Atlas of pollen and plants used by bees

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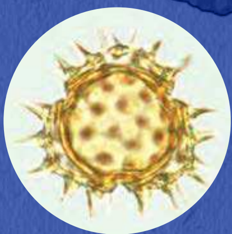
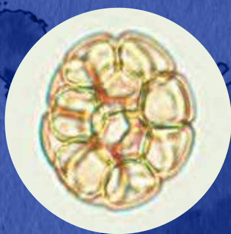
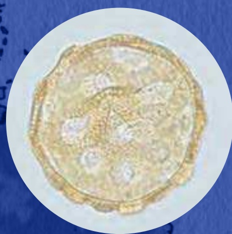
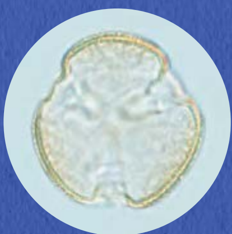

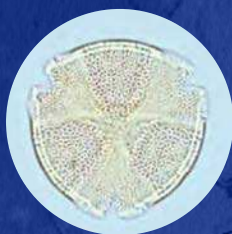

CISE
Consultoria Inteligente em Serviços Ecossistemicos

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Asociación Latinoamericana de Paleobotánica y Palinología

Las comunidades vegetales son componentes principales de los ecosistemas terrestres de las cuales dependen numerosos grupos de organismos para su supervivencia. Entre ellos, las abejas constituyen un eslabón esencial en la polinización de angiospermas que durante millones de años desarrollaron estrategias cada vez más específicas para atraerlas. De esta forma se establece una relación muy fuerte entre ambos, planta-polinizador, y cuanto mayor es la especialización, tal como sucede en un gran número de especies de orquídeas y cactáceas entre otros grupos, ésta se torna más vulnerable ante cambios ambientales naturales o producidos por el hombre. De esta forma, el estudio de este tipo de interacciones resulta cada vez más importante en vista del incremento de áreas perturbadas o modificadas de manera antrópica en las cuales la fauna y flora queda expuesta a adaptarse a las nuevas condiciones o desaparecer.

El catálogo cuenta con información sobre el contenido polínico y otros productos asociados (e.g. propóleo, resinas) ofrecidos por las plantas como sustento de sus polinizadores para todos los aspectos de su vida.

Por ello, la Comisión Directiva de la ALPP se enorgullece de presentar a la sociedad una obra de gran importancia socio-económica pues colabora con información útil para palinólogos y botánicos interesados en el estudio aplicado a la conservación de especies de insectos polinizadores.

La información presentada en forma de catálogo es incorporada en la Red de Catálogos Polínicos Online (RCPol www.rcpol.org.br), la cual es de libre acceso y permite a la comunidad científica establecer determinaciones taxonómicas de plantas y su polen de forma más precisa. Además, promueve la preservación de colecciones botánicas y palinológicas de manera virtual evitando su desaparición por daños ejercidos por el paso del tiempo u otro tipo de acontecimientos.

La aplicación de la información brindada en esta obra se extiende a otras disciplinas de la Palinología (Melisopalinología, Iatropalinología, Aeropalinología, Palinología Forense, Paleopalinología) agregando de esta forma más valor a este tipo de contribuciones.

Felicitamos a sus autores por este nuevo catálogo y estamos convencidos que será un ejemplo a seguir y por ello esperamos el apoyo de las editoriales para continuar con la publicación de nuevos resultados de este tipo de estudios científicos que constituyen un apoyo en diferentes ámbitos de la sociedad.

Mercedes di Pasquo
Presidente de la ALPP
(Gestión 2017-2020)

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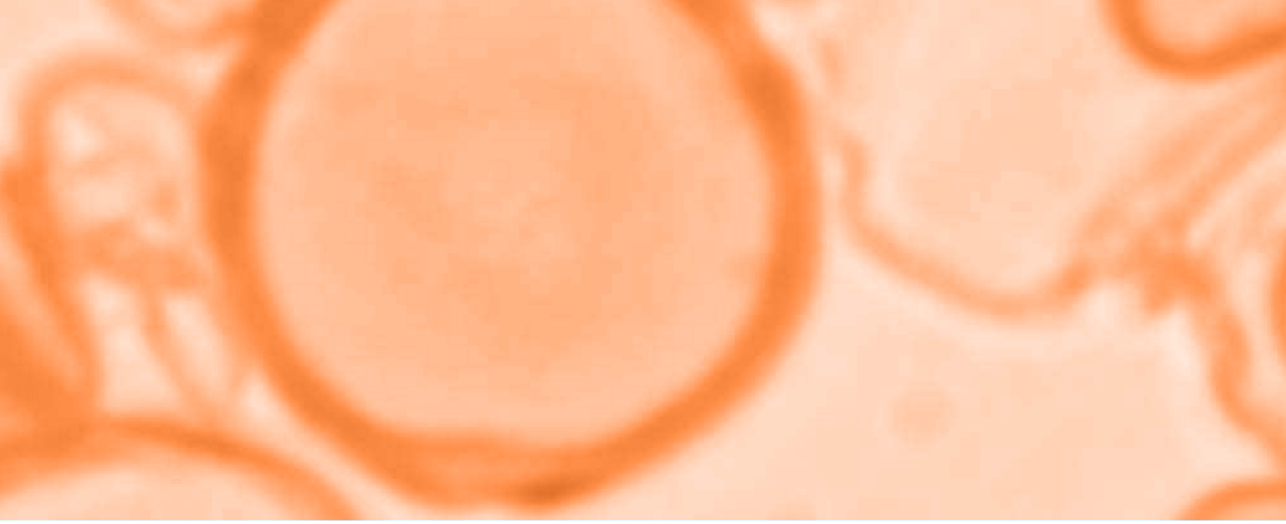
Pictures of pollen grains: RCPol's photographic collection, Cláudia Inês da Silva, Daniel Felipe Alvarado Ospino, Deicy Paola Alarcón-Prado, Jefferson Nunes Radaeski, Melissa Guerrero, Sandy C. Padilla-Báez.

Pictures of plants, flowers, bees, and nests: RCPol's photographic collection, Cláudia Inês da Silva, Carlos Poveda-Coronel, Cristiane Krug, Daniel Felipe Alvarado Ospino, Deicy Paola Alarcón-Prado, Epifânia Emanuela de Macêdo Rocha, Franciélli Cristiane Woitowicz-Gruchowski, Gercy Soares Pinto, Hugo A. Sanchez-Marroquín, Jefferson Nunes Radaeski, Kevin Farouk Miranda Deluque, Matheus Montefusco, Melissa Guerrero, Michael Hrncir, Paula Andrea Sepúlveda-Cano, Patrícia Nunes-Silva, Ruben D. Martín-Rojas, Sandy C. Padilla-Báez



The most intriguing insect on the planet is in focus again as we take a journey through the intricate details of bee life.

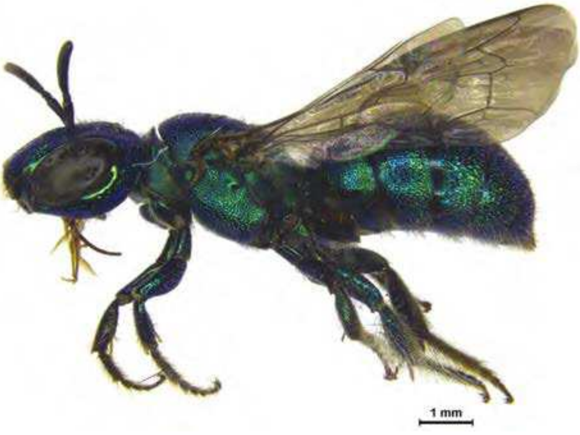
The incredible organization they apply to survive and thrive as a community has always been a matter of extreme interest to researchers and enthusiasts alike.

As a research and development company, Bayer has been dedicated to studying bees for more than thirty years. Understanding their relevance in pollination and in preserving biodiversity, the company has sponsored this project in order to establish a reference in literature.

This compilation of studies was published by the most important bee specialists.

We would like to thank all the entities and professionals involved, especially the coordination group for their dedication.

Claudia Quaglierini
Tropical Intelligence Manager
CEAT - BAYER



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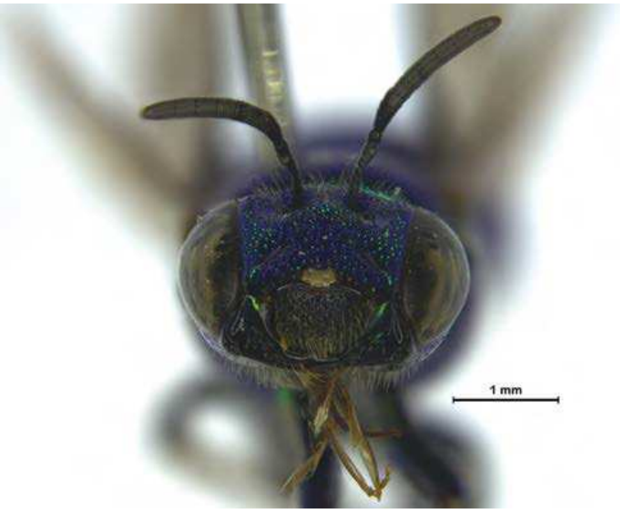
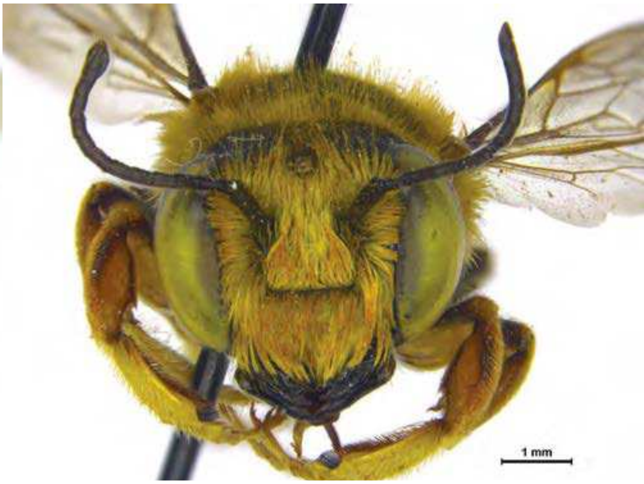


***Ceratina* sp.**

***Megachile* sp.**

***Megachile* sp.**



***Megachile* sp.**

Summary

Preface

Palynology is considered one of the most important tools in the study of plant-bee interactions. Among the various pollinating agents that exist in nature, bees occupy a prominent place because they live in society, but also in a solitary way, and have characteristics that favor pollination. In tropical regions, they are responsible for the pollination of most plant species. As a result, they are considered essential for maintaining biodiversity.

The knowledge of bees as pollinating agents and the use of their products, such as honey, go back to prehistoric times when honey was the only natural sweet food. Many species of plants depend on bees to transport pollen between flowers, while bees need pollen for their growth and development.

The role of bees in preserving many plant species through pollination is undoubtedly one of the most important alternatives for the sustainable development of a region. As it contains valuable data on the diversity of pollen collected by bees from different regions of the country and abroad, this work will certainly encourage researchers to expand their studies to learn about the diet of bees in different types of vegetation and climate, through pollen analysis. This knowledge of plants used as trophic resources by bees is important and serves as a basis for the conservation and maintenance of promising species for the production of honey in the tropical region, thus promoting the development of meliponiculture.

Descriptions of pollen morphology enriched with illustrations of the respective plant species may serve as inputs for the different areas of Palynology as well as for other areas of science. The data presented on the plants used by bees may indicate their enormous generalist potential or the tendency that some bees to depend on certain continuous sources of pollen throughout the year. Therefore, in these studies, the identification of pollen collected by bees is essential, a fact that highlights the relevance of the data presented in this Atlas for research involving plant-bee interactions and the important role they play in the pollination of many plant species, essential for the balance of ecosystems.

I greet all the authors and other collaborators who contributed to the realization of this important work that will greatly assist researchers, students of different levels of education, beekeepers and the general public.

Prof. Dr. Maria Lúcia Absy
Researcher
Instituto Nacional de Pesquisas da Amazônia (INPA)

Tetragonisca angustula **visiting flower of** ***Ocimum basilicum***

Online Pollen Catalogs Network: digital database of pollen and spores of current plants and fossils

CLÁUDIA INÊS DA SILVA, MERCEDES DI PASQUO, SORAIA GIRADI BAUERMANN, GONZALO JAVIER MARQUEZ, ASTRID DE MATOS PEIXOTO KLEINERT, FRANCISCO DE ASSIS RIBEIRO DOS SANTOS, MARIA IRACEMA BEZERRA LOIOLA, ALLAN KOCH VEIGA, ANTÔNIO MAURO SARAIVA

The Online Pollen Catalogs Network - RCPol (www.rcpol.org.br) was conceived in 2009, officially created in September 2013, and opened to the scientific community at the XIV International Palynological Congress and X International Organization of Palaeobotanical Conference in Salvador, State of Bahia, Brazil, in 2016. Since its conception, RCPol has been proposed with the main objectives of creating a digital repository of pollen and plant collections for their conservation and avoiding potential loss of material, becoming a free access tool to researchers (collaborators) and the global community.

A small technical group was responsible for carrying out the essential task of building the computer system and a group of collaborators established standards and protocols to be followed by the members of the network (Silva et al. 2014a, b; Figure 1). The achievement of this first major objective resulted in a digital platform through the development of a computational tool called "interactive key with multiple entries for species identification", by the coordinators of RCPol, Cláudia Inês da Silva, Antonio Mauro Saraiva and researchers from the Polytechnic School of the University of São Paulo, a stage made possible by the financing of the project by the University and Bayer.

Since 2016, the database has three interactive keys, Palynotaxonomy, Palynoecology and Paleopalynology, in which morphological traits of pollen and flower of current angiosperms can be consulted, in addition to scattered pollen and spores from the Quaternary. Each key has a glossary of terms and a template sheet that allows the network collaborator to upload the morphological and location information of their plant specimens and pollen grains contained in the plant and pollen collections (Table 1, Figure 2).

In 2016, it was proposed the expansion of the database to contain information about Gymnosperms and spores of Ferns and Lycophytes. In 2017, the process of building the interactive spore key and its corresponding glossaries and spreadsheets was carried out, and in

Figure 1. Workshop held at the University of São Paulo in 2016, in which researchers from various lines of research participated to help build the RCPol site.

Table 1. Example of the information incorporated by collaborators in the interactive key with multiple entries for species identification.

Institution	Number of specimens	Year	Key
CICYTTP	13	2017	Spores
ULBRA	14	2017	
UFRJ	54	2018	
ULBRA	106	2017	Paleopalynology
GOETTINGEN	225	2017	
FFCLRP-USP	99	2016	Palynoecology
UFC	364	2016	
UFU	77	2016	
UFERSA	64	2017	
UFC	82	2017	
UMNG	48	2018	
IBUSP	217	2019	
ULBRA	132	2017	Palynotaxonomy
FFCLRP-USP	99	2016	
UFC	364	2016	
UFU	77	2016	
UFERSA	64	2017	
UFC	82	2017	
UMNG	48	2018	
ITV	14	2017	
ULBRA	95	2018	
UFPR	29	2019	
IBUSP	169	2019	
FML	13	2019	
CBUMAG	71	2019	
ROM	29	2019	
UOFG	98	2019	
UEM	144	2020	

2018 the information from collections in Brazil and Argentina was made available online (Table 1, Figure 2).

In 2020, the key that contains essential information about the interaction of plants and bees to characterize their food resources was also made available (Figure 3). Funders and members of RCPol considered this issue to be of great importance. Fundamental financial support was provided to face numerous challenges that successfully materialized several achievements**:**

1. Four interactive keys are available with their glossaries of terms;
2. Outstanding increase in the number of species in each key and specimens belonging to various pollen collections, from many institutions in several countries (Table 1);
3. Seventeen collections were added to the network;
4. More than 12,830 pictures of plants (958), flowers (901), pollen (Palynotaxonomy = 6636; Palynoecology = 3604; Paleopalynology = 331; Spores of = 324) and bees (76) were added;
5. More than 1,200 participants joined 7 workshops and 12 scientific meetings, given by 30 instructors at scientific institutions and events in Brazil and other countries, and expressed their support and intention to collaborate with the information in their collections (see www.rcpol.com.br, Figure 4).

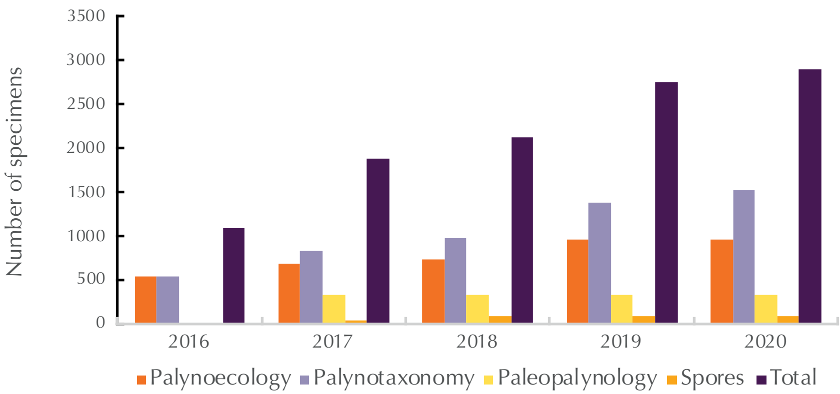


Figure 2. Evolution of the loading of pollen collection specimens in the RCPol from 2016 to 2020.

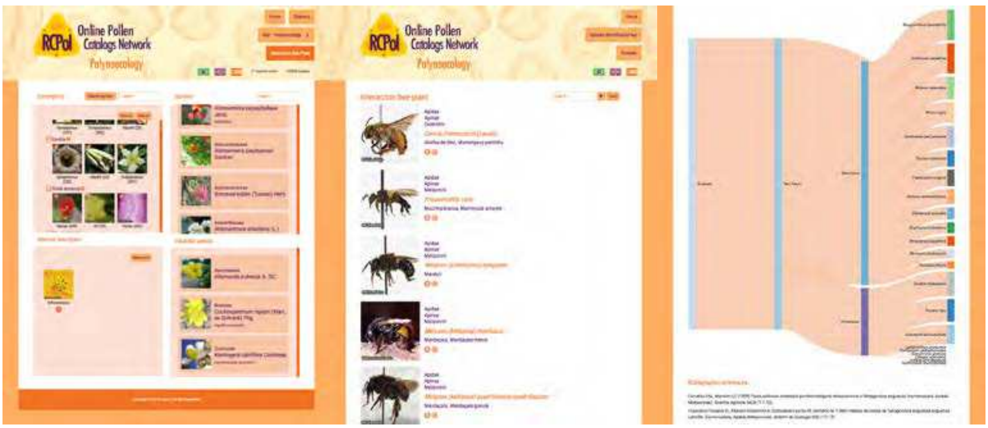


Figure 3. Palynoecology key and its application in the bee conservation.

Figure 4. Sample of activities carried out in workshops offered at different institutions in Brazil and other countries.

The information provided by RCPol allows the identification of current and Quaternary species as the first link in the development of applied studies in different lines of Palynology (e.g. Melissopalynology, Aeropalynology, Archeopalynology, Forensic palynology, Paleopalynology, Actuopalynology), Botany, Ecology, Zoology, Agronomy, etc. They are also essential information to generate good flora management in natural and cultivated areas, in order to preserve pollinator species that use pollen grains and other flower products as food resources. Studies on pollinator food preferences, typical of each region, allow to maintain or even improve fruit and seed production. Also are good tools to the conservation strategies in protected areas, which are the refuge of natural pollinators. The studies also allow us to know how these pollinators could adapt to natural or man-made environmental changes. A permanent challenge is to expand the collaborators base to add new collections and data.

The RCPol website (www.rcpol.org.br) also provides several information related to the institutions that host the collections and their managers (collaborators), in addition to bibliographic references used as support, news, events and courses of interest to the scientific community. It is also possible to download published regional flora catalogs that have adopted a format similar to that of RCPol.

A strategy to publicize the network and present successive advances included participation in scientific events and the provision of workshops and training courses at events and institutions in many countries. Different aspects were addressed in these events and courses, such as the use of computational tools for data loading and, fundamentally, the standardization of data quality in the morphological description of plants and pollen. This data quality control, as established in the network standards, is carried out by a group of scientists to allow the incorporation of the information in the database.

Another important point is the data usage policy of the RCPol network. It was very important to define the obligations and rights of those responsible for the data for each pollen collection and the conditions for access and use by users. In the first case, aspects such as data quality were considered and it was agreed that the data incorporated into the network must follow a standard quality policy. A collection of different data policy models was carried out to serve as a basis for discussing the policy that RCPol would adopt. It is important to note that the data come from researchers and their institutions and not from RCPol, which has only the tools for aggregating and disseminating information. This favors the meeting of researchers and information about their collections and work.

RCPol has a complex information system behind its website and its development faced five challenges in Biodiversity Informatics: 1) Data Integration; 2) Data Standardization; 3) Data Quality; 4) Data Internationalization; and 5) Data Publishing. The RCPol goal was to integrate high quality data provided by several researchers spread over several institutions and countries. These data must be standardized to allow integration and be easily used by a many people from around the world, with different interests, who can benefit from this pollen-related information. Enabling the access to integrated data from different sources enhances the usefulness of the data for application in a wide range of research, which could expand the scientific knowledge in several areas.

To allow data integration, a data standardization process must be carried out. The Biodiversity Information Standards (TDWG - www.tdwg.org) supported the standardization of data on biodiversity, focusing mainly on data on the occurrence of biological species. However, in the specific case of pollen data, RCPol had to create a new data standard to support the integration of pollen data. We adopted the Darwin Core (DwC) standard as much as possible (Wieczorek et al. 2012) and developed specific terms (its syntax and semantics) to accommodate the need to describe pollen data not addressed by DwC. This was done in conjunction with the members of RCPol and based on international literature to provide a solid foundation. The result can be consulted in a glossary of terms available in three languages (English, Brazilian Portuguese and Spanish) at http://chaves.rcpol.org.br/profile/glossary/eco.

To provide reliable data for data consumers, RCPol has adopted a data quality assurance policy. All datasets provided by RCPol members are evaluated by RCPol palynology specialists and, when a dataset is compatible with the RCPol's data quality policy, these data are published on the web-based system (http://chaves.rcpol.org.br). This data quality assessment used to be performed manually by specialists and was time consuming and subject to failure due to the large volume of data. To support the data quality assessment in a more automated and effective way, a data quality tool was developed that implements a series of mechanisms to measure, validate and improve integrity, consistency, compliance, accessibility and exclusivity of the data, before the manual evaluation by experts.

The system was designed according to the conceptual framework proposed in Task Group 1 of the TDWG Biodiversity Data Quality Interest Group (Veiga et al. 2017). For each dataset, the data quality tool generates a set of measurement assertions, validations and amendments for the records and the dataset itself, according to a data quality profile defined for RCPol. As RCPol has adopted a quality assurance approach (only data that are compatible with all quality requirements are published in the system), only datasets with 100% of integrity, consistency, compliance, accessibility and exclusivity are published.

This web-based tool is available at http://chaves.rcpol.org.br/admin/data-quality. Although this system contributes to significantly reduce the amount of work by specialists, some data may still contain values that cannot be easily and automatically assessed (for example, validating whether the content of an image corresponds to its scientific name). Thus, manual evaluation by specialists remains necessary in some cases. After the system reports that the data conforms to the profile, a manual assessment must be carried out by the experts (using the data quality report to support them) and, only after this process, will the dataset be ready for publication (Figure 5).

To make the RCPol data useful for most people from different countries, needs and backgrounds, the entire system and data are available in three languages. A mechanism was developed that translates datasets from their original language into English, Portuguese and Spanish, based on the RCPol standardized metadata scheme. Therefore, when a dataset originally created in English, for example, is published in the RCPol system, it is automatically available in three

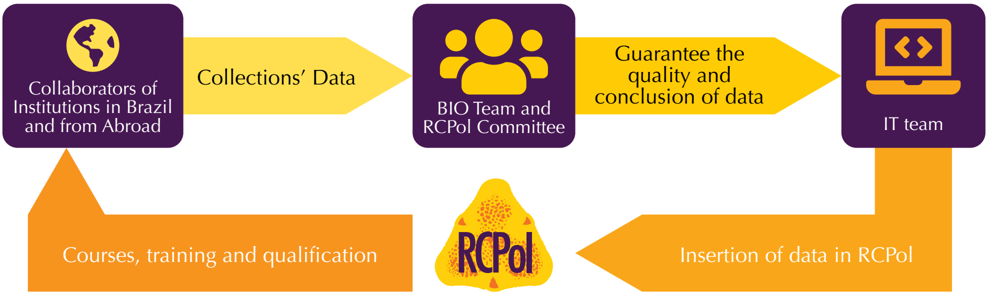


Figure 4. Process carried out by RCPol members.

languages for the RCPol data user, without any effort from our data providers to do the manual translation.

To enhance the usefulness of all data provided by RCPol members, these data are used to present information in an easier way for non-technical people. The RCPol system publishes data-based information in six ways: 1) interactive keys, to facilitate species identification based on pollen, flower and plant features; 2) species profiles, which provide various useful information about a species, compiled from several samples of specimens from the same taxon; 3) specimen profiles, containing information for each specimen provided by RCPol members, and which allow the generation of species profiles and interactive keys; 4) institution profiles, with contact information about RCPol members, to promote interactions between data providers and consumers; 5) bee-plant interactions, with information on interactions presented according to geographic regions; and 6) glossaries of terms, integrated with the interactive keys, species profiles, specimen profiles and interaction networks, which help non-technical people use and interpret RCPol's shared data.

So far, the RCPol website has more than 194,000 accesses and, as a demonstration of the system's impact, the data published by RCPol have been accessed 52,000 times and reached more than 11,000 people from more than 1,000 cities in 68 countries worldwide, according to Google anlaytics on April 1, 2020.

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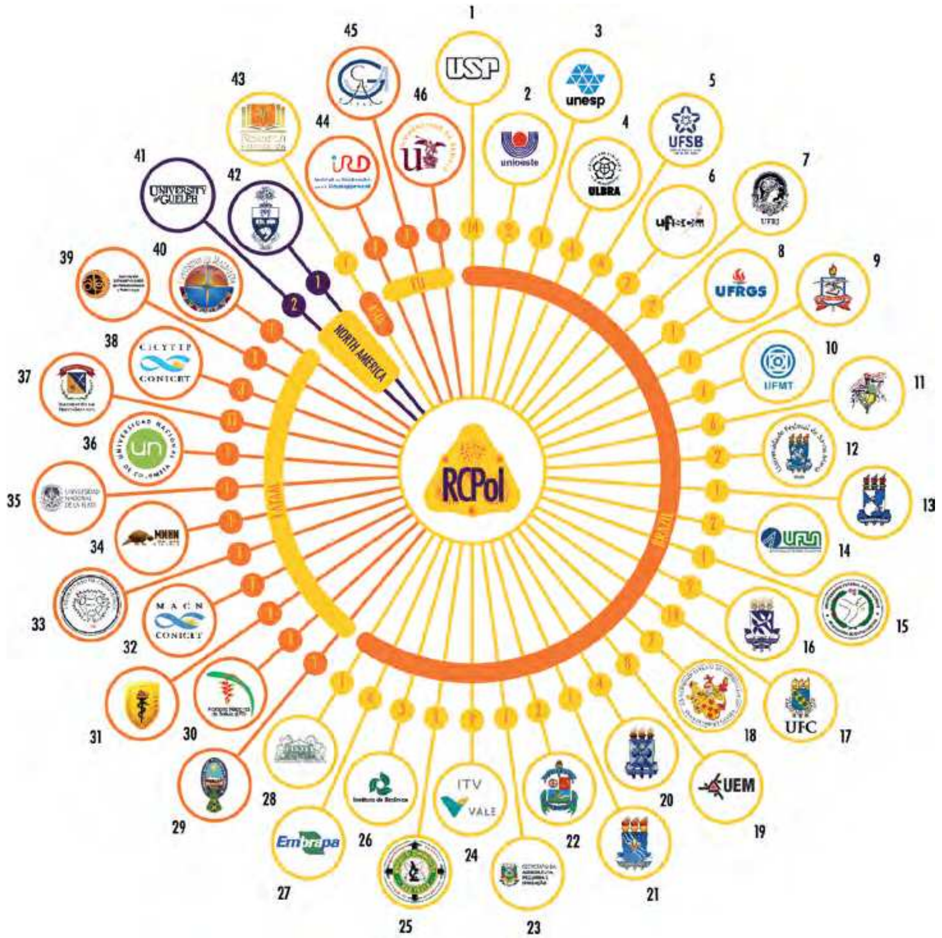

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Bombus atratus **visiting flower of** ***Pentas lanceolata***

Eucera pruniosa* visiting flower of *Cosmos bipinnatus

The plants visited by bees in Canada, with focus on *Eucera pruinosa* Say, 1837 (Apidae, Eucerini)

PATRÍCIA NUNES-SILVA, CLÁUDIA INÊS DA SILVA, DANIEL FELIPE ALVARADO OSPINO, PETER G. KEVAN

Introduction

This study was partially developed on Peter Kevan's laboratory, at the School of Environmental Sciences, University of Guelph (Figure 1). Peter Kevan's studies have been concentrated on applied ecology in terrestrial ecosystems from the far northern Arctic to the tropics. The work has focused especially on insect and plant interactions, notably pollination ecology in both natural and agricultural settings, and some emphasis in plant protection, plant reproductive biology and pollinator behavior. The overall thrust has been elucidation and use community functionality for basic evolutionary ecological understandings and application to "ecological intensification" a.k.a. "ecosystem stacking". Most recently, the work has been on apivectoring (using managed pollinators to disseminated biocontrol agents to crop plant flowers to protect them, and the crop, from pests (fungi to insects; Kevan et al. 2020a) and on micrometeorology within plants' stems, fruits and flowers (Kevan et al. 2020b).

The first author worked as a post-doctoral fellow on Peter Kevan's laboratory in 2017 and 2018, developing the project "The role of *Cucurbita* spp. (Cucurbitaceae) microclimate and floral morphology in their interaction with *Eucera pruinosa* Say (Apidae, Hymenoptera)". Although it was not exactly related to the main question of her study, she knew squash bees (*E. pruinosa*) are known to be oligolectic, collecting pollen only mostly from *Cucurbita* species

Figure 1. The building where Peter Kevan's laboratory is located at the School of Environmental Sciences at University of Guelph.

(Hurd and Linsley 1964). During field work on agricultural areas, squash bees were observed visiting the flowers of various plant species (Figure 2) other than *Cucurbita pepo* (Figure 3). The first author was intrigued by the lack of information on which the flowers of non-*Cucurbita* plant species that are visited by those bees for nectar (Hurd and Linsley 1964), reasoning that because those nectar sources may be important energy sources for the maintenance of squash bees in agricultural areas.

Material and Methods

To evaluate the diversity of nectar sources of squash bees, males and females were collected at 9 sites (Table 1) in Ontario, Canada. The sites are within ecoregions whose lands have been heavily converted (from around 60% to 80%) into cropland, pasture and urban areas. In fact, these ecoregions are the most densely populated, urbanized and industrialized in Ontario. Where natural vegetation remains, the forest cover includes deciduous, conifer-

Figure 2. Some of the plants visited by squash bees. A - C) Male on an Asteraceae. D - E) Female on Asteraceae. F) Female (bottom) and male (upper) on chicory flowers.

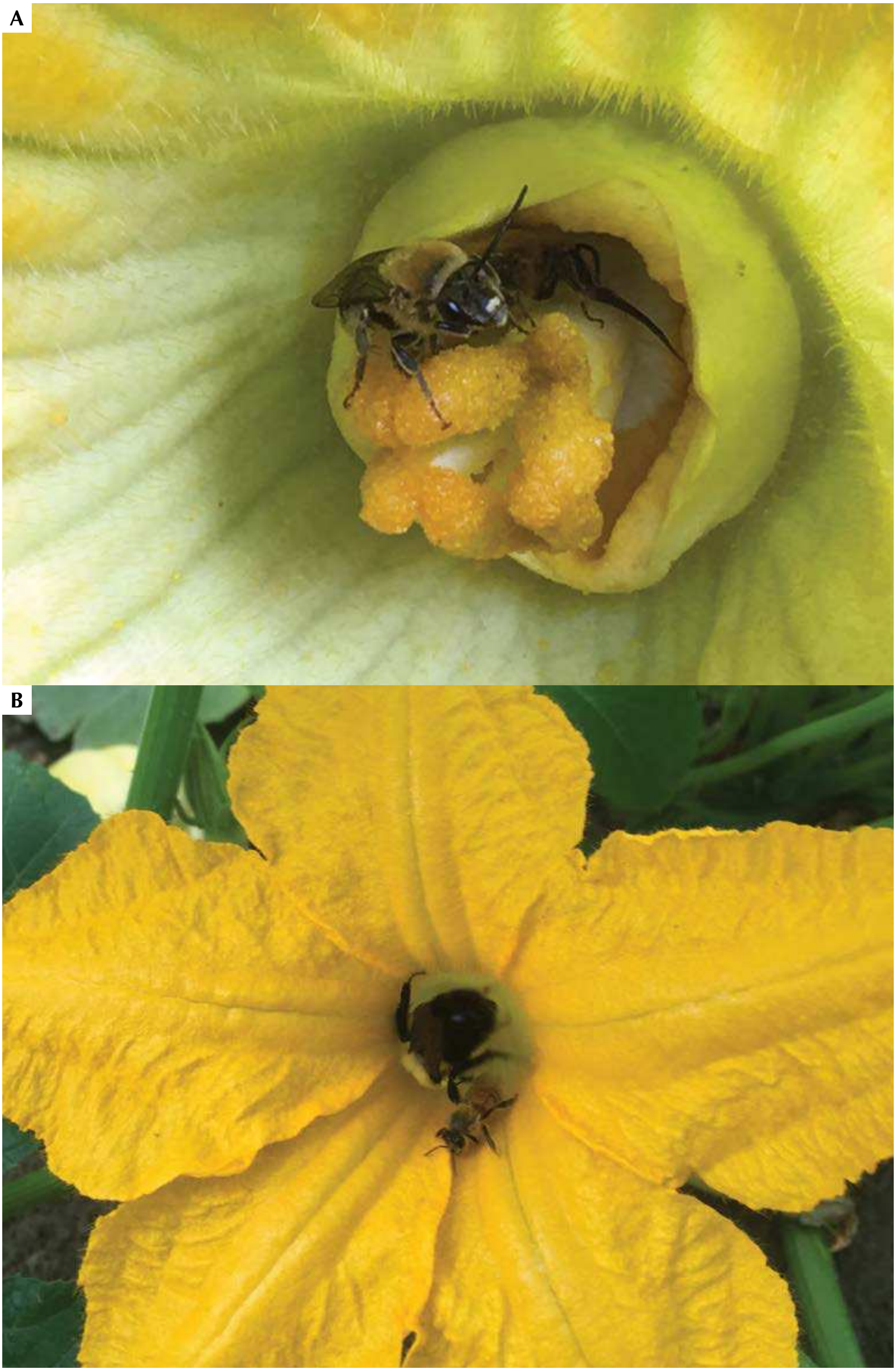

Figure 3. *Cucurbita pepo* flower. A) Squash bee males. B) Bumble bee (*Bombus impatiens*) and honey bee (*Apis mellifera*).

Table 1. Collection sites, geographical coordinates and number of bees collected in each site (N).

Locality	Sites	Geographical coordinates	N
Aylmer	Howe Family Farm	42°43′55.1″N 81°00′25.0″W	53
Guelph	Strom's Farm and Bakery	43°29′51.5″N 80°17′35.1″W	47
Alvinston	-	42°48′23.5″N 81°51′53.6″W	20
Janetville	Lunar Rhythm Gardens	44°08′20.1″N 78°41′46.3″W	24
Indian River	-	44°20′04.8″N 78°08′11.4″W	20
Lakefield	Buckhorn Berry Farm	44°32′23.0″N 78°18′22.7″W	30
Little Britain	StellMar Farm	44°14′36.0″N 78°46′32.8″W	24
Zephyr	Cooper's CSA Farm & Maze	44°08′52.0″N 79°15′06.7″W	23
Petersburg	Shantz Family Farm	43°23′46.5″N 80°34′15.2″W	37
	Total		267

ous, and mixed forest (Crins et al. 2009). All sites were agricultural farms (Figure 4).

Squash bees were collected as they visited flowers of *Cucurbita pepo* and other plant species in the study areas. They were stored in 2mL Eppendorf tubes and kept on ice during transport to the laboratory. There, after being woken up, they were washed, according to Silva et al. (2010), for pollen removal from their bodies (Figure 5) and stored in another 2mL Eppendorf tube. Both the body pollen and the bee specimens were preserved in 70% ethanol solution. The bee specimens were used for other studies, which included the removal of body parts and because of that were not deposited in any entomological collection.

The preparation of the pollen collection from the flowers of *C. pepo*, other plants, and from the bee's bodies followed the protocols described by Silva et al. (2014). For making pollen reference slides, non-dehisced anthers of the blooming plants present on the sites were collected. Pollen slides were deposited on the RCPol pollen collection (www.rcpol.org.br). A branch containing flowers and leaves of each was also collected and pressed. The exsiccates were prepared by the team of the herbarium, following standard methods, and deposited at the BIO (Biodiversity Institute) Herbarium at the University of Guelph. A total of 33 plants were surveyed.

Results

We found 71 pollen types on squash bees' bodies, always at very low amounts (around 4 pollen grains per bee). Of those, 67 are not *Cucurbita* pollen grains, demonstrating that squash bees visited several other plants species (Figure 2), presumably for nectar, which may be important for their survival on such anthropogenically disturbed areas.

Acknowledgments: TThe post-doctoral researcher scholarship was provided to Patrícia Nunes-Silva by National Council for Scientific and Technological Development – CNPq (201568/2017-9). To the RCPol - Online Pollen Catalogs Network (FDTE process #001505) for support in identification, measurements and descriptions of pollen grains. Carole Ann Lacroix and Charlotte Coates from OAC Herbarium, University Guelph for the support with plant identification.

Figure 4. Some of the collection sites. A) Guelph. B) Petersburg. C) Aylmer.

Figure 5. Squash bee male during pollen washing.

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Eucera pruniosa **visitng chicory flower**

Pollen load analysis of wild bees in an oil palm crop in Magdalena, Colombia

DANIEL F. ALVARADO OSPINO, KEVIN F. MIRANDA, PAULA A. SEPÚLVEDA-CANO

Research group and the palynological collection

Fitotecnia del Trópico research group belongs to Agronomic Engineering Program of University of Magdalena, located in Santa Marta, Colombia. We study the agricultural production environment, the plant-insect-microorganism interactions, the biodiversity in agroecosystems, and alternatives to traditional pest management in order to improve agricultural production. Our research includes the plant-pollinator interaction by analysis of bee pollen loads, pollination biology and the improvement of the stingless bee production system. The palynological collection was processed in the Entomology Laboratory and deposited in the Biological Collections Center of the University of Magdalena (CBUMAG) (Figure 1). This collection includes approximately 2,500 slides of bee pollen loads (60 species approximately) and plant pollen (258 species).

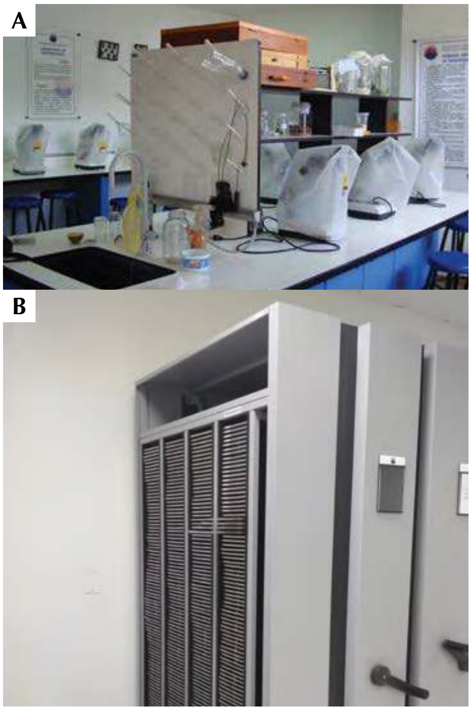

Figure 1. Biological Collections Center of the University of Magdalena (CBUMAG). **a)** Entomology Laboratory. **b)** Palynological collection of University of Magdalena.

The project

The palynological collection of University of Magdalena began with the project "Determination of the potential of palm agroecosystem for the development of conservation beekeeping proposals", whose objective was to identify the most important polyniferous and nectariferous plants used by wild and cultivated bees (stingless bees and honeybees) from pollen load analysis, associated with nine oil palm agroecosystems, in order to develop beekeeping proposals that improve the quality of life of small palm-growing families and contribute to the conservation of the socio-ecosystem components.

