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Diversity of urban trees in the city of Villahermosa, Tabasco, Mexico

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Abstract

The city of Villahermosa, Tabasco, has lost many trees so it is necessary to investigate and catalog the diversity of the vegetation through the collection of data on the species of urban trees present. For this reason, information and knowledge about the floristic richness must be updated by contributing with updated floristic lists of the urban flora of the city. The diversity of the urban tree flora of the city of Villahermosa was determined through the identification of urban tree species found along 16 road walkways within the city. With the information collected, an inventory of trees was made, a floristic list was drawn up and the ecological indices of biodiversity of Margalef, Shannon-Weaver and Simpson were determined. Additionally, the technical sheets of the species were built. In this study, a total of 5,936 trees, belonging to 60 species, distributed in 25 families, were counted. The city has a high biodiversity of tree species, pointing to it being a healthy and prosperous ecosystem; inverted Simpson dominance index (0.8985), there is no dominance by any species over the others, which will allow the trees not to fall into a homogeneous state of diversity over the years.

Keywords: Diversity; Flora; Trees; Villahermosa

1. Introduction

The flora of Tabasco has been drastically reduced inside and outside the cities, due to the modification of ecosystems by anthropogenic activities, such as deforestation and continuous urbanization [1].

Urban tree flora is a key element in the infrastructure and development of cities [2]. Trees fulfill social and environmental services, they are a component of the city's image (Figures 1, 2), they improve the microclimate by reducing temperature, they increase air quality through the reduction of atmospheric pollutants, they provide a habitat for urban fauna, they reduce the presence of carbon dioxide, they also modify the space in which they are planted, contrasting with buildings and adding places to the public space that stimulate cultural life of citizens and that they use for physical and recreational activities [3, 4].

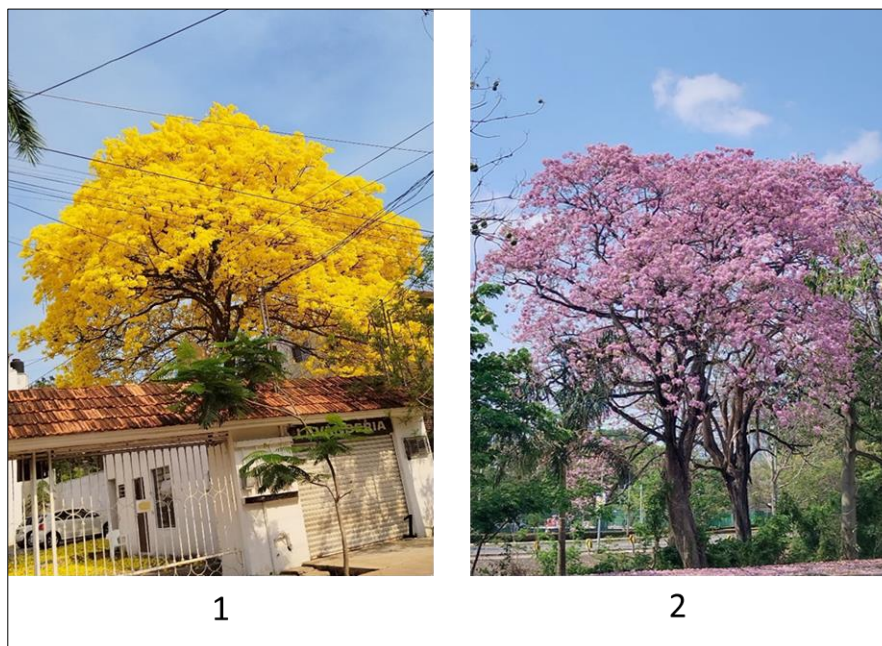
It is necessary to know the plant biodiversity of a region for the planning of conservation policies, urban planning and preservation of species and communities that interact with the flora [5].

The city of Villahermosa in the municipality of Centro, Tabasco was a place with many trees [6], which has decreased over the years under inclement weather, natural death, logging due to the increase in the number of lanes on the avenues and even due to the attack of pests and diseases [7, 8] carried out a thesis on the diversity of urban tree flora in some avenues of the city of Villahermosa, finding 51 species distributed in 25 families, without considering ecological indices.

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In another study of the tree flora, [9] counted 70 species in 31 families within the urban area of the municipality of Centro.

The purpose of this research is to determine the composition of the urban tree flora of the city of Villahermosa, Tabasco and to contribute with an updated floristic list of the urban flora of the city to complement the information generated by other works carried out in recent decades.



