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## *Yucca muscipula* (Asparagaceae, Agavoideae), a new species from central Mexico

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### Abstract

*Yucca muscipula* is described and illustrated as a new species endemic to the Barranca de Metztitlán Biosphere Reserve, Hidalgo, Mexico. This species is morphologically related to *Y. mixtecana* but is shorter, has a stem that lacks branching, and has glaucous leaves that are linear, with papillae on both surfaces and an entire margin, separating into recurved filaments. When dry, the leaves of *Y. muscipula* persist in the distal portion of the stem after the first flowering. It can grow sympatrically with *Y. filifera*, that also has a pendulous inflorescence and papillose filaments across entire surface, but from which it differs in several traits including glabrous branches, and larger flowers and fruits.

### Resumen

Se describe e ilustra *Yucca muscipula* como especie nueva endémica de la Reserva de la Biosfera Barranca de Metztitlán, Hidalgo, México. Esta especie se relaciona morfológicamente con *Y. mixtecana*, pero difiere de esta por tener una menor altura, tallo sin ramificarse, hojas glaucas, lineares, con papilas en ambas superficies y margen entero separándose en filamentos recurvados. Cuando secas, las hojas persisten en la porción distal del tallo después de la primera floración. *Y. muscipula* puede crecer simpátricamente con *Y. filifera*, que también tiene una inflorescencia péndula y filamentos con papilas en toda su superficie, pero de la que difiere en varios rasgos, como ramas de la inflorescencia glabras, flores y frutos más grandes.

**Keywords:** Agavaceae, Hidalgo, *Sarcocarpa*, Sierra Madre Oriental

### Introduction

*Yucca* Linnaeus (1753: 319) belongs to the family Asparagaceae, subfamily Agavoideae (APG IV, 2016). The type species of this genus is *Y. aloifolia* Linnaeus (1753: 319), which was designated by Britton & Shaffer (1908: 151). Linnaeus placed this species in the class Hexandria, order Monogynia. *Hesperoyucca* (Engelm.) Baker (1892: 8) was later proposed as a separate genus from *Yucca*. Clary (1997) analyzed the phylogeny of *Yucca* based on molecular, morphological, phenological and biogeographic characters, and only recognized *Yucca*. According to the type of fruit, Engelmann (1871) distinguished three sections, *Clistocarpa* Engelmann (1871: 496), *Chaenocarpa* Engelmann (1871: 496), and *Sarcocarpa* Engelmann (1871: 496) and two subgenera, *Euyucca* Engelmann (1871: 496) and *Hesperoyucca* Engelmann (1871: 497). McKelvey (1938, 1947) divided the genus into four sections: *Clistocarpa*, *Chaenocarpa*, *Hesperoyucca* and *Sarcocarpa* and proposed nine series based on floral and leaf characteristics. Species of section *Sarcocarpa* have fleshy and indehiscent fruits divided into three series: *Baccatae* McKelvey (1938: 13), *Faxonianae* McKelvey (1938: 13) and *Treculeanae* McKelvey (1938: 13). Matuda and Piña (1980) supported Engelmann's

classification modified by McKelvey (1938, 1947) to classify the *Yucca* species distributed in Mexico, recording 14 species for the series *Treculeanae*. Following this study five more species have been described: *Y. queretaroensis* Piña (1989: 52), *Y. linearifolia* Clary (1995: 394), *Y. capensis* Lenz (1998: 289), *Y. mixtecana* García-Mendoza (1998: 1) and *Y. pinicola* Zamudio (2020: 158), as well as the one described here. Based on morphological and molecular characters, these sections were shown to be nonmonophyletic (Clary 1997, Smith *et al.* 2008).

*Yucca* is distributed from southern Canada to Guatemala, mainly in the arid and semiarid zones of the United States of America and Mexico (García-Mendoza 1995, Clary 1997). The number of species of this genus varies depending on the criteria used by different authors, and 32 to 51 species are recognized (Espejo-Serna & López-Ferrari 1993, Thiede 2020, POWO 2021). These plants are pollinated by moths of the genera *Tegeticula* Zeller (1873: 232) and *Parategeticula* Davis (1967: 63), mainly by *T. yuccasella* Riley (1873: 56). However, some species have a specific pollinator, such as *Yucca elata* (Engelm.) Engelm (1882: 17) pollinated by *Tegeticula elatella* Pellmyr (1999: 261) and *Y. brevifolia* Engelm (1871: 496) by *T. synthetica* Riley (1892: 141), while *Y. jaegeriana* (McKelvey) Lenz (2007: 99) is pollinated by *T. antithetica* Pellmyr (2003: 718). Most of the species of the section *Sarcocarpa* are distributed in Mexico (Matuda & Piña, 1980).

