

Full Length Research Paper

Vegetation and melliferous flora in the borders of the states of Sinaloa and Chihuahua, Mexico

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Received 22 August, 2025; Accepted 5 January, 2026

Vegetation in the border region of Sinaloa and Chihuahua, Mexico, comprises Tropical Deciduous Forest (TDF), Pine Forest (PF), Oak Forest (OF), and Riparian Vegetation (RV). 50 individuals were interviewed across 10 villages and documented 279 melliferous/polliniferous species belonging to 203 genera and 69 families, with Fabaceae (25 species) and Asteraceae with 23 being the most prominent. Of these, 95 species occurred in wild habitats within TDF; 53 were classified as weeds (W), 51 as crops (C), and 44 as ornamentals (O). In addition, 15 species were found in PF, 11 in RV, and 10 in OF. Notably, 88.5% of the reported plant species were both nectariferous (N) and polliniferous (P), while the remaining 11.4% were exclusively polliniferous. The most common growth forms were herbs (H) with 78 species, followed closely by trees (T) with 77. Flowering phenology was dominated by spring (S) (51.9%) and summer (Su) (32.9%). Among the documented species, occasional (O) forms (73 species), abundant (A), and rare (R) forms, with 70 were most prominent. The melliferous plants most highly valued by local people included *Stenocereus montanus* (100%), *Pachycereus pecten-aboriginum* (96%), *Randia echinocarpa* (94%), *Wimmeria mexicana* (90%), and *Vitex mollis* (88%).

Key words: Vegetation, nectar, pollen, beekeeping, Sierra Madre, Sinaloa, Chihuahua, melliferous plants.

INTRODUCTION

Useful flora plays a key role in the daily lives of rural communities (Chambers and Conway, 1992), owing to the

many products these plants provide food, fuel, medicines, and clothing (Diazgranados et al., 2020). Method

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obtaining and extracting such resources vary according to both the availability of natural resources and the cultural-ethnic group involved (Lowe, 2021). These practices help maintain and reinforce traditional customs and knowledge (Avalos et al., 2022; Verma et al., 2024). Approximately 90% of angiosperm species depend on insect-mediated pollination (Klein et al., 2007), and similarly, about 85% of crops benefit in terms of yield through this process (Winfree et al., 2009). Hence, plant-pollinator interactions confer advantages both to plants and to the pollinating insects (Nitharwal et al., 2022).

Beyond their utilitarian value, plants contribute essential ecological services, most notably, pollination, which is integral to sexual reproduction. Cross pollination involves the transport of pollen from the anther of one flower to the stigma of another, increasing the likelihood of species continuity in plant communities and ecosystems, while also preserving crops that are vital for food security (Basualdo et al., 2022). In pollination, animals, mostly insects serve as the primary agents (Maggi et al., 2024), obtaining food in the form of pollen and nectar (Walker, 2020). Nectar is often transformed into honey, which in many cultures is highly valued both for its nutritional and medicinal properties. Honey is rich in sugars, amino acids (Baker and Baker, 1975; Hendriksma et al., 2014), and antioxidants such as flavonoids and phenolic acids (Cauich-Kumul et al., 2015; Magner et al., 2025). It can also function as a pheromone, attracting more pollinators and thereby enhancing pollination (Slavković and Bendahmane, 2023). To produce honey and related secondary products, many insect species have been domesticated since ancient times for example, species of the genus *Apis* in Europe (Rabeena et al., 2024) and *Melipona* among the Maya (Bacab-Pérez and Canto, 2020) while others are exploited in wild settings (Ribeiro et al., 2019). Bees, ants, and bumblebees are associated with melliferous plants that also produce pollen and wax (Villarreal-Cantú, 2024). These insects store honey and wax in structures such as hollow trunks, tree or bush branches, underground galleries, or hives (Smith et al., 2023) substances such as propolis and royal jelly are also collected from these storage sites (Pasupuleti et al., 2017; Roy et al., 2025).

In species that use a sting for defense, venom may have medicinal applications (Reed and Landolt, 2018). All these substances may be transformed into products whose sale provides income for both established honey producers and wild honey collectors (Ferreira et al., 2023). In the tropical dry and semi-dry forests of the Americas and Asia (Crane,

1998), as well as in Africa (Dietemann et al., 2009), a remarkable diversity of honey-producing organisms is associated with rich and varied nectariferous flora. These floras are dominated by spring-flowering woody plants (van Schaik et al., 1993), whereas herbaceous species more often bloom during summer and autumn (Stevenson et al., 2008). In Mexico, several studies have highlighted the extensive wealth of melliferous flora (Araujo-Mondragón and Redonda-Martínez, 2019; Baena-Díaz et al., 2022; González-Avilés et al., 2023), which is linked to climatic, edaphic, and orographic variability; these factors give rise to a great diversity of ecosystems (González-Medrano, 2017), in which many types of flowering plants flourish (Rodríguez et al., 2018). Such vegetation types include Tropical Dry Forests (TDF), perennial forests, xerophytic scrub, thorn scrub, mangroves, dune vegetation, and Gallery Forests (GF) (Miranda and Hernández, 1963; Rzedowski, 2006).

The present analysis aims to contribute further information on the diversity of melliferous plants in TDF and adjacent plant communities, and on their phenology, ecological, cultural, and economic importance. It focuses on the border region between the states of Chihuahua and Sinaloa in Mexico, a poorly studied area (Villaseñor, 2016) due to the serious situation of social violence (López-López and Camacho-Castro, 2024).

MATERIALS AND METHODS

Study area

The study area covers 462 km² and lies on the western slopes of the Sierra Madre Occidental, spanning the municipalities of Badiraguato (in Sinaloa) and Guadalupe y Calvo (in the southwestern corner of Chihuahua) (Figure 1). Elevation ranges from 1,609 m above sea level (in El Jacal) to 674 m (in Soyatita), both within Sinaloa. Most of the communities fall under a semi-warm, dry climate (BSHW) (National Institute of Statistics and Geography [INEGI, 2021]), except for El Jacal, which due to its elevation experiences a temperate, subhumid climate with a summer rainfall regime (Cw1) (INEGI, 2010). Soil types in the area are highly variable; the most common soils are derived from extrusive igneous rocks and include Litosols, Cambisols, Luvisols, and Regosols (INEGI, 2010). These soils support TDF on hillsides, GF along streams and the Sinaloa River, and at higher elevations patches of Oak Forest (OF) and Pine Forest (PF), in addition to extensive secondary bush vegetation. The human population is sparse, ranging from just 42 people in the Los Arroyitos community to over 600 in San José del Llano. Their income levels are classified as very low. Slash-and-burn agriculture is common, and livestock production (for both dairy and meat) is widespread. People also extract coal, firewood, and at a smaller scale medicinal and edible plants, which are sold in the main municipal towns.

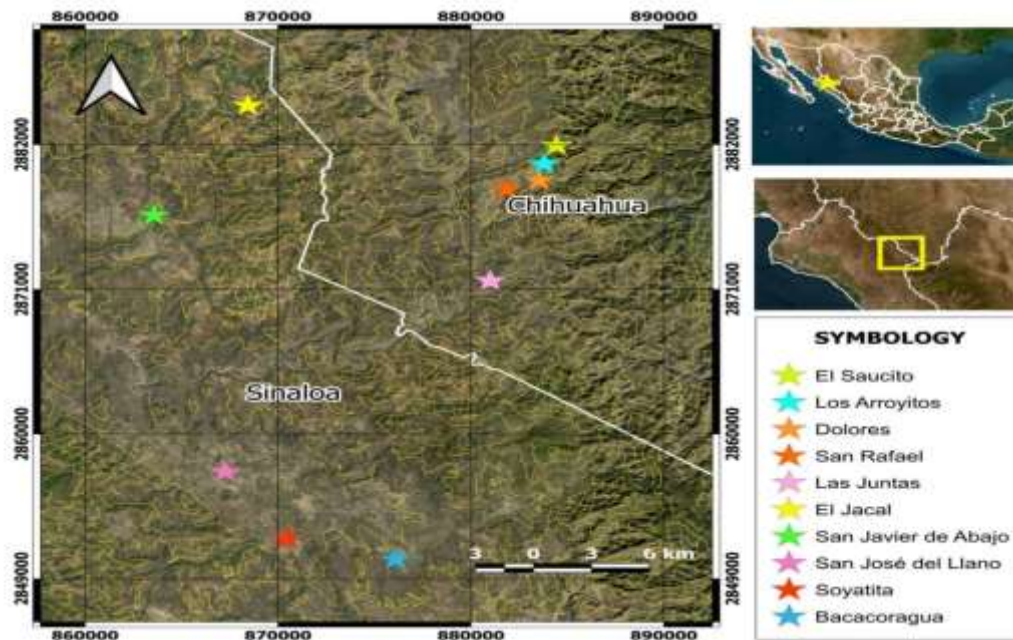


Figure 1. Study area located between the states of Sinaloa and Chihuahua, Mexico.

