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Taxonomy and distribution of Nolinoideae in Puebla

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Abstract

The Nolinoideae (Asparagaceae) subfamily is morphologically diverse and comprises seven tribes. The group has significant floral and vegetative diversity, resulting in a lack of morphological synapomorphies that differentiate it from other Asparagaceae subfamilies, being the absence of phytomelan in the seed coat its only distinguishing feature. They are widely distributed geographically in the Northern Hemisphere, inhabiting temperate, tropical, and arid regions. In Mexico, the subfamily is represented by three tribes: Nolineae, Polygonateae, and Rusceae. The most diverse tribe is Nolineae, which groups four genera and 65 species,followed by Polygonateae, which groups three genera and 12 species, and Rusceae, which groups one species. In Puebla, Nolineae has been reported with three genera and eight species, while Polygonateae has been reported with one genus and two species. Although Puebla has diverse vegetation types, little effort has been made to update the number of species and their geographic distribution in some regions of the state. Consequently, no work compiles information to help identify the species of Nolinoideae distributed in Puebla. To carry out the taxonomic treatment of the Nolinoideae family, we created botanical descriptions and taxonomic keys for the species in Puebla, as well as geographical distribution maps by vegetation types. This work was based on an exhaustive bibliographic search of specialized literature and consultation of digital scientific collections in public databases, as well as physical collections in HUAP, IBUG, MEXU, QMEX, and XAL herbaria. Since the species of the Nolinoideae subfamily in Puebla can be differentiated from each other based on a combination of floral and vegetative morphological characteristics, the obtained data suggests that the subfamily is represented by two tribes, four genera, and eleven species. Eight of these species are endemic to Mexico, and six are endemic to the study area. Additionally, *Maianthemum macrophyllum* is reported for the first time in this study. The greatest diversity of the subfamily was found in the xerophytic scrub with eight species, followed by the tropical deciduous forest and cloud forest, each with two species, and finally the tropical rain forest with one species.

Resumen

Nolinoideae (Asparagaceae) es un grupo morfológicamente diverso dividido en siete tribus. Posee una considerable diversidad floral y vegetativa lo que conduce a una falta de sinapomorfías morfológicas que permitan diferenciarla de otras subfamilias de Asparagaceae, excepto por la ausencia de fitomelanina en la testa de la semilla. Geográficamente se encuentran ampliamente distribuidas en el hemisferio norte, en regiones templadas a tropicales y áridas. En México la subfamilia está representada por tres tribus: Nolineae, Polygonateae y Rusceae. Nolineae es la tribu más diversa, agrupa cuatro géneros y 65 especies, seguida por Polygonateae con tres géneros y 12 especies y Rusceae con una especie. En Puebla, se ha reportado la presencia de Nolineae con tres géneros y ocho especies y Polygonateae con un género y dos especies. A pesar de que Puebla cuenta con diversos tipos de vegetación, es poco el esfuerzo realizado para actualizar el número de especies y su distribución geográfica en algunas regiones del Estado. Por lo tanto, no existe un trabajo que recopile la información y ayude a identificar las especies de Nolinoideae distribuidas en Puebla. Con el objetivo de llevar a cabo el tratamiento taxonómico de Nolinoideae, se elaboraron descripciones botánicas, claves taxonómicas y mapas de distribución geográfica de las especies de este grupo en Puebla, a partir de búsquedas bibliográficas exhaustivas de literatura especializada, consulta de colecciones científicas digitales en bases de datos públicas, así como colecciones físicas en los herbarios HUAP, IBUG, MEXU, QMEX y XAL y la creación de mapas de distribución geográfica por tipos de vegetación. Ya que las especies de Nolinoideae en Puebla pueden diferenciarse entre sí con base en la combinación de caracteres morfológicos florales y vegetativos, los datos obtenidos sugieren que la subfamilia está representada por dos tribus, cuatro géneros y once especies, de las cuales ocho especies son endémicas en México y seis son endémicas al área de estudio. Además, se reporta por primera vez la presencia de *Maianthemum macrophyllum*. La mayor diversidad de la subfamilia se encontró en el matorral xerófilo, con ocho especies, seguido por el bosque tropical caducifolio y el bosque mesófilo de montaña, con dos especies, y finalmente bosque tropical perennifolio, con una especie.

1. Introduction

The family Asparagaceae Juss. represents the largest group of monocotyledons, consisting of approximately 153 genera and 2900 species distributed worldwide (Stevens, 2001; Angiosperm Phylogeny Group III, 2009; APG IV, 2016) being the most morphologically diverse and species-rich family of Asparagales (Meng *et al*., 2021; Ji *et al*., 2023). Based on combined molecular and morphological studies, Chase *et al*. (2009) divided the family Asparagaceae into seven subfamilies: Agavoideae Herb., Aphyllantoideae Lindl., Asparagoideae Burmeist., Brodiaeoideae Traub, Convallarioideae Herb., Lomandroideae Thorne & Reveal, Nolinoideae Burnett, and Scilloideae Buernett.

The subfamily Nolinoideae comprises about 23 genera and is divided into seven tribes, namely Convallarieae Dumort., Dracaeneae Dumort., Eriospermeae Endl. ex Meisn, Nolineae S. Watson, Ophiopogoneae Voigt, Polygonateae Benth & Hook., and Rusceae Dumort. (Stevens, 2001), traditionally known as Convallariaceae, Dracaenaceae, Nolinaceae, and Ruscaceae, recognized by Dahlgren *et al*. (1985). Nolinoideae is a morphologically heterogeneous group with considerable floral and vegetative diversity, resulting in a lack of morphological synapomorphies to distinguish it from other Asparagaceae subfamilies, except for the absence of phytomelan in the seed coat (Rudall *et al*., 2000; Meng *et al*., 2021; Ji *et al*., 2023). Its geographical distribution occurs in the northern hemisphere, including western and eastern ranges. It extends from Europe through Siberia to Asia, the Himalayas, Indochina, and America (Conran & Tamura, 1998), mainly in temperate or tropical to subtropical areas (Rudall *et al*., 2000).

Nolinoideae is a group of plants of considerable economic importance. Many members of the subfamily have medicinal properties (e.g. *Convallaria, Dracaena* and *Polygonatum*), have ornamental value (e.g. *Beaucarnea*, *Hosta*, *Nolina*, *Ophiopogon*, and *Ruscus*), are used as industrial raw materials due to their high fibred and starch content (e.g. Nolineae), are used in horticulture (e.g. *Convallaria*, *Aspidistra*, *Liriope*, *Maianthemum*, *Ophiopogon* and *Polygonatum*), are edible (e.g. *Liriope*, *Maianthemum* and *Polygonatum*) and are used in distilleries (e.g. *Dasylirion*) (Bogler, 1998; Conran &Tamura, 1998; Rojas-Piña *et al*., 2014; Ji *et al*., 2023).

2. Background

2.1. Systematic history

Nolinoideae has a complex systematic history, the position and taxonomic delimitation of some genera and even the subfamily itself have been strongly debated and have undergone constant changes. The members of Nolinoideae have been placed in various families, subfamilies, and even tribes. Based on morphological and chemical characteristics, Bentham & Hooker (1883) included the members of this group in the tribe Dracaeneae or Nolineae (Krause, 1930). Later, they were included in Agavaceae (Hutchinson, 1959). Subsequently, Dahlgren *et al*. (1985) excluded them from Agaveceae, along with all genera and species, and placed them in Convallariaceae, Dracaenaceae, Eriospermaceae, Nolinaceae, and Ruscaceae.

At the end of the 20th century, phylogenetic studies based on morphological and molecular data suggested that all members of Dracaenaceae, Nolinaceae and Ruscaceae should be transferred to Convallariaceae (Chase *et al*., 1995; APG, 1998; Fay *et al*., 2000). Subsequently, Rudall *et al*. (2000) introduced a new classification: the family Ruscaceae *s.l.*, which includes members of Convallariaceae, Nolinaceae, Ruscaceae, Draceaenaceae, *Comospermum,* and *Eriospermum*. In this classification, Ruscaceae Spregel (1826) has nomenclatural priority over Convallariaceae Horaninow (1834) (Jang & Pfosser, 2002). This study was confirmed by Kim *et al*. (2010) who, based on plastic characters, recognized Nolinaceae close to Ruscaceae *s.s.*, Dracaenaceae, Convallariaceae, and Eriospermaceae in Ruscaceae *s.l*. Later, the APG II (2003) included Ruscaceae *s.l.* in Asparagaceae, near Agavaceae, Aphyllantaceae Burnett, Hesperocallidaceae Traub, Laxmanniaceae Bunabi, and Themidaceae Salisb. (Rojas-Piña, 2015). On the other hand, APG III (2009) made significant changes, retaining only the large monophyletic families, retaining Ruscaceae within Asparagaceae, and introducing a subfamily classification (Chase *et al*., 2009; Seberg *et al*., 2012).

The last classification of Asparagaceae (APG IV, 2016; Meng *et al*., 2021; Ji *et al*., 2023) divided the family into seven subfamilies: Agavoidea, Aphyllantoideae, Asparagoideae, Brodiaeoideae, Convallarioideae, Lomandroideae, Nolinoideae, and Scilloideae. The

subfamily Nolinoideae is divided into seven tribes: Convallarieae, Dracaeneae, Eriospermeae, Nolineae, Ophiopogoneae, Polygonateae, and Rusceae, comprising about 26 genera and about 590 species (Stevens, 2001). However, Tanaka & Nguyen (2023) suggested that the use of the name Convallarioideae Herbert (1837:48) has nomenclatural priority over other valid subfamily names, including Nolinoideae Eb. Fisch. & G. Mwachala.

The present study considers the classifications by Chase *et al*. (2009) and APG IV (2016), using the name Nolinoideae instead of Convallarioideae.

2.2. The subfamily Nolinoideae in Mexico

In Mexico, the subfamily Nolinoideae is represented by the tribes Nolineae, Polygonateae, and Rusceae. Nolineae is the most diverse tribe, represented by the genera *Beaucarnea* Lem., *Calibanus* Rose, *Dasylirion* Zucc., and *Nolina* Michx., comprising about 65 species. Morphologically, the species of Nolinoideae are dioecious to polygamo-dioecious plants, acaulescent, sarcocaulescent, shrubby or arborescent habit (Trelease, 1911). They have linear leaves grouped in rosettes, paniculate or spiciform inflorescences with small flowers in fascicles on articulated pedicels and dry indehiscent fruits (Hernández-Sandoval, 2020).

Nolineae is native to America, with its geographic distribution extending from North America to Central America, from the southern United States through Mexico to Guatemala (Rojas-Piña *et al*., 2014; Rojas-Piña & Alvarado-Cárdenas, 2016; Ruiz-Sanchez *et al*., 2019), considered as the Megamexico region by Rzedowski (1991). It is emblematic of the country´s arid ecosystems and is estimated to occur in 85% of the Mexican territory. Nolineae is generally restricted to xerophytic scrub and sometimes to tropical deciduous forest, and the individuals are often found on dry rocky slopes, outcrops, and sandy ridges (Bogler, 1998; García-Mendoza *et al*., 2012). Some of the habitats where they occur are subject to periodic burning thus adaptation to fire may have been important in the evolution of some taxa within the tribe (Bogler, 1998; Rodríguez *et al*., 2019).

The species provides valuable environmental services, such as soil protection and refuge for wildlife, mainly reptiles and small mammals (Quirino, 2017; Palacios-Romero *et al*., 2019). Although the flowers are small, insects are attracted by the nectar and abundant pollen. A wide variety of beetles, butterflies, flies, and wasps visit Nolineae, with the most common and abundant pollinators being small bees from the families Apidae, Andrenidae, Anthophoridae, Colletidae, Halictidae and Megachilidea (Bogler, 1995; 1998). In addition, most species are cultivated and commercialized worldwide as ornamental plants (Rojas-Piña & Alvarado-Cárdenas, 2014), and the leaves have been used since prehistoric times to weave baskets, sandals, hats, and other household items (Reyes-Valdés, *et al*., 2012, Rodríguez *et al*., 2019). They are also used to make floral arches for religious festivals (Haeckel, 2008) and are used in the production of the liquor known as “sotol”. Unfortunately, according to the NOM-059-SEMARNAT-2010 (Secretaría del Medio Ambiente y Recursos Naturales [SEMARNAT], 2010), all species are in a critical state, threatened or endangered due to the ongoing destruction of their habitat (e.g. agriculture and urbanization) and the illegal extraction for commercialization (Cardel *et al*., 1997; Hernández-Sandoval *et al*., 2012; Rojas-Piña and Alvarado-Cárdenas, 2016; SEMARNAT, 2018).

Polygonateae is represented by the genus *Maianthemum* F. H. Wigg., which is the only genus to be represented in the Neotropics (LaFrankie, 1986), and comprises about 28-38 species. Morphologically, they are rhizomatous perennial herbs, with a sympodial rhizome, an elongated aerial stem, distichous leaves, and a paniculate or racemose inflorescence (Kim *et al*., 2010; Conran & Tamura, 1998).

Geographically, the genus *Maianthemum* occurs in eastern Asia and Central and North America, with the species restricted to two regions on each continent, 50% of the species in the high mountains of southwest China and eastern Himalayas, and the other 50% in the mountains from central Mexico to western Panama (Meng *et al*., 2008). It is often found in areas with cool temperatures and abundant moisture, mainly cloud forests and coniferous forests (LaFrankie, 1986). In general, the species behaves like temperate understory herbs (Conran & Tamura, 1998).

There is little information on this group, but some studies report that the species are economically important and are occasionally cultivated for ornamental use (Galway, 1945). Little is known about the pollination biology of *Maianthemum,* but the floral morphology of the species suggests pollination by insects (LaFrankie,1986). A wide variety of small bees, flies, and beetles visit *Maianthemum*, but the most common are hoverflies of the family Syrphidae and small bees of the families Apidae, Bombyliidae, and Halictidae. However, some species are pollinated but never fertilized (Conran & Tamura, 1998). In addition, Piper (1986) reported that some birds eat and disperse fleshy fruits. This mechanism may best explain the intercontinental disjunction and diversification of *Maianthemum* (Meng, *et al*., 2008).

The tribe Rusceae is represented by the genus *Dracaena*, which comprises 60-80 species worldwide, mainly in the tropics and subtropics, with the exception of South America, where there are only two species (Lu & Morden, 2014). In Mexico, *Dracaena americana* Donn. commonly grows in humid forests on calcareous substrates. Morphologically, it is arborescent, with leaves grouped in rosettes, a paniculate inflorescence, and soft berries. In addition, it has value in horticulture, medicine, and ceremonies of different cultures (Orellana, 2013; Lu & Morden, 2014).

2.3. Taxonomic and floristic studies from the subfamily Nolinoideae in Mexico

Numerous floristic and taxonomic works have been carried out with the aim of unveiling the descriptive aspects of the distribution, and ecological aspects of this subfamily. Some authors have conducted taxonomic studies that include descriptions and keys for determining genera and species within the subfamily Nolinoideae. For example, Trelease (1911) carried out the taxonomic treatment of the family Nolinoideae, including the genera *Beaucarnea*, *Calibanus*, *Dasylirion,* and *Nolina,* and proposed two infrageneric divisions in *Beaucarnea*, *Dasylirion* and *Nolina,* and infraspecific divisions in *Dasylirion* and *Nolina.* LaFrankie (1986) carried out a taxonomic revision of the New World species of *Maianthemum* distributed from North and Central America and Eurasian. This study recognized nine species, one variety, and one subspecies distributed around the country.

Subsequently, López-Ferrari & Espejo (1993) published a treatment of the family Convallariaceae distributed in Veracruz, they included the genus *Maianthemum* with four species. Galván (2005) worked on the taxonomic treatment of the family Nolinaceae with distribution in the Valley of Mexico, including two genera and the species *Dasylirion acrotrichum* (Schiede) Zucc. and *Nolina parviflora* (Kunth) Hemsl. Quirino (2017) studied the family Nolinaceae from Nuevo León and included *Beaucarnea* with one species, *Dasylirion* with four species, and *Nolina* with three species. Hernández-Sandoval and Rebman (2018) made a taxonomic revision of the genus *Nolina* with distribution in the Baja California peninsula, including five species and a new nomenclatural combination of *Nolina brandregeei* (Trel.) L. Hern. Finally, Hernández-Sandoval (2020) made the taxonomic treatment of the family Nolinaceae, including the genera *Beaucarnea*, *Calibanus*, *Dasylirion,* and *Nolina*.

Other contributions provided additional information, such as that Garcia-Arevalo (1992), who described *Maianthemum mexicanum* García Arév. from Durango. Espejo *et al*. (1996) described *Maianthemum comaltepecense* Espejo, López-Ferr. & Ceja in Oaxaca. García-Mendoza *et al*. (2012) described *Nolina excelsa* García-Mend. & E. Solano from Oaxaca and Ruiz-Sanchez *et al*. (2019) described *Nolina caxcana* Ruiz-Sanchez, P. Carrillo & L. Hern., and *N. rodriguezzi* Ruiz-Sanchez, P. Carrillo & L. Hern endemic to Western Mexico.

Several floristic studies have also contributed to the knowledge of this group in Mexico. For example, Espejo (2012) made an updated checklist of the liliopsids endemic to Mexico, which includes 53 species of the family Nolinaceae and 12 species of the family Convallariaceae. Of this, 41 species (77.35%) of Nolinaceae and three species (25%) of Convallariaceae were endemic to Mexico.

2.4. The subfamily Nolinoideae in Puebla

One of the most relevant taxonomic contributions to the flora of Puebla is the “Flora del Valle de Tehuacán-Cuicatlán” project, an important floristic province in the south of the state. Sánchez-Ken (1997) carried out the taxonomic treatment of the family Convallariaceae, including the genus *Maianthemum* with three species: *Maianthemum*

amoenum (H. L. Wendl.) LaFrankie, *Maianthemum paniculatum* (M. Martens & Galeotti) LaFrankie, and *Maianthemum scilloideum* (M. Martens & Galeotti) LaFrankie. Subsequently, Rivera-Lugo & Solano (2012) made the taxonomic revision of the family Nolinaceae, including the genus *Beaucarnea* with three species: *Beaucarnea gracilis* Lem., *Beaucarnea purpusii* Rose, and *Beaucarnea stricta* (K. Koch. & Fintelm.) Lem., the genus *Dasylirion* with the species *Dasylirion lucidum* Rose and *Dasylirion serratifolium*, (Kar. ex Schult. & Schult. F.) Zucc., and the genus *Nolina* with the species *N. excelsa* and *N. parviflora*.