Figures 1 and 2 Guayacan *Handroanthus guayacan* and Macuilíz *Tabebuia rosea* the most colorful and attractive trees in Villahermosa, Tabasco

2. Material and methods

Villahermosa is the capital of the state of Tabasco, with a great abundance of natural resources [6]. It is located at coordinates 17°59' north latitude, 92°56' west longitude with an average altitude of 10 meters above sea level, bordering six main localities: Villa Ocuiltzapotlán, Villa Macultepec, Villa Parrilla 1^a. Section, Villa Playas del Rosario, Ixtacomitán, Anacleto Canabal and Río Viejo [10]. Urban areas have a hot humid climate with abundant rainfall in summer and are distributed mainly on Gleysol and Regosol soils, previously occupied by pastureland, agriculture, popal and tular, [11]. The tree flora present in the urban area of the city of Villahermosa delimited by the topographic map "E15D11a" 1:20000 of [12] was studied. For which the extension of 16 road walkways was considered to carry out the inventory, being the following public parks, avenues and main streets: 1) Periferico Carlos Pellicer Cámara, 2) Adolfo Ruíz Cortines Boulevard, 3) Carlos A. Madrazo Malecon, 4) Usumacinta Avenue, 5) 27 de Febrero Avenue, 6) Gregorio Méndez Magaña Avenue, 7) Paseo Tabasco Avenue, 8) Francisco Javier Mina Avenue, 9) Francisco I. Madero Avenue, 10) Revolution Avenue, 11) César Sandino Avenue, 12) Quintín Arauz Carrillo Avenue, 13) Tomás Garrido Canabal Park, 14) La Pólvara Park, 15) Infonavit Atasta Sports Park and 16) Sports Circuit. An inventory of trees whose normal diameter (Dn, 1.3 m) was greater than or equal to 10 cm was carried out, measuring with a tape measure, following the guidelines of [13]. The species, the number of individuals per species and their location were recorded. It was achieved through tours of the streets of the delimited area, considering the trees that grow on the sidewalk and those found inside the courtyards of the houses, whenever it was possible to see from the outside. Abandoned properties with free access were also considered and trees were also reported inside and outside the parks. For the identification of the trees, the works conducted by Magaña [14, 15, 7, 16, 17].

To compare and estimate the diversity of the community of the trees found in the delimited area, the Margalef index (DMg) was used, whose values less than 2 are considered low in species richness and values above 5 have a large number of species; while the Shannon-Weaver index (H) was used to calculate alpha diversity through the estimation of the heterogeneity of the community in relation to the with the relative abundance of the number of species present [18, 19, 20], in most natural ecosystems it varies between 0.5 and 5, although the normal value varies between 2 and 3 [21]; as well as the inverted Simpson dominance index (1-D) which represents the probability that two randomly

selected individuals within the same community do not belong to the same species [2]. These indices were calculated with the statistical program Past v3.25

3. Results

In total, 5,936 trees were counted in the urban area covered for this study. The largest number of individuals occurred on Ruíz Cortines Avenue with 1,130 trees, followed far below by the Carlos Pellicer Peripheral with 746. La Pólvora Park and Tomás Garrido Park have a similar number of individuals, the first with 604 and the second with 598 trees (without considering the trees inside the La Venta Museum). The avenues with the fewest trees are avenue Revolution with 60, Avenue Francisco Javier Mina with 59 and Avenue Francisco I. Madero with 33, (Table 1).

Table 1 Number of trees and species present in the city of Villahermosa

Lugar	No. de árboles	No. de especies
Carlos Pellicer Cámara Peripheral	746	42
Adolfo Ruíz Cortines Boulevard	1130	39
Carlos A. Madrazo Malecon	314	18
Usumacinta Avenue	409	34
27 de February Avenue	284	27
Gregorio Méndez Magaña Avenue	343	32
Paseo Tabasco Avenue	354	25
Francisco Javier Mina Avenue	59	12
Francisco I. Madero Avenue	33	7
Revolution Avenue	60	14
César Sandino Avenue	163	32
Quintín Arauz Carrillo Avenue	128	15
Tomás Garrido Canabal Park	598	34
La Pólvora Park	604	30
Infonavit Atasta Sports Park	248	25
Sports Circuit	463	36

A total of 60 tree species distributed in 25 families were recorded, with the Fabaceae family being the most abundant with 14 species. We also found the families Arecaceae, Bignoniaceae and Moraceae with 5 species each. The Myrtaceae family with 4 species, Malvaceae and Meliaceae with 3 and Anacardiaceae, Combretaceae and Rutaceae with 2 species. The rest of the families have only one species each, (Table 2).