Procedures

To create the map (Figure 2), the study communities was located using the free “Pro” version of Google Earth (Google, 2025). After identifying each community’s location, we saved their geographic coordinates. For spatial projection, we used the WGS84 / UTM Zone 12 N datum. As a base, we employed Landsat 8 satellite imagery with true-color composition and a 30 m pixel resolution (United States Geological Survey [USGS], 2025). State boundaries were delineated using vector data from the national geostatistical framework and generated contour lines from a 1:50,000 scale digital elevation model (INEGI, 2024). Map editing and production were carried out using the open-source Quantum GIS 3.14 software. The study was carried out in ten villages, five in the municipality of Badiraguato, Sinaloa, and five in Guadalupe y Calvo, Chihuahua (Table 1). To collect data on melliferous plants, interviews were conducted with 50 residents. The number of interviews to be performed was calculated using the formula proposed by Aguilar-Barojas (2005):

$$n = \frac{[N Z^2 pq]}{[d^2 (N - 1) Z^2 pq]}$$

where n = number of interviews required (50), N = sample size (2067), Z = Confidence interval (1.645), p = Approximate proportion of the study object (0.05), q = Approximate proportion that does not represent the study object (1 to 0.05, 0.95), d = Absolute precision

(Confidence interval, 5%).

A total of 50 inhabitants of various ages and occupational backgrounds, including housewives, junior high students, farmers, lumberjacks, coal producers, ranchers, and collectors of honeycombs, hives, and swarms, were interviewed using a set of 10 standardized questions. The purpose was to record the local common names and flowering periods of melliferous plant species in their area. To assess the degree of preference for the origin of nectar and/or pollen among the studied communities, the formula proposed by Madikizela et al. (2012) was applied:

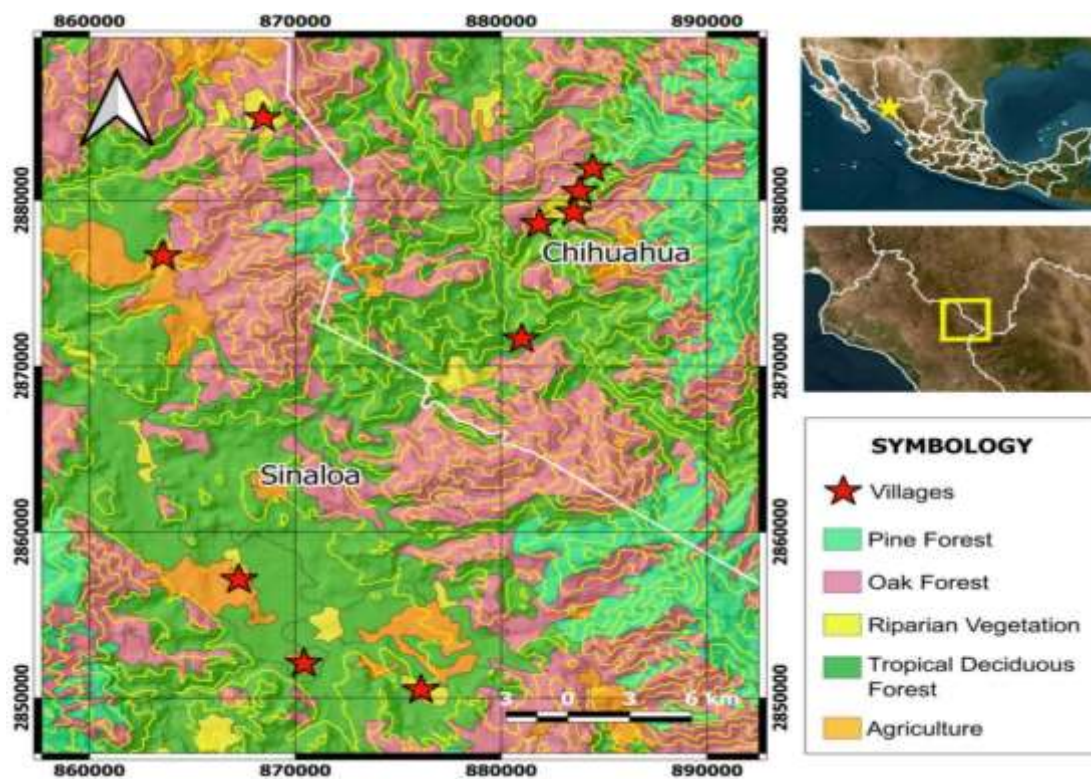
$$FI = (FC/N) \times 100$$

where: FI = Frequency Index that expresses the percentage of preference shown by participants after certain plants were mentioned, FC = number of participants that mentioned his/her preference for a particular species, N = number of participants.

Fieldwork was conducted across all four seasons from November 2021 to November 2024 to characterize vegetation types and melliferous flora. During each expedition, plants observed in-situ were tentatively identified, and individuals recognized as nectar producers were collected, documented, and deposited in the Herbarium of the Botanical Garden of Culiacán (HJBC, Sinaloa) and the Herbarium of the Faculty of Veterinary Medicine at the Universidad Autónoma de Chihuahua (HUACH). Specimen identification was confirmed by comparison with physical collections in these herbaria, consultation of the Mexican Herbarium Network,

Table 1. Location, altitude ASL, inhabitants and name of villages.

Village	Location	Altitude (Asl)	Inhabitants
San José del Llano	25° 47' 11" N 107° 20' 18" O	616	600
San Javier de Abajo	25° 57' 47" N 107° 22' 11" O	685	185
Soyatita	25° 44' 24" N 107° 18' 30" O	674	391
Bacacoragua	25° 43' 27" N 107° 15' 08" O	784	65
El Jacal	26° 02' 13" N 107° 19' 08" O	1609	220
El Saucito	26° 00' 16" N 107° 09' 36" O	1150	41
Los Arroyitos	25° 59' 31" N 107° 10' 01" O	1050	34
Dolores	25° 58' 54" N 107° 10' 12" O	908	456
San Rafael	25° 58' 33" N 107° 11' 13" O	828	36
Las Juntas	25° 54' 49" N 107° 11' 51" O	697	39

**Figure 2.** Distribution of vegetation types in the region, indicated by their distinctive colors.

specialized floras from Durango, Chihuahua, and Sinaloa (González-Elizondo et al., 1991; Martín et al., 1998; Vega-Aviña et al., 2021), and the Naturalist platform (www.inaturalista.org).

Natural vegetation types were named following Rzedowski (2006), citing the most frequent melliferous plants in each community. Individual species names (including authorship and family) followed

Plants of the World Online (POWO, 2025) and Villaseñor (2016). Weeds were identified using keys and guides from Villaseñor and Espinosa-García (2004), Randall (2017), and the Weeds of Mexico platform (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO], 2025). The floristic list was arranged alphabetically under the Angiosperm Phylogeny Group classification (APG, 2016), and includes family name, scientific name (with author), common name, and biological form (Climbing [Cl], columnar [C], creeping [Cr], globose [G], herb [H], rosetophilous [Ro], shrub [S], succulent [Su], tree [T]), following Macías-Rodríguez et al. (2018).

The vegetation type in which each species occurs is indicated: TDF, Riparian Vegetation (RV), PF and OF according with Rzedowski (2006). Additionally, each species was classified as a crop (C), ornamental (O), or weed (W). Species abundance was quantified through field surveys as well as sampling in streets, agricultural plots, orchards, and domestic yards. The abundance classes proposed was employed by Tansley (1946), namely: Dominant (D) >100 individuals, Abundant (A) 50 to 100, Frequent (F) 21 to 50, Occasional (O) 6 to 20, and Rare (R) 1 to 5 (Teurlincx et al., 2018). Flowering phenology was recorded by season: Autumn (A), Spring (S), Summer (Su), and Winter (Wi). Species were labeled as pollen producers (P), nectar producers (N), or both (N/P). Finally, a Frequency Index was calculated, indicating the percentage of interviews in which each plant was mentioned by respondents.

RESULTS

The study area (Figure 1) lies at the interface of the Mesoamerican Mountain and Caribbean regions, where the floristic provinces of the Sierra Madre Occidental and the Pacific Coast converge (Rzedowski, 2006). In most of the surveyed communities, PF and OF are scarce, except on the highest mountains, while TDF is predominant on hillsides. Extensive deforested zones attributable to seasonal agriculture and emerging livestock rearing were observed. Within the TDF, it was recorded that species such as *Lysiloma divaricatum* (Jacq.) J. F. Macbride, *L. acapulcense* (Kunth) Benth., *Guazuma ulmifolia* Lam., *Ipomoea arborescens* (Humb. and Bonpl. ex Willd.) G. Don, *Buddleja cordata* Kunth, *Ceiba aesculifolia* (Kunth) Britten and Baker f., *Stenocereus montanus* (Britton and Rose) Buxb., *Pachycereus pecten-aboriginum* (Engelm. ex S. Watson) Britton and Rose, *Bursera simaruba* (L.) Sarg., among others.

