Diversity, composition, distribution and similarity of hemiparasites (Loranthaceae and Santalaceae) in the Brazilian Amazon

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Abstract: The occurrence of hemiparasites in an urban environment is a relevant factor to be monitored, because in imbalance, it compromises the architecture of trees and, because it proliferates easily, can compromise the entire afforestation program. In view of the above, the objective of this research was to perform analyses of hemiparasites (Loranthaceae and Santalaceae) occurring in the urban afforestation of the municipality of Macapá (AP), as well as in the natural ecosystems of the states that make up the Brazilian Amazon. The inventory of tree species was determined in arboreal individuals with ≥ 5 cm diameter at breast height (DBH) and ≥1.30 m in height present in the afforestation of roads and public places in three neighborhoods (Jesus de Nazaré, Centro and Santa Inês) located in the city of Macapá, AP, Brazil. The similarity between environments (hemiparasites and tree species and hemiparasites and infested neighborhoods) was achieved using the Jaccard test. To analyze the similarity between the states that make up the legal Amazon, a survey of the existence of hemiparasites deposited in local herbaria and the occurrence data obtained from the literature review was carried out. Thus, nine bibliographic references were selected. For similarity analysis and multiple correspondence analysis, R software was used, and the Kernel Diagram was used to estimate the density of hemiparasite infestation. The Brazilian Amazon has 107 species of hemiparasites and, of these, the states of AM, PA and MT and the states of MA and TO have the greatest similarities between them. Andira inermis (W. Wright) Kunth ex DC., Ficus benjamina L., Terminalia catappa L. are the main host species of Passovia pedunculata (Jacq.), the main hemiparasite of the urban afforestation of Macapá (AP). The hemiparasites Oryctanthus florulentus (Rich.) Tiegh. and Psittacanthus acinarius (Mart.) Mart. exclusively infest Andira inermis in the urban afforestation of Macapá (AP). The distribution of the aggregated hemiparasites is probably directly related to the phylogenetic and ecological affinity and to the distribution of the hosts in the squares of Macapá (AP).

Palavras-chave: Urban afforestation, Birdweed, Hemiparasite.

1. Introduction

Urban afforestation brings numerous benefits to cities due to its aesthetic, ecological, physical and psychic values to man. However, there are a number of factors that affect the good performance of afforestation, since often the trees that are part of the landscape of cities are subject to some type of environmental stress due to the adverse conditions of the urban environment.

The occurrence of hemiparasites in an urban environment is a relevant factor to be monitored, because in imbalance, it compromises the architecture of trees and, because it proliferates easily, can compromise an entire afforestation program, a fact already pointed out by Rotta in (2001).

These plants attach themselves to the branches and trunks of the host plant, where they develop and occupy parts, or in some cases, the entirety of the canopy, reducing the photosynthetic efficiency of the host. Trees with a high degree of birdweed infestation are more predisposed to insect attack and more susceptible to environmental stress than healthy individuals of the same species. (Tattar, 1978; Norton; Carpenter, 1998; Cazetta; Galetti, 2003; Arruda, 2004; White, 2010).

According to studies by Der & Nickrent, 2008, the hemiparasitic species of Loranthaceae constitute the most expressive group of parasitic plants in the world flora, being photosynthesizing plants that obtain water and mineral salts from the host's xylem via the haustorial system. They are perennial plants that attach themselves to the branches and trunks of the host plant, developing vigorously and occupying parts or almost all the crown of a knotty stem formed by swollen nodes, simple, fleshy, green leaves, generally opposite, sometimes verticillate or alternate, and rarely tapering (Joly 1985).

An important factor to be addressed is the dispersal of this species. Haigh and Martinez Del Rio et al (1996) evaluated that this process has a high correlation with dispersing birds, influencing the population control aspect, as well as the floristic composition of a given species region. After regurgitation or defecation, the released seeds adhere to the branches of the host plants because they have a layer of mucilaginous substance (Cazetta & Galetti, 2007).

In Brazil, especially in the Amazon, little is known about the interaction between bird herbs and their hosts, since studies have been predominantly on anatomy and embryology. In a recent publication by Soares et. al. (2021), the researchers report that the city of Macapá, State of Amapá, has a high rate of infestation by birdweed (hemiparasites), reaching an infestation percentage of more than 40% of individuals established in central neighborhoods of the city. This pattern is similar to other major cities in the Amazon region (Manaus and Belém) and may be due to the planting of exotic species, as suggested for other locations (Gairola et al., 2013; Diáz-Limón et al., 2016).

In view of the above, the objective of this research was to perform analyses of the hemiparasites (Loranthaceae and Santalaceae) occurring in the urban afforestation of the municipality of Macapá (AP), as well as in the natural ecosystems of the states that make up the Brazilian Amazon, aiming to answer the following questions: i) What is the diversity and similarity of hemiparasites between the states of the Brazilian Amazon; ii) What are the main hosts and hemiparasites in urban afforestation in Macapá? iii) Is there specificity between hosts and hemiparasites? iv) Is the distribution of hemiparasites associated with the diversity, composition and distribution of urban afforestation?

2. Materials and Methods

2.1. Study area

The study was conducted for primary data in the municipality of Macapá (Figure 1), which has an area of 6,562.4 km², due to the complexity of working in the area of the city. Although Macapá is in the Amazon, it is one of the least forested cities in Brazil. For secondary data, information from urban areas of all states of the Brazilian Amazon was organized.

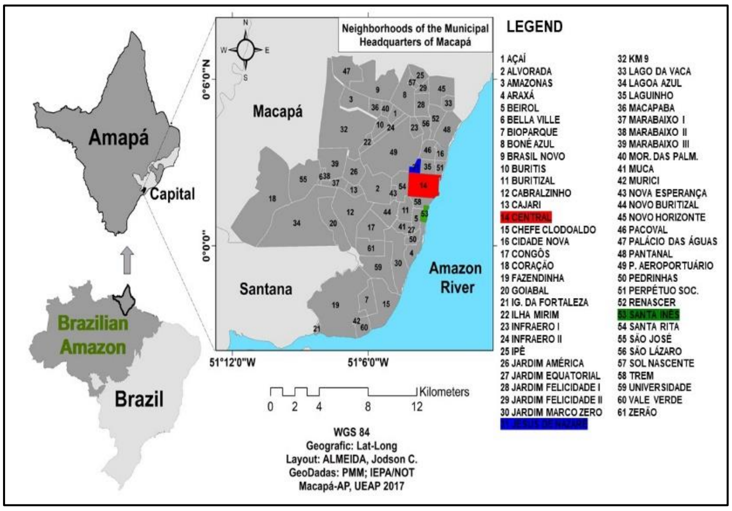

Figure 1. Neighborhoods of Macapá, Amapá, Brazil.

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2.2. Species Inventory

An inventory of tree species and hemiparasites (bird weeds) was carried out in all trees with ≥ diameter at breast height (DBH) and ≥1.3m in height present in the afforestation of roads and public places in three neighborhoods (Jesus de Nazaré, Centro and Santa Inês) of Macapá, Amapá, Brazil. The collection, herborization and listing of the exsiccates of the inventoried individuals followed procedures recommended by Fidalgo and Bononi (1989). Then, they were identified with the help of specialized literature and the support of specialists, comparison with materials deposited in the Herbarium of Amapá (HAMAB) and consultations in the online herbariums. The spelling of the scientific names of plants was confirmed on the website of Flora and Funga of Brazil (http://floradobrasil.jbrj.gov.br/) and Cantuária et al. (2022).

