Chapter 15

Synopsis of Mangle Species in Mexico

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.76975

Abstract

The objective of this documentary research work is to contribute to better knowledge of the mangrove species that are located in our country, as well as to provide readers with written and illustrated information on these species. The species described are *Avicennia bicolor* Standl., *Avicennia germinans* (L.) L., *Conocarpus erectus* L., *Laguncularia racemosa* (L.) Gaertner, *Rhizophora harrisonii* Leechm., and *Rhizophora mangle* L. The mangroves present in Mexico comprise three families, four genera, and six species. They have a distribution in the 17 coastal states of the country, the largest number of species in the state of Chiapas. The data obtained that are included in the information are identity, distribution, taxonomy, diagnosis, distribution, uses, and protection. In the case of *Avicennia bicolor* Standl. and *Rhizophora Harrisonii* Leechm., the information is more scarce, since their distribution is limited to the state of Chiapas.

Keywords: knowledge, Mexican, mangroves

1. Introduction

Regarding mangroves, taxonomic uncertainties persist despite the fact that there are currently many works that refer to these tree and shrub species; this is due to the fact that the characteristics that separate mangrove species are diffuse as they belong to different families, some of them more related to terrestrial environments. In addition, identifications in herbaria are erroneous even by specialists. As a consequence of these situations, the systematic and taxonomic knowledge of the mangroves is recent, despite the fact that their study goes back 300 years [47]. It is important to have a synopsis that outlines the main characteristics that distinguish mangrove species, in this chapter, referring to those found on the coasts of Mexico.

The material examined consisted of printed books and information obtained on the Internet concerning the species *Rhizophora mangle* L., *Avicennia germinans* (L.) L., *Laguncularia racemosa* (L.) C.F. Gaertn., *Conocarpus erectus* L., *Rhizophora harrisonii* Leechm., and *Avicennia bicolor* Standl.

The mangroves present in Mexico comprise three families, four genera, and six species. They are distributed in the 17 coastal states of the country, the largest amount of species in the state of Chiapas. In 16 states of the country there are four species (*R. mangle, A. germinans, L. racemosa,* and *C. erectus*); in Chiapas, in addition to the previous ones, *R. harrisonii* and *A. bicolor* are presented.

The family Rhizophoraceae comprises one genus, *Rhizophora,* and two species, *R. mangle* and *R. harrisonii;* the family Acanthaceae is represented by one genus, *Avicennia,* and two species *A. germinans* and *A. bicolor*; and the family Combretaceae has two genera, *Laguncularia*, with the species *L. racemosa* and the genus *Conocarpus*, with the species *C. erectus*.

2. Development

2.1. *Avicennia bicolor* Standl.

Valid name

Avicennia bicolor Standl. Journal of the Washington Academy of Sciences 13 (15): 354. 1923. (J. Wash. Acad. Sci.) By Paul Carpenter Standley [51].

Synonym

Tomlinson [46] considered *Avicennia tonduzii* as a synonym for this species. *A. tonduzii* was described by Mondelke in 1938 in Phytology 1: 273–4. Tomlinson [47], states that *A. tonduzii* appears to be only a variant of *A. bicolor*, distinguishing itself by its narrow leaves and the particular shape of its panicles with pairs of individual flowers separated therefrom.

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

Subkingdom Tracheobionta

Superdivision Spermatophyta

Division Magnoliophyta

Class Magnoliopsida

Subclass Asteridae

Order Lamiales

Family Acanthaceae (Verbenaceae; Avicenniaceae)

Subfamily Avicennioideae

Generic

Avicennia L. (1753) is currently derived from the Acanthaceae family, as per recent phylogenetic studies [5, 36, 45]. Although, it has been placed in the families Verbenaceae or Avicenniaceae in some classifications [33]. The genus can be treated as the subfamily Avicenniaceae [21].

The genus *Avicennia* was named in honor of the famous doctor and scientist, Abu-Ali al-Husayn ibn-Sina, known as Avicenna (980–1073 BC) [37].

Specifics

It is a bicolor species—bi meaning two. The corolla of the flower is white and may have a yellow hue at its base so that its flower is considered bicolor [46].

Type specimens

For *Avicennia bicolor* Standl. A, holotype has been reported in tropics.org [51] as follows: PANAMA: Province of Coclé: collected in mangrove swamp at Aguadulce, December 5, 1911. Collector and Number: H. Pittier 4968. Institution (s): HT: US-715142.

Type-protologue: distribution

Panama: Province of Coclé: collected in mangroves in Aguadulce, December 5, 1911 [51].

