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# AVAILABILITY OF TRUE MISTLETOE IN URBAN TREES, CASE OF: UNIVERSIDAD AUTONOMA METROPOLITANA-XOCHIMILCO

***José Francisco Reséndiz Martínez***
Biologist, Universidad Nacional Autónoma de México / Facultad de Biología; Centro Nacional de Investigación Disciplinaria en Conservación y Mejoramiento de Ecosistemas Forestales del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

***Héctor Omar Tapia Martínez***
Agronomist from the Universidad Autónoma Metropolitana-Xochimilco / Departamento de Producción Agrícola y Animal; Universidad Autónoma Metropolitana-Xochimilco

***Efraín Velasco Bautista***
D. in Science from the Colegio de Postgraduados, México / Ciencias Estadísticas; Centro Nacional de Investigación Disciplinaria en Conservación y Mejoramiento de Ecosistemas Forestales del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

***Victor Javier Arriola Padilla***
D. in Sciences from the Colegio de Postgraduados, México / Rama Entomología Centro Nacional de Investigación Disciplinaria en Conservación y Mejoramiento de Ecosistemas Forestales del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

***Georgel Moctezuma López***
Master of Science, Colegio de Postgraduados, México / Rama de Economía Agrícola, Centro Nacional de Investigación Disciplinaria en Conservación y Mejoramiento de Ecosistemas Forestales del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. México

**Abstract:** In Mexico, the Loranthaceae family is found in most of the natural ecosystems; there are 10 genera and about 150 species registered and it is considered the third agent of floral destruction in temperate climates and is present in 10% of the surface of the trees. The objective was to carry out a phytosanitary diagnosis of true canker in the trees of the Universidade Autônoma Metropolitana-Xochimilco (UAM-X), Mexico City, and to compare the proportions of infested trees among the areas through contingency analysis. The trees were infested by true mink, where the most affected species were Casuarina (Casuarina equisetifolia), Freixo (Fraxinus uhdei) and Jacaranda (Jacaranda mimosifolia). The main genus of mink determined was Cladocolea with 3.64% infestation, where the species Cladocolea loniceroides was the one with the highest incidence; the species with the highest infestation were Casuarina (Casuarina cunninghamiana), Fresno (Fraxinus uhdei), Jacaranda (J. mimosifolia) and Ahuejote (Salix bonplandiana), while trovão (Ligustrum lucidum), jacarandá (J. mimosifolia) and casuarina (Casuarina equisetifolia) were infested by Struthantus sp.; while the trovão (Ligustrum lucidum) was damaged by Phoradendron sp. It was concluded that the proportion of trees that presented viscum was not the same in zones A, B and C. Zone B had a higher incidence of infected trees.
**Palavras-chave:** green areas, urban trees, *Cladocolea*, *Phoradendron*, *Struthanthum*, infestation.

## INTRODUCTION

In cities, chronic exposure to air pollution, damage associated with vandalism, and incorrect planting sites are factors that decrease tree vitality and make them vulnerable to attack by pests and diseases (Zaragoza-Hernández *et al*., 2015).

Forest health and well-being has focused on the analysis of biotic and abiotic factors that affect vigor and productivity, and that manifest themselves through symptoms in the structures that make up the tree (PAOT, 2011; Koeser *et al*., 2013).

Recent research indicates that there are 4,100 species of parasitic angiosperms, with a wide range of hosts, forms, sizes and life strategies, distributed in 19 families and 227 genera (Bell and Adams, 2011).

In Mexico, parasitic plants of the *Loranthaceae* and *Santalaceae* families occur in almost all natural ecosystems. These types of plants have specialized structures (haustoria) to obtain from their hosts the support and nutrients necessary for their development (Conafor, 2007). The degree of dependence varies greatly among genera; some are specific, such as the genus *Arceuthobium* (dwarf mistletoe), which with its 23 taxa in Mexico parasitizes the subdivision Gymnospermae (Hawksworth *et al*., 2002).