The northern palm area of Colombia is characterized by the presence of important dry forest ecosystems and floodplains, both in a state of threat, and these agroecosystems have been established near natural areas considered of great value due to their biodiversity, such as the Ciénaga Grande de Santa Marta, considered the largest inland aquatic ecosystem in Colombia and the Sierra Nevada de Santa Marta declared a Biosphere Reserve by UNESCO (Aguilera 2011).

Here, we show the results of one of the nine fields evaluated, located in the commercial oil palm farm Tequendama (Aracataca, Colombia), at coordinates 10°32'55,3"N and 74°10'56,8"W (Figure 2). The climate in the region is Tropical Savanna Climate (Aw), according to the Köppen climate classification, and it is a Tropical Dry Forest, according to Holdridge life zone system. The average annual rainfall is 1,348 mm with temperature of 27.8 °C.

This area has organic oil palm crops, where the growth of wild vegetation is allowed (Figure 3). The landscape is composed of native plants (50%), exotic plants (7%), naturalized plants (5%) and plants whose origin is unknown (38%).

We established two 400 m transects, one in the field edge and one in the crop interior, where all flowering plants and bees were collected manually and with nets. We conducted seven surveys between February 2016 and August 2017. The plants were stored in the Herbarium UTMC of the University of Magdalena and identified. The bees were identified, and pollen samples were taken from their bodies and stored in Ependorf tubes with 70% alcohol.

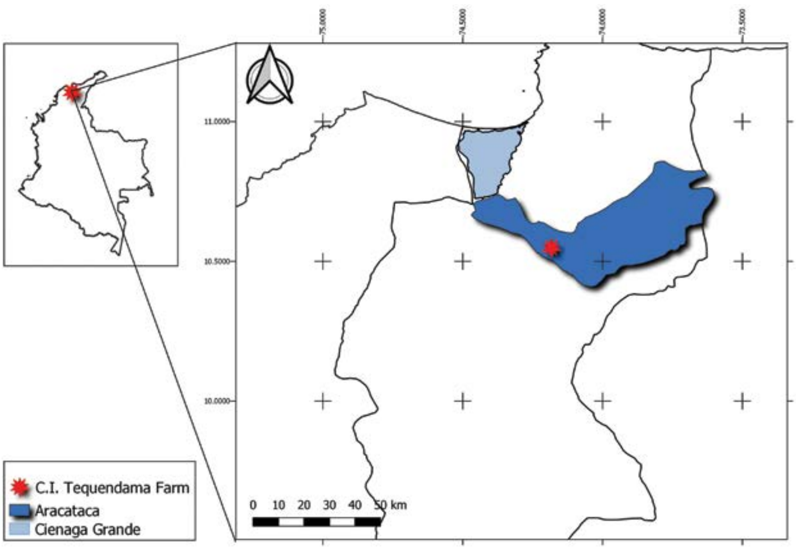

Figure 2. Location map of study area.

Seventy-five pollen loads were macerated with KOH digestion procedure Slides were prepared using a little piece of glycerin jelly, in which a drop of pollen grain suspension was added. Slides were sealed with paraffin. At least 400 pollen grains of each slide were counted and compared for taxonomic identification with a reference slide from a collection compiled by González and Tejeda (2018) from flowering plants collected in different palm agroecosystems.

Bee-plant interactions were represented in a graph of binary data interactions, where one (1) indicates the presence of interaction and zero (0), absence of interaction by the bipartite package (Dormann et al. 2008) in the R software (R Core Team 2020).

Where the bees collect pollen in an oil palm crop?

Palynological analysis were performed in 150 slides of pollen loads (two for each bee) corresponding to 19 bee species of three families: Apidae, Halictidae and Megachilidae (Table 1). Thirty-eight pollen types were identified in the bee pollen loads (Table 2). The most representative families were Fabaceae (with nine species of bee-visited plants), followed by Malvaceae, Cucurbitaceae and Asteraceae. Fabaceae is a common and large family of flowering plants, considered very important for the bee diet (Alves and dos Santos 2019; Grosso et al. 2014; Angel et al. 2001), especially in the Colombian Caribbean region (León 2014).

Figure 3. Oil palm crops landscape of northern of Colombia.

Table 1. Bee species found on the C.I. Tequendama and number of pollen types per bee species.

Family	Bee species	Pollen types (#)	Abbreviation
Apidae	*Ancyloscelis* sp. (n=2)	1	Ancysp
	Apis mellifera Linnaeus, 1758 (n=29)	7	Apimel
	Centris sp. *(n=1)*	4	Centsp
	Ceratina sp1 (n=1)	3	Cersp1
	Ceratina sp2 (n=3)	2	Cersp2
	Ceratina sp3 (n=3)	11	Cersp3
	Ceratina sp4 (n=1)	3	Cersp4
	Exomalopsis sp. (n=8)	11	Exomsp
	Paratetrapedia sp. (n=1)	4	Parasp
	Thygater sp. (n=1)	4	Thygsp
	Trigona fulviventris Guérin, 1844 (n=9)	11	Triful
	Trigona (Trigona) sp. (n=2)	1	Trigsp
	Xylocopa sp. (n=1)	4	Xylosp
Halictidae	*Augochlora* sp1 (n=2)	5	Augsp1
	Augochlora sp2 (n=2)	2	Augsp2
	Augochloropsis sp. (n=1)	2	Augsis
	Halictus ligatus Say, 1837 (n=1)	2	Hallig
	Lasioglossum sp (n=3)	4	Lasssp
Megachilidae	*Megachile* sp. (n=4)	7	Megasp

Cucurbita sp., *Spilanthes urens*, *Cucurbita maxima*, *Momordica charantia* and *Talinum* sp. were the plants most used by the bees evaluated (Figure 5). Family Asteraceae was the most abundant in the total of the analyzed individuals, especially *Spilanthes urens* followed by *Mikania michranta* (Figure 6). The preference of bees for Asteraceae flowers could be explained by the fact that these plants represent a high reward of pollen and nectar, bloom for a long period of time, have a great abundance and can be found in many different habitats (Muller and Bansac 2004).

Because 81.57 % of the identified plants were herbaceous, 7.89 % arboreal and 10.52 % had other habits, it is necessary to train farmers to recognize the importance of weeds for the support of the bee community in oil palm crops and investigate the real impact they can have on oil palm production, in order to conserve them in the ruderal areas.

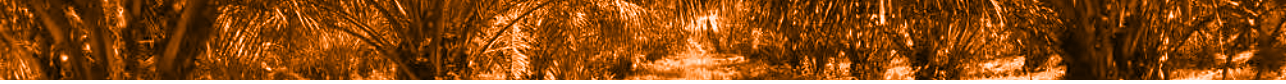

Table 2. Plant species corresponding to the pollen types found in the pollen loads of bees in C.I Tequendama and their frequency of occurrence.

Family	Plant species	Spanish common name	FO%	Abbreviation
Aizoaceae	*Trianthema portulcastrum* L.	Araña de perro	R	Tripor
Amaranthaceae	*Alternanthera albotomentosa* Suess	Abrojo blanco	PF	Altalb
Arecaceae	*Elaeis guineensis* Jacq.	Palma africana	*F*	Elagui
Asteraceae	*Asteraceae* sp1		*R*	Aster1
	Asteraceae sp2		*R*	Aster2
	Mikania micrantha Kunth	Guaco blanco	*R*	Mikmic
	Spilanthes urens Jacq.	Botón de plata, dormidera	*F*	Spiure
Caryophyllaceae	*Caryophyllaceae* sp1		R	Caryo1
Cleomaceae	*Cleome spinosa* Jacq.	Jardín del río	R	Clespi
Commelinaceae	*Commelina diffusa* Burm.f.	Canutillo	R	Comdif
	Murdannia nudiflora (L.) Brenan		R	Murnud
Convolvulaceae	*Ipomoea* sp1	Campanita	F	Ipomsp
Cucurbitaceae	*Cucurbita maxima* Duchesne	Ahuyama	F	Cucmax
	Cucurbita sp.		F	Cucusp
	Melothria pendula L.	Pepinillo de monte	R	Melpen
	Momordica charantia L.	Balsamina	F	Momcha
Fabaceae	*Caesalpinoidae*		R	Caesal
	Calopogonium caeruleum (Benth.) Sauvalle		R	Calcae
	Centrosema sp.		R	Centsp
	Chamaecrista sp.		R	Champ
	Mimosa pudica L.	Dormidera	R	Mimpud
	Mimosoidae		PF	Mimoso
	Pueraria phaseloides (Roxb.) Benth.	Kudzu	R	Puepha
	Senna obtusifolia (L.) H.S.Irwin & Barneby	Bicho macho	F	Senobt
	Vigna sp.	Platanillo	PF	Vignsp
Undeterminated taxa	Type 1.		R	Tipop1
	Type 2		R	Tipop2
	Type 3		R	Tipop3
Lythraceae	*Cuphea carthagenensis* (Jacq.) J.F.Macbr.		R	Cupcar
Malvaceae	*Corchorus aestuans* L.		R	Coraes
	Melochia parvifolia Kunth	Escoba blanca	R	Melpar
	Melochia pyramidata L.	Escoba	PF	Melpyr
	Sida jamaicensis L.	Escoba dura	PF	Sidjam
	Sida rhombifolia L.	Escoba amarilla	R	Sidrho
Nyctaginaceae	*Boerhavia erecta* L.		R	Boeere
Phytolaccaceae	*Microtea debilis* Sw.		PF	Micdeb
Rubiaceae	*Mitracarpus hirtus* (L.) DC.		PF	Mithir
Talinaceae	*Talinum* sp.	Verdolaga montaña	F	Talisp

Frequency of occurrence: very frequent (MF) (> 50%), frequent (F) (20-50%), infrequent (PF) (3-15%) and rare (R) (<10%)

Conclusion

Apparently, the community of bees present in the oil palm crop evaluated, is composed of bees with generalist behavior. Pollen of oil palm during its flowering stage is used by the bee community, however, many of the plants considered as weeds in oil palm crops and which are normally eradicated by farmers (such as *Momordica charantia*, *Spilanthes urens*, *Melochia parvifolia*, *Mimosa pudica*, *Commelina diffusa* or *Trianthema portulcastrum*) are important sources of pollen for the bees in the agroecosystem, causing bee populations to become at risk, especially those with a narrow diet.

Acknowledgments: We are indebted to Kevin Palmera, Germán Tejeda and Santiago González for their assistance in the field and laboratory activities and to Cláudia Inês da Silva for her selfless support in training us to work with pollen. We thank Eduino Carbonó for their assistance in plant identification, and Patricia and Amparo (DAABON group) for the logistic with the farmers. Partial support for this work was provided by IDB through a special agreement between Fedepalma, Apisierra, C.I. Tequendama S.A.S. and University of Magdalena. The first author was funded by the International Relations Office of the latter institution. To the RCPol - Online Pollen Catalogs Network (FDTE process #001505) for support in identification, measurements and descriptions of pollen grains.

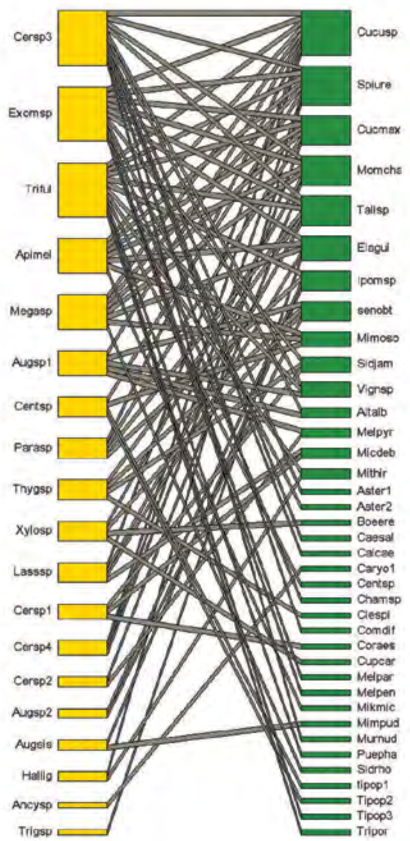

Figure 5. Diagram of bee-plant interaction networks based on the frequency of pollen types (Abbreviations: see table 1 and 2).

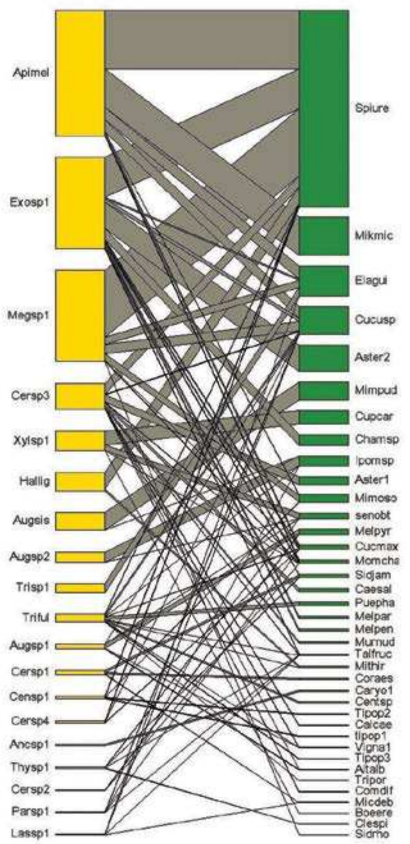

Figure 6. Diagram of plant-bee interaction networks from accumulated abundance (Abbreviations: see table 1 and 2)

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***Augochloropsis* sp.**

Bombus atratus **visiting flower of** ***Passiflora*** **sp.**

Floral resources used by *Bombus* spp. (Hymenoptera: Apidae) in the Bogotá plateau. A joined effort between BEAS group in Colombia and RCPol

SANDY PADILLA, DIEGO RIAÑO, JOSE R. CURE, CLÁUDIA INÊS DA SILVA, PAOLA ALARCON, MELISSA GUERRERO, RUBÉN MARTÍN, CARLOS POVEDA, HUGO SÁNCHEZ

Research group

The BEAS research group (Biodiversity and Ecology of Wild Bees) – Nueva Granada University (UMNG), Cajicá –, Colombia has been linked to the Faculty of Basic and Applied Sciences since its origins in 1998, offering uninterrupted opportunities of research to faculty and students interested in: a) analysis of plant-pollinator interaction networks based on palynological information; b) breeding of species of the genus Bombus for use as pollinators in crops; c) diversity, biology and taxonomy of Colombian pollinators; d) pollination ecology of crops in the Bogota plateau; and e) biological and ecological models of beneficial insects. Financial support has been provided by the University and by diverse groups of national research funding institutions. Nowadays, our group is led by PhD Marlene Lucia Aguilar.

We currently have a well-provided laboratory infrastructure with a bee collection (UMNG-ins), an herbarium (HBEAS) and a pollen collection (PBEAS), and a rearing chamber for bumblebees. We also have an outside facility, "Bombinario" for colony breeding and the study of bee behavior and pollination (Figure 1) (see Romero et al. 2013). Main species reared are bumblebees and Megachilidae. All the infrastructure is located at the university campus in the municipality of Cajica, 30km north from Bogotá.

Pollen collection (a joined effort between the University and RCPol)

The pollen collection has been developed based on 4 main projects.

Captive rearing for *B. atratus*

Wild queens start new colonies in the laboratory (Cruz et al. 2007; Pacateque et al. 2012) and then are transferred to different crops such as lulo *Solanum quitoense* (Almanza 2007), tomato *Solanum lycopersicum* (Aldana et al. 2007), uchuva *Physalis peruviana* (Camelo et al. 2004), strawberry *Fragaria x ananassa* (Poveda et al. 2018), blackberry *Rubus sil-*

vestris (Zuluaga 2011) and capsicum *Capsicum annuum* (Riaño et al. 2015). The project aimed at producing sexual forms (new queens and males) to feedback the rearing process. Colonies were located in two open fields and in the "Bombinario", where they completed their cycle. Under these conditions, the workers could freely forage to collect the pollen and nectar necessary to feed the offspring. Colonies located inside the greenhouse had access to floral resources that were both inside and outside the greenhouse (Figure 1). These colonies produced sexual forms satisfactorily (Padilla et al. 2017) but due to the differences found in their development, we were interested in studying the floral resources from which they fed. Collaborative work with RCpol started analyzing 105 pollen loads from the worker's corbicles of 13 colonies for three months. The herbarium (HBEAS) and the pollen collection (PBEAS) started with this project with the plants located inside and outside of the greenhouse. We identified 38 pollen types used by the colonies (Padilla et al. 2013; Padilla 2014). Due to the first interesting results obtained on the plants used by the bees to feed their larvae and because we found indeterminate pollen types, we decided to carry out another project on a larger scale.

Identification of floral resources used by *Bombus atratus* (Hymenoptera: Apidae) and colonies development under sub-urban conditions (2015 – 2018)

In this project, we carried out the plant checklist of the entire Campus. We identified 177 angiosperm species, distributed in 57 families,

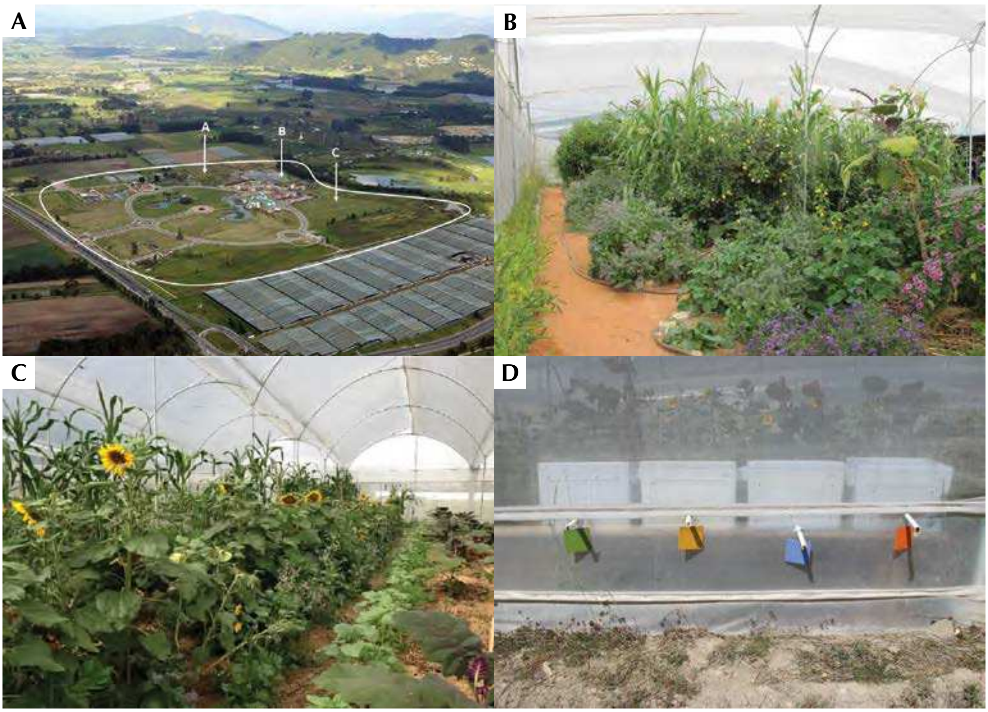

Figure 1. Colonies location. A: UMNG Campus showing the location of open fields (a, c) and the Bombinario greenhouse (b); B and C: Vegetation to feed *Bombus atratus* colonies inside the Bombinario. D: Colonies of *B. atratus* located inside the Bombinario, which have two exits that allow workers to forage inside and outside the greenhouse.

which are deposited in the herbarium and the pollen collection of the research group. We placed 14 colonies of *B. atratus* during a dry and rainy season in the Bombirario. We collected and analyzed pollen from larval cells during the monogynic phase until they reached the sexual phase. Although *B. atratus* collected pollen from 48 plants, we identified 14 important species for the diet of the colonies (Alarcón 2017; Riaño-Jiménez et al. 2020 in press).

This project allowed the identification of important plant species that support the development of colonies in the field and allow the colonies to reach the sexual phase. This work contributes to the breeding protocol of this species that has been developed in the research group during the last two decades.

Floral resources used by species of genus *Bombus* in a sub-paramo ecosystem of the Sabana de Bogotá (2014 – 2015)

Sub-paramo ecosystems are important for the regulation of the water cycle and the supply of the main cities of Colombia. In this area, the bees provide an important pollination service, which maintains the reproduction of most species of plants, many of them native and endemic. The aim of this work was to identify the floral resources collected by the native species *Bombus hortulanus* and *Bombus rubicundus* in a sub-paramo ecosystem and to evaluate the amplitude and the trophic niche overlap between them. The study was carried out in the Montaña del Oso Natural Reserve (Chia-Cundinamarca, Colombia), where we developed a floral checklist and a palynological analysis of bee pollen loads. We identified a total of 66 pollen types corresponding to different plants of native, endemic and introduced species to the sub-paramo ecosystem, used by bees as a source of nectar and pollen (Sánchez et al. 2014; Padilla et al. 2014).

Floral resources used by wild bees of High-Andean Ecosystems (2018 to current)

Bogotá plateau is in a process of increasing and constant urban densification. Despite the accelerated growth of Bogotá, some remains of native vegetation can still be found. One of these areas is the Cerro de la Conejera. Given the lack of information, the objective of this work was to characterize the wild bees present in the ecological park of the district of Cerro la Conejera (Bogotá, Colombia), and describe their interactions with the plants of this important ecosystem. We collected a total of 886 individuals, belonging to the 5 families of bees reported for Colombia, the most diverse family was Halictidae. We collected 111 plant species, of which only 48 were associated with bees. This Project showed that the Cerro de la Conejera presents a high diversity of bees. Despite of its isolation, the Cerro is home to a high diversity of solitary bee species, and we even recorded 7 new species of Colletidae and Halictidae bees (in publication). Besides, it identified the most important plants used by them, some of the plants are native species to the Sabana de Bogotá (Martín 2018).

Study areas and vegetation

The three study areas are located in the Bogotá plateau (Cundinamarca, Colombia) (Figure 2).

The Campus of the Nueva Granada University is located in Cajicá with an altitude of 2580 m.a.s.l and an area of 80 ha (04°56'33,9"N; 74°00'34,2"W) (Figure 2A). The Campus is an intervened area of the Sabana de Bogotá, which has research greenhouses, including the Bombinario, in which different crops of agricultural interest grow. Its vegetation consists of native and introduced plants of which 46% are cultivated and the rest grow spontaneously. The most represented families are Asteraceae, Fabaceae and Poaceae (Sánchez et al. 2015) (Figure 3A, 3B).

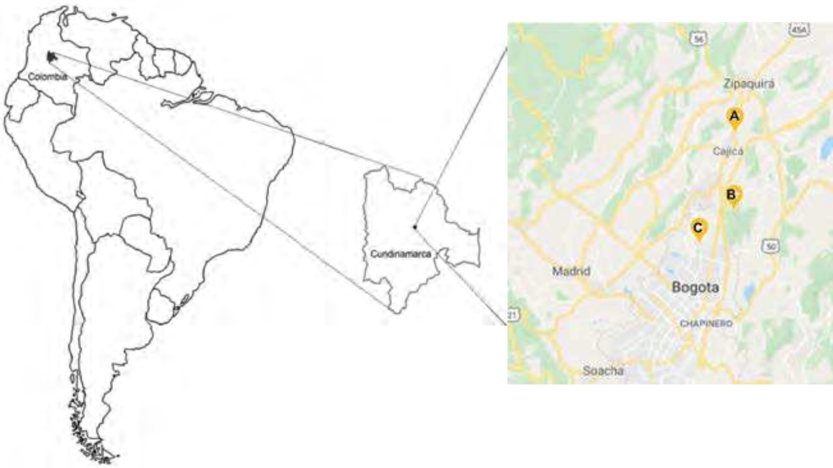

Figure 2. Study areas. A: Campus Nueva Granada, Cajicá; B: Natural Reserve Montaña del Oso, Chía; C: Ecological Park Cerro la Conejera, Bogotá.

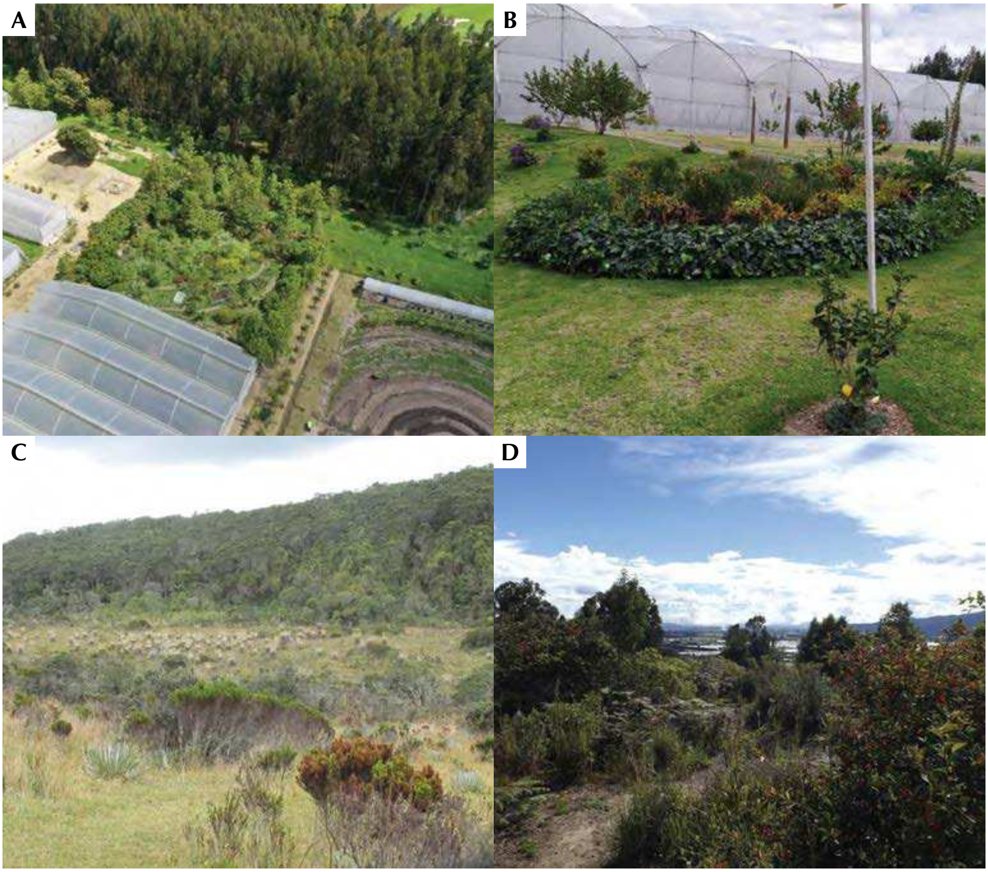

Figure 3. Vegetation of the study areas. A, B: Campus Nueva Granada, Cajicá; C: Natural Reserve Montaña del Oso, Chía; D: Ecological Park Cerro la Conejera, Bogotá.

The Natural Reserve Montaña del Oso is an area with a typical sub-mountain structure located in the eastern Andes mountain range in Chía with an altitude of 3118 m.a.s.l (04°49′18,6′′N; 74°00′48,9′′W) (Figure 2B, 3C). Finally, Ecological park Cerro La Conejera is a protected area, located in the northwest of the city of Bogota. It has an area of 161.4 ha and an altitude between 2565 and 2680 m.a.s.l (4°46′02.8″N; 74°04′14.8″W) (Figure 2C). Its main ecological structure is a low Andean forest and according to the Holdridge classification, it is a low montane dry forest (Pérez 2000) (Figure 3D).

Methods for plant, pollen and insect collection

The methodology used to organize the plant, bees and pollen collections was the same in the four projects. We collected flowering plants through transects which were identified and deposited in our Herbarium HBEAS. Flower buds were collected and subjected to acetolysis as described by Erdtman (1960) with the modifications proposed by Silva et al. (2014) for the extraction of pollen and preparation of permanent slides, which are deposited in our pollen collection PBEAS. Additionally, we made a digital pollen catalog to use it as a reference for the identification of pollen loads from the bees. Most of the information of our pollen collection is available in the Online Pollen Catalogs Network (RCPol, www.rcpol.org.br).

In the Campus, the pollen loads of *B. atratus* were collected from the workers present inside the colonies. The workers were not sacrificed in these cases. In the studies of the Montaña del Oso and Cerro la Conejera, bees were collected with entomological nets, and then sacrificed directly in Falcon tubes containing 70% alcohol. Subsequently, the tubes were centrifuged to decant the pollen found in the body of the collected bees. The bees were identified, labeled and deposited in the entomological collection UMNG-Ins. All the pollen samples were processed following the protocol described by Erdtman (1960) and Silva et al. (2014). The slides with the pollen loads are deposited in the pollen collection PBEAS as well.

Interaction of plant and bee species

Our Herbarium has 300 plant species deposited from the four projects, of which 84 are available in the RCPol. We identified 51 plant species in the pollen loads of *B. atratus, B. hortulanus*, and *B. rubicundus* in the study areas, which are distributed in 20 families, in which Asteraceae is the most common (Table 1). According to the quantitative analysis conducted in the studies, we identified 24 plant species important for the bumblebees (*, table 1). Species of the Asteraceae, Fabaceae, Solanaceae, Melastomataceae and Brassicaceae families are very important pollen resources for native bumblebees. Additionally, *B. hortulanus* has the highest number of interactions, half of which are with native plants, while 90% of *B. atratus* interactions are with introduced plants. There are 6 plant species used by the three bumblebee species, of which four are weeds. Most of the plants used by *B. rubicundus* are also used by *B. hortulanus* (Table 1).

Finally, the work carried out on the Campus allowed to identify the resources that should be offered to the colonies of *Bombus atratus* to complete their cycle, which has been an advance for the rearing system developed by our research group. Additionally, palynological studies have been an important tool to know the floral resources used by native bees (solitary and social), allowing to broaden our knowledge about their ecology in high-Andean ecosystems.

Table 1. Plant species used by *Bombus atratus, Bombus hortulanus* and *Bombus rubicundus* in 4 study areas in the Sabana de Bogota. (*) indicates the most important plants used for the bumblebees. The pollen type *Taraxacum officinale* also includes the species *Hypochaeris radicata*.

Family	**Specie**	*B. atratus*
Alstroemeriaceae	*Bomarea hirsuta* (Kunth) Herb.	
Asteraceae	*Ageratina gracilis* (Kunth) R.M.King & H.Rob.	
	Bidens pilosa L.	
	Dahlia imperialis Roezl ex Ortgies	X
	Espeletia argentea Humb. & Bonpl.	
	Espeletia grandiflora Humb. & Bonpl	
	*Helianthus annuus L.**	X
	*Pentacalia guadalupe (Cuatrec.) Cuatrec.**	
	*Pentacalia ledifolia (Kunth) Cuatrec. **	
	*Senecio madagascariensis Poir.**	X
	Sonchus oleraceus L.	
	Stevia lucida Lag.	
	Type *Taraxacum officinale (L.) Weber ex F.H.Wigg.*	X
	Hypochaeris sessiliflora Kunth.	
Bignoniaceae	*Tecoma stans* (L.) Juss. ex Kunth	X
Boraginaceae	*Borago officinalis* L.*	X
Brassicaceae	*Brassica rapa* L.*	X
	*Raphanus sativus L.**	X
Elaeocarpaceae	*Vallea stipularis* L. f. *	X
Ericaceae	*Bejaria resinosa* Mutis ex L. f. *	
	Gaultheria myrsinoides Kunth	
	Vaccinium floribundum Kunth	
Fabaceae	*Lupinus bogotensis* Benth.	X
	*Pisum sativum L. **	X
	*Senna multiglandulosa (Jacq.) H.S.Irwin & Barneby**	X
	*Trifolium pratense L.**	X
	*Trifolium repens L. **	X
	*Vicia benghalensis L.**	

B. hortulanus	*B. rubicundus*	**Origen**	**Study area**
	X	Native	Montaña del Oso
X		Native	Montaña del Oso
X		Native	La Conejera
		Introduced	Campus
X	X	Native	Montaña del Oso
	X	Native	Montaña del Oso
		Introduced	Campus
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X		Introduced	Montaña del Oso
X		Introduced	Montaña del Oso
X	X	Native	Montaña del Oso
X	X	Introduced	Montaña del Oso, Conejera, Campus
	X	Introduced	Montaña del oso
		Introduced	La Conejera
		Introduced	Campus
X	X	Introduced	Campus
X		Introduced	Montaña del Oso
X	X	Native	Montaña del Oso, Conejera
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X		Native	Montaña del Oso
X		Native	Montaña del Oso, Campus
		Introduced	Campus
X	X	Introduced	Campus, Conejera
X	X	Introduced	Campus, Montaña del oso, Ubate, Neusa
X	X	Introduced	Campus, Conejera
	X	Introduced	Montaña del Oso

Table 1. Continuation.

Family	Specie	*B. atratus*
Gentianaceae	*Halenia asclepiadea* (Kunth) G. Don	
Hypericaceae	*Hypericum goyanesii* Cuatrec.	
	Hypericum juniperinum Kunth *	
	Hypericum mexicanum L.	
Malvaceae	*Alcea rosea* L.	X
Melastomataceae	*Brachyotum strigosum* (L. f) Triana *	
	*Bucquetia glutinosa (L. f.) DC.**	
	*Chaetolepis microphylla (Bonpl.) Miq.**	
	Miconia chionophila Naudin*	
Myrtaceae	*Acca sellowiana* (O.Berg) Burret	X
	Callistemon speciosus (Sims) Sweet	
	*Eucalyptus globulus Labill.**	
Scrophulariaceae	*Digitalis purpurea* L.*	
Polygalaceae	*Monnina aestuans* (L.f.) DC.	
Rosaceae	*Rubus bogotensis* Kunth	
	Rubus fluribundus Weihe	
Rubiaceae	*Arcytophyllum nitidum* (Kunth) Schltdl.	
Solanaceae	*Solanum americanum* Mill.*	X
	*Solanum lycopersicum L.**	X
	*Solanum quitoense Lam.**	X
	Solanum tuberosum L.	X
Verbenaceae	*Lantana camara* L.	
	Verbena litoralis Kunth	X

B. hortulanus	*B. rubicundus*	Origen	Study area
X		Native	Montaña del Oso
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X		Native	Montaña del Oso
		Introduced	Campus
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
		Native	Campus
X	X	Introduced	Montaña del Oso
X		Introduced	Montaña del Oso
X	X	Introduced	Montaña del Oso
X		Native	Montaña del Oso, La Conejera
X		Native	Montaña del Oso
X	X	Native	Montaña del Oso
X	X	Native	Montaña del Oso
X		Introduced	Campus, La Conejera
		Introduced	Campus
		Native	Campus
		Introduced	Montaña del Oso
X		Native	La Conejera
		Native	Campus

Acknowledgments: This work was supported by the research funding from the Nueva Granada University with the projects CIAS 937 (2013 – 2014), CIAS 1463 (2014 – 2015), CIAS 1922 (2015-2017), IMP-CIAS 2296 (2017-2019) and IMP-CIAS 2926 (2019-2021). To the RCPol - Online Pollen Catalogs Network (FDTE process # 001505) for support in identification, measurements and descriptions of pollen grains. To Francisco Fajardo for his support with plant identification in the Sub-paramo project.

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Nest of *Bombus atratus*

Apis mellifera visiting flower of *Paullinia cupana*

Bees, plants and pollen in Central Amazonia - how surrounding areas contribute to pollination of guarana (*Paullinia cupana* var. *sorbilis* (Mart.) Ducke)

MATHEUS MONTEFUSCO, CLÁUDIA INÊS DA SILVA, FLÁVIA BATISTA GOMES, MARCIO LUIZ DE OLIVEIRA, MARCIA MAUÉS, CRISTIANE KRUG

Project Presentation

This study investigated visiting/pollinating bees in guarana (*Paulinia cupana* var. *sorbilis* [Mart.] Ducke) plantations and surrounding plants, and was developed as a part of the project "Plant-bees interaction networks with North and Northeast fruit trees (12.16 .04.024.00.00)" financed and developed by Embrapa in four Brazilian states in partnership with RCPol (Online Pollen Catalogs Network), various universities, and National Institute for Amazonian Research (INPA), with the general objective of "characterize plant-pollinator interactions of fruit species, with an emphasis on bees, aiming to support crop systems that co-share the most efficient pollinators and increase pollination and sustainability of agroecosystems".

Study Region

This study was carried out in a central Amazonian guarana cultivation area in the Embrapa Western Amazon experimental site (2°53′22.24″ S, 59°58′47.34″ W), located at Km 29 on the AM 010 highway, near Manaus, Amazonas State, Brazil (Figure 1). The cultivation area covers 7.63 ha.

Vegetation and Climate

The natural vegetation of the study area is upland (terra firme) Amazonian Rainforest (Hopkins 2005) and the climate is humid tropical, AM, with a mean annual temperature of 26.5° C (Köppen 1936). The rainy season generally occurs between January and June, with a noticeable reduction in rainfall between July and September (Antonio 2017).

Material and Methods

Data were collected monthly for 1 year, by two collectors on two consecutive days. These were carried out on the first day from 11:00 to 17:00 and on the second day, from 5:00 to 11:00, between May 2016 and June 2017. The sampled area corresponds to edges of a conventionally managed guarana plantation (Pereira et al. 2005). The edges of the plantation and access roads are bordered by upland Amazon forest with the presence of native and exotic ruderal species used by bees (Figure 1A).

Bee surveys

A transect of approximately 3.5 kilometers in length with 5 meters in width buffer was set between the plantation edge and the adjacent forest, and the roads that connect the guarana crop sites (Figure 1, line in yellow). Along this transect, all flowering plants, including guarana, which had at least three branches with flowers or inflorescences (used operationally as this is the minimum requirement for exsiccates), were evaluated/observed for five minutes, and all floral visitors present on the flowers over this time were collected with entomological nets. Following capture, insects were prepared, stored and labelled properly with information from the insect(s) and the plant visited. Pollen, when present on the body, corbiculae or scopa of each bee, was removed and duly labelled, for later acetolysis. Bees were identified by the authors and are deposited in the Invertebrate collection of INPA and classified following Michener (2007). In this study, we present only the data related to bees collected on guarana and plants visited by them in the surroundings, the target species for this chapter.

Plant and pollen collections

All species of plants sampled during the project had parts (fertile parts) collected for exsiccate and later identification (done in triplicate). In addition, fertile anthers of flowers and flower buds were collected from the respective plants visited to identify pollen

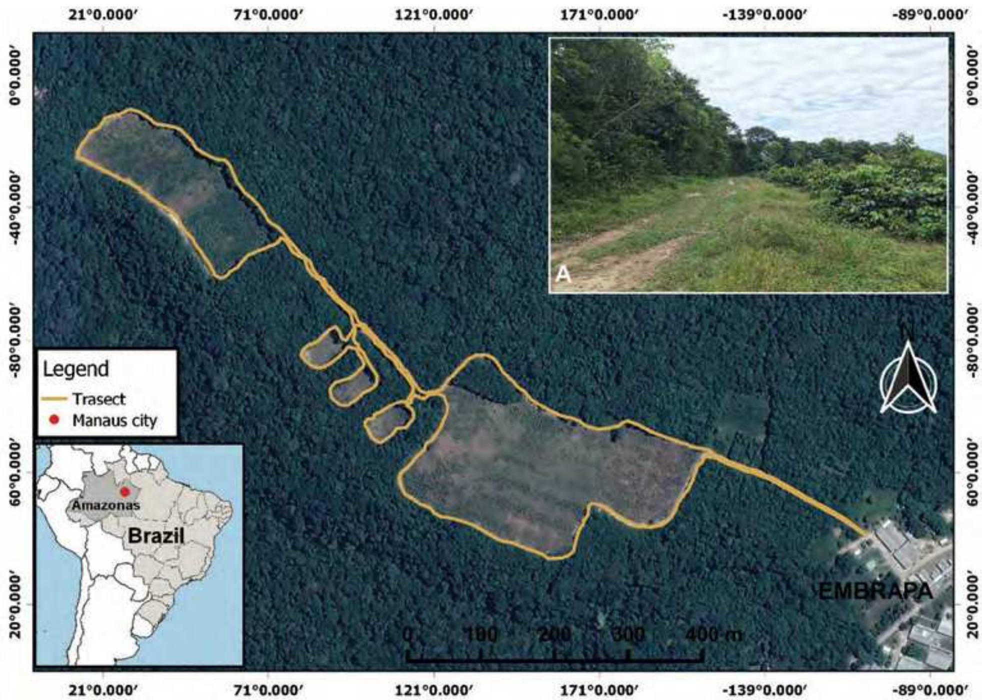

Figure 1. Map of the study area, showing the trasect in guarana plantation at the Embrapa Western Amazon experimental site (Manaus, AM). A: Image of a portion of the study site. Source: GoogleEarth, modified via Qgis version 3.6.3.

types and compose a reference pollen collection to assist in identification of the pollen collected and transported by bees. Collected plants were identified by specialists into the appropriate botanical groups and/or by comparison with material deposited in the herbarium of INPA, where the exsiccates were also deposited. Botanical families were classified following APG IV (2016).