Diagnosis

It is a small tree with an irregular crown. Its bark is whitish or light gray-brown (in contrast to the dark grayish coffee of *Avicennia germinans*). The leaves are elliptical, with a bright beam and totally without hairs, characteristic with which it can be differentiated from *A. germinans*, since this one has crystals in the beam and the back. The underside is somewhat hairy and is usually covered by salt crystals. The inflorescence is a terminal or axillary panicle of white, hairless flowers. The fruit is a rounded and a smooth capsule. It has vertical, spongy roots that project over the mud, absorb the air, and ventilate the support root system [4].

Common and vernacular names

Palo de sal [46]

Other common names in Mexico: Mangle negro [34].

Common names in other countries: Curumo blanco—Honduras; Madresal—El Salvador; mangle gateador—Panama; mangle salado—Panama; and Palo de sal (Guanacaste-Costa Rica) [4, 26].

Distribution

Moldenke [40], Tovilla-Hernández et al. [48], and, later, Nettel et al. [41] report that the geographical distribution of *Avicennia bicolor* Standl., at its northernmost end, is in Tonalá, Chiapas, in Mexico (9° 51 'N 84° 41' W). Recent studies by the Southern Border College of Tapachula Unit have located a mature *A. bicolor* forest between the municipal boundaries of Tonalá and Pijijiapan, Chiapas, in addition to finding new distribution sites for *Rhizophora harrisonii* Leechm.(Tovilla, 2012 com. in [44]).

Flowers and propagules of *Avicennia bicolor*. Cistian Tovilla Hernández. Diplomado Internacional en ecología, manejo, restauración y legislación en sistemas de manglares (2017). ECOSUR.

2.2. *Avicennia germinans* (L.) L.

Valid name

Avicennia germinans (L.) L. Linnaeus, Carl Von. Published in: Species Plantarum, ed. 3, 2: 891. 1764. Sp. Pl (ed.3) [52].

Basionym

Bontia germinans was published in Systema Naturae, Editio Decima 2: 1122. 1759. Syst. Nat. (Ed.10). 19 **Synonym**; 1 **Homonym** *Avicennia germinans* (L.) Stearn; 6 **Ifraspecific categories** (form and variety) [52].

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

Subkingdom Tracheobionta

Superdivision Spermatophyta

http://dx.doi.org/10.5772/intechopen.76975

Division Magnoliophyta

Class Magnoliopsida

Subclass Asteridae

Order Lamiales

Family Acanthaceae (Verbenaceae; Avicenniaceae)

Subfamily Avicennioideae

Generic

Avicennia L. (1753) is derived from the Acanthaceae family, as per recent phylogenetic studies [5, 36, 45], although it has been placed in the families Verbenaceae or Avicenniaceae in some classifications [33]. The genus can be treated as subfamily Avicennioideae [21].

The genus *Avicennia* was named in the honor of the famous doctor and scientist, Abu-Ali al-Husayn ibn-Sina, known as Avicenna (980–1073 BC) [37].

Specifics

Germinans is a Latin word meaning "sprouting" in reference to its particular form of reproduction; this is due to the early germination of the seed within the fruit [4].

Type specimens

For *Avicennia germinans* (L.) L., a lectotype, related to its basionym *Bontia germinans*, has been reported in the Atlas of Florida Plants and Tropicos ® as follows: JAMAICA: Without data, Browne s.n. (lectotype: LINN 813.2). Lectotypified by Stearn, Kew Bull. 1958: 34, 1958 [64] and LT: Browne s.n.; Jamaica (LINN-813.2) LT designated by Stearn, Kew Bull. 13: 35 (1958) [53].

Type-protologue: distribution

Jamaica: No data, Browne s.n. (lectotype: LINN 813.2). Lectured by Stearn, Kew Bull. 1958: 34, 1958 [64].

Diagnosis

It is a tree or shrub that reaches a size of 3–10 m in height [6]. Leaves excrete salt through specialized glands and can be covered by salt, thus contributing to salty leaf litter [35]. Panicle inflorescence in the form of spikes or panicles composed, 9 cm long and 2–5 cm wide. Fruit ovate-oblique, apiculate, 1.5–2 cm long and 1–1.5 cm wide, is sparsely sericeous [6].

It grows on sandy, muddy, or argillaceous soils. It is found in heavily oxidized clays or in soils with high concentrations of pyrite [3]. The species is sensitive to frost but is considered to be the most tolerant mangle species to low temperatures [11].

Common and vernacular names

Mangle negro, Mangle prieto [12].

