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Pollen dispersal distance of Brazilian native tree species: a systematic review

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Abstract
Knowledge of the pollen dispersal distance (PDD) is crucial for delimitating the collection radius of subpopulations in seed collection areas used as germplasm sources for genetic breeding, conservation, and restoration projects. Some studies have reported the PDD of trees, but these are scattered throughout the literature. Therefore, the objective of this study was to systematically review and report as many PDDs as possible found in the literature on native Brazilian tree species. In the present study, we identified the most and least studied species, temporal trends in publications, geographic distribution of studies, mating systems, and pollinator types for each species. A systematic review protocol was established, and the search criteria were improved, resulting in 543 articles. Forty-four articles contained information on native species, and 319 PDD from 41 tree species were extracted. The most investigated species for pollen dispersal were *Cariniana estrellensis* (Raddi) Kuntze (Jequitibá-branco) and *Araucaria angustifolia* (Bertol.) Kuntze (Araucária). The PDD values ranged from 9 m to 5229 m, averaging 543.9273 m. The five species with the highest average PDDs were *Centrolobium tomentosum* Guill. ex Benth. (Araribá), *Swietenia macrophylla* King (Mogno-brasileiro), *Hymenaea courbaril* L. (Jatobá), *Dipteryx alata* Vogel (Baru) and *Hymenaea stigonocarpa* Mart. Ex-Hayne (Jatobá do Cerrado) at 3191 m, 1472 m, 1450 m, 1215.12 m, and 1086.81 m, respectively. *Theobroma cacao* L. and *Ilex paraguariensis* A.St.-Hil. had the shortest PDDs averages at 28 m and 15.9 m, respectively. This work provides a valuable PDD database that will expand the possibilities for new research and guide projects related to seed collection, forest restoration, germplasm conservation, and genetic breeding of native Brazilian trees.

Keywords
Conservation genetics — Seed collection area— Population genetics — Timber species — Forest breeding

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1. Introduction

Knowledge of the pollen dispersal distance (PDD) is crucial for delimiting seed collection areas (SCAs) and the radius of tree subpopulations. SCAs are important germplasm sources for genetic breeding programs, conservation, and restoration projects involving trees (Mori et al., 2015). Studies on the PDD of trees are scarce due to the difficult to investigate pollen biology, ecology and dispersion of many tree native species. It is very important to know the distance that plant gametes travel via wind or dispersers, as this information is linked to the ability of trees to interbreed and therefore form a single subpopulation. The delimitation of these subpopulations is crucial for seed collectors to organize their expeditions and correctly carry out the collection and production of seedlings to be used in forest conservation, breeding, or restoration projects. Therefore, collecting and organizing pollen information from the literature into a single repository is imperative for easy access and application. Systematic reviews have been widely used in many areas of science and provide a standard method for storing, systematizing, and analyzing information, such as PDD (Donato & Donato, 2019). A systematic review of PDD is urgently needed, as it can provide pollen information for many Brazilian tree species and orientate forest projects.

The demand for seeds of forest species to restore degraded areas and establish germplasm banks has been

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growing in recent years due to climate change and the global need for reforestation. It is essential to understand and consider the genetic and ecological factors involved in establishing forest populations to ensure the success of these restoration projects (Freitas et al., 2015). Knowledge of the gene flow radius within forest populations and subpopulations is crucial for delineating SCAs. It is possible to estimate the distance of gamete change and crossings among trees of different subpopulations using PDD. Information on pollen dispersal distance can assist researchers in establishing SCAs and structuring future populations for planting in restoration areas or germplasm banks. Therefore, well-defined, and structured populations contribute to expanding the genetic base of planted forests and avoiding inbreeding depression caused by genetic bottlenecks (Sebbenn et al., 2011; Nunes, 2021).

Brazil is one of the most abundant plant biodiversity locations worldwide (Mittermeier et al., 2005). Many studies have reported the significant role of forests in reducing pollution levels and greenhouse gas emissions (Ribeiro & Pinheiro, 2022). Native forests are crucial for preserving plant and faunal biodiversity, safeguarding water, and soil resources, and serving as a source of income and employment. Because of the importance of native forests, their preservation and propagation from seed populations are essential to ensure ecosystem services. Therefore, understanding genetic dynamics and population genetics is vital for the sustainable management of these services and resources (Nunes, 2021).

Compared with that of exotic species, the economic potential of Brazilian native species is underexplored, and there is a lack of research on silviculture, genetic improvement, and pollen biology (Moura et al., 2019). Knowledge of genetic diversity is essential for developing conservation strategies. Assessment of PDD is fundamental in population genetics and has significant implications for the management and conservation of native species (Collevatti et al., 2013). Collecting genetic material from trees must be well-oriented to guarantee genetic conservation, ensuring genetic diversity in planting areas. Genetic diversity influences the adaptation of populations to environmental challenges (Ribeiro & Rodrigues, 2006; Nunes, 2021). Geographical obstacles can restrict gene flow between populations, leading to mating between close relatives and inbreeding depression (Costa et al., 2015; Pilakouta & Smiseth, 2016). In this context, a systematic review of PDD is fundamental in providing support for research on Brazilian native species, for the delineation of SCAs, and for the genetic structure of forest populations. Besides, this kind of research is recognized as a reliable and high-quality source as it consolidates the results of primary studies on a given topic (Galvão & Pereira, 2014; Donato & Donato, 2019). Despite the importance of organizing information and providing an applied source for PDD, no systematic reviews have reported this information for native Brazilian trees.

Therefore, providing such information to support silvicultural projects, restoration of degraded areas, and correct assembly of germplasm banks from a genetic and ecological point of view is critical. Then, collecting and organizing pollen information from the literature into a single repository is imperative for easy access and application. Considering these aspects, the objective of this study was to systematically review and report as many published PDDs of native Brazilian tree species as possible. This study has identified the most and least studied species, temporal trends in publications, geographic distribution of studies, mating systems, and pollinator types of each species.

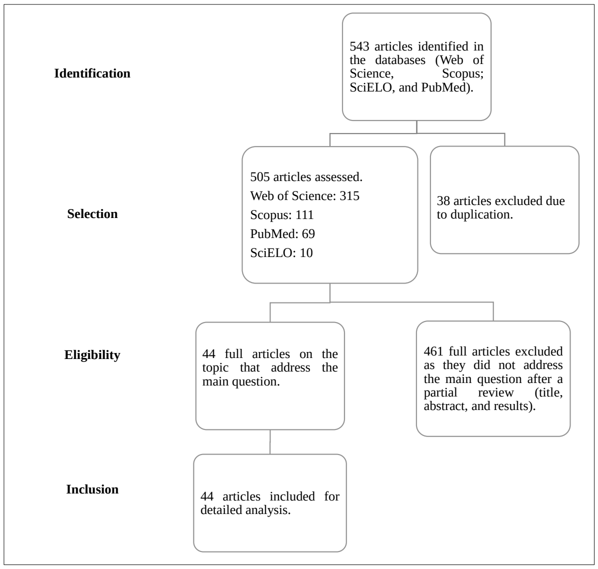

Figure 1. PRISMA 2020 adapted flowchart

2. Material and Methods

2.1 Materiais que foram usados texto texto

Four databases were selected for this study: Scopus, Web of Science, Scielo, and PubMed. Bibliographical materials in English, Spanish, and Portuguese were included, and a search string was developed in English. Articles on diseases, infections, or weeds were excluded. Searches were conducted in October 2024, and articles published between 1993 and 2024 were considered.

After this stage, adjustments were made to refine the search. The following string was developed: ("pollen flow") OR ("gene dispersal") OR ("pollen distance") OR ("pollen dispersal") AND (tree) AND (brazil) AND NOT (disease) AND NOT (infection) AND NOT (weed). The search resulted in 543 articles, and 38 duplicates were removed, resulting in 505 eligible studies, 44 of which contained information on native species. Of the 505 articles analyzed, 315 were from Web of Science, 111 were from Scopus, 69 were from PubMed, and ten were from Scielo (Figure 1).

