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## AGAVE AZUREA (AGAVACEAE), A NEW SPECIES FROM BAJA CALIFORNIA SUR, MÉXICO, WITH NOTES ON OTHER AGAVES ON THE VIZCAÍNO PENINSULA

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**Abstract:** *Agave azurea*, a new species of *Agave* from the Picachos de Santa Clara, Baja California Sur, México, is a medium-sized species with distinctive glaucous blue-green leaves that does not produce offsets, has a relatively short and narrow inflorescence, and a distinctive flower structure. The closest relative to this new species is *Agave vizcainoensis*, which occurs to the west on the Vizcaino Peninsula. This new species is a narrow endemic restricted to mostly rocky slopes and alluvial surfaces emanating from isolated mesas and peaks in an environment with strong fog influence. *Agave azurea* does not appear to be threatened by habitat modification. Field examinations and a review of herbarium specimens assigned to *Agave vizcainoensis*, *A. sebastiana*, and *A. gigantensis* led us to conclude that *A. sebastiana* is restricted to off-shore islands, *A. vizcainoensis* occurs on the western Vizcaino Peninsula, and *A. gigantensis* is restricted to the northern Sierra de la Giganta.

**Keywords:** *Agave*, Agavaceae, Baja California, arid environment, endemic species.

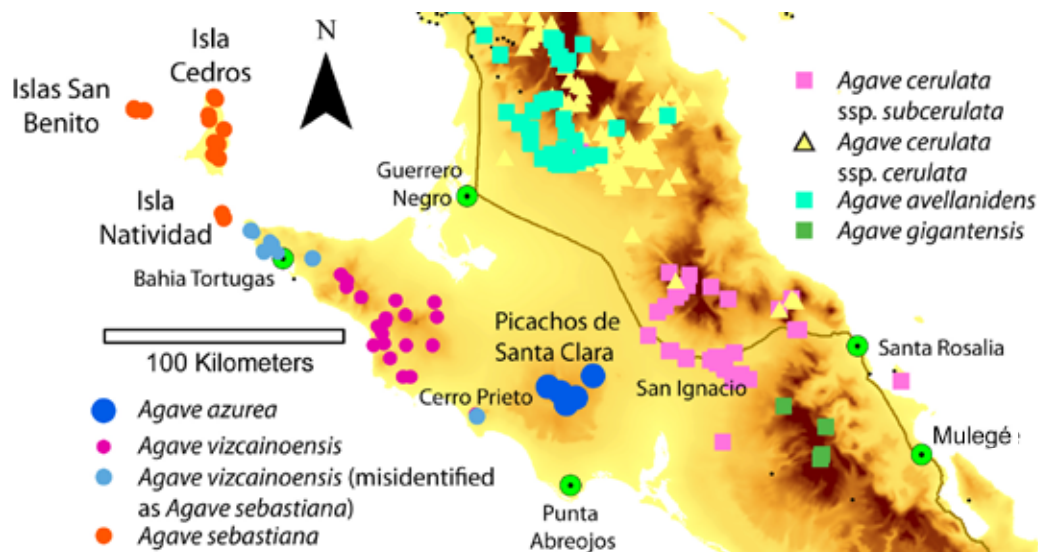
As part of a larger project inspired by Gentry (1978), we have been mapping the distribution of agaves on the Baja California peninsula. Of the 26 *Agave* taxa known from the Mexican states of Baja California and Baja California Sur, 24 are endemic to this peninsula or nearby islands (Gentry 1982, Webb & Salazar-Ceseña 2011), with only a few other members of this genus present in adjacent areas of California and southwestern Arizona (Hodgson 2001, Reveal & Hodgson 2002). To create distribution maps, we used both direct observations from a large database (Webb et al. 2013) as well as databases of herbarium specimens held in the United States and México.