Other relevant contributions include the work of Rodríguez *et al*. (2014), who made an exhaustive floristic study in the State of Puebla. This study reported the presence of the genus *Beaucarnea* with the species *B. gracilis*, *B. recurvata*, and *B. stricta*; the genus *Dasylirion* with the species *D. acrotrichum*, *D. lucidum,* and *D. serratifolium*; the genus *Maianthemum* with the species *M. paniculatum* and *M. scilloideum*; and the genus *Nolina* with the species *N. parviflora*, all grouped in the family Asparagaceae. Villaseñor (2016), working on an updated inventory of the native vascular plants of Mexico, reported for Puebla the genera *Beaucarnea* with four species: *B. gracilis*, *B. purpusii*, *B. recurvata,* and *B. stricta*; *Dasylirion* with three species: *D. acrotrichum*, *D. lucidum,* and *D. serratifolium*; *Maianthemum* with two species: *M. paniculatum* and *M. scilloideum*; and *Nolina* with the species *N. parviflora.*

In addition, Rojas-Piña & Alvarado-Cárdenas (2016) described a new species: *Beaucarnea olsonii* V. Rojas-Piña & L. O. Alvarado from the tropical deciduous forest of southwestern Puebla. This new addition brings the total number of endemic species of *Beaucarnea* from Mexico, increasing to ten species (Espadas, 2017).

3. Research justification

Puebla has diverse plant ecosystems that result from its latitudinal position and altitude changes (Yanes, 2011). However, most of the territory has received little attention in terms of taxonomic and floristic studies (Miguel-Vázquez, 2020). Although there are some floristic and taxonomic works in the State of Puebla that list and mention some species of Nolinoideae, little effort has been made to update the number of species and their geographical distribution in some regions. This has been influenced by the nomenclatural

criteria used to delimit taxa and the description of new species, which has caused the taxonomic delimitation of the group to be unstable and controversial. The most important studies in this issue are undoubtedly the Flora del Valle de Tehuacán-Cuicatlán project and many other works that have not been published but have contributed to the knowledge of the flora of the state. Therefore, there is no work that collects the information and helps people to identify the species distributed in Puebla. For this reason, the present study will provide the updated taxonomic treatment of the Nolinoideae, including described new records for the state, identification keys, distribution maps by species, and taxonomic descriptions

4. Hypotheses

Nolinoideae has a considerable floral and vegetative diversity, which results in a lack of morphological characteristics that allow it to be distinguished from other subfamilies of Asparagaceae. However, at the tribe level, they can be clearly distinguished based on reproductive and vegetative morphological characters. Therefore, the species of the subfamily Nolinoideae present in Puebla can be clearly identified based on their floral and vegetative morphological characters.

5. Aim

To conduct a taxonomic revision of the subfamily Nolinoideae in the State of Puebla.

5.1. Specific aims

1. Generate an updated list of genera and species of Nolinoideae.
2. To elaborate the botanical description of genera and species of Nolinoideae.
3. To create dichotomous keys to identify genera and species of Nolinoideae.
4. Represent in maps the geographic distribution of Nolinoideae.

6. Material and methods

6.1. Study area

The State of Puebla is located in the central-eastern part of Mexico, between 20°50’ N, 17°52’ S, and 96°43’ E, 99°04’ W. The state comprises 217 municipalities and covers an area of 34,309.6 km², representing 1.7% of the country's surface area.

Puebla borders Hidalgo and Veracruz to the north, Oaxaca and Veracruz to the east, Guerrero and Oaxaca to the south, and Guerrero, Hidalgo, Mexico, Morelos, and Tlaxcala to the west (Saldaña, 2011; INEGI, 2020). The entity is part of four biogeographic provinces: the Sierra Madre del Sur, the Trans-Mexican Volcanic Belt, the Sierra Madre Oriental, and the Cuenca del Balsas (Morrone, 2019) with ten physiographic sub-provinces with distinctive characteristics according to geology, altitude, hydrology, climate, precipitation, soil and vegetation (Saldaña, 2011). Altitudes range from 100 to 5,610 m, where the Pico de Orizaba or Citlaltépetl is the highest. According to the changes in altitude, Puebla has a great diversity of climates, the predominant climates are temperate sub-humid, warm sub-humid, dry, semi-dry, warm humid, temperate humid, and cold, present only in a small percentage of the state, which corresponds to the volcanic peaks. The mean annual temperature in the state is 17.5°C, and the mean annual precipitation is 1, 270 mm (Saldaña, 2011; INEGI, 2020). In terms of vegetation, according to Rzedowski (2006), the vegetation types are coniferous forests, oak forests, cloud forest, tropical semideciduous forest, tropical deciduous forest, xerophytic scrub, grassland, and aquatic vegetation.

6.2. Bibliographic research

An exhaustive bibliographic search was carried out of taxonomic treatises and floristic studies, in which at least one species of Nolinoideae was recorded in the state (García-Mendoza & Galván, 1995; Sánchez-Ken, 1997; Rivera-Lugo & Solano, 2012; Rodríguez *et al*., 2014; Rojas-Piña & Alvarado-Cárdenas 2016; Villaseñor, 2016; Ruíz-Fores & Castro-Castro, 2024). Also, a preliminary list of the taxa mentioned in the literature was made.

6.3. Herbaria review

A taxonomic revision of the herbarium specimens deposited in different herbaria in Mexico was carried out: HUAP, IBUG, MEXU, QMEX, and XAL (Thiers, 2024). In addition, digitalized specimens from the herbaria ASU, ARIZ, DES, GH, MICH, NY, RSA, SD, TEX, USF, and WIS were reviewed to complement the search (Thiers, 2024). All digitalized specimens were obtained from the databases of the platforms Colección del Instituto de Biología de la Universidad Nacional Autónoma de México (IBdata, 2022), Global Biodiversity Information Facility (GBIF, 2022), Red de Herbarios de Mexicanos (Red de Herbarios Mexicanos, 2022), and Southwest Environmental Information Network (SEINet, 2022). The nomenclature was updated according to Chase *et al*. (2009) and APG IV (2016), and International Plants Name Index (IPNI, 2024), Plants of the World Online (POWO, 2024) and World Flora Online (WFO, 2024) platforms were consulted for accepted names and synonyms.

6.4. Database elaboration

With the information obtained from the herbaria and digitalized specimens, a database was created in Microsoft Excel containing taxonomic data (order, family, genus, and scientific name), curatorial data (collector, collection number, identifier, identification date and duplicate), geographical data (country, state, municipality, locality, latitude, longitude, and altitude), and ecological data (habit, vegetation, phenology, substrate, substrate, characteristics and associated taxa).

6.5. Morphological description and taxonomic keys

To elaborate the botanical descriptions and taxonomic keys, a documentation of vegetative and reproductive characters of the genera and species was made following the botanical terminology of Harris & Woolf (2001). The characters documented were habit, leaves, inflorescences, flowers, and fruits. The morphological characters were verified through the examination of herbarium specimens and supplemented by specialized literature (LaFrankie, 1986, López-Ferrari & Espejo, 1993, Sánchez, 1997, Rivera-Lugo & Solano, 2012, Alvarado-Cárdenas 2016; Hernández-Sandoval, 2020). Diagnostic

characters of each genus and species were selected to elaborate the dichotomous keys (Table 1).

Table 1. A comparison of the diagnostic characters of *Beaucarnea*, *Dasylirion*, *Nolina,* and *Maianthemum*. NO = not observed.

		Nolineae		**Polygonateae**
Character/Taxon	***Beaucarnea***	***Dasylirion***	***Nolina***	***Maianthemum***
Habit	Arborescent	Shrubby	Arborescent	Herb
Stem	Swollen base	Cylindrical caudex	Not swollen base	Flexuous
Leaves	Linear to ensiform	Linear	Linear	Elliptic to lanceolate
Margin	Micro serrulate	Serrulate with prominent prickles	Serrulate or filiferous	Entire or undulate
Apex	Acute	Fibrous	Acute	Acuminate
Inflorescence	Lax panicle	Spiciform panicle	Lax panicle	Panicle or raceme
Flowers				
Tepals	Crenate	Crenate	Apical trichomes	NO
Pistillode	Inconspicuous papillose	Inconspicuous papillose	Prominent globose	NO
Gynoecium	Fleshy tripterous	Coriaceous tripterous	Fleshy lack wins	Fleshy
Ovary	Unilocular	Unilocular	Trilocular	Trilocular
Style	Short	Prominent infundibuliform	NO	Filiform
Stigma	Trilobed papillose	Trilobed not papillose	NO	Capitate or lobate
Fruit	Unilocular tripterous	Unilocular tripterous	Trilocular globose	Trilobed or spheric

6.6. Geographical data

Geographical coordinates were used when indicated on the herbarium specimen labels. When the specimens did not have latitude and longitude data, these were estimated using Google Earth Pro v. 7.3 (Google, 2024) following the SAGA protocol (Bloom, *et al*., 2017). If locations were not specified or lacked geographic coordinates, they were excluded. Duplicate, unlocated, or doubtful localities were excluded. Distribution maps were created using QGIS v. 3.34, (QGIS, 2024) following the proposal of potential vegetation of Mexico by Rzedowski (1990).

7. Results

A total of 300 specimens were examined. The taxa with the highest number of records were *N. parviflora* (76), *B. gracilis* (70) and *D. lucidum* (45). The taxa, with the lowest number of records were *D. serratifolium* (1). In addition, *Maianthemum macrophyllum* (M. Martens & Galeotti) LaFrankie was reported for the first time in Puebla.

The updated list included eleven species, four genera and two tribes naturally occurring in Puebla (Table 2). The most abundant genera were *Beaucarnea* with four species, followed by *Dasylirion* and *Maianthemum* with three species each, *N. parviflora* was the only species reported for the genus *Nolina*.

The following is the taxonomic treatment, including taxonomic keys to determine the eleven species, four genera, and two tribes of Nolinoideae, descriptions, and distribution maps.

Table 2. Updated list of Nolinoideae species. In bold, new records.

Tribes and species	References	Municipality
Nolineae		
Beaucarnea gracilis Lem.	García-Mendoza and Galván (1995), Rivera-Lugo and Solano (2012), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016)	CAL, TEH, SJM, ZAP
Beaucarnea olsonii V. Rojas-Piña & L.O. Alvarado	Rojas-Piña and Alvarado-Cárdenas (2016)	ACA
Beaucarnea purpusii Rose	García-Mendoza (1995), Rivera-Lugo and Solano (2012), Villaseñor (2016)	CAL, JNM, TEH, ZAP
Beaucarnea stricta (K. Koch & Fintelm.) Lem.	Rivera-Lugo and Solano (2012), Rodríguez *et al*. (2014), Villaseñor (2016)	JNM, TEH, XTS, ZAP
Dasylirion acrotrichum (Schiede.) Zucc.	García-Mendoza and Galván (1995), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016), Ruíz-Fores and Castro-Castro, (2024)	COX, COY, CUA, GVI, HUI, MOL, TEP, TPJ, TDR, SNB, XTS, YEH
Dasylirion lucidum Rose	García-Mendoza and Galván (1995), Rivera-Lugo and Solano (2012), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016), Ruíz-Fores and Castro-Castro, (2024)	CAL, CHA, ESP, GVI, PDB, SMA, SMH, TEP, TEH, TBJ, ZAP
Dasylirion serratifolium (Karw. ex Schult. & Schult. F.) Zucc.	Rivera-Lugo and Solano (2012), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016), Ruíz-Flores and Castro-Castro, (2024)	AJA
Nolina parviflora (Kunth) Hemsl.	García-Mendoza and Galván (1995), Rivera-Lugo and Solano (2012), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016)	ALJ, CHI, COX, CUY, GVI, LAF, ORI, PDB, SNB, SMA, TDR, TEP, TBJ
Polygonateae		
Maianthemum macrophyllum (M. Martens & Galeotti) LaFrankie	ND	AHU, ZAC

Maianthemum paniculatum (M. Martens & Galeotti) LaFrankie	Sánchez-Ken (1997), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016)	CUE, HUE, TLA, TEZ, TLC, ZAC,
Maianthemum scilloideum (M. Martens & Galeotti) LaFrankie	Sánchez-Ken (1997), Rodríguez-Acosta *et al*. (2014), Villaseñor (2016)	COX, HUA, XOC, XCH, ZAC, ZAU,

ACA=Acatlán de Osorio, AHU=Ahuacatlán, AJA=Ajalpan, ALJ=Aljojuca, CAL=Caltepec, CHA=Chapulco, CHI=Chignautla, COX=Coxcatlán, COY=Coyotepec, CUA=Cuautinchán, CUE=Cuetzálan de Progreso, CUY=Cuyoaco, ESP=Esperanza, GVI=Guadalupe Victoria, HUA=Huauchinango, HUE=Hueytamalco, HUI=Huitziltepec, JNM=Juan N. Méndez, LAF=Lafragua, MOL=Molcaxac, ORI=Oriental, PDB=Palmar de Bravo, SJM=San José Miahuatlán, SMA=San Martín Atexcal, SMH= Santiago Miahuatlán, SNB=San Nicolás Buenos Aires, TLA=Tlacotepec de Benito Juárez, TDL=Tepanco de López, TDR=Tepexi de Rondríguez, TEH=Tehuacán, TEP=Tepeyahualco, TPJ=Tepeojuma, TLA=Tlatlauquitepec, TLC=Tlacuilote, XCH=Xochiapulco, XOC=Xocoyolo, XTS=Xochitlán Todos Santos, YEH=San Simón Yehualtepec, ZAC=Zacapoaxtla, ZAP=Zapotitlán Salinas, ZAU=Zautla. ND=data no available.

7.1. Taxonomic treatment

Nolinoideae Burnett

Plants hermaphroditic, dioecious, or polygamodioecious, perennials, herbs rhizomatous, arborescent, sometimes shortly caulescent. **Stems** simple or branched, erect, arching, or decumbent. **Leaves** distichous or grouped in rosettes, sessile or petiolate, blade linear to ensiform or ovate to elliptic, base triangular or rounded, margin entire, undulate or serrulate, sometimes with prickles, apex acute, acuminate, rarely fibrous. **Inflorescence** paniculate or racemose, persistent bracts. **Flowers** small, inconspicuous, trimerous, actinomorphic, hypogynous, perianth cupuliform or spreading, sometimes reflexed, tepals 6 in two whorls, free, imbricate, ovate to elliptic, whitish to yellow, stamens 6, antepetalous, exerted, rudimentary in pistillate flowers, filaments whitish, anthers introrse, dorsifixed, longitudinal dehiscence, ovary tricarpellary, unilocular or trilocular, rudimentary in staminate flowers, style absent to prominent, stigma trilobed. **Fruits** are fleshy berries, spherical to trilobed, or dry indehiscent, winged, sometimes globose or trilobed. **Seeds** per fruit 1 to 3(-4).

Taxonomic key to the tribes of Nolinoideae in Puebla

1. Arborescent, sometimes shortly caulescent, leaves grouped in rosettes, blade linear, margin serrulate, sometimes with prickles, apex acute, sometimes fibrous, fruits dry indehiscent, winged or globose, trilobed…… Nolineae
2. Herbs rhizomatous, leaves distichous, blade ovate to elliptic, margin entire, apex acuminate, fruit fleshy berries, spherical or trilobed……... Polygonateae

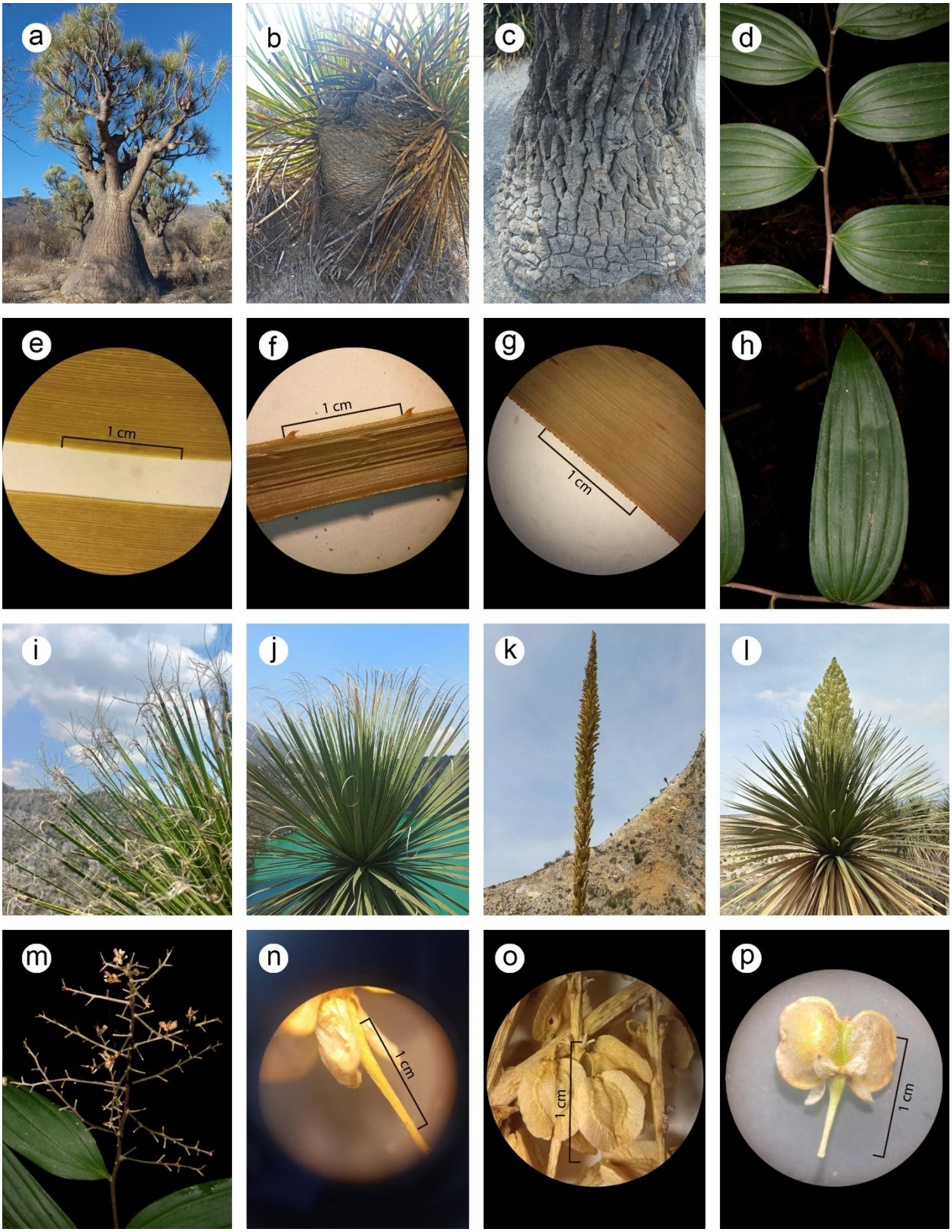

Figure 1. Some morphological differences between *Beaucarnea*, *Dasylirion*, *Nolina* and *Maianthemum*. **a**, stem of *Beaucarnea*; **b**, stem of *Dasylirion*; **c**, stem of *Nolina*; **d**, stem of

Maianthemum; **e**, margin of *Beaucarnea*; **f**, margin of *Dasylirion*; **g**, margin of *Nolina*; **h**, margin of *Maianthemum*; **i**, apex of *Dasylirion*; **j**, apex of Nolina; **k**, inflorescence of *Dasylirion*; **l**, inflorescence of *Nolina*; **m**, inflorescence of *Maianthemum*; **n**, tepals of *Nolina*; **o**, fruit of *Beaucarnea,* and **p**, fruit of *Nolina*.