The information extracted from the relevant articles, including article type, author names, year, scientific name, common name, pollen distance, geographic location, and important complementary information, was tabulated in an electronic spreadsheet. Data were analyzed through descriptive statistical analysis using R software (R Core Team 2024), and graphs were generated using the ggplot2 package (Wickham, 2016). For a detailed description of the process, a flowchart adapted from PRISMA 2020 (Figure 1) was developed (Galvão et al., 2022; Mendes, 2022).

3. Results

From the 44 articles with information, 319 PDD data points from 41 native tree species were extracted, as some articles addressed more than one species as a theme. The species with the most information was *Cariniana estrellensis* (Raddi) Kuntze (Jequitibá-branco), with 46 PDDs, followed by *Araucaria angustifolia* (Bertol.) Kuntze (Araucária) with 44 PDDs. Species such as *Acrocomia aculeata* (Jacq.) Lodd. Ex Martius and *Aspidosperma polyneuron* Müll.Arg had only one PDD dataset (Figure 2).

The articles mainly conducted their experiments within the national territory, with only two conducted abroad: in Costa Rica (Boshier et al., 1995) and Guiana (Hardy et al., 2006). Considering the papers in Brazil, most studies were concentrated in the southeast and south of the country, with nine articles featuring the Tapajós National Forest, Pará, and others spread across Ceará and Goiás states (Figure 3). The articles were published between 1995 and 2024, with most publications concentrated between 2007 and 2016. The other years had an average of two publications (Figure 4). The PDD values ranged from 9 m to 5229 m, with an average of 543.9273 m. The five species with the highest average PDDs were *Centrolobium tomentosum* Guill. ex Benth. (Araribá), *Swietenia macrophylla* King (Mogno-brasileiro), *Hymenaea courbaril* L. (Jatobá), *Dipteryx alata* Vogel (Baru) and *Hymenaea stigonocarpa* Mart. Ex-Hayne (Jatobá do Cerrado) at 3191 m, 1472 m, 1450 m, 1215.12 m, and 1086.81 m, respectively. *Theobroma cacao* L. and *Ilex paraguariensis* A.St.-Hil. had the shortest PDDs averages at 28 m and 15.9 m, respectively. Of the 41 native species with PDD information, 17 had only one record of pollen distance information; therefore, we could not report the standard deviation, maximum, or minimum values. The other 24 species had more than one measurement for analysis (Table S1). Bees were the most frequent pollinators, acting on 23 species. The greatest pollen dispersal distance average was observed for *C. tomentosum* Guill. ex Benth, at 3191 meters, and the shortest distance was observed in *Ilex paraguariensis A.St.-Hil.* at 15.9 m. All 41 studied species were predominantly crossing (Table S1).

4. Discussion

Notably, there is a lack of pollen information for Brazilian native trees. Considering the importance of knowing the PDD to orient seed collection, further studies should investigate pollen dispersal, ecology, and genetic factors. Seed collection from trees is a difficult task, and many factors must be considered to guarantee the success of future forests. Knowledge of the gene flow radius within forest populations and subpopulations is crucial for delineating seed areas (Telles et al., 2010). The distance of gamete changes and crossings among trees of different subpopulations can be estimated using PDD (Gonçalves et al., 2010). In genetic conservation projects, the decision maker frequently needs to know the distance between two or more subpopulations of a species. This information determines the quality of assembling future plantations as it can influence a population's genetic conservation degree.

The PDD repository assists forest initiatives by providing average distances for SCA delimitation. ConservaGen software (Nunes, 2021) can assist germplasm conservation projects by calculating population genetic parameters. It can be used for both in situ and ex situ germplasm conservation and assist decision-making in these projects. ConservaGen enables the estimation of the genetic diversity of a future plantation and requires information about the number of subpopulations visited for seed collection. Thus, the researcher can define the distance separating each species' subpopulation using the PDD repository and the software. In some cases, it is possible to use the average PDD and analyze the types of pollinators and reproductive systems to better estimate the SCA radius of species with no exact information.

The need of published articles on PDD is more pronounced when biomes are analyzed. Most articles were found in the Tapajós National Forest, and study clusters were observed around Brazil. The Tapajós National Forest was established in the western state of Pará in 1974 and is a federal conservation unit mainly characterized

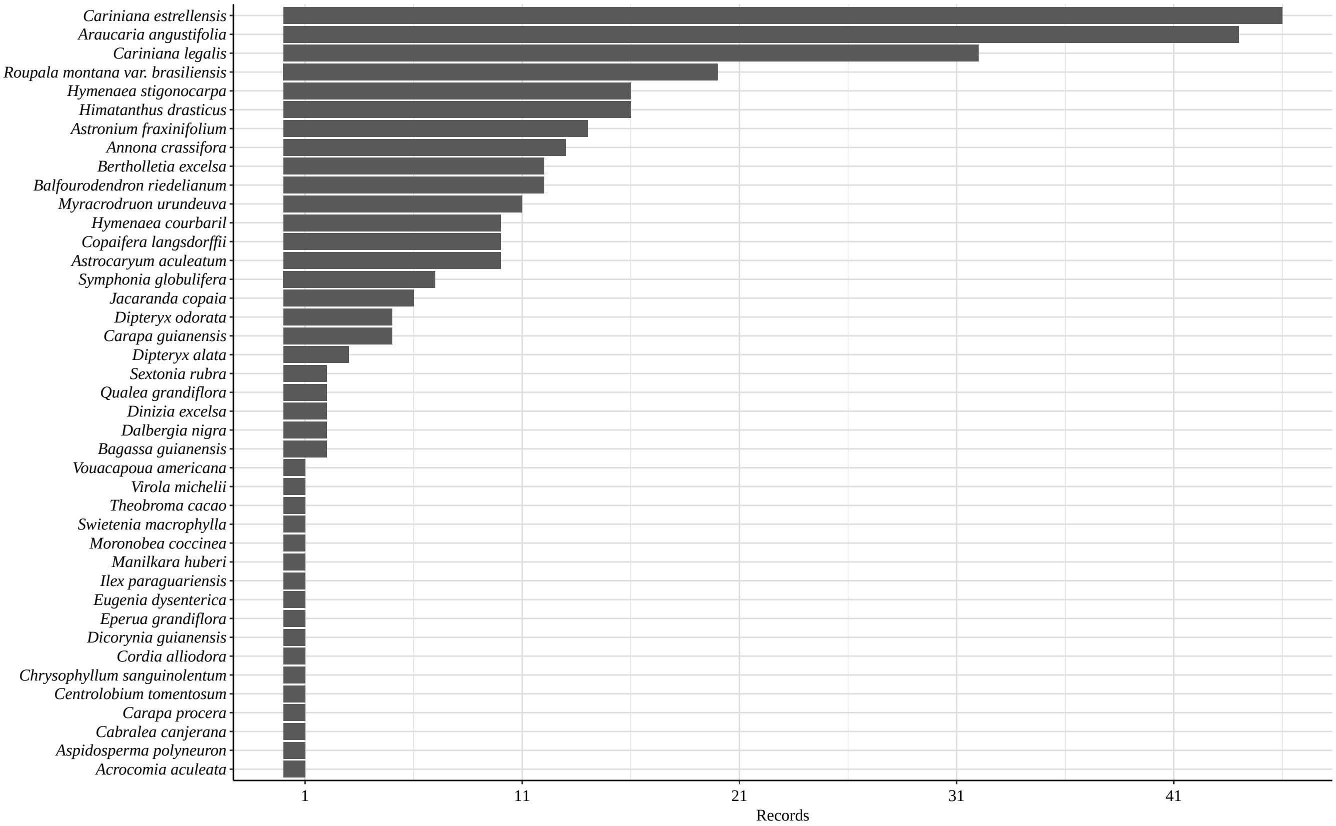

Figure 2. Number of pollen dispersal distance (PDD) records per species

by dense ombrophilous forests (Melo & Franceschinelli, 2016). Since then, this location has been the subject of scientific studies for various purposes, including floristic and phytosociological composition (Espírito-Santo et al., 2005), timber potential, and biodiversity of microorganisms (Rocha et al., 2017). Despite the importance of the Tapajos Forest, a notably high concentration of studies displayed in groups. Brazilian biomes are of great importance to biodiversity because of the combination of high species richness and endemic species (Aleixo et al., 2010). With such species richness, research on pollen dispersal distance is lacking in some biomes, such as the Pantanal, where no publications have been found, and in the Caatinga, Cerrado, and Pampa biomes, each with only one article on the topic.