We were drawn to the Vizcaíno peninsula, in northwestern Baja California Sur (Fig. 1), because of some anomalies in herbarium specimens and what appeared to be a unique species in the Picachos de Santa Clara. In his exsiccatae, Gentry (1978) reports herbarium specimens (Gentry 7693, 7713) submitted to the University of Arizona Herbarium with duplicates in several other herbaria, that are assigned to both *Agave vizcainoensis* and *A. gigantensis* with the note “doubtfully assigned here.” With regard to the plants from the Picachos de Santa Clara, Gentry (1982: 407) states: “The plants growing about the

Picachos de Santa Clara are more robust and less succulose than those in the Sierra Vizcaíno proper and resemble *A. gigantensis*.” Another set of herbarium specimens (Moran 5263-25269, SD) reports *Agave sebastiana* on Cerro Prieto, southwest of the Picachos de Santa Clara (Fig. 1). Other specimens, purportedly of *Agave sebastiana* (e.g., AGA1212810, MEXU), were collected in the vicinity of Bahía Tortugas north to Punta Eugenia.

A total of 6 species with 2 varieties occur within 200 km of the Picachos de Santa Clara (Fig. 1). To the northwest, *Agave vizcainoensis* Gentry commonly occurs in the Sierra Vizcaíno and other low mountains on the Vizcaino Peninsula. *Agave sebastiana* Greene occurs on Isla Cedros, Isla San Benito, Isla Natividad, and reportedly also north of Bahía Tortugas (Gentry 1978). *A. avellanidens* (Trel.) Gentry, *A. cerulata* ssp. *cerulata* (Trel.) Gentry, and *A. cerulata* ssp. *subcerulata* (Trel.) Gentry are quite distinct from *A. sebastiana* and *A. vizcainoensis* and occur in the hills and mountains to the east, north and northeast of the Picachos across the wide, sandy Vizcaino Desert. Finally, *A. gigantensis* Gentry occurs in the northern Sierra de La Giganta to the east of the Picachos. The Picachos de Santa Clara are effectively isolated from other populations of agaves by wide, sandy plains.

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**Figure 1.** Map of central Baja California showing the Vizcaíno Peninsula, Baja California Sur and Baja California, Mexico, and localities of *Agave* species. San Ignacio is the type locality for *A. cerulata* ssp. *cerulata*, hence the green marker for the town's location is obscured by pink squares. Small black dots are sampling localities where agaves were not observed.

*Agave azurea* R. H. Webb & G. D. Starr, **sp. nov.** Type: México. Baja California Sur: Picachos de Santa Clara, 50 km north of Punta Abreojos. April 2013, Webb-Starr 20130418-1 (holotype: HCIB 11721). (Figs. 2–5)



**Figure 2.** *Agave azurea* in the Picachos de Santa Clara. Howard Scott Gentry recognized that these plants were different from *Agave vizcainoensis*, initially referring to an herbarium specimen from this locality as *Agave sebastiana* and later as *Agave gigantensis*.





**Figure 3.** *Agave azurea* in the Picachos de Santa Clara.

Similar to *Agave vizcainoensis* but differs by the solitary habit, larger rosettes with more glaucous blue-green leaves, leaf shape, larger flower size, and filament insertion.

Solitary, acaulescent rosettes of 13–32 leaves, 80–90 cm tall by 100–153 cm across, monocarpic (Fig. 2). Leaves obovate to oblanceolate, glaucous blue-green, plane to slightly guttered, 55–76 cm