Samples of floral pollen and pollen removed from collected bees were prepared with the acetolysis method of Erdtman (1960) and Silva et al. (2014), which consists of the chemical treatment of the pollen grain, eliminating the cytoplasmic content and substances adhering to the grains, to expose the morphological characteristics useful for identification. Samples of floral pollen, after acetolysis, were mounted on permanent slides with gelatin (Kisser 1935) and sealed with paraffin. Pollen grains were described with the aid of an optical microscope with a camera attached and linked to the reference network of RCPol. Slide preparation methods followed Silva et al. (2014). Samples of acetolyzed pollen from bees were mounted on semi-permanent slides, in triplicate, and pollen present was identified with the aid of an optical microscope and the RCPol reference pollen library.

Results and Discussion

In total, 27 species of flower-visiting bees belonging to 4 families (Apidae, Colletidae, Halictidae and Megachilidae) were sampled (Table 1) visiting flowers of guarana and other plants surrounding the crop during the course of the 1-year study. In addition to guarana, the 20 native plants most used by these bees are listed in Table 2.

Eight bee species were the most abundant (i.e. had the largest number of individuals sampled), showing more than 50 visits to plants, and were responsible for 87% observed interactions. These were: *Apis mellifera* (46%), *Trigona guianae* (12.5%), *Aparatrigona impunctata* (7.6%), *Nannotrigona melanocera* (6%), *Trigona cilipes* (4.8%) and *Melipona (Michmelia) fulva, Frieseomelitta trichocerata, Tetragonisca angustula* (all with 3.5%). The remaining 19 bee species, in sum, were collectively responsible for 12.5% abundance.

Pollen grains were obtained from 21 species of flower-visiting bees. After evaluation on pollen data presented on bee species and their interactions with the plant species, we found that *Apis mellifera* (Figure 2A) had the greatest diversity of pollen types in pollen samples (N = 12), followed by *Melipona (Michmelia) fulva* (N = 9), *Trigona cilipes* (N = 7), *Paratetrapedia basilares* (N = 6) and *Trigona guianae* (N = 5).

Although *Apis mellifera* was the most abundant bee and had the highest diversity of pollen types, it was not the species that exploited the largest number of flowering plant species, visiting ten plant species. Of the native bee species, *Trigona guianae* was the one that interacted most with different species of flowering plants (N = 13). However, pollen samples from this species revealed that these bees exploit only a few plant species, in terms of pollen collected (N=5).

Of the plants most visited by bees, *Hyptis atrorubens* received 39% of all visits (Figure 2B), followed by *Borreria alata* (33%: Figure 2C) and *Paullinia cupana* var. *sorbilis* (8.5%). Together, these three species were responsible for about 80% of all visits. *Hyptis atrorubens* and *Borreria alata* remained on flowers for extended periods across the year, while *Paullinia cupana* var. *sorbilis* flowering was restricted to the July – September period. Such timing was an important factor for the dominance of these species in guarana plants, which, despite having a short flowering period, offers a large amount of pollen and nectar for bees visiting the plantation. The other 18 plant spe-

Table 1. Bees visiting flowers of guarana (*Paullinia cupana* var. *sorbilis*) and other plant species in adjacent habitats near Manaus, Amazonas State, Brazil.

Family	Species
Apidae	*Aparatrigona impunctata* (Ducke, 1916)
	Apis mellifera Linnaeus, 1758
	Cephalotrigona femorata (Smith, 1854)
	Frieseomelitta trichocerata Moure, 1990
	Melipona (Michmelia) fulva Lepeletier, 1836
	Melipona (Michmelia) seminigra merrillae Cockerell, 1919
	Melipona (Michmelia) seminigra seminigra Friese, 1903
	Nannotrigona melanocera (Schwarz, 1938)
	Paratetrapedia basilaris Aguiar & Melo, 2011
	Paratrigona euxanthospila Camargo & Moure, 1994
	Paratrigona melanaspis Camargo & Moure, 1994
	Paratrigona pannosa Moure, 1989
	Paratrigona sp. 1
	Partamona auripennis Pedro & Camargo, 2003
	Partamona vicina Camargo, 1980
	Tetragona kaieteurensis (Schwarz, 1938)
	Tetragonisca angustula (Latreille, 1811)
	Trigona cilipes (Fabricius, 1804)
	Trigona guianae Cockerell, 1910
	Trigona williana Friese, 1900
Colletidae	*Ptiloglossa* sp. 1
Halictidae	*Augochloropsis hebescens* (Smith, 1879)
	Megalopta amoena (Spinola 1853)
	Megalopta sodalis (Vachal 1904)
Megachilidae	*Coelioxys* sp. 1
	Hoplostelis (Rhynostelis) multiplicata (Smith, 1879)
	Megachile sp. 3

Table 2. Main flowering plants found in areas close to guarana (*Paullinia cupana* var. *sorbilis*) cultivation, which were visited by bees and/or had bees carrying their pollen.

Family	Species	Visit	Pollen
Asteraceae	*Pseudelephantopus spiralis* Cronquist	X	X
	Unxia camphorata L.f.	X	
Hypericaceae	*Vismia cayennensis* (jacq.) Pers	X	X
	Vismia japurensis Reichardt	X	
Cyperaceae	*Rhynchospora pubera* (Vahl) Boeck.	X	X
Lamiaceae	*Hyptis atrorubens* Poit.	X	X
Lauraceae	*Nectandra cuspidata* Nees	X	
Fabaceae	*Mimosa pudica* L.	X	X
	Mimosa sensitiva L.	X	
	Stryphnodendron pulcherrimum (Willd.) Hochr.	X	X
	Senna quinquangulata (Rich.) H.S.Irwin & Barneby	X	
	Zornia latifolia DC.	X	
Malpighiaceae	*Byrsonima chrysophylla* Kunth	X	X
Melastomataceae	*Bellucia dichotoma* Cogn.	X	X
	Clidemia hirta (L.) D.Don	X	X
Myrtaceae	*Eugenia stipitata* McVaugh		X
Rubiaceae	*Borreria alata* Aubl.	X	X
	Borreria verticillata (L.) G.Mey.	X	X
Sapindaceae	*Paullinia cupana* var. *sorbilis* (Mart.) Ducke	X	X
Solanaceae	*Solanum paniculatum* L.	X	X
Verbenaceae	*Stachytarpheta cayennensis* (Rich.) Vahl	X	X

cies received the remainder of the visits in a more equitable manner, with no species with more than 3% of the visits. Using only pollen data, we found the plant species with pollen most frequently found on bees were: *Byrsonima chrysophylla* (17%) (Figure 2D), *Borreria alata* (10.5%), *Rhynchospora pubera* (10.5%), *Solanum paniculatum* (9.2%) and *Bellucia dichotoma* (9.2%).

In this study, it became evident that pollen analysis provides complementary information for the study of interactions between bees and plants. It also showed that there were plants, such as *Eugenia stipitata*, not directly sampled, but whose pollen was used as a resource by some bee species.

Figure 2. *Apis mellifera* visiting guarana flowers (A), and individuals of *Hyptis atrorubens* (B), *Borreria alata* (C), and *Byrsonima chrysophylla* (D).

It is widely recognized that native bees are essential for pollination and for increasing the productivity in a variety of agricultural crops (Garibaldi et al. 2013). But it is important to note that, in addition to agricultural crops, these bees/pollinators depend on the floral resources offered by other plants present in the vicinity of the crops in question, for food and nutritional diversification. This pollen atlas aims to provide scientific and technical support for the maintenance of these pollinators associated with guarana crops, through the maintenance and/or inclusion of these pollinator-friendly plants in agricultural areas. The adoption of this practice will favor agricultural cultivation and the maintenance of the natural environmentally-based pollination service in the region.

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Figure 3. Staminate (A), pistilate (B) inflorescences and ripe guaraná fruits (C).

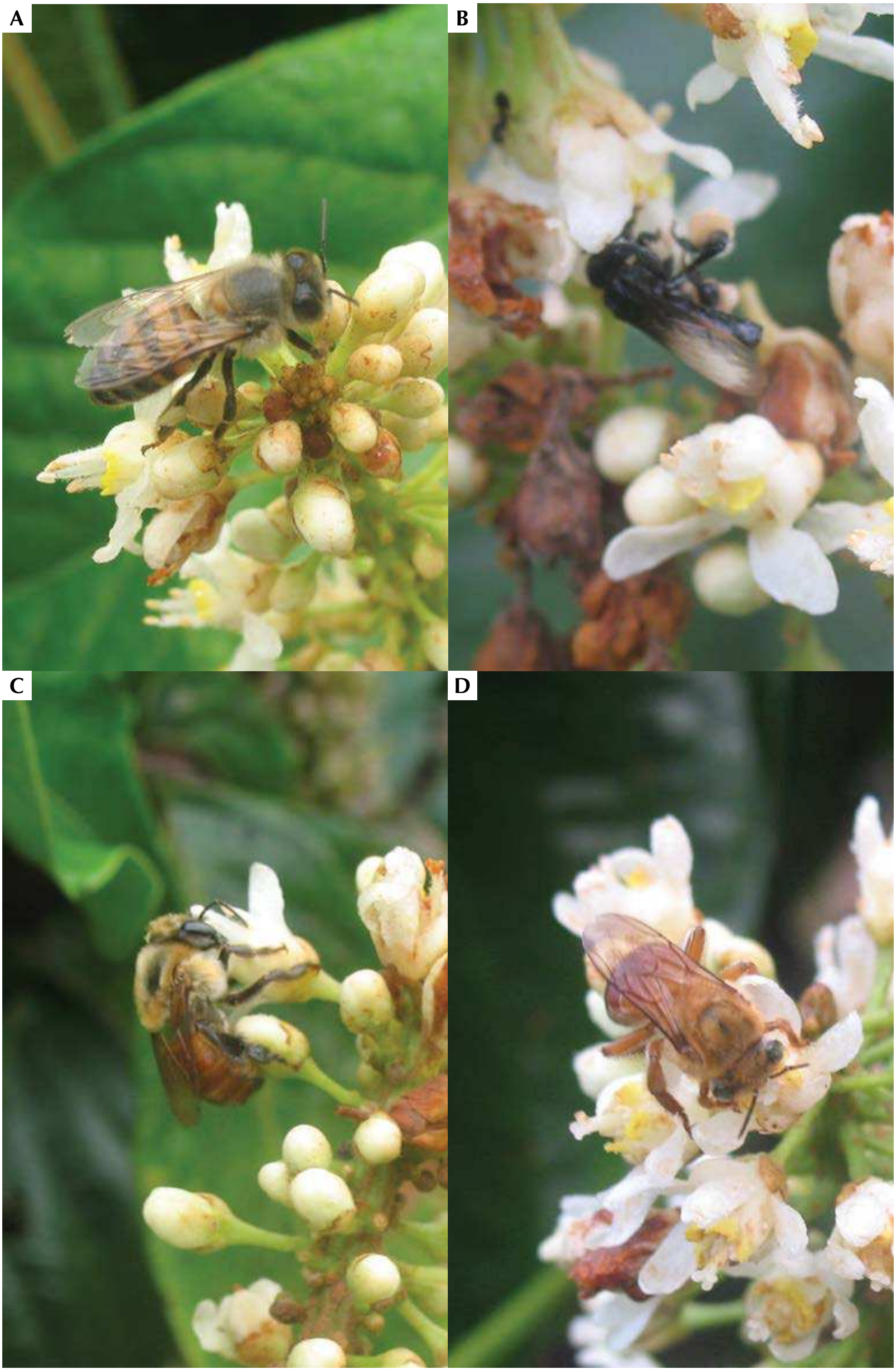

Figure 4. Bees visiting guaraná flowers, the exotic bee Apis mellifera (A) and native stingless bees (B,C,D).

Nest of *Euglossa cordata*

Contributions to the study of ecological interactions between euglossini bees and urbanized flora

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BRENO MAGALHÃES FREITAS, LUIZ WILSON LIMA-VERDE,
MARCELO CASIMIRO CAVALCANTE, MARIA IRACEMA B. LOIOLA

Introduction

Euglossini bees have a wide distribution in the Neotropical Region (Moure et al. 2012) and forage on a great diversity of botanical species to supply their nutritional and reproductive needs (Dressler 1982; Bezerra and Machado 2003). These bees are estimated to be pollinators of more than 40 botanical families (Dodson et al. 1969; Dressler 1982), the majority of which are wild species. The morphological and behavioral characteristics of Euglossini bees are compatible with the floral biology and pollination requirements of agricultural species of commercial importance. Fruit species such as *Passiflora edulis* (yellow passion fruit), *P. alata* (sweet passion fruit) and *Bertholletia excelsa* (Brazil nut), for example, require cross-pollination and are effectively pollinated by bees of the genera *Eulaema* and *Euglossa* (Cavalcante et al. 2012; Silva et al. 2012; Yamamoto et al. 2012). Although they are species of bees associated with natural areas and used as bioindicators of environmental quality, they are commonly found in urban environments, showing a high resilience to human activities (Silva et al. 2007).

These bees in general look for ecological resources for the construction of their nests and for their food. Euglossini females constantly visit tubular and zygomorphic flowers for collection of nectar and flowers with poricidal anthers or with a large number of anthers for collection of pollen. Studies on the diet of these bees are still few compared with their diversity. Much of the information on interactions with plants comes from direct observation of the visit of adult bees to flowers, and studies on the diet of immatures are rare. In part, this is due to the difficulty of finding nests of these bees in the wild. However, in the last decades, the use of trap nests has been important, as it allows access to feces of larvae which remain in the brood cells after the emergence of adults (Silva et al. 2016). Bee feces are basically residual pollen used in their food during the early developmental stages. Therefore, the identification of the diet can be done through pollen analysis of feces (Arriaga and Hernández 1998; Cortopassi-Laurino et al. 2009; Villanueva-Gutierrez et al. 2013; Otero et al. 2014; Ospina-Torres et al. 2015; Silva et al. 2016).

We present here some of the results obtained on the diet of two species of Euglossini, *Euglossa cordata* and *Eulaema nigrita*, which nested in two areas with coastal vegetation. Our goal was to contribute to the knowledge of the plants most used by these bees in urbanized environments and thus indicate plant species that must be maintained for their conservation.

Methodology

Study area

The Prof. Prisco Bezerra Campus, popularly known as Campus do Pici (3°34′16″ S and 38°34′ 42″ W) is located in the city of Fortaleza, State of Ceará and covers 212 hectares (Figure 1). According to the Köppen classification, the climate is Aw′ with an average annual rainfall of 1,448 mm and an average annual temperature of 26.3°C (Climate-Data 2020). The Campus is made up of extensive wooded areas with native and exotic species forming the current land-

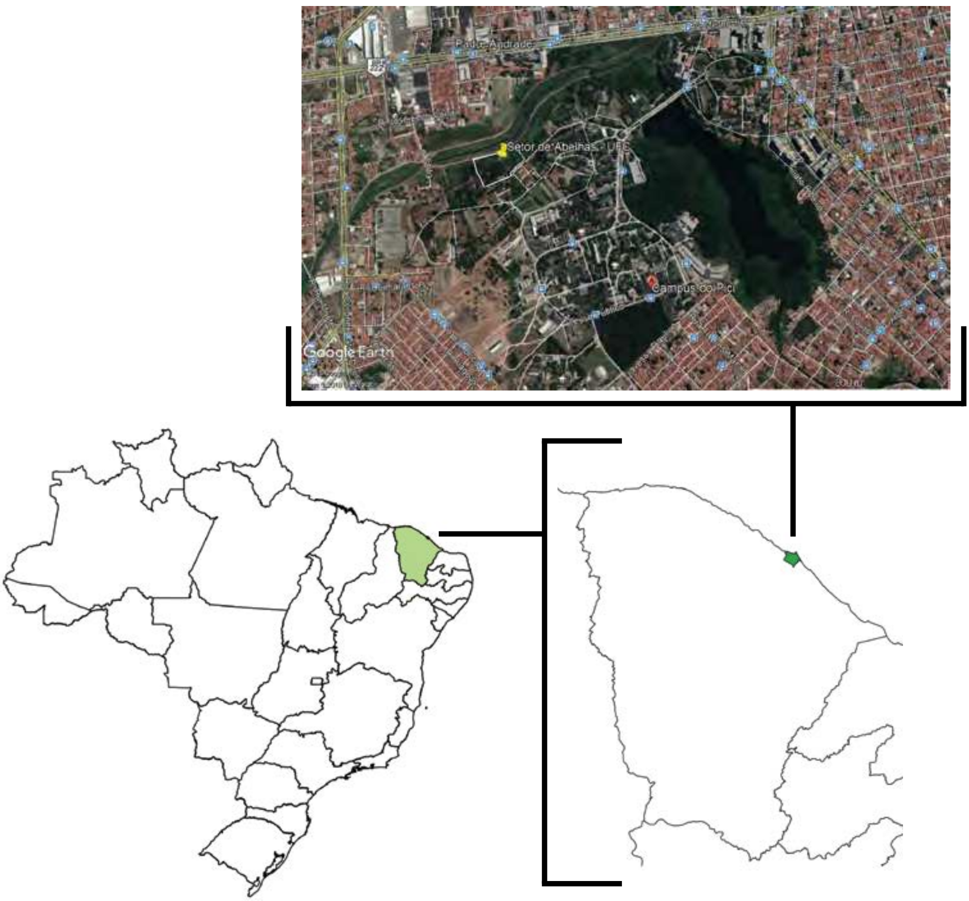

Figure 1. Location of the study area in Campus do Pici, Federal University of Ceará, municipality of Fortaleza, State of Ceará - Brazil, composed of small fragments of Semi-deciduous Lowland Forest.

scape and containing a small fragment of vegetation (8 ha) of Semi-deciduous Lowland Forest (Mata de Tabuleiro, IBGE 2012), on the banks of the Santo Anastácio Reservoir that flows into the Maranguapinho River. This forest is characterized as a medium-sized semideciduous forest, composed of woody individuals whose flora is represented by species from the Cerrado, the Caatinga, the Atlantic Forest and the Amazon (Castro et al. 2012; Moro et al. 2015). This forest is located inside an area recognized as an Area of Relevant Ecological Interest (ARIE of Matinha do Pici with 42.62 ha) according to Municipal Law 10.463, of March 31, 2016, which provides for the creation of the ARIE (Brasil 2016; Vasconcelos et al. 2019). The floristic surveys carried out (Fernandes et al. 2017) recorded hundreds of herbaceous, shrub and tree plant species and these plants represent an important source of resources for the local fauna.

Floristic survey and elaboration of the pollen reference collection

The collection and taxonomic identification of plant species in a given area are an important tool for understanding the floristic composition. In this way, five samples of each flowering species containing leaves, flowers and flower buds in pre-anthesis were collected monthly for 14 consecutive months (February 2015 to April 2016). The collections were conducted in a 2,000m radius, considering the Bee Laboratory, on the Campus do Pici, as a central point. Plant samples were herborized, identified and incorporated into the Herbarium Prisco Bezerra-EAC of the Federal University of Ceará. Concomitantly with the collection of plants, flower buds were collected in pre-anthesis. The material was stored in sterile Falcon tubes containing 70% alcohol. Anthers were separated and the pollen material was removed, following the method of Silva et al. (2014). Soon after, pollen was subjected to acetolysis as proposed by Erdtman (1960). The pollen material after acetolysis was kept in 50% glycerol-water solution until preparing the slides. For this, acetolyzed pollen was added to gelatin of Kisser (1935) and a seal was made with histological paraffin. A triplicate was prepared and the slides stored in the Pollen collection of the Bee Laboratory, Bee Sector, Department of Animal Sciences, Federal University of Ceará.

Sampling pollen in the nests

The nests of the bees were kept in the Bee Sector of the Department of Animal Sciences in boxes. The nest of *Eulaema nigrita* was originally occupying a wooden horizontal box (55x25x15cm) used for stingless bee breeding. A part of the brood cells that were already empty, after the emergence of adults, was removed and taken to the laboratory for the removal of pollen adhered to the cell walls. The nests of *Euglossa cordata* were kept in small wooden boxes (10x10x6cm), where the emergence of adults was observed for the immediate removal of pollen adhered to the wall of the brood cells. The rush is due to the fact that the females reuse the resin of old brood cells to build new cells. The residual pollen, for both studied species, was collected with the aid of a metallic, hollow-tipped instrument, in order to facilitate the removal of feces adhered to the wall of brood cells (Figure 2) according to the methodology used by Silva et al. (2016). Subsequently, the pollen was prepared following the same protocol used for the preparation of the reference slides and these were incorporated into the Pollen collection of the Bee Laboratory, Bee Sector, Department of Animal Sciences, Federal University of Ceará.

Results and discussion

This study identified 143 species of plants, distributed in 119 genera and 43 families (Figure 3). Information on

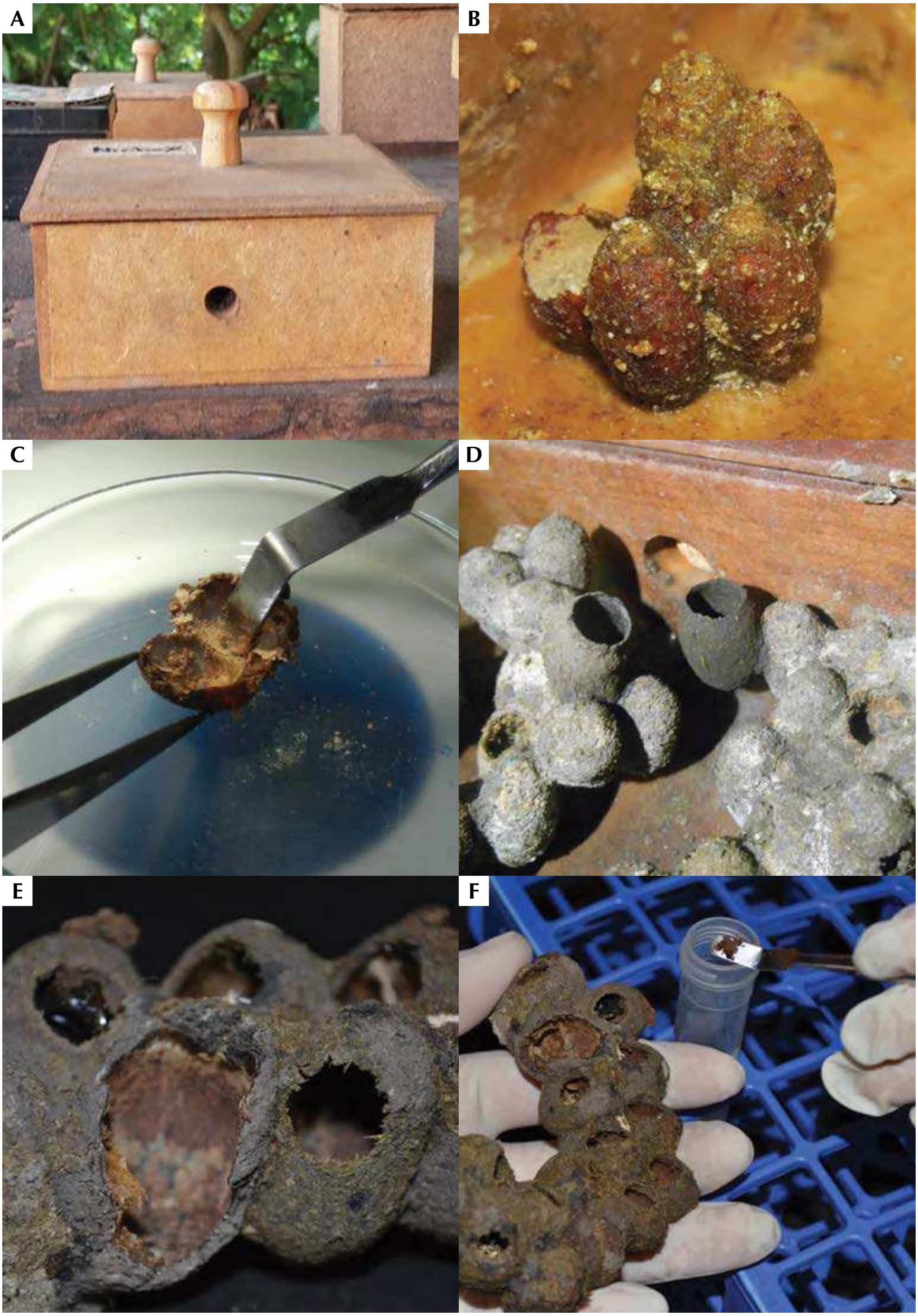

Figure 2. Nests and collection of residual pollen in brood cells of Euglossini bees. A: Bait box to attract Euglossini females. B: Brood cells of *Euglossa cordata*. C: Sampling of residual pollen from *Euglossa cordata* cells. D: Nest of *Eulaema nigrita* built in a rational box used for Meliponini breeding. E: Detail of brood cells of *Eulaema nigrita*. F: Sampling of residual pollen from *Eulaema nigrita* cells.

these species can be found on the RCPol website (www.rcpol.org.br). In the diet of *Euglossa cordata* and *Eulaema nigrita*, there were identified 114 pollen types, distributed in 74 genera and 36 botanical families (Figure 3), both species of bees are characterized as polylectic.

The plant species most often used to collect both pollen and nectar are trees, shrubs and lianas. Although Euglossini bees can travel distances greater than 20 km for the collection of resources (Janzen 1971; Ackerman et al. 1982), all important plant species were sampled in the study area within 1 km from the nesting site, corroborating Silva (2009) with bees of the genus *Xylocopa* that also have a long flight radius. The most important nectar-supplying species were *Centrosema brasilianum* (L.) Benth., *Clitoria fairchildiana* R.A. Howard, *Ixora chinensis* Lam., *Morinda citrifolia* L. and *Tabernaemontana laeta* Mart. While pollen-supplying species were *Cocos nucifera* L., *Psidium guajava* L., *Solanum paniculatum* L., *Cassia fistula* L and *Senna siamea* (Lam) H. S. Irwin & Barneby. In addition to these species, it is worth mentioning here a single species that produces resin, *Dalechampia pernambucensis* Baill, used by females for the construction of brood cells and the nest.

There was an overlap in the trophic niche between *Euglossa cordata* and *Eulaema nigrita*. These bees shared floral resources collected from 45 plant species. The overlap of plants used in the diet of these bees was expected, considering that they are species with sympatric distribution (López-Uribe et al. 2005; Castro et al. 2013). However, some species of these plants were used exclusively by each of them (Figure 4).

Considerations

This study evidenced that Campus do Pici is home to a considerable number of botanical species that provide trophic and non-trophic resources for bees, especially in the rainy season. *Euglossa cordata* and *Eulaema nigrita* showed generalist behavior regarding the use of floral resources, with a predominance for the use of native species over exotic ones. Nevertheless, the presence of exotic plants in the area, especially the species for landscape use, was important in maintaining these bees, mainly as sources of nectar throughout the year.

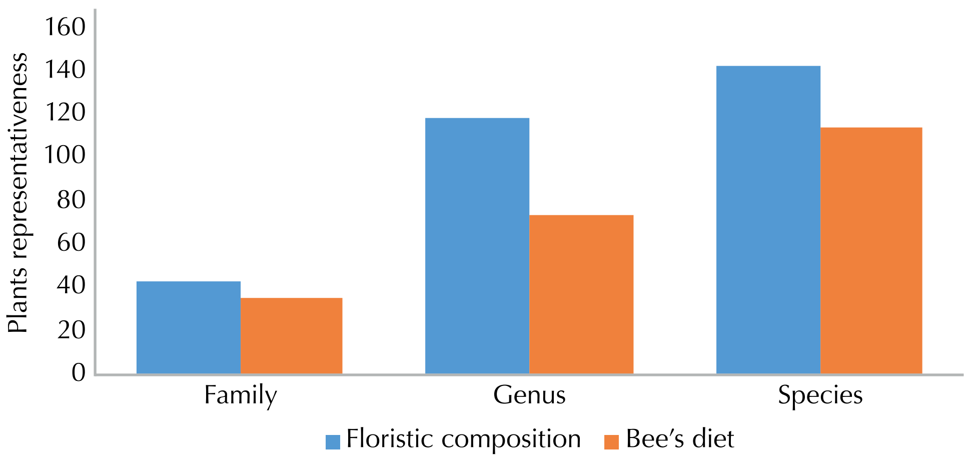

Figure 3. Number of botanical species identified in the study area and the pollen types identified in the diet of *Euglossa cordata* and *Eulaema nigrita* in the municipality of Fortaleza, State of Ceará, Brazil.

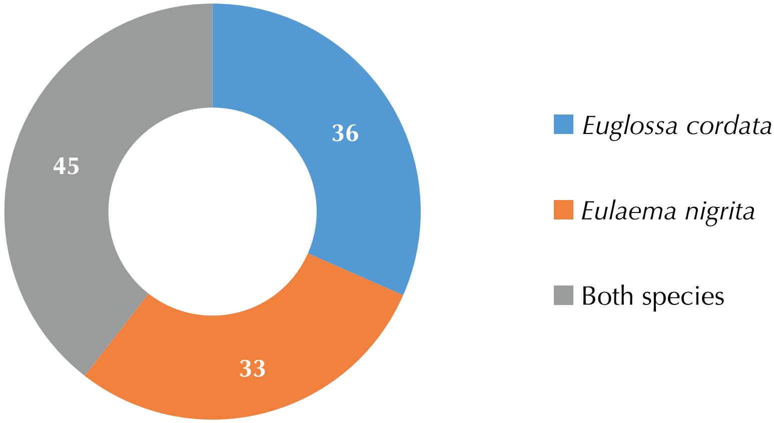

Figure 4. Number of botanical species composing the breadth and overlap of the trophic niche of *Euglossa cordata* and *Eulaema nigrita* in the municipality of Fortaleza, State of Ceará - Brazil, from September 2014 to January 2017.

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Ceratina **sp. visiting flower of** ***Turnera subulata***

Pollen collection of Brazilian Tropical Dry Forest

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Our pollen team

Melittopalynology, the analysis of pollen samples from bees, is an important tool to assess which plants have been visited by the foragers. Each plant species has pollen grains with unique characteristics in terms of ornamentation and morphology, which facilitates the taxonomic identification. However, pollen analysis requires prior knowledge of both the plant taxa and the morphological characteristics of their pollen grains available in the environment. Thus, for studies on the interaction between bees and plants in a specific geographical region, and for listing important plants for the bees' diet, reference collections of pollen grains are indispensable (Silva et al. 2012; Silva et al. 2014).

We initiated our pollen collection (Palinoteca ASA, Abelhas Semiárido) in 2010. Through the financial support from the National Council for Scientific and Technological Development (CNPq), we were able to start a laboratory specialized in palynology at the Federal Rural University of the Semi-Arid, Rio Grande do Norte, Brazil (Universidade Federal Rural do Semi-Árido, UFERSA). Our pollen team, led by Prof. PhD. Vera L. Imperatriz-Fonseca, was composed of post-doctoral researchers as well as doctoral and master students. Currently, our pollen collection contains samples of pollen grains from all the main plants of the Brazilian tropical dry forest (Caatinga).

Palynological studies require the collection and storage of the respective plants and their flowers. For our reference collection, the plants were collected at the Experimental Field Station Rafael Fernandes of the Brazilian Federal University at Mossoró (5º03′54.45″S, 37º24′03.64″W, altitude: 79 m) and at the National Forest Reserve at Açu, (5º34′59,13″S, 36º56′42,13″W), both located in areas with native vegetation typical for the Brazilian tropical dry forest (Figure 1). The botanical material was identified by specialists and deposited as exsiccates in the herbarium Dárdano de Andrade Lima (MOSS). Additionally, we collected pollen material from the flower buds and acetolyzed the samples following the methods described by Erdtman (1960). Part of the material was fixed on microscope slides labelled with the botanical identification and the collection information. The remaining acetolyzed pollen grains were stored in tubes and preserved in glycerin (Silva et al. 2012; Silva et al. 2014).

In addition to pollen from the main plant species found in the Brazilian tropical dry forest we sampled pollen from the food collected by bees, both directly from the body of foragers (Limão 2015; Maia-Silva et al. 2014; Maia-Silva et al. 2015; Pereira 2015; Maia-Silva et al. 2018) and from honey - and pollen - storages in nests of bees (Costa el al. 2017; Maia-Silva et al. 2018; Maia-Silva et al. 2020). The comparison between pollen from the bees' food with the reference collection allowed to identify the most important plant species for bees in the study region, which resulted in two doctoral theses (Camila Maia-Silva, Caio C. A. Costa) and two master's theses (Amanda A. C. Limão, Jaciara S. Pereira) between 2010 and 2017. Moreover, our database assisted scientific projects of students from the university's undergraduate course in ecology.

The description of the pollen grain morphology was supervised by PhD. Claudia Inês da Silva. To analyze and identify the botanical material, we used a Leica DM 2500 trinocular microscope equipped with a Leica DFC450 digital camera. The images were transferred to a computer for detailed measurement of the pollen grains and the morphological description. All information about plants and pollen grains is available on the webpage of the Online Pollen Catalogs Network (RCPol: http://chaves.rcpol.org.br/profile/palinoteca/eco/pt-BR:UFERSA:PALIASA). Our database, containing digitized images of pollen grains and their morphological information, is available online to assist and integrate researchers from all over the world.

Initially, our pollen collection was housed at the laboratory of behavioral ecology (BeeLAB, coordinated by Prof. PhD. Michael Hrncir). In 2018, with financial support from Syngenta, our collection gained its own space within the facilities built to house native stingless beehives (Meliponário Imperatriz). The space around the meliponary was restored as a bee garden (Espaço ASA) using primarily plants native to

Figure 1. Caatinga, the Brazilian tropical dry forest. Our studies were performed in the state of Rio Grande do Norte.

the study region to increase the populations of pollinating insects, therewith contributing to the conservation of local biodiversity (Figure 2). The selection of plant species was based on our studies on the pollen grains contributing to the diet of native bees. The bee garden comprises plants that bloom in the dry season as well as plants that produce flowers in the rainy season (Maia-Silva et al. 2012; Maia-Silva et al. 2019). The success of our environmental improvement underlines the importance of palynological studies for elaborating restoration plans for degraded areas (Maia-Silva et al. 2018).

Brazilian tropical dry forest

Just as other tropical seasonally dry forests, the Brazilian tropical dry forest is characterized by high average air temperatures throughout the year and short rainy periods at irregular intervals. The climate of this region is classified as semiarid, with average annual rainfall ranging from 240 mm to 1,500 mm (Prado 2003; Vasconcellos et al. 2010; Andrade et al. 2017). Most of the annual rainfall is concentrated in three to four consecutive months, which results in an elevated water deficit over a long period of the year (Figure 3).

Figure 2. Facility designed to house palynology laboratory, stingless bee hives and a bee garden (Espaço ASA) at the Federal Rural University of the Semi-Arid, Rio Grande do Norte, Brazil (Universidade Federal Rural do Semi-Árido, UFERSA).

Figure 3. Representative photographs of the caatinga vegetation **a)** in the dry season, and **b)** in the rainy season.

Owing to the severe water deficit, the vegetation of the Caatinga comprises mainly trees and shrubs adapted to the periodic drought, such as deciduous species and succulent plants (Prado 2003; Moro et al. 2014), with significant levels of endemism (Albuquerque et al. 2012). During the dry season, the trees lose their leaves and the landscape becomes dry and gray, and only a few tree species bloom during the dry season. During the rainy season, however, the leaves sprout again, and the vast majority of trees, shrubs and herbaceous species produce flowers (Reis et al. 2006; Maia-Silva et al. 2012; Santos et al. 2013; Quirino and Machado 2014). In this often very short period of high abundance of floral resources, bees quickly collect as much food as possible (Zanella and Martins 2003; Maia-Silva et al. 2015; Maia-Silva et al. 2018; Maia-Silva et al. 2020). Thus, the foraging activity of bees is highly synchronized with the annual flowering cycle of the plants (Table 1).

Melipona subnitida: a stingless bee species native of the Brazilian tropical dry forest

The geographic distribution of *Melipona subnitida* Ducke 1910 (Apidae, Meliponini) is restricted to the northeast of Brazil (Camargo and Pedro 2007; Giannini et al. 2017). This stingless bee species is one of the few eusocial bees adapted to the environmental peculiarities of the Brazilian tropical dry forest (Zanella 2000; Hrncir et al. 2019). The colonies, whose populations range from less than 100 individuals during the dry season to over 1,500 during the rainy season (Maia-Silva et al. 2016), nest in narrow cavities, preferentially on native tree species (Carvalho and Zanella 2017). To survive the unpredictable environmental conditions of the Caatinga, *M. subnitida* evolved several behavioural adaptations: (1) The bees preferentially collect food at highly profitable resources during the short rainy season; (2) During the dry months, the colonies reduce the construction of brood cells and, thus, the food requirements; (3) Adaptive physiological mechanisms allow the bees to tolerate high temperatures during foraging flights (Maia-Silva et al. 2015; Maia-Silva et al. 2016; Maia-Silva et al. 2018; Hrncir et al. 2019; Maia-Silva et al. 2020).

M. subnitida is traditionally used in regional meliponiculture, and the colonies are multiplied at large scale for honey production. Additionally, it is a key species in northeastern Brazil, both for the pollination of native plants and for agricultural production (Jaffé et al. 2015; Koffler et al. 2015). However, the vast reduction of natural habitat represents a major threat to the conservation of bee species in the Brazilian dry tropical forest. The indiscriminate cutting of trees in this biome reduces both nesting sites and resources for native bees (Zanella and Martins 2003).

Native plants of Brazilian tropical dry forest important to *Melipona subnitida*

The results of our melittopalynological surveys indicate that *M. subnitida* collects floral resources mainly from plants that provide large amounts of food (pollen, nectar), such as mass-flowering species, and plants with poricidal anthers. These highly lucrative food sources include trees, shrubs and herbaceous species of the native flora, which demonstrates the importance of all plant strata for the bees' diet. Most of these plants bloom during the rainy season and usually produce a great number of flowers. However, a few mass-flowering tree species bloom exclusively during the dry season, including *Anadenanthera colubrina* and *Myracrodruon urundeuva*. These lucrative pollen and nectar sources are essential for the maintenance of the colonies of eusocial bees

during the extended drought periods (Maia-Silva et al. 2015; Maia-Silva et al. 2018; Maia-Silva et al. 2020).

Based on our studies, we have compiled a list of the most important plants that provide floral resources for bees throughout the year, including drought periods (Table 1). We recommend these plants for areas of restoration and beekeeping to facilitate the conservation of native bees and assist local meliponiculture. These plants are important in areas of habitat restoration and habitat improvement to increase the success of conservation programs for native bee populations and to improve the productivity of stingless beekeeping (Maia-Silva et al. 2018).

Table 1: Plant species providing pollen and nectar for *Melipona subnitida* in the Brazilian tropical dry forest.

Family	Scientific Name
Anacardiaceae	*Myracrodruon urundeuva* Allemão
Convolvulaceae	*Ipomoea asarifolia (*Desr.) Roem. & Schult.
	Ipomoea bahiensis Willd. ex Roem. & Schult.
Euphorbiaceae	*Croton sonderianus* Müll.Arg.
Fabaceae, Caesalpinioideae	*Chamaecrista calycioides* (DC. ex Collad.) Greene
	Chamaecrista duckeana (P.Bezerra & Afr.Fern.) H.S.Irwin & Barneby
	Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz
	Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby
	Senna obtusifolia (L.) H.S.Irwin & Barneby
	Senna trachypus (Benth.) H.S.Irwin & Barneby
	Senna uniflora (Mill.) H.S.Irwin & Barneby
Fabaceae, Mimosoideae	*Anadenanthera colubrina* (Vell.) Brenan
	Mimosa arenosa (Willd.) Poir.
	M. caesalpiinifolia Benth.
	M. quadrivalvis L.
	M. tenuiflora (Willd.) Poir.
	Neptunia plena (L.) Benth.
	*Pityrocarpa moniliformis (*Benth.) Luckow & R.W.Jobson
	Senegalia polyphylla (DC.) Britton & Rose
Malvaceae, Malvoideae	*Sida cordifolia* L.
Rubiaceae	*Borreria verticillata* (L.) G.Mey.
Passifloraceae, Turneroideae	*Turnera subulata* Sm.