Despite the scarcity of PDD research, the repository generated in the present study is useful and can orient future projects for the species analyzed. Some species have a higher PDD than others, which is relevant and must be highlighted in the SCA delimitations. *C. estrellensis* (Jequitibá-branco) had the largest PDD dataset with 46 records. This species is a multipurpose species because of its wide range of applications, including timber, and handicrafts. *A. angustifolia* (Araucária) was the second most cited species with 44 PDD records. This species is highly valued for its utility in carpentry, timber sector and use of almonds traditionally sold and produced in southern Brazil. All these species have silvicultural potential and can be used in forest restoration initiatives in Brazil.

Another important silvicultural tree, *C. tomentosum*, had only one pollen dispersal source, whereas *H. stigonocarpa* (Jatobá do Cerrado) had 16 records, with a PDD minimum of 25 m observed in the presence of clustered trees and a maximum of 5229 m with isolated trees in pastureland. This difference between the observed minimum and maximum values resulted in a high standard deviation (1591.87 m). The species *Dinizia excelsa* Ducke had an average pollen dispersal distance of 860.5 meters, with a minimum distance of 212 m, a maximum of 1509 m, and a standard deviation of 917.12 m. Pollen distances were obtained under conditions similar to those of *H. stigonocarpa*. The intensity of pollen flow is influenced by many factors, including the amount of pollen produced and the presence of physical barriers, such as forests, mountains, buildings, and terrain topography (Costa et al., 2018). Forest fragmentation, which causes various alterations in ecosystem functioning also plays a

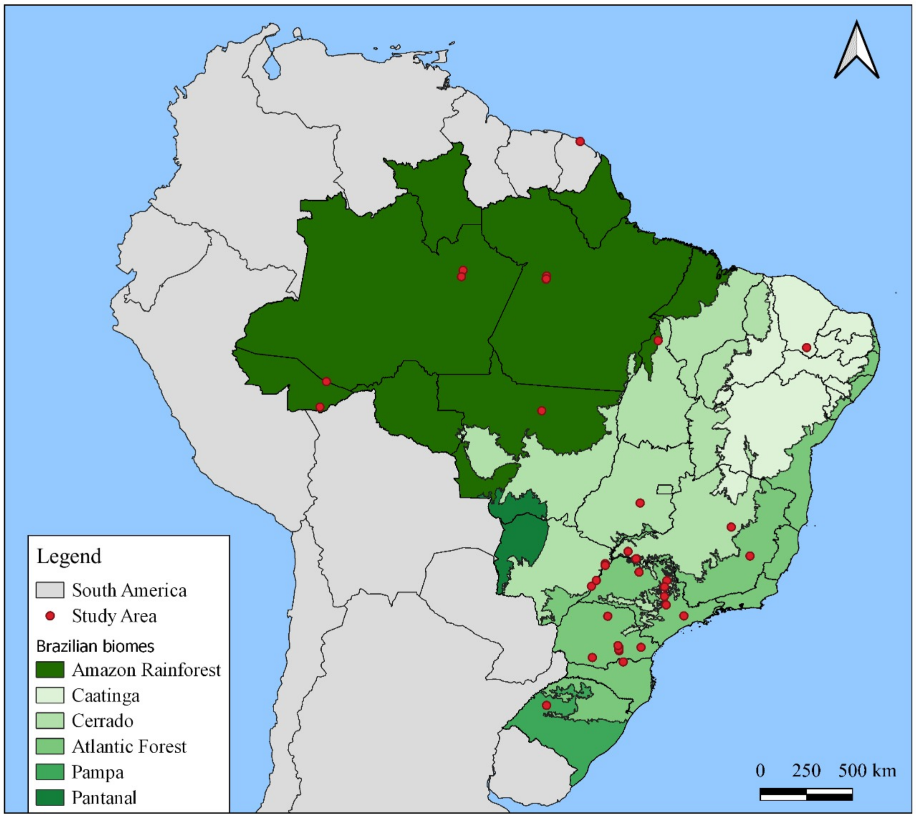

Figure 3. Geographic distribution of experiments conducted in the reviewed articles marked at yellow points

role (D´Arrochella, 2020). Fragmentation creates barriers that hinder dispersal between forest fragments, resulting in a decline in gene flow and genetic variability among species. Consequently, the ability of these species to adapt is negatively affected (Thiago et al., 2020). Furthermore, pollinator fauna may decline when associated with habitat loss, significantly compromising the pollination process (Mariot et al., 2014).

Collecting data on population structure and reproductive behavior is crucial because the distribution patterns of genetic variability are closely related to the reproductive system. Except for autogamous species, pollination is entirely dependent on animals or abiotic agents such as wind or water to occur (Rocha & Polatto, 2017). Native species rely on pollinating agents for reproduction. Pollination is an ecosystem service (Barbosa et al., 2017), and flowers are the main source of food for wasps, butterflies, beetles, bees, and flies, making feeding needs responsible for most flower visits (Agostini et al., 2014). However, there are differences between floral visitors and pollinators. To be an effective pollinator, visitors must transfer pollen from the anthers to the stigma of the same species of plant. Bees play a fundamental role as primary pollinators of plants (Souza et al., 2007).

The interactions between plants and their pollinators are guided by floral attributes, including morphology, coloration, nectar trails, and fragrance glands, which indicate the availability of floral resources (Deprá & Gaglianone, 2018). Bats appeared to be pollinator agents for all three native species. Among the three native species, the maximum distance observed was for *H. stigonocarpa* Mart. ex-Hayne at 5229 m, and the minimum distance observed was 9 m in *C. estrellensis* (Jequitibá-branco). Bats play a vital role in ecosystems, acting as pollinators of fruit trees and seed dispersers.

All the species analyzed are predominantly crossing. The mating system in trees can be classified as autogamy (self-fertilization with at least 80%); outcrossed (cross-fertilization with at least 80%); or as a mixed mating system when cross-fertilization occurs between 20 to 80% (Goodwillie et al., 2005). Crossing species seek efficient pollen and seed dispersal mechanisms to achieve reproductive success (Siqueira et al., 2010). For crossing species, pollination is a prerequisite for cross-fertilization (Deprá & Gaglianone, 2018). However, pollinator competition influences the distribution patterns and abundance of species involved in plant-pollinator interactions (Barônio et al., 2016). Examples of patterns suggesting competitive mechanisms in pollination biology include asynchronous flowering among plant species pollinated by the same pollinators and pollinator partitioning among synchronous plant species (Mitchell et al., 2009).