They are the second biological agent of disturbance in temperate forests, estimating annual losses of more than 2 million m total tree volume (TTV) of wood, without considering the death of trees and the predisposition to attack by forest pests and diseases. This would be equivalent to about 1.8 million hectares of coniferous and broadleaf forests. The effect of mistletoe parasitism caused the loss of up to 1.04 $m^3$/year/ha of wood, which in the past represented a national loss of about 2 million $m^3$ of roundwood per year (Vázquez *et al*, 2006).

Díaz-Limón *et al*. (2016) determined the mistletoe species present in the Tlalpan forest of Mexico City, the level of infection and the susceptibility of different tree species to mistletoe parasitism. *Cladocolea loniceroides* was found to be the most widely distributed species in 17 of the 20 sites. At least seven tree species were susceptible to infection by this mistletoe. *Phoradendron brachystachyum* (DC.) Oliv. was found at only four sites and only one species was susceptible to its infection. The most abundant, susceptible tree species with the highest height and crown length was *Fraxinus uhdei* (Wenz.) Lingelsh; these dasometric variables could be contributing to the high levels of infection found.

In Mexico City, particularly at UAM-Xochimilco, studies on the impact of true mistletoes on urban trees are incipient. Likewise, there is a lack of information related to the different species of mistletoes and the different species of host trees, as well as their degree of susceptibility.

The objective of this study was to carry out a phytosanitary diagnosis of true mistletoe in the trees of the Universidad Autónoma Metropolitana-Xochimilco (UAM-X), Mexico City, and a contingency analysis considering the proportion of mistletoe compared between zones of the study area.

## STUDY AREA

The Universidad Autónoma Metropolitana Unidad Xochimilco (UAM-X) is located at Calzada del Hueso 1100, Col. Villa Quietud, Delegación Coyoacán, 04960, CDMX, Mexico. It has an area of 24,091 square meters and has clay soil; its relief is completely flat and has green areas in half of its surface.

## TREE CENSUS

The inventory was carried out using a base map of the university, which contains the composition of the green area of the study area. The corresponding polygons of each wooded area were drawn on this map; the limits of each polygon were marked using a GPS (Garmin, GPS 64 s), which made it possible to determine its surface area. Thus, the green area was formed by zones A, B and C (Figure 1).

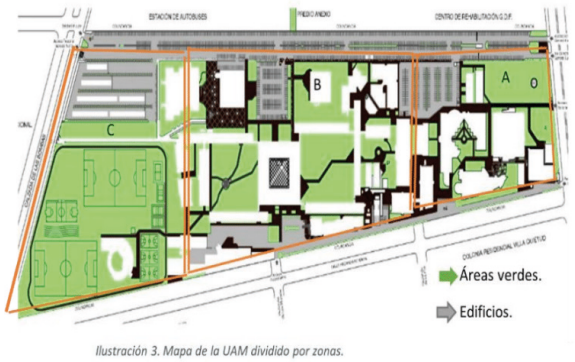



Ilustración 3. Mapa de la UAM dividido por zonas.

Figure 1. Distribution of polygons (A; B and C) in the UAM-X.

The tree register was carried out in a field format designed according to Conafor (2007). The variables considered were: scientific name of the tree, normal diameter (ND), total height, crown diameter, crown length, and presence or absence of true mistletoe (if applicable, species of mistletoe). The normal diameter was measured with a 5 meter diametric tape, Perfoparts brand, at a height of 1.30 meters. Tree height was recorded with a Haga Germany clinometer. The diameter of the crown was measured with a tape measure in two directions, north-south and east-west, taking as a reference the projection of the ends of the crown on the ground.

For their determination, samples of foliage, leaves, branches and flowering plant structures were collected and specialized keys of Rodriguez and Cohen (2003) and Martinez (2008) were used.

## EVALUATION OF THE LEVEL OF INFESTATION

To evaluate the degrees of infestation, the scale established by Alvarado-Rosales *et al.* (2003) was used, which indicates each level of damage in relation to the percentage of mistletoe presence in the tree crown, which specifies from absence as zero to very severe infection with a score of 6.