In the communities of Soyatita and Los Arroyitos, discontinuous patches were detected of *S. montanus*, *Mimosa distachya* Cav., and *Randia echinocarpa* Moc. and Sessé ex DC. Around Dolores, El Saucito, Los Arroyitos, and San Rafael, near PF and OF at higher altitudes, *Dodonaea viscosa* Jacq. was found. In those upper elevation sites, we additionally encountered *Quercus albocincta* Trel., *Q. chihuahuensis* Trel.,

magnoliifolia Née, *Q. urbanii* Trel., *Clethra mexicana* DC., *Vachellia pennatula* (Schltdl. and Cham.) Seigler and Ebinger, *Diphysa suberosa* S. Watson, as well as *Pinus herrerae* Martínez, *P. oocarpa* Schiede and Schltdl., *P. lumholtzii* B. L. Rob. and Fernald, *Arbutus xalapensis* Kunth, and *Arctostaphylos pungens* Kunth. In valley bottoms along creeks protected by mountain shade we documented riparian vegetation (RV), including *Populus mexicana* Wesm., *Salix bonplandiana* Kunth, *Platanus gentry* Nixon and + M. Poole, and *Sideroxylon palmeri* (Rose) T. D. Penn. (Figure 3).

In the streets of Dolores (Chihuahua) and San José del Llano (Sinaloa), the two largest communities in the study, several ornamental trees and shrubs were observed, including *Tabebuia rosea* (Bertol.) DC., *Terminalia buceras* (L.) C. Wright, *Azadirachta indica* A. Juss., *Melia azedarach* L., and *Ehretia tinifolia* L. Within residential backyards and patios, various cultivated fruit species coexist, serving dual purposes: fruit production and nectar provision. These include *Mangifera indica* L., *Spondias mombin* L., *Prunus persica* (L.) Batsch, *Psidium guajava* L., *Carica papaya* L., *Citrus × sinensis* (L.) Osbeck, *Citrus × lemon* (L.) Osbeck, and *Persea americana* Mill. Less frequently encountered species comprised *Juglans nigra* L., *Psidium oligospermum* Mart. ex DC., *Eriobotrya japonica* (Thunb.) Lindl., *Casimiroa edulis* La Llave, *S. montanus*, and *Pithecellobium dulce* (Roxb.) Benth. On adjacent lands surrounding houses, additional edible-fruit cultivars were present, such as *C. papaya*, *M. indica*, *P. guajava*, *P. americana*, *P. persica*, *Opuntia ficus-indica* (L.) Mill., and *Capsicum annuum* var. *aviculare* (Dierb.) D'Arcy and Eshbaugh. These plantings are supported by the "Sembrando Vida" program, subsidized by the Mexican federal government (Tapia-Alba and Chiatchoua, 2025).

In some backyards, along watercourses, and near the Sinaloa River, family orchards known locally as "veranos" are common. In these sites, people cultivate edible species such as *Cucurbita pepo* L., *Mustarda nigra* (L.) Bernh., *Coriandrum sativum* L., *Origanum vulgare* L., *Portulaca oleracea* L., *Brassica oleracea* L., *Raphanus raphanistrum* L., *Allium cepa* L., *A. sativum* L., *Physalis angulata* L., *Capsicum annuum* L., and *Solanum lycopersicum* L., alongside *Saccharum officinarum* L. Aromatic and meq and P. Wilson, *Salvia rosmarinus* Spenn., *Ruta chalepensis* L., and even the versatile *Aloe vera* (L.) Burm. f. is also cultivated. Ornamental gardens are widespread and some typical species are *Alcea rosea* L., *Justicia spicigera* Schltdl., *Gardenia jasminoides* J. Ellis, *Gossypium hirsutum* L., *Hibiscus rosa-sinensis* L., *H.*



Figure 3. Common melliferous plants in the study area: 1. *Kallstroemia grandiflora*; 2. *Ehretia tiniflora*; 3. *Mimosa distachya*; 4. *Pisonia capitata*; 5. *Bonnellia macrocarpa*; 6. *Heliotropium hartwegianum*; 7. *Sorghum halepense*; 8.- *Helianthus annuus*; 9. *Portulaca oleracea*; 10. *Combretum farinosum*; 11. *Randia thurberi*; 12. *Pereskia blakeana*.

sabdariffa L., *Kalanchoe blossfeldiana* Poelln., *K. daigremontiana* (Raym.-Hamet and H. Perrier), *Malvaviscus penduliflorus* Moc and Sessé ex DC., *Murraya paniculata* (L.) Jack, *Nerium oleander* L., *Papaver somniferum* L., *Portulaca grandiflora* Hook., *Rosa* spp., *Zephyranthes candida* Herb., and climbing species along fences such as *Parthenocissus quinquefolia* (L.) Planch.,

Vitis vinifera L., *Cissus verticillata* (L.) Nicolson and C. E. Jarvis, *Sicyos edule* Jacq., and *Lagenaria siceraria* (Molina) Standl. The most frequent and widespread crops are seasonal like *Zea mays* L., *C. pepo*, *Phaseolus vulgaris* L., *Arachis hypogaea* L., *Citrullus lanatus* (Thunb.) Matsum. and Nakai, and *Triticum aestivum* L. Meanwhile, *Sorghum bicolor* (L.) Moench and *S. drummondii* (Nees

ex Steud.) Millsp. and Chase are grown as livestock fodder.

In fields, along roads, and in the streets of the larger communities, numerous weed species thrive including *Baccharis salicifolia* (Ruiz and Pav.) Pers., *Amaranthus palmeri* S. Watson, *A. retroflexus* L., *A. spinosus* L., *Argemone mexicana* L., *Portulaca oleracea* L., *Sonchus oleraceus* L., *Asclepias curassavica* L., and *Foeniculum vulgare* Mill. Climbing species commonly found along crop-field fences include *Paullinia tomentosa* Jacq., *Serjania palmeri* S. Watson, *Momordica charantia* L., *Funastrum cynanchoides* (Decne.) Schltr., *Ruehssia edulis* (S. Watson) L. O. Alvarado, *R. coulteri* (Hemsl.) L. O. Alvarado, *Dioscorea carpomaculata* O. Téllez and B. G. Scub., *Antigonon leptopus* Hook and Arn., and *Gonolobus barbatus* Kunth.

Floristic richness

In this study, 279 species were recorded across 203 genera and 69 families, with particularly high richness in Fabaceae (25), Asteraceae (23), Malvaceae (18), Cactaceae (12), and Solanaceae (11). The genera *Bursera*, *Citrus*, *Ipomoea*, and *Solanum* each comprised five species; *Abutilon*, *Agave*, *Cordia*, *Opuntia*, and *Quercus* each included four. The predominant growth forms were herbs (78 species), followed by trees (77) and shrubs (64). Within the TDF were recorded the greatest species richness (95), followed by weeds (W: 53), crops (C: 51), and ornamentals (O: 44). The season with the most recorded flowering events was spring (S: 145), followed by summer (Su: 92). In terms of frequency of occurrence, occasional species (O) with 73 records, and both rare (R) and abundant (A) categories with 70 species each, were the groups with the highest representation (Figure 4).

In addition, 247 species were recorded as nectar and pollen producers, while 32 species were recorded as exclusively pollen producers. Among the plant species showing the highest preference for nectar production both in quantity and flavor are the columnar succulents *S. montanus* (100%) and *P. pecten-aboriginum* (96%); shrubs such as *R. echinocarpa* (94%) and *Pereskia blakeana* J. G. Ortega (82%); and some trees including *Wimmeria mexicana* (90%), *Vitex mollis* Kunth (88%), *Ipomoea arborescens* (86%), *Celtis pallida* Torr. (84%), *Casimiroa edulis* La Llave (80%) and *Buddleja cordata* Kunth (80%), all found within the TDF (Appendix I).

Another group of species highly favored for their fragrant and sweet honey includes *Arbutus xalapensis*, *Arctostaphylos pungens*, *Azadirachta indica*, *Citrus × sinensis*, *Citrus × limon*, *Ehretia tinifolia*, *Hintonia latiflora*, *Prunus persica*, *Psidium guajava*, *Psidium oligospermum*, *R. echinocarpa*, *Vachellia campeachiana*, and *Vachellia farnesiana*. Among the less preferred species are *Ambrosia ambrosioides* (Delpino) W. W. Payne, *Ambrosia psilostachya* DC., *Parthenium hysterophorus* L., and *Asclepias curassavica* L., all due to their bitter honey and/or pollen. *Ricinus communis* L. was rejected completely, being considered toxic.

