucapá and El Mayor are northwest to southeast trending, granitic-core desert mountains associated with the San Andreas fault zone and extensional rifting of the northern end of the Gulf of California (Barnard, 1968). The principal plutonic rocks in these mountains are the La Puerta Tonalite of Cretaceous–Jurassic age, the Cucapas Granodiorite of Cretaceous age, and the Cerro Centinela undifferentiated intrusives (Barnard, 1968). Cerro la Puerta, the tallest mountain in the Sierra Cucapá, stands approximately 1030 m above the Gulf, and Cerro El Mayor has a maximum elevation of about 882 m.

The known localities of *Agave turneri* range in elevation from 180 to 400 m (and likely higher), but the elevation range is restricted to the outcropping of La Puerta Tonalite and Cucapas Granodiorite (monzogranite). This species appears to be restricted to steep slopes or cliffs of Cucapas Granodiorite or the steep colluvial slopes beneath the outcrops of this unit, which, despite its spatial extent of about 100 km$^2$ (Barnard, 1968), occurs mostly on the eastern sides of the ranges. Furthermore, the plants on the east side generally occur on the leucocratic (i.e., white) phases of this monzogranite. At one locality on the west side of the range, plants were found on the La Puerta Tonalite (spatial extent of about 50 km$^2$; Barnard, 1968) and the melanocratic (dark) phases of the monzogranite (B. D. Hollingsworth, San Diego Natural History Museum, pers. comm., 2008).

Typical perennial species growing with *Agave turneri* are prominent members of the Lower Colorado River Valley subdivision of the Sonoran Desert and include *Olneya tesota* A. Gray, *Parkinsonia microphylla* (Torr.) Rose & I. M. Johnston, *Bursera microphylla* A. Gray, *Acacia greggii* A. Gray, *Hyptis emoryi* Torrey, *Larrea tridentata* (DC) Cov., *Fouquieria splendens* Engelm., *Ferocactus cylindraceus* (Engelm.) Orc., *Cylindropuntia ramosissima* (Engelm.) Rebman, *Echinocereus engelmannii* (Engelm.) Lem., *Asclepias albicans* S. Watson, and *Ambrosia dumosa* (A. Gray) Payne.

No climate stations are present in the habitat of *Agave turneri*. Mexicali, location of the closest climate station, is hyperarid with a mean annual precipitation of 85 mm with a bimodal seasonality (Fig. 4A); about two-thirds of the annual precipitation occurs from November–March. Similarly, Calexico, California (Fig. 1), has a mean annual precipitation of 69 mm (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca1288, accessed 25 May 2009). *Agave turneri* is one of the few members of this genus to grow in a hyperarid region with predominantly winter rainfall. From April 2001 through June 2002 (14 months), no rain fell at Calexico (Fig. 4B); periods of no rainfall spanning 8–9 months are common. From 2000–2008, there was no precipitation in 63% of the months. Summer temperatures are torrid with average high temperatures of 42° and 41°C in July and August, respectively; the record high of 50°C occurred in 1995. At Mexicali, the record low temperature of −8°C occurred in 1949, which indicates that *A. turneri* can withstand at least a moderate amount of frost.

*Etymology*.—This species is named in honor of Dr. Raymond M. Turner, a botanist who spent 45 years exploring and documenting the biogeography of Baja California and mapping the distribution of endemic agaves on the peninsula (Turner et al., 1995).

**Additional specimens examined. MEXICO**. **Baja California**: Sierra Cucapá, S of Mexicali: Col. La Puerta, 6 Mar 1997, *J. Rebman 3795* (SD); Sierra Cucapá, 25 km southwest of Mexicali, 28 Oct 2008, *M. Salazar 3725* (MEXU), *M. Salazar 3724* (NY), *M. Salazar 3723* (ARIZ), *M. Salazar 3722* (DES), 6 Mar 2009, *M. Salazar 3742* (ARIZ), *M. Salazar 3739* (BCMEX), *M. Salazar 3741* (SD), *M. Salazar 3743* (DES), *M. Salazar 3745* (NY).