Nolineae Watson

Plants dioecious to polygamodioecious, perennials, arborescent, sometimes shortly caulescent. **Stems** erect or decumbent, sometimes stem base swollen, simple or branched with terminal rosettes, sometimes with persistent marcescent leaves. **Leaves** linear to ensiform, canaliculate, flat or concave, smooth or rugose, base usually deltoid to triangular, concave, leaf margin serrulate, denticles inconspicuous, sometimes with prominent prickles, apex usually acute, sometimes fibrous. **Inflorescence** paniculate, lax, rarely spiciform, branches of primary and secondary order with papyraceous bracts decreasing in size towards the apex, flowers born in articulated pedicels along the branches in fascicles, membranous, laciniate bracteoles. **Flowers** with tepals erect to reflexed, ovate to obovate, whitish to cream, crenate or with trichomes. **Staminate flowers** with 6 stamens, exerted, filaments subulate, anthers introrse, dorsifixed, **pistillode** inconspicuous to prominent and functioning as a nectary. **Pistillate flowers** with tricarpellary ovary, fleshy or coriaceous, sometimes winged, unilocular or trilocular, style reduced to prominent, stigma trilobed, sometimes papillose, **staminodes** 6, included. **Fruits** dry indehiscent, winged or trilobed, globose, papyraceous or scarious, persistent tepals, sometimes persistent style. **Seed** per fruit 1 or 3, sometimes one per locule or none if ovules are abortive, trigonous or rounded.

Taxonomic key to the genera of Nolineae from Puebla

1. Plants arborescent, leaf margin serrulate, apex acute, inflorescence lax panicle……..... 2
1. Plants shortly caulescent, leaf margin serrulate with prickles, apex fibrous, inflorescence spiciform……... *Dasylirion*

2. Stem base massively swollen, tepals apex crenate, ovary unilocular, fruit winged……..... *Beaucarnea*

2. Steam base slightly swollen, tepals apex with glandular trichomes, ovary trilocular, fruit globose……. *Nolina*

Beaucarnea Lem.

Plants arborescent, dioecious, 3 to 12 m tall, **base** conic to globose, swollen, bark thick, tessellated, rugose, branching pseudo dichotomous with terminal rosettes. **Leaves**, linear to ensiform, smooth to papillose, erect, green to glaucous blue green, margin micro-serrulate, denticles persistent or deciduous with age, apex acute. **Inflorescence** paniculate, branching order primary, secondary, sometimes tertiary, decreasing in size acropetally, bracts usually linear to linear lanceolate, bracteoles per flower 1, usually enclosing the flower. **Staminate flowers** 2 to 6 per node, stamens exerted, anthers introrse, basifixed or versatile, longitudinal dehiscence, **pistillode** usually inconspicuous, trilobed, papillose. **Pistillate flowers** 1 to 2(3) per node, **ovary** fleshy, unilocular, tripterous, style usually reduced, stigma trilobed, papillose, exerted. **Fruit** tripterous, papyraceous, round to ellipsoid, yellow, apical notch ca. 1 mm, tepals and style persistent. **Seed** per fruit 1, trigonous, ovoid to ellipsoid, brown to reddish brown, rugose.

Taxonomic key to the species of *Beaucarnea* from Puebla

1. Marcescent leaves covering the branches …….…… 2
2. Leaves linear, margin green to yellowish, denticles not persistent, ovary pyriform, fruit ellipsoid……. *Beaucarnea purpusii*

2. Leaves ensiform, margin yellow, denticles persistent, ovary ellipsoid, fruit obovoid …..……..... *Beaucarnea stricta*

1. Without marcescent leaves covering the branches …….……..... 3
3. Short and robust branches, leaves narrowly linear, margin green tinged reddish, denticles persistent, ovary pyramidal, fruit round ……. *Beaucarnea gracilis*

3. Long and slender branches, leaves linear to ensiform, margin green, denticles not persistent, ovary pyriform, fruit ovoid to ellipsoid ……..…. *Beaucarnea olsonii*

Beaucarnea gracilis Lem., Ill. Hort. viii (1861) Misc. 61.

Ξ *Dasylirion gracilie* (Lem.). J.F. Macbr. in Contr. Gray Herb. 56: 17 (1918), nom. Illeg.

Ξ *Nolina gracilis* (Lem.) Cif. & Giacom. in Nomenclator Fl. Ital. 1:136 (1950)

= *Beaucarnea oedipus* Rose in Contr. U. S. Natl. Herb. 10:88 (1906)

= *Nolina histrix* Trel. In Proc. Amer. Philos. Soc. 50: 430 (1911)

Plants arborescent, (-3)5 to 8(-9) m tall, base conic to globose, 1.5 to 2.5 m diameter, bark thick, gray to brown, rugose, with rectangular to polygonal geometric plates, basal branches short and robust, terminal branches thin and elongate. **Leaves** linear, narrow, erect, green to glaucous green, base deltoid, flat to slightly concave, orangish, margin micro-serrulate, green, tinged reddish with age, denticles persistent, apex acute. **Inflorescence** ovoid, (0.4)0.6 to 1.0(1.5) m long, branches primary and secondary, sometimes tertiary in the base of the inflorescence, decreasing in size acropetally, branchlets 4 to 8 cm long, bracts linear to triangular, adpressed. **Staminate flowers** 4 to 6 per node, tepals ovate, erect, white to yellowish, filaments ca. 1 mm long, anthers dorsifixed to versatile, ca. 1 mm long. **Pistillate flowers** 4 per node, tepals white to yellowish, **ovary** pyramidal, style short to absent. **Fruit** round, yellowish. **Seed** ovoid, brown.

Habitat and distribution: This species is endemic to Tehuacán-Cuicatlán valley in the State of Puebla and grows in rocky soils on cliffs or mountain sides with steep slopes, in xerophytic scrub with *Cephalocereus columna-trajani* (Karw. ex Pfeiff.) K.Schum., *Neubuxbaumia tetetzo* (F.A.C. Weber ex J.M.Coult.) Backeb., *Agave* L., *Dasylirion* Zucc., *Hechtia* Klotzsch. and *Yucca* L., from 886 to 2373 m altitude (figure 2). This species flowers from March to August and fruits from September to January.

Taxonomic notes: *Beaucarnea gracilis* is so similar to *B. purpusii* and *B. stricta* that it is difficult to differentiate them. However, *B. gracilis* can be distinguished by its highly branched stem, narrow and erect leaves with a reddish-green and slightly concave, orangish base. However, the attribute that best distinguishes the species is the pyramidal ovary.

Examined specimens: MEXICO. Puebla: San José Miahuatlán, Agua Xoca; between Huajuapan and Tehuacán, 30 km from Tehuacán near km 30, 01 February 1966, *J. Henrickson and B. Christman 2128* (MICH); Cañada corral de burros, Cerro Tepetroja, al sur de Axuxco, 23 June 1992, *Antonio Salinas T. and Verónica Juárez J. 6958* (MEXU);

6-7 km al SO de Axuxco (entre Cerro Tepetroja y C. Chacantitla), 26 July 1992, *Antonio Salinas and Verónica Juárez Jaimes 7008* (MEXU, XAL). Tehuacán, 5 km al sur de Tehuacán, 01 January 1987, *Luis Hernández 2138* (IEB, MEXU, QMEX, XAL); km 14 de la carretera Tehuacán-Huajuapan de León, 16 June 1989, *Luis Hernandez S., Mahinda Martinez, D. Bogler and J. Bogler 2368* (IEB, LL, MEXU, QMEX, XAL), *2369* (IEB, LL, QMEX, XAL), *2370* (ARIZ, IEB, LL, MEXU, QMEX); km 14 de la carretera Tehuacán-Huajuapan, 07 January 1991, *Luis G. Hernández and Esteban Martínez 2509* (LL), *2510* (IEB, LL, MEXU, QMEX), *2512* (LL), *2513* (LL), *2514* (LL), *2515* (LL), *2516* (LL); Carretera 125, 1 km antes de San Antonio Texcala, 09 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 17* (MEXU); Colonia Los Manantiales o Los Paredones, 6 km al NW de Tehuacán, 15 June 1989, *Luis Hernandez S., Mahinda Martinez, D. Bogler and J. Bogler 2354* (IEB, LL, MEXU, QMEX, XAL), *2355* (IEB, LL, MEXU, QMEX, XAL), *2357* (LL, QMEX); El Ollal km 62, carretera Tehuacán-Huajuapan-Oaxaca, 01 January 1987, *Luis Hernández 2140* (IBUG, MEXU, QMEX); Meseta de San Lorenzo, Aut. 150-135 Cuacnopalan-Oaxaca, antes de entrar a Tehuacán, 07 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 9* (MEXU); Meseta de San Lorenzo, a 8 Km al W de Tehuacán, camino al Tecamachalco, 27 June 1987, *Esteban M. Martínez, Abisaí García and A. Salinas 21687* (MEXU); Meseta de San Lorenzo, a 8 Km al W de Tehuacán, camino al Tecamachalco, 06 June 1991, *Luis G. Hernández and Esteban Martínez 2334* (LL), *2357* (LL), *2498* (LL). Zapotitlán Salinas, 2 km al noroeste del poblado de San Juan Raya, 05 November 1991, *A. Valiente B., A. Casas and J. L. Viveros 360* (MEXU); 3.1 km al N de la localidad de Zapotitlán, 11 September 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13422* (HUAP); 0.5 km al S de Zapotitlán, 21 October 2009, *Luis Hernández-Sandoval 6298* (QMEX), 21 October 2010, *Hernández-Sandoval L. 6289* (QMEX);1 km al S de Zapotitlán de las Salinas, 07 March 1998, *Hernández-Sandoval L., Valiente, A. and Treviño, J. 4289* (QMEX), 26 September 2000, *J. I. Calzada 22896* (HUAP, XAL); 1 km al S de Zapotitlán Salinas, hacia Huajuapan de León, 07 January 1991*, Luis Hernández Sandoval and Esteban Martínez 2517* (LL), *2518* (LL), *2519* (LL), *2520* (LL), *2521* (LL), *2522* (LL), *2523* (LL), *2524* (LL); 5. 2 miles S of San Antonio Texcala, 17 July 1978, *M. Pennel and D. Dunn, C. Dziekanowski 196* (ASU); 3 Km al SW de San Antonio Texcala, 24 October 1964, *Jerzy Rzedowski 19137* (ENCB, LL,

MEXU); 1 km al W de Zapotitlán, hacia el N de la carretera, 04 June 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 12990* (HUAP), *12992* (HUAP), *12993* (HUAP); 3 km al W de la localidad de Zapotitlán, en dirección a Huajuapan y 1.3 km al N de la carretera, 11 September 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13433* (HUAP); 3 km al W de la localidad de Zapotitlán, en dirección a Huajuapan y 1.3 km al N de la carretera, 11 September 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13439* (HUAP); 3.8 km al W de Zapotitlán Salinas, 10 September 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13403* (HUAP), *13404* (HUAP); 3.9 km al W de Zapotitlán Salinas, 10 September 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13407* (HUAP); 5.4 km por desviación de terracería dirección San Juan Raya, a partir de carretera Zapotitlan – Huajuapan, 16 May 2019, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 13058* (HUAP), *13060* (HUAP), *13065* (HUAP); 85.5 km de Huajuapan, entre Huajuapan y Tehuacán, 09 June 2010, *Mark Olson 41* (MEXU); Along Hwy 125 about 12.9 mi NE of Oaxaca border, 23 July 1976, *W. D. Stevens, M. J. Donoghue, and M. L. Scott 2535* (MICH); Al SW de Barrio La Providencia en Loc. Zapotitlan, 16 May 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 13074* (HUAP); A orilla de cañada, al SW de Loc. Zapotitlan, 16 May 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 13072* (HUAP), *13073* (HUAP); A partir de carretera, 1.8 km sobre terracería en desviación a Loc. de San Juan Raya, 16 May 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 13068* (HUAP); Camino a Las Salinas de San Gabriel, a Salinas Rinconada, 04 May 1979, *J. I. Calzada 5339* (XAL); Camino a San Juan Raya, 01 September 1982, *J.M. Gallardo and J.A. Zavala 50* (MEXU, XAL); *8521* (LL, XAL); Carretera 125, 1 km antes de San Antonio Texcala, 09 August 2009, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 17* (MEXU); Carretera a Tehuacán 125, 2 km al sur de Zapotitlán, 23 October 1978, *B. Leuenberger et. C. Schiers 2558* (MEXU); Carr. Zapotitlán-Santiago Chazumba, 12 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 10* (MEXU); En la desviación a San Juan Raya, 12 January 1978, *V. Vazquez T. 651* (IBUG, IEB, MEXU, XAL); Proximidad a Zapotitlán de las Salinas, en el entronque a Los Reyes Metzontla, 02 May 2005, *Enrique Guízar Nolazco and Andrés G. Miranda Moreno 4946*

(CHAP, IBUG, IEB, MEXU, XAL); Terracería a Los Reyes Metzontla, 07 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 12* (MEXU).

Figure 2. *Beaucarnea gracilis*. **a**, inflorescence branch; **b**, leaves and bark; **c**, infructescence branch and leaves; **d**, infructescence branch.

Beaucarnea olsonii V. Rojas-Piña & L. O. Alvarado, Phytotaxa 286(1): 15 (2016).

Plants arborescent, 3 to 6(-8) m tall, base globose, 2.4 to 4 m diameter, bark tick, gray, rugose, forming irregular groves along the length of the stem, long and thin branches. **Leaves** linear to ensiform, erect, green to bluish glaucous green, base triangular to widely triangular, flat to involute, whitish to greenish, margin micro serrulate to entire, green with denticles not persistent, apex acute**. Inflorescence** ovoid, branching primary, secondary and tertiary, decreasing in size acropetally, bracts narrowly triangular to triangular decreasing in size acropetally. **Staminate flowers** not observed. **Pistillate flowers** 3 per node, tepals ca. 2 mm long, **ovary** pyriform, style short, stigma conic, prominent. **Fruit** ovoid to ellipsoid, yellowish. **Seed** brown, rugose.

Habitat and distribution: Plants of *Beaucarnea olsonii* grow on steep slopes in the southwest of Puebla, in tropical deciduous forest with *Acacia* M., *Agave*, *Bursera* Jacq. ex L., *Dioon* Lindl., *Gonolobus* Michx., *Hechtia* Klotzsch., *Ipomea* L., *Manihot* Mill., *Pachycereus* (A. Berger) Britton & Rose and *Stenocereus* (A. Berger) Riccob, at altitudes above 1200 m. (figure 2). This species flowers from September, fruits from August to February.

Taxonomic notes: *B. olsonii* is easy to distinguish because the base tapers abruptly into a few long and thin branches, the leaf margin is serrulate or entire with denticles not persistent, and the base is involute, whitish to greenish. Moreover, *B. olsonii* also differs from the other species in its ovary, which is pyriform with a conical, prominent stigma. Although the description in this study was based on herbarium specimens without flowers, *B. olsonii* can be distinguished on the basis of vegetative characters and habitat.

Examined specimens: MEXICO. Puebla: Acatlán de Osorio, 3.1 km al W de Loc. Nuevos Horizontes, 28 February 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 12904* (HUAP), *12905* (HUAP), *12906* (HUAP), *12907* (HUAP); 4.3 km al W de Nuevos Horizontes, sobre carretera, 23 November 2018, *Lucio Caamacho Onofre and Eladio Cesar Flores Huitzil 12722* (HUAP), *12723* (HUAP), *12724* (HUAP); 4.5 km al W de localidad Nuevos Horizontes, sobre carretera Internacional, 07 August 2018, *Lucio*

Caamacho Onofre and Michelle Xicotencatl Lozano 12767 (HUAP), *12768* (HUAP); Carr. 190 Izúcar-Huajuapan, entre la desviación a Ahuehuetitla y La Noria, 08 June 2018, Vanessa Rojas Piña junto and Mark Olson 37 (MEXU); Carr. 190 Izúcar-Huajuapan. A 21.6 km de Tehuitzingo, entre la desviación a Ahuehuetitla y la desviación a La Noria, 28 September 2006, *Mark Olson, Angélica Cervantes and Ken Olsen 1044* (MEXU); Carretera Internacional 190, 2.8 km antes de llegar a localidad Nuevos Horizontes en dirección Izúcar-Acatlán, 01 February 2017, *Lucio Caamacho Onofre 10278* (HUAP); Carretera Izúcar-Acatlán, 22 April 2015, *Vanessa Rojas, Mark Olson, Francisco Vergara and Darren Burton 57* (MEXU); Carretera Izúcar-Acatlán, entre la desviación a Noria Chica y la desviación a Ahuehuetitla, 22 April 2015, *Vanessa Rojas, Mark E. Olson, Francisco Vergara and Darren Burton 58* (MEXU); Carr. 190 Izúcar-Huajuapan, entre la desviación a Ahuehuetitla y La Noria, 08 June 2018, Vanessa Rojas Piña junto and Mark Olson 37 (MEXU).

Figure 3. *Beaucarnea olsonii*. **a**, infructescence branch; **b**, leaves.