The presence or absence of true mistletoe was considered as a binomial variable, i.e., the variable is equal to 1 when mistletoe is present and is equal to 0 otherwise. In addition, in the presence of mistletoe, different degrees of infestation were recorded, as shown in Table 1.

| Value | Degree of infection | Percentage |
|---|---|---|
| 1 | No | 0 |
| 2 | Incipient | <10 |
| 3 | Moderate | 10-30 |
| 4 | Regular | 30-50 |
| 5 | Severa | 50-80 |
| 6 | Very severe | 80 |

Table 1. Categories of mistletoe infestation.

Source: own elaboration

To determine the genera or species of mistletoe, mistletoe samples were collected from infected trees, photographed and placed in a ziploc bag labeled as follows: sample point, zone and tree species. Each sample was transferred to the forest health laboratory of the National Center for Disciplinary Research in Conservation and Improvement of Forest Ecosystems (Cenid-Comef) of INIFAP and a Zeiss microscope (Model Stemi 200-C) and taxonomic keys were used.

## STATISTICAL ANALYSIS

The analysis of the information for the comparison of proportions of mistletoe-infested trees between zones was performed using the statistical method "contingency analysis" (Agresti 2007), which considers the squared distance between the observed and expected frequency, corresponding to the cross-factor cell (presence/absence and zone); the expected frequency was obtained under the assumption of independence. The test statistic, defined as the sum of the squared distances between the observed frequencies, is distributed as a chi-square, whose degrees of freedom correspond to the product of the number of rows by the number of columns in the

contingency table (Wackerly *et al*. 2008). The working hypothesis refers to the equality of proportions of mistletoe-infested trees between zones. The analysis was carried out using R software (R Core Team, 2020).

## RESULTS AND DISCUSSION

A total of 549 trees were recorded in the three established polygons, which were grouped into 42 species. The species with the highest frequency were: *Casuarina equisetifolia* L. with 134 specimens (24.41%), *Fraxinus uhdei* (Wenz.) Lingelsh with 63 (11.48%), *Jacaranda mimosifolia* D. Don with 50 (9.11%), *Salix bonplandiana* Kunth with 34 (6.19%), *Cupressus lusitanica* Mill with 37 (6.74%) and *Ficus benjamina* L. with 32 specimens (5.83%), shown in (Figure 2). Together these species include about 64% of the specimens.

Figure 2 shows the number of trees found by species, represented by the blue color, while the orange color shows the overall relative frequency. When comparing the results of this study with those obtained by Cervantes *et al.* (2019) in the Third Section of Chapultepec Forest, which has an area of 240.90 hectares, where 1,731 trees were recorded, grouped into 25 species, based on this information it was determined that in UAM-Xochimilco there is greater diversity of trees, although it has only an area of 2.4 hectares, and therefore fewer trees. This situation may be due to the participation of academic staff and students in reforestation campaigns at the university. Regarding the species used, it is observed that there is coincidence in: *Casuarina equisetifolia, Fraxinus uhdei and Jacaranda mimosifolia*.

Alvarado (2021), determined 19 genera of trees and shrubs, whose frequencies were: Fraxinus (31.97%), Populus (16.71%), Ulmus (7.64%), Eucalyptus (7.32%), Ligustrum (6.78%), Casuarina (6.05%), Cupresus (5.85%), Jacaranda (5.52%), Ficus (2.63%) and Acacia (2.09%). Other genera such as Salix, Pinus, Acer, Grevillea, Alnus, Liquidámbar, Schinus and Eritrina had frequencies of less than 2 %. The species used in the reforestation programs in the green areas of Mexico City are generally the same, what changes is the arrangement of the plant. The UAM- Xochimilco is no exception, where the species with the highest frequency are: *Casuarina equisetifolia, Fraxinus uhdei and Jacaranda mimosifolia*.