2.3. Experimetal design and statistical analysis

The analysis of variance was performed in a completely randomized block design and confirmed by the application of the f Test and, in case of significant f, the means were compared by the Tukey test at 5% probability Software R (R® Core Team, 2017). The similarity between environments (hemiparasites and tree species and hemiparasites and infested neighborhoods) was achieved using the Jaccard test (SJ) that aimed to analyze the similarity and similarity between the environments, used for the analysis of clusters, by the method of unweighted arithmetic means (UPGMA). The calculations were performed on the R platform (R Core Team, 2017), using the Spatstat package (Baddeley, Turner, 2005).

2.4. Literature Review for Comparison of Similarity

Initially, to analyze the similarity between the states that make up the legal Amazon, a survey was carried out on the existence of hemiparasites deposited in local herbaria and on occurrence data obtained from the review of specialized literature. The data found in this survey were selected with the aim of standardizing information and were systematized in an electronic spreadsheet, according to the occurrence. Thus, the following references were selected: Barbosa (2011), Silva (2012), Silva and Fadini (2017), Barbosa and Liesenfeld (2018), Flora do Brasil, (2020), Franco et al., (2020), Gomes & Ximenes (2020) and Dettke and Caires (2021), Soares (2022).

To verify the correspondence between the occurrence of hemiparasites and the affected host species, the field collection data were compiled in an electronic spreadsheet, classifying the hemiparasite species up to the genus level and the host plant species up to the family level, the latter being identified according to origin.

For the geostatistical analysis of the spatial pattern of hemiparasite occurrence, the Kernel density was applied, a non-parametric statistical method that produces a smoothed cumulative density function (Levine, 2002). The geographic coordinates, in decimal degrees and in the SIRGAS 2000 datum, were obtained from the SIRGAS 2000 datum, from the collection points of the hemiparasites and hosts inventoried in the initial study, where it was not necessary to carry out the collection.

2.5. Data Preparation and Analysis

Based on the bibliographic references, a list of 106 species was prepared of hemiparasitic plants with confirmed occurrence for the Amazon, this list of species was then converted into a presence/absence matrix, used for cluster analysis by the Jaccard method.

The field collections identified 4 (four) species of hemiparasites and 14 (fourteen) host species that were botanically classified, with each classification being considered a categorical variable for the purposes of analysis of the multiple correspondence analysis.

The geographic coordinates of the occurrences were compiled in electronic spreadsheets in excel format and transformed into a shapefile using the Convert Coordinate Notation function of the Data Management Tools tool of the ArcGis software, version 10.8.

2.5. Simple Cluster Analysis

For the multivariate analysis of similarity of the existence of hemiparasites in the Amazon, the technique of cluster analysis by similarity was applied, considering the presence and absence. To this end, the Jaccard index was used, also known as Jaccard's similarity coefficient (Jaccard, 1912), a statistic used to measure the similarity and diversity of sets of samples, indicating the proportion of species shared between two samples in relation to the total number of species.

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From the binary matrix created in the study, representing the presence/absence of hemiparasite species in each state, the similarity matrix obtained by calculating Jaccard's community coefficient was used. In the preparation of the dendrogram, the complete ligation method was used, which has the function of finding similar clusters.

A binary data matrix (107 species x 9 states) was considered, in which the intersection of the rows and columns indicated the value of presence of each species, which, by convention, designates 1 = present species and 0 = absent species. Each row and column of the X matrix were described, respectively, a species vector (X107) and a state vector (X9).

To compare the species between the states, cluster analysis was performed using the complete linkage method (also called the furthest neighbor method), as well as the calculation of the Jaccard coefficient (Jaccard, 1912, Souza et al., 1997) as a measure of similarity. The Jaccard community coefficient has a value of 1 if the samples are identical and a value of 0 if they are completely different.

With the data from this coefficient, the similarity matrix S of dimension 09 x 09 was constructed. For the delimitation of the groups, the complete linking method was used, with this method the distance between two clusters is the maximum distance between an observation in one cluster and an observation in the other cluster.

With the similarity matrix, the cluster hierarchy analysis was calculated by the R's Hcluster function. This function performs hierarchical cluster analysis using a set of dissimilarities for the "n" objects being grouped. Initially, each object is assigned its own cluster, and then the algorithm proceeds iteratively, at each stage joining the two most similar clusters, continuing until there is only a single cluster. At each stage, the distances between clusters are recalculated by the Lance-Williams dissimilarity update formula according to the clustering method of the farthest neighbor (R Core Team, 2021).

For the analyses of this topic, the factoextra and vegan packages of the R program were used (Oksanen et. al., 2020; Kassambara & Mundt, 2020; R Core Team, 2021).

Analisar, igualmente, as principais teorias de estado, especialmente as formuladas por Thomas Hobbes (1979), na obra O Leviatã de 1651; Montesquieu (1995), em ***Do Espírito das Leis*** de 1748; e Marx & Engels (1979a) em ***A origem da Família, da Propriedade Privada e do Estado*** de 1884, cuja correta interpretação nos ajudará a compreender as distintas manifestações da sociedade e dos governos nas relações sociais.

2.6. Multiple Match Analysis

In the second analysis, we sought to explore the joint relationships between the occurrence of hemiparasites and the host species through multiple correspondence analysis.

Correspondence Analysis is an exploratory multivariate analysis technique, developed for the study of the relationship between qualitative variables, which aims to geometrically arrange the variables, their categories and the objects observed in the database in a space of reduced dimensions, so that the proximity in space indicates a certain association or similarity between the rows and columns (Clausen, 1998; Greenacre, 2010). The relationship between the categories of variables is investigated without the designation of a causal structure being primary, nor without previously assuming a distribution of probabilities, being appropriate in population studies along the lines of a non-inferential technique (Greenacre, 1981; Mota, 2007).

For Simple Correspondence Analysis (SCA), the application is made in two-entry tables, where the categories of a variable are represented in the rows, the categories of another variable in the columns, and the observed frequencies of objects or individuals in the cells. For Multiple Correspondence Analysis (MCA), the analyses are performed based on multidimensional tables, where the rows represent the observations, and the columns represent the different categories of different variables (Greenacre, 2007; Le Roux & Rouanet, 2010).

Thus, the data obtained in the field (occurrence of hemiparasites versus host) and the literature review were compiled into a matrix, and then the botanical classification of the individuals was carried out, with the row represented by each occurrence and the column by each botanical classification.

Considering the nature of the data (categorical) and the existence of many variables (hemiparasite species, hemiparasite genus, host plant family, and host plant species), we opted for the use of MCA. For its generation, the packages FactoMineR 2.4 (Lê et. al., 2008) and factoextra 1.0.7 (Kassambara & Mundt, 2020) were used through the free software R version 4.1.0 (R Core Team, 2021).

In order to obtain the planes that represent the configuration of the categories of the variables in space, a set of factorial axes was calculated, maximizing a portion of the data variability in each one. The set of these axes defined the multidimensional space using a perceptible dimension of two axes to analyze the position of the points in space, generating a Biplot graph.

Thus, by means of a graphical representation of the MCA, the positions of the categories of each variable in the multidimensional plane can be interpreted as associations (Pereira, 1999; Mota, 2007). In order to determine the importance of each category of variable in the construction of the axes, measured through the relative contribution, a graph was generated with the percentage of contributions of the 15 (fifteen) most important variables. It should be noted that the relative contribution of a category measures how much of its variability is being explained by the axis (Mota, 2007).