Yuccas are perennial and succulent plants with poorly or well-developed stems. Their leaves are grouped at the apex of the stem, they are sword-shaped and sometimes linear. Their flowers are grouped in racemes or panicles; most species have white tepals, whereas in a few they become purple, whitish-green, whitish with pink, reddish or greenish apex. The fruits can be fleshy or dry, dehiscent or indehiscent with numerous blackish seeds (Hess & Robins 1996, García-Mendoza 2011).

Many species of *Yucca* are economically important. The plants are used as living fences and windbreaks; their fibers are extracted from the leaves to make twines, baskets and other utensils; and their fruits and flowers are edible (Matuda & Piña 1980, Sheldon 1980, Bartlett 2019). The roots, stems, leaves, shoots, flowers and seeds of several species such as *Y. schidigera* Ortgies (1871: 110) and *Y. gloriosa* Linnaeus (1753: 319) contain antioxidant, antimicrobial, anti-inflammatory, antidiabetic and hypocholesterolemic compounds, among others (Cheeke *et al.* 2006, Patel 2012).

In the present study, we describe and illustrate a new species of the genus *Yucca* from xeric scrub in the state of Hidalgo, Mexico, which contributes to the knowledge of one of the most emblematic succulent monocotyledonous genera with a high percentage of endemism, present in arid zones and semi-arid areas of Mexico and the United States of America.

## Materials and methods

During the systematic review of *Yucca* carried out by the authors of this article, field work was realized in the southwestern United States of America and Mexico were explored botanically. In the state of Hidalgo, Mexico, individuals of this genus with different characteristics from the species already described by other authors were observed. In the field, the type of soil, vegetation, elevation, geographic coordinates and associated species were recorded. In addition to the height of the individuals, the color of the main stem, the persistence of the dry leaves, the color of the mature leaves, the base, flowers, peduncle and floral branches, the type of inflorescence and its orientation were recorded. In the herborized specimens and those stored in 96% ethyl alcohol, the vegetative and reproductive characters were recorded and compared between the new species described here and others, particularly *Y. mixtecana* and *Y. filifera* because its morphology is similar to the first species, and with the second it grows sympatrically (Table 1). An illustration was prepared, and the collection locations were georeferenced to develop a geographical distribution map. The risk category was determined based on Criteria B1, extent of occurrence (EOO) and B2, area of occupancy (AOO) of the International Union for Conservation of Nature (IUCN 2019).