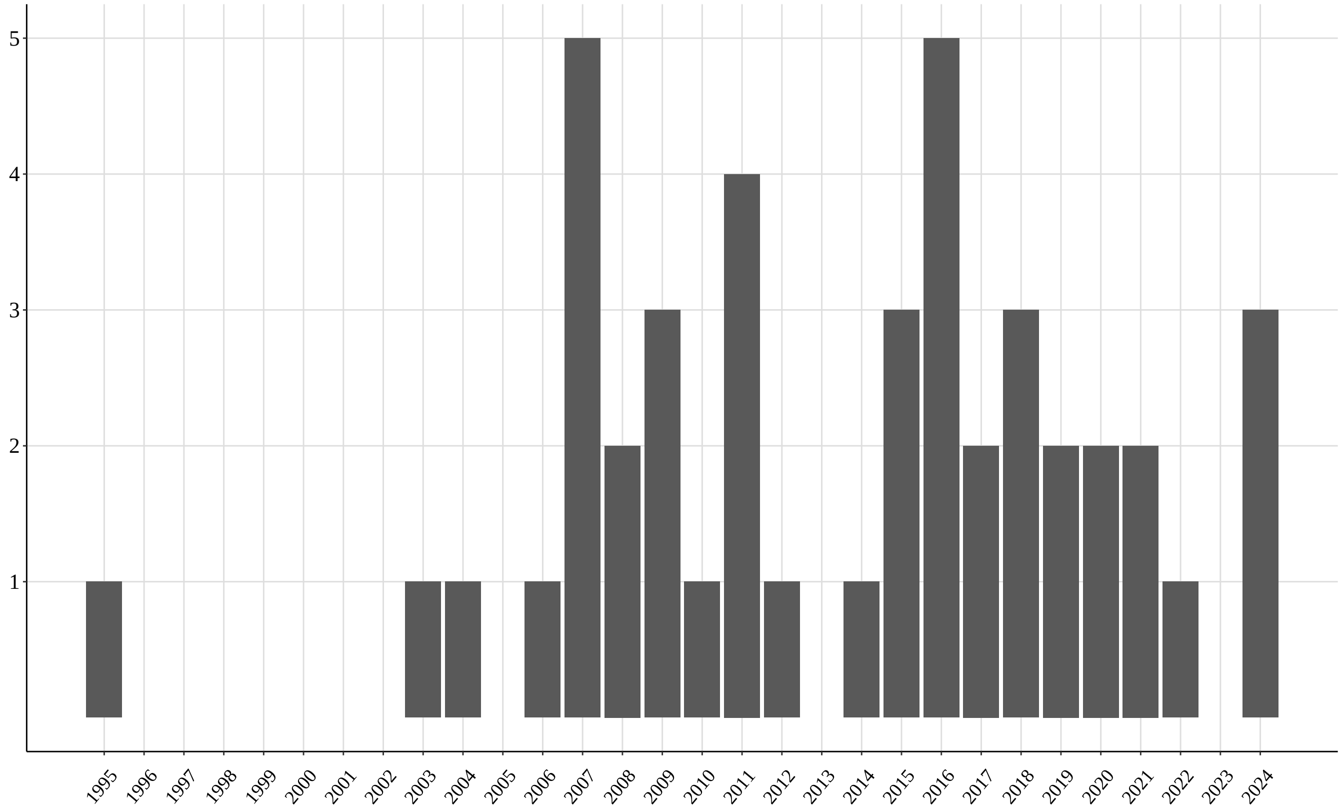

Figure 4. Total number of published articles per year containing pollen dispersal distance (PDD)

The systematic review protocol provides an essential repository of information on the PDD of Brazilian tree species. Some species have a higher PDD than others, and ecological and genetic factors, such as pollinators and reproductive systems, must be considered for SCA delimitations. In practical terms, this review serves to alert governments to establish public policies to promote more research on gene flow. There is no standard from government agencies that guide the collection of seeds for forest conservation or restoration purposes. Embrapa Florestas collects seeds from 25 to 30 healthy mother trees per population, approximately 100 m, to avoid closely related individuals (Carlos & Medeiros, 2006). This is a standard strategy used by many researchers in Brazil; however, several studies show that this number of mother trees is insufficient to sample the genetic base of the original population. As reported in a literature review, the number of mother trees for seed collection ranged from 29 to 76 for reforestation purposes (Sebbenn, 2006). PDD is related to subpopulation delimitations to seed collection from mother tree sampling. Thus, our study provides a valuable PDD database that can be easily used as a guide to orient new academic research and projects related to seed collection, forest restoration, germplasm conservation, and genetic breeding of native Brazilian trees. Considering the average value of PDD found in our study, subpopulations should generally have a radius of at least around 543.9273 m. However, each species must require a greater or lesser value of subpopulation delimitation for seed collection, which may vary from 9 m to 5229 m, according to the species reported in our study.

5. Conclusion

The PDD database generated in our study supports new academic initiatives and forest projects for seed collection, forest restoration, germplasm conservation, and genetic breeding of native Brazilian trees. The PDD value of each species should be used as a radius value for subpopulations delimitations in seed collection. Brazil has great biodiversity in its biomes, and more information is needed information for establishing standards by government agencies to guide the collection of seeds on reforestation and genetic conservation purposes. Regarding the species reported in our study, subpopulations should generally have a radius of around 543.9273 m, which may vary from 9 m to 5229 m. Therefore, it is essential to sample more tree species from different biomes and environmental conditions to contribute to the present database and assist in appropriately establishing seed collection strategies.

Author Statements

- ✓ No conflicts of interest were declared.
- ✓ All existing funding sources were acknowledged.
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- ✓ There is no evidence of plagiarism in this article.

References

Agostini K., Lopes A.V., & Machado I.C. (2014). Recursos florais. In A. R. Rech, K. Agostini, P. E. Oliveira, & I. C. Machado (Eds.), *Biologia da polinização* (pp. 130–150).

Aguiar, B. I., Freitas, M. L. M., Zannato, A. S., Tambarussi, E. V., Moraes, M. L. T., Ambrosano, M. N., Pereira, L. C. S. M., Gandara, F. B., Kageyama, P. Y., & Sebbenn, A. M. (2020). The effects of pollen dispersal and mating pattern on inbreeding depression and hybrid vigor in *Balfourodendron riedelianum* (Engl.) Engl. (Rutaceae). *Conservation Genetics*, *21*(2), 305–317. https://doi.org/10.1007/s10592-020-01250-0

Aleixo, A., Albernaz, A. L., Grelle, C. E. V., Vale, M. M., & Rangel, T. F. (2010). Mudanças Climáticas e a Biodiversidade dos Biomas Brasileiros: Passado, Presente e Futuro. In *Natureza & Conservação* (Vol. 8, Issue 2, pp. 194–196). https://doi.org/10.4322/natcon.00802016

Almeida-Júnior, E. B., Collevatti, R. G., Telles, M. P. de C., Chaves, L. J., Neres, D. F., & Soares, T. N. (2018). Short-distance pollen dispersal in a protogynous Annonaceae tree species from the Brazilian Cerrado. *Plant Systematics and Evolution*, *304*(9), 1091–1099. https://doi.org/10.1007/s00606-018-1534-z

Araújo, M. R. G., Melo Júnior, A. F. de, Menezes, E. V., Brandão, M. M., Cota, L. G., Oliveira, D. A. de, Royo, V. de A., & Vieira, F. A. (2017). Fine-scale spatial genetic structure and gene flow in *Acrocomia aculeata* (Arecaceae): Analysis in an overlapping generation. *Biochemical Systematics and Ecology*, *71*, 147–154. https://doi.org/10.1016/j.bse.2017.02.005

Azevedo, V. C. R., Kanashiro, M., Ciampi, A. Y., & Grattapaglia, D. (2007). Genetic structure and mating system of *Manilkara huberi* (Ducke) A. Chev., a heavily logged Amazonian timber species. *Journal of Heredity*, *98*(7), 646–654. https://doi.org/10.1093/jhered/esm074

Baldauf, C., Ciampi-Guillardi, M., Aguirra, T. J., Corrêa, C. E., dos Santos, F. A. M., de Souza, A. P., & Sebbenn, A. M. (2014). Genetic diversity, spatial genetic structure and realised seed and pollen dispersal of *Himatanthus drasticus* (Apocynaceae) in the Brazilian savanna. *Conservation Genetics*, *15*(5), 1073–1083. https://doi.org/10.1007/s10592-014-0600-5

Baldoni, A. B., Wadt, L. H. O., Campos, T., Silva, V. S., Azevedo, V. C. R., Mata, L. R., Botin, A. A., Mendes, N. O., Tardin, F. D., Tonini, H., Hoogerheide, E. S. S., & Sebbenn, A. M. (2017). Contemporary pollen and seed dispersal in natural populations of *Bertholletia excelsa* (Bonpl.). *Genetics and Molecular Research*, *16*(3). https://doi.org/10.4238/gmr16039756