In addition, in order to define the most important observations (relationships between species), a graph was generated with the 30 (thirty) most relevant observations. The analysis of the relative contribution of the categories, together with the observation of the position of the points on the graph, in relation to the axes, has the potential to provide the interpretation of the factors and help in the conceptual characterization of the axes.

2.7. Kernel Diagram

From the geographic coordinates of the occurrences transformed into shapefile by means of the "Convert Coordinate Notation" function, all features were converted to decimal degrees, in the SIRGAS 2000 Horizontal Datum SIRGAS 2000 Geographic Coordinate System.

Density values were calculated using the algorithm of the Kernel Density tool, "Density" function, of the "Spatial Anayst Tools" tool of ArcGIS version 10.8. The Kernel Density tool uses a cell size equal to the default value divided by four. Considering that the input features were points and that the data were stored in a geographic coordinate system and not a planar one, the distances were measured using the geodetic method.

The geodetic method makes use of the geodetic distances between features, taking into account the curvature of the spheroid and correctly handles the data of the present study. To determine the output values of the generated raster file, the density option was selected. The file was later reclassified by the quantile method into 5 (five) categories, being very low, low, medium, high and very high.

Also, for the calculation of the classes of each category, the reclassified raster file was converted to polygon. To better representation and analysis of the results of the Kernel density, a color map was generated with the plotting of the points that gave rise.

3. Results and Discussion

For the Brazilian Amazon, 107 species of hemiparasites were recorded, belonging to 14 genera and two botanical families (Loranthaceae and Santalaceae), and for the states of Amapá, Rondônia and Roraima only 22 species of hemiparasites were observed (Table 1). Loranthaceae has the highest number of genera (8) and species (68) for the Brazilian Amazon (Table 1) *Oryctanthus florulentus* (Rich.) Tiegh., *Passovia pedunculata* (Jacq.) Kuijt, *Passovia pyrifolia* (Kunth) Tiegh., *Phoradendron crassifolium* (Pohl ex DC.) Eichler and *Phoradendron piperoides* (Kunth) Trel. were the species observed in all states of the Brazilian Amazon (Table 1). The largest number of species was found in the states of Amazonas (72), Mato Grosso (55) and Pará (44) (Table 1).

In research conducted by Barbosa (2011) in the city of Itacoatiara-AM, his results were similar to those found in this research. The main genera found were *Phthirusa* and *Orcytanthus* of the Loranthaceae family, while in works cited by Leal L. Bujokas W. M. and Biondi D. (2006), the hemiparasitic plants *Tripodanthus acutifolius* (Ruiz & Pav.) were found Tiegh. and *Struthanthus marginatus* (Desr.) G.Don.

Table 1. Diversity of hemiparasites (Loranthaceae and c) in the Brazilian Amazon, Brazil.

Family	Species	AC	AM	AP	MA	MT	PA	RO	RR	TO	AF[1]	RF[1](%)
Loranthaceae	*Gaiadendron punctatum* (Ruiz & Pav.) G.Don	0	0	0	0	0	0	0	1	0	1	11,1
	Oryctanthus alveolatus (Kunth) Kuijt	1	1	1	1	1	1	1	1	0	8	88,9
	Oryctanthus florulentus (Rich.) Tiegh.	1	1	1	1	1	1	1	1	1	9	100,0
	Oryctanthus phthirusoides Rizzini	0	1	0	0	0	0	1	0	0	2	22,2
	Oryctina scabrida (Eichler) Tiegh	0	0	0	0	0	0	0	0	1	1	11,1
	Oryctina subaphylla Rizzini	0	0	0	0	0	0	0	0	1	1	11,1

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Passovia bisexualis (Rizzini) Kuijt	0	1	0	0	0	1	0	0	0	2	22,2
Passovia brasiliana Kuijt	0	1	0	0	0	0	1	0	0	2	22,2
Passovia caucana (Eichler) Caires	1	0	0	0	0	0	0	0	0	1	11,1
Passovia disjectifolia (Rizzini) Kuijt	0	1	0	0	0	1	0	1	0	3	33,3
Passovia lobaterae (G.Ferrari ex Rizzini) Caires	0	1	0	0	0	1	1	1	0	4	44,4
Passovia micrantha (Eichler) Tiegh.	0	1	0	1	0	1	0	1	0	4	44,4
Passovia murcaei (Rizzini) Caires	0	1	0	0	0	0	0	0	0	1	11,1
Passovia murcaei (Rizzini) Caires	0	1	0	0	0	0	0	0	0	1	11,1
Passovia myrsinites (Eichler) Tiegh.	0	1	1	0	0	1	0	0	0	3	33,3
Passovia ovata (Pohl ex DC.) Tiegh.	0	0	0	0	0	0	0	0	1	1	11,1
Passovia pedunculata (Jacq.) Kuijt	0	1	1	1	1	1	1	1	1	8	88,9
Passovia pycnostachya (Eichler) Tiegh.	0	1	1	0	0	0	0	0	0	2	22,2
Passovia pyrifolia (Kunth) Tiegh.	1	1	1	1	1	1	1	1	1	9	100,0
Passovia rufa (Mart.) Tiegh.	0	1	1	0	0	1	0	0	0	3	33,3
Passovia santaremensis (Eichler) Tiegh.	0	1	0	0	0	1	0	1	0	3	33,3
Passovia stenophylla (Eichler) Tiegh.	0	1	0	0	0	0	0	0	0	1	11,1
Passovia theloneura (Eichler) Tiegh.	0	0	0	0	1	1	0	0	0	2	22,2
Peristethium polystachyum (Ruiz & Pav.) Kuijt	1	1	0	0	0	0	0	0	0	2	22,2
Peristethium reticulatum (Rizzini) Caires	0	0	1	0	1	1	1	0	0	4	44,4
Peristethium tortistylum (Kuijt) Kuijt	1	0	0	0	0	0	0	0	0	1	11,1
Psittacanthus acinarius (Mart.) Mart.	0	1	1	0	1	1	1	1	1	7	77,8
Psittacanthus amazonicus (Ule) Kuijt	1	0	0	0	0	0	0	0	0	1	11,1
Psittacanthus atrolineatus Kuijt	0	0	0	0	0	0	1	0	0	1	11,1
Psittacanthus biternatus (Hoffmanns.) G.Don	0	1	1	0	1	1	1	0	1	6	66,7
Psittacanthus brachynema Eichler	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus cinctus (Mart.) Mart.	0	1	0	0	0	1	1	0	1	4	44,4
Psittacanthus clusiifolius Willd. ex Eichler	1	1	0	0	0	0	0	1	0	3	33,3
Psittacanthus cordatus (Hoffmanns.) G.Don	0	1	0	0	0	1	1	0	1	4	44,4
Psittacanthus crassifolius (Mart.) Mart.	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus cucullaris (Lam.) G.Don	1	1	1	1	0	1	0	0	1	7	66,7
Psittacanthus dentatus Kuijt	0	0	0	0	1	1	0	0	0	2	22,2
Psittacanthus elegans Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus eucalyptifolius (Kunth) G.Don	1	1	1	1	0	1	0	0	1	7	66,7
Psittacanthus geniculatus Kuijt	1	0	0	0	0	0	0	0	0	1	11,1
Psittacanthus grandifolius (Mart.) Mart.	0	1	0	0	0	1	0	0	0	2	22,2
Psittacanthus irwinii Rizzini	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus lamprophyllus Eichler	1	1	1	0	1	1	1	0	0	6	66,7
Psittacanthus montis-neblinae Rizzini	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus nodosissimus Rizzini	0	1	0	0	0	1	0	0	0	2	22,2
Psittacanthus ovatus Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus peculiaris A.C.Sm.	0	1	0	0	0	0	0	0	0	1	11,1
Psittacanthus peronopetalus Eichler	1	1	1	0	1	1	1	0	0	6	66,7