**Figure 4A.** Leaves of *Agave azurea*.



**Figure 4B.** Leaves of *Agave vizcainoensis*.



**Figure 5A.** Flowering individual of *Agave azurea*. Pico de Gato appears in the background.

long by 14–22 cm wide at widest point just above the middle, 10–17 cm wide at narrowest point below the middle, attenuate at the tip, light bud printing, faint to moderate banding, smooth to slightly rough below, slightly rough and waxy above (Fig. 4A). Margin straight to rarely undulate, teeth on small teats or no teats, deflexed towards base, orange-yellow, reddish purple or brownish red, aging to whitish gray, 10–15 mm long, 40–50 mm apart; terminal spine 40–70 mm long, decurrent to the first 1–2 pair of teeth. Inflorescence 2–4.5 m tall (Fig. 5A), infertile part 0.7 to 3 m long, flower-bearing part 1.3–1.5 m long with 6–9 lateral branches each with 6–8 flower-bearing peduncles; bracts on scape 14–17 cm long by 2–3 cm wide at base, 2–3 cm long terminal spine, bracts in flower-bearing portion 7 cm long by 4 cm wide, lacking terminal spine. Flowers 79–85 mm long (Fig. 5C), yellow-orange, pedicel 6–30 mm long, 8–14 flowers per umbel (Fig. 5B); ovary inferior, 30–40 mm long; neck 6–10 mm long; tube 9–22 mm long by 15–22 mm wide; inner tepals 21–29 mm long by 10–13 mm wide, outer tepals 22–30 mm long by 9–13 mm wide; stamens inserted on rim of tube or 14–15 mm above base of tube, filaments 43–65 mm long, anthers 16–28 mm long, pollen yellow; style 85–90 mm long when fully exerted. Capsules with a 1–5 mm beak, oblong with transverse lineations on the cells, 35–60 mm long by 16–19 mm wide. Seeds black and shiny, lunate to ovate, 5–7 mm long, 4–5 mm wide. In three inflorescences, only a quarter to one-third of the seeds



**Figure 5B.** Flower umbel of *Agave azurea*.



**Figure 5C.** Dry, sectioned flower of *Agave azurea*. The bent, brown structure in the center is the style.

were black (viable).

**Type locality**—Picachos de Santa Clara, east slopes of Mesa la Distiladera, Baja California Sur, Mexico. Latitude N 27.12769°, longitude W 113.59095°, elevation 365 m (Fig. 6).

**Relation to other species**—Table 1 provides a comparison between the three species of *Agave* on





**Figure 6.** Northeast slope of Mesa La Distiladera looking towards Mesa Cirio showing many inflorescences of *Agave azurea* and its habitat.

Characteristic	<i>Agave azurea</i>	<i>Agave vizcainoensis</i> <sup>1</sup>	<i>Agave sebastiana</i> <sup>1</sup>
Group	Deserticolae	Deserticolae	Umbelliflorae
Habit	solitary	offsetting	offsetting
Height (cm)	80–90	30–50	60–120
Live width (cm)	100–153	50–90	n.d.
Number of leaves	13–32	16–20 <sup>2</sup>	30–60 <sup>2</sup>
Leaf color	glaucous blue-green	gray to green	glaucous gray or green
Leaf impressions	light bud printing	bud printed <sup>2</sup>	bud printed
Leaf shape	obovate to oblanceolate	linear-lanceolate to obovate-lanceolate	elliptic ovate to broadly linear ovate
Leaf apex	attenuate	acute to attenuate	acute
Leaf margin	straight, rarely attenuate with small teats	undulate with large teats	no teats to small teats
Leaf length (cm)	55–76	25–40	25–45
Leaf width (wide/narrow)(cm)	14–22 / 10–17	25–40 / 6–10	8–24
Teeth length (mm)	10–15	5–10	5–10
Teeth spacing (mm)	40–50	10–30	10–20
Terminal spine (mm)	40–70	25–40	20–30
Inflorescence height (m)	2.0–4.5	2.0–3.0	2.0–3.0
Ovary length (mm)	30–40	36–41	35–55
Tube (L x W) (mm)	9–22 x 15–22	8–12 x 15	14–20 x 18–22
Filament insertion (mm)	14–15	7–9	8–14
Outer tepal (L x W) (mm)	22–30 x 9–13	21–26 x 4–5	16–25 x 5–7
Capsules (L x W) (mm)	35–60 x 16–19	50–70 x 20	60–80 x 30
Seeds (L x W) (mm)	5–7 x 4–5	6–7 x 4.5	7 x 11

<sup>1</sup> From Gentry (1982) except as noted. <sup>2</sup> This study.