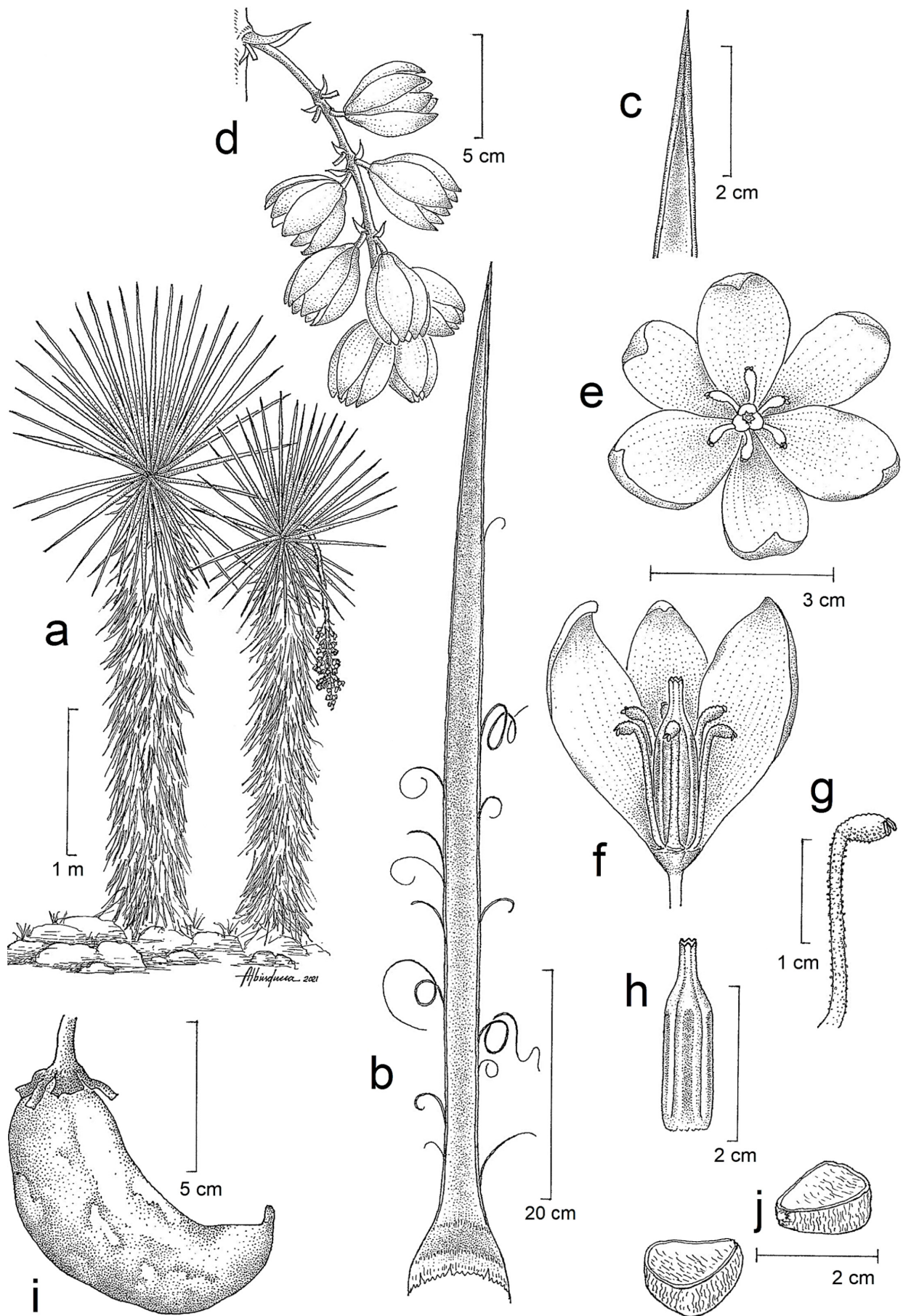
## Description of the new species

*Yucca muscipula* M. Ayala-Hern., Ríos-Gómez, E. Solano & A. García-Mend., *sp. nov.* (Figs. 1, 2).