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Common Name	Stratum	Floral resources	Blooming
aroeira	tree	nectar	dry season
salsa	herbaceous	nectar	rainy season
salsa	herbaceous	nectar	rainy season
marmeleiro	shrub	nectar	rainy season
mata-pasto	herbaceous	pollen	rainy season
mata-pasto	herbaceous	pollen	rainy season
jucá	tree	nectar	rainy season
são-joão	tree	pollen	rainy season
mata-pasto	shrub		rainy season
canafístula	shrub	pollen	rainy season
mata-pasto	shrub	pollen	rainy season
angico	tree	pollen	dry season
jurema	tree	pollen	rainy season
sabiá	tree	pollen	rainy season
malícia	shrub	pollen	rainy season
jurema-preta	tree	pollen	rainy/dry seasons
jurema-d'água	herbaceous	pollen	rainy season
catanduva	tree	nectar/pollen	rainy/dry seasons
unha-de-gato	tree	nectar	rainy season
malva	herbaceous	nectar	rainy season
cabeça-de-velho	herbaceous	nectar	rainy season
chanana	herbaceous	pollen	rainy season

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Inflorescence of *Aechmea bromeliifolia*

Incredible information that pollen can tell us about the bee plant interaction

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Introduction

Pollen is a natural marker used in investigative studies, due to its resistant dispersal structure, that is responsible for the transport of male gametes of flowers. Pollen grains have a wall made up of sporopollenin that provides a toughness and longevity, due to the need to protect male gametes from adversities like UV light, water stress, wind and the mechanical action by floral visitors (Erdtman 1960). The distance that pollen grains travel from the anthers of one flower to the stigma of another flower can be short or very long, from centimeters to kilometers. It depends on the dispersal agent, which can be the water, wind or animals like insects and vertebrates.

Most flower visitors collect pollen grains for consumption or to feed their offspring. However, pollen can often be removed accidentally, for example, when animals visit flowers to collect nectar, fragrance, floral oils or resin. While touching the anthers, pollen grains adhere to different parts of their bodies. Generally, these grains are used in the pollination process, which guarantees the plants the sexual reproduction and maintenance of their genetic variability in the populations (Rech et al. 2014). In this interaction, most of the time both are benefited: the plants with the cross pollination, and the animals with the floral resources.

Among the pollinators, bees stand out for their diversity and dependence on flowers for survival. Bees gather pollen, which is used as a source of protein, minerals, vitamins and hormone precursors. Bees also collect nectar, which is rich in carbohydrates, water, minerals and vitamins. Floral oils are the source of lipids and are used in the diet of several solitary bees (Michener 2007).

Pollen deposited on the body of bees, directly or indirectly collected, indicates the sources of floral resources they visited. Due to the unique morphological features of pollen grains, it is possible to identify the plant species, consequently the composition of plants in the bee diet (Silva et al. 2014). Furthermore, analyzing the pollen stored in brood cells allows to obtaining information about the flower availability in the field, the foraging routes of the bees and their nutritional demands, classifying them as oligolectic or polilectic (Cane and Sipes 2006). In addition, after identifying the plant species used by the bees, it is possible to search for them in the field and evaluate the contribution of bees to their reproduction systems.

Hereby, we presented the results of a long-term study of an orchid bee, *Euglossa* (*Glossura*) *annectans* Dressier, 1982 (Euglossini), that we had the opportunity to raise in laboratory for some generations.

IBUSP tradition in studies on trophic niche of bees

The Bee Laboratory of the Institute of Biosciences at the University of São Paulo has a long tradition on studies of native bee and trophic niche using pollen analysis. Different protocols were used to evaluate pollen and honey samples, depending on the purpose of the research. However, in almost all studies, pollen samples were prepared using the acetolysis method proposed by Erdtman (1960), while honey samples were treated according to Louveaux et al. (1970), modified by Iwama and Melhem (1979). Pollen from samples was identified by comparison with the reference slide collection located in the Bee Laboratory and the specialized literature (see www.rcpol.org.br).

Studied species and sampling procedure

A nest of *E. annectans* was kept at the Bee Laboratory for 5 years. This species is communal, which means that more than one female inhabits the nest (Garófalo et al. 1998; Boff et al. 2017). During the period from September 2014 to March 2019, pollen stored in brood cells of nests and present on the bees' bodies was sampled. At the same time, we observed the bees visiting flowers in the campus, especially in the gardens of the Institute of Biosciences (IBUSP) of the University of São Paulo (23°56′47.93″ S e 46°73′11.27″ W) (Figure 1).

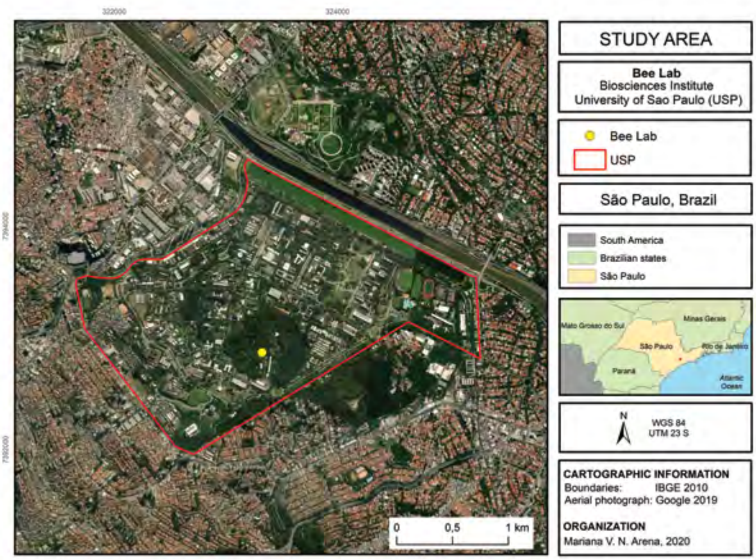

Figure 1. Location of the Bee Laboratory of the Institute of Biosciences, in the campus of the University of São Paulo, São Paulo, Brazil.

According to the classification proposed by Köppen (1948), the climate of São Paulo is humid subtropical, characterized by a dry winter and a rainy summer. The IBUSP gardens comprise an area of about 4.5 ha, with occurrence of native and exotic ornamental plant species, as well as ruderal species (see Knoll 1990; Kleinert and Silva 2020), with an adjacent area of 10 ha of semi-deciduous Atlantic Forest. Additional information on the flora of the USP campus can be found in Delitti & Pivello (2017) and Pirani & Luz (2020).

To sample the pollen, we inserted microtubes with 1 mm diameter into the brood cells to collect a vertical sample of the food, before the female completed the provision process and laid the egg (Figure 2). After then, the microtubes were inserted in a Falcon tube with 2 mL 70% alcohol for at least 24 hours. Afterwards, the pollen material was subjected to acetolysis (Erdtman 1960).

Pollen analysis

After acetolyzed, Pollen samples were embedded in Kisser gelatin (Kisser 1935) mounted on slides sealed with transparent varnish. For each sample of pollen grains, a qualitative analysis was conducted by identifying the pollen types or plant species. The first 400 pollen grains in each sample were examined, as suggested by Montero and Tormo (1990). Afterwards, the percentage of each pollen type in a sample was calculated and then classified according to Maurizio and Louveaux (1965): dominant pollen (> 45% of all grains counted in each sample), accessory pollen (15–45%), important isolated pollen (3–15%), and occasional isolated pollen (< 3%), due to the frequency of the pollen types in the samples.

Results and discussion

A total of 156 brood cells of *E. annectans* were analyzed and 37 pollen types were identified (Table 1). In some brood cells, the pollen provisioned was represented by almost only one plant species (9 > 90%; 3 = 100%). This is usual for several bee species, but in this case, it was surprising since this plant have nectariferous but not polliniferous flowers. We found that the diet of 19 individuals of *E. annectans* consisted of over 70 to 100% Bignoniaceae pollen (Pollen type *Tecoma stans*, including *Handroanthus impetiginosus*), while the diet of 10 individuals comprised over 45 to 100% pol-

Figure 2. Nest of *Euglossa annectans* showing females working in the cells. The arrows indicate the brood cells, before the female completed the provision process and laid the egg.

Table 1. Plant species identified by analysis of pollen stored in brood cells of *Euglossa annectans* during the period from September 2014 to March 2019, at the Bee Laboratory of Institute of Bioscience, University of São Paulo, Brazil. MAR: Main Available Resource to attract the floral visitor. The pollen type *Tecoma stans* include *Handroanthus impetiginosus* (Mart. ex DC.).

Family	Pollen types/species	MAR	Total
Acanthaceae	*Thumbergia erecta* (Benth.) T. Anderson	n	0,25
Apocynaceae	*Mandevilla* sp.	n	0,01
Asphodelaceae	*Bulbine frutescens* (L.) Willd.	n	0,02
Balsaminaceae	*Impatiens walleriana* Hook. f.	n	0,14
Bignoniaceae	*Amphilophium* sp.	n	0,09
	Tecoma stans (L.) Kunth	n	16,55
Bromeliaceae	*Aechmea bromeliifolia* (Rudge) Baker	n	3,17
	Aechmea distichantha Lem.	n	4,23
	Quesnelia arvensis Mez	n	5,11
Commelinaceae	*Commelina erecta* L.	p,n	2,88
	Tradescantia pallida Boom	p,n	0,45
Convulvolaecae	*Ipomoea* sp.	n	0,02
Heliconiaceae	*Heliconia psittacorum* L. f.	n	0,05
Indeterminated	*Indet* sp1		0,86
	Indet sp2		0,13
Lamiaceae	*Callicarpa reevesii* Wall. ex Walp.	n	0,21
Leguminosae	*Poincianella pluviosa* (DC.) L.P. Queiroz	n	0,01
	Senna sp.	p	7,83
	Anadenanthera macrocarpa (Benth.) Brenan	p,n	0,08
	MiMimosa caesalpiniifolia Benth.	p	2,05
	Erythrina sp.	n	0,04
Malvaceae	*Ceiba speciosa* (A.St.-Hil., A. Juss. & Cambess.) Ravenna	n	0,4
Melastomataceae	*Miconia* sp.	p	0,06
	Tibouchina granulosa (Desr.) Cogn.	p	6,17
Muntingiaceae	*Muntingia calabura* L.	p,n	0,48
Myrtaceae	*Eucalyptus citriodora* Hook.	p,n	0,26
	Eucalyptus grandis W. Mill	p,n	1,83
	Eucalyptus globulus Labill.	p,n	1,01
	Eugenia brasiliensis Lam.	p	1,43
	Eugenia uniflora L.	p	2,41
	Syzygium sp.	p,n	0,98
Rubiaceae	*Palicourea* sp.	n	0,29
Rutaceae	*Citrus* sp.	p,n	0,02
Sapindaceae	*Serjania* sp.	n	0,01
Solanaceae	*Solanum paniculatum* L.	p	38,4
Verbenaceae	*Petrea volubilis* L.	n	0,01
Vochysiaceae	*Vochysia* sp.	n	2,08

len of *Aechmea bromelifolia*, *Aechmea distichantha* or *Quesnelia arvensis* (Bromeliaceae). How to explain that females have collected a large amount of pollen in this type of flower, where the anthers are inserted into the floral tubes?

The most representative floral morphology in these two botanical families are the following: Species of Bignoniaceae have tubular flowers with a narrowing at the base of the corolla, where there is the nectar chamber (Figure 3A-D). Stamens are positioned on the inside top of the corolla, which restricts access to pollen (Figure 3A-D). Moreover, pollen grains are released in clumps when the floral visitor exerts pressure on tecas, distending the longitudinal opening (Silva et al. 2007). In the case of Bromeliaceae (Figure 3 E-J), flowers are tubular and stamens are fused at the center (Figure 3 F and J) (Bernardello et al. 1991). The anthers present longitudinal opening and are directed towards the corolla (Figure 3H-J). Flowers of these two plant families are exclusively nectariferous (Galetto and Bernardello 2003) and pollen is accidentally deposited on the body of floral visitors, especially on the head (Silva et al. 2007; Araújo et al. 2011).

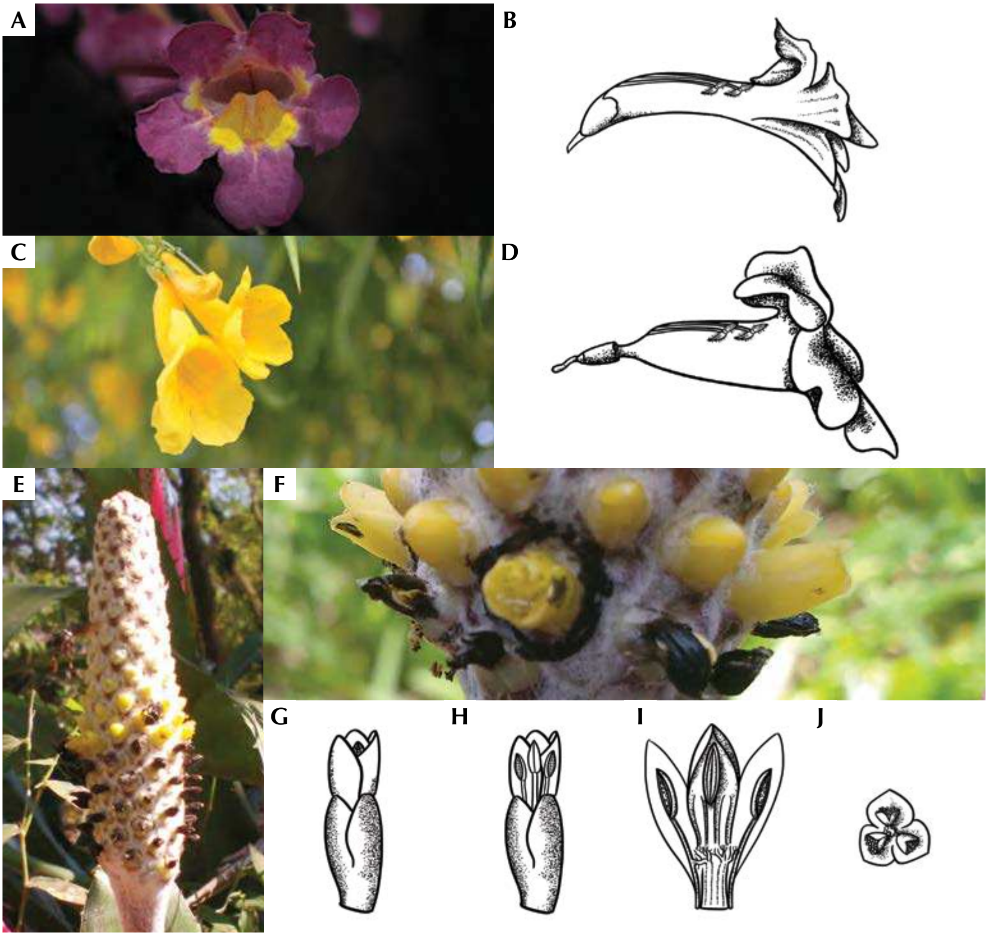

Figure 3. Flowers of Bignoniaceae and Bromeliaceae. A-B: *Handroanthus impetiginosus*. C-D: *Tecoma stans*. E-I: *Aechmea bromelifolia*. E-F: inflorescence. G-I: isolates flowers - lateral view, lateral view showing the anther's positions, section of the flower with anthers longitudinal opening directed towards the corolla and across section of the flower, respectively.

Because of the floral morphology of Bignoniaceae and Bromeliaceae, as described above, bees require certain abilities to collect pollen when foraging on these flowers. Observing the visits of *E. annectans* to flowers of *A. bromelifolia*, we recorded that, while collecting nectar, a large amount of pollen is deposited on the tongue of the females (Figure 4 A-E). When leaving the flowers, still with distended glossa, the females transfer the pollen to corbiculae in the hind legs. Females always move in and out of a flower with distended tongues, either in species of Bromeliaceae or Bignoniaceae. This behavior has been reported in Euglossini species visiting flowers of *T. stans* (Silva et al. 2007), *Odontadenia lutea* (Apocynaceae) (Silva and Torezan-Silingardi 2008) and *Jacaranda rugosa* (Milet-Pinheiro and Schlindwein 2009).

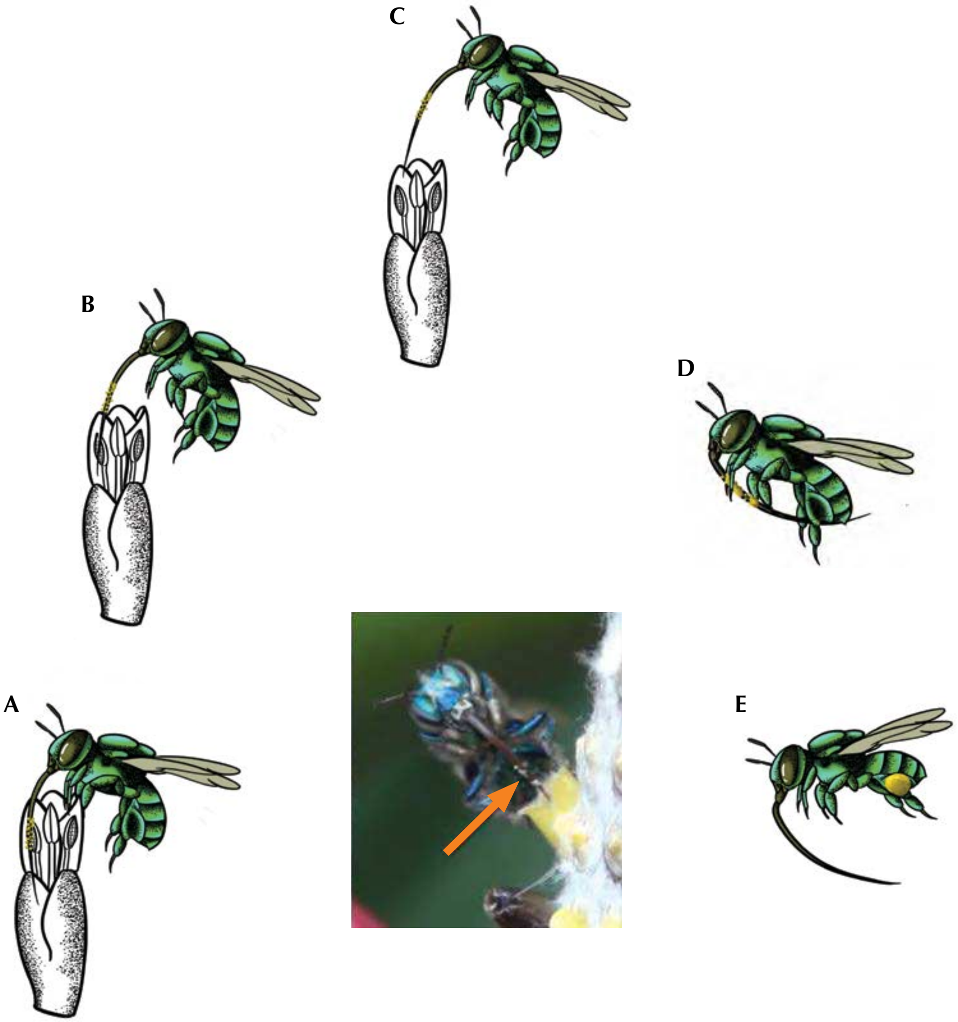

Figure 4. Visit sequence of *Euglossa annectans* female in flower of *Aechmea bromelifolia* to collect nectar and pollen using proboscis. A: female inserts its proboscis into the flower to gather nectar and pollen. B-C: female leaves the flower with pollen grains deposited in the tongue. D: female scrape the tongue with the first and medium legs and transfer to the hind legs. E: Female with the pollen stored in the corbiculae of the hind tibia.

In the campus, we also observed that when *E. annectans* females leave the flower of *T. stans* and *H. impetiginosus* (Bignoniaceae), they clean their tongue with pollen clumps with the fore legs, and transfer the pollen grains to the middle legs and then to corbiculae (Figure 5 A-I), exactly as observed in Bromeliaceae flowers. In flowers of these Bignoniaceae, the anthers are positioned at the top of the tubular corolla with the longitudinal slits facing downwards (Figure 3D). This morphology precludes collecting the pollen with the legs (Figure 5 A-I). After observations in the field and in experimental simulations, it was confirmed that females of *E. annectans* actively collected pollen grains synchronically with the nectar collection using their tongues.

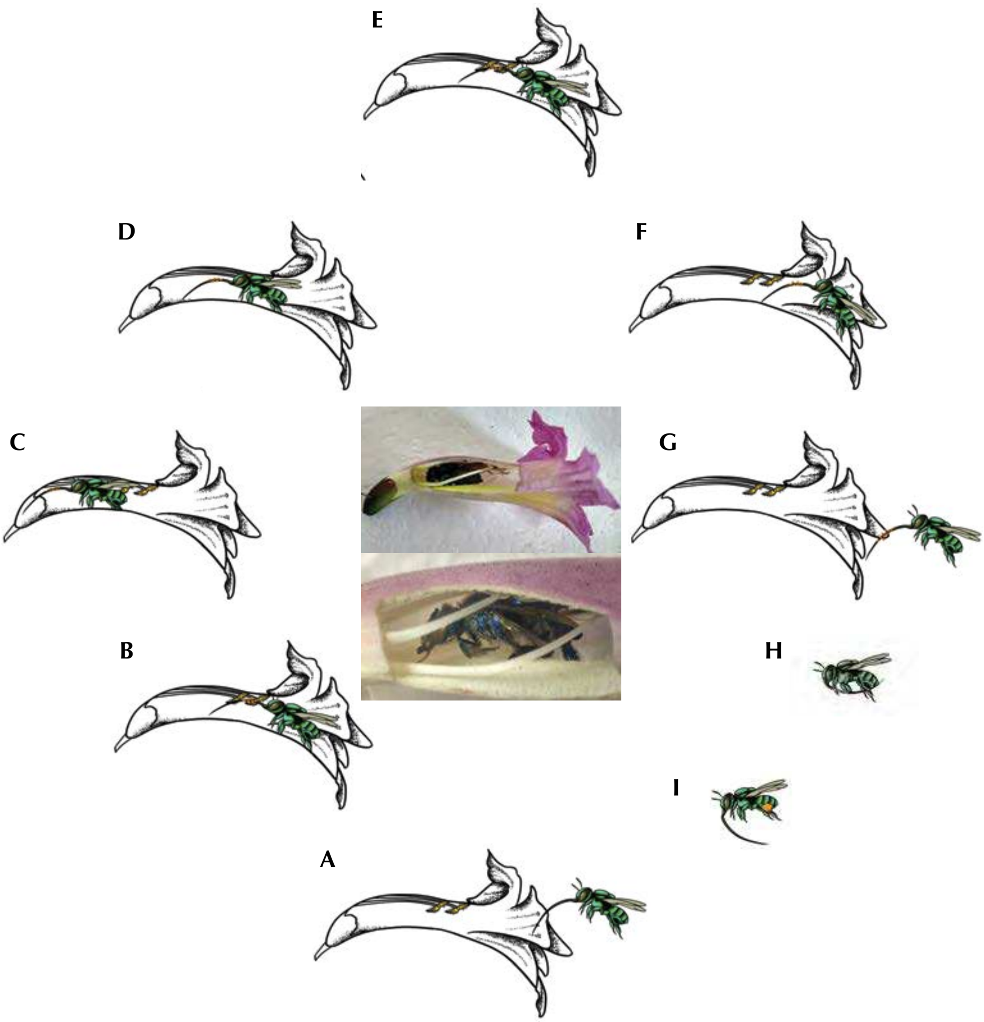

Figure 5. Visit sequence of *Euglossa annectans* female in flower of *Handroanthus impetiginosus* to collect nectar and pollen using proboscis. A: female arrives in the flowers with the proboscis extended B-C: female inserts its proboscis into the flower to gather nectar. D-G: female leaves the flower with pollen grains deposited in the tongue. H: female scrape the tongue with the first and medium legs and transfer to the hind legs. I: Female with the pollen stored in the corbiculae of the hind tibia.

Both *H. impetiginosus* and *T. stans* have bifid stigma, which is sensitive to touch (Silva et al. 2007). Just after the bee enters the flower and touches the stigma, it closes, preventing the flower from being self-pollinated, since the bee carries a large amount of pollen in its glossa, exactly as shown in Figure 5 A-I. Milet-Pinheiro and Schlindwein (2009) found that the same happens in Jacaranda rugosa, after the visit of *E. melanotrica* and *E. cordata*.

Gentry (1974) associated the pollination of most Bignoniaceae species studied in Costa Rica and Panama with Euglossini bees, but until then the complete process of pollen transference was not clear. Silva et al. (2007) observed seven species of Euglossini bees (*Eulaema*, *Eufriesea* and *Euglossa*) visiting flowers of *T. stans* in different areas of São Paulo and Minas Gerais. Furthermore, a significant amount of Bignoniaceae' pollen was recorded in the brood cells of *Euglossa* spp. in Santa Marta (Colombia) and Belem (Brazil) (Sepulveda and Silva unpublished data, respectively), showing that Bignoniaceae' species contribute significantly to the diet of the offspring of *Euglossa* in different regions.

It is possible that several Bromeliaceae species depend on Euglossini for pollination. Silva (unpublished data) observed *Euglossa* spp. visiting flowers of *Q. arvensis* in Cardoso Island, southern São Paulo, and pollen of this species was also present in the diet of the immature of *E. annectans* (Table 1). In the present study, we show the importance of refined observations on the behavior of floral visitors and also how much information pollen can reveal about the bee and plant interaction. We are conducting now a study on the pollination of the Bromeliaceae species identified in the diet of *E. annectans* in order to understand how exactly the collection of pollen with the tongue takes place, as well as to evaluate the role of this bee species as a pollinator.

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Melipona marginata **in honey pots**

Trophic niche of *Melipona (Eomelipona) marginata* Lepeletier, 1836 – in floodplain fields of National Forest Reserve (FLONA) of Três Barras, in the southern Atlantic Forest of Brazil

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CLÁUDIA INÊS DA SILVA, MAURO RAMALHO

Institution and research group

The present research was developed at the Pollination Ecology Laboratory (Ecopol), of the Federal University of Bahia (UFBA). Lines of research of the laboratory: Ecology of communities; pollination ecology; ecology of animal-plant interaction and conservation ecology. The aim is to generate ecological subsidies for the management of natural environments, aiming at alternatives that promote connectivity in fragmented landscapes.

The project

The influence of biodiversity on the regulation of ecosystem processes and services is one of the best-established scientific findings in contemporary ecology. Thus, the identification of the role of functional groups on the topology of ecological interaction networks is of great interest when it comes to the conservation of pollination services at different spatial scales (local, regional and global). The social bees Meliponini form a group of central importance in the pollination process in tropical and subtropical environments, given their numerical dominance in ecological communities and the generalist behavior of using floral resources. Although their populous colonies with a perennial life cycle lead to a generalist behavior, many species may have temporary preferences, concentrating the exploration of nectar and pollen on some floral sources, often more productive (abundant and concentrated in space-time, such as species with mass-flowering, for example).

In this project, in an unprecedented way, we manipulated the abundance of a focal species, in this case, a more abundant Meliponini in the local community. Thereafter, we crossed extensive business data on flowers to data on pollen and nectar foraging for this species. The organization and complementarity of these data (observations on flowers and parallel characterization of pollen on the body of bees), with the characterization of the general network in the community and the detailing of sub-structures (pollen or nectar networks; dynamics of the networks) must enable a more realistic structural and dynamic analysis of ecological functionality in the flower-visiting-pollinator community. As a result of the project, we obtained the PhD thesis in Postgraduate Program in Ecology and Biomonitoring - Federal University of Bahia (UFBA), entitled: Influence of social bees Meliponini on the topology of flower-visitor interaction networks: experimental field test.

National Forest Reserve (FLONA) of Três Barras

The study was carried out in floodplain fields within the National Forest Reserve (FLONA) of Três Barras, South Region of Brazil (26°13’12.81”S; 50°18’16.76”W). FLONA is located within the Atlantic Forest Domain (Tropical Rain Forest), where Ombrophilous Mixed Forest (*Araucaria* Forest) predominates. Two other very significant plant formations occur within the distribution area of Ombrophilous Mixed Forest on alluvial soils on flat relief along river banks (IBGE 2004): “Alluvial Ombrophilous Mixed Forest” (Gallery Forest) and pioneer vegetation with fluvial influence, also known as “floodplain fields”. Alluvial forests and floodplain fields account for 50% of the area of FLONA (Figure 1). The climate of the region is Cfb (Köppen 1948), temperate, constantly moist, without a dry season, with cool summers and frequent frosts during the winter. The mean annual temperature varies from 15.5 to 17.0°C. Annual total rainfall varies between 1,360 and 1,670 mm and the relative humidity between 80.0 and 86.2 %.

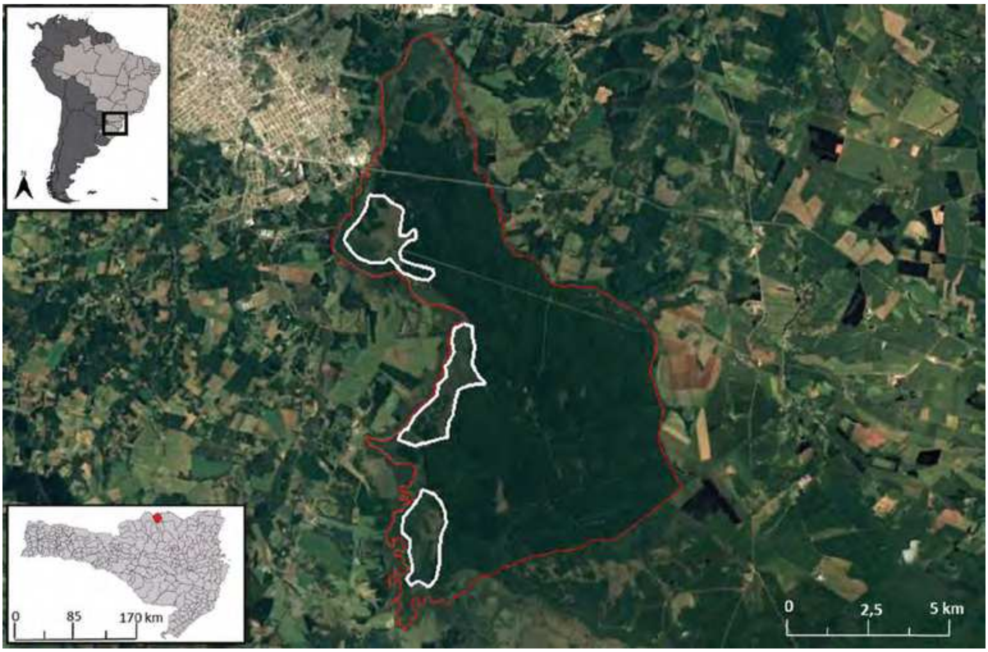

Figure 1. Satellite image of National Forest Reserve (FLONA) of Três Barras (delimited in red), in the southern Atlantic Forest, State of Santa Catarina, Brazil, with the three experimental sites of floodplain fields delimited in white.

Description of the vegetation in the study area

The floodplain fields are associated with hydromorphic soils, with good levels of nutrients (Marques 2007). They are fragile environments, with origin and functioning linked to the deposition of geologically recent sediments, subjected to flooding during a certain period of the year, as a result of rainfall regimes (Ducke and Black 1954). From an ecological point of view, they are called transition areas, presenting characteristics of the land and the fluvial environment, with several particularities (Schöngart et al. 2004). They are characterized by a plant community of very homogeneous appearance, with color ranging from green in summer to brown in winter, due to the action of frosts (Figure 2) and are home to a high biodiversity of plants and animals (Mata et al. 2011). The uses of this environment are centered on plant extraction and extensive livestock production, with few studies on biological interactions and sustainable exploitation.

Figure 2. Image of the floodplain fields of National Forest Reserve (FLONA) of Três Barras, in the southern Atlantic Forest of Brazil.

Methods used to organize the plants (herbarium), pollen and bee (entomological) collections

Field samplings were conducted in the summer and in the spring in 2016 and 2017, encompassing the seasons during which bees forage most intensely on flowers. Three floodplain experimental sites were selected, and they were separated by at least 1 km – spatially independent sites. At each sampling area, three 500 x 20 m (1 ha) rectangular plots were demarcated for data collection, for a total of 18 plots (3 experimental sites x 2 areas x 3 plots). The abundance of *M. marginata* was increased in one sampling area of each experimental site by inserting a nest of this bee at the center of each of the three plots (PWN), while no nests were inserted in the other plots (PWoN) (without change in abundance). We chose *M. marginata* for this experiment on the effect of abundance on interaction networks because it is abundant in FLONA and naturally present in all experimental sites of floodplain fields.

In each plot, bees foraging pollen and/or nectar were recorded and sampled with entomological nets between 9:00 and 16:30 in order to reduce the effects of daily variation on foraging activity. During this time of the day, for the first 30 minutes of each hour, a collector monitored the entire area of each plot (1 ha), collecting bees for at least five minutes on each plant. Collected bees were fixed, measured and identified to genus or morphospecies level with the aid of specialists. The vouchers were deposited in the entomological collection of BIOSIS – Laboratório de Bionomia, Biogeografia e Sistemática de Insetos, of the Federal University of Bahia (UFBA).

Samples of the flowering plants visited by the bees were collected for the preparation of exsiccates. The vouchers are deposited in the Herbarium of Municipal Botanical Museum of Curitiba, State of Paraná. Pre-anthesis flower buds were sampled for each plant species and preserved in 70% alcohol and subjected to acetolysis, following the protocol of Silva et al. (2014). With acetolysed pollen, microscopic slides were prepared, which were deposited in the Pollen collection of the Bee Laboratory, Institute of Biology, University of São Paulo (IBUSP). Pollen grains were photographed and described following the protocol of the RCPol - Online Pollen Catalogs Network (www.rcpol.org.br).

Pollen was collected from the body of the bees (including pollen from corbicles) and subjected to acetolysis (Erdtman, 1952) following the protocol of Silva et al. (2014). The pollen grains on the bees were identified by comparison with the reference pollen.

Under the optical microscope, the first 400 pollen grains from each sample were counted and identified (Montero and Tormo 1990). According to the percentage in the sample, the grains were categorized according to Louveaux et al. (1970, 1978). For a plant to be considered important in the diet of *M. marginata*, it was arbitrarily pre-established that its pollen should have the minimum representation of 10% (Ramalho et al. 1985) in the set of pollen samples from the set of sampled bees of this species, each day.

Melipona (Eomelipona) marginata Lepeletier, 1836

Social stingless bees (Apidae: Meliponini) are important floral visitors of several botanical species, due to their feeding habits and foraging behavior (Ramalho et al. 1990). *Melipona (Eomelipona) marginata,* popularly known as Manduri, is one of the smallest of its genus (Nogueira-Neto 1963). Along with other species of the genus, *M. marginata* has been shown to be dependent on forest environments, not being found in open environments, being also, apparently, demanding as to the size of and/or quality of the forest fragment (Silveira et al. 2002).

In the samplings in the floodplain fields in FLONA during spring and summer, we found *M. marginata* visiting a total of 21 plant species. Based on the analysis of pollen adhered to the body and the corbicles of forager *M. marginata,* we related 13 plant species used for their feeding and we found that this generalist species interacted with practically all plant species with abundant blooms in the habitat, often concentrating foraging within this subset (Table 1). During spring, *M. marginata* concentrated pollen and nectar foraging on plant species exclusively mass-flowering. At this time of the year, it foraged pollen mainly in flowers of *M. eousma* (40%), *S. terebinthi-*

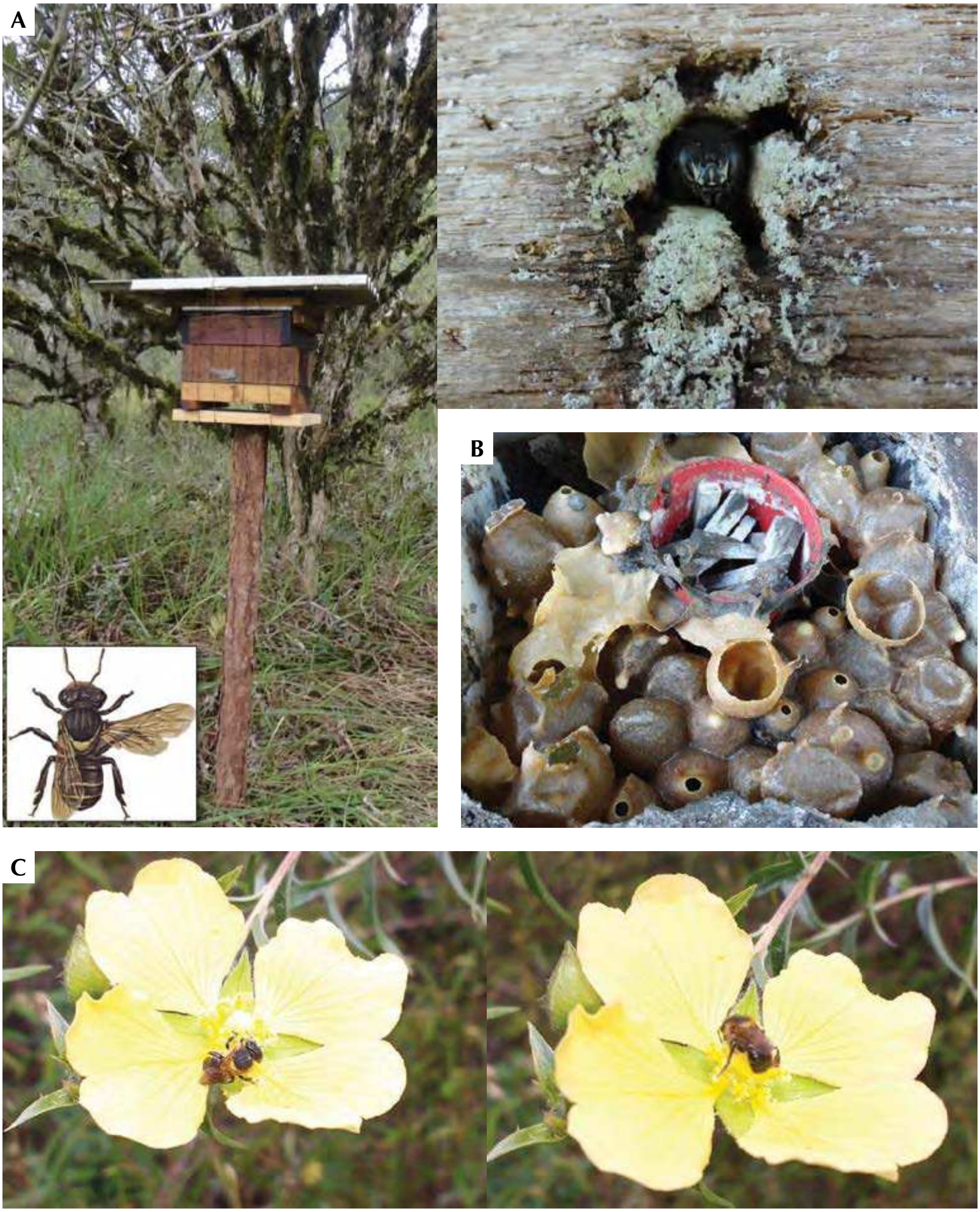

Figure 3. Image of *Melipona (Eomelipona) marginata* Lepeletier, 1836 nest (A), honey and pollen pots (b) and visiting flowers of *Ludwigia sericea* (Cambess.) H.Hara, in the floodplain fields of National Forest Reserve (FLONA) of Três Barras, in the southern Atlantic Forest of Brazil. * Image of *Melipona (Eomelipona) marginata* Lepeletier, 1836: Camargo et al. 1967.

folius (16%) and *R. sphaerosperma* (13%) and nectar, in flowers of *R. sphaerosperma* (45%), *S. glandulosomarginata* (20%) and *B. psudovillosa* (11%). During summer, *M. marginata* foraged nectar in flowers of only two plant species: *H. rigidum* (75%) and *L. sericea* (25%), and *H. rigidum* (32%) and *L. sericea* (26%) also stood out as pollen sources in this period, followed by *C. ceanothifolius* (21%). Only this last pollen source has mass-flowering. Of all the plant species sampled in the present study in the floodplain areas, 82% have mass-flowering (Woitowicz 2019), which favors visitation by species adapted to this type of flowering, such as the bee species of the Meliponini tribe, as noted here. Native stingless bees generally appear associated with massive blooms, registered mainly in tree species of the Atlantic forest (Ramalho 2004; Ramalho and Batista 2005) and, probably, have a strong influence on the reproductive success of these trees, playing a relevant role in the natural regeneration of the forest (Ramalho 2004). Such association with trees that exhibit mass flowering is frequent, since individuals from the Meliponini tribe have adaptations for exploiting resources concentrated in space and time, such as large perennial colonies, communication of floral sources, and storage of excess pollen and nectar for future use (Michener 2000; Ramalho 2004).