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	Psittacanthus plagiophyllus Eichler	0	1	1	0	1	1	1	1	0	6	66,7
	Psittacanthus robustus (Mart.) Mart.	1	1	1	1	1	1	0	0	1	7	77,8
	Struthanthus concinnus (Mart.) Mart.	1	0	0	0	1	0	0	0	1	3	33,3
	Struthanthus flexicaulis (Mart.) Mart.	0	0	0	0	0	0	0	0	1	1	11,1
	Struthanthus gracilis (Gleason) Steyerm. & Maguire	0	0	0	0	0	0	0	1	0	1	11,1
	Struthanthus marginatus (Desr.) G.Don	0	1	0	1	1	1	0	0	0	4	44,4
	Struthanthus meridionalis Kuijt	0	0	0	0	1	0	0	0	0	1	11,1
	Struthanthus ophiostylus Kuijt	1	0	0	0	0	0	0	0	0	1	11,1
	Struthanthus orbicularis (Kunth) Eichler	0	1	1	0	1	1	0	0	0	4	44,4
	Struthanthus phillyreoides (Kunth) G.Don	1	0	0	0	0	0	0	1	0	2	22,2
	Struthanthus polyanthus (Mart.) Mart.	0	0	0	0	1	0	0	0	1	2	22,2
	Struthanthus prancei Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
	Struthanthus rubens (Mart.) Mart.	0	1	0	0	0	0	0	0	0	1	11,1
	Struthanthus staphylinus (Mart.) Mart.	0	1	0	0	0	0	0	0	0	1	11,1
	Struthanthus syringifolius (Mart.) Mart.	1	1	0	0	1	0	0	0	0	3	33,3
	Struthanthus uraguensis (Hook. & Arn.) G.Don	0	0	0	0	1	0	0	0	0	1	11,1
	Tripodanthus acutifolius (Ruiz & Pav.) Tiegh.	0	0	0	0	1	0	0	0	0	1	11,1
	Acanthosyris annonagustata C.Ulloa & P.Jørg.	1	0	0	0	0	0	0	0	0	1	11,1
	Antidaphne amazonensis Rizzini	0	1	0	0	0	1	0	0	0	2	22,2
	Antidaphne viscoidea Poepp. & Endl.	0	0	0	0	0	1	0	0	0	1	11,1
Santalaceae	*Dendrophthora elliptica* (Gardner) Krug & Urb.	0	1	0	0	0	0	0	1	0	2	22,2
	Dendrophthora warmingii (Eichler) Kuijt	0	1	1	0	1	1	1	0	1	7	66,7
	Phoradendron bathyoryctum Eichler	0	1	0	1	0	1	0	0	1	4	44,4
	Phoradendron berteroanum (DC.) Griseb.	1	0	0	0	0	0	0	0	0	1	11,1
	Phoradendron bicarinatum Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
	Phoradendron caripense Eichler	0	1	0	0	1	1	0	0	0	3	33,3
	Phoradendron congestum Trel.	0	1	0	0	1	1	0	0	0	3	33,3
	Phoradendron coriaceum Mart. ex Eichler	0	1	0	0	1	0	0	0	0	2	22,2
	Phoradendron craspedophyllum Eichler	0	0	0	0	0	1	0	0	0	1	11,1
	Phoradendron crassifolium (Pohl ex DC.) Eichler	1	1	1	1	1	1	1	1	1	9	100,0
	Phoradendron diminutivum E.A. Kellogg	0	1	0	0	0	0	0	0	0	1	11,1
	Phoradendron dipterum Eichler	0	0	0	0	1	1	0	0	1	2	33,3
	Phoradendron ensifolium (Pohl ex DC.) Eichler	0	0	0	0	1	1	0	0	0	2	22,2
	Phoradendron herbert-smithii Trel.	1	0	0	0	0	0	0	0	0	1	11,1
	Phoradendron hexastichum (DC.) Griseb.	0	1	0	0	0	0	0	1	1	3	33,3
	Phoradendron inaequidentatum Rusby	0	1	0	0	1	1	1	0	0	4	44,4
	Phoradendron juruanum Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
	Phoradendron krukovii Kuijt	0	1	0	0	0	0	0	0	0	1	11,1
	Phoradendron laxiflorum Ule	0	1	0	0	0	0	0	0	0	1	11,1
	Phoradendron mucronatum (DC.) Krug & Urb.	0	1	0	1	1	1	0	0	1	5	55,6
	Phoradendron northropiae Urb.	0	0	0	1	1	1	0	0	0	3	33,3

Phoradendron obtusissimum (Miq.) Eichler	1	1	0	1	1	1	1	1	1	8	88,9
Phoradendron oliveirae Kuijt	0	0	0	0	0	1	0	0	0	1	11,1
Phoradendron pellucidulum Eichler	1	1	1	0	1	1	0	1	0	6	66,7
Phoradendron perrottetii (DC.) Eichler	0	1	0	1	1	1	0	1	1	6	66,7
Phoradendron piperoides (Kunth) Trel.	1	1	1	1	1	1	1	1	1	9	100,0
Phoradendron platycaulon Eichler	0	1	0	0	1	1	1	1	0	5	55,6
Phoradendron poeppigii (Tiegh.) Kuijt	1	1	0	0	0	1	0	0	0	3	33,3
Phoradendron pteroneuron Eichler	0	1	1	0	1	1	0	0	0	4	44,4
Phoradendron quadrangulare (Kunth) Griseb.	0	1	0	1	0	1	0	0	1	4	44,4
Phoradendron racemosum (Aubl.) Krug & Urb.	1	1	1	0	1	1	1	0	1	7	77,8
Phoradendron singulare Kuijt	0	0	0	0	0	1	0	0	0	1	11,1
Phoradendron strongyloclados Eichler	0	1	1	1	1	1	0	0	1	6	66,7
Phoradendron tunaeforme (DC.) Eichler	0	1	0	0	0	1	0	0	0	2	22,2
Phoradendron undulatum (Pohl ex DC.) Eichler	0	1	0	0	1	1	0	1	0	4	44,4
Thesium aphyllum Mart. ex A. DC.	0	0	0	0	1	0	0	0	0	4	11,1
AF[2]	29	72	24	18	44	55	24	24	28	107	
RF[2]	27	67	22	17	41	51	22	22	26		100

Adapted of: Flora do Brasil (2020), Barbosa (2011), Dados da pesquisa, Barbosa e Liesenfeld (2018), Silva (2012), Gomes e Ximenes (2020), Silva e Fadini (2017), Dettke e Caires (2021), Franco et al., (2020). Legenda: AC – Acre, AM – Amazonas, AP – Amapá, MA – Maranhão, MT – Mato Grosso, PA – Pará, RO – Rondônia, RR – Roraima, TO – Tocantins, AF1 – Absolut Frequency in Amazon, AF2 – Absolut Frequency in States, RF1 – Relative Frequency in Amazon and RF – Relative Frequency in States.