Because of its solitary habit, *Agave turneri* is similar to only two other agaves in the

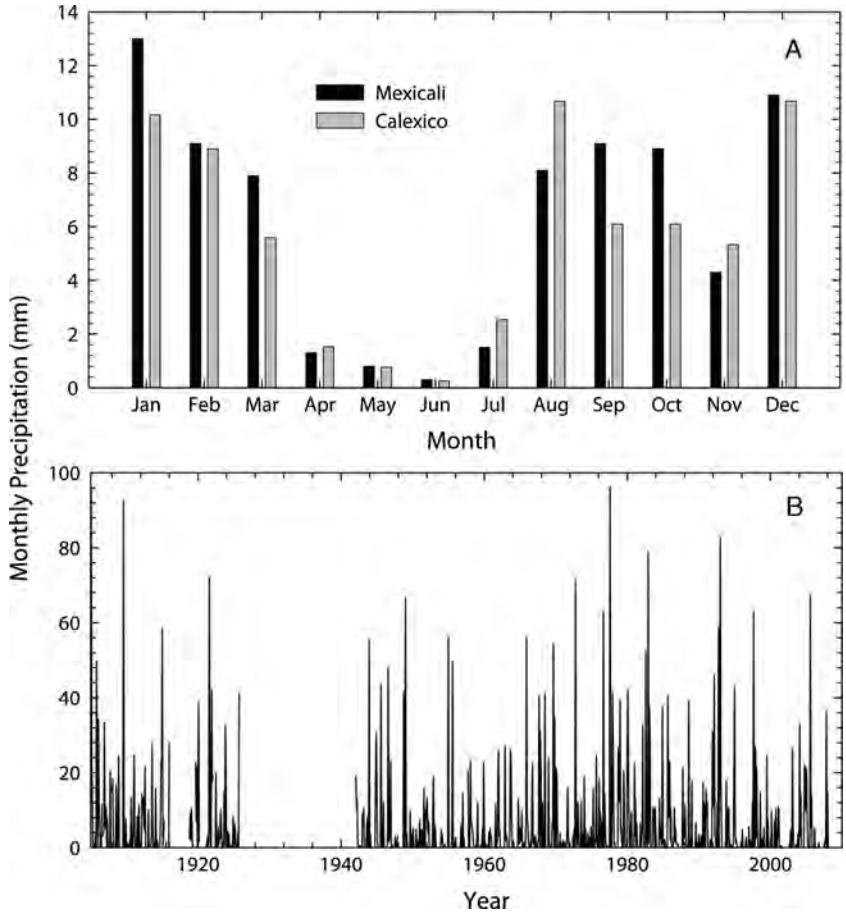


**Fig. 4.** **A.** Seasonal precipitation in Mexicali, Baja California, and Calexico, California. **B.** Time series of monthly precipitation in Calexico, California. Numerous months are missing from 1905 through 1925 and no data were collected between 1926 and 1942.

region: *Agave moranii* and *A. deserti* var. *simplex* (Table I). *Agave moranii* has larger rosettes with light-green leaves and grows about 200 km south of the Sierra Cucapá, near the southern end of the Sierra San Pedro Martír; its panicle is more robust, wider, and crowded than *A. turneri*. *Agave deserti* var. *simplex* has smaller, solitary rosettes of gray-green leaves with prominent teeth borne on shallow teats and recurved towards the rosette (Gentry, 1978); the panicle on this species is much taller and the lateral branches are 20–30 cm shorter than the broadly capitate inflorescence of *A. turneri*. *Agave turneri* appears to be restricted in habitat to monzogranite, and neither *A. moranii* nor *A. deserti* var. *simplex* have significant substrate restrictions. *Agave turneri* flowers in summer and winter–spring, apparently responding to episodic rainfall in its desert environment and differing from either *A. moranii* or *A. deserti* var. *simplex*, which typically only flower in spring. The yellow-green, open flowers of *A. turneri* with equally inserted filaments are also distinct from the yellow, more upright flowers of *A. moranii* and the cream-yellow flowers with unequal filament insertion of *A. deserti* var. *simplex*.