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Table 1. Plant species used by *Melipona (Eomelipona) marginata* Lepeletier, 1836 in areas of floodplain fields in FLONA (Três Barras Forest, SC; Southern Brazil)

Family	Species/Genus of plants
Anacardiaceae	*Schinus terebinthifolius* Raddi
Aquifoliaceae	*Ilex dumosa* Reissek
Asteraceae	*Baccharis psudovillosa* Malag. & J.Vidal
Asteraceae	*Lessingianthus glabratus* (Less.) H.Rob.
Euphorbiaceae	*Croton ceanothifolius* Baill.
Hypericaceae	*Hypericum rigidum* A.St.-Hil.
Lamiaceae	*Vitex megapotamica* (Spreng.) Moldenke
Myrtaceae	*Myrceugenia euosma* (O.Berg) D.Legrand
Myrtaceae	*Myrcia selloi* (Sreng.) N. Silveira
Onagraceae	*Ludwigia sericea* (Cambess.) H.Hara
Rhamnaceae	*Rhamnus sphaerosperma* Sw.
Rosaceae	*Prunus myrtifolia* (L.) Urb.
Symplocaceae	*Symplocos glandulosomarginata* Hoehne

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Melipona quadrifasciata

Important floral sources used to feed bees in southern Brazil

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Introduction

The pollen grain is the transporter of the male gamete of plants. Pollen grains are microscopic sized (20-100 micrometers, on average), and are used by bees as a source of food, along with nectar. When feeding, the bee takes the pollen grain from one plant to another, carrying out pollination. It is estimated that the services provided by pollinators in agricultural areas are worth around 153 billion euros per year, and that their extinction may reduce, by up to 12%, the production of fruit consumed in the world (Drumond 2013). Not all plants are pollinated by bees, some can be pollinated by the wind (e.g. corn and wheat), water, or other animals, such as bats (e.g. pequi). However, bees are still the most important and efficient pollinators. A survey of floral visitors on *Solanum sisymbriifolium* Lam. (*Physalis* L.) registered the predominance of insects from the Hymenoptera group (order of bees), totaling 84% floral visitors, followed by Coleoptera (order of ladybugs and beetles), with 12%, and other insects, with 4% (Ramos 2013).

In Brazil, unlike the United States and other countries from Europe, the use of bees on pollination is scarce. Nonetheless, in the Northeast region, it is a common practice to rent beehives for the pollination of melon crops, and in the South region, for the pollination of apple trees.

It is estimated that around 20,000 of field bees are needed for the fertilization of flowers produced in 1 hectare of land, an average of 3 to 5 colonies per hectare (Almeida et al. 2003). The bee most commercially used by farmers is *Apis mellifera* L. (please see Table 1), due to the resistance of their hives and to the easy replication. However, there are many native bees, mostly social, that are essential for maintaining ecosystems, such as the Caatinga, where 187 species of native bees have already been identified (Maia-Silva et al. 2012).

Weeds around crops can be of great importance as a food resource for

Table 1. Increase on the productivity of agricultural crops with the use of *Apis mellifera* on pollination (adapted from Almeida et al. 2003).

Agricultural crop	Productivity increase (%)
Pumpkin	76.9
Coffee	39.2
Onion	89.3
Apple	from 75 to 94.4
Peach	94.4
Orange	from 15.5 to 36.3
Bean	21
Sunflower	from 300 to 600
Soy	from 6 to 230

bees. In the State of Rio Grande do Sul, pollen grains of Asteraceae Bercht. & J.Presl (wildflorers), *Butia* (Becc.) *Becc.* (butiá) and *Passiflora* L. (passion fruit) were registered in honey samples of Africanized bees (*Apis mellifera* L.) in hives from coastal cities in the north of the state (Nobre et al. 2014). Pollen from native plants have also been found in honey samples of *Apis mellifera* L. and *Tetragonista angustula* Latreille (Jataí-amarela) from the Vale do Taquari region (Osterkamp 2009). In addition, 116 plants with known medicinal use were registered, such as "sabugueiro" (*Sambucus nigra* L.), "marcela" (*Achyrocline satureoides* (Lam.) DC.), "carqueja" (*Baccharis trimera* (Less.) DC.), "urucum" (*Bixa orellana* L.), and sweet passion fruit (*Passiflora alata* Curtis), which are also apicultural plants (Mouga and Dec 2012).

Bees also visit and feed on pollen and nectar from commercial plants, such as passion fruit (*Passiflora edulis* Sims) and "acerola" (*Malpighia emarginata* DC). Small areas can be of great importance for bees. On the USP Ribeirão Preto campus, 100 species of plants were used as a food resource for bees (Silva et al. 2014). Although these studies highlight the plant species visited by social bees, the State of Rio Grande do Sul still has a shortage of melissopalinological work demonstrating bee-plant relationships (Radaeski et al. 2019). In this sense, the objective of this study was to carry out a qualitative analysis of pollen grains dispersed in honey of social bees, and corbicular pollen of bees from the State of Rio Grande do Sul, in order to elucidate which plants the bees visit.

Material and Methods

We collected honey from *Apis mellifera*, *Tetragonisca angustula*, *Melipona quadrifasciata*, *Scaptotrigona bipunctata*, *Plebeia remota* and *Plebeia droryana* (Figure 1), in addition to *Bombus morio* corbicular pollen for palynological analysis. Honey samples of stingless bees were obtained from a meliponary located near the riparian forest of the Gravataí River in the municipality of Cachoeirinha (Figure 2), metropolitan region of Porto Alegre (29°57′46.2″S 51°06′24.3″W). Honey samples of *Apis mellifera* were collected from an apiary located in Gravataí (29°52′53.87″S 50°58′15.37″W). Pollen samples of *Bombus morio* were collected in the municipality of Itaara (29° 36′ 35″ S 53° 45′ 53″ W).

Samples were processed according to Erdtman (1952). Afterwards, slides were mounted with glycerin gelatin and analyzed in an optical microscope with 400x magnification. For the identification of pollen grains contained in the honey samples, we consulted publications on pollen descriptions for the regional flora (Evaldt et al. 2009; Bauermann et al. 2013; Radaeski et al. 2014 2019; Liskoski et al. 2018), the Online Pollen Catalogs Network (RCPol 2020), and the Pollen collection of the Palynology Laboratory of Ulbra.

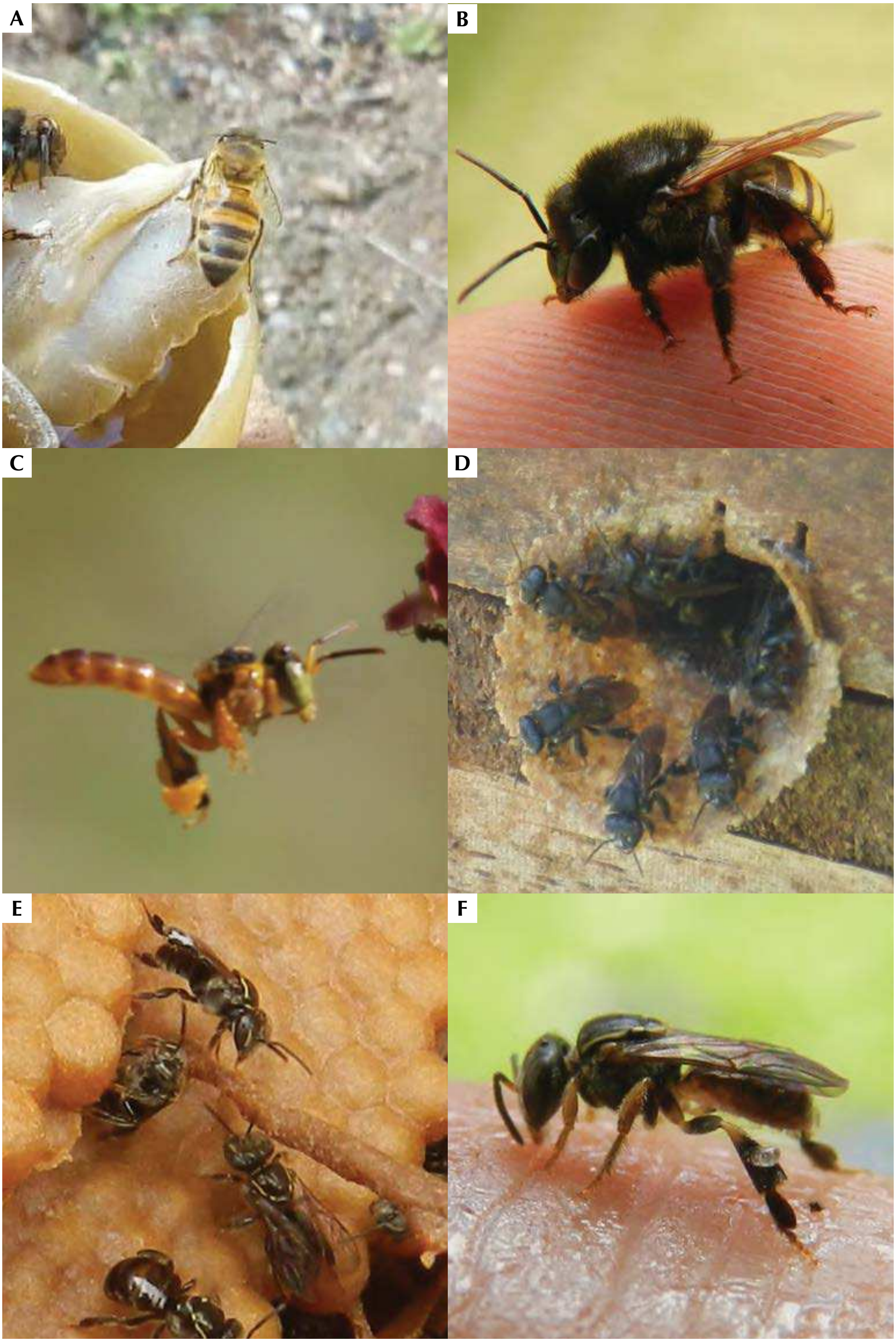

Figure 1. Social bees from which pollen was collected. *Apis mellifera* (A), *Melipona quadrifasciata* (B), *Tetragonisca angustula* (C), *Scaptotrigona bipunctata* (D), *Plebeia remota* (E) e *Plebeia droryana* (F).

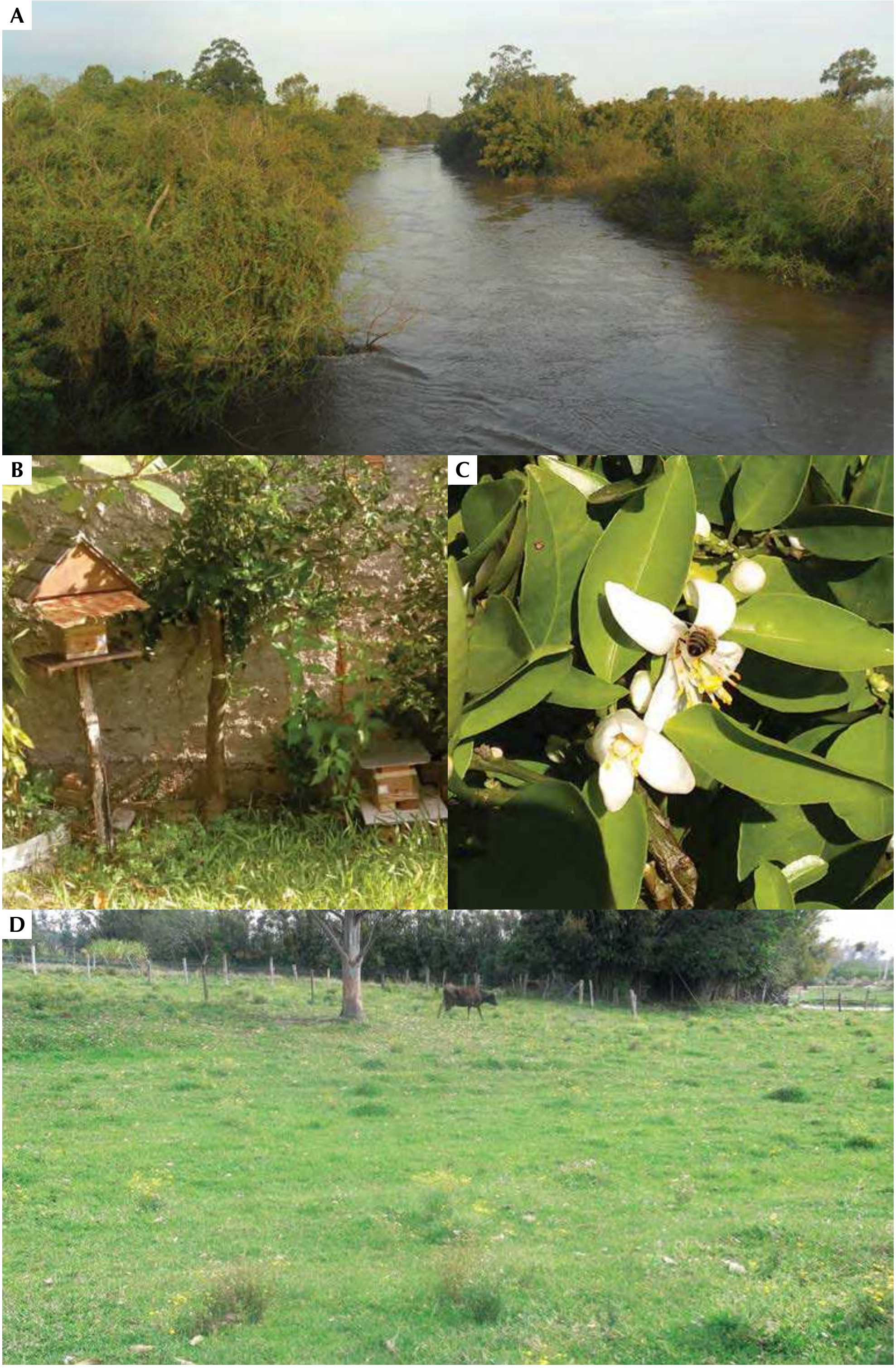

Figure 2. Landscape and vegetation from the meliponary in Cachoeirinha (A, B) and from the apiary in Gravataí (C, D).

Table 2. Relationships between plant species and bee species identified by pollen grains in honey and social bees in Rio Grande do Sul.

Plant family	Plant species	Bee species
Begoniaceae	*Begonia cucullata* Willd.	*Melipona quadrifasciata* Lepeletier, 1836
Bignoniaceae	*Handroanthus chrysotrichus* (Mart. ex DC.) Mattos	*Bombus morio* (Swederus, 1787), *Tetragonisca angustula* (Latreille, 1811)
Passifloraceae	*Passiflora caerulea* L.	*Xylocopa* sp. Latreille, 1802
Solanaceae	*Solanum lycopersicum* L.	*Bombus morio* (Swederus, 1787), *Melipona quadrifasciata* Lepeletier, 1836
Melastomataceae	*Pleroma granulosa* (Bonpl.) D. Don	*Bombus morio* (Swederus, 1787)
Anacardiaceae	*Schinus terebinthifolia* Raddi	*Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758
Sapindaceae	*Allophylus edulis* (A.St.-Hil., A.Juss. & Cambess.) Radlk.	*Scaptotrigona bipunctata* (Lepeletier, 1836)
Myrtaceae	*Psidium cattleianum* Afzel. ex Sabine	*Melipona quadrifasciata* Lepeletier, 1836, *Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758, *Scaptotrigona bipunctata* (Lepeletier, 1836), *Plebeia droryana* (Friese, 1900), *Plebeia remota* (Holmberg, 1903)
Myrtaceae	*Eucalyptus grandis* W.Hill	*Melipona quadrifasciata* Lepeletier, 1836, *Apis mellifera* Linnaeus, 1758
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	*Apis mellifera* Linnaeus, 1758
Arecaceae	*Butia yatay* (Mart.) Becc.	*Plebeia remota* (Holmberg, 1903), *Plebeia droryana* (Friese, 1900), *Scaptotrigona bipunctata* (Lepeletier, 1836), *Apis mellifera* Linnaeus, 1758, *Melipona quadrifasciata* Lepeletier, 1836, *Tetragonisca angustula* (Latreille, 1811)
Moraceae	*Sorocea bonplandii* (Baill.) W.C.Burger, Lanj. & de Boer	*Tetragonisca angustula* (Latreille, 1811)
Lythraceae	*Heimia myrtifolia* Cham. & Schltdl.	*Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758
Malvaceae	*Luehea divaricata* Mart.	*Tetragonisca angustula* (Latreille, 1811), *Plebeia remota* (Holmberg, 1903)
Salicaceae	*Casearia sylvestris* Sw.	*Apis mellifera* Linnaeus, 1758
Euphorbiaceae	*Sebastiania commersoniana* (Baill.) L.B.Sm. & Downs	*Apis mellifera* Linnaeus, 1758, *Tetragonisca angustula* (Latreille, 1811), *Scaptotrigona bipunctata* (Lepeletier, 1836), *Plebeia remota* (Holmberg, 1903)
Myrtaceae	*Acca sellowiana* (O.Berg) Burret	*Melipona quadrifasciata* Lepeletier, 1836, *Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758
Myrtaceae	*Eugenia uniflora* L.	*Plebeia remota* (Holmberg, 1903), *Plebeia droryana* (Friese, 1900), *Scaptotrigona bipunctata* (Lepeletier, 1836), *Apis mellifera* Linnaeus, 1758, *Melipona quadrifasciata* Lepeletier, 1836, *Tetragonisca angustula* (Latreille, 1811)
Aquifoliaceae	*Ilex paraguariensis* A.St.-Hil.	*Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758
Euphorbiaceae	*Sapium glandulosum* (L.) Morong	*Tetragonisca angustula* (Latreille, 1811), *Apis mellifera* Linnaeus, 1758, *Plebeia remota* (Holmberg, 1903)

Results

We identified 20 plant species from the pollen grains present in samples of honey and corbicular pollen from bees from the State of Rio Grande do Sul (Table 2). Some of the identified plant species are visited by many bees, such as *Psidium cattleianum, Butia yatay, Eugenia uniflora, Sebastiania commersoniana*, and *Acca sellowiana*. The visit of different bees to these plant species indicates that they are potential suppliers of nectar and/or pollen and that it is interesting to manage these plants in the vicinity of meliponaries and apiaries. On the other hand, some plants were visited by a smaller number of bees, such as *Begonia cucullate*, visited by *Melipona quadrifasciata*, and *Allophylus edulis*, visited by *Scaptotrigona bipunctata*.

Conclusions

The plant species identified in the palynological samples evidence their relationship with the bees in the State of Rio Grande do Sul. Knowing these bee-plant relationships is important for the management of the vegetation in apiaries and meliponaries. We show that both native and cultivated plant species were visited by bees, demonstrating the bees' role in the maintenance of these plant communities through pollination. This list of plants obtained through the identification of pollen in the samples can assist both honey producers and restorative agents of native vegetation, by applying knowledge about which bees visit certain plants.

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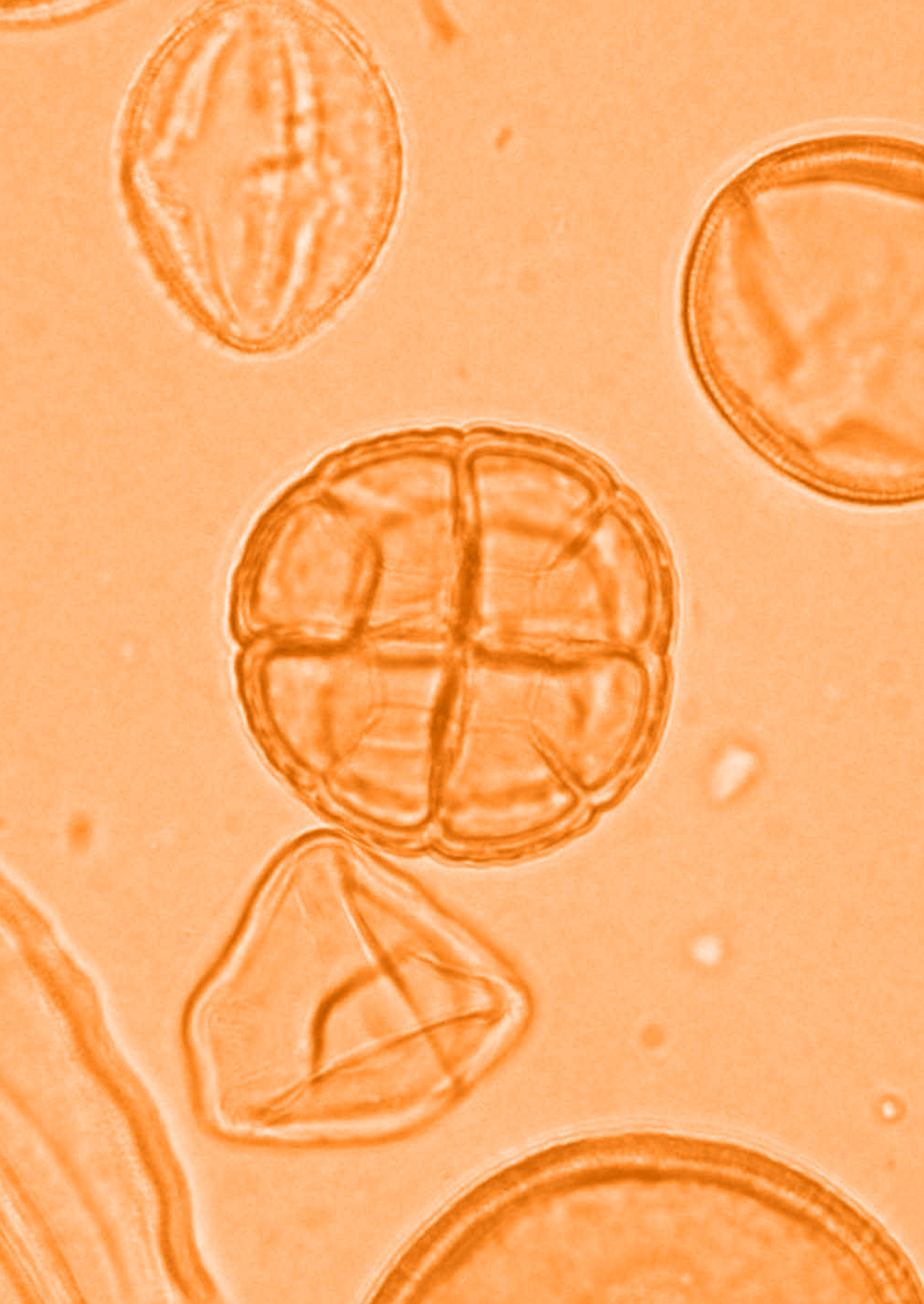

Pollen catalog of plants used in bee's diet in different types of vegetation

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Introduction

Pollen is a reproductive structure of the plant that has the function of producing and transporting male gametes from the anthers to the stigma of flowers. In angiosperms, after the microsporogenesis process, when microspores (pollen grains) are formed, they are released by the anthers, allowing pollination to occur (Figure 1A). In the reproductive process, angiosperms have different pollination systems (Figure 1B-D), such as apomixis, in which the flower does not need pollination and pollen for its fertilization (self-fertilization), and self-pollination, in which the stigma receives pollen from the same flower (autogamy; Figure 1B) or from another flower from the same individual (geitonogamy; Figure 1C). In these two processes, there is no exchange of genetic material between individual plants. However, in most species of flowering plants there is some level of self-incompatibility, which in several cases makes cross-pollination mandatory (allogamy; Figure 1D). This means that, for a flower to be fertilized, it needs to receive pollen from another flower from a different individual from the population, in which case there is exchange of genetic material inside it.

Male gametes are produced in pollen grains through a process called microgametogenesis, in which two gametes are formed. These two gametes are essential for the formation of fruits and seeds in angiosperms. The role of pollen grains in protecting gametes is fundamental to the reproductive success of plants. Pollen undergoes many obstacles until it reaches the stigma of the flower. Once released from the anthers, pollen may suffer from dehydration or excess water, receive UV light, come into contact with the wind, suffer mechanical action from pollinators, among others. When they reach the stigmatic papillae, they face other barriers, such as the presence of other intra or interspecific pollen grains. Then, from that moment, through substances secreted by the stigmatic papillae, the rupture of the pollen grain apertures begins and the leakage of

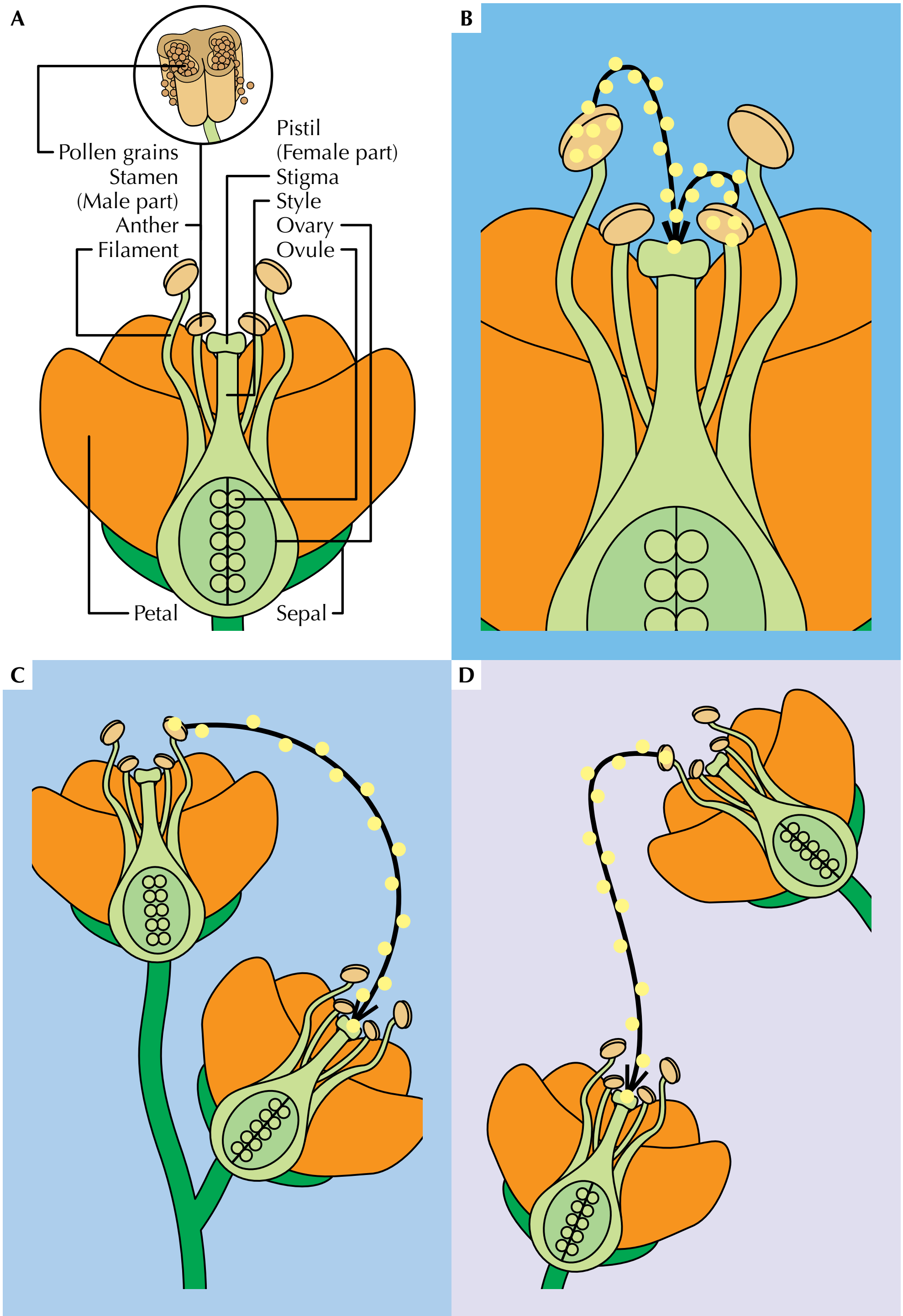

Figure 1. Pollination systems. A: flower morphology. B: self-pollination, in which the stigma receives pollen from the same flower (autogamy). C: geitonogamy, in which the flower accepted the pollen from another flower from the same individual. D: cross-pollination mandatory (allogamy), in which the flower needs to receive pollen from another flower from a different individual.

the cytoplasmic content forms the pollen tube that will take the gametes to the eggs, located in the ovules of the flowers.

After the release of the cytoplasmatic content by pollen in the stigmas of flowers, the pollen wall, or exine, loses its function, but assumes a spectacular ecological role. Only the wall of the pollen grains remains on the stigmatic surfaces, which is highly resistant and can persist after the flowers fall to the ground, for thousands of years, depending on environmental conditions. A substance called sporopollenin (Zetsche 1932) is found in the pollen wall, providing high resistance and protection to the pollen, mainly related to hostile environments (Moore and Webb 1978). Pollen can withstand more than 300°C in temperature and chemical treatments (Erdtman 1960). Pollen wall is formed by three layers (Figura 2): the intine, which is the innermost layer that makes contact with the cytoplasmic content; exine is the middle layer; and the sexine, which is the outer layer. The sexine has ornamental and tectate elements, such as spine, reticule, baculum, etc. (Salgado-Labouriau 1973; Punt et al. 2007; Hesse et al. 2009). Exine ornamentation is one of the most important morphological characteristics of the pollen grain used to identify the identity of the plant species to which it belongs, besides shape, size, number of apertures, etc.

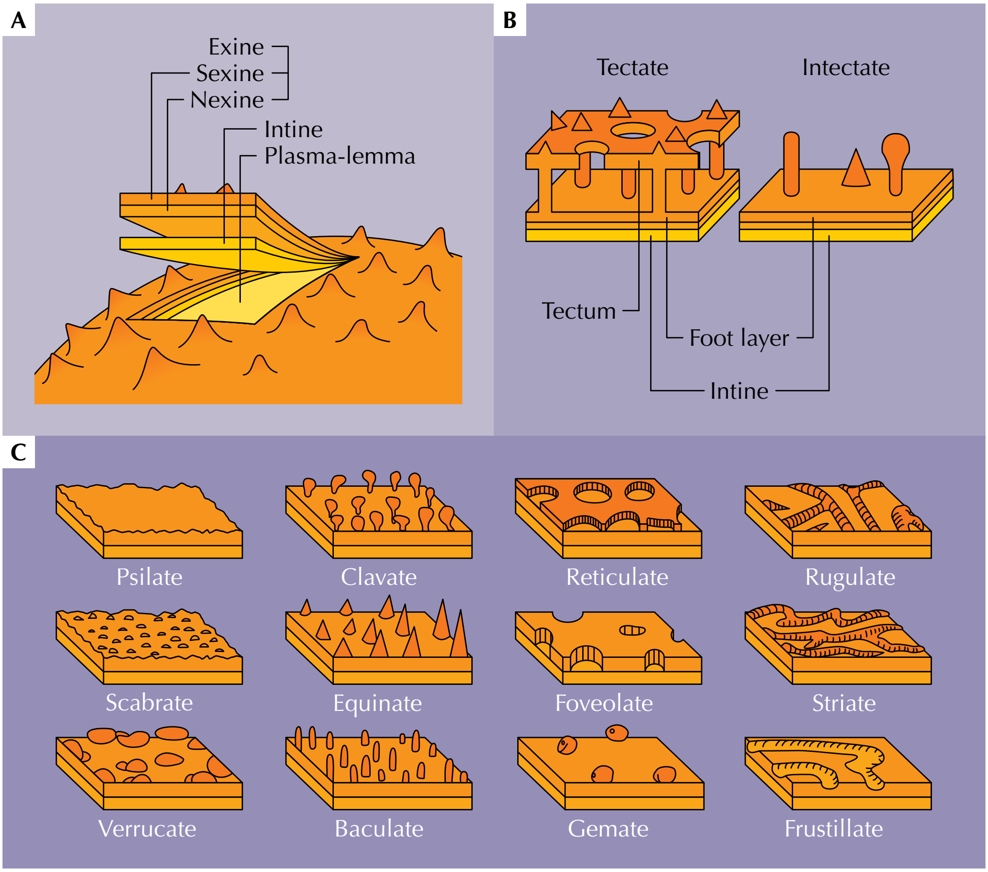

Figure 2. Pollen wall. A: three layers of the pollen wall; the intine, which is the innermost layer that makes contact with the cytoplasmic content; exine is the middle layer; and the sexine, which is the outer layer. B: sexine has ornamental and tectate elements (Modified from Erdtman 1952). C: types of the pollen wall ornamentation (Modified from Tschudy & Scott, 1969).

Because of the morphological characteristics and the resistance of the exine, pollen can tell us amazing histories. For example, when deposited in sediments, it is possible to reconstruct the plant composition of determined geological ages (Bauermann 2003, Bauermann et al. 2008, Behling et al. 2004). Paleopalynologists may reconstruct past vegetation and can even contribute to paleoclimatic studies. Other fascinating use of the pollen as a natural marker is related to samples of pollen deposited on the animal bodies during their visits to collect the floral resource. This pollen can be transported on their bodies for a long distance and might indicate the foraging routes and plants blooming periods, bringing important information about the ecological interactions. Palynoecologists study the plant-pollinator interaction network through the pollen grains.

Pollen is also part of bee products, such as bee pollen, honey and royal jelly. Melissopalynologists identify the botanical origin of bee products through the types of pollen found in samples of these products (Barth 2004, Silva et al. 2019, Nascimento et al. 2019). In some rituals, such as mummification processes, the archeopalynologist helps to recognize types of plants and products, revealing the medicinal or food plants used by ancient peoples (Chaves and Reinhard 2003, Moe and Oeggl 2014, Reinhard et al. 2017). In addition, in criminal investigations, the forensic palynologist can find crucial results about adulterated products, crime routes and even murders.

Pollen and bee interaction

Pollen is like a fingerprint, as each plant species has its own identity, just like humans. Palynology is the science responsible mainly for the study of the morphology of pollen grains and spores (Erdtman 1952), and is an important science for plant pollination interaction studies (Silva et al. 2012a). The palynoecologist is capable to indicate with precision what type of plant species is visited by bee adults, males and females.

Flowers are visited by bees to collect floral resources (pollen, nectar, resin or floral oils) used to feed adults and their offspring (Silva et al. 2012, 2016, 2017). Females may use floral resources, such as resin and floral petals, to build their nests (Rozen et al. 2010, Silva et al. 2016). Euglossini males collect some fragrances used for different purposes (Dressler 1982), among them to attract females for mating or other males to form nocturnal aggregations in dormitories and to demarcate territories (Silva et al. 2011).

For palynological studies, pollen grains can be sampled directly from the bodies of flower visitors, from nests, from brood cells or from bee feces. (Figura 3 A-D). Through these pollen samples, it is possible to obtain a list of the most important or preferred plant species for the bee's diet. This information can be very useful to better understand the trophic niche of bees (Dórea et al. 2010, Faria et al. 2012, Silva et al. 2016, 2017, Sabino et al. 2018).). In relation to plants, on the other hand, after identifyingthe pollen grains, it is possible to visit the plant species in the field and observe if the visiting behavior of bees contributes or not to the pollination process and reproductive system of these plants (Silva et al. 2016). Most of the time, the contribution of the bee's visit to the flowers to collect floral resources is significantly important to the pollination process. In Brazil, for example, bees contribute to pollination in 78% of cultivated plants (Wolowski at al 2019), about 50% in the tropical rain forest (Bawa et al. 1985) and in more than 80% of the Brazilian savanna (Silva et al 2012b).

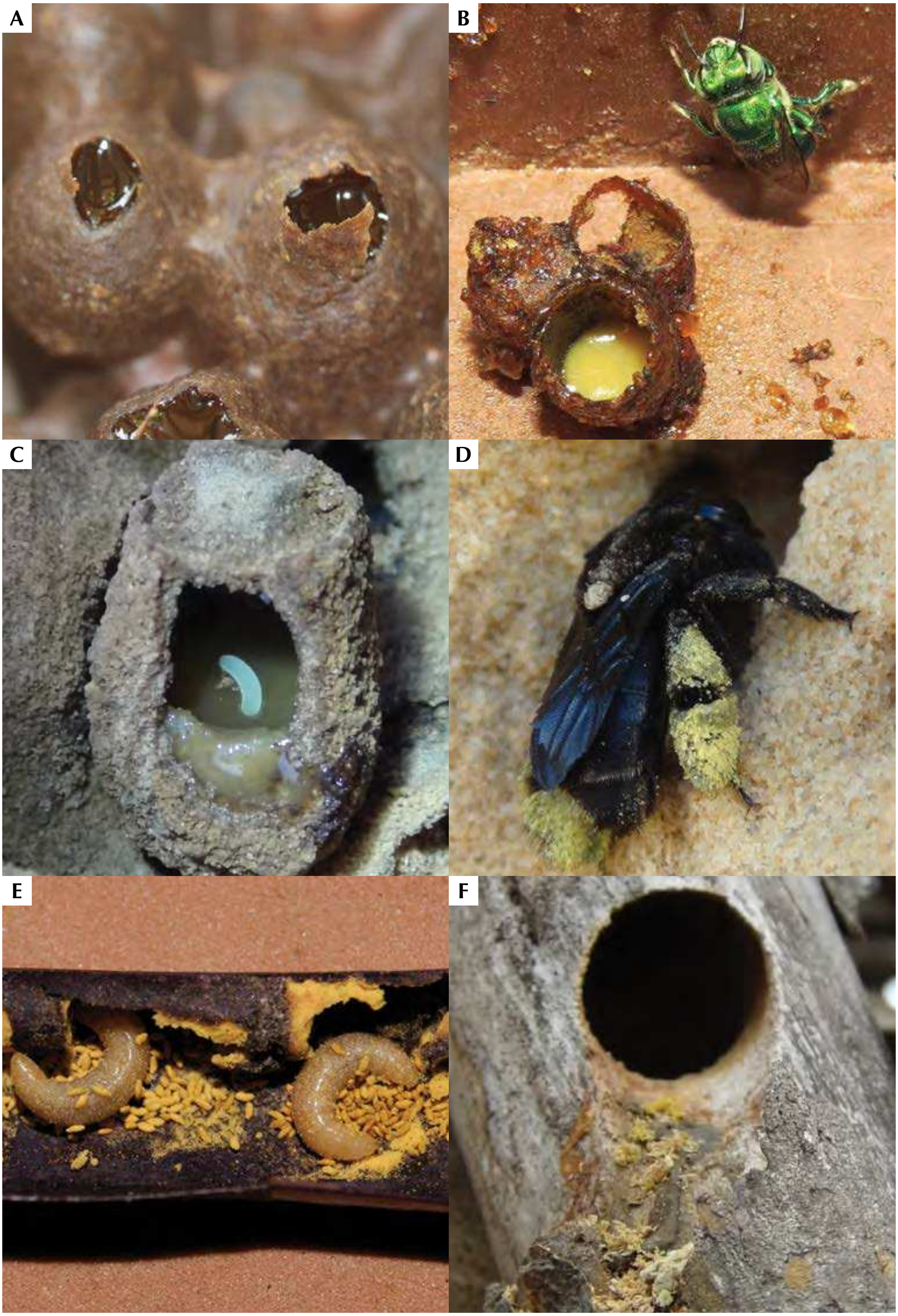

Figure 3. Type of bee food samples. A: Honey storage in nest of *Melipona subnitida*. B: food provisioned in brood cells by *Euglossa cordata*. C: food provisioned in brood cells by *Centris burgdorfi*. D: Pollen grains in scopae of *Centris burgdorfi*. E: Feces inside of brood cells of *Tetrapedia diversipes*. F: Feces deposited outside of the nest entrance of *Xylocopa cearensis*.

Procedures for palynological studies

When pollen leaves the flower anther, it has its cytoplasmic content and its wall impregnated with pollen and other compounds deposited during its development in the anthers. These compounds are part of important processes, such as protection against drying, UV protection, adhesion to the body of the floral visitor, etc. However, in studies on the morphology of pollen grains, the cytoplasmic content and these compounds adhered to the exine can hinder or even prevent their description for their morphological characterization. For this reason, Erdtman (1960) developed a protocol that, through acids, can open pollen grains in order to promote the extravasation of the cytoplasmic content and the cleaning of the compounds impregnated in the pollen wall. Due to this cleaning, it is possible to visualize the morphological characteristics of the pollen, such as the number and type of apertures and the exine ornamentation.

The acetolysis process is used in all areas of palynology and was the method adopted by RCPol to describe the pollen morphology in most plant species, except those that have an extremely delicate exine that cannot resist the acids used (see Silva et al. 2014a). In this case, for grains with more delicate exine, methods of lactic acetolysis (ACLAC) of Raynal and Raynal (1971) or Wodehouse (1935) are recommended, in which the pollen is cleaned with alcohol. For the study of pollen grains in Palynoecology, Silva et al. (2014b) designed a protocol with adaptations, which is based on the acetolysis process proposed by Erdtman (1960). This protocol was used in research on the bee's diet and bee-plant interaction. It was also used during RCPol qualification and training courses in different regions of Brazil and in other countries, in order to allow comparative studies.

In the digital age, RCPol contributed significantly to studies that use palynology , and for that, built and made available computational tools useful for the identification of plant species. With identification keys with multiple entries, it is possible to search for plant species or palynomorphs by selecting the morphological characteristics of the spores (http://chaves.rcpol.org.br/spore), pollen (http: //chaves.rcpol.org.br/taxon), pollen and flowers (http://chaves.rcpol.org.br/eco), or even fossil palynomorphs, which help to understand the flora of the past (http://chaves.rcpol.org.br/paleo). In addition, it also contains a key to the bee-plant interaction that helps in the search for the plants used in the bee's diet (http://chaves.rcpol.org.br/interactions). Among the objectives of RCPol, facilitating the collection of information, promoting the sharing of data from pollen collections, encouraging new researchers to work with palynology, and updating or building new pollen collections using the same protocol are among the most important. Such objectives were included during the development of the project entitled "Study of bee flora and pollen grains for the insertion of data in the RCPol - online pollen catalogs network: subsidy for bee management and conservation". This Atlas presents a sample of data from RCPol, in which several researchers inserted data from their collections (Palynoecology and Palynotaxonomy), which are freely available on the site for the whole community (http://rcpol.org.br/pt/home/).