By means of Jaccard's Similarity, there was the formation of 5 groups for hemiparasite species (Loranthaceae and Santalaceae) among the states of the Brazilian Amazon, with Group 1 formed by the states of Amazonas, Mato Grosso and Pará, Group 2 by Tocantins and Maranhão, Group 3 by Amapá and Rondônia and, the last two groups, Group 4 and 5, by only 1 state, Acre and Roraima, respectively (Figure 2). For Groups 1 and 2, the greatest similarities are associated with geographic proximity and the same phytophysiognomies, similar to what was observed among urban tree species between the states of the Brazilian Amazon, according to Soares et al. (2021).

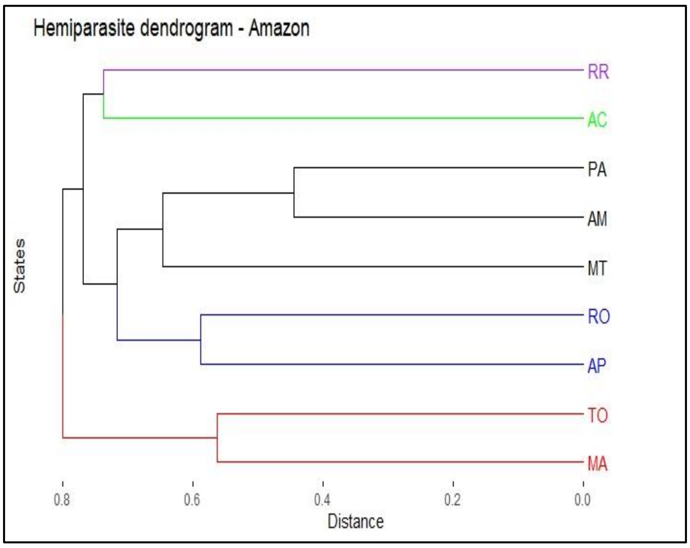

Figure 2. Jaccard similarity dendrogram for hemiparasite species (Loranthaceae and Santalaceae) between states of the Brazilian Amazon, Brazil.

In the urban afforestation of Macapá (AP), 3434 arboreal individuals were recorded, of which 2525 individuals of species infested by Loranthaceae, belonging to 10 botanical families, 21 genera and 23 families (Chart 2). Similarly, in Santarém (PA), 310 trees belonging to 10 botanical families, 19 genera, and 22 species were recorded in urban afforestation (Silva and Fadini, 2017) (Table 2).

Table 2. Hosts and their respective hemiparasites (Loranthaceae) of urban afforestation in three neighborhoods of Macapá, AP, Brazil.

Host										Hemiparasite									
Family	Species (E)	F (E)		F (INPE)		Loranthaceae		E		*O. florulentus*		*P. pedunculata*		*P. rufa*		*P. acinarius*		F (IPE)		F (IPI)	
		FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)	FA (U)	FR (%)
Arecaceae	*Roystonea oleraceae* (Jacq.) O.F. Cook	106	4,2	105	99,1	1	100	0	0	0	0	0	0	0	0	0	0	1	0,9	1	0,04
Fabaceae	*Acacia mangium* Willd.	1	0	0	0	1	100	0	0	0	0	0	0	0	0	0	0	1	100	1	0,04
Fabaceae	*Caesalpinia pluviosa* DC.	14	0,6	13	92,9	1	100	0	0	0	0	0	0	0	0	0	0	1	7,1	1	0,04
Fabaceae	*Cassia fistula* L.	14	0,6	13	92,9	1	100	0	0	0	0	0	0	0	0	0	0	1	7,1	1	0,04
Fabaceae	*Tamarindus indica L.*	1	0	0	0	0	0	1	100	0	0	1	100	0	0	0	0	1	100	1	0,04
Lauraceae	*Persea americana* L.	1	0	0	0	1	100	0	0	0	0	0	0	0	0	0	0	1	100	1	0,04
Rubiaceae	*Ixora chinensis* Lam.	1	0	0	0	0	0	1	100	0	0	1	100	0	0	0	0	1	100	1	0,04
Bignoniaceae	*Tabebuia aurea* Benth. & Hook.F ex S. Moore	76	3	74	97,4	2	100	0	0	0	0	0	0	0	0	0	0	2	2,6	2	0,08
Fabaceae	*Caesalpinia ferrea* Mart. ex Tul.	3	0,1	1	33,3	1	50	1	50	0	0	1	33,3	0	0	0	0	2	66,7	2	0,08
Fabaceae	*Senna siamea* (Lam.) HS Irwin & Barneby	5	0,2	3	60	0	0	2	100	0	0	2	40	0	0	0	0	2	40	2	0,08
Fabaceae	*Albizia lebbeck* (L.) Benth.	3	0,1	0	0	3	100	0	0	0	0	0	0	0	0	0	0	3	100	3	0,12
Fabaceae	*Cassia grandis* L.f.	16	0,6	13	81,3	3	100	0	0	0	0	0	0	0	0	0	0	3	18,8	3	0,12
Anacardiaceae	*Spondias mombin L.*	9	0,4	5	55,6	3	75	1	25	0	0	1	11,1	0	0	0	0	4	44,4	4	0,16
Myrtaceae	*Eucalyptus* x *urograndis*	6	0,2	1	16,7	5	100	0	0	0	0	0	0	0	0	0	0	5	83,3	5	0,2
Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	54	2,1	47	87	5	71,4	2	28,6	0	0	2	3,7	0	0	0	0	7	13	7	0,28
Malvaceae	*Hibiscus rosa- sinensis* L.	20	0,8	10	50	8	80	2	20	0	0	2	10	0	0	0	0	10	50	10	0,4
Chrysobalanaceae	*Moquilea tomentosa*	183	7,2	171	93,4	9	75	3	25	0	0	3	1,6	0	0	0	0	12	6,6	12	0,48
Myrtaceae	*Syzygium cumini*	29	1,1	13	44,8	12	75	5	25	0	0	3	10,3	1	3,4	0	0	16	55,2	16	0,63
Anacardiaceae	*Mangifera Indica*	1007	39,9	978	97,1	26	89,7	3	10,3	0	0	3	0,3	0	0	0	0	29	2,9	29	1,15
Myrtaceae	*Syzygium malaccense*	371	14,7	339	91,4	27	84,4	7	15,6	0	0	3	0,8	2	0,5	0	0	32	8,6	32	1,27
Combretaceae	*Terminalia catappa*	84	3,3	28	33,3	45	80,4	19	19,6	0	0	3	3,6	8	9,5	0	0	56	66,7	56	2,22
Moraceae	*Ficus benjamina*	176	7	109	61,9	57	85,1	10	14,9	0	0	10	5,7	0	0	0	0	67	38,1	67	2,65
Fabaceae	*Andira inermis*	345	13,7	189	54,8	137	87,8	19	12,2	2	0,6	15	4,3	1	0,3	1	0,3	156	45,2	156	6,18
Total	Total/Media	2525	100	2112	54	348	84,26	76	15,74	2	0,03	50	14,12	12	0,6	1	0,01	413	46	413	0,71

Legend: E – Species, F – Frequency, U – Unit, AF – Absolute frequency, RF – Relative frequency, IPE – Individuals parasitized by species, INPE – Non-parasitized individuals by species and IPI – Individuals parasitized by individuals.

The greatest diversity of infested species in the urban afforestation of Macapá (AP) was observed in the families Fabaceae (11 species), Myrtaceae (3 species) and Anacardiaceae (2 species) (Table 2). According to Silva and Fadini (2017), the families most infested by hemiparasites were also Fabaceae (8 species), Anacardiaceae (2 species), and Myrtaceae (2 species), except Bignoniaceae (4 species) and Chrysobalanaceae (2 species).