**Table 1.** Characteristics of three *Agave* species from the Vizcaino Peninsula and adjacent islands.



**Figure 7.** The distinctive green *Agave gigantensis* in the northern Sierra de la Giganta.

the Vizcaíno Peninsula or its off-shore islands. *Agave azurea* does not offset, is larger than *A. vizcainoensis* in most characters, its leaves are significantly different in shape and margins (Fig. 5A), and its capsules and seeds are smaller. It is evident that *Agave azurea* and *A. vizcainoensis* are closely related, but what is not clear, is the relationship of those two to other species on the peninsula. Gentry (1978, 1982) stated that, because of the deep flower tube, *A. vizcainoensis* does not show a close relation with other members of the Deserticolae, but he included it in that group for lack of a better option.

It is our opinion that these two species appear to form a bridge between the Gentry (1978) groups of Deserticolae and the Umbelliflorae. The shorter, more congested inflorescence shape of *Agave azurea* (Fig. 4A) is more similar to that of the Umbelliflorae than the narrow, elongated shape of the inflorescences found on members of the Deserticolae. Not only does the deeper tube (Table 1) suggest an affinity to the Umbelliflorae, as Gentry (1978, 1982) noted, but the tepal length to tube length ratio (from less than 3:1 to less than 2:1) is closer to that of the Umbelliflorae (about 2:1) than it is to other members of the Deserticolae (from 3:1 to nearly 5:1). Finally, the overall flower length approaches that of other members of Umbelliflorae more so than it does for those of Deserticolae.

**Distribution and climate**—This species appears to be restricted to rocky colluvial hillslopes and alluvial fans in the Picachos de Santa Clara on the Vizcaíno Peninsula, Baja California Sur, Mexico (Figs. 1, 6). We did not find *Agave azurea* on sandy soils west of the type locality nor in the sandy plains to the east. An aerial survey in December 2012 indicated a large population in the vicinity of the type locality, particularly on the north slope of Mesa la Distiladera, the colluvial slopes and alluvial fans south of Cerro el Cirio, and the north slopes of Cerro el Cardón and Cerro Santa Clara. In addition, from the air we saw scattered individuals on Cerro Victoriano northeast of the main picachos.

Temperature and rainfall on the Vizcaíno Peninsula are poorly known but are highly variable and influenced by seasonal fog and tropical cy-



**Figure 8.** *Agave vizcainoensis* from near Cerro La Minita, Vizcaino Peninsula.

clones. Punta Abrejos, the closest climate station but on the coast of the Pacific Ocean, has a mean annual precipitation of 68 mm with extreme inter-annual variability; the warmest month is September (average high: 33.9° C, average low: 18.9° C; <http://www.weatherbase.com/weather/weather.php3?s=983047&cityname=Punta-Abrejos-Baja-California-Sur-Mexico&set=metric>, accessed 25 September 2013). Temperatures in the Picachos de Santa Clara likely are more variable because they are farther from the moderating effects of the Pacific Ocean, and annual precipitation likely is greater, but probably less than 200 mm.

**Phenology**—We first observed this species in May 2010, and no plants were observed to be flowering. We found flowers on this species in April 2013 (Fig. 4), after Hurricane Fabio (July 2012), Tropical Storm Norman (September 2012), and Hurricane Paul (October 2012) brought what appeared to be considerable rainfall and minor flooding to the Vizcaíno Peninsula. Because no plants appeared to be flowering in May 2010, our impression is that this species opportunistically flowers, possibly in response to incursions of tropical cyclones.