Other common names in Mexico: mangle blanco—Veracruz, Oaxaca, Tabasco, Yucatan; mangle negro, madre de sal—Acapetagua, Chis; Mangle prieto—Yucatán; Puyeque—Sinaloa [14]. Maya: tab che ', taab che' tat xiül [12].

Black mangrove (Belize); Culumate (Costa Rica); Curumo negro (Honduras); istatén (Costa Rica and El Salvador); mangle negro (El Salvador, Guatemala, Nicaragua, and Panama); Mangle prieto, Mangle salado (Panama); Mangle salsa (Costa Rica); Palo de sal (Costa Rica, Nicaragua) [4]; mangle iguanero (Colombia and Ecuador); mangle rosado (Venezuela) [8].

Distribution

It is found on both coastlines of the country, from the state of Tamaulipas to the Yucatan Peninsula in the Gulf of Mexico and the Caribbean Sea and from the states of Baja California and Sonora to Chiapas in the coast of the Pacific Ocean [42]

Flowers and propagules of *Avicennia germinans*. Agustín de Jesús Basáñez Muñoz (2006). Universidad Veracruzana

2.3. *Conocarpus erectus* L.

Valid name

Conocarpus erectus L. Linnaeus, Carl Von. Published in: Species Plantarum 1: 176. 1753. (1 May 1753) (Sp. Pl.) As erecta [54].

Basionym

The species *Conocarpus erectus* L. has as basionym *Terminalia erecta* (L.) Baill *, which means that this species was initially described by Linnaeus in the genus *Conocarpus* and later reported by Baillon in the genus *Terminalia*. 10 **Synonyms**; 8 **Ifraspecific name** (form and variety) [54].

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

http://dx.doi.org/10.5772/intechopen.76975

Subkingdom Tracheobionta

Superdivision Spermatophyta

Division Magnoliophyta

Class Magnoliopsida

Subclass Rosidae

Order Myrtales

Family Combretaceae

Generic

The genus *Conocarpus L. comes* from the Greek word "konos", cone and "carpos" fruit because the fruits resemble a conical shape [31].

Specifics

erectus.- masculine erectus, feminine *erecta*, neuter *erectum*; means erect, right; by the erect habit of the plant [63].

Type specimens

For *Conocarpus erectus* L., the Atlas of Florida Plants and Tropicos ® have reported as follows: JAMAICA: Without data (lectotype: Sloane, Voy Jamaica t 161 (2) 1703.). Lectotipified by Wijnands, Bot. Commelins 66, 1983 [64] and LT: Sloane, Voy. Jamaica t. 161, f. 2 (1725); LT designated by Wijnands, Bot. Commelins 66 (1983); TOP: Sloane Herb., 5: fol. 63 TT designated by C.E. Jarvis [54].

Type protologue: distribution

Jamaica: No data (lectotype: Sloane, Voy Jamaica, 161 (2) 1703.). Lectotipified by Wijnands, Bot. Commelins 66, 1983 [64].

Diagnosis

Conocarpus erectus L.: differs from mangroves in their reproductive strategy; it is reproduced through seeds [30].

It has an erect trunk or several trunks but may assume a prostrate body; the crust is gray or brown, wrinkled, fibrous, and moderately thin; the inner crust is dark cream color. The leaves are alternate, simple, and oblong, 2–7 cm in length (rarely 10 cm long) and 1–3 cm in width, with a decrease in the tip; they are dark green and bright in the bundle and pale in tone and with fine silky hairs on the underside. The inflorescences are terminal or axillary panicles, of small flowers of greenish-white color grouped in spheroidal heads of 3–5 mm in diameter. Fruits, 4-mm winged nuts, are added in globose brown heads, 1–1.3 cm in diameter. *Conocarpus erectus* L. is intolerant to shade [28].

Common and vernacular names

Mangle botoncillo [15].

Other common names in Mexico: mangle negro, mangle prieto—Veracruz, Tabasco, Campeche, Oaxaca, Guerrero; mangle botoncillo—Yucatan and Veracruz [42]. Maaya: k'an che '[27].

Botoncillo (El Salvador, Honduras, Nicaragua); buttonwood (Belize); mangle boton (Costa Rica, Panama); mangle botoncillo (Guatemala); mangle gris (Honduras); mangle negro (Costa Rica); palo boton (Honduras) [4]. Mangle zaragoza (Costa Rica, Panama) [29].

Distribution

It is found on both coastlines of the country, from the state of Tamaulipas to the Yucatan Peninsula in the Gulf of Mexico and the Caribbean Sea and from the states of Baja California and Sonora to Chiapas in the Pacific Ocean [42].

Flowers and fruits of *Conocarpus erectus*. Agustín de Jesús Basáñez Muñoz (2006). Universidad Veracruzana.