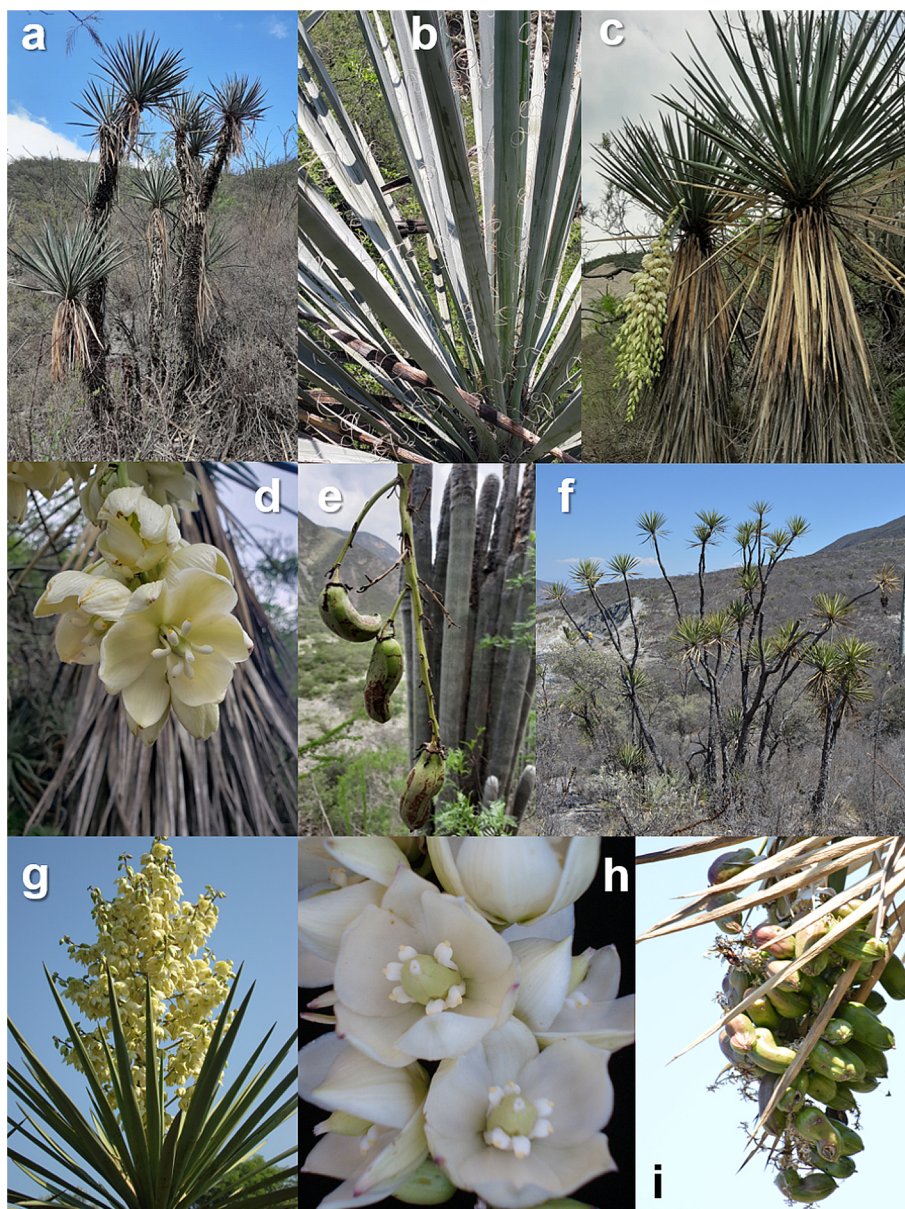
*Yucca muscipula* is morphologically similar to *Yucca mixtecana* and to a few branched individuals of *Y. filifera*, from which it differs in the unbranched stem, and longer leaves that are persistent on the distal portion of the stem after the first flowering. Its tepals are 4–5 cm long, with the outer ones being 1.0–1.5 cm wide and the inner ones being 1.4–2.0 cm wide. Its filaments are 1.8–2.8 cm long and papillose, while its ovary is 1.8–2.3 cm long and 3.3–6.3 mm in diameter; the fruit and seeds are larger than those of *Y. filifera*.

**TABLE 1.** Morphological differences, geographic distribution, phenology and habitat of *Yucca muscipula* and *Y. mixtecana* and *Y. filifera*. Data of *Y. mixtecana* are from García-Mendoza (1998, 2011). Data of *Y. filifera* are from Matuda & Piña (1980), Rentería (2000), and Galván (2005).

Character	<i>Yucca muscipula</i>	<i>Y. mixtecana</i>	<i>Y. filifera</i>
Stem	2–4 m, simple	2.5–5 m, simple or branched	Up to 10 m, simple or branched, mostly in old plants
Persistence of dry leaves on the stem	Deciduous in the basal portion, and persistent in the distal half in individuals after the first flowering	Deciduous	Persistent
Leaves margin	Glaucous Filiferous, recurved filaments	Glaucous Entire, rarely filiferous, straight filaments	No glaucous Filiferous, recurved filaments
Papillae	Present	Absent	Absent
Inflorescence	Panicle pendulous, 80–110 cm, glabrous	Panicle erect, 50–80 cm, puberulent	Panicle pendulous, until 150 cm, glabrous, peduncle and pedicels rarely pilose
Flowers	Campanulate, pendulous	Campanulate, pendulous	Extended, pendulous
Tepals	3.8–5.0 × 1.0–1.5 cm	2–3 × 0.4–0.7 (1.0) cm	3.8–5.2 × 0.7–2.5 cm
Filaments	1.8–2.8 cm long	1.0–2.0 cm long	1.0–1.5 cm long
Papillae	Across the entire surface	In two marginal lines	Across the entire surface
Gynoecium	2.1–2.9 cm long	1.5–2.0 (–3.0) cm long	2.3–2.5 cm long
Carpelar depressions	Little deep	Very deep	Very deep
Fruit	8.5–11.7 × 2.5–3.2 cm	3.0–8.0 × 2.0–2.5 cm	5.0–8.8 × 2.7–3.3 cm
Seeds	8.0–10.0 × 6.0–7.0 mm	5.0–7.0 × 5.0–6.0 mm	6.0–8.0 × 2.0–5.0 mm
shape	Prismatic	Prismatic	Oblong
Geographical distribution	Barranca de Metztitlán, Hidalgo, Mexico	Valle de Tehuacán-Cuicatlán, Puebla and Oaxaca, Mexico	Broad range, mainly in the Eastern portion of the Mexican Plateau and the transition with the Sierra Madre Oriental and the Transmexican Volcanic Belt
Elevation	1294–1350 m	1370–2200 m	500–2400 m
Phenology	Flowers from April to July, fruits from June to August	Flowers from March to May, fruits from July to September	Flowers from March to August, fruits from June to October
Habitat	Xeric scrubland, thorn forest	Xeric scrubland, deciduous tropical forest	Xeric scrubland