Regarding the distribution of tree species in the three polygons, it was determined that polygon "B" presented the greatest number of individuals with 327 specimens, followed in order of importance by polygon "A" with 135 and "C" with 87 individuals. In polygon B the predominant species were: *Casuarina equisetifolia* 15.30%), *Jacaranda mimosifolia* (8.19%) and *Fraxinus uhdei* (6.92%), while in polygon "A" the most used tree species were: *Casuarina equisetifolia and Salix bonplandiana*, which are shown in (Figure 3).

Based on the previously mentioned tree species, those with the highest percentage of true mistletoe infestation were: ash (*Fraxinus uhdei*) with 43 %, casuarina *(Casuarina equisetifolia*) with 27.77 % damage, ahuejote *(Salix bonplandiana* with 23.18, oleander *(Nerium oleander* L.) 7.24 %, weeping willow *(Salix babylonica*) with 5.79 %, while plum *(Prunus domestica* L.), peach (*Prunus persica* (L.) Batsch) and thunder (*Ligustrum lucidum*) presented 4.34 % damage (Figure 4).

On the other hand, the species with less mistletoe parasitism were: ahuehuete (*Taxodium mucrunatum*) with 4.01 %, cepillo (*Callistemon citrinus*), with 4.55 % of deterioration, Ficus benjamina with 5.83 %, common cypress (*Cupressus sempervirens* L.) and white cedar (*Cupressus lusitanica*), both with a deterioration of 6.74 % each and as shown in (Figure 5).

The host species most damaged by mistletoe in this work coincide with those recorded by Marchal (2009), where he cites that Jacaranda *mimosifolia* is attacked by both *Stru-*