2.4. *Laguncularia racemosa* (L.) C.F. Gaertn.

Valid name

Laguncularia racemosa (L.) C.F. Gaertn. Gaertner, Carl (Karl) Friedrich Von. Published in: Supplementum Carpologiae 209. 1807. (Suppl Carp) [55].

Basionym

The basionym of this species is *Conocarpus racemosus* L. *, initially described in the genus *Conocarpus* by Linnaeus and translated by C.F. Gaertner in 1807 to the genus *Laguncularia*. The first publication of the species *Conocarpus racemosus* was in Systema Naturae, Editio Decima 2: 930. 1759. Syst. Nat. (Ed.10). 5 **Synonym**; 2 **Ifraspecific categories** (form and variety) [55].

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

Subkingdom Tracheobionta

Superdivision Spermatophyta

Division Magnoliophyta

Class Magnoliopsida

Subclass Rosidae

Order Myrtales

Family Combretaceae

Generic

Laguncularia Gaertn (1807) is a monotypic genus (a single species) from tropical America and Africa [22].

Its name (*Laguncularia*) comes from the Latin term "laguncula," diminutive of "lagena," which means bottle; because the limbus of the chalice, when closing, constitutes the shape of the fruit (propagule), it is shaped like a small bottle [31] (and Personal Commentary, 2018).

Specifics

racemosa comes from the Latin racemosa, which means cluster, which alludes to the type of inflorescence that the plant presents (cluster type) [39].

Type specimens

The Atlas of Florida Plants and Tropicos ® [2] report a lectotype for *Laguncularia racemosa* (L.) C.F. Gaertn. rather related to his basionym *Conocarpus racemosus*: Without data (lectotype: LINN 237.2). Lectotypified by Bornstein, in R. A. Howard, Fl. Antill., Dicot. 2: 459, 1989 [64] and LT: Anon.; (LINN-237.2) LT designated by Bornstein, Fl. Lesser Antilles 5: 459 (1989) [56].

Type protologue: distribution

Jamaica: Without data (lectotype: Sloane, Voy, Jamaica, 161 (2), 1703). Lectotypified by Wijnands, Bot. Commelins 66, 1983 [64].

Diagnosis

This species presents as shrubs or trees, which reach a size of up to 10 m high, frequently with pneumatophores. Its trunk is straight with ascending branches, rounded, and a dense cup. The leaves of the white mangrove are opposite, elliptical, and rounded at both the base and the apex; they measure from 4–10 cm in length and from 2–4 cm in width; the top of the leaf (beam) is bright dark green and the bottom (underside) is yellowish green. The flowers appear in axillary and terminal panicles, are fragrant, and measure 1.5 mm in diameter [4].

Its silky and fleshy fruits have a flattened bottle shape, measure between 1 and 2.5 cm in length, and have several longitudinal grooves. They contain a seed; the seed often begins to germinate inside the fruit when it is still attached to the tree [42].

Common and vernacular names

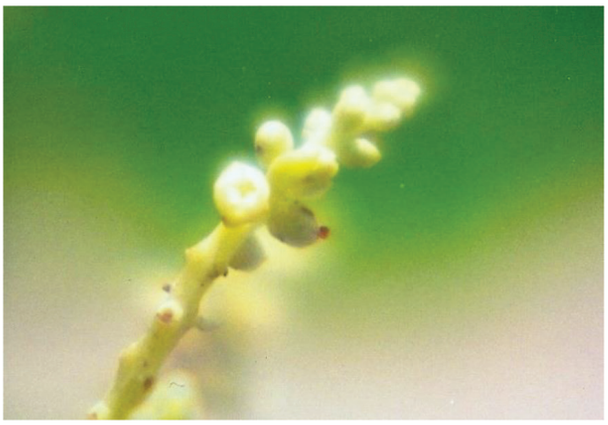
Mangle blanco [16].

Other common names in Mexico: Mangle blanco—Tamaulipas, Oaxaca; mangle bobo—Yucatán; Mangle chino—Sinaloa [14] Sak-okom (Mayan language)—Yucatan; tzakol-kon—Yucatan Peninsula (Martínez, 1979 in [14]).

Patabán (Cuba); White mangrove (United States); Cincahuite, Palo de Sal (Costa Rica); akira (Suriname); jeli de mangle (Peru). [16].

Distribution

It is found on both coastlines of the country, from the state of Tamaulipas to the Yucatan Peninsula in the Gulf of Mexico and the Caribbean Sea and from the states of Baja California and Sonora to Chiapas in the Pacific Ocean [42].