Beaucarnea purpusii Rose, Contr. U. S. Natl. Herb. 10: 89 (1906)

Plants arborescent, (-4)6 to 10(-12) m tall, base widely conic, 1 to 2(-3) m diameter, bark thick, gray, brown, forming rectangular plates, few branches, robust, marcescent leaves along the branches. **Leaves** linear, almost flat, green to green glaucous, base deltoid to triangular, orangish, margin micro serrulate to entire, denticles not persistent, green to yellowish, apex acute. **Inflorescence** ovoid to ellipsoid, 1.3 to 1.5 m long, branches primary and secondary decreasing in size acropetally, branchlets ca. 4 to 9 cm long, triangular, bracts. **Staminate flowers** 4(-5) per node, tepals ovate, erect, white to yellowish, filaments ca. 1 mm long, anthers dorsifixed to versatile, ca. 1 mm long, sagittate. **Pistillate flowers** 2 to 3 per node, tepals ca. 1.5 to 2 mm long, **ovary** pyriform, style short, stigma with prominent lobules. **Fruit** ellipsoid, yellow. **Seed**, ellipsoid, reddish brown.

Habitat and distribution: This species is endemic to Tehuacán-Cuicatlán valley in the State of Puebla, and grows on steep slopes, on calcareous outcrops in ravines and canyons, in xerophytic scrub with *Agave*, *Acacia*, *Brahea* Mart. Ex Endl., *Coryphantha* (Engelm.) Lem., *Dasylirion*, *Euphorbia* L., *Ferocactus* Britton & Rose and *Yucca*, from 1417 to 2320 m altitude (figure 2). This species flowers from January to June, fruits from May to October.

Taxonomic notes: *Beaucarnea purpusii* is morphologically most similar to *B. stricta* in and is generally considered to be this. However, *B. purpusii* is distinguished by having a green to yellowish leaf margin with non-persistent denticles, and an orangish leaf base, and a pyriform ovary and stigma with prominent lobules.

Examined specimens: MEXICO. Puebla: Caltepec, 4 km al E de Caltepec, 22 October 2010, Hernández-Sandoval L. 6291 (QMEX); 8 km al W de Chazumba, alrededores de la Colonia San Miguel, límite entre los estados de Puebla y Oaxaca, 16 June 1989, *Hernández-Sandoval, L., Martínez, Mahinda, Bogler, D. and Bogler, J. 2371* (QMEX), 07 January 1991, *Luis Hernández Sandoval and Esteban Martínez 2528* (LL), *2531* (LL), *2532* (LL), *2533* (LL), *2534* (LL); Carretera Tehuacán-Huajuapan, 01 January 1987, *Hernández-Sandoval, L. 2139* (QMEX); Cerro de Las Flores, 12 km después de San Francisco Xolotitlán, rumbo a San Luis Atolotitlán, 01 January 1991, *Hernández-*

Sandoval, L. 4331 (QMEX); Colonia San Miguel. 8 km al E de Chazumba, en la carr. Tehuacán-Huajuapan de León, 07 January 1999, *Luis Hernández Sandoval and Esteban Martínez 2525* (LL), *2526* (LL), *2527* (LL), 2529 (LL), 2530 (LL); El Coro, 10 km al NW de Caltepec, 6.6 km al SE de Acatepec, 09 May 1983, *P. Tenorio L. and C. Romero de T. 3886* (XAL); Límite entre Puebla y Oaxaca. A 68 km de Huajuapan, por la desviación a Caltepec. A 75.4 km de Huajuapan, en Caltepec, 08 June 2010, *Vanessa Rojas Piña and Mark Olson 39* (MEXU). Juan N. Méndez, 3.5 km al E de Zonatitlanapa, 19 October 1988, Pedro Tenorio L. and Rafael Torres C. 15302 (XAL). Santiago Miahuatlán, 4.6 Km (by road) NWN of Tehuacán, along E of Hwy 150, *James P. Folsom, Brown James Dice and H. Wier 11173* (LL). Tehuacán, Carretera Zapotitlán Salinas, 28 August 1999, Hernández-Sandoval, L., 4423 (QMEX); Colonia Los Manantiales o Los Paredones, 6 Km al NNW de Tehuacán, 15 July 1989, Jim Bogler, Luis Hernández Sandoval Mahinda Martinez and David J. Bogler 2558 (LL), Meseta de San Lorenzo, a 8 Km al W de Tehuacán, camino al Tecamachalco, 06 January 1991, *Hernández Sandoval and Esteban Martínez 2499* (LL), *2500* (LL), *2501* (LL), *2502* (LL), *2503* (LL), *2505* (LL), *2507* (LL), *2508* (LL). Xochiltepec, 2 km al S de Xochiltepec, Luis Hernández S. 6290 (QMEX). Zapotitlán Salinas, 1 km al suroeste de Zapotitlán de Salinas, por una brecha abandonada, 12 June 1991, A. Valiente Banuet. A. Casas, J. L. Viveros, C. Montaña and A. Montana 933 (XAL); 3.1 km al N de la localidad de Zapotitlán, 11 September 2019, *Lucio Camaacho Onofre and Eladio Cesar Flores Huitzil 13415* (HUAP), *13426* (HUAP), *13427* (HUAP), *13428* (HUAP); 5 km al SE de Xochiltepec, por el camino hacia Atolotitlan, 06 May 1997, *Abisaí García Mendoza and Laura de la Rosa 6496* (ASU, DES, MEXU)

Figure 4. *Beaucarnea purpusii*. **a**, leaves; **b**, infructescence branch.

Beaucarnea stricta Lem.

Ξ *Dasylirion strictum* (K. Koch & Fintelm.) J. F. Macbr. In Contr. Gray Herb. 56: 17 (1918)

Ξ *Nolina stricta* (K. Koch & Fintelm.) Mottet. In Dict. Pract. Hort. 3: 481 (1895-1896)

Ξ *Pincenectia stricta* K. Koch & Fintelm. In Wochenschr. Gärtnerei Pflanzenk. 2: 112 (1859)

= *Beaucarnea glauca* (K. Koch & Fintelm.) Hereman in Pocket Bot. Dict., New ed.: 602 (1868)

= *Dasylirion laxiflorum* Baker in J. Bot. 120: 299 (1872)

= *Nolina glauca* (K. Koch & Fintelm.) Mottet in Dict. Prat. Hort. 3:481 (1895-1896)

= *Pincenectia glauca* K. Koch & Fintelm. In Wochenschr. Gärtnerei Pflanzenk. 2: 112 (1859)

Plants arborescent (-3)4 to 8 m tall, base widely globose to conic, 0.8 to 2 m diameter, bark tick, gray to brown, with rectangular to polygonal geometric plates, few branches, robust, marcescent leaves under the rosettes. **Leaves** ensiform, flat or slightly concave, reflexed with age, light green to nearly yellow, base deltoid, flat, yellowish to orangish, margin micro serrulate, yellow, denticles persistent, apex acute. **Inflorescence** paniculate, ellipsoid, 0.9 to 1 m long, greenish to yellowish, branches primary, secondary and tertiary decreasing in size acropetally, branchlets 3 to 10 cm long, linear to triangular bracts decreasing in size towards the apex, bracteoles per flower 1, scarious. **Staminate flowers** 4 to 6 per node, tepals ca. 3.5 mm long, ovate, white to cream, filaments ca. 1 mm long, anthers dorsifixed or versatile, ca. 1 mm long. **Pistillate flowers** 1 to 2 per node, tepals ca. 1.5 to 2 mm long, ovate, white, **ovary** ellipsoid. **Fruit** obovoid, yellowish. **Seed** ellipsoid, brown reddish.

Habitat and distribution: This species grows in shallow calcareous and sandy soils at 1500 to 2100 m altitude in xerophytic scrub and tropical deciduous forest, and it is endemic to the Tehuacán-Cuicatlán valley in the State of Puebla (figure 2). The plant flowers from January to September, and fruits from March to December.

Taxonomic notes: *Beaucarnea stricta* is morphologically similar to *B. gracilis* and *B. purpusii* but differs in having ensiform leaves, light green to almost yellow margin, and a greenish to yellowish inflorescence.

Examined specimens: MEXICO. Puebla: Caltepec, El Coro, 10 km, NW of Caltepec or 6 km, SE of Acatepec, 09 May 1983, *P. Tenorio L. and C. Romero de T. 2370* (DES), *P. Tenorio L. 3886* (MEXU, WIS). Juan N. Méndez, La Cuesta, 3.5 km al E de San Andrés Zoyatitlanapan, 10 October 1988, *P. Tenorio L. and R. Torres C. 15302* (HUAP). Tehuacán, 47 km al SW de Tehuacán, por la carretera a Huajuapan de León, 03 September 1979, *Fernando Chiang C., F. G. Medrano and V. Jaramillo, P. Dávila 374* (ASU, MEXU). Xochitlán Todos Santos, Carretera Santiago Alseseca-Xochitlán Todos Santos Al N de Xochitlán en Capilla, 19 February 2015, *Lucio Caamacho Onofre and Allen J. Coombes 6851* (HUAP). Zapotitlán Salinas, 1 km al SO de Zapotitlán Salinas, 12 July 1991*, A. Valiente B., A. Casas, J. L. Viveros, C. Montana and A. Montana 933* (HUAP); 3 km al E de Los Reyes Metzontla, 17 February 1988, *Antonio Salinas T. and Gabriel Flores*

F. 4672 (MEXU); Carretera 125, Límite entre Puebla y Oaxaca, 08 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 14* (MEXU), 09 August 2006, *Vanessa Rojas Piña, Rosalinda Medina and Leonardo Alvarado 15* (MEXU).

Figure 5. *Beaucarnea stricta*. **a**, inflorescence branch; **b**, infructescence branch with immature fruits; **c**, **d**, infructescence branch and leaves.

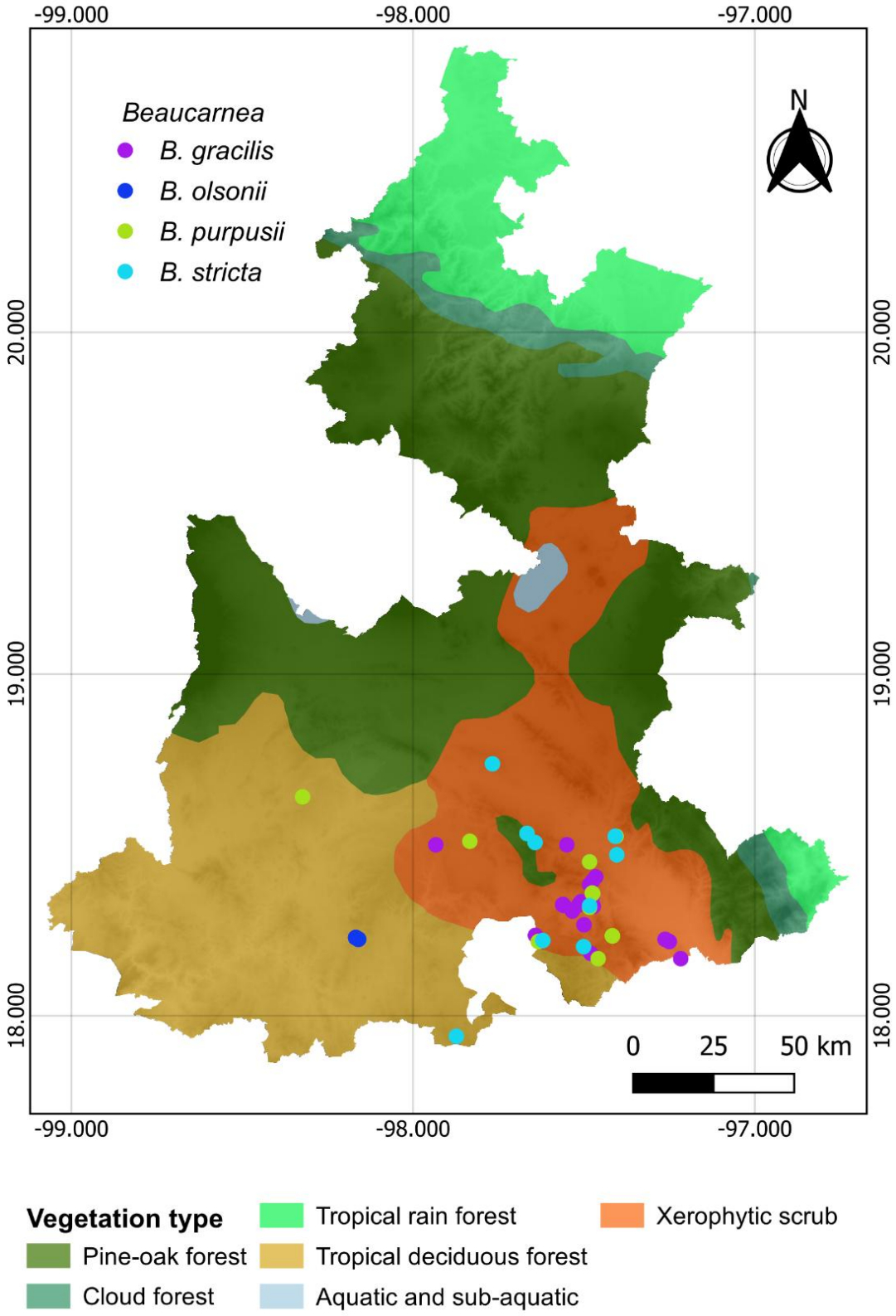

Figure 6. Geographic distribution of *Beaucarnea* by vegetation type. Image by Araceli Morales González.

Dasylirion Zucc.

Plants dioecious, shortly caulescent, 2 m tall. **Stems** erect or decumbent, simple or branched with terminal rosettes and marcescent leaves. **Leaves** linear, erect, stiff, canaliculate, smooth to papillose, sometimes with a coat of wax, green to green glaucous, base deltoid, concave, lustrous, margin membranous, leaf margin serrulate, usually with prominent prickles, falcate, antrorse or retrorse, apex fibrous almost acute. **Inflorescence** paniculate, narrow, branches usually short, pedunculate or sessile, adpressed, bracts triangular, papyraceous, very acuminate, margin serrulate, sometimes with apex fibrous, or recurved, flowers in fascicles on articulated pedicels subtended by bracteoles scarious. **Staminate flowers** with stamens exerted, anthers introrse, dorsifixed or versatile, sagittate, dehiscence longitudinal, **pistillode** mostly inconspicuous, trilobed, lacking papillae, trilobed, functioning as a nectary. **Pistillate flowers** with **ovary** coriaceous, unilocular, tripterous, style prominent, infundibuliform, stigma trilobed, lacks papillae. **Fruit** tripterous, papyraceous, usually ovoid or ellipsoid, apical notch ca. 1mm, tepals and style usually persistent. **Seed** per fruit 1, trigonous, brown to reddish brown, rugose.

Taxonomic key to the species of *Dasylirion* from Puebla

1. Leaves green to glaucous green…….…….. 2
2. Base of leaf abruptly tapering to the blade, prickles yellow tinged reddish…….…… *Dasylirion acrotrichum*
2. Base of leaf gradually tapering to the blade, prickles yellow, fruit-tinged purple…….…. *Dasylirion serratifolium*
1. Leaves green to yellowish, margin yellow, prickles yellow to reddish brown ……..……*Dasylirion lucidum*

Dasylirion acrotrichum Zucc., Abh. Math. -Phys. Cl. Königl. Bayer. Akad. Wiss. 3:228 (1843)

Ξ *Roulina acrotricha* (Schiede) Brongn., in Ann. Sci. Nat., Bot., sér. 2, 14: 320 (1840)

Ξ *Yucca acrotricha* Schiede in Linneae 4: 230 (1829)

= *Bonapartea gracilis* Sweet in Hort. Brit, ed. 2: 597 (1830), nom. nud.

= *Dasylirion gracile* (Brongn.) Zucc. in Abh. Math. -Phys Cl. Königl. Bayer. Akad. Wiss. 4(2): 22 (1845)

= *Dasylirion graminifolium* S. Watson in Proc. Amer. Acad. Arts. 14:249 (1879), nom. Illeg.

= *Dasylirion robustum* Gorl. Ex Trel. in Proc. Amer. Philos. Soc. 50: 438 (1911)

= *Roulina gracilis* Brongn. in Ann. Sci. Nat., Bot., sér. 2, 14: 320 (1840)

= *Barbacenia gracilis* (Brongn.) Baker in J. Linn. Soc., Bot. 18: 239 (1980)

Plants shrubby, (-0.4) 0.5 to 1.5 (-2) m long, frequently branched, decumbent with age, marcescent leaves. **Leaves** linear, green to green glaucous, without wax, base deltoid, concave, yellowish, abruptly tapering to the blade, margin serrulate, greenish to yellow, denticles simple, sometimes bicuspidate, prickles, antrorse, sometimes retrorse, yellow tinged reddish, apex fibrous, sometimes absent in old leaves. **Inflorescence** ellipsoid, 1.5 to 4 m long, branches with 3 to 5 branchlets, the central of ca. 4.5 to 9 cm long, the lateral ca. 6 cm long, sessile or pedunculate bracts very acuminate, margin serrulate, apex erect to curved. **Staminate flowers** 2 per node, ovate to ellipsoid, involuted, **pistillode** inconspicuous. **Pistillate flowers** 2 per node, tepals ca. 2 mm long, **ovary** ellipsoid. **Fruit** ellipsoid to obovoid, yellowish. **Seed** obovoid, brown.

Habitat and distribution: This species grows on steep slopes, on igneous rock outcrops, on calcareous and gypsum soils, sometimes its abundance seems to be favored by the fire in Central-Eastern Puebla, in xerophytic scrub and pine-oak forest with *Agave*, *Acacia*, *Brahea*, *Ephedra* Tourn. ex L., *Ferocactus*, *Gochnatia* Kunth, *Hechtia*, *Juniperus* L., *Mimosa*, *Nolina parviflora* (Kunth) Hemsl, *Pinus* L., *Quercus* L., *Yucca* and various legumes at 1600 to 2400 m altitude (figure 3). Flowers from March to September, fruits from July to October.

Taxonomic notes: *Dasylirion acrotrichum* is easily distinguished from other similar *Dasylirion* species by its green to green glaucous leaves, greenish to yellow margin, and yellow to reddish prickles.