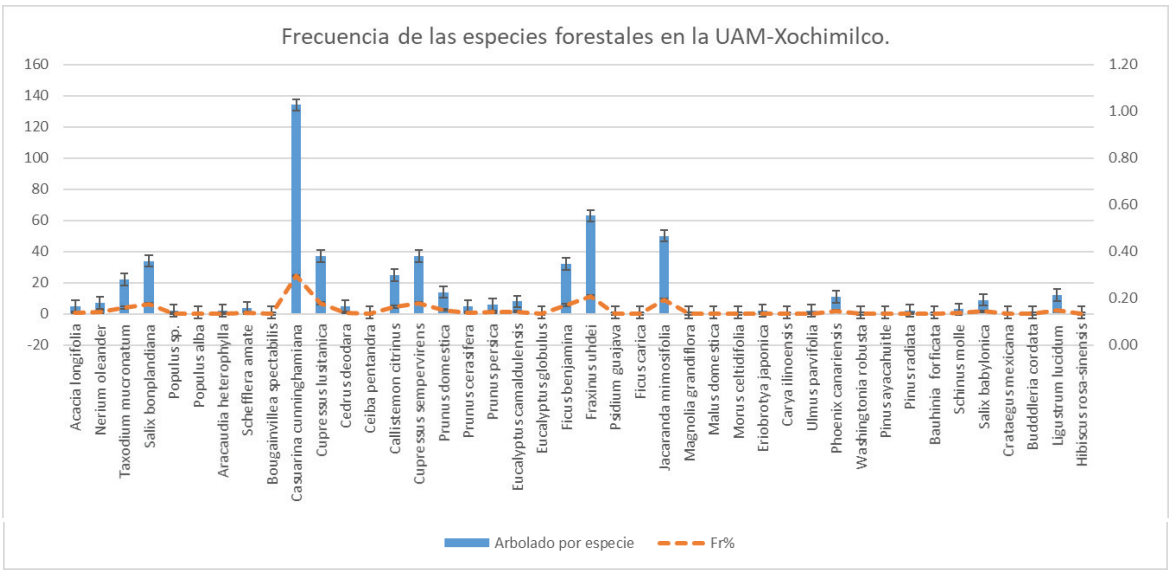
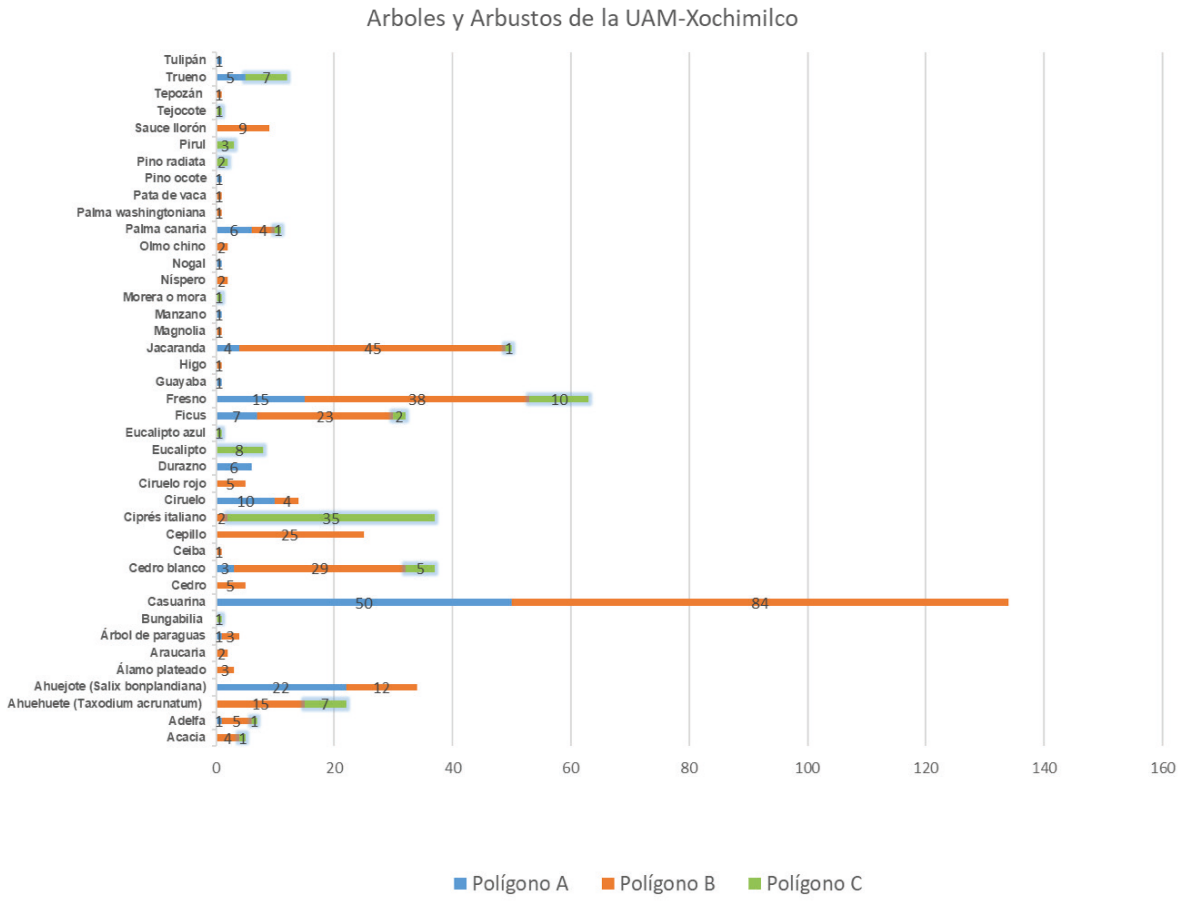



Figure 2. Frequency of forest species at the Universidad Autónoma Metropolitana-Xochimilco. elaboration




Distribution of trees and shrubs in the polygons of the study area.
Own elaboration.