Barbosa, D. B., Crupinski, E. F., Silveira, R. N., & Limberger, D. C. H. (2017). As abelhas e seu serviço ecossistêmico de polinização. *Revista Eletrônica Científica Da UERGS*, *3*(4), 694–703. https://doi.org/10.21674/2448-0479.34.694-703

Barônio, G. J., Maciel, A. A., Oliveira, A. C., Kobal, R. O. A. C., Meireles, D. A. L., Brito, V. L. G., & Rech, A. R. (2016). Plants, pollinators and some contributions from pollination biology to the ecological theory. *Rodriguesia*, *67*(2), 275–293. https://doi.org/10.1590/2175-7860201667201

Bittencourt, J. V. M., & Sebbenn, A. M. (2007). Patterns of pollen and seed dispersal in a small, fragmented population of the wind-pollinated tree *Araucaria angustifolia* in southern Brazil. *Heredity*, *99*(6), 580–591. https://doi.org/10.1038/sj.hdy.6801019

Bittencourt, J. V. M., & Sebbenn, A. M. (2008). Pollen movement within a continuous forest of wind-pollinated *Araucaria angustifolia*, inferred from paternity and TwoGener analysis. *Conservation Genetics*, *9*(4), 855–868. https://doi.org/10.1007/s10592-007-9411-2

Boshier, D. H., Chase, M. R., & Bawa, K. S. (1995). Population genetics of *Cordia alliodora* (Boraginaceae), a neotropical tree. *American Journal of Botany*, *4*(82), 476–483.

Buzatti, R. S. D. O., Ribeiro, R. A., Filho, J. P. D. L., & Lovato, M. B. (2012). Fine-scale spatial genetic structure of *Dalbergia nigra* (Fabaceae), a threatened and endemic tree of the Brazilian Atlantic Forest. *Genetics and Molecular Biology*, *35*(4), 838–846.

Carlos, A., & Medeiros, S. (2006). *Planejamento da Coleta de Sementes Florestais Nativas*.

Carneiro, F. D. S., Sebbenn, A. M., Kanashiro, M., & Degen, B. (2007). Low interannual variation of mating system and gene flow of *Symphonia globulifera* in the Brazilian Amazon. *Biotropica*, *39*(5), 628–636. https://doi.org/10.1111/j.1744-7429.2007.00314.x

Carneiro, F. da S., Degen, B., Kanashiro, M., de Lacerda, A. E. B., & Sebbenn, A. M. (2009). High levels of pollen dispersal detected through paternity analysis from a continuous *Symphonia globulifera* population in the Brazilian Amazon. *Forest Ecology and Management*, *258*(7), 1260–1266. https://doi.org/10.1016/j.foreco.2009.06.019

Carneiro, F. S., Lacerda, A. E. B., Lemes, M. R., Gribel, R., Kanashiro, M., Wadt, L. H. O., & Sebbenn, A. M. (2011). Effects of selective logging on the mating system and pollen dispersal of *Hymenaea courbaril* L. (Leguminosae) in the Eastern Brazilian Amazon as revealed by microsatellite analysis. *Forest Ecology and Management*, *262*(9), 1758–1765. https://doi.org/10.1016/j.foreco.2011.07.023

Carvalho, P. E. (2006). *Espécies arbóreas brasileiras*. Embrapa.

Chaves, C. L., Sebbenn, A. M., Baranoski, A., Goez, B. D., Gaino, A. P. S. C., Ruas, C. F., Ruas, E., & Ruas, P. M. (2016). Gene dispersal via seeds and pollen and their effects on genetic structure in the facultative-apomictic Neotropical tree *Aspidosperma polyneuron*. *Silvae Genetica*, *65*(2), 46–57. https://doi.org/10.1515/sg-2016-0016

Cloutier, D., Kanashiro, M., Ciampi, A. Y., & Schoen, D. J. (2007a). Impact of selective logging on inbreeding and gene dispersal in an Amazonian tree population of *Carapa guianensis* Aubl. *Molecular Ecology*, *16*(4), 797–809. https://doi.org/10.1111/j.1365-294X.2006.03193.x

Cloutier, D., Hardy, O. J., Caron, H., Ciampi, A. Y., Degen, B., Kanashiro, M., & Schoen, D. J. (2007b). Low inbreeding and high pollen dispersal distances in populations of two Amazonian forest tree species. *Biotropica*, *39*(3), 406–415. https://doi.org/10.1111/j.1744-7429.2007.00266.x

Collevatti, R. G., Telles, M. P. D. C., & Soares, T. N. (2013). Dispersão do pólen entre pequizeiros: uma atividade para a genética no ensino superior. *Genética Na Escola*, *8*(1), 18–27.

Costa, D. F., Vieira, F. de A., Fajardo, C. G., & Chagas, K. P. T. (2015). Diversidade genética e seleção de iniciadores ISSR em uma população natural de mangaba (*Hancornia speciosa* Gomes) (Apocynacea). *Revista Brasileira de Fruticultura*, *37*(4), 970–976. https://doi.org/10.1590/0100-2945-246/14

Costa, D. L. Da, Santos, M. F., Bezerra, T. G., Ribeiro, R. B. S., Gama, J. R. V., Melo, L. O., Ximenes, L. C., & Coelho, A. A. (2018). Estrutura e distribuição espacial de *Symphonia globulifera* L. f. em floresta de várzea baixa, Afuá-PA. *Advances in Forestry Science*, *5*(1), 275–281.

D´Arrochella, M. L. G. (2020). Fragmentação florestal da Mata Atlântica: conectividade potencial via polinização por mariposas e modelagem atmosféri ca. *Geografia Em Atos (Online)*, *3*(18), 101–116. https://doi.org/10.35416/geoatos.v3i18.7362

Oliveira Melo, A. T., & Franceschinelli, E. V. (2016). Gene flow and fine-scale spatial genetic structure in *Cabralea canjerana* (Meliaceae), a common tree species from the Brazilian Atlantic forest. *Journal of Tropical Ecology*, *32*(2), 135–145. https://doi.org/10.1017/S0266467416000067

Pereira, F. B., Sebbenn, A. M., Boshier, D. H., Rossini, B. C., Marino, C. L., Freitas, M. L. M., Rosa, J. R. B. F., Vidal, E., & Tambarussi, E. V. (2024). Gene flow, mating patterns and inbreeding depression in *Roupala montana* var. brasiliensis, a neotropical timber species. *New Forests*, 55(4), 897–920. https://doi.org/10.1007/s11056-023-10009-7

Degen, B., & Roubik, D. W. (2004). Effects of animal pollination on pollen dispersal, selfing, and effective population size of tropical trees: A simulation study. *Biotropica*, *36*(2), 165–179. https://doi.org/10.1111/j.1744-7429.2004.tb00309.x

Deprá, M. S., & Gaglianone, M. C. (2018). Interactions between plants and pollinators in a temporal perspective. *Oecologia Australis*, *22*(1), 1–16. https://doi.org/10.4257/oeco.2018.2201.01

Dick, C. W., Etchelecu, G., & Austerlitz, F. (2003). Pollen dispersal of tropical trees (*Dinizia excelsa*: Fabaceae) by native insects and African honeybees in pristine and fragmented Amazonian rainforest. *Molecular Ecology*, *12*(3), 753–764. https://doi.org/10.1046/j.1365-294X.2003.01760.x

Donato, H., & Donato, M. (2019). Etapas na Condução de uma Revisão Sistemática. *Acta Medica Portuguesa*, *32*(3), 227–235. https://doi.org/10.20344/amp.11923

Espírito-Santo, F. D. B., Shimabukuro, Y. E., Aragão, L. E. O. C. de, & Machado, E. L. M. (2005). Análise da composição florística e fitossociológica da floresta nacional do Tapajós com o apoio geográfico de imagens de satélites. *Acta Amazonica*, *35*(2), 155–173.