**FIGURE 1.** *Yucca muscipula*: a) complete plant, b) leaf, c) apex leaf, d) branch inflorescence, e) flower, f) dissected flower, g) stamen, h) gynoecium, i) fruit, j) seeds. Illustration by Albino Luna Sánchez.



**FIGURE 2.** *Yucca muscipula*: a) plants, b) leaves with margin filaments, c) plants with inflorescence, d) flowers, e) fruits. *Y. mixtecana*: f) plants, g) inflorescence, h) flowers, i) fruits (photos: R. Ríos-Gómez, a, c and e; E. Solano, b and d; A. García-Mendoza, f–i).

**Type:**—MEXICO. Hidalgo: Municipality Metztitlán, highway San Juan Metztitlán-Zoquizoquipan, approximately 2.6 km northeast from San Juan Metztitlán, xeric scrubland, 1320 m, 26 Jun 2021 (fl), R. Ríos-Gómez *et al.* 2046 (**Holotype:** MEXU!; **Isotypes:** CIIDIR!, DES!, FEZA!, UAMIZ!).

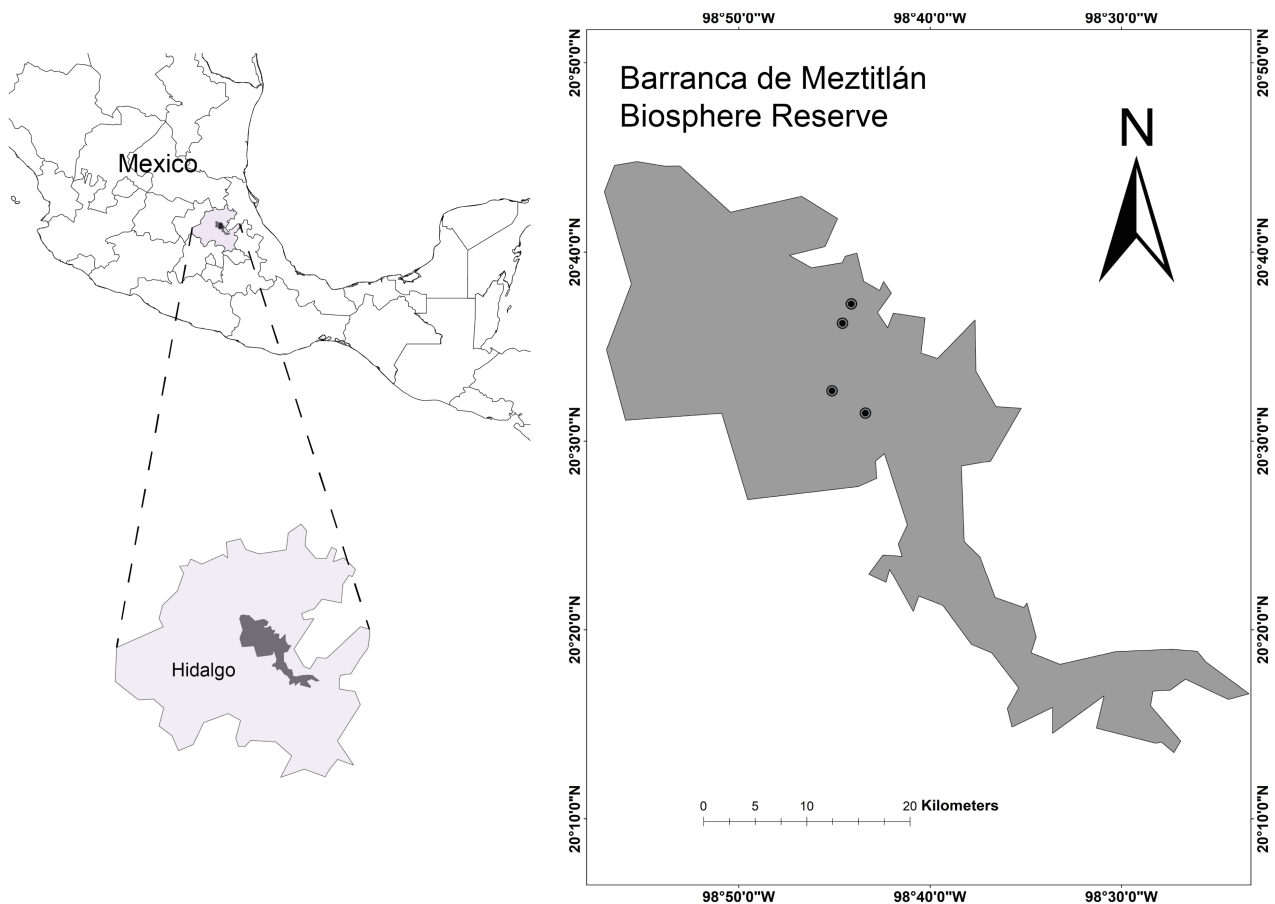
Plants arborescent, iteroparous, 2–4 m tall, rarely surculose. Stem simple, cylindrical, dry leaves persistent in the distal portion of individuals after the first flowering. Rosette leaves at the apex of the stems, linear, 63.5–82.6 cm long, 1.6–2.5 cm wide in the middle portion, ascending to appressed, coriaceous, glaucous, papillate on both surfaces, margin entire, filiferous, the filaments recurved, gray; terminal spine 0.6–1.0 cm long, brown, ribbed, conical, base bicolored, basally white, distal portion reddish-brown. Inflorescence paniculate, pendulous, 80–110 cm long, rachis white-greenish, once branched, branches 10–17 cm long, glabrous; bracts lanceolate, 7–14 cm long, 1–2 cm wide in the middle, yellowish-white, papyraceous, base reddish-brown, truncated, margin entire, apex acuminate. Flowers