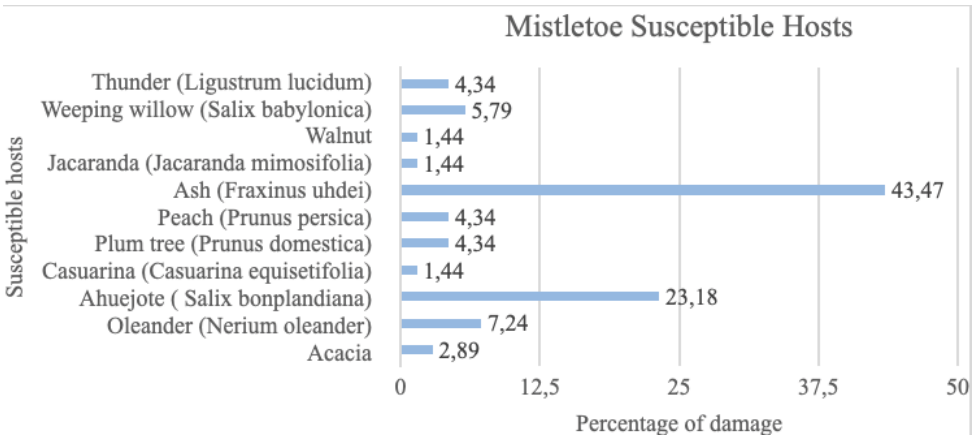



Figure 4. Hosts most infested by true mistletoe.

Own elaboration.

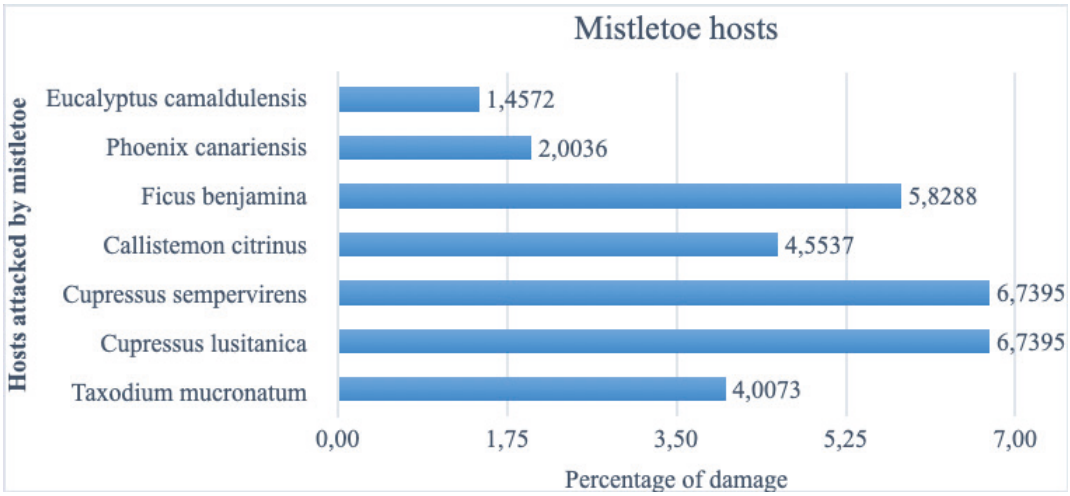



Figure 5. Hosts less infested by true mistletoe.

Own elaboration

*thanthus quercicola* (Schltdl. & Cham.) Blume and *Cladocolea loniceroides*; casuarina is more prone to both mistletoe and *Cuscuta corymbosa* Ruiz & Pav.; peach, plum and tejocote are affected by *Phoradendron velutinum* (DC.) Oliv.; red ahuejote, white ahuejote and American poplar are susceptible to both *S. quercicola* and *C. loniceroides*.

For their part, Zaragoza-Hernández *et al.* (2015), in their study on the identification of damage to trees in three parks in Mexico City, calculated that 83 out of every 100 trees in the city could be infested by parasitic plants of the genera *Cladocolea* and *Struthanthus* and that at least 53 % of them would have a severe level of damage. This is aggravated when considering that, of the 68 most common tree species in green areas of Mexico City, 95% are susceptible to colonization by some type of mistletoe. It is important to note that these mistletoe genera are also frequent in the UAM-Xochimilco trees. Alvarado-Rosales and Saavedra-Romero (2005) found that in our country the *Cladocolea* genus has at least 19 species that mainly affect broadleaved trees, although they can also occur in conifers, with the *Salix* genus being one of the most severely affected. The mistletoe genera *Cladocolea* and *Struthanthus* were also found in the trees at UAM-Xochimilco, the former infesting the genus *Salix*.