DISCUSSION

The vegetation types described in this study correspond closely with those reported by Lebgue et al. (2005) for the Copper Canyon area in Chihuahua, located north of the study region, as well as with those identified along the eastern boundary with the state of Durango by González-Elizondo et al. (2012, 2007). The TDF, in addition to being the most extensive vegetation type in the state of Sinaloa (Berlanga-Robles et al., 2018), is remarkable for its abundance of flowering species, as noted by Rzedowski and Rzedowski (2013). Despite this, it remains one of the most heavily disturbed vegetation types in Mexico (Dirzo et al., 2011; Monjardín-Armenta et al., 2017). Across all regions where it occurs, the TDF is characterized by a marked deciduousness during the dry season, when most species shed their foliage (Singh and Chaturvedi, 2017; Hernández-Rodríguez et al., 2021). This is typically followed by floral development, during which flowers remain fully exposed to pollinators at anthesis. Because flowering occurs mainly during the spring, this period coincides with the highest abundance of nectariferous species, resulting in peak honey production both in the study area and in other regions dominated by TDF (Cortopassi-Laurino, 2004; Suhri et al., 2024). Under these conditions, TDF plants play a crucial ecological role by sustaining bee foraging activity in an environment marked by pronounced seasonal drought. This mutualistic interaction ensures the accumulation of adequate food reserves during critical seasonal periods (Maia-Silva et al., 2015; Aleixo et al., 2017). Regarding the PF and OF, these communities are composed primarily of anemophilous taxa. Species of the genera *Pinus* and *Quercus* bear odorless cones or catkins, and they do not produce nectar; in consequence, they are rarely visited by bees or other

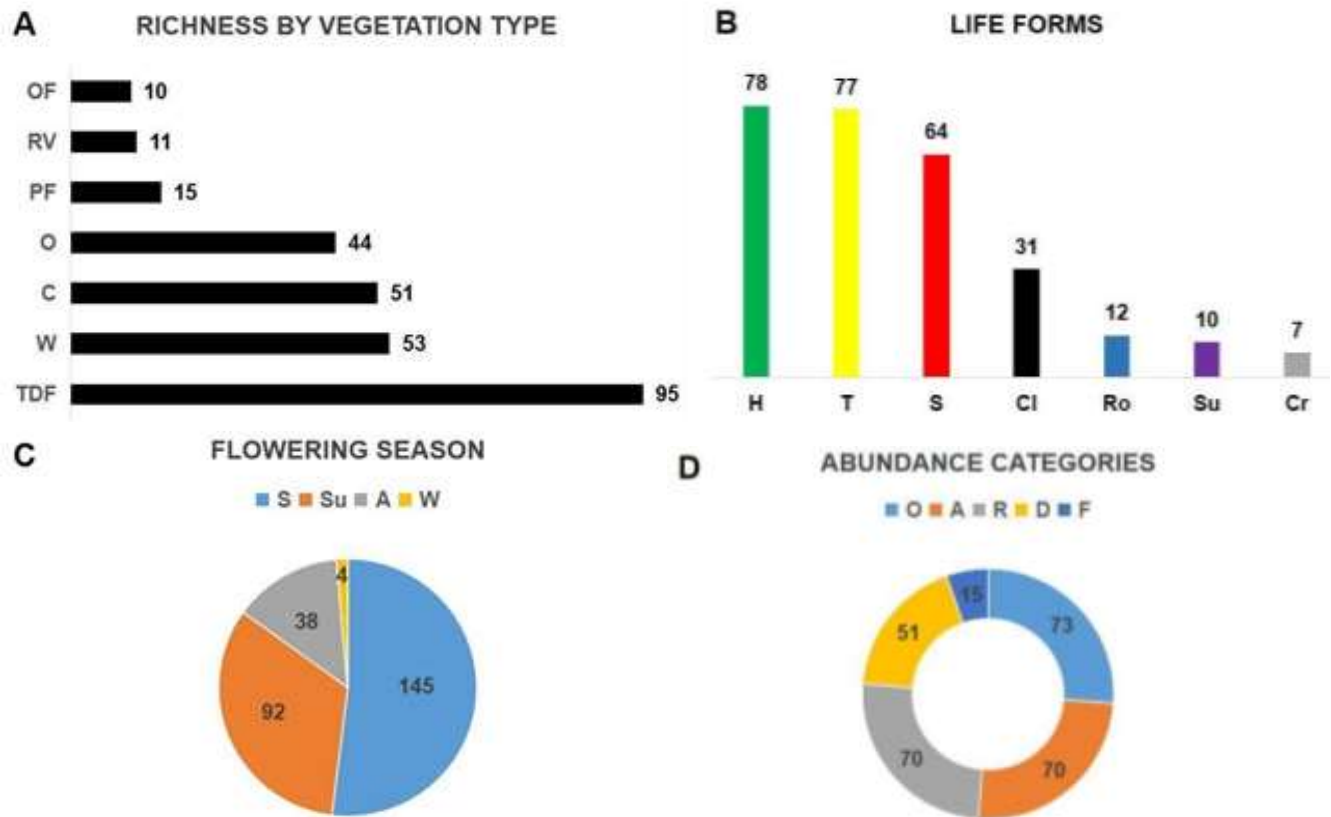


Figure 4. (A) Richness by vegetation type; (B) Life forms; (C) Flowering season; (D) Abundance categories.

pollinators, which depend on nectar for foraging (Ulyshen et al., 2024). Within their ranges, only a few species such as *Arbutus xalapensis* and *Arctostaphylos pungens* are widely recognized as melliferous (that is, honey-producing) plants (Márquez-Linares et al., 2006; Luna et al., 2021). The floristic richness recorded in this study exceeds that reported in other regional surveys in Mexico: 215 species for the state of Tamaulipas (González-Suárez et al., 2020), 216 species in Veracruz (Real-Luna et al., 2021), and 196 species in Atlixco, Puebla (Hernández-Ascensión et al., 2025). This high richness is largely attributable to the dominance of the TDF in the study area, which is also the most extensive vegetation type in the state of Sinaloa (Villaseñor and Ortiz, 2025) and thereby contributes the greatest nectar input from melliferous plants. The occurrence of numerous allochthonous species in the study area is explained by seasonal agricultural practices in the local communities.

Cultivated crops include maize, wheat, peanuts, watermelon, regional varieties of pumpkin, and beans, along with ornamental plants. Fruit trees are also important, including *Carica papaya*, *Psidium guajava*, *Persea americana*, *Prunus persica*, and *Capsicum annuum* var. *aviculare*. In home gardens and along waterways, family orchards are conspicuous: households cultivate a mix of edible, medicinal, and aromatic plants, reflecting a deep-rooted cultural tradition in Mexico (Cano-Contreras, 2015). Nicholls and Altieri (2013) emphasize that such practices are crucial for maintaining pollinator diversity. Similarly, weeds ubiquitous along roads, seasonal croplands, and irrigated fields also fulfill ecological roles in supporting pollinators (Landis et al., 2025). Menezes et al. (2022) further underscore that ornamental flowering plants help feed bees, wasps, and ants, and that greater floral abundance correlates with higher diversity of pollinating insects. In this sense, our findings align with those of

Gómez-Martínez et al. (2022), landscape heterogeneity significantly enhances the richness of honey-producing plant species.

Finally, the most prominent plant families in the region are Fabaceae and Asteraceae, which agrees with earlier findings for TDF in Michoacán (Ibarra-Manrique et al., 2022; Luna et al., 2021), and in Ribeiro-Preto in Brazil (Aleixo et al., 2017). The widespread attractiveness of Fabaceae species to pollinators stems from their often abundant nectar and pollen production (Silva et al., 2018), as well as their zygomorphic floral morphology, which facilitates access for a diverse suite of pollinating insects (Xu and Deng, 2016). Similarly, flowers of the Asteraceae family produce copious amounts of pollen and nectar (Biral and Lombardi, 2012). In addition, many Asteraceae are herbaceous, occurring in dense clusters with numerous flowers in proximity, which further facilitates efficient foraging by insects (Allen-Perkins et al., 2024; Redonda-Martínez, 2025).

Both herbs and trees were among the most frequent growth forms observed and are major contributors to nectar and pollen supply in their communities (Chamorro et al., 2021). Flowering phenology is also critical: trees tend to bloom primarily in spring, whereas many herbs flower in summer, coincident with increased rainfall (Wood et al., 2022). This staggered pattern of flowering ensures that food resources for pollinators are available through much of the year. Certain melliferous species particularly columnar cacti such as *S. montanus*, *P. pecten-aboriginum*, and *Pachycereus blakeana* are especially favored by bees. This preference is largely due to their nectar biochemical composition (Santos-Díaz and Camarena-Rangel, 2019), combined with their conspicuous abundance in the area (Salomón-Montijo et al., 2022; Díaz et al., 2024). Other preferred species include *Rhus echinocarpa*, *Viguiera mollis*, and *Coutarea edulis*. Although these are not dominant in the TDF of Sinaloa (Márquez-Salazar et al., 2019), they are abundant in the study area; moreover, their edible fruits are heavily harvested by local people throughout their distribution in Mexico (Torres-Montúfar and Jiménez-Noriega, 2025; Pío-León et al., 2018; Agustin et al., 2017).