Boschetti (2020) in an arboreal-shrub survey, identified the following families with greater representativeness: Fabaceae, Oleaceae, Bignoniaceae and Myrtaceae. Data found by Soares et al., (2021) show the main families of occurrence in urban afforestation, among which the families were cited: Anacardiaceae, Fabaceae, Myrtaceae, Combrataceae, Moraceae, Chrysobalanaceae, Arecaceae, Bignoniaceae, Cycadaceae.

On the other hand, the highest frequencies of individuals in urban afforestation in Macapá (AP) were in the families Anacardiaceae (1016 individuals), Fabaceae (456 individuals) and Myrtaceae (406 individuals) (Table 2). Similarly, in Santarém (PA), the families Anacardiaceae (149 individuals) and Fabaceae (24 individuals), except Bignoniaceae (78 individuals) and Moraceae (29 individuals) (Silva & Fadini, 2017).

The highest frequencies of infested species in urban afforestation in Macapá (AP) were in *Mangifera indica* L. (1007 individuals), *Syzygium malaccense* (L.) Merr. & L.M. Perry (371 individuals), *Andira inermis.* (345 individuals), *Moquilea tomentosa* (Benth.) Fritsch. (183 individuals) and *Ficus benjamina* L. (176 individuals) (Table 2). In Santarém (PA), the species infested in the urban afforestation were also M. indica (145 individuals), F. benjamina (29 individuals) and A. inermis (10 individuals), except for *Handroanthus serratifolius* (Vahl) S. Grose (71 individuals), according to Silva and Fadini (2017).

In the urban afforestation of Macapá (AP), the infestation by species and by individual was 46.0 and 0.71%, respectively (Table 2). On the other hand, in the urban afforestation of the campus of the Federal University of Acre, Rio Branco (AC) and Santarém (PA), the percentages of plants infested by hemiparasites were lower, 17.0 and 19.3%, respectively (Maranho & Paula, 2014, Silva & Fadini, 2017). When analyzing the similarity of species in public spaces, Almeida and Rondon-Neto (2010); Parry et al., (2012) observed a similar pattern in other cities investigated, according to the authors, the greater the variety of tree species, the lower the rate of hemiparasite infestation

Albizia lebbeck (L.) Benth. (3 individuals), Acacia mangium Willd. (1 individual), Tamarindus indica L. (1 individual), Persea americana L. (1 individual) and Ixora chinensis Lam. (1 individual) showed 100% of the individuals infested by species in the urban afforestation of Macapá (AP) (Table 2). A. inermis (6.18%), F. benjamina (2.65%), Terminalia catappa L. (2.22%), S. malaccense (1.27%) and M. indica (1.15%) had the highest frequencies of hemiparasite infestation per individual (Figure 3A, 3B, 3C, 3D, and Table 2).

In the urban afforestation of the campus of the Universidade Federal do Acre (Rio Branco – AC), the largest infestations were in Samanea tubulosa (Benth.) Barneby & J.W.Grimes (57.4% of individuals), Annona muricata L. (53.8%), Spathodea campanulata P. Beauv. (23.9%), Inga marginata Willd. (23.4%), Adenanthera pavonina L. (15.4%) and Platypodium elegans Vogel (30%), according to Maranho & Paula (2014).

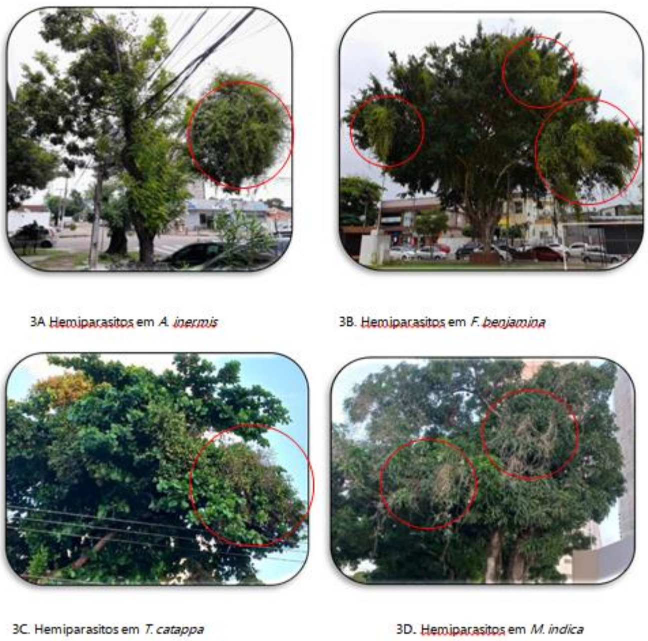

Figure 3. Trees and Hemiparasites.

Of the hemiparasites of the urban afforestation of Macapá, only 15.7% were collected and, of these, 4 species were identified with Oryctanthus florulentus, Passovia pedunculata, P. rufa and Psittacanthus acinarius,. were two new records for the state of Amapá (Figure 4 A, 4B, 4C and 4 D, Table 1 and 2). On the other hand, in Santarém (PA) and Carceres (MT), only two species, O. florulentus and Passovia theloneura and one, *Struthanthus flexicaulis* of hemiparasites (Silva & Fadini, 2017, Franco et al., 2020, Gomes and Ximenes, 2020) were observed, and the last two species did not present records for the state of Amapá (Chart 1).

Figure 4. Hemiparasites in Macapá.

All hemiparasite species, *Oryctanthus florulentus*, *Passovia pedunculata*, P. rufa and Psittacanthus acinarius were observed in Andira inermis in the urban afforestation of Macapá (AP), and O. florulentus and P. acinarius infested only the host species (Table 2). Similarly, O. florulentus and P. acinarius showed greater correspondence with Andira inermis (Figure 4). The distribution of birdweed showed an aggregate pattern, possibly related to both the aggregate spatial arrangement of hosts and may be related to dispersing agents (Figure 5).

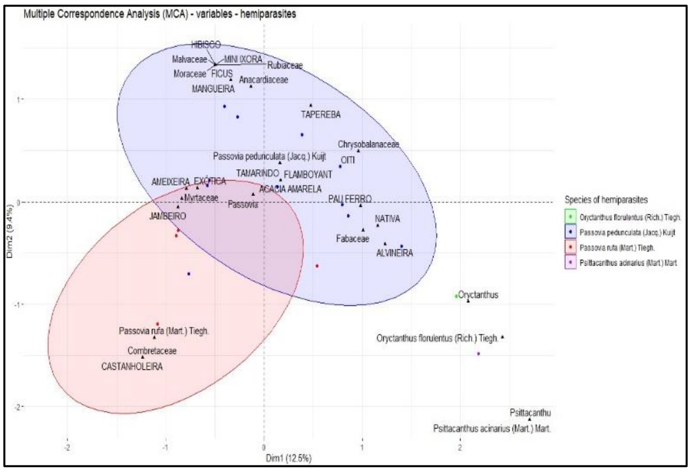

Figure 5. Multiple correspondence analysis for hemiparasites and their respective host species in the urban afforestation of Macapá, AP, Brazil.

The highest frequencies of infestation in the urban afforestation of Macapá (AP) were observed in Passovia pedunculata and P. rufa (0,6%) (Table 2).

Studies carried out by Arce-Acosta et al., 2016 Shackleton, 2016 suggest that the abundance of hemiparasites is inversely proportional to the diversity of host trees, for the authors exotic species are more susceptible to infestation than native ones and that the infestation rates may be related to the distance from vegetation fragments as well as the low richness of species identified in the square and the low frequency of native trees may be related to the amount of tree infestation.