Flowers and propagules of *Laguncularia racemosa*. Agustín de Jesús Basáñez Muñoz (2006). Universidad Veracruzana.

2.5. *Rhizophora harrisonii* Leechm.

Valid name

Rhizophora harrisonii Leechm: Bulletin of Miscellaneous Information Kew 1918 (1): 8, f. A. 1918. (Bull Misc.Kew Inform) [57].

Synonym

Rhizophora brevistyla Salvoza [57].

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

Subkingdom Tracheobionta

Superdivision Spermatophyta

Division Magnoliophyta

Class Magnoliopsida

Subclass Rosidae

Order Malpighiales

Family Rhizophoraceae

Generic

Rhizophora: The word "rhiza" (root) and "phoros" (bearer or bearer) means in Greek "bearing the roots" and refers to its aerial (willow) roots' characteristics of the genus [25].

Specific

Harrisonii: In the honor of Professor J.B. Harrison, C.M.G., M.A. Director of Science and Agriculture in British (English) Guiana [32].

An important aspect to emphasize is the use of taxonomic status:

Rhizophora x harrisonii was proposed by Tomlinson in 1986 [18] in his book "The Botany of Mangroves." The author mentions that "in relation to *Rhizophora x harrisonii*, there is circumstantial evidence that the species is a hybrid between *Rhizophora mangle* and *Rhizophora racemosa.*"

In this regard, a study of hybridization and introgression between the species of the genus *Rhizophora* of the New World (*R. mangle, R. racemosa* and *R. harrisonii*) carried out by Cerón et al. [10], concludes that "our data support an ancient and persistent hybridization of the *Rhizophora* genus and propose a complete review of the group's systematic relationships based on finer morphological, ecological and genetic analyzes." "However, we found no genetic evidence that *R. harrisonii* is a hybrid species". Rather, *R. harrisonii* appears to represent a morphotype produced by a process of hybridization and backcrossing between *R. mangle* and *R. racemosa* [10].

Type specimens

Rhizophora harrisonii Leechm. has a lectotype as follows: LT: Leechman s.n.; Guyana (K) LT designated by Barrie, Fl. Mesoamer. 4 (1): ined. [57].

Type-protologue: distribution

Guyana: British Guiana: Two-mile stretch of coast, in the vicinity of Georgetown [57].

Diagnosis

Rhizophora harrisonii Leechm. are trees up to 25 m with leaves from 9–13 cm in length and from 3–8 cm in width, elliptic, acute apex, and the petiole measures are from 1–3 cm. It presents dichotomically branched inflorescences of 5–6 times or the first tricotómica branch; the branches are thin, laxas, and arranged in acute angles. The flower buds are 3–9 mm, ellipsoid, and the apex is slightly attenuated; sepals are of 8–10 mm compared to their petals of 5–6 mm; they are deciduous, abaxially glabrous, villous margins; they present 8 stamens of 4.5–5 mm and sessile and are apiculated. The fruit is 28–33 mm long with its hypocotyl from 11–40 cm, straight or curved [58].

Common and vernacular names

Mangle caballero, Mangle zapatero [7].

Common name in other countries: Mangle rojo—Venezuela [20].

Distribution

Rico-Gray [43] said that *Rhizophora harrisonii* Leechm. "is a new record for the coasts of Mexico", reporting to the species for the State of Chiapas. Recent studies by the South Border College of Tapachula Unit have located a mature forest of *Avicennia bicolor* between the municipal boundaries of Tonalá and Pijijiapan, Chiapas, in addition to finding new distribution sites for *Rhizophora harrisonii* (Tovilla, 2012 com. [44]).

Flowers and propagules of *Rhizophora harrisonii*. Cistian Tovilla Hernández. Diplomado Internacional en ecología, manejo, restauración y legislación en sistemas de manglares (2017). ECOSUR.

2.6. *Rhizophora mangle* L.

Valid name

Rhizophora mangle L. Linnaeus, Carl Von. Species Plantarum 1: 443. 1753. (1 May 1753) (Sp. Pl.) [59].

Synonym

Rhizophora americana Nutt.

Rhizophora mangle var. samoensis Hochr.

Rhizophora samoensis (Hochr.) Salvoza.

Name accepted

Nasir and Ali in 1972 [38], consider *Rhizophora mucronata* Lam. as an accepted name (it is the name which can be used to refer to species (or subspecies, varieties, or forms) of *Rhizophora mangle* L. 2 **Ifraspecific categories** (variety).