Plants whose honey is highly prized for its pleasant aroma often owe this trait to complex mixtures of floral volatile compounds including terpenoids, aromatic alcohols, esters, phenylpropanoids, and phenols. These compounds have been identified in species of *Azadirachta* (Siddiqui et al., 2003), *Citrus* (González-Ibeas et al., 2021), *Prunus* (Du et al., 2018), *Psidium* (Romero-Frías et al.,

2015), and *Vachellia* (Knudsen et al., 2006; Papaefthimiou et al., 2017). Such aromatic traits confer a distinct adaptive advantage by making flowers more easily detectable by pollinators in tropical and subtropical environments, where competition for pollinator attention tends to be intense (Grajales-Conesa et al., 2011; Chen et al., 2025).

In contrast, some melliferous species are less favored by bees and other pollinators. For example, *Ambrosia* species produce abundant sesquiterpenes, which are bitter secondary metabolites, possibly reducing nectar palatability (Kovács et al., 2022) and *Parthenium hysterophorus* is also known to generate sesquiterpenoid compounds (Paudel, 2009), while *Asclepias curassavica* produces cardenolides that impart a bitter flavor in nectar (Warashina et al., 2008). In the case of *Ricinus communis*, ricin is present in pollen, making it toxic to bees (De Assis Junior et al., 2011), contributing to its avoidance by local human populations when observed.

Conclusion

This study, conducted in communities along the boundary between the states of Sinaloa and Chihuahua, documents a high species richness in the region and highlights both ecological and apicultural value of the TDF ecosystem characterized by deciduousness in the dry season, harbors an outstanding diversity of melliferous species, with Fabaceae, Asteraceae, and Malvaceae being the most species-rich families. Most of the identified melliferous flora are wild species located in dry tropical vegetation, followed by agricultural weeds and cultivated crops. In terms of beekeeping resources, ~88.5% of the species provide nectar, whereas the remaining ~11.5% offer only pollen. Among the biological forms, herbs and trees dominate, indicating a structurally complex and diverse plant community.

Phenological analysis revealed that approximately half of the recorded species flower in spring, and about one-third in summer, corresponding well with the regional climatic pattern of seasonal rainfall. This synchrony ensures that floral resources are available for pollinators during key periods of water availability. In terms of abundance, there is a balanced distribution between occasional (rare) and abundant species, suggesting a dynamic and resilient plant community structure. Among the melliferous species most favored in this region are columnar cacti, along with certain trees and shrubs. These taxa are not only crucial for honey and nectar production

but also provide essential ecosystem services such as habitat structure, food provisioning, and maintenance of pollinator populations.

In summary, the studied region exhibits substantial beekeeping potential, underpinned by its rich floristic diversity and the prevalence of TDF vegetation. The identification, documentation, and conservation of melliferous species are fundamental to promoting sustainable apiculture and preserving the natural ecosystems that support them. Efforts should include habitat protection, restoration where degraded, and integrative management that recognizes local uses and the role of wild flora.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors appreciate the support and protection provided by the inhabitants of the villages visited as well as the willingness of those interviewed to share their traditional knowledge, especially to Jesús Díaz and Armida Carrillo from Los Arroyitos and San Rafael, Chihuahua, Mexico.

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Appendix I. Checklist of melliferous plants.

Families and Species		1	2	3	4	5	6	7
Gymnospermae								
Pinaceae	<i>Pinus herrerae</i> Martínez	Pino chino	T	PF	S	D	P	10
	<i>P. lumholtzii</i> B. L. Rob. & Fernald	Pino llorón	T	PF	S	D	P	10
	<i>P. oocarpa</i> Schiede ex Schltdl.	Pino prieto	T	PF	S	D	P	10
Monocots								
Agavaceae	<i>Agave inaequidens</i> K. Koch	Lechuguilla	Ro	OF	A	O	N/P	34
	<i>A. maximiliana</i> Baker	Lechuguilla	Ro	OF	A	O	N/P	34
	<i>A. rhodacantha</i> Trel.	Magüey	Ro	TDF	A	A	N/P	40
	<i>A. vilmoriniana</i> A. Berger	Amole	Ro	RV	A	A	N/P	48
Amaryllidaceae	<i>Allium cepa</i> L.	Cebolla	Ro	C	S	A	N/P	78
	<i>A. sativum</i> L.	Ajo	Ro	C	S	F	N/P	46
	<i>Crinum asiaticum</i> L.	Araña	Ro	O	Su	R	N/P	6
	<i>Hippeastrum reginae</i> (L.) Herb.	Lirio rojo	Ro	O	Su	R	N/P	10
	<i>Hymenocallis acutifolia</i> (Herb. ex Sims) Sweet	Cebolleta	Ro	RV	Su	R	N/P	14
	<i>Zephyranthes candida</i> Herb.	Lirio	H	O	Su	R	N/P	10
Arecaceae	<i>Brahea aculeata</i> (K. Brandegee) H. E. Moore	Soyate	T	TDF	S	A	N/P	44
	<i>B. dulcis</i> (Kunth) Mart.	Soyate	T	TDF	S	A	N/P	44
Asphodelaceae	<i>Aloe vera</i> (L.) Burm. f.	Sávila	Ro	O	S	F	N/P	56
Bromeliaceae	<i>Bromelia pinguin</i> L.	Aguama	Ro	TDF	Wi	O	N/P	26
Dioscoreaceae	<i>Dioscorea carpomaculata</i> O. Téllez and B. G. Schub.	Barbasco	Cl	TDF	Su	R	N/P	16
Poaceae	<i>Arundo donax</i> L.	Carrizo	S	W	A	R	P	16
	<i>Cenchrus ciliaris</i> L.	Buffel	H	W	A	D	P	26
	<i>Saccharum officinarum</i> L.	Caña	S	C	A	R	P	28
	<i>Sorghum bicolor</i> (L.) Moench	Sorgo	H	C	A	D	P	32
	<i>S. x drummondii</i> (Nees ex Steud.) Millsp. & Chase	Sudán	H	C	A	D	P	5
	<i>S. halepense</i> (L.) Pers.	Johnson	H	W	S	D	P	28
	<i>Triticum aestivum</i> L.	Trigo	H	C	A	D	P	20
	<i>Zea mays</i> L.	Maíz	H	C	Su	D	P	78
Smilacaceae	<i>Smilax moranensis</i> M. Martens & Galeotti	Zarzaparrilla	Cl	PF	Su	R	N/P	8
Typhaceae	<i>Typha domingensis</i> Pers.	Tule	H	RV	S	O	P	14

Appendix I. Cont'd

Eudicots								
Acanthaceae	<i>Justicia spicigera</i> Schtdl.	Micle	S	O	Su	F	N/P	18
	<i>Ruellia inundata</i> Kunth		H	O	S	O	N/P	16
Amaranthaceae	<i>Amaranthus palmeri</i> S. Watson	Quelite	H	W	Su	D	P	42
	<i>A. retroflexus</i> L.	Quelite	H	W	Su	A	P	42
	<i>A. spinosus</i> L.	Quelite	H	W	Su	A	P	38
	<i>Gomphrena globosa</i> L.	Amor seco	H	W	A	R	P	28
Anacardiaceae	<i>Mangifera indica</i> L.	Mango	T	C	S	A	N/P	78
	<i>Spondias mombin</i> L.	Ciruela	T	C	S	A	N/P	70
Apiaceae	<i>Coriandrum sativum</i> L.	Cilantro	H	C	Su	O	N/P	16
	<i>Foeniculum vulgare</i> Mill.	Eneldo	H	W	A	R	N/P	8
Apocynaceae	<i>Asclepias curassavica</i> L.	Señorita	H	W	S	O	N/P	18
	<i>Cascabela thevetia</i> (L.) Lippold	Fortuna	S	O	Su	R	N/P	10
	<i>Funastrum clausum</i> (Decne.) Schltr.	Talayotillo	Cl	W	S	O	N/P	22
	<i>F. cynanchoides</i> (Decne.) Schltr.	Tumbacercos	Cl	W	S	O	N/P	22
	<i>F. pannosum</i> (Jacq.) Schltr.	Talayotillo	Cl	W	S	O	N/P	28
	<i>Gonolobus barbatus</i> Kunth	Palometa	Cl	TDF	Wi	F	N/P	44
	<i>G. naturalistae</i> M. G. Chávez, Pío León & L. O. Alvarado	Palometa	Cl	TDF	Wi	R	N/P	36
	<i>Nerium oleander</i> L.	Laurel	S	O	S	F	N/P	46
	<i>Ruehssia coulteri</i> (Hemsl.) L. O. Alvarado	Talayotillo	Cl	TDF	S	D	N/P	76
	<i>R. edulis</i> (S. Watson) L. O. Alvarado	Talayote	Cl	TDF	S	D	N/P	82
Asteraceae	<i>Vallesia glabra</i> Cav.	Cacaragua	S	TDF	S	R	N/P	12
	<i>Ambrosia ambrosioides</i> (Delpino) W. W. Payne	Chicura	S	W	S	A	P	66
	<i>A. monogyra</i> (Torr. & A. Gray) Strother & B. G. Baldwin	Latilla	S	RV	S	A	P	30
	<i>A. psilostachya</i> DC.	Estafiate	H	W	S	D	P	66
	<i>Baccharis heterophylla</i> Kunth	Jarilla	S	PF	S	R	N/P	10
	<i>B. salicifolia</i> (Ruiz & Pav.) Pers.	Jarilla	S	W	S	O	N/P	24
	<i>Cirsium raphilepis</i> Petr.	Cardo	H	W	A	R	N/P	10
	<i>Cosmos bipinnatus</i> Cav.	Aceitilla	H	W	S	D	N/P	62
	<i>C. sulphureus</i> Cav.	Aceitilla	H	W	S	D	N/P	74
	<i>Dahlia coccinea</i> Cav.	Dalia	H	PF	Su	O	N/P	28
	<i>Galinsoga parviflora</i> Cav.	Estrellita	H	PF	S	O	N/P	48