Pollen is a natural marker that should be used more often. Palynology as a science is supported by taxonomy, and plant taxonomists are fundamental parts. These professionals organize, describe and identify the plant species in taxa according to their phylogeny. Plant taxonomists also act as herbarium curators, where plant exsiccates are deposited and preserved. Pollen collection must always be linked to a herbarium (Silva et al. 2010) to ensure that the information, after undergoing changes due to taxonomic reviews, is always be available. In addition, when pollen is used to identify plant species, they must have a voucher deposited in a herbarium.

The multidisciplinary study, involving botanists, plant taxonomists, palynologists, ecologists and zoologists, is necessary to understand plant-pollinator interactions at the community level. Information obtained from this perspective have contributed to the development of management and conservation plans for plants and their pollinators, in addition to being fundamental for restoration projects that consider functional ecology. Increasingly, researchers and the community, in general, understand the importance of multidisciplinarity for the conservation and maintenance of ecosystem services, from macro to microscopic aspects, as in the case of pollen grains, for example.

Pollen and flower description

Pollen grains were measured in micrometers (µm) and the images are presented in the Catalog following the order of the polar and equatorial views, exine thickness, exine ornamentation, and details of the associated elements, whenever possible. For each plant species, at least 25 measurements were made for the different pollen grain diameters in the polar (P) and equatorial (E) views, and at least 10 for the other measurements of the morphological characteristics of the pollen grains. Pollen grains were described and/or classified according to their morphological characteristics in: Pollen dispersal unit, whether monad, tetrad or polyad; Pollen size, very small (< 10 µm), small (10-25 µm), medium (25-50 µm), large (50-100 µm), very large (100- 200 µm) or giant (> 200 µm); Pollen symmetry: radial, bilateral or asymmetric; Pollen polarity: isopolar, apolar or heteropolar; Pollen amb: circular, triangular, subcircular, subtriangular, elliptical, plane circular, quadrangular; Pollen shape: the ratio of the polar diameter to the equatorial diameter, called the P/E ratio (Polar/Equatorial) - peroblate (< 0.50 µm), oblate (0.50-0.74 µm), suboblate (0.75-0.87 µm), oblate spheroidal (0.88-0.99 µm), spherical (1.00 µm), prolate spheroidal (1.01-1.14 µm), subprolate (1.15-1.33 µm), prolate (1.34- 2.00 µm), perprolate (> 2.00 µm); Type and number of apertures: inaperturate or apertured; Thickness of the exine (Exi), type of ornamentation: structures of the infratectum, tectum and supratectal elements.

For pollen terms, we used the nomenclature presented by Punt et al. (2007) and Hesse et al. (2009). The glossary of the nomenclature used in this Catalog is presented on the RCPol website (http://chaves.rcpol.org.br/profi le/glossary/taxon). This Catalog presents descriptions for 126 plants species from 101 genus and 43 families, used in the bee's diet in different regions of Brazil and countries in the Americas (Figures 4 and 5; Table 1).

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Table 1. Information on the pollen collections that feature data in the Pollen catalog of plants used in bee's diet in different types of vegetation.

Map ID	Institution	Site	Country
A	University of Guelph	Howe Family Farm	Canada
A		Strom's Farm and Bakery	
A		Alvinston	
A		Lunar Rhythm Gardens	
A		Indian River	
A		Buckhorn Berry Farm	
A		StellMar Farm	
A		Cooper's CSA Farm & Maze	
A		Shantz Family Farm	
B	University of Magdalena	C.I. Tequendama	Colombia
C	Nueva Granada University	Nueva Granada campus	
C		Natural Reserve Montaña del Oso	
C		Ecological Park Cerro la Conejera	
D	National Amazon Research Institute and Embrapa Western	Embrapa Western Amazon experimental site	Brazil
E	Federal University of Ceará	Campus do Pici	
F	Federal Rural University of the Semi-Arid	Experimental Field Station Rafael Fernandes	
F		National Forest Reserve at Açu	
G	University of São Paulo	University of São Paulo	
H	Federal University of Bahia	National Forest Reserve (FLONA) of Três Barras	
I	Lutheran University of Brazil	Meliponary in Cachoeirinha	
I		Apiary in Gravataí	
J	National Council for Scientific and Technical Research	El Palmar National Park	Argentina

State	City	Vegetation	X	Y
Ontario	Aylmer	Crop area	81°00′25.0″W	42°43′55.1″N
	Guelph		80°17′35.1″W	43°29′51.5″N
	Alvinston		81°51′53.6″W	42°48′23.5″N
	Janetville		78°41′46.3″W	44°08′20.1″N
	Indian River		78°08′11.4″W	44°20′04.8″N
	Lakefield		78°18′22.7″W	44°32′23.0″N
	Little Britain		78°46′32.8″W	44°14′36.0″N
	Zephyr		79°15′06.7″W	44°08′52.0″N
	Petersburg		80°34′15.2″W	43°23′46.5″N
Magdalena	Aracataca		74°10′56,8″W	10°32′55,3″N
Cundinamarca	Cajica	Intervened area	74°00′34,2″W	04°56′33,9″N
	Chia	Sub-paramo	74°00′48,9″W	04°49′18,6″N
	Bogota	Low montane dry forest	74°04′14.8″W	4°46′02.8″N
Amazonas	Manaus	Amazon forest	59° 58′47.34″W	2° 53′22.24″N
Ceará	Fortaleza	Semi-deciduous lowland forest	38°34′42″W	3°34′16″S
Rio Grande do Norte	Mossoró	Brazilian dry forests	37°24′03.64″W	5°03′54.45″S
	Açu		36°56′42,13″W	5°34′59,13″S
São Paulo	São Paulo	Urban area	46°43′50.4″W	23°33′54.9″S
Santa Catarina	Três Barras	Tropical rain forest	50°18′16.76″W	26°13′12.81″S
Rio Grande do Sul	Cachoeirinha	Pampa	51°06′24.3″W	29°57′46.2″S
	Gravataí		50°58′15.37″W	29°52′53.87″S
Entre Rios	Ubajay	Savannah with grassland and palms	58°15′31.6″W	31°51′52.5″S

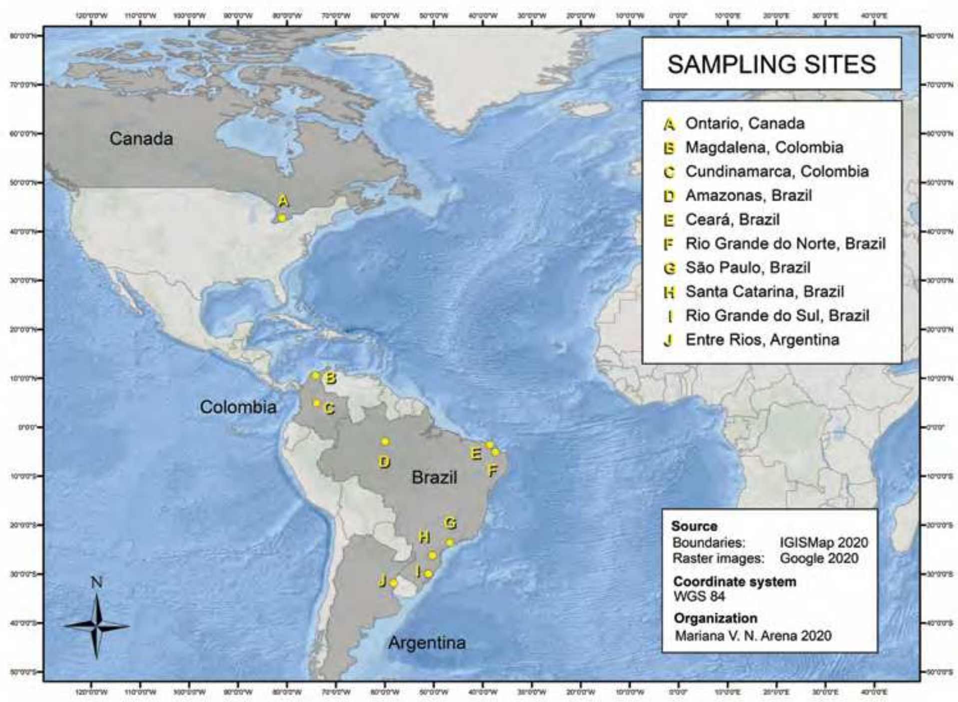

Figure 4. Location map of the sampling sites for the atlas surveys.

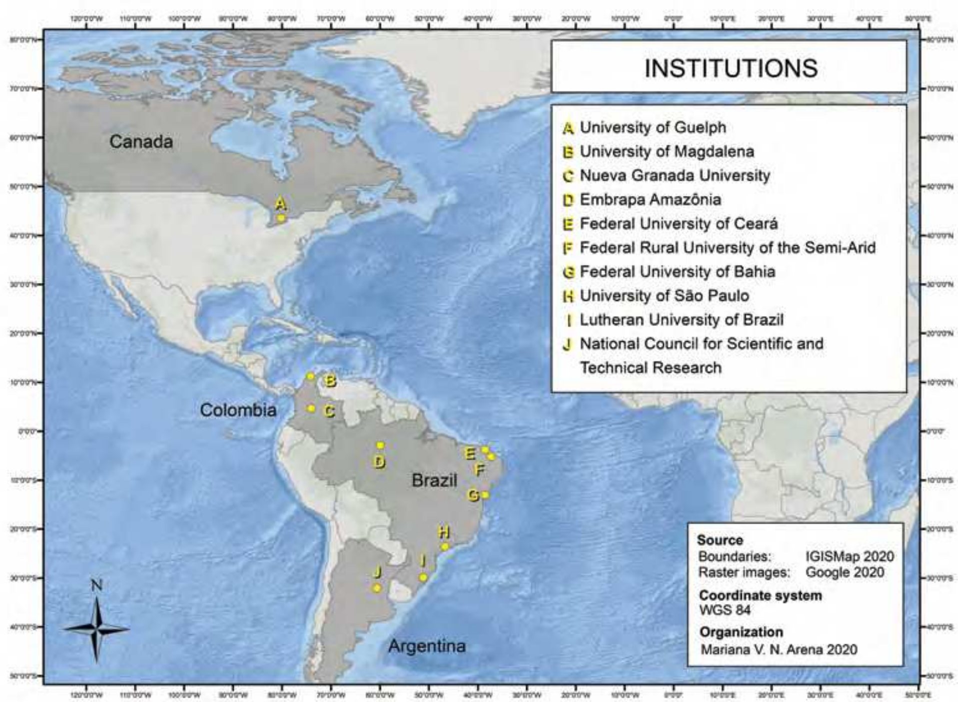

Figure 5. Map of the institutions that conducted the surveys from the Atlas.

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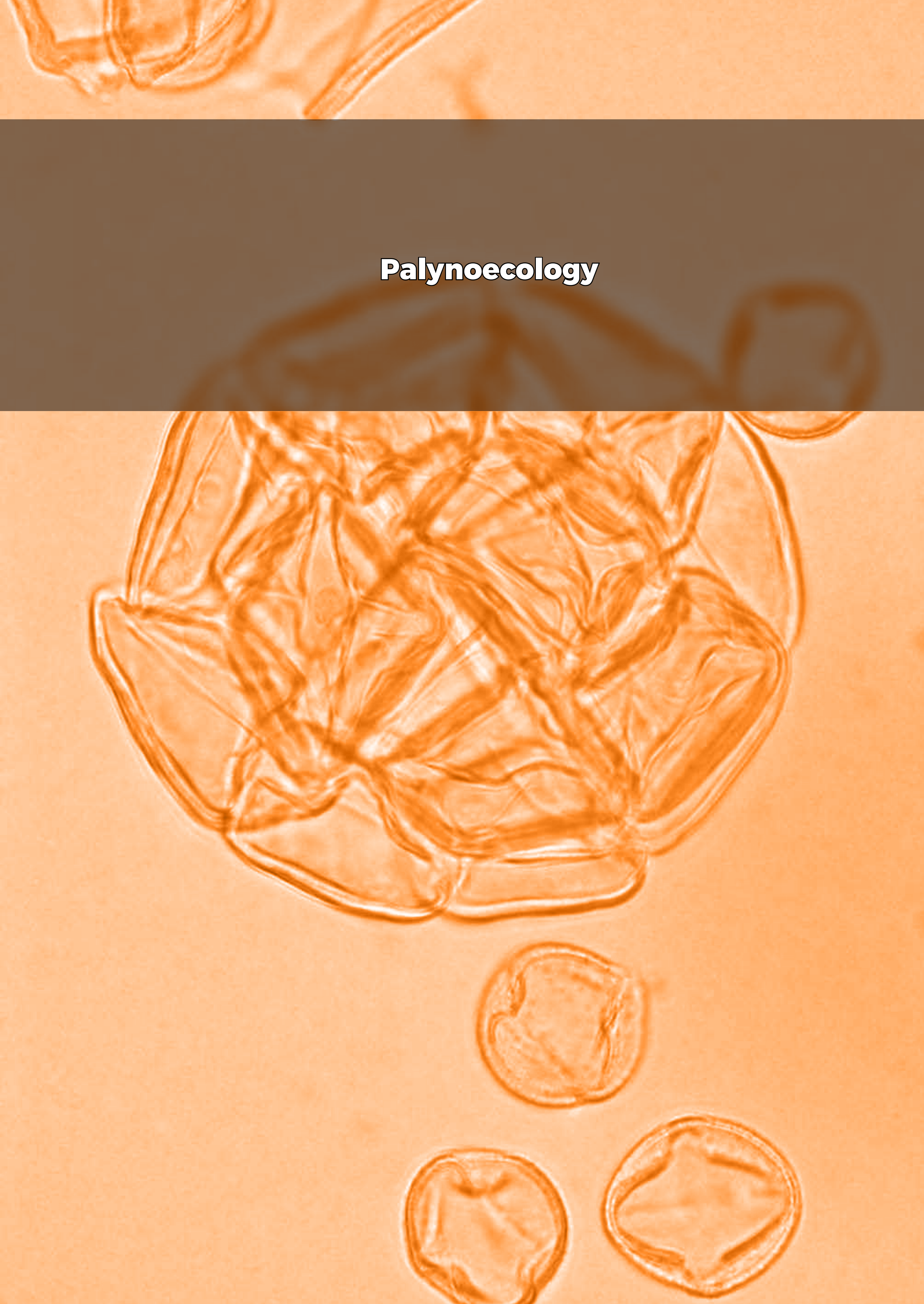
Melipona quadrifasciata

Meliponini visiting flower of *Ixora chinensis*

Palynoecology



Acanthaceae

Ruellia chartacea (T. Anderson) Wassh.

“RUÉLIA-VERMELHA”

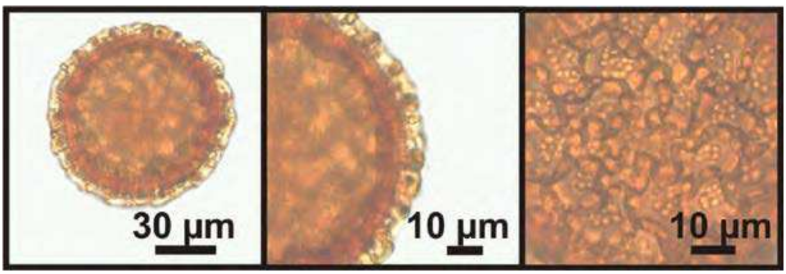
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 79
Pollen catalog number: PALIIBUSP 180
Habit: shrubby
Origin: native

Flower features

Pollination system: by birds
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: salverform (hypocrateriform)
Flower symmetry: zygomorphous
Flower color: red
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large to very large, D = 92.76 ± 7.77 (80.41-107.63), radial, isopolar, circular amb, spheroidal, triporate, pore circular. Exine reticulate, heterobrochate, Exi = 12.69 ± 1.88 (9.67-16.08).



Acanthaceae

Thunbergia erecta T. Anderson
"MANTO-DE-REI"

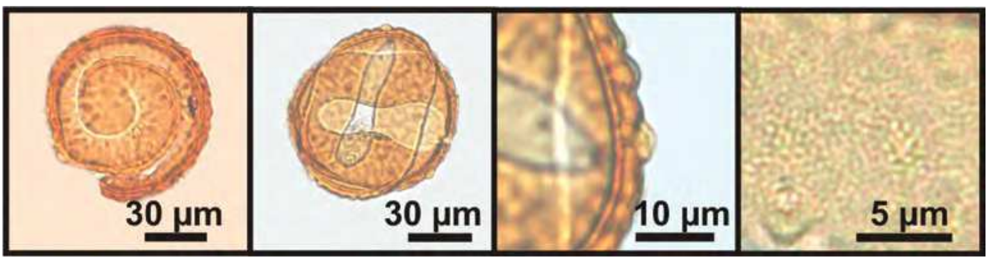
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 2
Pollen catalog number: PALIIBUSP 103
Habit: shrubby
Origin: exotic

Flower features

Pollination system: by birds
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: infundibular
Flower symmetry: zygomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large, D = 81.11 ± 8.72 (62.86-98.54), asymmetric, apolar, circular amb, spheroidal, pantocolpate, colpus very long, spiraperturate. Exine microreticulate, Exi = 4.67 ± 0.64 (3.43-6.28).



Amaranthaceae

Alternanthera tenella Colla

"APAGA-FOGO"

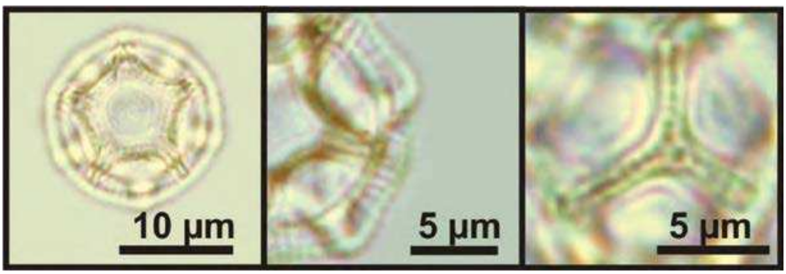
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13860
Pollen catalog number: PALIASA 64
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small, D = 16.72 ± 1.20 (14.96-18.82), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinolophate, Exi = 2.65 ± 0.32 (2.01-3.11).



Anacardiaceae

Myracrodruon urundeuva M. Allemão

"AROEIRA-DO-SERTÃO"

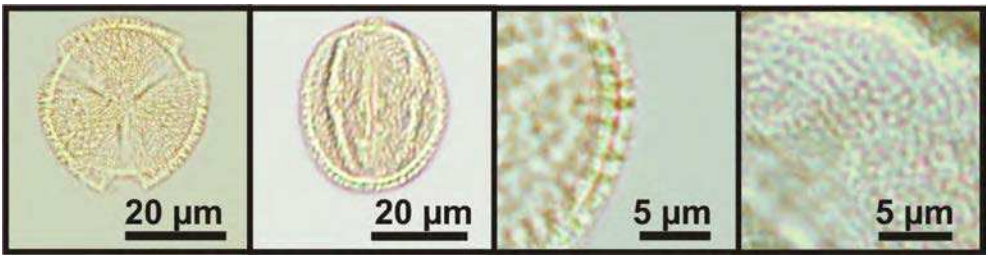
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13852
Pollen catalog number: PALIASA 124
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual
Flower size: very small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

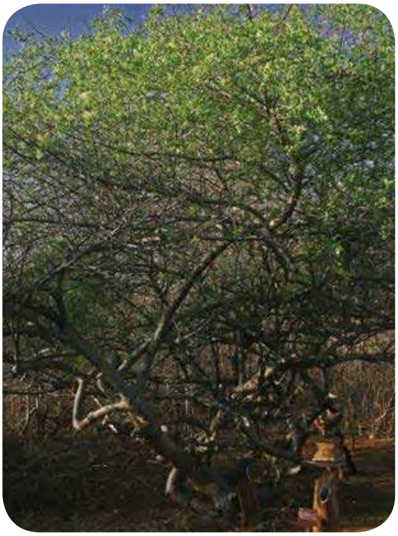
Pollen description

Monad, medium, P = 36.92 ± 3.43 (29.54-44.87), E = 34.18 ± 3.62 (27.42-42.85), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.08 ± 0.06 (0.98-1.22), tricolporate, colpus long, pore lalongate. Exine striate, reticulate, Exi = 2.83 ± 0.33 (1.81-3.46).



Anacardiaceae

Spondias tuberosa Arruda
"UMBU"



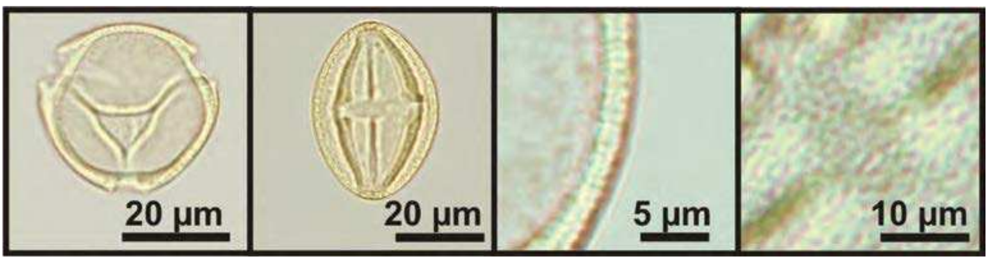
Vegetation: Semi-deciduous lowland forest
MOSS catalog number: MOSS 13889
Pollen catalog number: PALIASA 125
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 40.98 ± 1.60 (38.73-1.24), E = 34.27 ± 1.82 (31.91-39.98), radial, isopolar, subtriangular amb, prolate spheroidal to subprolate, P/E = 1.20 ± 0.05 (1.05-1.24), tricolporate, colpus long, pore lalongate. Exine striate, microreticulate, Exi = 2.29 ± 0.20 (2.00-2.60).



Apocynaceae

Tabernaemontana laeta Mart.
"LÍRIO"

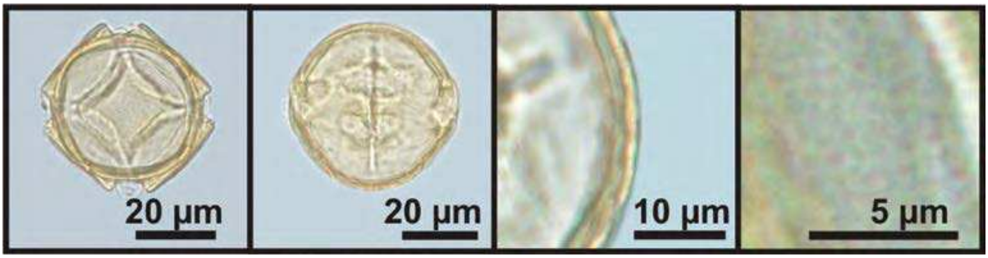
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59096
Pollen catalog number: PALIUFC 315
Habit: shrubby
Origin: native

Flower features

Pollination system: by butterflies and by nocturnal moths
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: salverform (hypocrateriform)
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal and dusk
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, medium, P = 45.79 ± 2.57 (40.54-50.12), E = 44.72 ± 3.77 (36.3-50.8), radial, isopolar, quadrangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.02 ± 0.07 (0.91-1.14), tetracolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 3.00 ± 0.59 (1.85-3.80).



Apocynaceae

Thevetia peruviana (Pers.) K. Schum.

"TEVETIA"

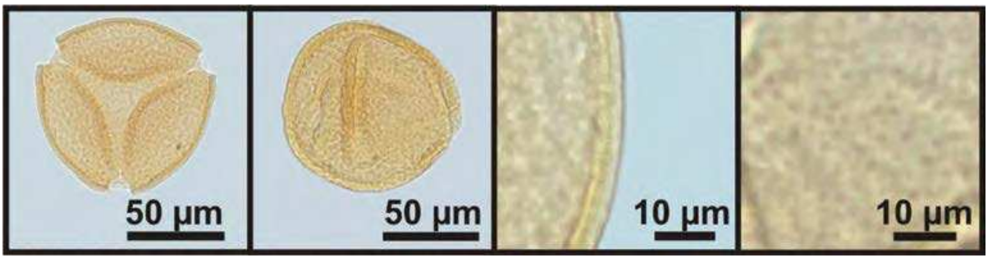
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59414
Pollen catalog number: PALIUFC 377
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: salverform (hypocrateriform)
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large to very large, P = 102.56 ± 7.95 (86.07-114.39), E = 94.74 ± 7.82 (78.09-110.84), radial, isopolar, subtriangular amb, suboblate to prolate, P/E = 1.08 ± 0.12 (0.78-1.44), tricolporate, colpus long, syncolporate, pore lalongate. Exine microreticulate, Exi = 4.56 ± 0.50 (3.80-5.41).



Aracaceae

Cocos nucifera L.
“COQUEIRO”

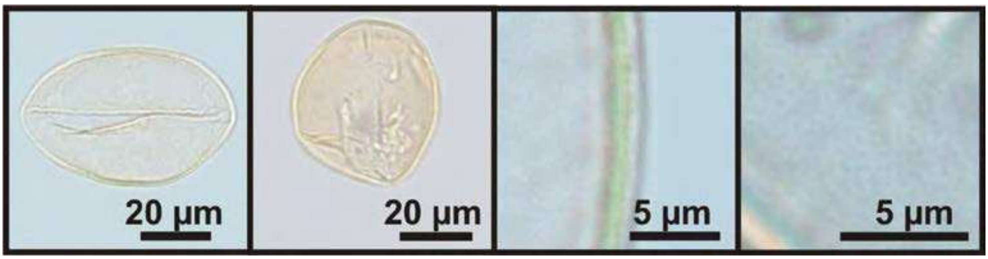
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59406
Pollen catalog number: PALIUFC 257
Habit: arboreal
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 37.78 ± 4.51 (33.85-49.29), Dem = 41.24 ± 3.21 (36.71-48.87), DEM = 62.86 ± 3.61 (56.74-68.76), bilateral, heteropolar, elliptical amb, subprolate to prolate, P/E = 1.52 ± 0.16 (1.21-1.83), monosulcate. Exine microreticulate, Exi = 2.15 ± 0.37 (1.40-3.03).



Asphodelaceae

Bulbine frutescens Willd.
"BULBINE"

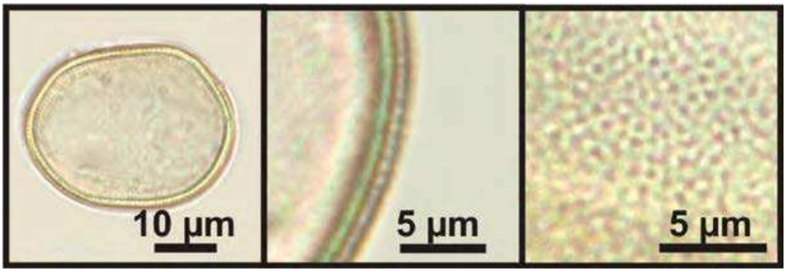
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 18
Pollen catalog number: PALIIBUSP 119
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: orange and yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 23.88 ± 1.65 (21.67-26.66), Dem = 29.09 ± 1.64 (25.99-32.05), DEM = 34.31 ± 1.48 (31.45-37.49), bilateral, heteropolar, elliptical amb, oblate to oblate spheroidal, P/E = 1.02 ± 0.81 (0.69-0.90), monosulcate. Exine microreticulate, Exi = 1.78 ± 0.23 (1.40-2.34).



Asteraceae

Emilia sonchifolia (L.) DC. ex Wigh
"SERRALHINHA"

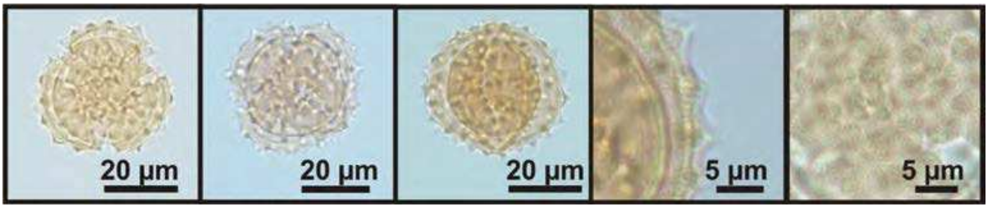
Vegetation: Urban area
EAC catalog number: EAC 59103
Pollen catalog number: PALIUFC 273
Habit: herbaceous
Origin: native

Flower features

Pollination system: by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 42.02 ± 3.07 (33.90-47.33), E = 41.26 ± 3.12 (33.53-45.68), radial, isopolar, subtriangular and quadrangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.02 ± 0.05 (0.92-1.10), tricolporate and tetracolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.31 ± 0.44 (1.80-3.41).



Asteraceae

Helianthus annuus L.

“GIRASOL”

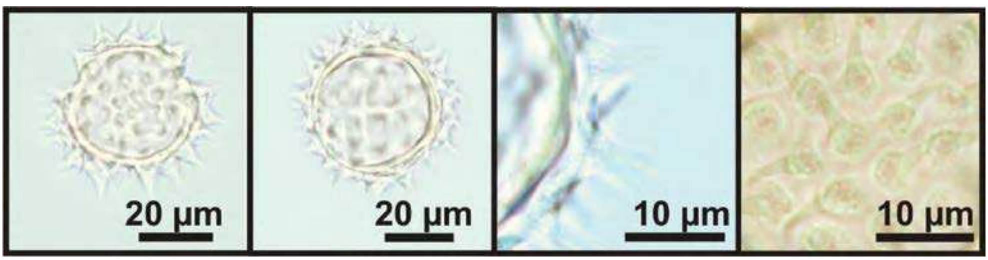
Vegetation: Intervened area and Crop area
UMNG-H catalog number: UMNG-H 963
Pollen catalog number: PBEAS 84
Habit: herbaceous
Origin: cultivated

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: very small
Flower shape: ligulate and campanulate
Flower symmetry: zygomorphous and actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, P = 53.66 ± 3.34 (47.22-61.45), E = 52.55 ± 3.91 (46.53-63.98), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.02 ± 0.06 (0.91-1.12), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.71 ± 0.49 (1.81-3.65).



Asteraceae

Pseudelephantopus spiralis (Less) Cronquist

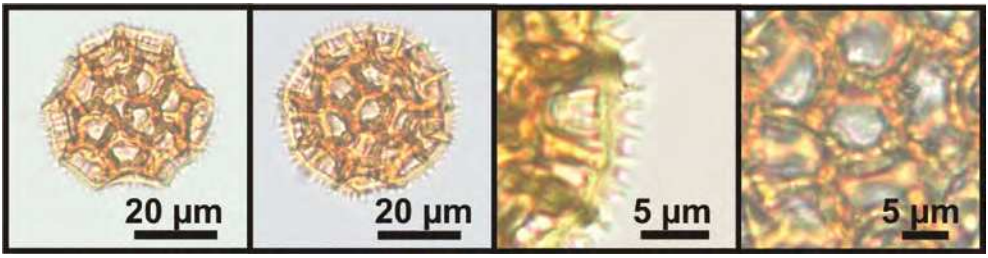
Vegetation: Amazon forest
INPA catalog number: INPA 278137
Pollen catalog number: PALIIBUSP 20
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: infundibular
Flower symmetry: zygomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, D = 44.49 ± 2.56 (38.85-48.40), radial, isopolar, subtriangular amb, spheroidal, triporate, pore circular. Exine echinolophate, Exi = 1.57 ± 0.28 (1.02-2.21).



Asteraceae

Sphagneticola trilobata (L.) Pruski
"MARGARIDINHA"

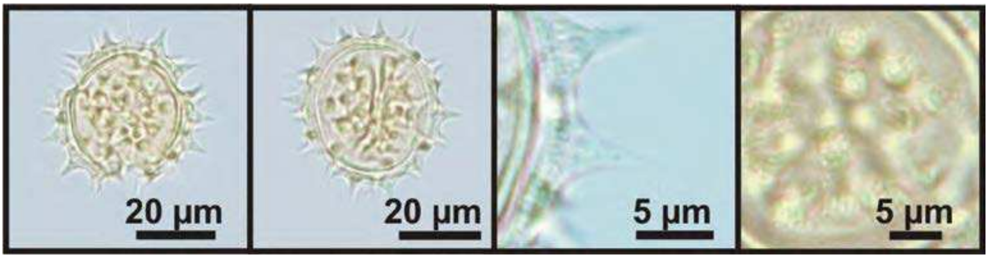
Vegetation: Crop area
EAC catalog number: EAC 59382
Pollen catalog number: PALIUFC 372
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: very small
Flower shape: ligulate and tubular
Flower symmetry: zygomorphous and actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, P = 45.28 ± 1.83 (41.32-48.13), E = 44.01 ± 2.96 (39.64-51.10), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.03 ± 0.06 (0.88-1.14), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 3.62 ± 0.64 (2.09-4.87).



Asteraceae

Taraxacum officinale F.H. Wigg
"DIENTE DE LEÓN"

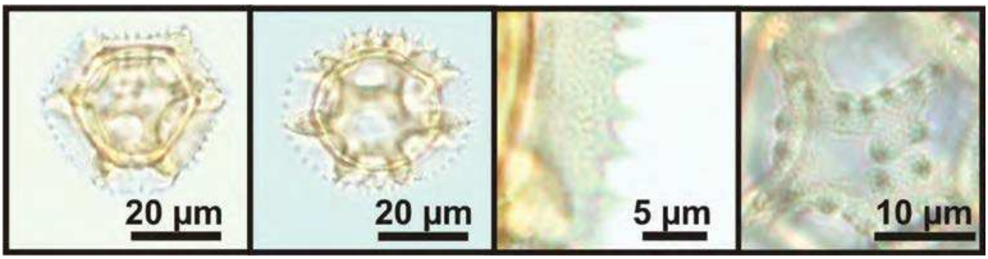
Vegetation: Urban area, Sub-paramo, Conejera, Intervened area and Crop area
UMNG-H catalog number: UMNG-H 114
Pollen catalog number: PBEAS 108
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees and by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: ligulate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 40.44 ± 1.48 (37.56-42.85), E = 43.81 ± 1.85 (38.48-47.59), radial, isopolar, subtriangular amb, suboblate to oblate spheroidal, P/E = 0.92 ± 0.03 (0.84-0.99), triporate, pore circular. Exine echinolophate, Exi = 4.73 ± 0.56 (3.80-6.10).



Asteraceae

Tridax procumbens L.
"ERVA-DE-TOURO"

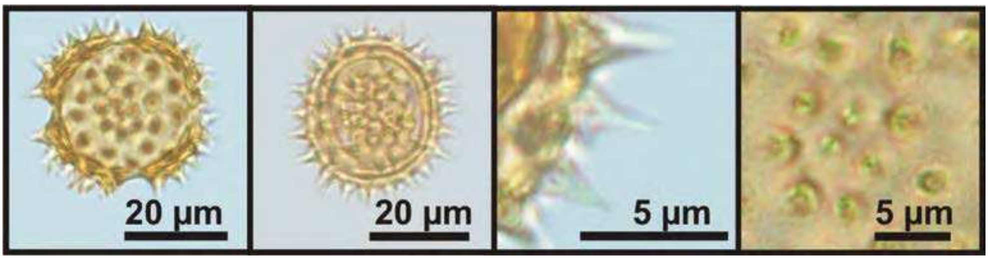
Vegetation: Urban area, Crop area and Semi-deciduous lowland forest
EAC catalog number: EAC 59106
Pollen catalog number: PALIUFC 321
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: very small
Flower shape: ligulate and tubular
Flower symmetry: zygomorphous and actinomorphous
Flower color: yellow and cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 38.99 ± 3.83 (28.05-47.15), E = 38.55 ± 3.98 (27.73-48.53), radial, isopolar, quadrangular amb, oblate spheroidal to subprolate, P/E = 1.01 ± 0.05 (0.96-1.19), tetracolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.54 ± 0.66 (1.80-4.01).



Asteraceae

Unxia camphorata L.f.
"SÃO-JOÃO-CAÁ"

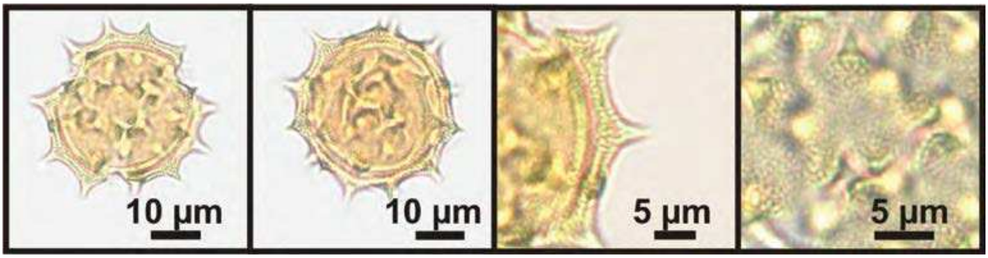
Vegetation: Amazon forest
INPA catalog number: INPA 278144
Pollen catalog number: PALIIBUSP 28
Habit: herbaceous and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual
Flower size: very small
Flower shape: infundibular and ligulate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 38.67 ± 2.25 (33.52-42.68), E = 38.02 ± 2.49 (33.41-42.68), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.02 ± 0.04 (0.93-1.13), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.31 ± 0.39 (1.81-3.05).



Asteraceae

Vernonanthura polyanthes (Spreng.) A.J.Vega & Dematt.
"ASSA-PEIXE-BRANCO"

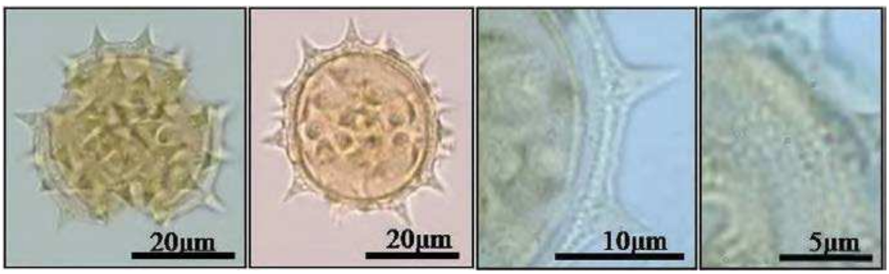
Vegetation: Urban area
HUFU catalog number: HUFU 50072
Pollen catalog number: PALIUFU 34
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 35.20 ± 1.46 (32.59-37.68), E = 33.29 ± 2.51 (30.16-38.69), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.06 ± 0.08 (0.91-1.23), tricolporate, colpus short, pore lalongate, pore circular. Exine echinate, perfurate, Exi = 1.80.



Balsaminaceae

Impataiens walleriana Hook. f.
"MARIA-SEM-VERGONHA"

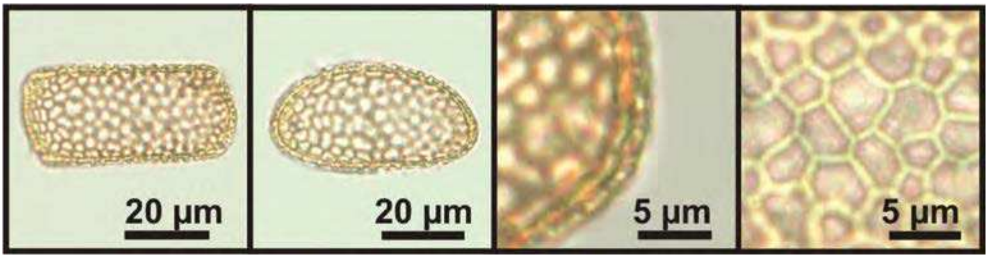
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 19
Pollen catalog number: PALIIBUSP 120
Habit: herbaceous
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence and flower
Flower sexuality: bisexual
Flower size: large
Flower shape: calcarate
Flower symmetry: zygomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to large, P = 25.35 ± 2.74 (18.85-28.43), E = 51.00 ± 2.92 (43.32-54.98), bilateral, isopolar, quadrangular amb, peroblate to oblate, P/E = 0.50 ± 0.07 (0.37-0.64), tetracolpate, colpus short. Exine reticulate, heterobrochate, Exi = 2.47 ± 0.32 (2.00-3.13).