**Associated perennial vegetation and habitat**—Typical perennial species growing with *Agave azurea* are prominent members of the Vizcaíno subdivision of the Sonoran Desert and include *Pachycormus discolor* (Benth.) Cov. var. *veatchianus* (Kell.) Gentry, *Olnya tesota* A. Gray, *Parkinsonia microphylla* (Torr.) Rose & I.M. Johnston, *Bursera microphylla* A. Gray, *Encelia farinosa* A. Gray, *Larrea tridentata* (DC) Cov., *Fouquieria diguetii* (Van Tieghem) I.M. Johnston, *Ferocactus peninsulae* (Engelm. ex Weber) Britt. & Rose var. *viscainensis* (Gates) Lindsay, *Cylindropuntia molesta* (Brand.) Knuth var. *clavellina* (Engelm.) Rebman, *Stenocereus gummosus* (Engelm.) Gibson & Horak, *Pachycereus pringlei* (Engelm.) Britton & Rose, and *Jatropha cinerea* (Ort.) Muell. Arg. in A. DC.

*Agave azurea* is narrowly endemic to an isolated arid mountain range on the Vizcaíno Peninsula well away from metropolitan areas, recreational development, or other potentially deleterious land uses. The only land use in the vicinity is livestock grazing by



**Figure 9.** *Agave vizcainoensis* from Cerro Prieto, Vizcaino Peninsula. These plants were misidentified as *Agave sebastiana* in herbarium specimens, probably because of the large number of leaves. However, the undulate margins, abundant leaf impressions, and particularly the short, narrow inflorescence (not shown) indicate that it either belongs to *A. vizcainoensis* or is a new subspecies.

cattle, horses, and goats and appears to be light. The climate is partially moderated by fog, particularly around the higher peaks of the Picachos de Santa Clara. Precipitation is highly variable in amounts and seasonality, owing to prolonged winter droughts, unpredictable summer rainfall, and the potential for incursions of tropical cyclones that can drop substantial rainfall on these mountain ranges. Future climate change is unlikely to change this high variability or affect this species unless the incidence of fog is reduced. The low production of viable seeds, however, could suggest a problem with pollinators. More research would be needed to determine what pollinators visit these plants and whether they might be threatened.

#### NOTES ON THE DISTRIBUTION OF OTHER *AGAVE* SPECIES ON THE VIZCAÍNO PENINSULA

As previously noted, six species occur within 200 km of the Picachos de Santa Clara (Fig 1). Because *Agave avellanidens* and *A. cerulata* are quite different from and have not been confused with *Agave vizcainoensis*, *A. gigantensis*, and *A. sebastiana*, only the latter three will be considered here in relation to *Agave azurea*. Webb and Starr (2013) discussed the characteristics and distribution of *Agave gigantensis*, which, with its medium-green color and large size, does not resemble any species on the Vizcaino Peninsula (Fig. 7). In addition, that species appears confined to elevations above 1,000 m in the Sierra de la Giganta. Gentry (1978) discussed herbarium specimens (Gentry 7693, 7713, ARIZ, DES, MEXU, SO, UC, UM; November 1947) that he doubtfully

assigned to both *Agave vizcainoensis* and *A. gigantensis*, and another set of herbarium specimens (Gentry 10339, 10342, DES, MEXU, US; 4-5 April 1951) doubtfully assigned to *A. gigantensis*. We reviewed the specimens at ARIZ and conclude that they are not *A. gigantensis*, but instead are *A. azurea*. We therefore reject Gentry's (1982) assertion that *A. gigantensis* occurs in the Picachos de Santa Clara.

*Agave vizcainoensis* (Fig. 8) is a highly variable species that Gentry (1978) described from the Sierra de Vizcaino in the west-central part of the Vizcaino Peninsula. On 19 February 1978, Reid Moran climbed the slopes of Cerro Prieto, southwest of the Picachos de Santa Clara (Fig. 1), and collected specimens that he believed were of *Agave sebastiana* (Moran

25263-25269, SD). We visited Cerro Prieto on 20 April 2013 and examined the plants found there (Fig. 9). Although the plants in this population were variable in leaf number and degree of undulation in the leaf margin, they resembled plants in a population of *Agave vizcainoensis* seen northwest of Cerro Prieto along the road from Mexico Highway 1 to Bahía Tortugas. Furthermore, other characteristics, particularly their dried and narrow inflorescences, indicate a closer relationship with *A. vizcainoensis* and not *A. sebastiana* or *A. azurea*.