Appendix I. Cont'd

	<i>Helianthus annuus</i> L.	Girasol	H	W	S	O	N/P	70
	<i>Lagascea decipiens</i> Hemsl.	Confiturilla	H	TDF	S	A	N/P	56
	<i>Montanoa bipinnatifida</i> (Kunth) K. Koch	Tacote	S	O	S	R	N/P	8
	<i>M. tomentosa</i> Cerv.	Tacote	S	TDF	A	A	N/P	54
	<i>Parthenium hysterophorus</i> L.	Hierba del burro	H	W	S	F	P	26
	<i>Pluchea odorata</i> (L.) Cass.	Alinanche	S	W	S	O	N/P	28
	<i>Sonchus oleraceus</i> L.	Borraja	H	W	Su	O	N/P	28
	<i>Tagetes filifolia</i> Lag.	Damiana	H	RV	A	A	N/P	38
	<i>Taraxacum officinale</i> F. H. Wigg	Diente de león	H	W	A	A	N/P	26
	<i>Tithonia calva</i> Sch. Bip.	Mirasol	H	TDF	A	D	N/P	64
	<i>Tridax procumbens</i> L.	Aceitilla	H	W	S	A	N/P	24
	<i>Vickianthus liatroides</i> (DC.) H. Rob.		S	PF	S	A	N/P	20
	<i>Zinnia elegans</i> Jacq.	Caléndula	H	TDF	A	D	N/P	46
Bignoniaceae	<i>Crescentia alata</i> Kunth	Ayale	T	TDF	S	O	N/P	30
	<i>Parmentiera aculeata</i> (Kunth) Seem.	Cuajilote	T	C	S	R	N/P	8
	<i>Tabebuia rosea</i> (Bertol.) DC.	Amapa	T	O	A	A	N/P	42
	<i>Tecoma stans</i> (L.) Kunth	Tronadora	S	O	S	O	N/P	58
Boraginaceae	<i>Cordia alliodora</i> (Ruiz & Pav.) Oken	Amapa prieta	T	TDF	S	O	N/P	44
	<i>C. dentata</i> Poir.	Palo baboso	T	O	S	R	N/P	12
	<i>C. elaeagnoides</i> A. DC.	Inmortal	T	O	S	R	N/P	12
	<i>C. sonora</i> Rose	Palo asta	T	TDF	A	A	N/P	48
	<i>Ehretia tinifolia</i> L.	Pingüica	T	O	S	O	N/P	24
	<i>Heliotropium angiospermum</i> Murray	Bigotitos	H	TDF	Su	F	N/P	10
	<i>H. hartwegianum</i> (Steud.) Halse & Feuillet	Tatachinole	H	W	Su	O	N/P	12
	<i>H. indicum</i> L.	Bigotitos	S	TDF	Su	F	N/P	50
	<i>Wigandia urens</i> (Ruiz & Pav.) Kunth	Quemadora	S	W	S	A	N/P	38
Brassicaceae	<i>Brassica oleracea</i> L.	Repollo	Ro	C	A	O	N/P	52
	<i>Mutarda nigra</i> (L.) Bernh.	Mostaza	H	C	A	O	N/P	12
	<i>Raphanus raphanistrum</i> subsp. <i>sativus</i> (L.) Schmalh.	Rábano	H	C	A	R	N/P	8
Burseraceae	<i>Bursera bipinnata</i> (Moc. & Sessé ex DC.) Engl.	Copal	T	TDF	S	A	N/P	52
	<i>B. excelsa</i> (Kunth) Engl.	Copal santo	T	TDF	S	A	N/P	52
	<i>B. fagaroides</i> (Kunth) Engl.	Torotillo	T	TDF	S	A	N/P	50
	<i>B. grandifolia</i> (Schltdl.) Engl.	Papelillo	T	TDF	S	A	N/P	50

Appendix I. Cont'd

	<i>B. simaruba</i> (L.) Sarg.	Mulato	T	TDF	S	A	N/P	56
	<i>Echinocereus subinermis</i> Salm-Dyck ex Scheer	Alicoche	GSu	TDF	S	O	N/P	10
	<i>Ferocactus pottsii</i> (Salm-Dyck) Backeb.	Viznaga	GSu	TDF	S	O	N/P	16
	<i>Mammillaria marksiana</i> Krainz	Viznaguita	GSu	TDF	S	A	N/P	24
	<i>Opuntia decumbens</i> Salm-Dyck	Nopal tortuga	SSu	TDF	S	A	N/P	28
	<i>O. ficus-indica</i> (L.) Mill.	Nopal	TSu	C	S	O	N/P	34
Cactaceae	<i>O. pubescens</i> H. L. Wendl. ex Pfeiff.	Choya	HSu	TDF	S	D	N/P	44
	<i>O. wilcoxii</i> Britton & Rose	Nopalera	SSu	TDF	S	A	N/P	40
	<i>P. pecten-aboriginum</i> (Engelm. ex S. Watson) Britton & Rose	Cardón	CSu	TDF	S	D	N/P	96
	<i>Pereskopsis blakeana</i> J. G. Ortega	Alcayeye	S	TDF	A	A	N/P	82
	<i>P. porteri</i> (Brandegee ex F.A.C. Weber) Britton & Rose	Alcahuésar	S	TDF	A	A	N/P	56
	<i>Pilosocereus alensis</i> (F.A.C. Weber ex Rol.-Goss.) Byles & G. D. Rowley	Viejo	CSu	TDF	Su	A	N/P	78
	<i>Stenocereus montanus</i> (Britt. & Rose) Buxb.	Pitaya	CSu	TDF	S	D	N/P	100
Cannabaceae	<i>Celtis pallida</i> Torr.	Bainoro	T	TDF	S	A	N/P	84
Caricaceae	<i>Carica papaya</i> L.	Papayo	T	C	Su	O	N/P	54
Celastraceae	<i>Wimmeria mexicana</i> (Moc. & Sesse ex DC.) Lundell	Venadillo	T	TDF	S	A	N/P	90
Clethraceae	<i>Clethra mexicana</i> DC.	Jaboncillo	T	PF	Su	R	N/P	10
Combretaceae	<i>Combretum farinosum</i> Kunth	Compio	CI	TDF	S	O	N/P	50
	<i>Distimake aegyptius</i> (L.) A. R. Simões & Staples	Huirote	CI	TDF	Su	O	N/P	16
	<i>Ipomoea arborescens</i> (Humbl. & Bonpl. ex Willd.) G. Don	Palo blanco	T	TDF	A	D	N/P	86
Convolvulaceae	<i>I. bracteata</i> Cav.	Jícama de monte	CI	TDF	S	D	N/P	56
	<i>I. carnea</i> Jacq.	Flor de la mañana	S	O	S	R	N/P	24
	<i>I. pedicellaris</i> Benth.	Trompillo	CI	TDF	Su	O	N/P	16
	<i>I. triloba</i> L.	Trompillo	CI	W	S	O	N/P	32
Crassulaceae	<i>Kalanchoe blossfeldiana</i> Poelln.	Bruja	H	O	S	R	N/P	40
	<i>K. daigremontiana</i> Raym.-Hamet & H. Perrier	Bruja	H	O	S	R	N/P	40
	<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	Sandía	Cr	C	Su	D	N/P	54
	<i>Cucurbita pepo</i> L.	Calabaza	Cr	C	Su	D	N/P	64
Cucurbitaceae	<i>Ibervillea maxima</i> Lira & Kearns	Guareca	CI	TDF	Su	R	N/P	12
	<i>Lagenaria siceraria</i> (Molina) Standl.	Bule	CI	C	Su	O	N/P	16
	<i>Momordica charantia</i> L.	Cundeamor	CI	W	Su	F	N/P	18
	<i>Sicyos edulis</i> Jacq.	Chayote	CI	O	Su	R	N/P	14