The distribution of hemiparasites is probably directly related to the phylogenetic and ecological affinity and to the aggregate distribution of hosts in the squares of Macapá (Figure 6).

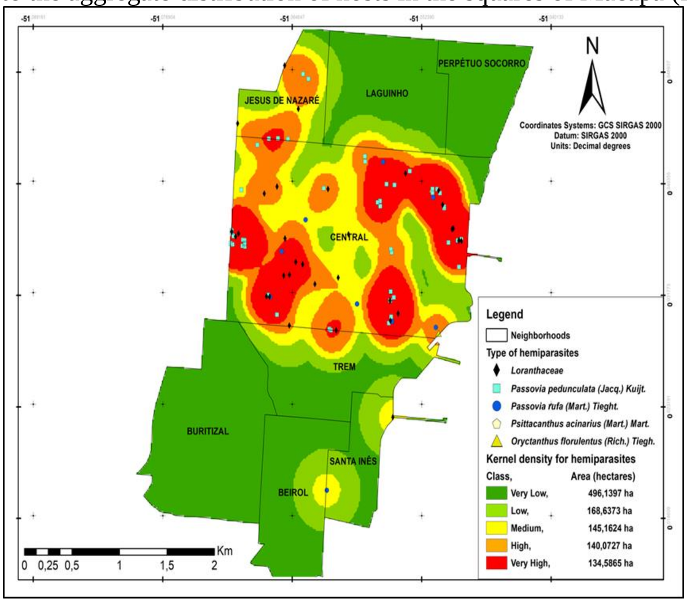

Figure 6. Kernel density map of hemiparasite and host infestations in urban afforestation of Macapá, AP, Brazil.

According to information obtained in the article published by Santos e Silva (2020), birdweeds have shown great success in establishing themselves in an urban environment and, knowing their damage to the species they parasitize, it is important to understand the distribution pattern of hemiparasites in order to minimize their impacts on urban flora, whose ecological and social role are extremely relevant.

4. Conclusion

The Brazilian Amazon has 107 species of hemiparasites and, of these, the states of AM, PA and MT and the states of MA and TO have the greatest similarities between them.

A. inermis, F. benjamina, and T. Catappa are the main host species of P. pedunculata, the main hemiparasite of urban afforestation in Macapá (AP).

The hemiparasites O. florulentus and P. acinarius exclusively infest the tree species A. inermis in the urban afforestation of Macapá (AP).

The distribution of the aggregated hemiparasites is probably directly related to the phylogenetic and ecological affinity and to the aggregate distribution of the hosts in the squares of Macapa (AP).

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References

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Arce-Acosta, I.; Suzán-Azpiri, H.; García-Rubio, O. (2016) Biotic factors associated with the spatial distribution of the mistletoe Psittacanthus calyculatus in a tropical deciduous forest of central Mexico, Botanical Sciences, v. 94, n. 1, p. 89-96.

Almeida, D. N., & Rondon-Neto, R. M. (2010). Análise da arborização urbana de três cidades da região norte do Estado do Matro Grosso. Acta Amazônica, 647-655.

Almeida, J. R., & Barbosa, C. G. (2010). Diagnóstico da arborização urbana da cidade de Cacoal-RO. Revista da Sociedade Brasileira de Arborização Urbana, 5(1), 61-81. http://dx.doi.org/10.5380/revsbau.v5i1.66239.

Arruda, R. S. (2004) Especificidade de hospedeiros por Struthanthus aff. polyanthus (Loranthaceae) em uma área de cerrado, Uberlândia, Minas Gerais. 2004. 34 f. Dissertação (Mestrado em Ecologia e Conservação de Recursos Naturais) – Universidade Federal de Uberlândia, Uberlândia.

Baddeley, Turner. (2005). Spatstat Analysing Spatial Point Patterns. Fonte: Spatstat Analysing Spatial Point Patterns: https://spatstat.org/

Barbosa, N. P. (1 de Julho de 2011). Estudo de fatores ecológicos entre ervas-de-passarinho, hospedeiros e vetores na área urbana de Itacoatiara/AM. Itacoatiara: Universidade Federal do Amazonas.

Barbosa, T. d., & Liesenfeld, M. V. (2018). Plantas hemiparasitas ocorrentes na vegetação urbana de Cruzeiro do Sul, Acre. Revista Anthesis.

Boschetti, A., C. et.al. (2020) Distribuição espacial da infestação por hemiparasitas Loranthaceae na arborização viária de Blumenau, SC. DOI: 10.5212/TerraPlural.v.14.2015070.062.

BFG [Brazil Flora Group]. (2022). Brazilian flora 2020: leveraging the power of a collaborative scientific network. Taxon 71: 178–198.

Campbell, M. J., Edwards, W., Magrach, A., Alamgir, M., Porolak, G., Mohandass, D. (2018). Edge disturbance drives liana abundance increase and alteration of liana–host tree interactions in tropical forest fragments. Ecology and Evolution, v. 8, pp. 4237–4251. https://doi.org/10.1002/ece3.3959

Cantuária, P. de C.; Medeiros, T. D. S.; Cantuária, M. F.; Soares, A. C. S.; Silva, B. M. da S. e; Almeida, S. S. M. da S. de; Krahl, A. H.; Costa-Campos, C. E.; Silva, R. B. L. (2022). Do you know the biological nomenclature? Learn the correct way to write the names of organisms. Research, Society and Development, [S. l.], v. 11, n. 3, p. e21711326378. DOI: 10.33448/rsd-v11i3.26378.

Cazetta, E.; Galetti, M. (2003.) Ecologia das ervas-de-passarinho. Ciência Hoje, v. 33, n. 194, p. 72-74.

Cazetta, E., & Galetti., M. (2007). Frugivoria e especifidade por hospedeiros na erva-de-passarinho Phoradendron rubrum (L.) Grusev (Viscaceae). Brazilian Journal of Botany, v. 30, 351-357.

Clausen S, E. (1998) Applied correspondence analysis: an introduction. Quantitative Applications in the Social Sciences Thousand Oaks, CA: Sage University Papers Series.

Dettke, G. A., & Caires, C. S. (2021). Psittacanthus (Loranthaceae) in Brazil: new occurrences, lectotypifications, new synonyms and an illustrated key. Rodriguésia Revista do Jardim Botânico do Rio de Janeiro, 1-15.

Der, J. P. Nickrent, D. L. (2008). A Molecular Phulogeny of Santalaceae (Santalales). Systematic Botany, 107-116.

Diáz-Limón, M.P.; Cano-Santana, Z.; Queijeiro-Bolaños, M.E. (2016). Mistletoe infection in an urban forest in Mexico City.Urban Forestry & Urban Greening, 17: 126-134.

Ferreira, R.L., Mota, A.C., Silva, J.A., Marangon, L.C., & Santos, E.D. (2008). Comparação de duas metodologias multivariadas no estudo de similaridade entre fragmentos de Floresta Atlântica. RevistaArvore, 32, 511-521.

Fidalgo, O., & Bononi, V. L. (1989). Técnicas de coleta, preservação e herborização de material botânico. São Paulo: Instituto de Botânica.

Flora do Brasil (2020). Jardim Botânico do Rio de Janeiro. Disponível em: < http://floradobrasil.jbrj.gov.br/ >. Acesso em: 19 jan. 2022.