Bignoniaceae

Handroanthus impetiginosus (Mart. ex. DC.) Mattos
“IPÊ-ROXO”

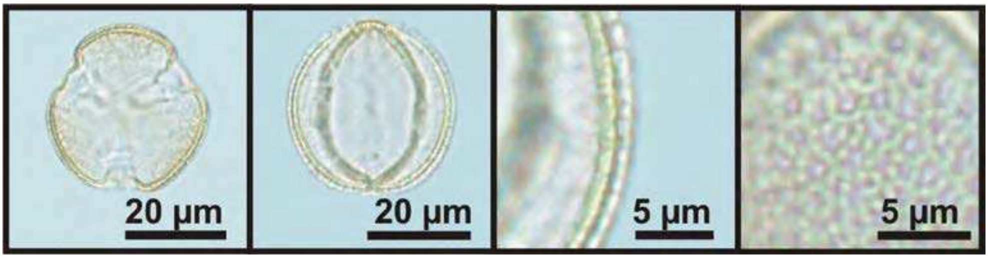
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59198
Pollen catalog number: PALIUFC 294
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: salverform (hypocrateriform)
Flower symmetry: zygomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, medium, P = 34.41 ± 1.59 (32.29-38.10), E = 33.45 ± 1.90 (30.04-37.94), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.03 ± 0.07 (0.94-1.21), tricolporate, colpus long, pore lalongate. Exine reticulate, Exi = 2.48 ± 0.22 (2.20-3.01).



Bignoniaceae

Tecoma stans (L.) Kunth
"IPÊ-DE-JARDIM"

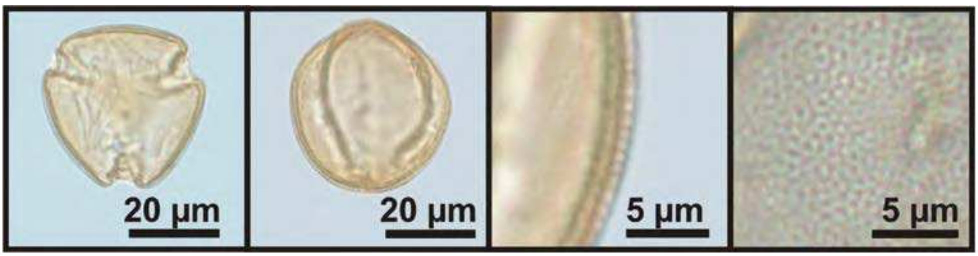
Vegetation: Urban area and Semi-deciduous lowland forest
EAC catalog number: EAC 59199
Pollen catalog number: PALIUFC 277
Habit: arboreal
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: infundibular
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, medium, P = 39.39 ± 2.89 (33.65-44.43), E = 36.82 ± 2.27 (30.76-41.01), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.07 ± 0.09 (0.92-1.24), tricolporate, colpus long, pore lolongate. Exine microreticulate, Exi = 2.40 ± 0.23 (2.01-3.06).



Boraginaceae

Borago officinalis L.
"BORRAJA"

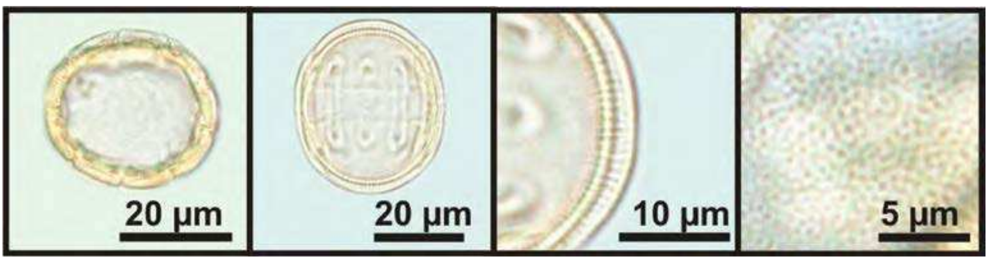
Vegetation: Intervened area
UMNG-H catalog number: UMNG-H 1004
Pollen catalog number: PBEAS 89
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 39.16 ± 1.60 (35.64-42.40), E = 31.60 ± 1.64 (27.56-34.38), radial, isopolar, circular amb, prolate spheroidal to prolate, P/E = 1.24 ± 0.07 (1.13-1.44), 9-colporate, colpus long, pore lalongate, endocingulum. Exine microreticulate, Exi = 3.51 ± 0.36 (2.80-4.32).



Brassicaceae

Brassica rapa L.
"NABO"

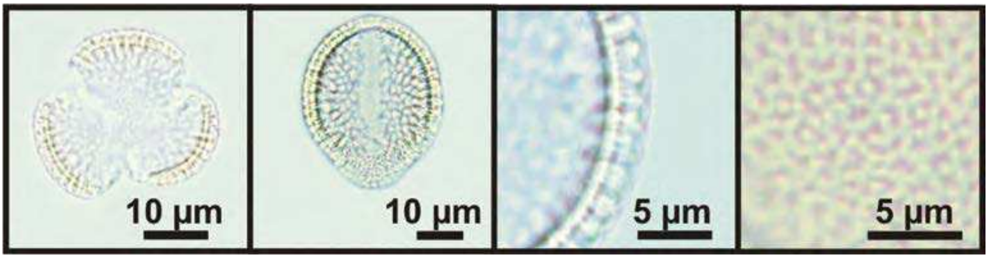
Vegetation: Intervened area
UMNG-H catalog number: UMNG-H 1010
Pollen catalog number: PBEAS 88
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: cruciform
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 37.17 ± 4.21 (29.03-42.90), E = 29.15 ± 3.18 (21.67-33.98), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.28 ± 0.08 (1.07-1.42), tricolpate, colpus long. Exine reticulate, heterobrochate, Exi = 3.30 ± 0.37 (2.67-4.02).



Brassicaceae

Raphanus sativus L.
"RÁBANO"

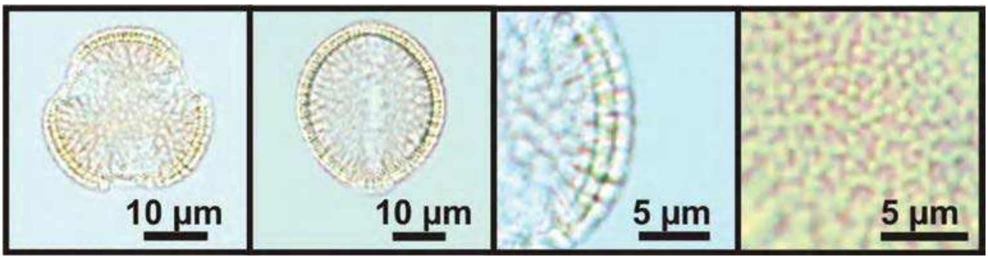
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1016
Pollen catalog number: PBEAS 85
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: cruciform
Flower symmetry: actinomorphous
Flower color: white and lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium, P = 33.96 ± 1.27 (31.43-36.40), E = 27.18 ± 1.11 (25.23-29.29), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.25 ± 0.05 (1.14-1.34), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.96 ± 0.38 (2.40-3.65).



Bromeliaceae

Aechmea distichantha Lem.

“PLANTA-VASO”

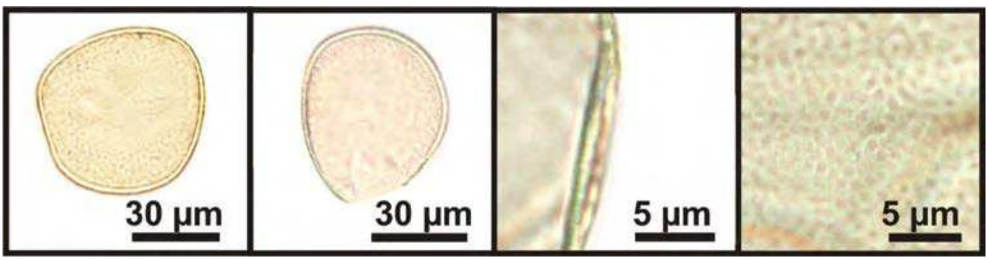
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 71
Pollen catalog number: PALIIBUSP 172
Habit: herbaceous
Origin: native

Flower features

Pollination system: by butterflies, by flies, by birds and by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: tubular
Flower symmetry: actinomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, P = 47.82 ± 5.04 (41.08-55.53), Dem = 47.18 ± 4.31 (41.25-59.79), DEM = 57.81 ± 6.33 (48.45-76.64), bilateral, heteropolar, elliptical amb, suboblate to subprolate, P/E = 1.02 ± 0.09 (0.87-1.20), monosulcate. Exine reticulate, homobrochate, Exi = 1.91 ± 0.33 (1.27-2.61).



Combretaceae

Combretum leprosum Mart.
"MOFUMBO"

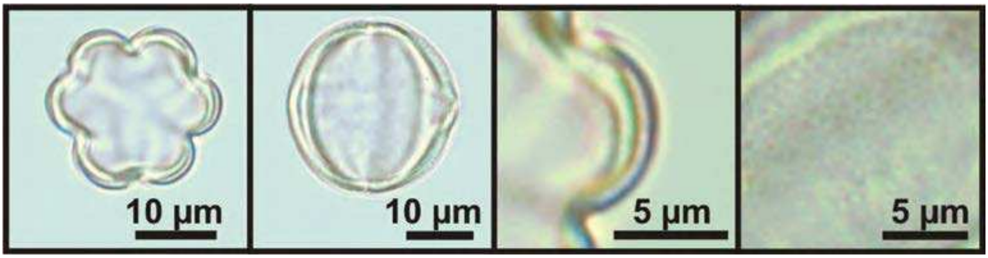
Vegetation: Semi-deciduous lowland forest
MOSS catalog number: MOSS 13896
Pollen catalog number: PALIASA 67
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 26.90 ± 1.95 (23.69-30.21), E = 22.58 ± 1.37 (20.21-24.91), radial, isopolar, circular amb, prolate spheroidal to subprolate, P/E = 1.19 ± 0.05 (1.11-1.32), tricolporate, tripseudocolpate, colpus long, heteroaperturate, pore lalongate. Exine microreticulate, Exi = 1.99 ± 0.28 (1.40-2.24).



Commelinaceae

Tradescantia pallida (Rose) D.R.Hunt

"TABOQUINHA ROXA"

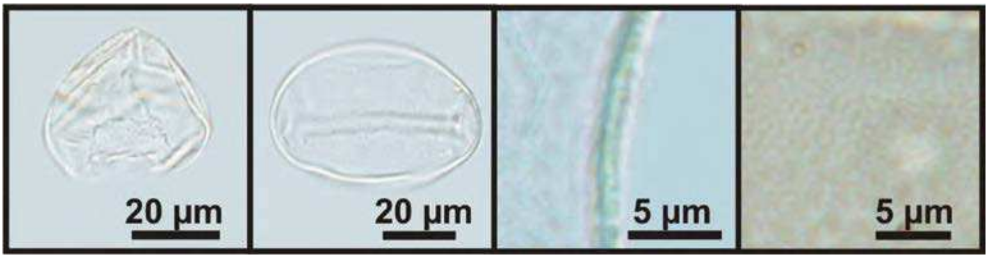
Vegetation: Urban area and Semi-deciduous lowland forest
EAC catalog number: EAC 59085
Pollen catalog number: PALIUFC 268
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: zygomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 58.20 ± 4.54 (51.25-67.59), E = 38.27 ± 4.39 (32.14-47.82), bilateral, heteropolar, elliptical amb, subprolate to prolate, P/E = 1.52 ± 0.17 (1.19-1.77), monosulcate. Exine microreticulate, Exi = 1.63 ± 0.40 (1.00-2.41).



Convolvulaceae

Ipomoea asarifolia Roem. & Schult.
"SALSA-ROXA"

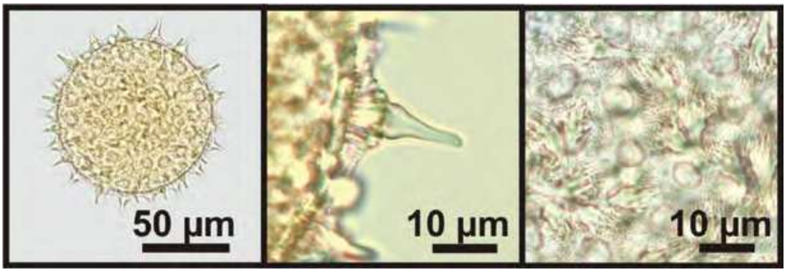
Vegetation: Brazilian dry forests and Semi-deciduous lowland forest
MOSS catalog number: MOSS 13840
Pollen catalog number: PALIASA 27
Habit: herbaceous and vine
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: very large
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, large to very large, D = 107.86 ± 11.45 (82.18-124.55), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 5.94 ± 1.24 (3.89-7.55).



Convolvulaceae

Ipomoea bahiensis Willd. ex Roem. & Schult.
"JETIRANA ROSA"

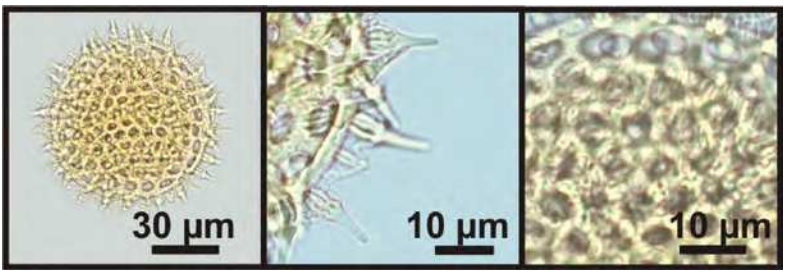
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13858
Pollen catalog number: PALIASA 44
Habit: vine
Origin: native

Flower features

Pollination system: by bees and by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

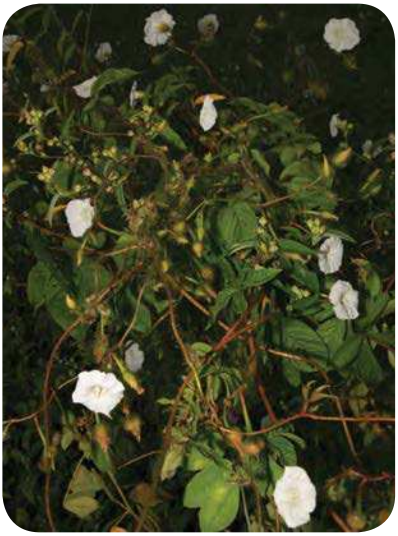
Pollen description

Monad, large, D = 90.81 ± 5.94 (78.60-100.62), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 5.29 ± 0.44 (4.82-6.00).



Convolvulaceae

Merremia aegyptia (L.) Urb.
“JETIRANA”



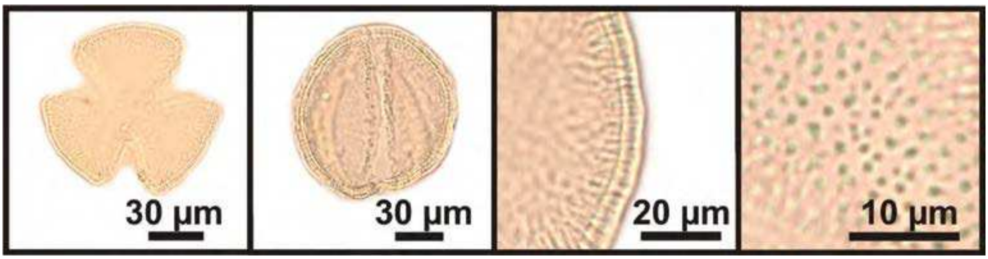
Vegetation: Semi-deciduous lowland forest
MOSS catalog number: MOSS 13856
Pollen catalog number: PALIASA 113
Habit: vine
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: white
Anthesis: dusk
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, large to very large, P = 109.67 ± 29.72 (62.71-150.42), E = 99.21 ± 22.49 (66.21-125.27), radial, isopolar, subtriangular amb, suboblate to prolate, P/E = 1.11 ± 0.27 (0.75-1.52), tricolpate, colpus long. Exine perfurate, Exi = 6.23 ± 1.43 (4.02-8.25).



Cyperaceae

Rhynchospora pubera Boeckeler

"CAPIM-ESTRELA"

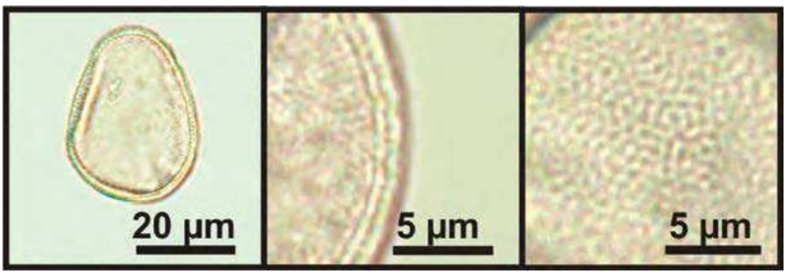
Vegetation: Amazon forest
INPA catalog number: INPA 278130
Pollen catalog number: PALIIBUSP 13
Habit: herbaceous
Origin: native

Flower features

Pollination system: by wind and by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: very small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, Dem = 27.09 ± 2.94 (21.95-35.26), DEM = 32.51 ± 3.27 (27.59-41.24), radial, heteropolar, circular amb, spheroidal to prolate, P/E = 1.20 ± 0.12 (1.00-1.48), triporate, pore lolongate. Exine microreticulate, Exi = 1.65 ± 0.25 (1.00-2.09).



Ericaceae

Bejaria resinosa L.f.
"MATAMOSCA AND PEGAPEGA"

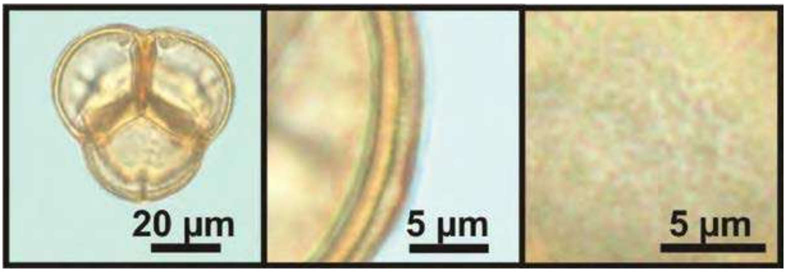
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1052
Pollen catalog number: PBEAS 37
Habit: shrub
Origin: native

Flower features

Pollination system: by bees and by birds
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Tetrad, medium to large, D = 53.77 ± 3.21 (46.54-59.85), subtriangular amb in front view, spheroidal, tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.94 ± 0.50 (2.00-4.02).



Euphorbiaceae

Croton sonderianus Müll.Arg.
"MARMELEIRO"

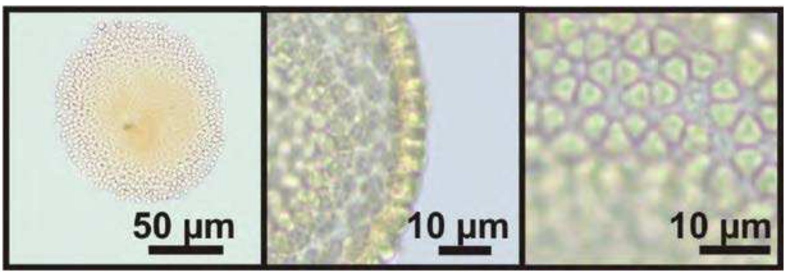
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13882
Pollen catalog number: PALIASA 3
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees and by flies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

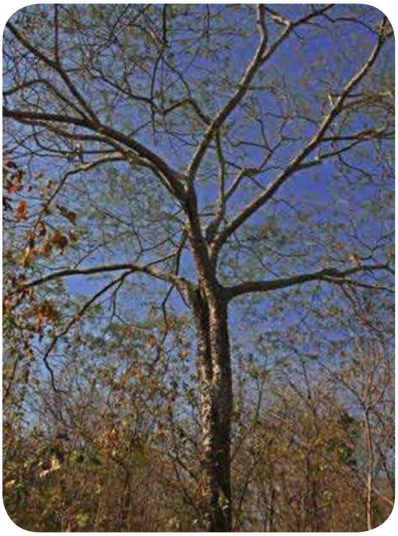
Monad, large to very large, D = 114.77 ± 11.79 (84.59-134.16), radial, apolar, circular amb, spheroidal, inaperturate. Exine Croton pattern, Exi = 5.83 ± 0.70 (5.21-6.52).



Fabaceae

Anadenanthera colubrina (Vell.) Brenan

"ANGICO"



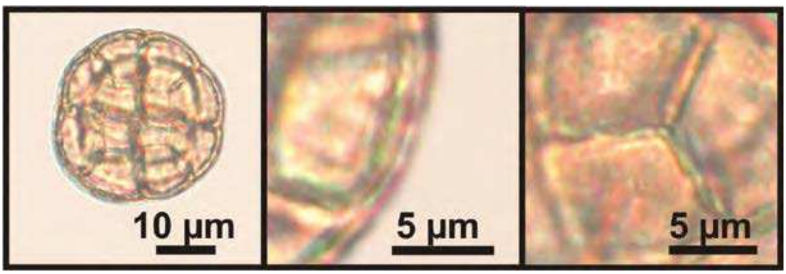
Vegetation: Brazilian dry forests and Urban area
MOSS catalog number: MOSS 13887
Pollen catalog number: PALIASA 137
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Polyad, medium, D = 29.11 ± 2.03 (26.10-34.47), circular amb in front view, spheroidal. Exine areolate, Exi = 1.58 ± 0.27 (1.20-2.24).



Fabaceae

Cassia fistula L.
"CHUVA-DE-OURO"

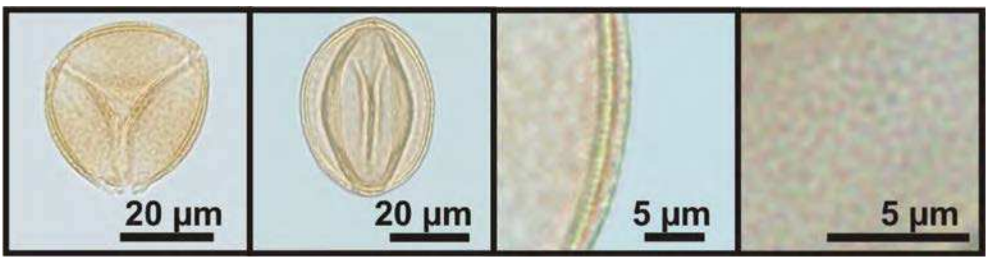
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59226
Pollen catalog number: PALIUFC 254
Habit: arboreal
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 45.73 ± 4.63 (40.38-58.37), E = 35.43 ± 3.51 (27.75-44.20), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.29 ± 0.12 (1.11-1.65), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.68 ± 0.37 (2.17-3.56).



Fabaceae

Centrosema brasilianum Benth.
“CUNHÃ”

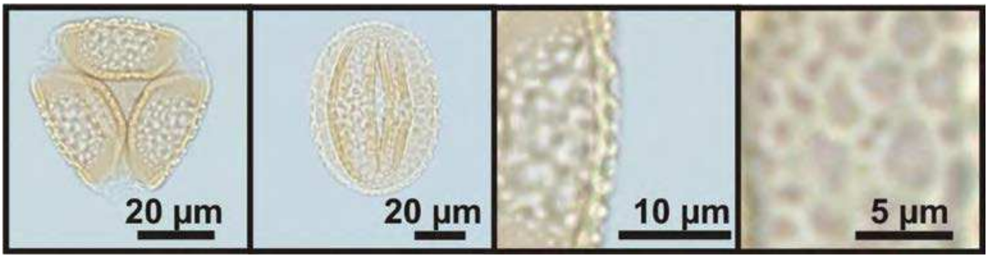
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59224
Pollen catalog number: PALIUFC 256
Habit: vine
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: small
Flower shape: papilionaceous
Flower symmetry: zygomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, medium to large, P = 69.14 ± 5.06 (47.94-75.55), E = 48.29 ± 2.28 (42.48-53.20), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.43 ± 0.11 (1.11-1.63), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.65 ± 0.33 (2.02-3.11).



Fabaceae

Chamaecrista calycioides (DC. ex Collad.) Greene

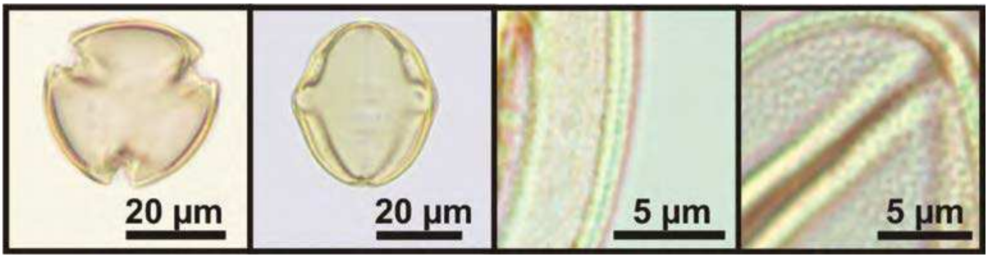
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13839
Pollen catalog number: PALIASA 14
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: small
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium, P = 39.88 ± 2.64 (34.45-43.90), E = 33.31 ± 1.48 (31.22-36.79), radial, isopolar, subtriangular amb, spheroidal to prolate, P/E = 1.20 ± 0.08 (1.00-1.38), tricolporate, colpus long, fastigium, pore lalongate. Exine microreticulate, Exi = 1.55 ± 0.23 (1.00-1.85).



Fabaceae

Chamaecrista duckeana (P.Bezerra & Afr.Fern.) H.S.Irwin & Barneby

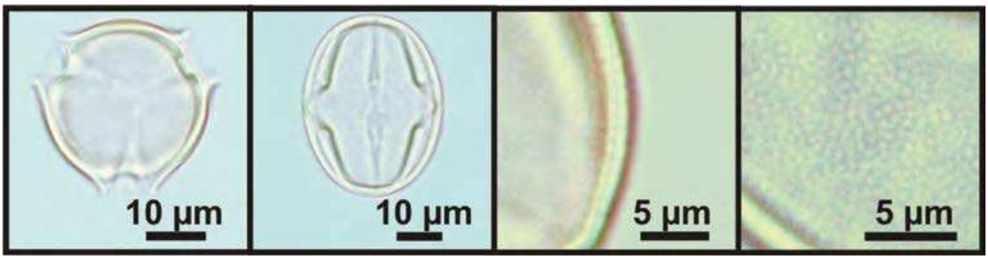
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13906
Pollen catalog number: PALIASA 95
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: medium
Flower shape: anomalous
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 31.63 ± 3.27 (23.24-38.59), E = 19.45 ± 2.47 (15.20-23.78), radial, isopolar, subtriangular amb, prolate, P/E = 1.64 ± 0.15 (1.39-1.93), tricolporate, colpus long, fastigium, pore lalongate. Exine microreticulate, Exi = 1.67 ± 0.30 (1.32-1.89).



Fabaceae

Clitoria fairchildiana R.A.Howard
"FAVEIRA"

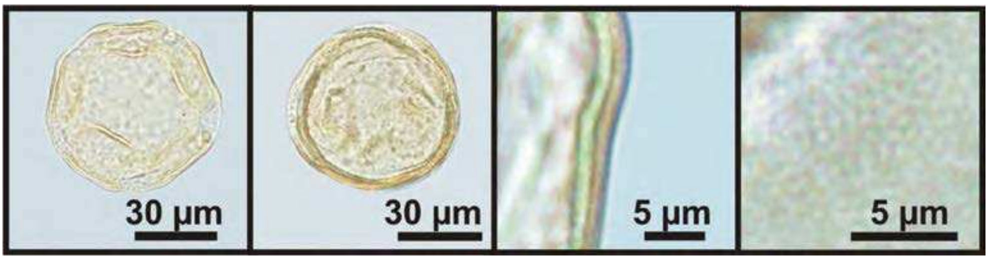
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59373
Pollen catalog number: PALIUFC 360
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: papilionaceous
Flower symmetry: zygomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, large, P = 57.89 ± 3.26 (51.94-64.15), E = 62.90 ± 3.92 (56.09-70.85), radial, isopolar, circular amb, suboblate to oblate spheroidal, P/E = 0.92 ± 0.05 (0.83-0.99), pentaporate, pore lolongate. Exine microreticulate, Exi = 3.26 ± 0.64 (2.21-4.57).



Fabaceae

Crotalaria retusa L.

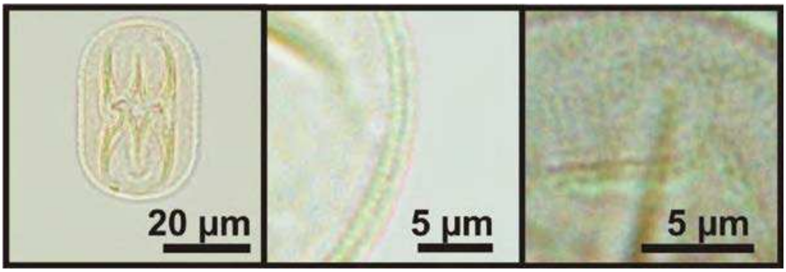
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59221
Pollen catalog number: PALIUFC 329
Habit: shrubby
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: papilionaceous
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, small to medium, P = 42.92 ± 3.79 (34.84-47.48), E = 27.90 ± 3.87 (20.05-36.24), radial, isopolar, subtriangular amb, subprolate to prolate, P/E = 1.54 ± 0.15 (1.25-1.91), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 1.94 ± 0.35 (1.08-2.41).



Fabaceae

Leucaena leucocephala (Lam.) de Wit
"LEUCENA"

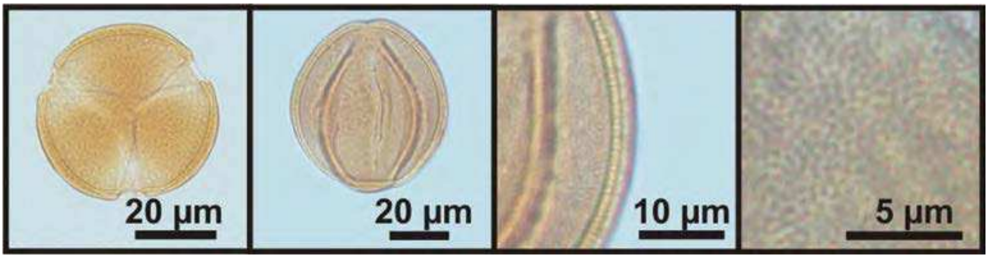
Vegetation: Urban area
EAC catalog number: EAC 59234
Pollen catalog number: PALIUFC 258
Habit: arboreal
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, P = 57.50 ± 5.58 (49.17-66.91), E = 47.21 ± 3.38 (40.52-52.83), radial, isopolar, subtriangular amb, oblate spheroidal to prolate, P/E = 1.22 ± 0.12 (0.96-1.39), tricolporate, colpus long, pore lolongate. Exine fossulate, Exi = 2.63 ± 0.32 (1.97-3.03).



Fabaceae

Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz

“PAU-FERRO”

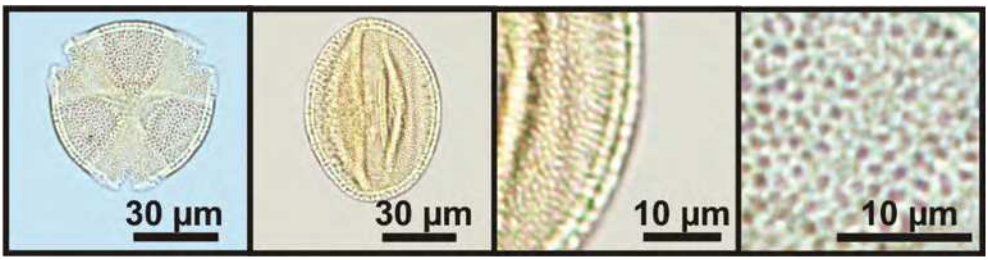
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13874
Pollen catalog number: PALIASA 12
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large, P = 75.88 ± 3.79 (66.52-82.89), E = 60.21 ± 5.05 (52.18-71.66), radial, isopolar, triangular amb, prolate spheroidal to prolate, P/E = 1.26 ± 0.09 (1.07-1.38), tricolporate, colpus short, margo, pore lolongate. Exine reticulate, heterobrochate, Exi = 4.11 ± 0.46 (3.20-5.01).



Fabaceae

Mimosa arenosa Poir.
"CALUMBI"

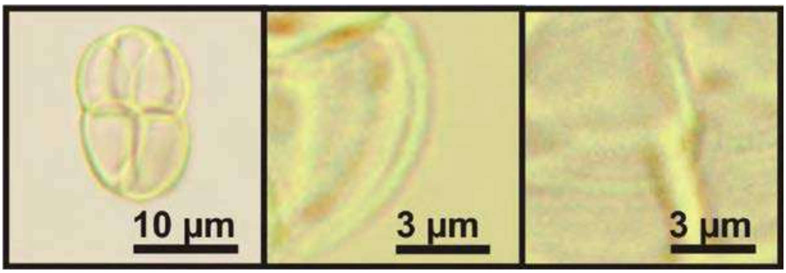
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13865
Pollen catalog number: PALIASA 16
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Polyad, small, D = 17.56 ± 1.48 (12.27-19.98), circular amb in front view, spheroidal. Exine verrucate, areolate, Exi = 1.09 ± 0.22 (0.73-1.34).



Fabaceae

Mimosa caesalpiniifolia Benth.
"SABIÁ"

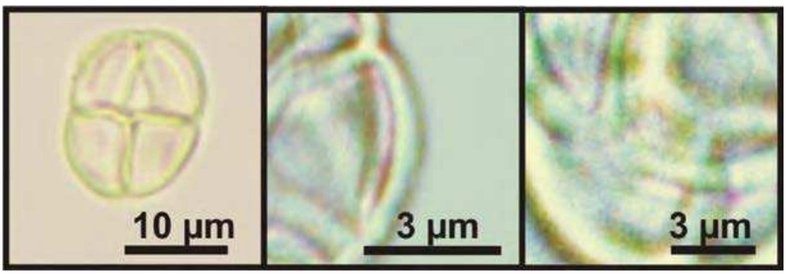
Vegetation: Urban area and Brazilian dry forests
MOSS catalog number: MOSS 13862
Pollen catalog number: PALIASA 76
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Polyad, small, D = 16.60 ± 1.23 (13.03-18.65), circular amb in front view, spheroidal. Exine verrucate, areolate, Exi = 1.09 ± 0.24 (0.66-1.71).



Fabaceae

Mimosa candollei R.Grether

"MIMOSA"

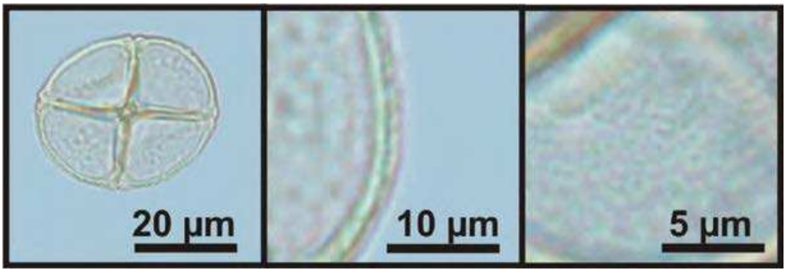
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59404
Pollen catalog number: PALIUFC 394
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Tetrad, medium, D = 35.84 ± 2.32 (32.31-41.27), circular amb in front view, spheroidal. Exine areolate, verrucate, Exi = 1.45 ± 0.34 (0.80-2.04).



Fabaceae

Mimosa pudica L.

"DORMIDEIRA AND SENSITIVA"

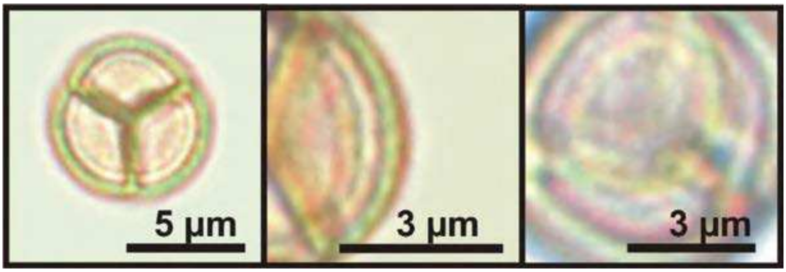
Vegetation: Amazon forest and Crop area
INPA catalog number: INPA 278122
Pollen catalog number: PALIIBUSP 5
Habit: herbaceous and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen

Pollen description

Tetrad, very small, D = 7.74 ± 0.26 (7.25-8.23), circular amb in front view, spheroidal. Exine areolate, Exi = 0.95 ± 0.16 (0.60-1.32).

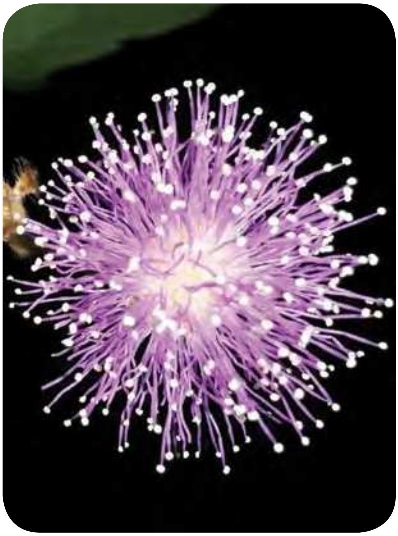


Fabaceae

Mimosa sensitiva L.

"ENGANCHA-BOI, UNHA-DE-GATO AND MALÍCIA"

Vegetation: Amazon forest
INPA catalog number: INPA 278120
Pollen catalog number: PALIIBUSP 3
Habit: herbaceous and shrubby
Origin: native

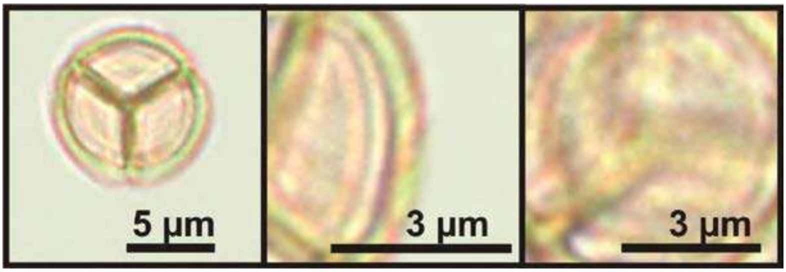


Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen

Pollen description

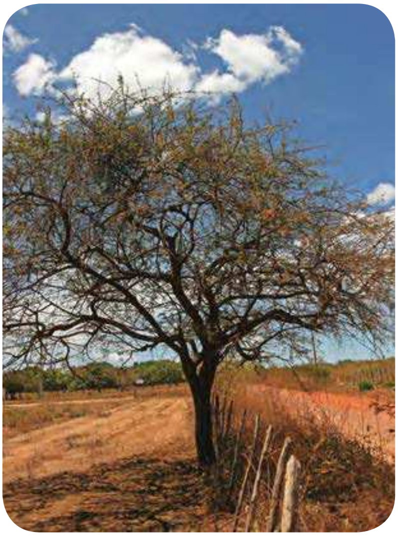
Tetrad, very small, D = 8.90 ± 0.27 (8.24-9.34), circular amb in front view, spheroidal. Exine verrucate, areolate, Exi = 0.94 ± 0.20 (0.54-1.60).



Fabaceae

Mimosa tenuiflora (Willd.) Poir

"JUREMA-PRETA"



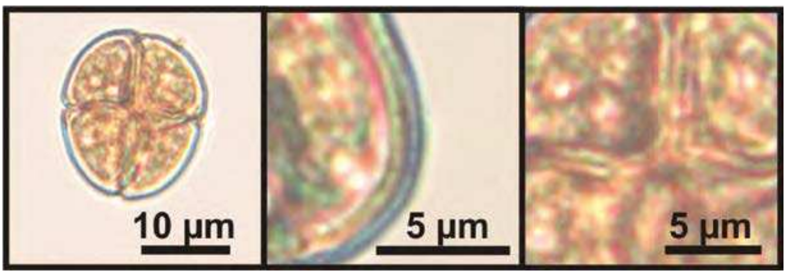
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13837
Pollen catalog number: PALIASA 120
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Tetrad, small, D = 19.91 ± 1.59 (15.84-22.51), circular amb in front view, spheroidal. Exine areolate, verrucate, Exi = 1.25 ± 0.24 (0.80-1.80).



Fabaceae

Neptunia plena (L.) Benth.