Appendix I. Cont'd

Ebenaceae	<i>Diospyros aequoris</i> Standl.	Guayparín	T	TDF	Su	R	N/P	10
Ericaceae	<i>Arbutus xalapensis</i> Kunth	Madroño	T	PF	Su	O	N/P	40
	<i>Arctostaphylos pungens</i> Kunth	Pinguica	S	PF	Su	O	N/P	6
Erythroxylaceae	<i>Erythroxylum mexicanum</i> Kunth	Pico de pájaro	S	TDF	S	F	N/P	34
Euphorbiaceae	<i>Jatropha peltata</i> Sessé	Bonete	S	TDF	Su	A	N/P	54
	<i>Ricinus communis</i> L.	Higuerilla	S	W	S	O	P	40
Fabaceae	<i>Albizia lebbbeck</i> (L.) Benth.	Capiro	T	O	S	O	N/P	36
	<i>Arachis hypogaea</i> L.	Cacahuete	H	C	Su	D	N/P	64
	<i>Bauhinia variegata</i> L.	Pata de vaca	T	O	Su	R	N/P	14
	<i>Caesalpinia pulcherrima</i> (L.) Sw.	Tabachín	S	TDF	S	D	N/P	64
	<i>Calliandra houstoniana</i> (Mill.) Standl.	Pelo de ángel	S	OF	S	O	N/P	10
	<i>Chloroleucon mangense</i> (Jacq.) Britton & Rose	Palo fierro	T	TDF	S	A	N/P	48
	<i>Coulteria platyloba</i> (S. Watson) N. Zamora	Arellano	T	TDF	S	A	N/P	56
	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	Tabachín	T	O	S	O	N/P	38
	<i>Diphysa suberosa</i> S. Watson	Corcho	S	TDF	S	A	N/P	28
	<i>Enterolobium cyclocarpum</i> (Jacq.) Griseb.	Huejote	T	C	S	R	N/P	48
	<i>Erythrina flabelliformis</i> Kearney	Chilicote	T	TDF	Wi	A	N/P	58
	<i>Erythrostemon palmeri</i> (S. Watson) Gagnon & G. P. Lewis	Palo Piojo	S	TDF	S	A	N/P	24
	<i>Haematoxylum brasiletto</i> H. Karst.	Brasil	T	TDF	S	A	N/P	38
	<i>Leucaena leucocephala</i> (Lam.) de Wit	Guaje	T	O	S	O	N/P	20
	<i>Lysiloma acapulcense</i> (Kunth) Benth.	Tepehuaje	T	TDF	S	D	N/P	74
	<i>L. divaricatum</i> (Jacq.) J. F. Macbr.	Mauto	T	TDF	S	D	N/P	76
	<i>Mimosa distachya</i> Cav.	Gatuño	S	TDF	Su	D	N/P	80
	<i>Neltuma juiflora</i> (Sw.) Raf.	Mezquite	T	TDF	S	R	N/P	14
	<i>Phaseolus vulgaris</i> L.	Frijol	H	C	Su	D	N/P	66
	<i>Pithecellobium dulce</i> (Roxb.) Benth.	Guamúchil	T	TDF	S	A	N/P	40
	<i>Senna atomaria</i> (L.) H. S. Irwin & Barneby	Palo zorrillo	T	TDF	S	A	N/P	36
	<i>S. occidentalis</i> (L.) Link.	Café de burro	H	W	Su	A	N/P	14
	<i>Tara cacalaco</i> (Bonpl.) Molinari & Sánchez Och.	Huizache	T	TDF	S	A	N/P	22
	<i>Vachellia campeachiana</i> (Mill.) Seigler & Ebinger	Vinolo	S	W	S	A	N/P	62
	<i>V. farnesiana</i> (L.) Wight & Arn.	Vinorama	S	W	S	D	N/P	76
	<i>V. pennatula</i> (Schldl. & Cham.) Seigler & Ebinger	Algarrobo	S	OF	S	A	N/P	56
	<i>Quercus albocincta</i> Trel.	Roble	T	OF	S	D	P	56

Appendix I. Cont'd

	<i>Q. chihuahuensis</i> Trel.	Encinillo	T	OF	S	D	P	32
	<i>Q. magnoliifolia</i> Née	Encino amarillo	T	OF	S	A	P	18
	<i>Q. urbani</i> Trel.	Encino cucharón	T	OF	S	A	P	24
Fouquieriaceae	<i>Fouquieria macdougalii</i> Nash	Ocotillo	S	TDF	S	O	N/P	18
Juglandaceae	<i>Juglans nigra</i> L.	Nogal	T	C	S	R	N/P	40
	<i>Condea albida</i> (Kunth) Harley & J. F. B. Pastore	Tepozana	S	TDF	S	A	N/P	28
	<i>Leonotis nepetifolia</i> (L.) R. Br.	Chuparrosa	H	RV	S	O	N/P	20
	<i>Lepechinia caulescens</i> (Ortega) Epling	Cascabel	H	PF	S	O	N/P	16
	<i>Mentha spicata</i> L.	Hierbabuena	H	C	S	R	N/P	16
Lamiaceae	<i>Mesosphaerum urticoides</i> (Kunth) Kuntze	Salvia	H	C	Su	O	N/P	4
	<i>Ocimum basilicum</i> L.	Albahaca	H	C	S	A	N/P	26
	<i>Origanum vulgare</i> L.	Orégano	H	C	Su	A	N/P	26
	<i>Salvia mexicana</i> L.	Salvia	H	TDF	Su	D	N/P	16
	<i>S. rosmarinus</i> Spenn.	Romero	H	C	S	O	N/P	18
Lauraceae	<i>Persea americana</i> Mill.	Aguacate	T	C	S	D	N/P	68
Lythraceae	<i>Punica granatum</i> L.	Granado	S	C	S	R	N/P	16
	<i>Byrsonima crassifolia</i> Kunth	Nanche	T	C	Su	R	N/P	8
Malpighiaceae	<i>Callaeum macropterum</i> (Moc. & Sessé ex DC.) D.M. Johnson	Matanene	Cl	W	S	O	N/P	32
	<i>Galphimia glauca</i> Cav.	Árnica	H	PF	S	R	N/P	12
	<i>Abutilon abutiloides</i> (Jacq.) Garcke ex Hochr.	Pelotazo	H	W	Su	O	N/P	24
	<i>A. incanum</i> (Link) Sweet	Malva	H	W	Su	O	N/P	28
	<i>A. palmeri</i> A. Gray	Colotahue	H	TDF	Su	A	N/P	30
	<i>A. trisulcatum</i> (Jacq.) Urb.	Malva	H	W	Su	A	N/P	34
	<i>Alcea rosea</i> L.	Malvarrosa	H	O	A	R	N/P	32
	<i>Anoda cristata</i> (L.) Schldl.	Quesito	H	W	Su	O	N/P	8
Malvaceae	<i>Ayenia aculeata</i> (Jacq.) Christenh. & Byng	Regresadora	Cl	TDF	S	F	N/P	42
	<i>Ceiba aesculifolia</i> (Kunth) Britten & Baker	Pochote	T	TDF	S	A	N/P	64
	<i>C. pentandra</i> (L.) Gaertn.	Ceiba	T	O	S	R	N/P	16
	<i>Gossypium hirsutum</i> L.	Algodón	S	C	S	O	N/P	28
	<i>Guazuma ulmifolia</i> Lam.	Guásima	T	TDF	S	D	N/P	74
	<i>Herissantia crispa</i> (L.) Brizicky	Munditos	H	W	Su	A	N/P	14
	<i>Hibiscus sabdariffa</i> L.	Jamaica	H	C	Su	R	N/P	8

Appendix I. Cont'd

	<i>H. x rosa x sinensis</i> L.	Obelisco	S	O	Su	R	N/P	18
	<i>Malvaviscus penduliflorus</i> Moc. & Sessé ex DC.	Chuparrosa	S	O	Su	R	N/P	18
	<i>Melochia pyramidata</i> L.	Malvita	H	W	Su	O	N/P	10
	<i>Sida acuta</i> Burm. f.		H	W	Su	O	N/P	10
	<i>Waltheria indica</i> L.	Hierba del soldado	H	W	Su	O	N/P	8
Martyniaceae	<i>Martynia annua</i> L.	Uña de gato	H	O	Su	O	N/P	26
	<i>Proboscidea louisianica</i> (Mill.) Tell.	Cuernitos	H	O	Su	O	N/P	32
Melastomataceae	<i>Miconia xalapensis</i> (Bonpl.) M. Gómez	Capulín	S	O	S	O	N/P	14
Meliaceae	<i>Azadirachta indica</i> A. Juss	Neem	T	O	S	O	N/P	38
	<i>Melia azederach</i> L.	Paraíso	T	O	S	R	N/P	32
	<i>Swietenia humilis</i> Zucc.	Caoba	T	O	S	R	N/P	24
Moringaceae	<i>Moringa oleifera</i> Lam.	Moringa	T	O	S	R	N/P	14
Myrtaceae	<i>Psidium friedrichsthalianum</i> (O. Berg) Nied.	Guayaba ácida	T	C	S	R	N/P	24
	<i>P. guajava</i> L.	Guayaba	T	C	Su	D	N/P	72
	<i>P. oligospermum</i> Mart. ex DC.	Arrayán	T	O	A	O	N/P	56
Nyctaginaceae	<i>Boerhavia coccinea</i> L.	Pegajosa	H	W	S	O	N/P	10
	<i>Commicarpus scandens</i> (L.) Standl.	Sonorita	H	TDF	Su	O	N/P	16
	<i>Pisonia capitata</i> (S. Watson) Standl.	Garabato	T	TDF	S	A	N/P	36
Papaveraceae	<i>Argemone mexicana</i> L.	Cardo	H	W	S	D	P	42
	<i>Papaver somniferum</i> L.	Amapola	H	C	A	F	P	56
Phytolaccaceae	<i>Phytolacca icosandra</i> L.	Jaboncillo	H	O	S	R	P	4
Picramniaceae	<i>Alvaradoa amorphoides</i> Liebm.	Pata de gallo	S	TDF	S	A	N/P	38
Plantaginaceae	<i>Scoparia dulcis</i> L.	Hierba dulce	H	RV	S	R	N/P	6
Platanaceae	<i>Platanus gentryi</i> Nixon & J. M. Poole	Aliso	T	RV	S	D	P	68
Polygonaceae	<i>Antigonon leptopus</i> Hook. & Arn.	Coronita	Cl	TDF	Su	D	N/P	44
Portulacaceae	<i>Portulaca grandiflora</i> Hook.	Chisme	Cr	O	Su	R	N/P	24
	<i>P. oleracea</i> L.	Verdolaga	Cr	W	S	A	N/P	24
	<i>P. pilosa</i> L.	Verdolaga	Cr	TDF	Su	O	N/P	10