Turner et al. (1995) report an herbarium specimen (TLB 7238) and 3 sightings they made of *Agave sebastiana* in the vicinity of Bahía Tortugas and northwards to Punta Eugenia. Reid Moran identified one of his specimens (Moran 19924; SD) as *Agave sebastiana*, which he collected on 8 February 1973 on the east shore of Bahía Tortugas at an elevation of 10 m. In his field books (<http://bajaflora.org/Moran-PageDisplay.aspx?P=13091>), he states that the plant had 30 leaves, which again seems to be the primary reason for assigning it to *A. sebastiana* instead of *A. vizcainoensis*, not inflorescence characters. Another specimen (AGA1212810, MEXU) was collected on 22 March 2007 south of Punta Eugenio. In August 1999, October 2008, May 2010, and May 2011, we visited this part of the Vizcaino Peninsula and only found *Agave vizcainoensis*, although the number of leaves on the individuals we found was highly variable. We conclude from our field examinations that only *A. vizcainoensis* occurs on the western part of the Vizcaino Peninsula.

*Agave sebastiana* was the focus of a trip to Isla Cedros in May 2011, and plants were examined at





**Figure 10.** *Agave sebastiana* on Isla Cedros in front of *Pachycormus discolor* ssp. *veatchiana*.

several localities on the island. The plants were solitary to offsetting and formed large colonies; had numerous, glaucous gray leaves (Fig. 10) with relatively straight margins and numerous teeth; had a short, acute tip below the stout terminal spine, which was decurrent to the fifth or sixth pair of teeth; and had relatively short, wide inflorescences as befitting the Umbelliflorae. These plants agree with the published descriptions of *A. sebastiana* (restated in Gentry 1978, 1982) and are easily distinguished from plants found on the mainland. Gentry (1978, 1982) discussed the relationship of *A. sebastiana* to *A. shawii* based on floral morphology in the Umbelliflorae, whereas plants on the peninsula are either in the Deserticolae or transitional between the two groups (like *A. azurea*).

## DISCUSSION AND CONCLUSIONS

As is the case with many *Agave* species, the plants in the Picachos de Santa Clara should be examined relative to other closely related species, as well as in relation to what other scientists have found or collected on the Vizcaíno Peninsula. As Gentry noted in his definitive monograph on the agaves of Baja California (1978) and expanded book on agaves of Continental North America (1982), the plants he observed and collected in the Picachos de Santa Clara were unusual. It is curious that instead of describing them as a new species, he placed them into two different species—*Agave vizcainoensis* and *A. gigantea*—that would have required a substantial enlargement of those species' characteristics. We chose instead to describe these plants as a new species owing to field

investigations of Gentry's, as well as observations of the differences between *Agave azurea* and other species in the region.

In addition to describing the plants in the Picachos de Santa Clara as *Agave azurea*, we would add that the unusual and highly variable forms of *A. vizcainoensis* on the Vizcaíno Peninsula warrant further investigation, and we have redefined the distributions of the previously identified species that are known from this peninsula and its off-shore islands. We conclude that *Agave sebastiana*, as it was originally described, only occurs on Isla Cedros, Isla Natividad, and Islas San Benito (Fig. 1). *Agave vizcainoensis* is the most widely distributed *Agave* on the Vizcaíno Peninsula, and additionally, plants on Cerro Prieto are an unusual form. After further investigation, we found only *Agave vizcainoensis* in the western mountains of the Vizcaíno Peninsula and north of Bahía Tortugas. Further, we have determined that *A. gigantea* occurs in the northern Sierra de La Giganta, and its range does not extend to the Picachos de Santa Clara. Finally, *Agave azurea* is restricted to the Picachos de Santa Clara, and specimens collected from there and listed as other species are incorrectly named.

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