Gairola, S.; Bhatt, A.; Govender, Y.; Baijnath, H.; Proches, S.; Ramdhani, S. (2013). Incidence and intensity of tree infestation by the mistletoe Erianthemumdegrei (Eckl. & Zeyh.) V.Tieghemin Durban, South Africa. Urban Forestry & Urban Greening, 12: 315-322.

Greenacre M. J. (1981). Practical Correspondence Analysis. In: Barnett V, editor. Looking at Multivariate Data New York: J. Wiley & Sons. Greenacre, M. J. (2007) Correspondence Analysis in Practice. 2 ed. Chapman & Hall/CRC.

Greenacre, M. J. (2010). Correspondence analysis Computational Statistics - Focus Article, v. 2, p.613-619, 2010.

Gomes, M.S., Ximenes, L.C. (2020) Arborização urbana de uma avenida na zona norte de Santarém, PA. Revista de Ciências Ambientais, Canoas, v. 14, n. 2, p. 77-91.

Jaccard, P. (1912), The distribution of the flora in the alpine zone. New Phytologist, 11:37-50. https://doi.org/10.1111/j.1469-8137.1912.tb05611.

Jaccard P (1901). "Étude comparative de la Distribution Floraledansune piece des Alpes et des Jura". Bulletin de la Sociétévaudoise des sciences naturelles . 37:547–579.

Joly, A. B. (1985). Botânica: Introdução à taxonomia vegetal. 7° ed. São Paulo: Ed. Nacional, 777p

Kassambara, A.; Mundt, F. (2020). Package “factoextra” for R: Extract and Visualize the Results of Multivariate Data Analyses. R package version 1.0.7. https://CRAN.R project.org/package=factoextra.

Lê, S.; Josse, J.; Husson, F. (2008) FactoMineR: An R package for multivariate analysis. JournalofStatistical Software. 25(1), 1–18.

Leal, L.; Bujokas, W. M.; Biondi, D. (2006) Análise da infestação de Erva-de-Passarinho na arborização de ruas de Curitiba, PR. Floresta, Curitiba, PR,v. 36, n. 3, set./dez.
LeRoux, B; Rouanet, H. (2010). Multiple CorrespondenceAnalysis. Edição ilustrada. v. 163. Londres: Sage.
Levine, N. (2002). CrimeStat II: A Spatial Statistics Program for the Analysis of Crime Incident Locations (version 2.0). Ned Levine and Associates Annandale, VA and The National Institute of Justice, Washington, DC.
Maranho, A.S.; Paula, S.R. (2014) Diversidade em uma área verde urbana: avaliação qualitativa da arborização do campus da Universidade Federal do Acre, Brasil Revista Agro@mbiente On-line, v. 8, n. 3, p. 404-415.
Martínez-Ambriz, E. (2020) Flora del Bajío y de Regiones adyacentes (Familia: Loranthaceae). Revista do Instituto de Ecologia A.C. Centro Regional del Bajío, Pátzcuaro, Michoacán, México. Fascículo 214. ISSN 0188-5170.
Martínez Del Rio, C., Silva, A., Medel, R. & Hourdequin (1996). Seed dispersers as disease vectors: bird transmission of mistletoe seed to plant hosts. Ecology. Vol. 77, 912-921.
Melo, R. B., Ferreira, C. S., Lopes, A., Vinson, C. C., & Franco, A. C. (2020). Dispersal mode constrains allocation of carbon and mineral nutrients in seeds of forest and savanna trees. Plant Biology, v. 22, 203-211.
Moia Junior, R.; Silva, J. M. S. da; Gonçalves, A. V. E Oliveira, L. W. de. (2018) Infestação de Erva-de-Passarinho (Phoradendron affine, (Pohl Ex Dc.) Engl. & Krause - Viscaceae) em espécies arbóreas no Parque do Povo de Presidente Prudente – SP. Colloquium Vitae, Vol. 10, N. Especial 5, Jul– Dez, P.135-142. ISSN: 1984-6436. DOI: 10.5747/Cv.2018.V10.Nesp5.0003.
Mota, J. C.da, Vasconcelos, A. G. G. e Assis, S. G.de. (2007) Análise de correspondência como estratégia para descrição do perfil da mulher vítima do parceiro atendida em serviço especializado. Ciência & Saúde Coletiva [online]. 2007, v. 12, n. 3 [Acessado 25 Janeiro 2022], pp. 799-809. Disponível em: <https://doi.org/10.1590/S1413-81232007000300030>. Epub 09 Maio 2007. ISSN 1678-4561. https://doi.org/10.1590/S1413-81232007000300030.
Norton, D. A.; Carpenter, M. A. (1998.) Mistletoes as parasites: host specificity and speciation. Trend in Ecology and Evolution, v. 13, p. 101-105.
Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H. and Wagner, H. (2020). Vegan: Community Ecology Package. R PackageVersion 2.5-7. http://CRAN.Rproject.org/package=vegan.
Parry, M. M., Silva, M. M., Sena, I. S. & Oliveira, F. P. M. (2012). Composição florística da arborização da cidade de Altamira, Pará. Revista da Sociedade Brasileira de Arborização Urbana, 7, 143-158. http://dx.doi.org/10.5380/revsbau.v7i1.66550.
Pereira, J.C.R. (1999). Análise de dados qualitativos estratégias metodológicas para as ciências da saúde, humanas e sociais. São Paulo: Editora da Universidade de São Paulo.
R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
R Core Team (2017). The R Project for Statistical Computing. Fonte: R Foundation for Statistical Computing, V: https://www.r-project.org
Rotta, E. (2001). Erva-de-passarinho (Loranthaceae) na arborização urbana: passeio público de Curitiba, um estudo de caso, Curitiba, Paraná, 2001. Tese (Doutorado em Ciências Florestais) - Universidade Federal do Paraná, Paraná.
Santos, G.L., Silva, W.R. (2020) Padrões de infestação e dispersão das ervas-de-passarinho no campus da Unicamp. XXVIII Congresso de Iniciação Ciêntífica da UNICAMP- Intituto de Biologia, 5p.
Shackleton, C. do Indigenous Street Trees Promote More Biodiversity than Alien Ones? Evidence Using Mistletoes and Birds in South Africa (2016). Forests, v. 7, n. 134, 9p
Silva, F.P., Fadini, R.F. (2017) Observational and experimental evaluation of hemiparasite resistance in trees in the urban afforestation of Santarém, Pará, Brazil. Acta Amazonica. v. 47, n. 4, p. 311-320.
Silva, R. d. (31 de Julho de 2012). Estudo da preferência por hospedeiros pela erva-de-passarinho Passovia stelis (LORANTHACEAE) na área urbana de Itacoatiara - AM. Itacoatiara: Universidade Federal do Amazonas.
Soares et al. (2021). Paradox of afforestation in cities in the Brazilian Amazon: An understanding of the composition and floristic similarity of these urban green spaces. Urban Forestry & Urban Greening 66 (2021) 127374.
Soares et al. (2021). Hemiparasitos e suas relações com a arborização urbana no Município de Macapá, Amapá, Brasil. Research, Society and Development, v. 10, n. 13| ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v10i13.21240.
Souza, A. L.; Ferreira, R. L. C.; Xavier, A. (1997) Análise de Agrupamento Aplicada à Ciência Florestal. Viçosa: SIF. 109 f. (Documento SIF, 16). Tattar, T. A. (1978) Diseases of shade trees. New York: Academic. 361 p.
White, B. L. A. et al. (2011) Floresta, Curitiba, PR, v. 41, n. 1, p. 1-8, jan./mar.