campanulate, whitish, greenish-white or yellowish-white, pedicels 1.0–1.8 cm long, ascending, rarely arched, terete, glabrous; external tepals 3.9–5.0 cm long, 1.0–1.5 cm wide, ovate-elliptical, base attenuate, margin entire, apex acute, the internal ones similar to the external ones but wider, 1.4–2 cm wide; filaments flattened, the apical portion thickened, diffuse, papillose; anthers yellow, 1.5–2.3 mm long, sagittate, extrose; ovary 1.8–2.5 cm long, 3.3–6.3 mm diameter, cylindrical, with slightly sunken carpels, septa prominent, green, style short; stigma 3-lobed, lobes 3.5–5.0 mm long, retuse, white, with scattered papillae. Fruits baccate, 8.0–11.7 cm long, 2.5–3.2 cm diameter, cylindrical, pendulous,

arched above the middle, crowned by the remains of the dried perianth, fleshy, indehiscent. Seeds 0.8–1.0 cm long, prismatic, slightly rough, black, dull; endosperm ruminated.

**Geographical distribution and habitat:**—Endemic to the municipality of Metztlán, Hidalgo, Mexico; in xeric scrublands and thorny forests with *Acacia farnesiana* (L.) Willdenow (1806: 1083), *Agave striata* Zuccarini (1833: 678), *A. xylonacantha* Salm-Reifferscheid-Dyck (1859: 92), *Bursera* Jacquin ex Linnaeus (1762: 471), *Cephalocereus senilis* (Haw.) Pfeiffer (1838: 142), *Cnidoscolus multilobus* (Pax) Johnston (1923: 86), *Fouquieria splendens* Engelman (1848: 98), *Jatropha dioica* Sessé (1794: 4), *Mimosa* Linnaeus (1753: 516), *Myrtillocactus geometrizans* Console (1897: 10), *Prosopis laevigata* (Humb. & Bonpl. ex Willd.) Johnston (1962: 78) and *Yucca filifera* Chabaud (1876: 432); on lithic leptosols and regosols at elevation 1294–1350 m (Fig. 3).