Appendix I. Cont'd

Primulaceae	<i>Ardisia revoluta</i> Kunth	Laurel	T	TDF	S	O	N/P	6
	<i>Bonellia macrocarpa</i> (Cav.) Ståhl. & Källersjö	San Juan	S	TDF	S	O	N/P	68
Ranunculaceae	<i>Clematis dioica</i> L.	Barbas de Chivo	CI	TDF	A	O	N/P	38
	<i>C. drummondii</i> Torr. & A. Gray	Barbas de Chivo	CI	TDF	A	O	N/P	38
Rhamnaceae	<i>Gouania rosei</i> Wiggins	Bejuco	CI	TDF	A	R	N/P	6
	<i>Karwinskia humboldtiana</i> (Willd. ex Schult.) Zucc.	Cacachila	S	TDF	A	F	N/P	48
Rosaceae	<i>Crataegus mexicana</i> Moc. & Sessé ex DC.	Tejocote	T	C	Su	R	N/P	6
	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Nispero	T	C	Su	R	N/P	4
	<i>Prunella vulgaris</i> L.	Bretónica	H	PF	S	R	N/P	2
	<i>Prunus persica</i> L.	Durazno	T	C	Su	D	N/P	56
	<i>P. serotina</i> Ehrh.	Capulín	T	C	S	R	N/P	4
	<i>Rosa</i> spp.	Rosal	S	O	S	A	P	22
	<i>Rubus coriifolius</i> Liebm.	Zarzamora	S	PF	Su	R	N/P	16
Rubiaceae	<i>Coffea arabica</i> L.	Cafeto	S	C	S	R	N/P	6
	<i>Gardenia jasminoides</i> J. Ellis	Gardenia	S	O	S	R	N/P	6
	<i>Hintonia latiflora</i> (Sessé & Moc. ex DC.) Bullock	Copalquín	S	TDF	Su	O	N/P	38
	<i>Ixora coccinea</i> L.	Isora	S	O	S	R	N/P	12
	<i>R. echinocarpa</i> Moc. & Sessé ex DC.	Papache	S	TDF	Su	D	N/P	94
	<i>R. laevigata</i> Standl.	Sapuche	S	OF	Su	R	N/P	34
	<i>S. thurberi</i> S. Watson	Papachillo	S	TDF	Su	A	N/P	82
Rutaceae	<i>Casimiroa edulis</i> La Llave	Chapote	T	TDF	S	D	N/P	80
	<i>Citrus x latifolia</i> (Yu. Tanaka) Yu. Tanaka	Lima	T	C	A	R	N/P	26
	<i>C. limon</i> (L.) Osbeck	Limón	T	C	Su	A	N/P	58
	<i>C. paradisi</i> Macfad.	Toronjo	T	C	Su	R	N/P	20
	<i>C. reticulata</i> Blanco	Mandarino	T	C	A	O	N/P	48
	<i>C. sinensis</i> (L.) Osbeck	Naranjo	T	C	A	A	N/P	68
	<i>Murraya paniculata</i> (L.) Jack	Limonaria	S	O	S	R	N/P	12
	<i>Ruta chalepensis</i> L.	Ruda	H	C	S	R	N/P	6
Salicaceae	<i>Casearia arguta</i> Kunth	Chilillo	S	TDF	S	O	N/P	4
	<i>Populus mexicana</i> Wesm.	Álamo	T	RV	S	R	P	18
	<i>Salix bonplandiana</i> Kunth	Sauce	T	RV	S	A	P	36

Appendix I. Cont'd

Sapindaceae	<i>Cardiospermum halicacabum</i> L.	Munditos	CI	TDF	Su	O	N/P	6
	<i>Dodonaea viscosa</i> Jacq.	Jarilla	S	OF	S	D	N/P	58
	<i>Litchi chinensis</i> Sonn.	Lichi	T	C	S	R	N/P	1
	<i>Paullinia tomentosa</i> Jacq.	Bejuco	CI	W	S	O	N/P	8
	<i>Serjania palmeri</i> S. Watson	Huirote	CI	W	S	O	N/P	4
Scrophulariaceae	<i>Buddleja cordata</i> Kunth	Nacare	T	TDF	S	A	N/P	80
	<i>Buddleja sessiliflora</i> Kunth	Tepozán	S	TDF	S	D	N/P	54
Solanaceae	<i>Capsicum annuum</i> L.	Chile	H	C	Su	A	N/P	58
	<i>C. annuum</i> var. <i>aviculare</i> (Dierb.) D'Arcy & Eschbaugh	Chiltepín	S	TDF	Su	D	N/P	74
	<i>Nicotiana glauca</i> Graham	Tabacón	S	W	Su	O	N/P	8
	<i>N. obtusifolia</i> M. Martens & Galeotti	Tabaquillo	H	W	Su	O	N/P	8
	<i>N. tabacum</i> L.	Tabaco	H	C	Su	A	N/P	18
	<i>Physalis angulata</i> L.	Tomatillo	H	TDF	Su	D	N/P	36
	<i>Solanum americanum</i> Mill.	Chiquelite	H	RV	Su	O	N/P	24
	<i>S. erianthum</i> D. Don	Lavaplatos	S	TDF		A	N/P	46
	<i>S. houstonii</i> Martyn	Duraznillo	H	W	A	A	N/P	52
	<i>S. lycopersicum</i> L.	Tomate	H	C	A	D	N/P	58
	<i>S. torvum</i> Sw.	Sacamanteca	S	TDF	Su	A	N/P	50
Verbenaceae	<i>Lantana camara</i> L.	Confite prieto	S	TDF	S	D	N/P	68
	<i>L. velutina</i> M. Martens & Galeotti	Confiturilla	S	TDF	S	D	N/P	78
	<i>Lippia origanoides</i> Kunth	Orégano	S	TDF	S	F	N/P	46
	<i>L. alba</i> (Mill.) N. E. Br. ex Britton & P. Wilson	Poleo	S	O	S	R	N/P	6
	<i>Priva aspera</i> Kunth	Pegarropa	H	W	Su	R	N/P	2
	<i>Vitex mollis</i> Kunth	Uvalama	T	TDF	S	D	N/P	88
Viburnaceae	<i>Sambucus nigra</i> L.	Sáuco	S	O	Su	R	N/P	4
Vitaceae	<i>Cissus verticillata</i> (L.) Nicolson & C. E. Jarvis	Tripa de zopilote	CI	W	Su	R	N/P	8
	<i>Parthenocissus quinquefolia</i> (L.) Planch.	Parra virgen	CI	O	S	R	N/P	10
	<i>Vitis tiliifolia</i> Humbl. ex Bonpl. et Kunth	Uva cimarrona	CI	TDF	S	R	N/P	6
	<i>V. vinifera</i> L.	Parra	CI	O	S	R	N/P	12
Zygophyllaceae	<i>Kallstroemia grandiflora</i> Torr. ex A. Gray	Baiburín	Cr	W	Su	A	N/P	14

<i>K. maxima</i> (L.) Hook. & Arn.	Baiburin	Cr	W	S	F	N/P	12
1) Common name (2) Life forms: T (Tree), S (Shrub), H (Herb), Cl (Climbing), Cr (Creeping), G (Globose), C (Columnar), Su (Succulent), Ro (Rosetophilous) (3) Vegetation type: RV (Riparian Vegetation), PF (Pine Forest), OF (Oak Forest), TDF (Tropical Deciduous Forest), O (Ornamental), W (Weed), C (Crop) (4) Flowering season: Wi (Winter), A (Autumn), S (Spring), Su (Summer) (5) Abundance grade: A (Abundant), D (Dominant), F (Frequent), O (Occasional), R (Rare) (6) Product: P (Pollen), N/P (Nectar/Pollen). (7) Acceptance Frequency Index.							