The main genus of mistletoe identified was *Cladocolea,* which was found in most of the trees (66); *Cladocolea loniceroides* caused the most damage (96 %), infesting tree species such as ash (*Fraxinus uhdei*), peach (*Prunus persica*), thunder (*Ligustrum lucidum*), poplar (*Populus alba* L.), ahuejote *(Salix bonplandiana*), oleander *(Nerium oleander*), plum *(Prunus domestica*) and acacia *(Acacia longifolia* (Andrews) Willd.). The genus *Struthanthus* sp. was also found to affect jacaranda and casuarina with 3%, while *Phoradendron* sp. infested trueno, jacaranda and walnut with 1%, as shown in Table 2. The affectation by *Cladocolea* coincides with that recorded by Alvarado-Rosales and Saavedra-Romero (2005), who mention ahuejotes (*Salix bonplandiana*) as host trees.

| Genus or species | Number of trees | % |
|---|---|---|
| Cladocolea loniceroides | 66 | 96 |
| *Phoradendron* sp. | 1 | 1 |
| *Struthanthus* sp. | 2 | 3 |
| **Total** | **69** | **100** |

Genus or species of true mistletoe infesting trees at UAM-X.

Own elaboration.

Arriola *et al*. (2013) identified *Cladocolea loniceroides, Phoradendron velutinum* and *Struthanthus interruptus* (Kunth) G. Don in seven delegations, from 17 hosts belonging to 10 botanical families, where the first true mistletoe species infested ash (*Fraxinus udhei*), thunder (*Ligustrum lucidum*), ahuejote *(Salix bonplandiana*); while *Struthanthus* sp. infected Casuarina *(Casuarina equisetifolia)* and ash (*Fraxinus udhei*), among others. These mistletoe genera coincide with those found in some hosts at UAM-Xochimilco.

Días-Limón et al 2016, found mistletoe species in the Tlalpan Forest in Mexico City, determined the level of infection and susceptibility of different tree species to mistletoe parasitism in 20 randomly distributed sites in the study area. They determined that the most widely distributed species was *Cladocolea loniceroides* in 17 of the 20 sites. At least seven tree species were susceptible to mistletoe infection. *Phoradendron brachystachyum* was found at only four sites and only one species was susceptible to its infection. The most abundant tree species of larger sizes (height and crown length) was ash (*Fraxinus uhdei*). These genera of true mistletoe are found infesting different hosts in the different green areas of Mexico City, particularly UAM--X.

The majority of the vegetation in the study area was free of true mistletoe infestation at 87%. On the other hand, tree infestation levels ranged from 3.6 % to 1.8 % (Table 3). These results show that the presence of mistletoe at UAM-X is not alarming; in fact, less than 5 % of the trees are severely and very severely infested.

| # | Mistletoe infestation category | Tree | Percentage (%) |
|---|---|---|---|
| 1 | No | 479 | 87.25 |
| 2 | Incipient Infestation | 20 | 3.64 |
| 3 | Moderate infestation | 18 | 3.28 |
| 4 | Regular Infestation | 11 | 2.00 |
| 5 | Severe Infestation | 11 | 2.00 |
| 6 | Very Severe Infestation | 10 | 1.82 |
| | Total | 549 | |

Degrees of infestation caused by true mistletoe at UAM-Xochimilco.

Own elaboration

In this regard, Alvarado (2021), in his work on Damage to trees and impact of mistletoe in urban green areas, evaluated 4,775 trees in 16 green areas in eight municipalities of Mexico City. Of the trees evaluated, 3,318 showed damage. For damage type 1, Cladocolea and Struthanthus mistletoe had an average incidence of 42%. For type 2, 20 agents were identified and for type 3, 11 were identified. The tree genera affected were Ulmus and Populus.

Cladocolea was found towards the south and Struthanthus in the north. Based on these results, it is evident that there is less infestation in the trees of UAM-Xochimilco, but it is necessary to consider the small surface and number of trees and shrubs of this University.