Table 2 Number of species per family present in the city of Villahermosa

Familia	No. de especies
Fabaceae	14
Arecaceae	5
Bignoniaceae	5
Moraceae	5
Myrtaceae	4
Malvaceae	3
Meliaceae	3
Anacardiaceae	2
Combretaceae	2
Rutaceae	2
Apocynaceae	1
Bixaceae	1
Burseraceae	1
Casuarinaceae	1
Cupressaceae	1
Lamiaceae	1
Lauraceae	1
Malpighiaceae	1
Muntingiaceae	1
Rubiaceae	1
Salicaceae	1
Sapindaceae	1
Sapotaceae	1
Urticaceae	1

Considering the number of trees counted in all the roads and parks, the most abundant species is the macuilis (*Tabebuia rosea* L.) with 1,594 specimens, which represents 26.85% of the total count. Ficus or Indian laurel (*Ficus benjamina* L.), framboyan (*Delonix regia* (Bojer) Raf.), guaiac (*Tabebuia guayacan* (Seem.) Hemsl) and almond (*Terminalia catappa* L.) are the next most abundant species, with 501, 453, 384 and 315 trees, respectively. The least numerous species are other Indian ficus (*Ficus microcarpa* L.f.), mango (*Mangifera indica* L.), coconut palm (*Cocos nucifera* L.), royal palm (*Roystonea dunlapiana* P.H. Allen), Indian tulip (*Spathodea campanulata* P. Beauv.), willow (*Salix humboldtiana* Willd.), ceiba (*Ceiba pentandra* (L.) Gaertn.), cedar (*Cedrela odorata* L.) and Christmas palm (*Adonidia merrillii* (Becc.) Becc.), between 100 and 300 specimens were found.

The remaining 46 species had a low tree count, not exceeding 100 specimens per species, with 2 specimens being the lowest value (Figure 3). Together they account for only 19.71% of the total population counted.



Figure 3 Ceiba tree (*Ceiba pentandra*), in one of the avenues of Villahermosa, Tabasco

The biodiversity analysis of the tree community, through the ecological indexes, indicates that there is high biodiversity, considering that the Margalef index (DMg) was 6.79, a high value that indicates great species richness. The Shannon-Weaver index (H) was 2.98, a value considered high in biodiversity, and Simpson's inverted dominance index (1-D) was 0.8985, which predicts that it is very probable that two individuals taken at random do not belong to the same species, meaning that there is no dominance of any species over the others, which implies good diversity of tree species.

These ecological indices were also calculated for each of the sites visited throughout the city of Villahermosa, which allowed us to locate the points with the greatest biological diversity and differentiate those with low biodiversity. According to the Margalef index, seven of the sixteen sites exceeded the value of 5, considered high; eight more oscillate between 2 and 5 and only one of the sites is below 2, considered low in species richness. Ruíz Cortines Avenue is the most diverse with a value of 6,198, followed by César Sandino Avenue with 6,086 and Sport Circuit with 5,702. The sites with intermediate richness are Carlos A. Madrazo, Quintín Arauz and Francisco Mina Avenues with 2,957, 2,885 and 2,452, respectively. Francisco I. Madero Avenue has the lowest value, 1.716.

The Shannon index places 2 sites with high diversity, higher than 3; 4 sites with low diversity whose values are below 2 and the rest are between values of 2 and 3. César Sandino Avenue is the most biologically diverse with a value of 3.058, followed by Sports Circuit with 3.039 and the Carlos Pellicer peripheral with 2.819. The sites with low diversity are Quintín Arauz Ave. with 1,926, Malecon Carlos A. Madrazo with 1,555, Francisco I. Madero Ave. with 1,487 and Francisco J. Mina Ave. with 1,429.

As for Simpson's inverted index, most of the sites do not show dominance of any species, with values higher than 0.8 in 10 of the 16 sites. The sites with the most equal species dominance are Sport Circuit, César Sandino Avenue and Infonavit Sports Park with 0.9328, 0.931 and 0.9026, respectively. However, some values suggest that some species may be showing a little dominance, according to the presence of values lower than 0.7, such as Francisco I. Madero Avenue with 0.6961, the Carlos A. Madrazo boardwalk with 0.6742 and Francisco J. Mina Avenue with 0.5694.

Additionally, it was identified that 32 of the 60 species found are native, which represents 53% of the total, while 28 are of exotic origin, considered introduced.