Freitas, M. L., Aguiar, A. V., Spoladore, J. S., & et al. (2015). Produção de sementes de espécies florestais nativas: estratégias de melhoramento. In F. C. M. Pinã-Rodrigues, M. B. Figliolia, & A. Silva (Eds.), *Sementes Florestais Tropicais: da ecologia à produção* (pp. 285–307). Abrates.

Gaino, A. P. S. C., Silva, A. M., Moraes, M. A., Alves, P. F., Moraes, M. L. T., Freitas, M. L. M., & Sebbenn, A. M. (2010). Understanding the effects of isolation on seed and pollen flow, spatial genetic structure and effective population size of the dioecious tropical tree species *Myracrodruon urundeuva*. *Conservation Genetics*, *11*(5), 1631–1643. https://doi.org/10.1007/s10592-010-0046-3

Galvão, T. F., & Pereira, M. G. (2014). Revisões sistemáticas da literatura: passos para sua elaboração. *Epidemiologia e Serviços de Saúde*, *23*(1), 183–184. https://doi.org/10.5123/s1679-49742014000100018

Galvão, T. F., Tiguman, G. M. B., Sarkis-Onofre, R., Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., . . . Moher, D. (2022). A declaração PRISMA 2020: Diretriz atualizada para relatar revisões sistemáticas. *Epidemiologia e Serviços de Saúde*, *31*(2). https://doi.org/10.5123/S1679-49742022000200033

Gonçalves, A. C., Reis, C. A. F., Vieira, F. A., & Carvalho, D. (2010). Estrutura genética espacial em populações naturais de *Dimorphandra mollis* (Fabaceae) na região norte de Minas Gerais, Brasil. *Revista Brasileira de Botânica*, *33*(2), 325–332.

Goodwillie, C., Kalisz, S., & Eckert, C. G. (2005). The evolutionary enigma of mixed mating systems in plants: Occurrence, theoretical explanations, and empirical evidence. *Annual Review of Ecology, Evolution, and Systematics*, *36*, 47–79. https://doi.org/10.1146/annurev.ecolsys.36.091704.175539

Guidugli, M. C., Nazareno, A. G., Feres, J. M., Contel, E. P. B., Mestriner, M. A., & Alzate-Marin, A. L. (2016). Small but not isolated: A population genetic survey of the tropical tree *Cariniana estrellensis* (Lecythidaceae) in a highly fragmented habitat. *Heredity*, *116*(3), 339–347. https://doi.org/10.1038/hdy.2015.108

Guimarães, R. A., Miranda, K. M. C., Chaves, L. J., Naves, R. V., Telles, M. P. de C., & Soares, T. N. (2019). Mating system and pollen dispersal in *Dipteryx alata* Vogel (Leguminosae): comparing in situ and ex situ conditions. *Tree Genetics and Genomes*, *15*(2). https://doi.org/10.1007/s11295-019-1337-6

Hardy, O. J., Maggia, L., Bandou, E., Breyne, P., Caron, H., Chevallier, M. H., Doligez, A., Dutech, C., Kremer, A., Latouche-Hallé, C., Troispoux, V., Veron, V., & Degen, B. (2006). Fine-scale genetic structure and gene dispersal inferences in 10 Neotropical tree species. *Molecular Ecology*, *15*(2), 559–571. https://doi.org/10.1111/j.1365-294X.2005.02785.x

Kubota, T. Y. K., Hallsworth, J. E., da Silva, A. M., Moraes, M. L. T., Cambuim, J., Corseuil, C. W., & Sebbenn, A. M. (2024). Pollen dispersal and mating patterns determine resilience for a large-yet-fragmented population of *Cariniana estrellensis*. *Conservation Genetics.* https://doi.org/10.1007/s10592-023-01557-8

Manoel, R. O., Rossini, B. C., Cornacini, M. R., Moraes, M. L. T., Cambuim, J., Alcantara, M. A. M., Silva, A. M., Sebbenn, A. M., & Marino, C. L. (2021). Landscape barriers to pollen and seed flow in the dioecious tropical tree *Astronium fraxinifolium* in Brazilian savannah. *PLoS ONE*, *16*(8 August). https://doi.org/10.1371/journal.pone.0255275

Mariot, A., Mantovani, A., Bittencourt, R., & Sedrez dos Reis, M. (2014). Aspectos da biologia reprodutiva de *Drimys brasiliensis* Miers (Winteraceae) em floresta ombrófila mista, sul do brasil. *Ciência Florestal*, *24*(4), 877–888.

Martins, K., Santos, R. da S. O., Campos, T., & Wadt, L. H. de O. (2018). Pollen and seed dispersal of Brazil nut trees in the southwestern Brazilian Amazon. *Acta Amazonica*, *48*(3), 217–223. https://doi.org/10.1590/1809-4392201800021

Medina-Macedo, L., Sebbenn, A. M., Lacerda, A. E. B., Ribeiro, J. Z., Soccol, C. R., & Bittencourt, J. V. M. (2015). High levels of genetic diversity through pollen flow of the coniferous *Araucaria angustifolia*: a landscape level study in Southern Brazil. *Tree Genetics and Genomes*, *11*(1). https://doi.org/10.1007/s11295-014-0814-1

Melo, A. T. de O., & Franceschinelli, E. V. (2016). Gene flow and fine-scale spatial genetic structure in *Cabralea canjerana* (Meliaceae), a common tree species from the Brazilian Atlantic forest. *Journal of Tropical Ecology*, *32*(2), 135–145.

Mendes, C. (2022). *Fluxograma PRISMA para Revisão Integrativa*. Https://Camilamendes.Com.Br/Fluxograma-Prisma-Para-Revisao-Integrativa. https://camilamendes.
com.br/fluxograma-prisma-para-revisao-integrativa

Mitchell, R. J., Flanagan, R. J., Brown, B. J., Waser, N. M., & Karron, J. D. (2009). New frontiers in competition for pollination. *Annals of Botany*, *103*(9), 1403–1413. https://doi.org/10.1093/aob/mcp062

Mittermeier, R. A., Da Fonseca, G. A. B., Rylands, A. B., & Brandon, K. (2005). A brief history of biodiversity conservation in Brazil. In *Conservation Biology* (Vol. 19, Issue 3, pp. 601–607). https://doi.org/10.1111/j.1523-1739.2005.00709.x

Moraes, M. L., & Sebbenn, A. M. (2011). Pollen dispersal between isolated trees in the Brazilian savannah: a case study of the Neotropical tree *Hymenaea stigonocarpa*. *Biotropica*, *2*(43), 192–199.

Moreno, M. A., Boshier, D., Tarazi, R., Tambarussi, E. V., Aguiar, B. I., Ferraz, E. M., Kageyama, P. Y., & Sebbenn, A. M. (2022). Long distance pollen dispersal and intrapopulation genetic structure determined by clonal diversity in *Hymenaea stigonocarpa* populations of the Brazilian savanna. *Trees - Structure and Function*, *36*(1), 471–484. https://doi.org/10.1007/s00468-021-02222-8

Mori, N. T., Mori, E. S., Tambarussi, E. V., & et al. (2015). Sistema de cruzamento em populações de *Handroanthus heptaphyllus* (Vell.) Mattos e suas implica
ções para a coleta de sementes para fins de conservação e melhoramento genético. *Scientia Forestalis* 43: 675–681.