Examined specimens: MEXICO. Puebla: Atoyatempan, Al S del municipio, límite con Molcaxac, entrada 1 km adelante de Puente de Dios, 20 October 2011, *Lucio Caamacho*

Onofre 773 (HUAP). Coxcatlán, Ejido Vigastepec, 16.2 km sobre carretera Teotitlán en dirección a Huautla, 23 October 2017*, Lucio Camaacho Onofre and Michelle Xicotencatl 11556* (HUAP). Coyotepec, San Vicente Coyotepec, 06 November 2011, Lucio Caamacho Onofre, 313 (HUAP). Cuautinchán, 2.5 km al W de Cuautinchán en dirección Alpuyeca, 18 January 2017, *Lucio Caamacho Onofre 10260* (HUAP); Cerro Xonaca al N de Cuautinchán, 07 July 1986, *Lazcano, Olivas and Sánchez 418* (HUAP). Guadalupe Victoria, Parte N de Laguna, San Luis Atexcac, 29 September 2006, *Lucio Caamacho Onofre and Allen J. Coombes 9526* (HUAP); San Luis Atexcac, 12 km al SW de Alchichica, sobre la carretera a San Salvador El seco, 03 February 1972, *Jerzy Rzedowski 31692* (IBUG, ENCB, MICH). Huitziltepec, Cerro al N de la cabecera municipal de Santa Clara Huitziltepec, 20 March 2013, *Lucio Caamacho Onofre 2229* (HUAP). Puebla, Entrando por el camino de terracería opuesto al crucero de Tecali, sobre carretera a Valsequillo, Ejido de Santo Tomas Chautla, 14 June 2013, *Lucio Caamacho Onofre and Allen J. Coombes 2778* (HUAP). San Nicolás Buenos Aires, 5.6 km al W de Zacatepec, al S de Derrumbadas, 29 September 2006, *Lucio Caamacho Onofre and Allen J. Coombes 9465* (HUAP); Hills SW of Tlachichuca foothills of Orizaba, 06 April 1990, *David J. Bogler and Jim Bogler 814* (IEB, LL, MEXU), *815* (LL). Tecali de Herrera, Barranca Chimultepec, 1 km al NE de la Trinidad Tianguismanalco, 17 February 1987, *M. Linares A. 221* (HUAP); Barranca de Los Órganos, al N de La Trinidad Tianguismanalco, 19 January 1987, *M. Linares A. 191* (HUAP); La Magdalena Cuaxixtla, 26 November 1987, *Gamboa, Serrano and Guzmán 223* (HUAP). Tepeojuma, 1.5 km al S de Zoyatla, 16 November 2016, *Lucio Caamacho Onofre, 9907* (HUAP). Tepexi de Rodríguez, Cañada 2 km antes de Agua de la Luna, sobre cañada a un costado de la carretera de terracería Tepexi-Agua de la Luna, 09 July 2013, *Lucio Caamacho Onofre and Cruz-Martínez Mireida 3063* (HUAP); Camino Lomas de San Francisco, 05 September 2013, *Caamacho-Onofre Lucio and Cerón-Carpio Amparo B. 68* (HUAP). Tepeyahualco.

Figure 7. *Dasylirion acrotrichum*. **a**, inflorescence; **b**, inflorescence branch and leaves; **c**, infructescence branch and leaves; **d**, leaves.

Dasylirion lucidum Rose

Plants shrubby, 0.6 to 1.5 m long, erect, frequently decumbent, occasionally branched in the apex, marcescent leaves. **Leaves** linear, green-yellowish, base deltoid, concave, yellowish, margin serrulate, yellow, denticles simple, sometimes bicuspidate, yellow, prickles usually antrorse, yellow to brown reddish, apex fibrous. **Inflorescence** 2 to 3 (-4) m long, branches with 5 branchlets, ca. 3 to 5 cm long, bracts usually lanceolate, very acuminate, apex curved. **Staminate flowers** with tepals ca. 2 to 3 mm long, ovate, involute, stamens with filaments ca. 1 mm long, anthers ca. 1 to 2 mm long, yellow, **pistillode** inconspicuous. **Pistillate flowers** with tepals ca. 2, ovate, white to yellowish, **ovary** obovoid. **Fruit** obovoid, yellowish, rarely tinged with purple. **Seed** rounded, brown.

Habitat and distribution: This species occurs on hillsides, on gravel slopes and on calcareous and possibly gypsum soils in Southeast of Puebla, endemic to the Tehuacán-Cuicatlán valley. The plants grow in xerophytic scrub and pine-oak forests with *Agave*, *Brahea*, *Hechtia*, *Nolina*, *Mimosa*, *Quercus* and *Yucca*, from 1600 to 2400 m (figure 3). The plants flowers from May to August, fruits from April to February.

Taxonomic notes: *Dasylirion lucidum* is similar to *D. acrotrichum* in general appearance, but differs in its green yellowish leaves, margin yellow and yellow to brown reddish prickles.

Examined specimens: MEXICO. Puebla, Caltepec, 1 km de Sabina Farol, 22 January 2000, *Enrique Guízar Nolazco 4786* (CHAP, IEB); 4.3 km al SE de Caltepec, 4 June 2019, *Lucio Caamacho Onofre 13009* (HUAP); Cerro El Chicamole al E de Membrillos, límite Estado de Puebla y Oaxaca, Ejido Acatitlán, 12 February 1987, *Pedro Tenorio L. 12475* (MEXU); Paraje Loma Escobillera, 1.5 km de Sabina Farol, terrenos de bienes comunales de Acatepec, 30 April 2000, *Enrique Guízar Nolazco and Andrés G. Miranda Moreno 4908* (CHAP, MEXU), *4911* (CHAP, MEXU). Chapulco, 2 km al E de la Intersección Tehuacán-Esperanza, 18 July 1990, *Antonio Salinas T. 5453* (MEXU, RSA); 8 km al NO de Azumbilla, carretera Esperanza-Tehuacán, 26 June 1987, *Abisaí García M., A. Salinas and E. Martínez 3257* (ASU, DES, MEXU). Chila de las Flores, Paraje a un lado de la carretera Acatlán-Huajuapán de León. 4 km al N del poblado de Yucunduchi, 30 December 2000, *Arturo Castañeda Mendoza 728* (MEXU). Cuautinchán, a 25 km de la

Presa de Valsequillo (Manuel Ávila Camacho), lado oriente, 09 August 2009, *Suriel E. Flores and Eduardo Pineda Villanueva 6* (MEXU). Esperanza, 5 km al O de Esperanza, carr. Puebla-Veracruz, 2320 m, 8 Septembre 1998, *Abisaí García Mendoza, Sonia Franco and Alejandro Gutiérrez 6659* (MEXU); 8 km al NO de La Esperanza, carretera a Orizaba, 2340 cm, 25 June 1992, *Abisaí García Mendoza and Felipe Palma 5614* (ASU, MEXU). Palmar de Bravo, 5 km al O de Esperanza, carretera Puebla-Veracruz, 08 September 1998, *Abisaí García Mendoza, Sonia Franco and Alejandra Gutiérrez 6659* (MEXU); Cuesta Blanca, cerro El Chivo, cerca de Esperanza, 09 March 1971, *R. Hernández M. and R. Cedillo Trigos 1140* (MEXU). Santiago Miahuatlán, km 25.85 carr. Cuacnopalan-Oaxaca, 16 November 2006, *M. Ayala R., I. Rosas R., C. Castillo L. y R. X. Alvarez E. y M. E. Parra O. 2059* (MEXU). Tecamachalco, 4 km al NE de Tecamachalco, Puebla, rumbo a Tehuacán, 01 May 1980, *F.G. Medrano, V. Jaramillo, R. Ruiz, J.L. Villaseñor and S. Singer 915* (MEXU). Tehuacán, 2-3 miles west of Tehuacán in hills directly above “El Riego”, and old spa now close to the public, the type locality of D. lucidum, 15 June 1989, *D. Bogler 640* (MEXU); About 3 miles SW of Tehuacán on Hwy 125, just past dump at crest of hill, 16 June 1986, *D. Bogler, J. Bogler, L. Hernández and M. Martínez 641* (IEB, MEXU, TEX). Tepeyahualco, Cerro de La Preciosa, October 1981, *M. Cházaro B. and M. Oliva 1797* (XAL); Hacienda Atlapaleca, 19 May 1985, *G. Segura 189* (XAL). Tlacotepec de Benito Juárez, Km 10 de la autopista Cuacnopalan-Oaxaca, 2418 m, 18 November 2004, *O. Téllez V., I. Méndez L., M. Ayala R. and I. Rosas R. 18148* (MEXU). Zacatepec, cerro de Las Derrumbadas, 1 km al norte rumbo a Perote, 13 September 1986*, Alejandro Novelo* (MEXU); Cerro de Las Derrumbadas between Zacatepec and Alchichica, 27 February 1974, *Howard Scott Gentry 23373* (DES). Zapotitlán Salinas, 32 miles S of Tehuacán, near Colonia San Miguel, near the border with Oaxaca, 16 June 1989*, D. Bogler with J. Blogler, L. Hernández, M. Martínez 643* (MEXU, TEX), *Martínez 644* (MEXU, TEX), 645 (MEXU, TEX); Km 46.5 de la carretera federal Tehuacán-Huajuapan, 18 January 2001, *I. Rosas R., O. Tellez V., M. Ayala R. and C. Castillo L. 418* (MEXU); Los Reyes Metzontla, aproximadamente 1 km al NW de Los Reyes Metzontla, 15 November 1991, *A. Valiente B., A. Casas, J. L. Viveros 4410* (MEXU).

Figure 8. *Dasylirion lucidum*. **a**, leaves; **b**, **d**, infructescence branch and leaves; **c**, inflorescence branch.

Dasylirion serratifolium (Karw. ex Schult. & Schult. F.) Zucc.

Ξ *Roulinia serratifolia* (Karw. ex Schult. & Schult.f.) Brongn. in Ann. Sci. Nat., Bot., sér. 2, 14: 320 (1840)

Ξ *Yucca serratifolia* Karw. ex Schult. & Schult.f. in J. J. Roemer & J. A. Schultes, Syst. Veg., ed. 15[bis]. 7: 1716 (1830)

Plants shrubby, 0.5 to 2 m long, erect or reclining, sometimes branched near the base, marcescent leaves. **Leaves** erect or reflexed, green yellowish, rugose, without wax, base deltoid, concave, cream to yellowish, margin serrulate, yellow, denticles prominent, prickles usually cuspidate sometimes antrorse and retrorse, yellow, apex fibrous. **Inflorescence** (-2) 3 to 4 m long, peduncle usually tinged reddish or purple, branches with 5 to 7 branchlets, ca. 5 to 6 cm long, bracts lanceolate, long acuminate, margin serrulate, decreasing in size towards the apex. **Staminate flowers** with tepals ca. 2 mm long, involute yellow, **pistillode** inconspicuous. **Pistillate flowers** with tepals ca. 2 mm long, obovate, yellow, usually tinged purple, **ovary** obovoid. **Fruit** ellipsoid to obovoid, yellow tinged with purple. **Seed** brown.

Habitat and distribution: The species grows on calcareous hills of volcanic origin, on the border of Puebla and Oaxaca in xerophytic scrub and pine-oak forest with *Acacia*, *Agave*, *Nolina*, *Quercus* and *Yucca*, at altitudes between 1300 and 2700 m (figure 3). The plant flowers from May to June and fruits from May to November.

Taxonomic notes: *Dasylirion serratifolium* is easily recognized because it is branched near the base, has rugose, green-yellowish leaves, with yellow prickles on the margin and the inflorescence is usually tinged reddish or purple.

Examined specimens: MEXICO, Puebla, Ajalpan, 16.2 km al NE de Zinacatepec, 12 October 2006, *Rosas R., M. Ayala R., C. Castillo L. and R. Álvarez E. 1910* (MEXU).

Figure 9. *Dasylirion serratifolium* leaves.

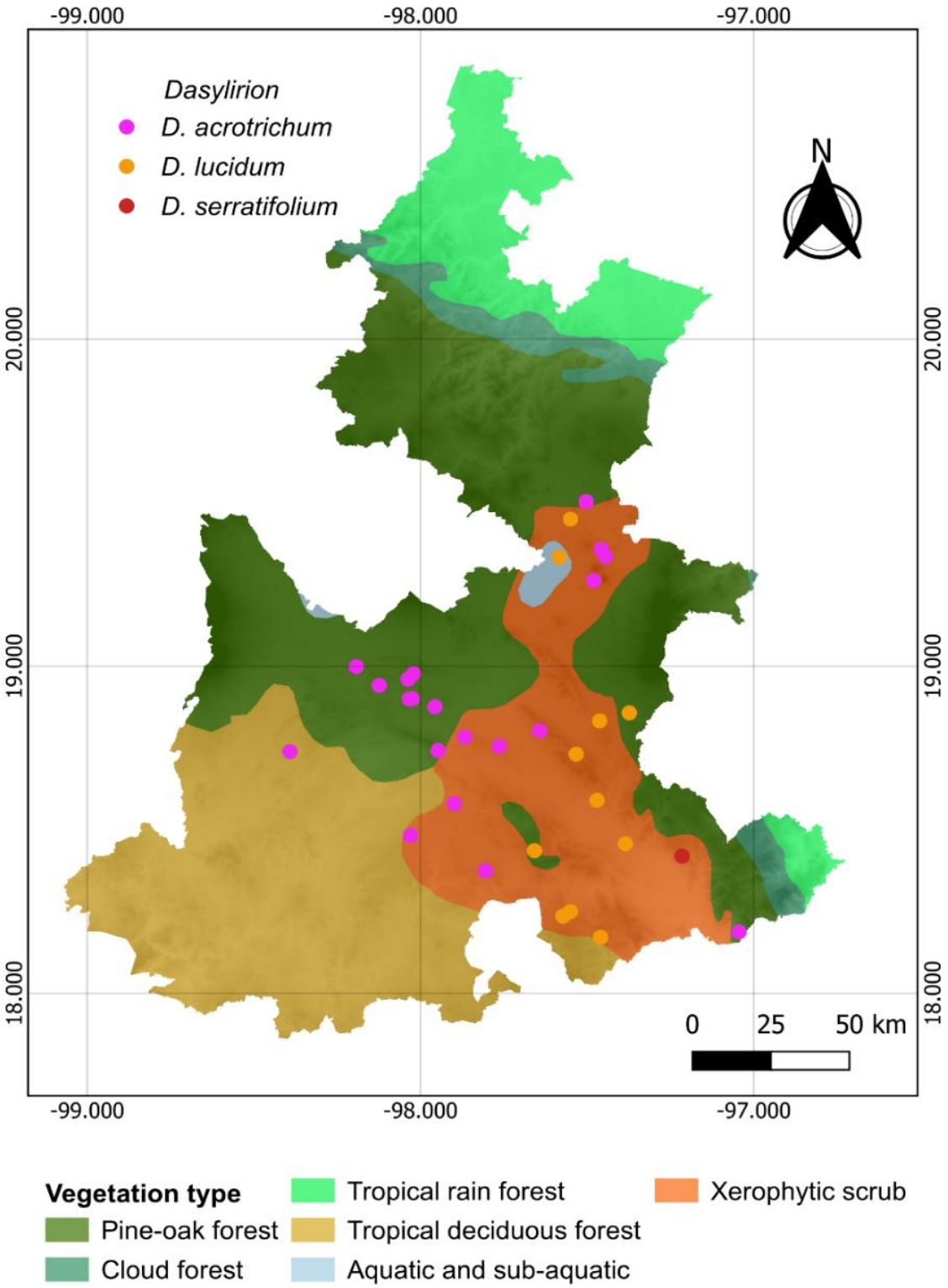

Figure 10. Geographical distribution of *Dasylirion* by vegetation type. Image by Araceli Morales González.

Nolina Michx.

Plants polygamous-dioecious, arborescent. **Stems** upright but not swollen at the base, rosettes at the apices of stems and branches, marcescent foliage. **Leaves** linear, erect, or arched, persistent or deciduous, green or glaucous green, base deltoid, margin serrulate or filiferous, apex acute, erect or helical. **Inflorescence** paniculate, with scape and branches subtended by triangular to linear papyraceous bracts, flowers in fascicles on articulated pedicel, subtended by scarious bracteoles, tepals with glandular trichomes at the apex. **Staminate flowers** with stamens included, anthers introrse, dorsifixed, dehiscence longitudinal, **pistillode** prominent, functioning as a nectary. **Pistillate flowers** with trilocular **ovary**, fleshy, with two ovules per carpel. **Fruit** trilocular, globose, papyraceous or membranous, apical notch ca. 1 mm, stigma and tepals persistent. **Seed** rounded, 1 to 2 (-3) per fruit, rounded, brown, rugose.

Nolina parviflora (Kunth) Hemsl.

Ξ *Beaucarnea parviflora* (Kunth) Baker in J. Bot. 10: 328 (1872)

Ξ *Cordyline parviflora* Kunth in F.W.H.von Humboldt, A.J.A.Bonpland & C.S. Kunth, Nov. Gen. Sp. 1: 269 (1816)

= *Beaucarnea longifolia* (Karw. ex Schult. & Schult. F.) Baker in J. Bot. 10: 324 (1872)

= *Dasylirion humboldtii* Kunth in Abh. Königl. Akad. Wiss. Berlin 1842: 32 (1844)

= *Dasylirion longifolium* (Karw. ex Schult. & Schult. F.) Zucc. in Abh. Math. -Phys. Cl. Königl. Bayer. Akad. Wiss. 3: 224 (1843)

= *Dracaena parviflora* Willd ex Schult. & Schult. F. in J. J. Roemer & J. A. Schultes, Syst. Veg., ed. 15[bis]. 7: 348 (1829), not validly publ.

= *Nolina altamiranoana* Rose in Proc. U. S. Natl. Mus. 29: 438 (1905)

= *Nolina elegans* Rose in Contr. U.S. Natl. Herb. 10: 91 (1906)

= *Nolina longifolia* (Karw. ex Schult. & Schult. F.) Hemsl. in Biol. Cent. -Amer., Bot. 3: 372 (1884)

= *Roulinia humboldtiana* Brongn. in Ann. Sci. Nat., Bot., sér. 2, 14: 320 (1840)

= *Roulinia karwinskiana* Brongn. in Ann. Sci. Nat., Bot., sér. 2, 14: 320 (1840)

= *Yucca longifolia* Karw. ex Schult. & Schult. F. in J.J.Roemer & J.A.Schultes, Syst. Veg., ed. 15[bis]. 7: 1715 (1830)

Plant arborescent, (-1) 2 to 6 (-8) m tall, base slightly swollen, bark forming irregular longitudinal groves along the stem, 1 to 6 (-8) branches, rosettes apical, marcescent foliage. **Leaves** long linear, flat, reflected with age, green to green glaucous, base deltoid, whitish to cream, margin serrulate to filiferous, denticles simple or bicuspidate, green yellowish to reddish with age, apex acute, dry, erect or helical, sometimes lacerate. **Inflorescence** ovoid, erect, lax, 1.5 to 2.5 (-3) m long, branches ca. 20 to 30 cm long, adpressed, branchlets erect to sinuous, ca. 12 cm long decreasing in size towards the apex, subtended by triangular to linear bracts. **Staminate flowers** 2 per node, tepals ca. 3 mm long, lanceolate to ovate, cream tinged green, **pistillode** prominent, globose. **Pistillate flowers** 4 to 8 per node, tepals elliptic to lanceolate, ca. 2.5 mm long, whitish to cream, **ovary** trilocular, stigma trilobed. **Fruit** trilocular, globose, pendent, 1 or 2 per node, yellowish. **Seed** rounded, 1 to 2 (-3) per fruit, sometimes one per locule or none if ovules are abortive, rounded, brown.