**Phenology:**—*Yucca muscipula* flowers from April to July and fruits from June to August.

**Additional specimens examined (paratypes):**—MEXICO. Hidalgo: Metztlán Municipality, La Paila de Anáhuac, 1322 m, 17 April 2021, *R. Ríos-Gómez et al.* 2038 (FEZA); San Juan Metztlán, 1294 m, 26 June 2021, *R. Ríos-Gómez et al.* 2047 (FEZA); Banks of the Pía Sapa stream, 3 km from San Juan Metztlán, 1350 m, 6 July 2021, *R. Ríos-Gómez* 2048 *et al.* (FEZA).



**FIGURE 3.** Geographic distribution of *Yucca muscipula* in Hidalgo, México.

**Etymology:**—The epithet is derived from the common name by which this plant is known in the type locality, “mousetrap palm” (mousetrap = *muscipula*).

**Uses:**—The whole plant is used to establish living fences and the flowers are edible.

**Conservation status:**—*Yucca muscipula* is Critically Endangered according to IUCN criterion B1, since it covers an extent of occurrence (EOO) of <100 km<sup>2</sup> and Endangered based on criterion B2, because the area of occupancy (AOO) covers <500 km<sup>2</sup>. This species is restricted to four locations in the Barranca de Meztlán Biosphere Reserve and its populations occupy 1.7% of its surface, which is 96,042 ha. In addition, it forms localized populations with few individuals in habitats close to rural human settlements and roads.

## Discussion

Given the fleshy fruit of *Yucca muscipula*, this species is considered to belong to the *Sarcocarpa* section, series *Treculeanae*. This series is characterized by pistils of 2 to 3.25 cm, rarely up to 4 cm in length, short perianth tubes, filaments adnate to the base of the tepals, and fleshy fruits that rarely exceed 10.25 to 11.5 cm in length and 2.5 to 3.25 cm in diameter. We reviewed McKelvey (1938) and Matuda y Piña (1980), as well as the publication of the new species described after these studies, and with 20 species, *Treculeanae* contains the highest number of species (McKelvey 1938, Matuda & Piña 1980, Piña 1989, Clary 1995, Lenz 1998, García-Mendoza 1998, Zamudio 2020). Including the one described here, 13 of these species are endemic to Mexico. This new species is recognized because its stems do not branch; it has glaucous leaves that are papillose on both surfaces; the margin is entire, shedding in recurved filaments; the inflorescence is pendulous, once branched, with glabrous rachis; and the flowers and fruits are larger. It is morphologically related to *Y. mixtecana*, which is distributed in the Valle de Tehuacán-Cuicatlán Biosphere Reserve.

*Yucca muscipula* is distributed in the Barranca de Metztitlán Biosphere Reserve, in the south of the Sierra Madre Oriental biogeographic region and the Southern Plateau, which are areas with high species richness and endemism (Rzedowski 1991, 2015, Salinas *et al.* 2017, Morrone 2019). Ten endemic species have been previously recorded in this protected natural area: *Cephalocereus senilis*, *Laelia gouldiana* Reichenbach (1888: 41), *Mammillaria hidalgensis* Purpus (1907: 118), *M. ingens* Backeberg (1942: 63), *M. polythele* Martius (1832: 328), *M. schiedeana* Ehrenberg (1838: 249), *M. wiesingeri* Boedeker (1933: 204), *Tillandsia mauryana* Smith (1937: 31), *Turbinicarpus horripilus* (Lem.) John & Říha (1983: 22) (CONANP 2003) and *Rogiera metztitlensis* Torres-Montúfar, E. Solano, Morales-Garduño & Ochoterena-Booth in Torres-Montúfar *et al.* (2019: 2). With the description of this new species, the number of endemic species increases to 11. There are only two known species of *Yucca* in the state of Hidalgo, Mexico: *Y. filifera* and *Y. muscipula*, which occur sympatrically.

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