Martínez-Castruita *et al.* (2021) evaluated 4,154 individuals in Parque Rodolfo Landeros Gallegos in the city of Aguascalientes, of which 2,343 were affected by mistletoe, equivalent to an infestation incidence of more than 56 %. The low percentage of infestation in the trees at UAM-Xochimilco is apparently due to the fact that this university has personnel specialized in gardening and professionals who are technically involved in the management of its vegetation.

The observed and expected frequencies corresponding to the cross-factors of true mistletoe and zone type corresponding to the main part of the contingency analysis (Table 4). Based on this information, the differences between observed and expected frequencies in some cases were notable.

| | Zone A | Zone B | Zone C | Total |
|---|---|---|---|---|
| Presence | 28 (16.87)* | 34 (41.17) | 7 (10.95) | 69 |
| Absence | 106 (117.13) | 293 (285.83) | 80 (76.05) | 479 |
| Total | 134 | 327 | 87 | 548 |

Table 4. Observed and expected frequencies for the cross factors true mistletoe and zone.

*Expected frequencies

Own elaboration

The contingency analysis resulted in a test statistic of 11.46 with a corresponding p-value of 0.003248, so the hypothesis of equal proportions among the three zones is rejected at a significance level of 0.05 and it is concluded that the proportion of trees with mistletoe is not the same in zones A, B and C. This situation is shown in Figure 6, which shows that the rectangles of the six cells resulting from the crossed factors presented different areas, in particular the "presence-B" and "presence--C" cells were notably different.

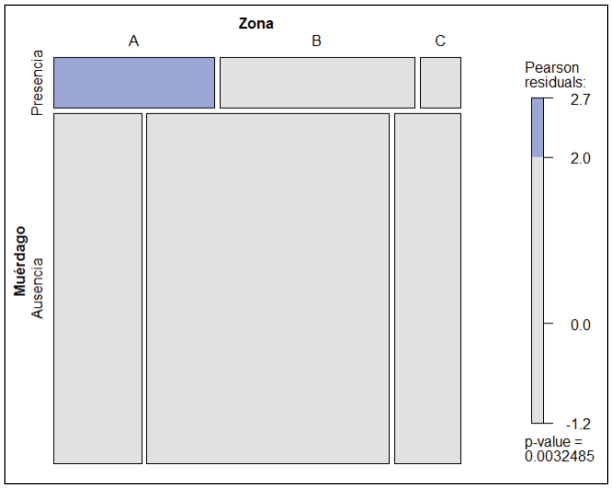



Figure 6. Association between the mistletoe and zone factors in the contingency analysis. The area of each rectangle is proportional to the resulting count in each cell of the cross-classification.

The analysis of the Pearson residuals determined that the cell "presence of mistletoe in zone A" contributed 64 % to the test statistic; a fact evidenced by a Pearson residual 2.7, marked in deep blue in Figure 6.

## CONCLUSIONS

From the census it was determined that the most abundant tree species in the study area were: Casuarina *(Casuarina equisetifolia*) and Ash (*Fraxinus uhdei*), which have been the most used in reforestation programs in other green areas of Mexico City.

The percentage of infestation caused by true mistletoe was low at 13%, where the species most susceptible to this parasitic plant were ash (*Fraxinus uhdei*), Casuarina *(Casuarina equisetifolia*) and ahuejote *(Salix bonplandiana*).

The main genus of mistletoe identified was *Cladocolea,* which was found in most of the trees, with the species *Cladocolea loniceroides* causing the most damage. However, the genera *Phoradendron* and *Struthanthus* were also identified.

The proportion of trees with mistletoe is not the same in zones A, B and C, in particular zones B and C were notably different. Zone B stands out with the highest relative frequency, amounting to 50%.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

## CONTRIBUTION BY AUTHOR

José Francisco Reséndiz Martínez: Establishment of the methodology, field data recording and writing of the manuscript; Héctor Omar Tapia Martínez: field sampling, elaboration of tables and figures. Efraín Bautista Velasco: statistical analysis; Victor Javier Arriola Padilla: revision and correction of the manuscript and Georgel Moctezuma López: final revision, formatting and management.

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