Habitat and distribution: This species grows on mountain slopes, in sandy soils and igneous rocks in eastern, Central and Southern Puebla in oak, pine, pine-oak, pine-juniper forests and xerophytic scrub with *Agave*, *Dasylirion*, *Hechtia*, *Juniperus*, *Opuntia* Mill., *Pinus*, *Quercus*, *Yucca* and grasses, 1600 to 2900 m altitude (figure 4). Individuals of *N. parviflora* can withstand periodic wildfires. The plants flowers from February to August and fruits from April to November.

Taxonomic notes: *Nolina parviflora* is morphologically similar to the arborescent species of *Nolina but* can be distinguished by its size (2 to 6 m), slightly swollen base, apical rosettes with marcescent close to the rosettes, leaf margin green yellowish to reddish with the age and apex lacerate, erect or helical.

Examined specimens: MEXICO. Puebla, Aljojuca, Cerro al E de Aljojuca,19 May 2005, *J. L. Contreras J. 8285* (HUAP, MEXU), *8286* (HUAP). Atzizintla, Carretera Esperanza a Cd. Serdán, 05 April 2000, *Abisaí García Mendoza 6927* (MEXU). Caltepec,

Aproximadamente 2 km al NE de Acatepec, por la carretera Tehuacán-Huajuapan de León, 23 March 1980, *F, González Medrano, V. Jaramillo, P. Dávila and J. L. Villaseñor 741* (MEXU). Chalchicomula de Sesma, 3 km al NW de El Sabinal, carretera a Cd. Serdán, 26 June 1992, *Abisaí García Mendoza and Felipe Palma 5626* (MEXU); Cerca de Cd. Serdán, carretera a Esperanza, 05 April 2000, *Abisaí García Mendoza 6928* (MEXU). Chignautla, Al O de Los Humeros, 21 August 2014, *Lucio Caamacho Onofre 5797* (HUAP); Los Humeros, 18 March 1992, *R. Acosta P., M Cházaro B. and R. Patiño 4537* (XAL). Coxcatlán, 1.6 km sobre terracería en dirección de Tecoltepec, al N de Ocotlamanic, 15 August 2017, *Lucio Caamacho Onofre 11145* (HUAP). Cuyoaco, 0.9 km al SO de Temextla por camino de terracería hacia Ocotepec, 25 September 2014, *Lucio Caamacho Onofre 6112* (HUAP); Zona arqueológica de Cantona, 10 km al NO de Tepeyahualco y a 3 km de Tezontepec, camino a Texcal, 2 August 2002, *A. García Mendoza and Fco. Martínez 7399* (MEXU). Guadalupe Victoria, 1 km al NO de San Luis y a 7 km al S de Alchichica, carr. Zacatepec-Alchichica, 21 February 1986, *Abisaí García Mendoza and Raquel Galván, 6147* (ASU, MEXU); 6 km después de San Luis Atexcac, yendo de Perote a Alchichica, 18 April 1991, *A. Espejo and A. R. López Ferrari 4415* (XAL); 7 km al SW de Alchichica, sobre la carretera a Perote, 21 November 1996, *R. Galván 4610* (MEXU), *4611* (MEXU); 8 km al S de Alchichica, *Abisaí García Mendoza 3210* (MEXU); 8 km al SW de Alchichica, 7 March 2003, *S. Zamudio Ruiz 12292* (ASU, MEXU); En la desviación de la carretera a Guadalupe Victoria, 18 April 2000, *Abisaí García Mendoza* 6929 (MEXU); Las Derrumbadas, 13 June 1973, *F. Aventura A. 8358* (MEXU); Mexcaltilahuac, en la desviación de la carretera a Guadalupe Victoria, 18 April 200, *Abisaí García Mendoza 6929* (MEXU); Parte N de Laguna, San Luis Atexcac, 29 September 2016, *Lucio Caamacho Onofre, Allen J. Coombes 9528* (HUAP). Lafragua, 0.5 km al N de Loma Linda, 22 August 2016, *Lucio Caamacho Onofre 8998* (HUAP); 6.3 km al NE de la desv. A González Ortega, carr. Zacatepec -Perote, 20 March 1983, *R. Galván 1150* (MEXU), *1151* (MEXU). Oriental, Cerro al S de San Antonio Virreyes, 7 July 2013, *Lucio Caamacho Onofre, Reyes-Santiago, Jerónimo; Gonzales-Zorzano, Omar; Islas-Luna, Angeles 3005* (HUAP); Cerro de Las Derrumbadas 3 miles NE of Zacatepec, 14 March 1974, Howard Scott Gentry 23388 (ASU, DES, MEXU); Low hills between Oriental and Libres, about 3 mi S of Libres, 5 April 1991, *David J. Bogler, Jim Bogler, Luis*

Hernández Sandoval, Mahinda Martinez 809 (MEXU, TEX), *810* (TEX), *811* (TEX), *812* (TEX). Palmar de Bravo, 6.41 km al NE de Palmar de Bravo, 12 June 2011, *Lucio Caamacho Onofre, J.P. Abascal, D. Álvarez, E. Martínez S. 2929* (HUAP); Parque eólico PIER II; parcela 3 de reforestación social, alrededor de 2 km al sur (en línea recta) del poblado de Esperanza, 17 September 2019, *Luis Hermann Bojórquez Galván Nallely Pérez Gómez and Luis Lagunes Galindo 4193* (HUAP). San Martín Atexcal, 3 km al SO de Santiago Nopala, carr. Ixcaquixtla-Tehuacán, 28 May 2003, *A. García-Mendoza, A. Castañeda and S. Franco 7515* (MEXU). San Nicolás Buenos Aires, 2 km al W de la desv. a Emilio Portes Gil, carr. México-Veracruz01 March 1981, F. Zavala C. 305 (MEXU); 2.8 km al NE de Zacatepec, por la carr. Zacatepec-Perote, 20 March 1982, R. Galván 1149 (MEXU); 4 km en dirección NE de Zacatepec, en la parte S de Derrumbadas, 29 September 2016, *Lucio Caamacho Onofre and Allen J. Coombes 9418* (HUAP); Along Puebla-Jalapa hihgway, about 7 km northeast of Zacatepec, 05 February 1951, E. C. Ogden, C. L. Gilly, E. Hernández X. 5183 (MEXU); Carretera 140, tramo Derrumbadas, 1 km antes de San Luis Atexcac, 12 April 2013, *Lucio Caamacho Onofre and Allen J. Coombes 2295* (HUAP); Cerro de las Derrumbadas, 3 miles NE of Zacatepec, 14 March 1974, *Howard S. Gentry 23388* (DES); Emilio Portes Gil, a 5 km de Zacatepec, carretera a Veracruz, 28 February 1981, C. Muñoz B. 19 (MEXU). Tepanco de López, 5 km al W de San Andrés Cacaloapan, 13 February 1993, *P. Tenorio L. and F. Tenorio L. 18510* (MEXU). Tepeyahualco, 1 km al NO de San Luis y a 7 km al S de Alchichica. Carretera Zacatepec-Alchichica, 2380 m, 21 February 1996, *Abisaí García Mendoza and Raquel Galván 6147* (ASU, MEXU); 2-3 km al E de Alchichica, km 85 de la carr. Puebla-Xalapa,05 October 2002, *Luis Hernández 5003* (MEXU, QMEX); A los rededores de la Laguna de Alchichica, 18 July 1998, *Luis Hernández 4315* (MEXU, XAL); Cerro Yolotepec, delante de San José Alchichica, 19 April 1967, *F. G. Medrano and M. Rosas 1163* (MEXU); En el Potrero Ruíz al N del volcán de Pizarro, 03 August 1978, J. I. Calzada, F. Lozano and E. Martinez, 4639 (XAL); Ladera N en cerro de las Águilas al SE de Xaltipanapa, 20 October 2016, *Lucio Caamacho Onofre 9808* (HUAP); Faldas del cerro de Las Derrumbadas, a 1 km del pueblo Zacatepec, 13 September 1986, *P. Ramírez 383* (MEXU). Tlacotepec de Benito Juárez, 6 km de Cuacnopalan a San Martín Esperilla, 18 November 2004, *O. Téllez V., I. Méndez L., M. Ayala R. and I. Rosas R. 18155* (MEXU); At 6.9 km from Cacaloapan,

San Jerónimo Soyatitlanapan-Zamarilla, 03 February 2002, *Calzada J.I. 23811* (MEXU). Xiutetelco, Sierra de Maxtaloyan al oeste de la Geotérmica de Los Humeros, 01 April 1988, *M. Cházaro B. and Paty Hernández de Ch. 5344* (XAL).

Figure 11. *Nolina parviflora*. **a**, **c**, **d**, infructescence branch and leaves; **b**, infructescence branch with immature fruits.

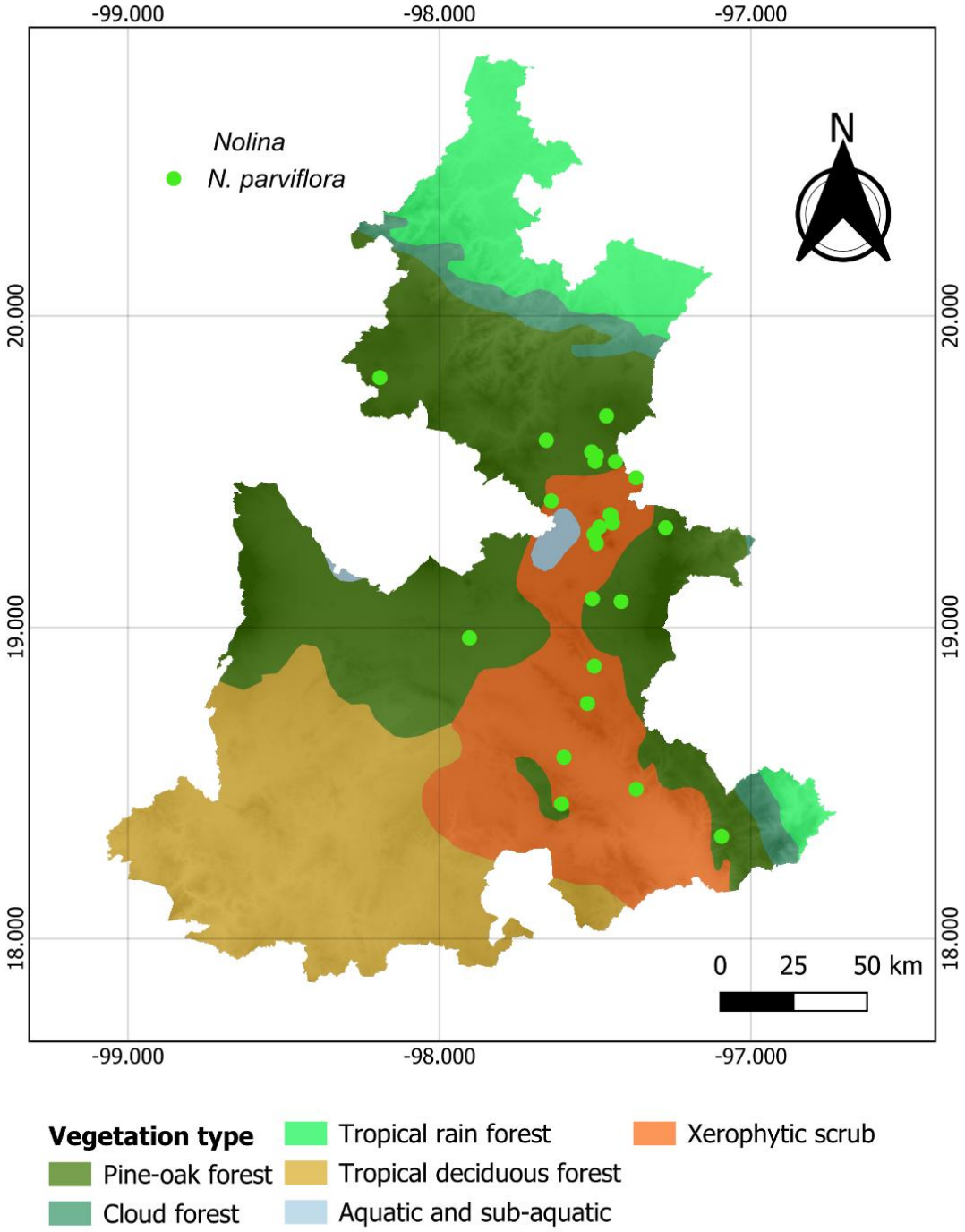

Figure 12. Geographical distribution of *Nolina* by vegetation type. Image by Araceli Morales González.

Polygonateae Bentham & J. D. Hooker

Plants herbs, rhizomatous, perennials. **Stems** simple, arching or upright. **Leaves** distichous, petiolate or sessile, with or without sheathing base, blade usually ovate, elliptic or lanceolate with a few prominent parallel veins, margin entire or slightly undulate, apex mostly acuminated. **Inflorescence** axillary or terminal, panicle or raceme subtended by scarious bracts, inconspicuous. **Flowers** hermaphrodite, actinomorphic, hypogynous, tepals in two whorls, both whorls of similar length, whitish to green, sometimes tinged with purplish red, **stamens** (-4) 6 (-8) in two whorls, free, epipetalous, anthers introrse, dorsifixed, longitudinally dehiscent, **ovary** fleshy, tricarpellary, trilocular, (-2) 3 (-4) ovules per locule, style erect, filiform, stigma capitate or lobated. **Fruit** a red, black, or blue berry.

Maianthemum F.H. Wigg**.**

Plants terrestrial, epiphytic or ridiculous herbs, 15 to 150 cm tall. **Rhizome** fleshy, persistent, densely clumped, with units cylindrical or subspherical. **Stems** simple, flexuous, reclining, upright or pendent. **Leaves** simple, short to long petiolate, blade ovate, elliptic, or lanceolate, base rounded or attenuate, margin entire or undulated, apex mostly acuminated, glabrous. **Inflorescence** terminal, panicle or racemose. **Flowers** on pedicels subtended by scarious bract, perianth spreading, reflexed or cupuliform, white, yellow or pinkish, tepals uniform, ovate or obovate, **stamens** 6 inserted at tepal base, filaments filiform, **ovary** tricarpellary, swollen, style long, stigma 3-lobated. **Fruit** trilobed or spherical, red.

Key to species of *Maianthemum* from Puebla

1. Inflorescence a panicle…….. *Maianthemum paniculatum*

1. Inflorescence a complex raceme……..……. 2

2. Inflorescence arched upward, 2 to 4 flowers per node, perianth cupuliform, epiphytic…… *Maianthemum macrophyllum*

2. Inflorescence upright, 2 flowers per node, perianth spreading or reflexed, terrestrial, terrestrial……. *Maianthemum scilloideum*

Maianthemum macrophyllum (M. Martens & Galeotti) LaFrankie in Taxon 35: 588 (1986)

Ξ *Smilacina macrophylla* M. Martens & Galeotti in Bull. Acad. Roy. Sci. Bruxelles 9(2): 387 (1842)

Epiphytic herbs, 60 to 120 cm tall. **Rhizome** sympodial, rhizome units subspherical. **Stem** pendent, slightly arched, glabrous. **Leaves** lanceolate to ovate, petiole 3.5 to 8 mm long, blade 14 to 20 cm long by 3.5 to 9 cm width, base rounded, margin entire, apex acuminate. **Inflorescence** racemose, 7.5 to 15 cm long, arching upward, flowers arranged in helix on main axis subtended by a scarious, green bract. **Flowers** usually 2 to 4 per node subtended by a scarious bract, inconspicuous, pedicels erect or pendent, 4 to 8 mm long; perianth cupuliform, usually yellow green, tepals obovate to ovate, oblong, 4.5 to 5.5 mm long by 1.5 to 3 mm width; **stamens** ca. 2.5 mm long, anthers sagittate, yellow, 1.3 mm long; **ovary** trilocular, slightly globose, style 1 to 1.5 mm long, stigma slightly trilobed. **Fruit** trilobed, red when mature. Seeds 6 to 13 per fruit slightly flat.

Habitat and distribution: This species grows on the branches trees canopies and on rocks near the rivers associated with riparian vegetation in cloud forest and pine-oak forest with *Liquidambar* L., *Persea* Mill., and *Platanus* L., 1365 to 1545 m in altitude in northern Puebla (figure 5). The plants flowers from April to June and fruit from October.

Taxonomic notes: *Maianthemum macrophyllum* is easily recognized by its epiphytic habit, long leaves (14 to 20 cm), dense upwardly arching racemes, and cupuliforms, yellow green flowers.

Examined specimens: MEXICO. Puebla, Ahuacatlán, Desviación 1.5 km delante de Ahuacatlán en río, 04 June 2015, *Lucio Caamacho Onofre 7299* (HUAP). Zacapoaxtla, Cascada, San Juan Tahitic, 19 November 2014, *Lucio Caamacho Onofre 6360* (HUAP). Paradero en Finca Sta. Ma. Tres arroyos, sobre carretera Zacapoaxtla-Cuetzalan, 30 May 2014, *Lucio Caamacho Onofre 5322* (HUAP); San Juan Tahitic a 100 m de la carretera de Ramonco, en la localidad de Ayahualco, 03 May 2015, *Anastasio Sotero Hernández 20950* (HUAP).

Figure 13. *Maianthemum macrophyllum*. **a**, inflorescence and leaves; **b**, leaves; **c**, inflorescence; **d**, infructescence.