*Agave turneri* clearly belongs within subgenus *Agave* and group Deserticolae on the basis of its form, flowers, and habit. As noted in Gentry (1982), the species *A. moranii*, *A. avellanidens*, and *A. gigantensis* from Baja California could be considered a subsection of Deserticolae, and *A. turneri* would join that subsection should one be erected.

TABLE I
COMPARISON OF MORPHOLOGY OF *AGAVE TURNERI*, *A. MORANII*, AND *A. DESERTI* VAR. *SIMPLEX* (ADAPTED FROM GENTRY, 1982).

| Characteristic | *Agave turneri*[a] | *Agave moranii* | *Agave deserti* var. *simplex* |
|---|---|---|---|
| Habit | Solitary | Solitary | Solitary |
| Height (m) | 0.78±0.06 | 1.0–1.5 | 0.40–0.60 |
| Live width (cm) | 93±9 | 200 | 30–50 |
| Bole width (cm) | 16±2 | n.d. | n.d. |
| Leaf color | Glaucous green | Light green | Glaucous green |
| Leaf impressions | Yes | No | Yes |
| Leaf shape | Curved, not guttered | Straight, guttered | Curved, guttered |
| Leaf length (cm) | 58±4 | 70–120 | 25–40 |
| Leaf width (cm) | 8–10 | 8–12 | 6.5–10 |
| Leaf margin | Straight | Straight | Straight to undulate |
| Spine form | Straight to flexed on straight margin | Flexed both directions, straight margin | Flexed towards base, weak to moderate teats |
| Spine length (mm) | 5±0.4 | 6–12 | 5–8 |
| Spine spacing (mm) | 14±1 | 20–40 | 10–30 |
| Terminal spine (cm) | 5.4±0.5 | 4–6 | 3–4 |
| Panicle height (m) | 2–4 | 4–5 | 4–6 |
| Lateral branches (cm) | 20–30 | 20–40 | 5–15 |
| Ovary (L × W) (mm) | 22.4×5.6 | 25–40 | 20–30 |
| Tube (L × W, mm) | 3.3×8 | 4–6×12–13 | 6–7×12–13 |
| Filament insertion (mm) | 3.3, equal | n.d., equal | n.d., unequal |
| Outer tepal (L × W, mm) | 21.4×6.9 | 18–24×6–7 | 15–20×4–5 |
| Seed length (mm) | 6.1±2.2 | 7–8 | 5–6 |
| Seed width (mm) | 5.2±2.8 | 5–6 | 4.0–4.5 |

[a] N = 11 individuals. n.d. = no data

*Agave turneri* is narrowly endemic to a hyperarid mountain range near a major metropolitan area in northeastern Baja California. It appears to be restricted to monzogranites that outcrop in an area of about 150 km$^2$. Our observations during prolonged droughts in the early 21$^{st}$ century indicate that climate change could threaten the survival of this species. In 2007 at one site in the Sierra Cucapá, we estimated that approximately 75% of the individuals were dead from drought or following flowering with unknown seed production. Precipitation is highly variable, owing to prolonged winter droughts, unpredictable summer rainfall, and the potential for incursions of tropical cyclones (chubascos) that can drop substantial rainfall on these mountain ranges.

Mexicali is a rapidly growing city with an urban population of 653,000 and a municipality population in 2005 of 855,962 concentrated within a short distance of the city (http://www.nationmaster.com/encyclopedia/Municipality-of-Mexicali, accessed 22 June 2009). This regional center supplies the surrounding farming communities, hosts cross-border industries and serves as a hub for produce transport via rail from the interior of Mexico to the border crossings into California. Numerous sand and gravel mining operations supplying construction materials for Mexicali are present on the alluvial fans on the eastern side of the Sierra Cucapá and Sierra el Mayor; some of these are near the apices of alluvial fans and are close to habitat of *Agave turneri*. Off-road vehicle racing is common on both sides of the Sierra Cucapá, although the rocky habitat of *A. turneri* precludes vehicular access to most areas. We found no evidence that this species is harvested for mescal production. Woodcutting operations in the canyons of both mountain ranges may create an indirect threat because harvesting of *Olneya* could remove potential nurse plants for seedlings. This combination of threats may endanger this narrowly endemic species.

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