Moura, D. F., Martins, R. D., & Silva, M. V. (2019). Nerolidol: Fitoconstituinte de Óleos Essenciais de Plantas da Caatinga. *Brazilian Journal of Development*, *5*(12), 33402–33416. https://doi.org/10.34117/bjdv5n12-384

Nunes, A. C. P. (2021). ConservaGen software: A useful tool for genetic conservation of germplasm. *Crop Breeding and Applied Biotechnology*, *21*(4), 38992144. https://doi.org/10.1590/1984

Oliveira, S. S., Campos, T., Sebbenn, A. M., & d'Oliveira, M. V. N. (2020). Using spatial genetic structure of a population of *Swietenia macrophylla* King to integrate genetic diversity into management strategies in Southwestern Amazon. *Forest Ecology and Management*, *464*. https://doi.org/10.1016/j.foreco.2020.118040

Pilakouta, N., & Smiseth, P. T. (2016). Maternal effects alter the severity of inbreeding depression in the offspring. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1838). https://doi.org/10.1098/rspb.2016.1023

Potascheff, C. M., Oddou-Muratorio, S., Klein, E. K., Figueira, A., Bressan, E. A., Oliveira, P. E., Lander, T. A., & Sebbenn, A. M. (2019). Stepping stones or stone dead? Fecundity, pollen dispersal and mating patterns of roadside *Qualea grandiflora* Mart. trees. *Conservation Genetics*, *20*(6), 1355–1367. https://doi.org/10.1007/s10592-019-01217-w

R Core Team (2024). *R: A language and environment for statistical computing*. https://www.R-project.org/

Ramos, S. L. F., Dequigiovanni, G., Sebbenn, A. M., Lopes, M. T. G., Kageyama, P. Y., Macêdo, J. L. V., Kirst, M., & Veasey, E. A. (2016). Spatial genetic structure, genetic diversity and pollen dispersal in a harvested population of *Astrocaryum aculeatum* in the Brazilian Amazon. *BMC Genetics*, *17*(1). https://doi.org/10.1186/s12863-016-0371-8

Ribeiro, N. G. R., & Pinheiro, R. T. (2022). Multitemporal analysis of vegetation cover in the urban master plan of Palmas, Tocantins. *Ciência Florestal*, *32*(2), 1024–1046. https://doi.org/10.5902/1980509843524

Ribeiro, R. A., & Rodrigues, F. M. (2006). Genética da conservação em espécies vegetais do cerrado. *Revista de Ciências Médicas e Biológicas*, *5*(3), 253–260.

Rocha, A. N., & Polatto, L. P. (2017). *Bixa orellana* L. (Bixaceae): dependência de polinizadores e estratégias de forrageio dos visitantes florais. *Biota Amazônia*, *7*(3), 1–7. https://doi.org/10.18561/2179-5746/biotaamazonia.v7n3p1-7

Rocha, F. V. R., Souza, B. S., Feitosa, M. A. C., & Santos, T. T. (2017). Fungos associados a troncos de árvores em decomposição na Floresta Nacional do Tapajós, Pará, Brasil. *SaBios: Rev. Saúde e Biol., v*, *12*(2), 43–52.

Rodrigues, E. B., Collevatti, R. G., Chaves, L. J., Moreira, L. R., & Telles, M. P. C. (2016). Mating system and pollen dispersal in *Eugenia dysenterica* (Myrtaceae) germplasm collection: tools for conservation and domestication. *Genetica*, *144*(2), 139–146. https://doi.org/10.1007/s10709-016-9884-3

Sebbenn, A. M. (2006). Sistema de reprodução em espécies arbóreas tropicais e suas implicações para a seleção de árvores matrizes para reflorestamentos ambientais. In A. R. Higa & L. Silva (Eds.), *Pomar de sementes de espécies florestais nativas* (Vol. 1, p. 93). FUPEF.

Sebbenn, A. M., Carvalho, A. C. M., Freitas, M. L. M., Moraes, S. M. B., Gaino, A. P. S. C., Da Silva, J. M., Jolivet, C., & Moraes, M. L. T. (2011). Low levels of realized seed and pollen gene flow and strong spatial genetic structure in a small, isolated and fragmented population of the tropical tree *Copaifera langsdorffii* Desf. *Heredity*, *106*(1), 134–145. https://doi.org/10.1038/hdy.2010.33

Silva, C. R. S., Albuquerque, P. S. B., Ervedosa, F. R., Mota, J. W. S., Figueira, A., & Sebbenn, A. M. (2011). Understanding the genetic diversity, spatial genetic structure and mating system at the hierarchical levels of fruits and individuals of a continuous Theobroma cacao population from the Brazilian Amazon. *Heredity*, *106*(6), 973–985. https://doi.org/10.1038/hdy.2010.145

Silva, M. B., Kanashiro, M., Ciampi, A. Y., Thompson, I., & Sebbenn, A. M. (2008). Genetic effects of selective logging and pollen gene flow in a low-density population of the dioecious tropical tree *Bagassa guianensis* in the Brazilian Amazon. *Forest Ecology and Management*, *255*(5–6), 1548–1558. https://doi.org/10.1016/j.foreco.2007.11.012

Siqueira, A. C. M. de F., Sebbenn, A. M., Ettori, L. de C., & Nogueira, J. C. B. (2010). Variação genética entre e dentro de populações de *Balfourodendron riedelianum* (Engler) Engler PARA conservação *ex situ*. *Revista Do Instituto Florestal de São Paulo*, *12*(2), 89–103.

Souza, D. L., Evangelista-Rodrigues, A., & Pinto, M. do S. de C. (2007). As abelhas como agentes polinizadores. *Revista Electrónica de Veterinaria*, *8*(3), 1–7.

Souza, F. B. de, Kubota, T. Y., Tambarussi, E. V, Freitas, M. L., Moraes, M. L., Silva, A. M. da, Cambuim, J., & Sebbenn, A. M. (2018). Historic pollen and seed dispersal in fragmented populations of the two largest trees of the Atlantic Forest. *Forestry Research and Engineering: International Journal*, *2*(2). https://doi.org/10.15406/freij.2018.02.00033

Sujii, P. S., Tambarussi, E. V., Grando, C., Silvestre, E. de A., Viana, J. P. G., Brancalion, P. H. S., & Zucchi, M. I. (2021). High gene flow through pollen partially compensates spatial limited gene flow by seeds for a Neotropical tree in forest conservation and restoration areas. *Conservation Genetics*, *22*(3), 383–396. https://doi.org/10.1007/s10592-021-01344-3

Tambarussi, E. V., Boshier, D., Vencovsky, R., Freitas, M. L. M., & Sebbenn, A. M. (2015). Paternity analysis reveals significant isolation and near neighbor pollen dispersal in small *Cariniana legalis* Mart. Kuntze populations in the Brazilian Atlantic Forest. Ecology and Evolution, 5(23), 5588–5600. https://doi.org/10.1002/ece3.1816

Tarazi, R., Moreno, M. A., Gandara, F. B., Martins Ferraz, E., Luiz, M., Moraes, T., Vinson, C. C., Ciampi, A. Y., Vencovsky, R., & Kageyama, P. Y. (2009). High levels of genetic differentiation and selfing in the Brazilian cerrado fruit tree *Dipteryx alata* Vog. (Fabaceae). *Genetics and Molecular Biology*, *33*, 78–85.

Telles, M. P. C., Silva, S. P., Ramos, J. R., Soares, T. N., Melo, D. B., Resende, L. V., Batista, E. C., & Vasconcellos, B. F. (2010). Estrutura genética em populações naturais de *Tibouchina papyrus* (pau-papel) em áreas de campo rupestre no cerrado. *Revista Brasileira de Botânica*, *33*(2), 291–300.

Thiago, C. R. L., Magalhães, I. A. L., & Santos, A. R. (2020). Identificação de Fragmentos Florestais Potencias para a delimitação de Corredores Ecológi cos na bacia hidrográfica do Rio Itapemirim, ES por meio técnicas de Sensoriamento Remoto. *Revista Brasileira de Geografia Física*, *13*, 595–612.

Vinson, C. C., Kanashiro, M., Harris, S. A., & Boshier, D. H. (2015). Impacts of selective logging on inbreeding and gene flow in two Amazonian timber species with contrasting ecological and reproductive characteristics. *Molecular Ecology*, *24*(1), 38–53. https://doi.org/10.1111/mec.13002

Wendt, S. N., Sousa, V. A., Quoirin, M., Mazza, M. C., Sturion, J. A., & Sebbenn, A. M. (2009). Baixa taxa de contaminação de pólen, desvios de cruzamentos aleatórios e endogamia em um pomar de sementes de Ilex paraguariensis l. *Scientia Forestalis*, *37*, 185–196.