Taxonomy

Affinities

Suprageneric

Kingdom Plantae

SubKingdom Tracheobionta

Superdivision Spermatophyta

Division Magnoliophyta

Class Magnoliopsida

Subclass Rosidae

Order Malpihiales

Family Rhizophoraceae

Generic

Rhizophora: The word "rhiza" (root) and "phoros" (bearer or bearer) means in Greek "bearing the roots" and refers to its aerial (willow) roots characteristics of the genus [25].

Specific

Mangle: The word mangle is derived from Guarani and means "twisted tree" [1].

Type specimens

The tropicos.org ® website reports an epithet such as, ET: Jamaica (F; IET: DUKE, MICH) ET designated by Barrie, Fl. Mesoamer. 4 (1): ined. As well as a Lectotype: LT: Plumier, Nov. Pl. Amer. t. 15 (1703) LT designated by Barrie, Fl. Mesoamer. 4 (1): ined., And another related to: LT: Herb. Sloane 6: 62; (BM) LT designated by Keay, Kew Bull. 8 (1): 123 (1953) [59].

Type protologue: distribution

Jamaica (F; EET: DUKE, MICH) ET designated by Barrie, Fl. Mesoamer. 4 (1): ined. [59].

Diagnosis

The trees of *Rhizophora mangle* are from 4 to 10 m in height, their shape is like a tree or and evergreen shrub. The leaves are simple, opposite, petiolate, with rounded leaf, and they are elliptic to oblong; these are agglomerated at the tips of the branches, their color is dark green in the bundle, and yellowish on the underside. The flowers are small, 2.5 cm in diameter with four speared sepals, thick and leathery. The flower has four yellowish white petals. It has two to four flowers per stem or peduncle. The fruits are presented in the form of a brown, coriaceous, hard, piriform, farinous berry. A seed is developed, rarely two, per fruit [62].

Common and vernacular names

Common names in Mexico: Candelón—Veracruz, Colima, Sinaloa; Mangle; Mangle colorado; Mangle dulce—Baja California, Oaxaca; Mangle rojo; Mangle tinto—Veracruz [17, 62]. Maya: Tabché, Tapché, Xtabché [17, 62].

Mangle colorado, mangle (Honduras); mangle rojo (Costa Rica); mangle salado (Panama); Candelin, Mangle dulce (Mexico); mangle caballero, mangle gateador (Colombia); Mangle verdadero, mangle zapatero (Ecuador); purgua (Venezuela); apareiba, mangle zapateiro, mangle vermelho (Brazil); mang wouj (Haiti) [8].

Distribution

It is found on both coastlines of the country, from the state of Tamaulipas to the Yucatan Peninsula in the Gulf of Mexico and the Caribbean Sea and from the states of Baja California and Sonora to Chiapas in the Pacific Ocean [42].

Flowers and propagules of *Rhizophora mangle*. Agustín de Jesús Basáñez Muñoz (2006). Universidad Veracruzana

3. Importance

Mexico is among the five countries in the world with the largest extension of mangroves distributed; by 2015, 7,75,555 ha of mangroves have been registered in both coasts of the country covering at least 60% of the coastline [61].

In 2005, the National Commission for the Knowledge and Use of Biodiversity (CONABIO) initiated the bases for what is now called the Mangrove Monitoring System of Mexico. The aim of the SMMM is to generate information about changes in the mangrove ecosystem through the evaluation of its spatial distribution and condition over time. From this information, we also look for the identification of existing, latent threats and trends of changes (loss, deterioration, or recovery), in such a way as to support their conservation, understanding, and management. Based on the information generated, the threats and trends of change that through analysis have been incorporated into the conservation of this ecosystem have been

identified. The results show a strong occurrence of both natural processes and human activities, which influence the loss of coverage or disturbance of the mangrove. Of these, those of anthropic origin stand out for their importance. In this category, two classes are presented: the agricultural-livestock and a pattern of occupation of land use derived from development. The first one is related to primary economic activities, that is to say agriculture (both irrigation and seasonal), livestock, and forestry. The second class encompasses land uses, such as rural areas, urban areas, industrial zones, aquaculture farms, ports, tourist infrastructure, and so on [61].

The tendency of loss of coverage occurred mainly in the period from 1970 to 2005 (up to 27,557 ha), there being a drastic change from 2005 to 2015, with the last period reported from 2010 to 2015 with a loss of 1090 ha but a profit of 1296 ha. Within the categories identified by the SMMM as threats in the loss of mangrove are the areas under construction, aquaculture farms and artificial ponds, hydraulic infrastructure (canals or dams), industrial zones (oil wells, salt pans, thermoelectric plants, complexes), and communication routes [61].

In Mexico, 6 of the world's 70 mangrove species (8.5%) have been reported [50] and contribute 5.4% of the total mangrove area, after Indonesia with 22.6%, Australia with 7.1%, and Brazil with 7% [60].