Maianthemum paniculatum (M. Martens & Galeotti) LaFrankie in Taxon 35: 588 (1986)

Ξ *Smilacina paniculata* M.Martens & Galeotti in Bull. Acad. Roy. Sci. Bruxelles 9(2): 388 (1842)

Ξ *Tovaria paniculata* (M. Martens & Galeotti) Baker in J. Linn. Soc., Bot. 14: 568 (1875)

Ξ *Vagnera paniculata* (M. Martens & Galeotti) Standl. in J. Washington Acad. Sci. 15: 457 (1925)

= *Maianthemum septifolium* LaFrankie in J. Arnold Arbor. 67: 427 (1986)

= *Smilacina laxiflora* (Baker) Hemsl. in Biol. Cen. -Amer., Bot. 3: 368 (1884)

= *Smilacina nervolusa* (Baker) Hemsl. in Biol. Cen. -Amer., Bot. 3: 368 (1884)

= *Smilacina thyrsoidea* (Baker) Hemsl. in Biol. Cen. -Amer., Bot. 3: 368 (1884)

= *Tovaria laxiflora* Baker in J. Linn. Soc., Bot. 14: 569 (1875)

= *Tovaria nervulosa* Baker in J. Linn. Soc., Bot. 14: 569 (1875)

= *Tovaria thyrsoidea* Baker in J. Linn. Soc., Bot. 14: 568 (1875)

Terrestrial herbs, 40 to 150 cm tall. **Rhizome** sympodial, rhizome units cylindrical to claviform. **Stem** flexuous, arching, or erect, glabrous. **Leaves** ovate, elliptic or lanceolate, petiole 3 to 5 mm long, blade 9.5 to 15 cm long by 3 to 6 cm width, base rounded or attenuate, margin entire to undulate, apex acuminate to long acuminate. **Inflorescence** paniculate, erect or slightly arching, 7 to 16 cm long, lateral axes racemose, arranged in helix, spreading or ascending, 2 to 8 cm long, decreasing in size towards the apex, each raceme subtended by a green bract. **Flowers** on pedicels 2 to 8 mm long, subtended by a bract scarious, inconspicuous, perianth spreading, reflexed, white, tepals ovate, 1.6 to 2 mm long by 1 to 1.4 width, **stamens** ca. 1 to 1.5 mm long, filaments white, anthers white or yellow, ca. 0.6 to 1 mm long, **ovary** tricarpellary, globose, occasionally pinkish, ca. 1 to 2 mm, style ca. 0.5 to 1 mm long, slightly trilobed. **Fruit** spherical or trilobed, green tinged red when young, red when mature. **Seed** 1 to 6 per fruit, globose.

Habit and distribution: This species grows on roadsides, near rivers and in light gaps in pine-oak forest, cloud forest and tropical rainforest at altitudes of 1486 to 1800 m, in northern and South-Eastern Puebla (figure 5). The plants flower and fruit all year round.

Taxonomic notes: *Maianthemum paniculatum* is easily recognized because of its short cylindrical to narrowly claviform rhizome units, its usually undulate margin leaf, its lax inflorescence with spreading lateral axes, its flowers with pinkish tepals and spherical or trilobed berries, green tinged red when young and red when mature.

Examined specimens: MEXICO. Puebla, Ahuacatlán, Agua Dulce, 4 km al SE de Ahuacatlán, 12 June 1985, *Pedro Tenorio L. and C. Romero de T. 8995* (MEXU). Below Honey Station, 6 May 1904, *C. G. Pringle 8836* (MEXU). Coyomeapan, Ajalpan Grande al NE de Coyomeapan, 31 December 1988, *Pedro Tenorio L. 15426* (MEXU). Cuetzalan de Progreso, Cerro Hueyetepec, 10 March 1998, *J.L. Contreras J. 4555* (HUAP, MEXU); La Galera, partiendo de La Galera tomando una vereda que conduce al lugar denominado La Primavera hasta llegar a la mojonera que divide Cuetzalan y Tlatlauquitepec 1 hora y 20 minutos del centro de La Galera, 15 September 2015, *Ceferino Salgado 2655* (HUAP, MEXU). Teziutlán, 8.6 km al NE de Teziutlán, sobre carretera federal 129 en dirección a Veracruz, 24 April 2019, *Lucio Caamacho Onofre* and *Michelle Xicotencatl Lozano 12934* (HUAP). Hueyatamalco, 12 km al N de Teziutlán, carr. a Nautla. 03 September 1988, *Pedro Tenorio L. 15072* (MEXU). Tlacuilotepec, 4 km al NW de Tlacuilotepec a orilla de camino, 25 April 2018, *Lucio Caamacho Onofre 12062* (HUAP). Tlatlauquitepec, Xucayucan, 10 k al N de Tlatlauquitepec, carretera de Mazatepec, 5 October 1998, *J. L. Contreras J. 5879* (HUAP, MEXU), 12 January 1999, *J. L. Contreras J. 6780* (HUAP*), 6802* (HUAP). Xiutetelco, Km 10 sobre carretera Teziutlán-Hueytamalco, lado N del puente San Miguel, 25 February 2015, *Lucio Caamacho Onofre and Cerón Carpio Amparo 57651* (HUAP). Yoanáhuac, 09 July 1986, *Pedro L. Tenorio 15072* (ENCB, MEXU). Zacapoaxlta, San Juan Tahitic a 20 minutos de la finca Calatepec rumbo a Tepeikan (Baesko), 14 Dic 2014, *Canek Ledesma Corral and Anastasio Sotero Hernández 20457* (HUAP).

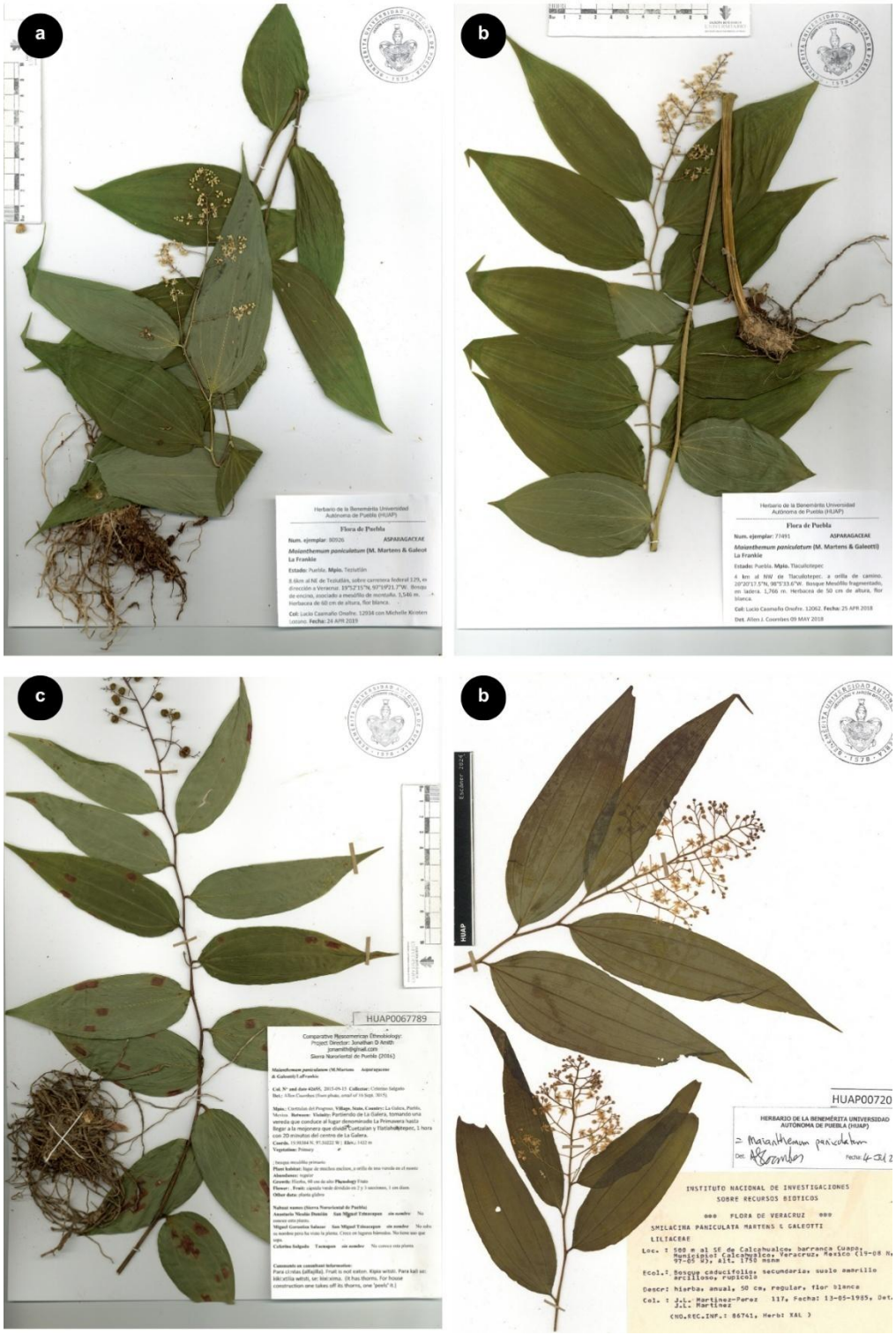

Figure 14. *Maianthemum paniculatum*. **a**, **b**, inflorescence and rhizome; **c**, infructescence; **d**, inflorescence.

Maianthemum scilloideum (M. Martens & Galeotti) LaFrankie in Taxon 35: 588 (1986)

Ξ *Smilacina scilloidea* M.Martens & Galeotti in Bull. Acad. Roy. Sci. Bruxelles 9(2): 888 (1842)

Ξ *Tovaria scilloides* (M.Martens & Galeotti) Baker in J. Linn. Soc., Bot. 14: 567 (1875)

= *Smilacina scilloidea* var *acutifolia* M.Martens & Galeotti in Bull. Acad. Roy. Sci. Bruxelles 9(2): 388 (1842)

= *Smilacina scilloidea* var *rosea* Emons in Ann. Missouri Bot. Gard. 32: 406 (1945)

Terrestrial herbs, 15 to 50 cm tall. **Rhizome** sympodial, rhizome units cylindrical, slightly flattened. **Stem** flexuous, erect, glabrous. **Leaves** lanceolate to ovate, sessile or petiolate, 3 to 4 mm long, blade 6 to 12 cm long by 2 to 3 cm width, base rounded or slightly attenuate, margin entire, apex acuminate. **Inflorescence** racemose, erect, sometimes flexuous, 2 to 5 cm long, 2 or 3 (-4) flowers per node, arranged in helix, subtended by a scarious bract. **Flowers** on pedicels, 3 to 9 mm long, perianth spreading or reflexed, usually white, tepals elliptic, rounded at the apex, oblong, ca. 4 to 5 mm long by 1 mm width, **stamens** ca. 2mm long, white, anthers white, oblong, 5 to 9 mm long, **ovary** globose, ca. 2 mm, style ca. 1 mm long, slightly trilobed. **Fruit** spherical to slightly trilobed, green when young, red when mature. **Seeds** 1 to 3 per fruit, globose.

Habitat and distribution: This species grows in soils rich in organic matters, roadsides and light gaps in pine-oak, oak and cloud forests in 1800 to 2500 m altitude, in the north and Southeast of Puebla (figure 5). The plants flower and fruit throughout the year. The plants flower from April to August and fruit from June to December.

Taxonomic notes: *Maianthemum scilloideum* is easy to distinguish because it is a small plant (15 to 50 cm), its rhizome units are cylindrical and slightly flattened, the leaves are usually ovate, the inflorescence is erect or flexuous and the perianth is usually white. It is also one of the two terrestrial species of *Maianthemum* with a racemose inflorescence.

Examined specimens: MEXICO. Puebla, Chapulco, Cumbres de Acultzingo camino a Puente Colorado, límite entre Veracruz y Puebla, 06 November 1985, J. Martínez and R. Acosta P. 997 (XAL). Coyomeapan, Cerro Mototepec 4 km al SE de Coyomeapan, 25

May 1986, *P. Tenorio L. 11348* (MEXU); La Y griega, desviación a Coyomeapan de la brecha a Zoquitlán, 28 September 1984*, P. Tenorio L., C. Romero de Tenorio and Leobardo Tenorio M. 7496* (MEXU). Coxcatlán, 19.5 km de Coxcatlán brecha a Zoquitlán, 21 December 2000, *P. Tenorio L. 19876* (MEXU). Huauchinango, 1.9 km al NEW de Loc. Venta Grande, 18 June 2019, *Lucio Caamacho Onofre and Michelle Xicotencatl Lozano 13204* (HUAP); 8 km al E de Venta Grande, camino a Ocpaco, 15 August 2007, *J. L. Contreras J. 8791* (HUAP, MEXU). Tepetzintla, Cerro Chiquinahuitzamatl, al W de Tepetzintla,01 July 1987, *Pedro Tenorio L., A. Campos V. and G. Toriz A. 13818* (MEXU). Tlaola, Caxapotla, Cerro Chalchihuitl, 28 May 2009, *M. Cortés R. 31* (HUAP). Xochiapulco, Rosa Chica, en el manantial, 200 m antes de llegar a la caja de agua, en dirección a Xochiapulco, 26 April 2015, *Miriam Jiménez Chimil and Mariano Gorostiza Salazar 30658* (HUAP). Zautla, Rosa de Catilla, Mexcaltenoh, a 45 minutos del pueblo, en la parte suroeste del mismo, cerca de la cañada de Zolayapan, 2128 m, 18 September 2014, *Miriam Jiménez Chimil 30158* (HUAP).

Figure 15. *Maianthemum scilloideum*. **a**, inflorescence; **b**, infructescence and rhizome.

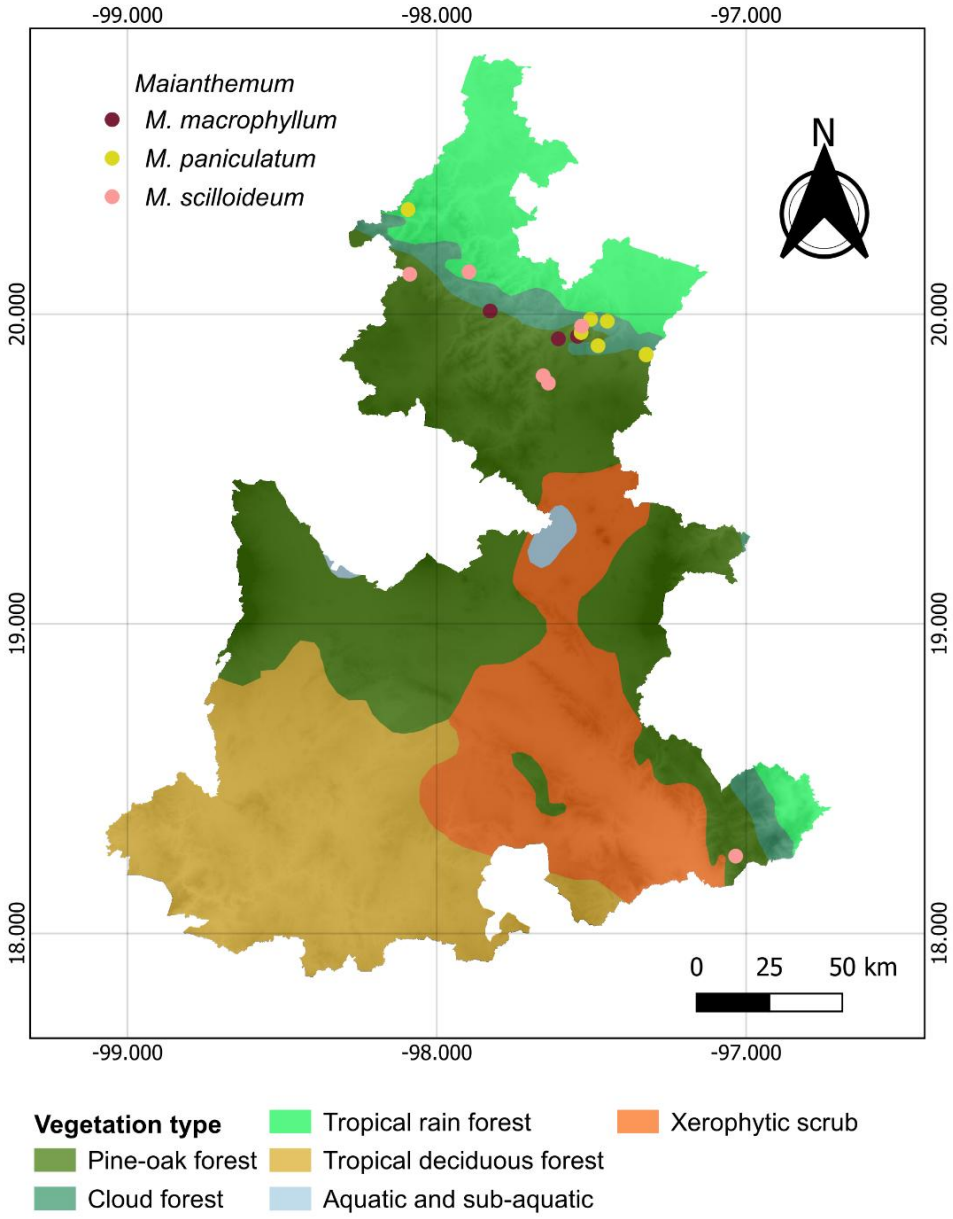

Figure 16. Geographic distribution of *Maianthemum* by vegetation type. Image by Araceli Morales González.

8. Discussion

8.1. Morphological descriptions and taxonomic keys

Nolinoideae is a taxonomically difficult group, the problems with the taxonomy arise from the fact that it is not easy to find complete herbarium specimens. Most of the species in this group are arborescent, have rosettes with many leaves that have serrulate margins that can cut the skin and large inflorescences. Consequently, just collected young and immature leaves and on herbarium specimens it is common to find only a leaf and inflorescence fragments and taxonomically important characters such as inflorescence size, shape, inflorescence bracts, number of branches, branch bracts, branchlets, branchlet size, are usually missing from specimens and are not recorded in the label data (Hernández-Sandoval & Rebman, 2018). In this study seven diagnostic characters were selected which can be used in combination to distinguish the two tribes in the subfamily. The selected characters are habit, phyllotaxy, leaf shape, leaf margin type, leaf apex, inflorescence type and fruit type.

Nolineae can be distinguished from Polygonateae by its arborescent to short caulescent habit, rosette phyllotaxy, leaves long linear, usually erect, leaf margin serrulate sometimes with prickles or filiferous, leaf apex usually acute or fibrous, lax or spiciform panicle and dry indehiscent fruit winged or globose. While Polygonateae are distinguished by their herbaceous terrestrial and epiphytic habit, distichous phyllotaxy, leaves ovate to elliptic, leaf margin entire or undulate, leaf apex acuminate, panicle or complex raceme, and berries spheric or trilobed. The results are similar to those reported by Rivera-Lugo (2010), who carried out a morphological study of the subfamily Nolinoideae, in addition, to recognized as diagnostic characters the absence of phytomelan, few ovules per locule, articulated pedicel and chromosome number n=9.