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis* (H. Wickham, Ed.; 2nd ed.). Springer.

Zaruma, D. U. G., Sebbenn, A. M., Rossini, B. C., Pardo, A. C. F., Silvestre, M. A. M., Cambuim, J., da Silva, A. M., Pupin, S., Rodrigues, C. J., Marino, C. L., & de Moraes, M. L. T. (2024). Mating system and inbreeding depression in *Hymenaea stigonocarpa*. *Tree Genetics and Genomes*, *20*(1). https://doi.org/10.1007/s11295-024-01639-9

TREED0273 – Supplementary Material

Pollen dispersal distance of Brazilian native tree species: a systematic review

Guimaraes et al., 2024.

Table S1. Descriptive statistical analysis of pollen dispersal distance (PDD) data from the species.

References	**Species**	**Common name**	**Mating system***	**Pollinator***	**Average (m)**	**Standard deviation (m)**	**Minimum (m)**	**Maximum (m)**
Sujii et al. (2021)	*Centrolobium tomentosum* Guill. ex Benth.	Araribá	Crossing	Bees	3191	-	3191	3191
Oliveira et al. (2020)	*Swietenia macrophylla* King	Mogno-brasileiro	Crossing	Bees and moths	1472	-	1472	1472
Carneiro et al. (2011)	*Hymenaea courbaril* L.	Jatobá	Crossing	Bats and hummingbirds	1450	908.3	100	2800
Guimarães et al. (2019); Tarazi et al. (2009)	*Dipteryx alata* Vogel	Baru	Crossing	Bees and small insects	1215.12	1478.32	135.37	2900
Moraes & Sebbenn (2011); Zaruma et al. (2024)	*Hymenaea stigonocarpa* Mart. ex Hayne	Jatobá do Cerrado	Crossing	Bats	1086.81	1591.87	25	5229
Pereira et al. (2024)	*Roupala montana* var. brasiliensis	Carvalho-Brasileiro	Crossing	Bees	938.75	932.54	25	3000

Dick et al. (2003)	*Dinizia excelsa* Ducke	Angelim-Vermelho	Crossing	Small insects	860.5	917.12	212	1509
Manoel et al. (2021)	*Astronium fraxinifolium* Schott	Gonçalo-alves	Crossing	Bees	850	1400.82	50	5000
Degen & Roubik (2004); Vinson et al. (2015)	*Dipteryx odorata* (Aubl.) Forsyth f.	Cumaru	Crossing	Bees	837.72	323.44	335.6	1092
Guidugli et al. (2016); Souza et al. (2018)	*Cariniana estrellensis* (Raddi) Kuntze	Jequitibá-branco	Crossing	Bees and small insects	714.26	983.15	9	4000
Silva et al. (2008)	*Bagassa guianensis* Aubl.	Tatajuba	Crossing	Wind and thrips	634.5	461.74	308	961
Carneiro et al. (2007); Hardy et al. (2006)	*Symphonia globulifera* L. F	Guanandi	Crossing	Birds, bats, and lepidopterans	629.71	372.81	141	963
Degen & Roubik (2004); Hardy et al. (2006); Vinson et al. (2015)	*Jacaranda copaia* (Aubl.) D.Don	Jacaranda copaia	Crossing	Bees	539.65	343.61	147.9	1180
Hardy et al. (2006)	*Virola michelii* Aubl.	Casca-de-vidro	Crossing	Small insects	505	-	505	505
Souza et al. (2018); Tambarussi et al. (2015)	*Cariniana legalis* Mart. O. Ktze	Jequitibá-rosa	Crossing	Bees	503.69	550.95	20	2928

Baldoni et al. (2017); Martins et al. (2018)	*Bertholletia excelsa* Bonpl.	Castanha-do-pará	Crossing	Bees	491.42	306.25	100	1000
Gaino et al. (2010)	*Myracrodruon urundeuva* M. Allemão	Aroeira	Crossing	Bees and small insects	427.27	294.42	50	900
Cloutier et al. (2007b); Hardy et al. (2006)	*Sextonia rubra* (Mez) van der Werff	Louro vermelho	Crossing	Small insects	414.5	464.57	86	743
Hardy et al. (2006)	*Chrysophyllum sanguinolentum* L.	Bapeba-veludo	Crossing	Bees	413	-	413	413
Bittencourt & Sebbenn (2007); Bittencourt & Sebbenn (2008); Medina-Macedo et al. (2015)	*Araucaria angustifolia* (Bertol.) Kuntze	Araucária	Crossing	Wind	352.84	472.2	25	2200
Hardy et al. (2006)	*Eperua grandiflora* Aubl.	Muirapiranga	Crossing	Bees	323	-	323	323
Potascheff et al. (2019)	*Qualea grandiflora* Mart.	Pau-terra	Crossing	Moths	292.8	327.96	60.9	524.7
Boshier et al. (1995)	*Cordia alliodora* (Ruiz & Pav.) Cham	Louro-Freijó	Crossing	Moths	280	-	280	280
Oliveira Melo & Franceschinelli (2016)	*Cabralea canjerana* (Vell.) Mart.	Cedro-canjerana	Crossing	Moths	206	-	206	206
Hardy et al. (2006)	*Dicorynia guianensis* Hamshoff	Angélica do Pará	Crossing	Bees	203	-	203	203
Hardy et al. (2006)	*Moronobea coccinea* Aubl.	Bacuri	Crossing	Small insects	195	-	195	195

Almeida-Júnior et al. (2018)	*Annona crassifora* Mart.	Marolo	Crossing	Bees and beetles	188.38	111.72	16	360
Hardy et al. (2006)	*Carapa procera* Aubl	Andiroba	Crossing	Bees	182	-	182	182
Hardy et al. (2006)	*Vouacapoua americana* Aubl.	Acapú	Crossing	Small insects	176	-	176	176
Cloutier et al. (2007a)	*Carapa guianensis* Aubl.	Andiroba	Crossing	Bees and small insects	150.6	105.84	69	268
Sebbenn et al. (2011)	*Copaifera langsdorffii* Desf.	Copaíba	Crossing	Bees	137.5	75.69	25	250
Buzatti et al. (2012)	*Dalbergia nigra* (Vell.) Allemao ex Benth	Jacarandá-da-bahia	Crossing	Bees and small insects	116.5	38.89	89	144
Ramos et al. (2016)	*Astrocaryum aculeatum* G.Mey	Tucumã	Crossing	Bees	110.1	60.5	20	200
Araújo et al. (2017)	*Acrocomia aculeata* (Jacq.) Lodd. ex Martius	Macaúba	Crossing	Bees and beetles	105	-	105	105
Aguiar et al. (2020)	*Balfourodendron riedelianum* (Engl.) Engl.	Pau-marfim	Crossing	Small insects	97.5	54.08	15	180
Baldauf et al. (2014)	*Himatanthus drasticus* (Mart.) Plumel	Janaguba	Crossing	Small insects	87.5	52.6	10	200
Rodrigues et al. (2016)	*Eugenia dysenterica* DC.	Cagaita	Crossing	Bees	80.45	-	80.45	80.45
Chaves et al. (2016)	*Aspidosperma polyneuron* Müll.Arg	Peroba	Crossing	Moths	65	-	65	65

Azevedo et al. (2007)	*Manilkara huberi* (Ducke) A. Chev.	Maçaranduba	Crossing	Bees	47	-	47	47
Silva et al. (2011)	*Theobroma cacao* L.	Cacaueiro	Crossing	Small insects	28	-	28	28
Wendt et al. (2009)	*Ilex paraguariensis* A.St.-Hil.	Erva-mate	Crossing	Small insects	15.9	-	15.9	15.9

*Adapted from Carvalho (2006).