4. Discussion

Urban trees have been the subject of few studies over the years in the country, so they should begin to be given the importance they deserve, highlighting mainly their benefits on the reduction of pollutants and particle concentration in the urban atmosphere [22]. The presence of trees should be considered valuable when their richness and biodiversity is high according to the values of ecological indexes, which statistically reflect the importance in ecosystems. Urban trees are so valuable that they could even be valued economically [23].

However, trees are underestimated as an important factor in the search for sustainability in cities, when in fact they should be safeguarded using techniques that combine tree census, inventories, management plans in green areas, development and planning for urban trees [24, 25].

Within these guidelines we found some similar works in other states of the country. Among those that stand out is the study by [26] in Zapopan, Jalisco, in which he correlates the diversity of urban tree species with the presence of several bird species. He found that the presence of 109 tree species (1,768 individuals) allowed the establishment of 47 bird species, concluding on the great importance of the richness of urban trees for the benefit of avifauna.

[27] carried out a preliminary diagnosis in a highly urbanized place such as Mexico City, where 51 tree species were recorded, of which 37.2% are native species and 62.8% are introduced species, out of a total of 1467 individuals recorded.

[28] made an inventory of trees, shrubs and climbing species in the city of Morelia, Michoacán, in which he identified more than 130 species. However, [29] identified 67 species of urban trees. In this same city, it should be noted that [30] evaluated the relationship between tree characteristics, mainly the size of their roots, and the damage they cause to urban infrastructure. He concluded that there is greater damage to sidewalks and proposed the ideal dimensions of planters to reduce the breakage of these structures.

[31] conducted a dasometric evaluation in a section of the Chapultepec Forest in Mexico City, in which they recorded 1,843 trees belonging to 41 species and argue that it is of great value to continually maintain research within this framework in as many green areas of the country as possible, providing support for the management plans that are carried out.

In Xalapa, Veracruz, 1,116 individuals were recorded in 140 species of trees and shrubs, distributed in 49 families, with the Arecaceae and Fabaceae families being the most abundant, a condition like that found in this work. In addition, according to [32], it was found that 44.3% of the species are native, a lower proportion than that in the city of Villahermosa, Tabasco, which is 53%.

In another city in the country, Linares, Nuevo León, [33] identified a total of 41 species distributed in 25 families, the most representative being the Fabaceae family. Thirty-four percent are native species. They evaluated the Margalef (DMg) and Shannon (H) index at 5.24 the former and 1.99 for the latter, values that are below those calculated in this study (DMg = 6.79 and H = 2.981).

In Linares there was an update from 1995 to 1999. [34] recorded 525 individuals in 39 species, representing 19 families in 1995 and 922 individuals in 49 species representing 27 families in 1999. He points out the difference in the number of individuals per species present between 1995 and 1999, but also emphasizes that the diversity of urban trees is low and remained so between both years, according to Simpson's (normal) index, which takes a value of 0.8698 in 1995 and 0.7793 in 1999, which denotes a high dominance of one species over the rest. It should be noted that there was no change in Villahermosa between 2005 and 2019.

5. Conclusion

The urban tree population of the city of Villahermosa, Tabasco is high in species richness. In the selected study area, 5,936 trees belonging to 60 species in 25 families were found, of which 32 are native.

Approximately a quarter of the total tree population is represented by a single native species, the Macuilis (*Tabebuia rosea* L.). However, the next two species in abundance are introduced; Ficus (*Ficus benjamina* L.) and Framboyan (*Delonix regia* (Bojer) Raf.). The second most abundant native species is the Guayacan (*Tabebuia guayacan* (Seem.) Hemsl).

According to the results of the ecological indexes: Margalef index (6.79), the number of species found is high; Shannon index (2.981), the city has a high biodiversity of tree species, indicating that it is a healthy and thriving ecosystem; Simpson inverted dominance index (0.8985), there is no dominance of any species over the others, which will allow the trees not to fall into a homogeneous state of diversity over the years.

In the last 15 years, the city of Villahermosa has suffered a significant loss of tree specimens, this when comparing the 2005 numbers with the current ones, highlighting that there are currently 5936 trees in 16 sites, while in that year there were 6369 trees in only 7 sites. On the contrary, the number of species has increased. This inversely proportional change meant that the ecological indices remained similar between the two years and that the ecosystem apparently did not suffer any alterations.

This has caused that, statistically, we see healthy tree biodiversity in the city, but at the same time created the illusion that urban trees have not been decimated by urban sprawl.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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