8.2. Morphological characteristics of the tribe Nolineae

The morphological characters of the Nolineae genera are consistent with the descriptions of Rivera-Lugo & Solano (2012) and Hernández-Sandoval (2020). The three genera have a similar habit, but all have easily recognizable characters that are useful for their

identification (Rojas-Piña *et al*., 2014). In this study nine diagnostic characters were found to differentiate *Beaucarnea*, *Dasylirion* and *Nolina*. All *Beaucarnea* species from Puebla are arborescent and they are easily distinguished from the other genera by their swollen bases. *Dasylirion* species are shortly caulescent and are easily distinguished by their cylindrical caudex. *Nolina* is arborescent but does not have a swollen base. Rojas-Piña *et al*. (2014) considered the bark as a character useful for the identification of the genera, but this feature is similar between *Beaucarnea* and *Nolina*, in both genera the bark is tick, tessellated and tends to form irregular grooves along the stem, while in *Dasylirion* there is no bark, but the cylindrical caudex is covered with marcescent leaves (Bogler, 1995). In this study this character is not considered diagnostic because it was not observed, it is usually missing in specimens and are not recorded in the label data.

Variations in leaf shape, margin and apex provide important information for the identification of genera. This study reports that *Beaucarnea* have linear to ensiform leaves with microserrulate margins and acute apices. In *Dasylirion* the leaves are linear, with serrulate margins and prominent prickles and, fibrous apex. In *Nolina* the leaves are linear, with serrulate to filiferous margin and acute apex. These morphological characters are consistent with the descriptions of Rojas-Piña *et al*. (2014) and Sandoval-Hernández (2020). Another diagnostic feature is the shape of the inflorescence, which is particularly useful in identifying *Dasylirion* (Bogler, 1995). *Beaucarnea* and *Nolina* have a lax panicle, whereas *Dasylirion* has a spiciform panicle.

Reproductive characters best reflect the differences between the four genera, but it was difficult to find specimens with staminate flowers, pistillate flowers and mature fruits. The characters selected to differentiate the genera are tepals detail, pistillode detail, gynoecium detail and fruit shape. In this study it was observed that *Beaucarnea* and *Dasylirion* have crenate tepals while *Nolina* has tepals with apical trichomes (Rojas-Piña *et al*., 2014; Hernández-Sandoval, 2020). Also, the pistillode of staminate flowers in *Beaucarnea* and *Dasylirion* is usually inconspicuous and papillose, whereas in *Nolina*, it is prominent and globose (Rojas-Piña *et al*., 2014). The gynoecium in *Beaucarnea* is fleshy and tripterous, the ovary is unilocular, the style is short, and the stigma is papillose. In *Dasylirion* it is coriaceous and tripterous, the ovary is unilocular, the style is prominent

and infundibuliform and the stigma is not papillose. In *Nolina* is fleshy and lacks wings, the ovary is trilocular, the style is short, and the stigma is papillose (Rojas-Piña, 2015). However, pistillate flowers were not observed in *Nolina.* Finally, in *Beaucarnea* and *Dasylirion* the fruit is unilocular and tripterous, while in *Nolina* is trilocular and globose (Rivera-Lugo & Solano, 2012; Hernández-Sandoval, 2020).

According to Hernández-Sandoval et al. (2012) the characters that provide information to identify *Beaucarnea* species are the variation in habit, base shape, bark, branching pattern, terminal branch shape, rosette buds, leaf shape, leaf margin, leaf base, inflorescence shape, peduncle size, number of branchlets, bracts shape, number of staminate flowers, number of pistillate flowers, fruit shape and seed shape. On the other hand, Rivera-Lugo & Solano (2012) are distinguished species by the number of branches in inflorescence, the size of the leaves and presence or absence of marcescent leaves. In this work, the diagnostic characters chosen to differentiate the species in *Beaucarnea* are the variation in leaf shape, leaf margin, leaf base and ovary shape. All *Beaucarnea* species are similar in size and morphology, with the four species having conical or globose base, thick, rugose, grey bark, and erect, blue-green, glaucous leaves. Based on these morphological characters, Rojas-Piña (2015) argues that they may be adaptations to drier environments with more pronounced temperature and drought extremes. Rivera-Lugo (2010) mentions that *B. gracilis*, *B. purpusii* and *B. stricta* are sympatric and therefore, they have similar leaf characteristics (shape, size, and color) and inflorescence shape, suggesting that they hybridize with each other. However, B. *gracilis* its can be distinguished by its highly branched trunk, narrowly linear leaves, with a flat to slightly concave orangish base and green reddish margin (Hernández-Sandoval, 2012). Whereas in *B. olsonii* the base tapers abruptly into few slander branches (Rojas-Piña & Alvarado-Cárdenas, 2016), leaves are linear to ensiform with involute, whitish to greenish base and margin is greenish with not persistent denticles. *B. purpusii* is morphologically similar to *B. stricta*, which even some authors treat as a synonym of *B. stricta* (Trelease, 1991). Hernández-Sandoval (1993) reported that *B. purpusii* occurs at higher altitudes, whereas *B. stricta* occurs in lowlands. On the other hand, Rojas-Piña (2015) reported that *B. purpusii* has longer and thicker bracts than *B. stricta*. In this study, *B. purpusii* is characterized by its flat, linear leaves, orangish base and green to yellowish margin with

not persistent denticles (Rivera-Lugo & Solano, 2012). These, on the other hand, are ensiform, flat to concave with yellowish to orangish base and yellow margin with persistent denticles in *B. stricta*. Variation in the shape of the ovary also provides important information for species differentiation. In *B. gracilis* it is pyramidal (Rivera-Lugo, 2010), while in *B. olsonii* it is pyriform with a conical stigma (Rojas-Piña & Alvarado-Cárdenas, 2016). In contrast, *B. purpusii* differs from *B. olsonii* in having a stigma with prominent lobules, and in *B. stricta* is ellipsoid (Rivera-Lugo & Solano, 2012).

In the case of *Dasylirion*, leaf characters are very important in the classification of species. Bogler (1995) mentions that the characters used to determine species are the texture of the leaf, the presence of wax, the shape and color of the prickles, also the number of branches, the variation in the pistillate flowers (size differences in the tepals, style and stigma lobes), the length and shape of the wings in the fruits and the apical notch. In addition, Hernández-Sandoval (2020) considered leaf size, inflorescence shape, fruit shape, seed shape and pedicel measures on pistillate flowers and fruits, while Rivera-Lugo & Solano (2012) considered leaf apex length and bract shape. In this study characters such as number of branches, variation in pistillate flowers and bract shape, were not considered as diagnostics characters because they were not observed in all specimens. It is common to find specimens that do not contain complete leaves, inflorescences, flowers and mature fruits, so characters such as pedicel measures on flowers and fruits cannot be obtained. Similarly, the apical notch was excluded as a diagnostic character because it is a highly variable character even at the individual level (Quirino, 2017). The diagnostic characters selected to differentiate the species in *Dasylirion* are leaf color, texture, presence or absence of wax, leaf margin color, shape and color of prickles, and shape and color of fruit. On the basis of morphology, *D. acrotrichum*, *D. lucidum* and *D. serratifolium* are very similar. However, *D. acrotrichum* can be clearly distinguished by its green to glaucous green leaves, smooth surface, unwaxed, abruptly tapering to the base, green to yellowish margin, antrorse and retrorse prickles, yellowish reddish and ellipsoid to obovoid fruits (Galván, 2005; Hernández-Sandoval, 2020). Whereas D*. lucidum* has green yellowish leaves, smooth surface, waxy, yellow margin, prickles usually antrorse, yellow to brown reddish and obovoid fruit tinged purple (Rivera-Lugo & Solano, 2012). *D. serratifolium* is distinguished by its green to glaucous

green leaves, scabrous surface, unwaxed, margin yellow, prickles usually cuspidate, yellow and ellipsoid to obovoid fruit tinged reddish to purple (Rivera-Lugo & Solano, 2012). In his taxonomic treatment Rivera-Lugo (2010) mentions that the populations of *D. lucidum* in Northern Puebla are sympatric with *D. acrotrichum* and some populations of *D. serratifolium* in Oaxaca, and that there are individuals with intermediate characters that differs in leaf texture and prickles between the species. However, even though the leaves do not lose their characters after herborization (Quirino, 2017), field work is needed to assess whether these characters are necessary to consider them as hybrids.

In the case of *Nolina* species, according to Ruiz-Sanchez *et al*. (2019), the characters that best reflect differences between species are habit, plant height, marcescent leaves, variation in leaf shape as apex shape, margin color, denticles orientation, denticle size (mm), inflorescence length, inflorescence branches, bracts shape, staminate flores per node, pedicel length, fruit length, seed color and phenology. In addition, García-Mendoza *et al*. (2012) considered the color of the tepals, the shape of the seed and the ornamentation of the seed. In this study, *N. parviflora* is distinguished by its arborescent habit, slightly swollen base, bark that forms irregular grooves along the stem, marcescent leaves near the rosettes (Ruiz-Sanchez *et al*., 2019), leaves reflexed with the age (Galván, 2005), margin serrulate to filiferous, denticles simple or bicuspid, green yellowish to red with the age and apex acute, dry, erect, helical and lacerate (Rivera-Lugo & Solano, 2012; Hernández-Sandoval, 2020). According to Ricker & Hernandez (2010), it is one of the four species of Nolina that is taller than 5 m.

8.3. Morphological characteristics of the tribe Polygonateae

The morphological characteristics of Polygonateae are correspond to those described by of López-Ferrari & Espejo (1993) and Sánchez-Ken (1997). Polygonateae are characterized by a subterranean rhizome, a leafy aerial stem and a fruit that is always a berry (Galway,1945). *Maianthemum* differs from other genera of the tribe by having a simple aerial stem, a terminal inflorescence that can be either racemose or paniculate, spotting on immature berries and a chromosome number of 18 (Galway,1945; LaFrankie, 1986).

Characteristics such as growth habit, rhizome shape, stem shape, leaf shape, inflorescence shape and perianth shape provide essential information for identifying *Maianthemum* species (LaFrankie, 1986). In addition, López-Ferrari & Espejo (1993) and Sánchez-Ken, (1997) considered length and shape of the roots to be important characters, but roots are of limited taxonomic importance. In this study, characters such as rhizome shape and roots length and shape were excluded as diagnostic characters because they were not observed. The diagnostic characters selected to differentiate the species in *Maianthemum* are habit, stem shape, leaf shape, inflorescence shape and perianth shape and color. *M. macrophyllum* is clearly identified by its epiphytic and rupicolous habit (López- Ferrari & Espejo, 1993), pendent and slightly arched stem, lanceolate to ovate leaves, inflorescence arching upward and perianth cupuliform, yellow green (LaFrankie, 1986). Otherwise, *M. paniculatum*, has a terrestrial habit, flexuous, erect or arching stem, ovate, elliptic or lanceolate leaves, paniculate inflorescence and perianth spreading to reflexed, white (Sánchez-Ken; López- Ferrari & Espejo, 1997). *M. scilloideum* can be clearly identified because it's a small plant (15 to 50 cm tall) with a terrestrial habit, a flexuous and erect stem, ovate and sessile or petiolate leaves, a racemose and flexuous inflorescence and a spreading perianth, white.

8.4. Distribution

This study reports that two tribes, four genera and ten species represent the subfamily Nolinoideae from Puebla, of which eight species are endemic to Mexico and six species are endemic to the study area. These results are similar to those reported in other studies (Olvera-Valero, 2006; Espejo, 2012; Ruíz-Flores & Castro-Castro, 2024). Rodríguez-Acosta *et al.* (2014) reported four genera and eight species, while Villaseñor (2016) reported four genera and ten species. Although the number of taxa reported is similar, there are differences in the identity of the species reported. The first study did not report the presence of *B. purpusii*, however, both studies considered the presence of *B. recurvata* in Puebla, but as this is a floristic study, the specimens examined to confirm the identity of the taxa are not reported. It is therefore necessary to carry out extensive fieldwork in the state to determine whether these are the natural patterns of their distribution. As a contribution to the above mentioned works, are report here for the first

time the presence of *B. olsonii* and *M. macrophyllum* in Puebla. The increase in the number of species recorded in the state may be due to increased botanical exploration in the state and the discovery of new species. For example, the work of Rodríguez *et al*. (2014) and Villaseñor (2016) was carried out before the description of *B. olsonii* (Rojas-Piña & Alvarado-Cárdenas, 2016).

The most diverse genera in the state are also the most diverse in Mexico. In this study, *Beaucarnea* and *Dasylirion* are at the top of the list. In addition, Hernández-Sandoval (2018) included *Nolina* among the most diverse genera. In Puebla, however, this genus is represented by one species since its greatest diversity occurs in the north of the country. In addition, new records are reported from Puebla. *M. macrophyllum* has been reported in the limits of Oaxaca and Veracruz (Espejo, 2012; Villaseñor, 2016). Also, LaFrankie (1986) also reported it as endemic to Veracruz. In this study, *M. macrophyllum* has four supporting specimens, so the new records may be related to the lack of exploration in the state. Field work is essential for taxonomic treatments, providing useful information for detailed descriptions and accurate determination (Rostro del Muro *et al*., 2024).

In this study, Nolinoideae species grow in five vegetation types; xerophytic scrub and pine-oak forest are the most diverse with eight taxa, followed by tropical deciduous forest and cloud forest with two taxa, and finally tropical rain forest with one taxon. All Nolinoideae species were recorded in a wide altitudinal and ecological range. It has been reported that species such as *B. gracilis*, *B. purpusii* and *B. stricta* can grow on rocky soils with steep slopes in xerophytic scrub at different altitudes. *B. gracilis* is known at 1300 to 200 m in elevation (Rivera-Lugo & Solano, 2012) and it was found at 886 to 2373 m in elevation in xerophytic scrub and disturbed scrub (figure 2). It is an endemic species to the state and is reported in the category of endangered according to NOM-059-SEMARNAT-2010 (SEMARNAT, 2010). *B. purpusii* has been reported at altitudes between1600 and 2200 m (Rivera-Lugo and Solano, 2012) and was found at altitudes between 1417 and 2320 m in elevation in xerophytic scrub and pine-oak forest (figure 2), is endemic to the state and is reported in the category of in danger of extinction (SEMARNAT, 2010). *B. stricta* is known only from 1200 to 1500 m in elevation (Rivera-Lugo & Solano, 2012) and was found from 1500 to 2100 m in elevation in xerophytic scrub and pine-oak forest (figure 2), is an

endemic species of the state and is reported in the category of endangered (SEMARNAT, 2010). On the other hand, *B. olsonii* is only known to grow on steep slopes at elevations above 1200 m in elevation in tropical deciduous forest and is only known from the type locality (figure 2) (Rojas-Piña & Alvarado-Cárdenas, 2016) and is reported in the category of critically endangered according to the UICN (2012).

D. acrotrichum, *D. lucidum* and *D. serratifolium* have been reported that growing on igneous rocks and calcareous soils in xerophytic scrub and pine-oak forest at different altitudes. *D. acrotrichum* has been reported at 2250 to 3000 m in elevation (Galván, 2005) and was found at 1600 to 2400 m in elevation in xerophytic scrub, pine-oak forest and tropical deciduous forest (figure 3), and is listed in the category of endangered (SEMARNAT, 2010). *D. lucidum* has been reported at 1500 to 2300 (Rivera-Lugo & Solano, 2012) m in elevation and has been found at 1600 to 2400 m in elevation in xerophytic scrub and pine-oak forest (figure 3) and is endemic to the state. *D. serratifolium* is known only at 1300 to 2700 m in elevation in xerophytic scrub and pine-oak forest (Rivera-Lugo & Solano, 2012), is endemic and occurs on the border of Puebla and Oaxaca (figure 3). *N. parviflora* has been reported to grow on mountain slopes, on rocky and sandy soils at altitudes of 1800 to 3200 m in xerophytic scrub, oak forest, pine-oak forest and pine forest at altitudes of 1600 to 2900 m in elevation in xerophytic scrub and pine-oak forest (figure 4).

Among the *Maianthemum* species, *M. macrophyllum* is known only in pine-oak forest, tropical rain forest and cloud forest at altitudes between1300 and 2700 m (LaFrankie, 1986; López-Ferrari & Espejo, 1993) and was found at 1365 to 1545 in pine-oak forest and cloud forest (figure 5). *M. paniculatum* has been reported from oak forest, pine forest, pine-oak forest and tropical rain forest at 1400 to 2700 m in elevation *(*López-Ferrari & Espejo, 1993; Sánchez-Ken, 1997) and was found at 1486 to 1800 m in elevation in pine-oak forest, cloud forest and tropical rain forest (figure 5). *M. scilloideum* is only known in 1700 to 3500 m in elevation pine-oak forest and oak forest (LaFrankie, 1986; Sánchez-Ken, 1997) and was found at 1800 to 2500 m in elevation in pine-oak forest, cloud forest and tropical rain forest (figure 5).

9. Conclusions

In the State of Puebla, the subfamily Nolinoideae is represented by two tribes, four genera and eleven species. The most diverse genus was *Beaucarnea* with four species, followed by *Dasylirion* and *Maianthemum* with three species each, and *Nolina* with the species *N. parviflora*. Eight species are endemic to Mexico, and six species are endemic to Puebla. In the case of the tribe Nolineae, four species are listed as endangered according to the NOM-059-SEMARNAT-2010, and one species is reported in the category of critically endangered according to the UICN. In the case of the tribe Polygonateae, *M. macropphyllum* was reported for the first time in the state, representing the extent of its known range. However, greater effort is needed to collect material in the field and prioritize species that have few specimens, such as this species with only four records in the state, and *D. serratifolium* with one record.

The morphological differences between Nolineae and Polygonateae are very contrasting. They can be distinguished based on characteristics such as habit, phyllotaxy, leaf shape, leaf margin type, leaf apex, inflorescence type, and fruit type. Additionally, Nolineae is restricted to xerophytic scrub and pine-oak forests, contrasting with the Polygonateae distribution in cloud forests and tropical rain forests. Therefore, the hypothesis that the species of Nolinoideae present in Puebla can be identified based on floral and vegetative morphological characters is accepted.

It is important to recognize the boundaries of the study. This research relied on the use of herbarium specimens, consequently, it was not easy to find complete herbarium specimens, and taxonomically important characteristics that are usually missing. In *Dasylirion*, for example, the absence of some floral characteristics results in an ambiguous and difficult determination because the species present vegetative characters that are very similar. It’s important to consider field work, as it provides information such non-morphological characteristics, flowering season or habitat, which may help to characterize species.

Botanical monographs play a central role in taxonomic research. They are the basis for the development of other types of research and are essential for defining the current state

of the vegetation and strategies for its conservation. This work is a contribution to the knowledge of the flora of Puebla and is the first study to provide updated information on the diversity of the subfamily Nolinoideae in the state, including descriptions, identification keys, photographs, and distribution maps.

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