Its biological importance lies in being places of rest and nesting of birds (*Egretta caerulea, E. rufescens, E. tricolor, Ardea herodias, Aramides cajaneus, Sula leucogaster, Phalacrocorax auritus, Fregata magnificens, Ajaia ajaja,* among others). They represent an important habitat for species with some risk category (NOM-059-SEMARNAT-2010) such as Mexican *Tamandua mexicana, Buteogallus anthracinus, Rostrhamus sociabilis, Mycteria americana, Vireo pallens, Megascops cooperi, Crocodylus acutus, C. moreletii, Ctenosaura pectinata, C quinquecarinata, C. similis, C. acanthura, C. hemilopha,* and *Iguana iguana* [50].

The biological and ecological importance of mangroves has led CONABIO to establish 81 priority sites, determined by specialists in the subject; of these 29 are located on the Pacific coast, 27 in the Gulf of Mexico, and 25 in the Yucatan Peninsula. Each of these sites of interest has a characterization sheet with information on site location, physical characteristics, socioeconomic, uses, importance, impacts, and threats and transformation processes [13].

4. Uses

They are used in firewood and coal; poles for fences, piles, railway sleepers, piers, boats, telegraph poles, and electricity; and furniture, cabinets, door frames, musical instruments, handles for tools, and agricultural implements. Newborn seedlings are edible if cooked but raw seeds are poisonous. The bark contains tannin and is used to tan skins. The infusion of its cooking is drunk as a remedy for diarrhea, intestinal irritation and colic, washing or bathing to heal wounds and hemorrhoids, or in bleeding gums rinses. The flowers are rich in honey and in nectar. The honey obtained is white, clear, and of excellent quality [4].

5. Protection

In Mexico, the mangrove is considered a commonly used asset, although the General Law of National Assets prevents a private or public entity from making use of them; it will require the processing of a concession or assignment, which will never generate real rights, exclusively and without prejudice to third parties; it will only generate the right to use or exploit the assets with the limits set forth by the laws and concession. Revocation of a concession may exist, for example, if fixed constructions are made that damage the present ecosystems. From this regulation, in 1996, the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) determines, in its Article 28, that the environmental impact assessment procedure should start if works or activities that can be carried out are carried out. A delay can cause ecological imbalances in coastal ecosystems, coastal wetlands, mangroves, lagoons, rivers, lakes, and estuaries connected to the sea. In 2000, the General Wildlife Law was enacted, which excludes timber resources from sustainable use and species whose livelihood is water, if they are considered as species or populations at risk. To consider those species that were considered at risk, in 2001, Official Mexican Standard NOM-059-ECOL-2001 was published, listing the species referred to in the General Wildlife Law. In this Official Mexican Standard the four mangrove species with a national presence (*Rhizophora mangle, Avicennia germinans, Laguncularia racemosa,* and *Conocarpus erectus*) are integrated with the status of special protection. In the reform of the Official Mexican Standard (NOM-059-SEMARNAT-2010 [24]) mangrove species are considered as threatned.

Parallel to these instruments of environmental policy, since 2000, work began on an Official Mexican Standard (NOM) that established the specifications for the preservation, conservation, sustainable use, and restoration of coastal wetlands in mangrove areas; in 2003, when it is published, the NOM refers to a series of provisions that are mandatory for those responsible for carrying out works or activities that are intended to be located in coastal wetlands or whose characteristics may negatively influence them. At the same time, with the enactment of the General Law of Sustainable Forestry Development in 2003, legal uncertainty was created in the protection of mangroves when considering, in Article 28 of its regulation (published in 2005), that the areas with mangrove vegetation are areas of conservation and restricted use.

To give greater legal certainty to the protection of mangroves, in 2007, a reform to the General Wildlife Law was published, Article 60 TER, which specifies that any activity that affects the integrity of the species and its productivity is prohibited, as well as the hydrological flow and environmental services provided by the mangroves [9, 49]. Actions in favor of mangroves in the face of climate change are considered in the General Law on Climate Change published in 2012, which in its Article 26 mentions as the fundamental principle of the Law the conservation of ecosystems and their biodiversity, giving priority to wetlands, mangroves, reefs, dunes, coastal zones, and lagoons, that provide environmental services, fundamental to reduce vulnerability.

To support the protection of mangroves, the government of Mexico, through NOM-022-SEMARNAT-2003 [23], empowers the Federal Environmental Protection Agency (PROFEPA) to monitor the provisions stipulated. PROFEPA has established a policy of inspection and surveillance for the conservation of mangroves in which non-compliance

with the provisions of prevention, conservation, sustainable use, and restoration is considered an environmental crime. In turn, the Secretariat of the Navy (SEMAR) through its institutional program for protection, conservation, restoration, and reforestation of the mangrove collaborates in the protection and conservation of the mangrove in places that are outside of some kind of special protection (e.g., that are not within protected natural areas) to diminish their deterioration.

In Mexico there are no regulations for the species *Avicennia bicolor* Standl and *Rhizophora harrisonii* Leechm. The International Union for the Conservation of Nature (IUCN) has them in the category of vulnerable species, given that there are only reports of few individuals (without specifying how many) present of these species within the mangrove (dominated by the other species of mangrove), without forming extensive pure masses.

6. Discussion

The current situation of the mangroves of Mexico is presented in a favorable context due to the fifth place that occupies worldwide by surface covered in mangrove, the existence of six species whit the representativeness of four of them in the 17 coastal states and they covered 60% of the coastal surface. Although there are threats that can cause loss of mangrove areas, 9.4% in 45 years (1970–2015) due mainly to the lack of urban, industrial, and tourist development planning, as well as the advancement of the agricultural frontier and the activities related to aquaculture, there is legislation and regulations for its long-term protection. The protection strategies hitherto employed have yielded good results, although there is still a need for more constant vigilance and not only through programmed operations. In relation to their conservation, the decrees of Natural Protected Areas and Ramsar Sites have under their protection more than 50% of the mangroves of the country; the actions aimed to generate greater decrees of mangrove zones are continued. The support to the rehabilitation and restoration of the mangroves has become a national strategy of government agencies that are related to these communities, including the Secretary of Environment and Natural Resources (SEMARNAT), the National Commission of Natural Protected Areas (CONANP), the National Forestry Commission (CONAFOR), the National Commission for the Knowledge and Use of Biodiversity (CONABIO), as well as decentralized public agencies such as Petroleos Mexicanos (PEMEX) and the Federal Electricity Commission (CFE).

The conservation of mangroves not only ensures the perpetuity of mangrove species but also the species that inhabit or rest in these environments—both at the level of those that are under some risk status and at the level of those that maintain the fishing production of the coastal zones.

The documented material consisted of printed books [9] and information obtained on the Internet concerning the species *Rhizophora mangle* L., *Avicennia germinans* (L.) L., *Laguncularia racemosa* (L.) C.F. Gaertn., *Conocarpus erectus* L., *Rhizophora harrisonii* Leechm., and *Avicennia bicolor* Standl. It was observed that the information obtained through written means is more truthful and reliable than the information obtained via the Internet. The information obtained from the Internet is more practical and easy to find, but when reviewing and analyzing this information we can see a repetition of pages, with the same information but with different

authorship for different species of mangroves and in most cases the author of the informative text does not appear (reason why it was discarded).

It should be noted that the most reliable and quoted information was found on websites of other countries, mainly the United States and Australia. In addition, translations from English, French, and Portuguese into Spanish had to be done. On other occasions the original documents of the description of the species had to be reviewed, such as *R. harrisonii* and *A. bicolor*, using the search engine Biodiversity Heritage Library (biodiversitylibrary.org), which is a consortium of natural history and libraries of botanical topics that have come together to digitize the legacy of the literature on the biodiversity of their collections and make the available open access literature and for responsible use as part of the "global commons of biodiversity."

7. Conclusion

With the proposed synopsis, we have a broad overview of the systematic and taxonomic information of mangrove species in Mexico, which is not easily found in a single compendium, so that their contribution is of special interest to students of the upper levels, as well as the people who are interested in the topic of mangroves. A thorough investigation was undertaken on the meaning of their scientific names, an exercise that is not very common in the disclosure of species fills that gap of information. The topics of its importance, uses, and protection were approached with the most recent knowledge available, complemented by the authors' opinions. In relation to the importance of the mangroves, the species that are found listed in irrigation in the NOM-059-SEMARNAT-2010 [24] and that inhabit the mangroves stand out. The uses of mangrove species have not yet been addressed by citizen participation research in which use values are discussed; only references are made in relation to surveys among the inhabitants, and there is a lack of information. Legislation that protects mangroves is effective in the written word, but greater vigilance is needed in their compliance; their conservation strategies are carried out through decrees of Natural Protected Areas and Ramsar Sites but there are still strategic mangrove sites that they must be incorporated. The support granted to the rehabilitation and restoration of the mangroves is used by the inhabitants who adjoin these communities; the non-governmental organizations and the researchers of universities and institutes are to work in favor of this precious resource.

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