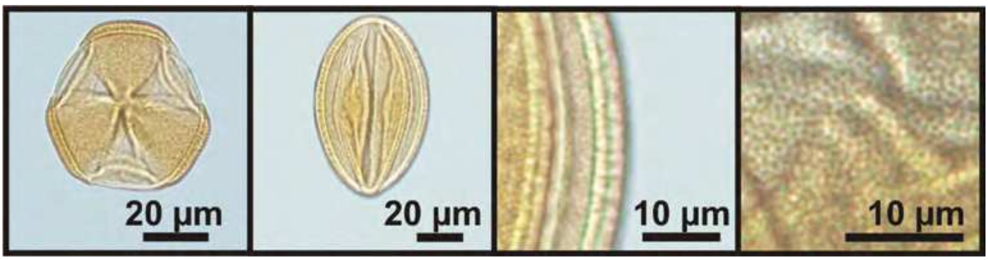
Vegetation: Brazilian dry forests
EAC catalog number: EAC 59379
Pollen catalog number: PALIUFC 347
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: medium
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

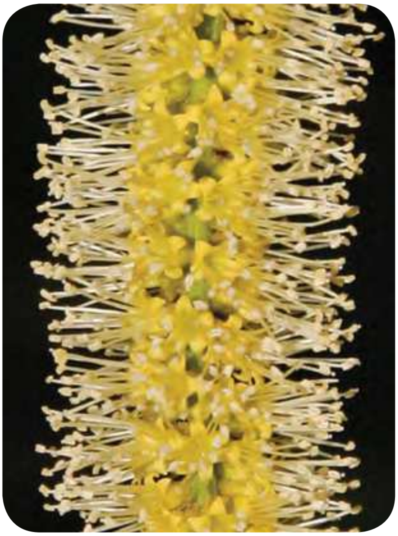
Pollen description

Monad, medium to large, P = 78.01 ± 6.24 (59.60-86.64), E = 51.43 ± 3.55 (45.05-60.25), radial, isopolar, subtriangular amb, subprolate to prolate, P/E = 1.52 ± 0.11 (1.32-1.70), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 4.27 ± 0.46 (3.43-5.01).



Fabaceae

Pityrocarpa moniliformis (Benth.) Luckow & R.W.Jobson



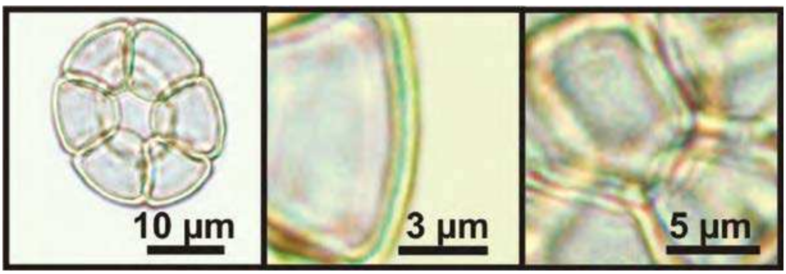
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 14275
Pollen catalog number: PALIASA 4
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: tubular
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

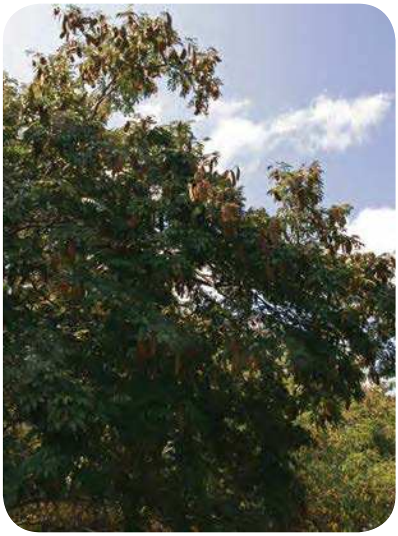
Polyad, small to medium, D = 24.41 ± 1.86 (21.63-28.74), circular amb in front view, spheroidal. Exine verrucate, areolate, Exi = 1.08 ± 0.23 (0.60-1.61).



Fabaceae

Senegalia polyphylla Britton & Rose ex Britton & Killip

"ANGIQUINHO, MONJOLEIRO AND PERIQUITEIRA"



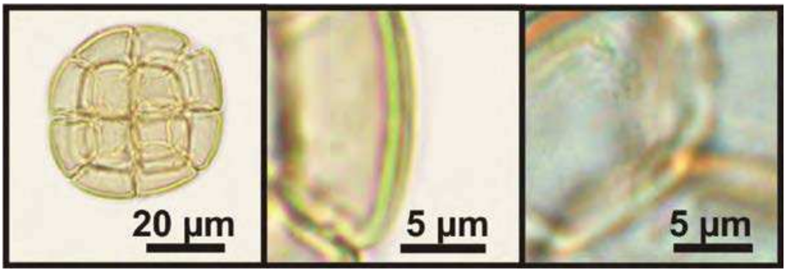
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13895
Pollen catalog number: PALIASA 69
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Polyad, medium to large, D = 45.49 ± 3.89 (39.39-51.70), circular amb in front view, spheroidal. Exine psilate, Exi = 1.40 ± 0.16 (1.20-1.60).



Fabaceae

Senna macranthera (DC. ex Collad.) H.S. Irwin & Barneby
"FEDEGOSO"

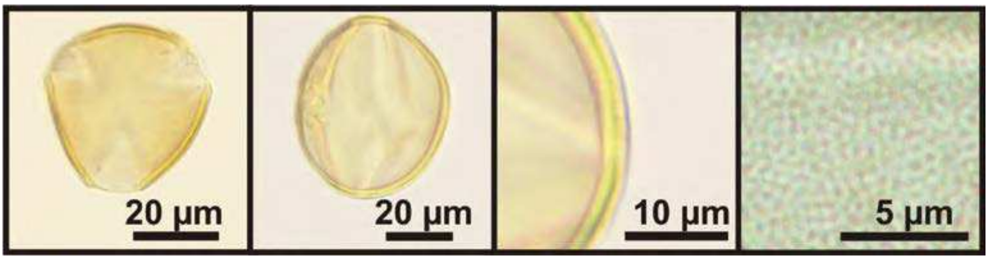
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13886
Pollen catalog number: PALIASA 45
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 55.45 ± 5.08 (48.08-66.70), E = 39.98 ± 3.96 (32.95-49.11), radial, isopolar, subtriangular amb, subprolate to prolate, P/E = 1.39 ± 0.07 (1.28-1.54), tricolporate, colpus long, pore lolongate. Exine microreticulate, Exi = 2.51 ± 0.49 (2.00-3.23).



Fabaceae

Senna multiglandulosa (Jacq.) H.S.Irwin & Barneby
"ALCAPARRO CHICO AND ALCAPARRITO"

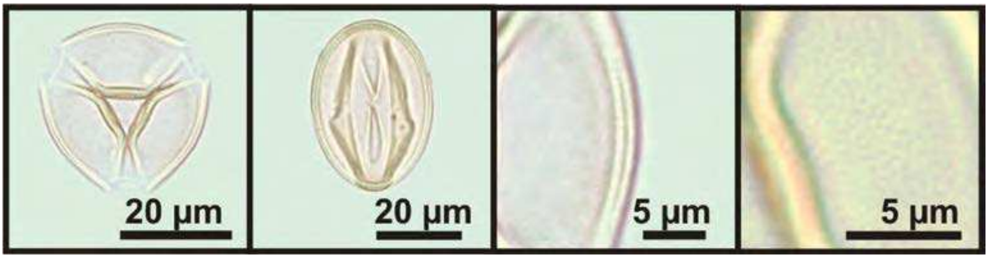
Vegetation: Intervened area and Conejera
UMNG-H catalog number: UMNG-H 1102
Pollen catalog number: PBEAS 82
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium, P = 40.02 ± 1.40 (37.66-43.25), E = 31.56 ± 1.19 (28.68-33.73), radial, isopolar, subtriangular amb, subprolate to prolate, P/E = 1.27 ± 0.07 (1.15-1.40), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.32 ± 0.30 (1.60-2.87).



Fabaceae

Senna obtusifolia (L.) H.S.Irwin & Barneby

"MATA-PASTO"

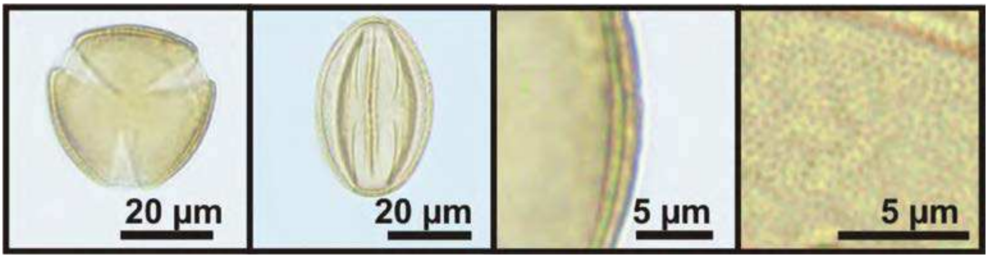
Vegetation: Brazilian dry forests, Crop area and Semi-deciduous lowland forest
MOSS catalog number: MOSS 13864
Pollen catalog number: PALIASA 7
Habit: herbaceous and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium, P = 43.31 ± 1.78 (40.67-47.94), E = 37.55 ± 1.23 (35.62-39.85), radial, isopolar, subtriangular amb, prolate spheroidal to subprolate, P/E = 1.15 ± 0.06 (1.07-1.29), tricolporate, colpus long, pore circular. Exine microreticulate, Exi = 2.31 ± 0.25 (1.81-2.67).



Fabaceae

Senna quinquangulata (Rich.) H.S.Irwin & Barneby
"INGÁ-DE-MORCEGO"

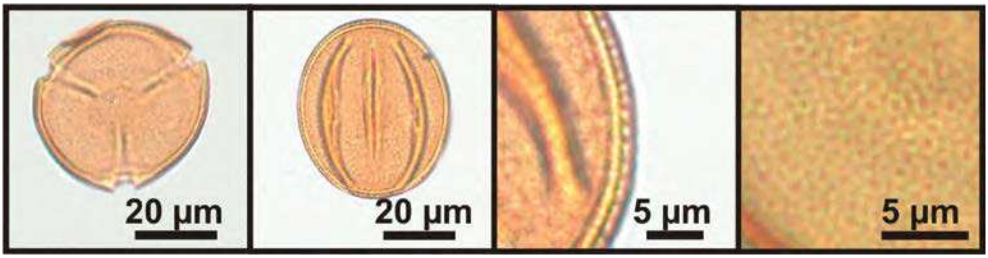
Vegetation: Amazon forest
INPA catalog number: INPA 278163
Pollen catalog number: PALIIBUSP 47
Habit: arboreal, shrubby and vine
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 50.52 ± 3.80 (44.03-59.19), E = 43.17 ± 3.42 (35.95-50.08), radial, isopolar, subtriangular amb, prolate spheroidal to subprolate, P/E = 1.17 ± 0.08 (1.01-1.32), tricolporate, colpus long, pore circular. Exine microreticulate, Exi = 2.41 ± 0.28 (1.81-3.11).



Fabaceae

Senna siamea (Lam) H.S.Irwin & Barneby

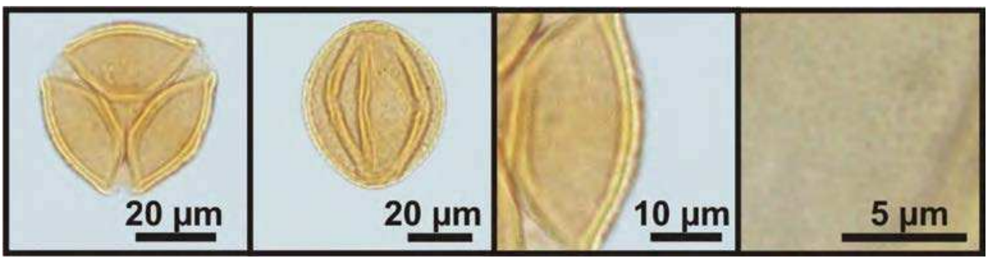
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59232
Pollen catalog number: PALIUFC 296
Habit: arboreal
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 53.36 ± 4.13 (47.32-64.08), E = 44.46 ± 3.97 (39.46-54.28), radial, isopolar, subtriangular amb, prolate spheroidal to subprolate, P/E = 1.20 ± 0.07 (1.05-1.32), tricolporate, colpus long, costa, pore lolongate. Exine microreticulate, Exi = 3.44 ± 0.52 (2.61-4.71).



Fabaceae

Senna trachypus (Benth.) H.S.Irwin & Barneby

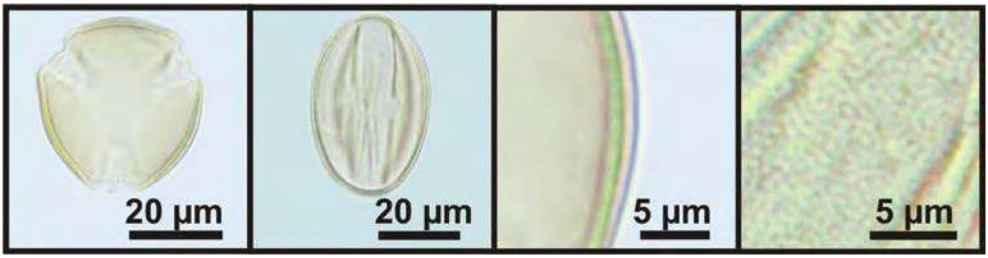
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 8958
Pollen catalog number: PALIASA 6
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium, P = 44.44 ± 2.53 (39.56-48.88), E = 36.60 ± 1.96 (31.66-39.29), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.22 ± 0.06 (1.14-1.35), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.49 ± 0.29 (2.01-3.00).



Fabaceae

Senna uniflora (Mill.) H.S.Irwin & Barneby

"MATA-PASTO"

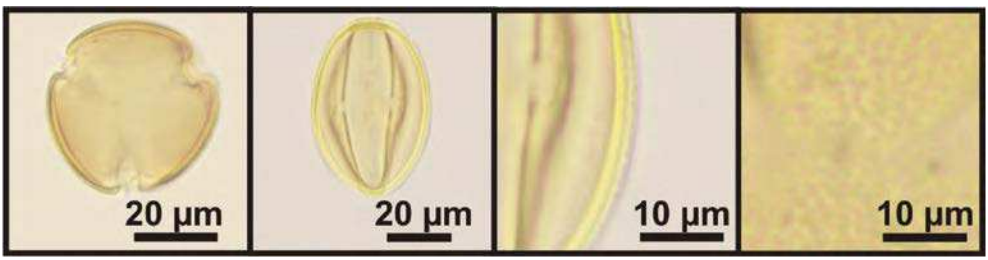
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13900
Pollen catalog number: PALIASA 71
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, medium to large, P = 56.00 ± 2.86 (50.32-61.77), E = 42.85 ± 2.64 (36.25-46.82), radial, isopolar, subtriangular amb, subprolate, prolate, P/E = 1.31 ± 0.09 (1.18-1.48), tricolporate, colpus long, pore lolongate. Exine microreticulate, Exi = 3.04 ± 0.29 (2.79-3.80).



Fabaceae

Stryphnodendron pulcherrimum Hochr.

"FAVA, TIMBAÚBA,TIMBÓ-DA-MATA, TIMBORANA, PARICARANA AND CAMUZÉ"

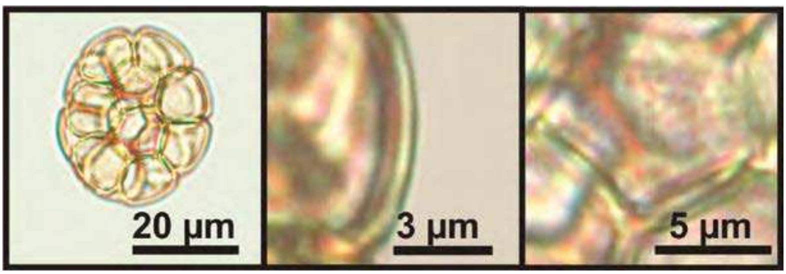
Vegetation: Amazon forest
INPA catalog number: INPA 278150
Pollen catalog number: PALIIBUSP 34
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual and bisexual
Flower size: very small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: cream and yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Polyad, medium, D = 30.94 ± 2.02 (26.96-34.77), circular amb in front view, spheroidal. Exine verrucate, Exi = 1.06 ± 0.22 (0.60-1.42).



Fabaceae

Trifolium pratense L.
"TRÉBOL ROJO AND TRÉBOL MORADO"

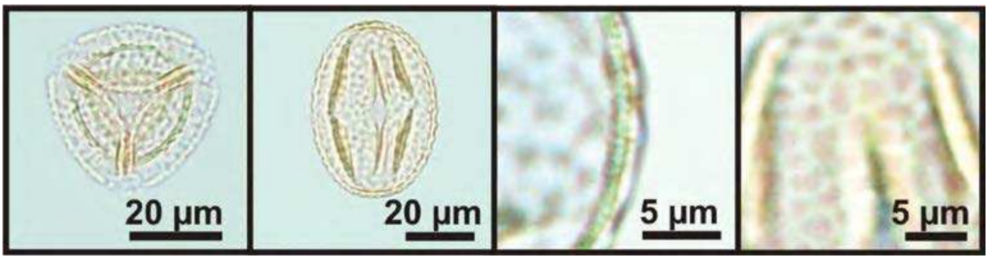
Vegetation: Intervened area, Sub-paramo and Crop area
UMNG-H catalog number: UMNG-H 1008
Pollen catalog number: PBEAS 80
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees and by birds
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: papilionaceous
Flower symmetry: zygomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, medium to large, P = 52.01 ± 6.67 (40.90-62.63), E = 38.73 ± 2.97 (33.31-44.09), radial, isopolar, triangular amb, prolate spheroidal to prolate, P/E = 1.34 ± 0.12 (1.10-1.52), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.13 ± 0.35 (1.22-3.00).



Fabaceae

Trifolium repens L.
"TRÉBOL BLANCO"

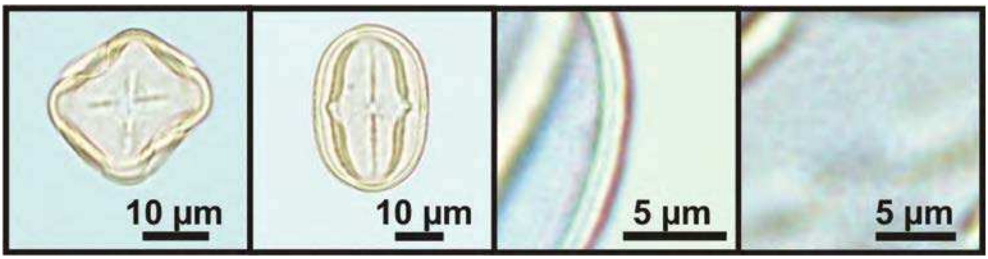
Vegetation: Intervened area, Conejera and Crop area
UMNG-H catalog number: UMNG-H 1111
Pollen catalog number: PBEAS 81
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees and by birds
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: papilionaceous
Flower symmetry: zygomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, small to medium, P = 35.32 ± 2.21 (30.12-38.48), E = 25.84 ± 1.78 (19.96-27.81), radial, isopolar, subtriangular and quadrangular amb, subprolate to prolate, P/E = 1.37 ± 0.08 (1.20-1.57), tricolporate and tetracolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 1.74 ± 0.23 (1.22-2.20).



Fabaceae

Vachellia farnesiana (L.) Wight & Arn.
"ACÁCIA-YELLOW"

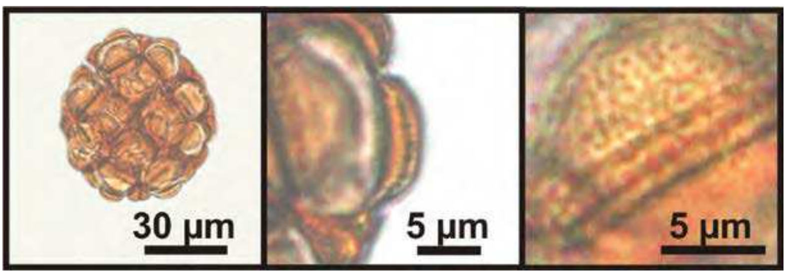
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 30
Pollen catalog number: PALIIBUSP 131
Habit: shrubby and arboreal
Origin: native

Flower features

Pollination system: by bees and by flies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: very small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen

Pollen description

Polyad, large, D = 62.13 ± 5.06 (52.38-71.38), circular amb in front view, spheroidal. Exine microreticulate, Exi = 2.76 ± 0.51 (1.79-3.50).



Heliconiaceae

Heliconia psittacorum L.f.
"HELICÔNIA-PAPAGAIO"

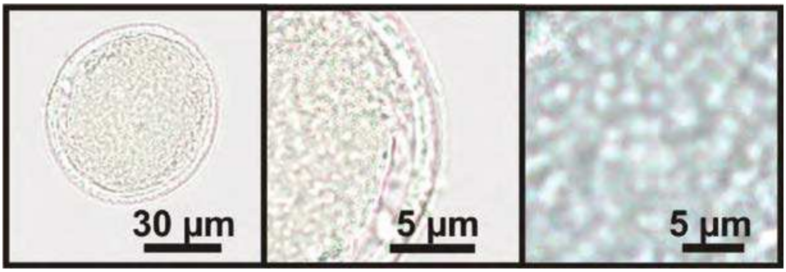
Vegetation: Urban area
SPF catalog number: F.Y.S. Arakaki 52
Pollen catalog number: PALIIBUSP 238
Habit: shrubby
Origin: exotic

Flower features

Pollination system: by birds and by butterflies
Attraction unit: flower
Flower sexuality: bisexual
Flower size: very large
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, D = 68.36 ± 13.32 (46.69-86.14), radial, apolar, circular amb, spheroidal, inaperturate. Exine microechinate, Exi = 1.54 ± 0.40 (0.83-2.21).



Hypericaceae

Hypericum juniperinum Kunth
"CHITE"

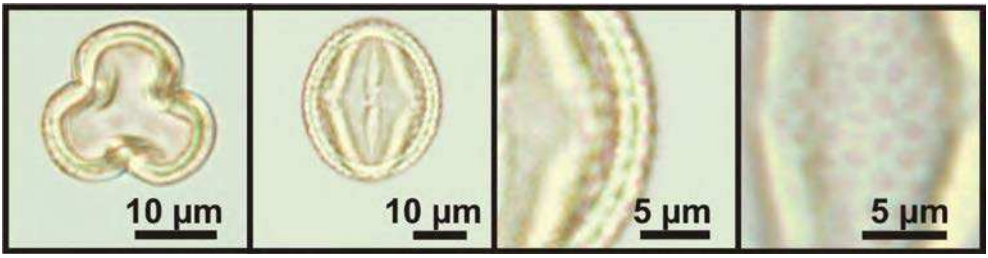
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1140
Pollen catalog number: PBEAS 14
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 30.03 ± 1.84 (26.07-32.64), E = 22.81 ± 1.63 (19.76-25.64), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.32 ± 0.13 (1.08-1.61), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.88 ± 0.29 (2.24-3.46).



Hypericaceae

Vismia cayennensis (Jacq.) Pers.
"LACRE"

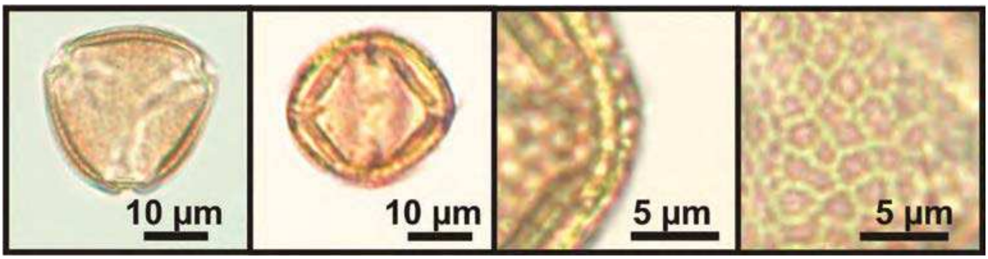
Vegetation: Amazon forest
INPA catalog number: INPA 278149
Pollen catalog number: PALIIBUSP 33
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 26.06 ± 2.59 (20.83-31.05), E = 27.43 ± 2.21 (23.13-32.32), radial, isopolar, triangular amb, suboblate to prolate spheroidal, P/E = 0.95 ± 0.06 (0.86-1.07), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.38 ± 0.38 (1.71-3.46).



Hypericaceae

Vismia japurensis Reichardt

"LACRE, PICHARRINHA, PAU-DE-LACRE AND PURGA-DE-VENTO"

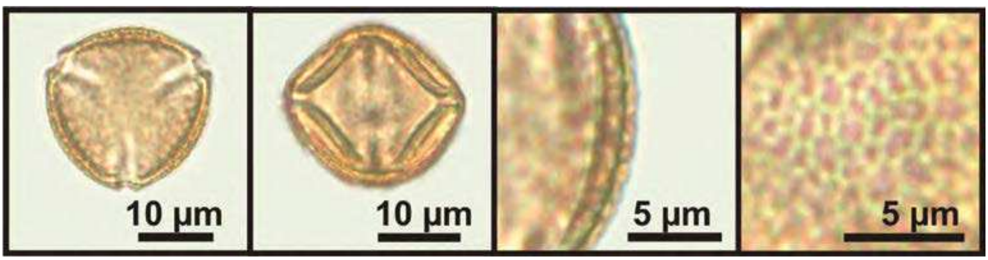
Vegetation: Amazon forest
INPA catalog number: INPA 278141
Pollen catalog number: PALIIBUSP 25
Habit: arboreal and shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: unisexual
Flower size: medium
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white and green
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 21.48 ± 1.49 (18.24-24.63), E = 22.86 ± 1.92 (20.50-27.10), radial, isopolar, triangular amb, suboblate to prolate spheroidal, P/E = 0.94 ± 0.06 (0.84-1.05), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.05 ± 0.26 (1.61-2.48).



Lamiaceae

Hyptis atrorubens Poit.

"CABEÇA-BRANCA, HORTELÃ-BRAVA, HORTELÃ-DO-CAMPO AND MENTINHA"

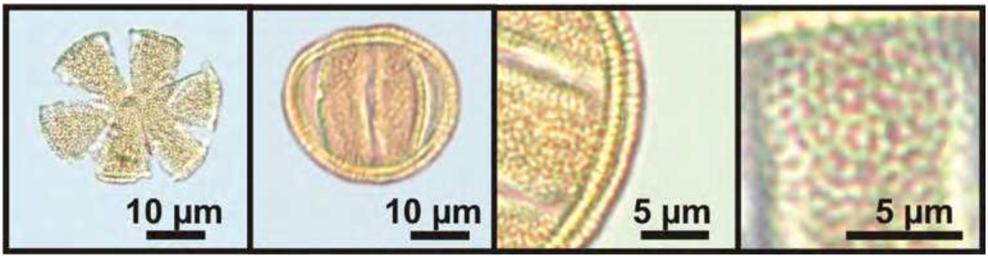
Vegetation: Amazon forest
INPA catalog number: INPA 278125
Pollen catalog number: PALIIBUSP 8
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: bilabiate
Flower symmetry: zygomorphous
Flower color: lilac
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 28.01 ± 2.29 (23.99-33.93), E = 31.86 ± 2.26 (27.43-38.05), radial, isopolar, circular amb, oblate to oblate spheroidal, P/E = 0.88 ± 0.06 (0.72-0.99), hexacolpate, colpus long. Exine microreticulate, Exi = 2.82 ± 2.26 (2.40-3.21).



Lamiaceae

Leonurus japonicus Houtt.
"ERVA-MACAÉ AND RUBIM"

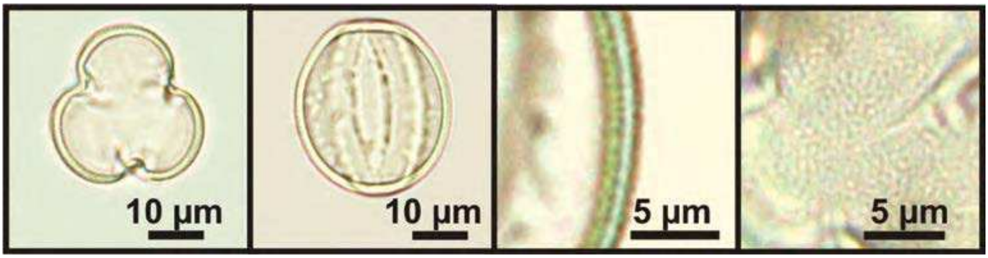
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 45
Pollen catalog number: PALIIBUSP 146
Habit: herbaceous
Origin: naturalized

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: bilabiate
Flower symmetry: zygomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, small to medium, P = 31.87 ± 1.82 (27.50-35.55), E = 28.62 ± 1.50 (24.44-31.14), radial, isopolar, subtriangular amb, oblate spheroidal to prolate, P/E = 1.11 ± 0.09 (0.99-1.36), tricolpate, colpus long. Exine microreticulate, Exi = 2.00 ± 0.32 (1.60-2.61).



Lythraceae

Cuphea gracilis Kunth
"CUFEIA"

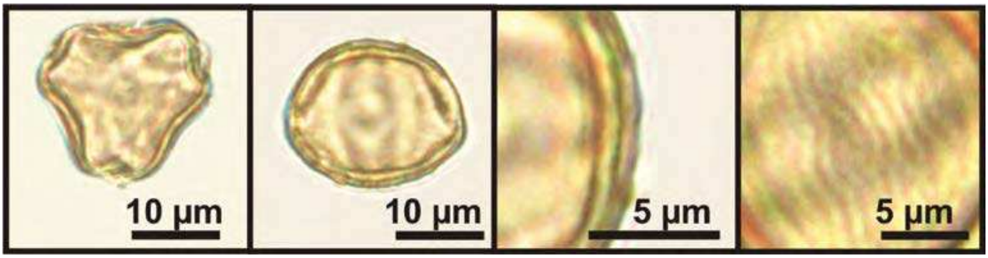
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 22
Pollen catalog number: PALIIBUSP 123
Habit: herbaceous
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: calcarate
Flower symmetry: zygomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, small, P = 18.01 ± 1.40 (15.85-20.67), E = 20.83 ± 2.03 (16.66-25.01), radial, isopolar, triangular amb, oblate to subprolate, P/E = 0.86 ± 0.09 (0.74-1.15), tricolporate, colpus long, pore lalongate. Exine striate, reticulate, Exi = 1.65 ± 0.32 (1.02-2.41).



Malpighiaceae

Byrsonima chrysophylla Kunth
"MURICI"

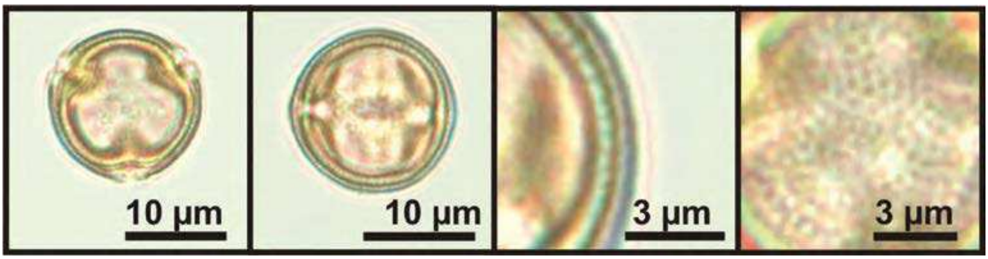
Vegetation: Amazon forest
INPA catalog number: INPA 278136
Pollen catalog number: PALIIBUSP 19
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and oil

Pollen description

Monad, small, P = 15.33 ± 0.69 (14.19-16.44), E = 15.65 ± 0.52 (14.61-16.61), radial, isopolar, subcircular amb, oblate spheroidal to prolate spheroidal, P/E = 0.98 ± 0.03 (0.93-1.05), tricolporate, colpus short, fastigium, pore lalongate. Exine microreticulate, Exi = 1.44 ± 0.23 (1.02-1.85).



Malpighiaceae

Byrsonima intermedia A.Juss.
"MURICI"

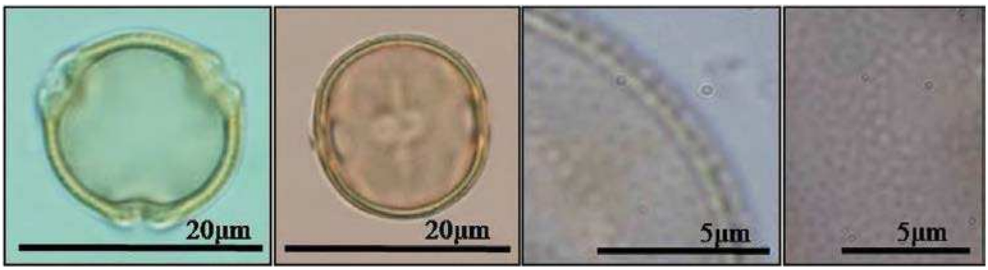
Vegetation: Urban area
HUFU catalog number: HUFU 50159
Pollen catalog number: PALIUFU 1
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: unguiculate
Flower symmetry: zygomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and oil

Pollen description

Monad, small, P = 18.74 ± 1.11 (16.97-20.19), E = 17.96 ± 0.82 (16.92-19.34), radial, isopolar, subcircular amb, oblate spheroidal to prolate spheroidal, P/E = 1.04 ± 0.03 (0.95-1.10), tricolporate, colpus short, fastigium, pore lalongate. Exine perfurate, Exi = 1.05.



Malvaceae

Dombeya burgessiae Gerr. ex Harv. & Sond.

“DOMBEIA”

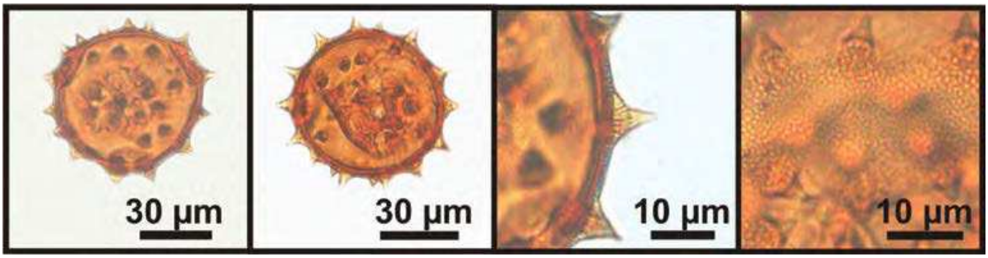
Vegetation: Urban area
SPF catalog number: J.A. Pissolato 4
Pollen catalog number: PALIIBUSP 105
Habit: arboreal
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large, D = 70.06 ± 4.69 (58.03-77.16), radial, isopolar, subcircular amb, spheroidal, triporate, pore circular, annulus. Exine echinate, Exi = 3.13 ± 0.48 (2.20-4.02).



Malvaceae

Sida cordifolia L.

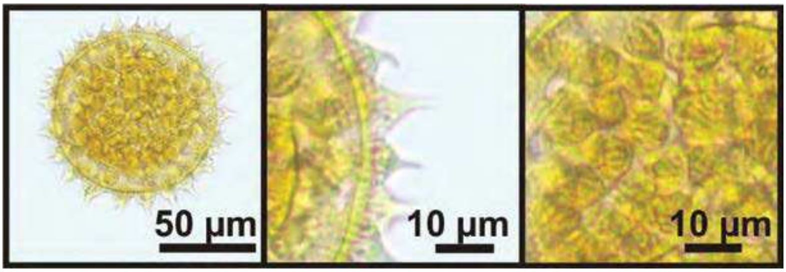
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13887
Pollen catalog number: PALIASA 2
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: pollen and nectar

Pollen description

Monad, large to very large, D = 105.26 ± 17.38 (76.83-136.04), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 3.77 ± 0.29 (3.56-3.97).



Malvaceae

Waltheria bracteosa A.St.-Hil. & Naudin

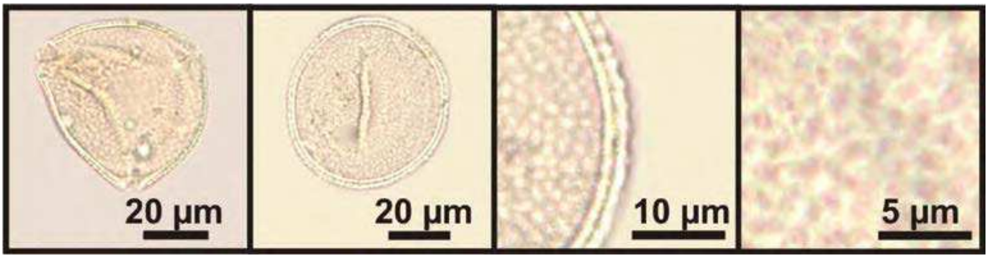
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13872
Pollen catalog number: PALIASA 61
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, medium to large, P = 56.63 ± 3.10 (50.13-60.72), E = 52.81 ± 2.96 (48.32-58.75), radial, isopolar, subtriangular amb, prolate spheroidal, P/E = 1.07 ± 0.04 (1.01-1.14), tricolporate, colpus long, pore lalongate. Exine reticulate, Exi = 2.40 ± 0.16 (2.28-2.51).



Melastomataceae

Bellucia grossularioides Triana
"ARAÇÁ-DE-ANTA"

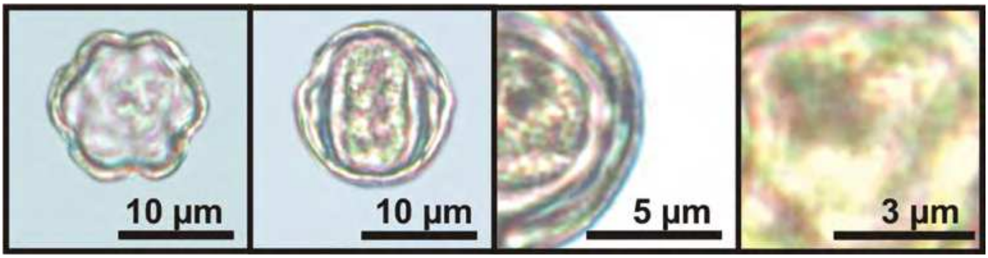
Vegetation: Amazon forest
INPA catalog number: INPA 278155
Pollen catalog number: PALIIBUSP 39
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: dusk
Anther dehiscence: poricidal
Scent: presence of odor
Floral resource: pollen

Pollen description

Monad, small, P = 15.20 ± 0.47 (14.16-16.11), E = 14.49 ± 0.88 (12.44-15.91), radial, isopolar, circular amb, oblate spheroidal to subprolate, P/E = 1.05 ± 0.07 (0.92-1.21), tricolporate, tripseudocolpate, colpus long, heteroaperturate, pore lalongate. Exine microreticulate, Exi = 1.15 ± 0.18 (0.80-1.40).



Melastomataceae

Brachyotum strigosum Triana
"MORADITO"

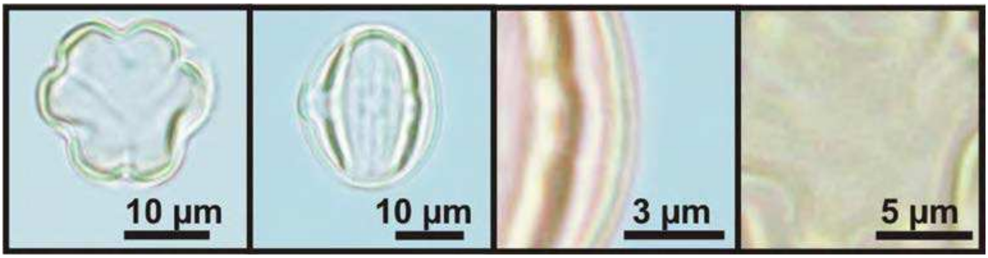
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1172
Pollen catalog number: PBEAS 19
Habit: shrub
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: campanulate
Flower symmetry: actinomorphous
Flower color: purple and pink
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 25.89 ± 1.18 (23.88-27.67), E = 21.58 ± 1.41 (16.04-24.02), radial, isopolar, circular amb, prolate spheroidal to prolate, P/E = 1.20 ± 0.08 (1.10-1.49), tricolporate, tripseudocolpate, colpus long, heteroaperturate, pore lalongate. Exine psilate, Exi = 1.43 ± 0.26 (1.02-1.85).



Melastomataceae

Bucquetia glutinosa DC.
"CHARNE AND ANGELITO"

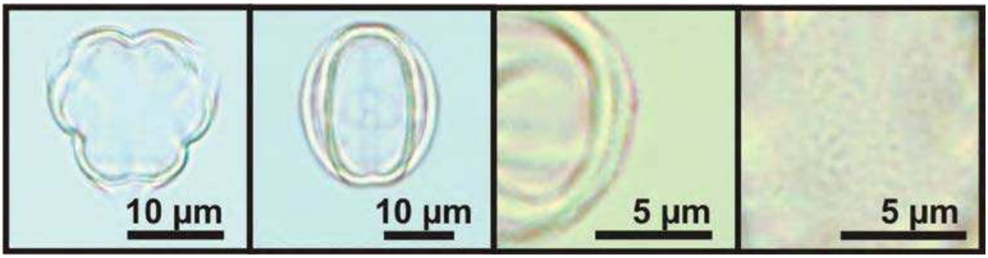
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1169
Pollen catalog number: PBEAS 17
Habit: shrub
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: cruciform
Flower symmetry: actinomorphous
Flower color: pink and red
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 23.54 ± 1.90 (20.28-27.49), E = 18.86 ± 2.03 (15.48-23.37), radial, isopolar, circular amb, prolate spheroidal to prolate, P/E = 1.25 ± 0.17 (1.02-1.63), tricolporate, tripseudocolpate, colpus long, heteroaperturate, pore lalongate. Exine microreticulate, Exi = 1.77 ± 0.35 (1.02-2.44).



Melastomataceae

Chaetolepis microphylla Miq.
"DORADILLA AND VENADILLO"

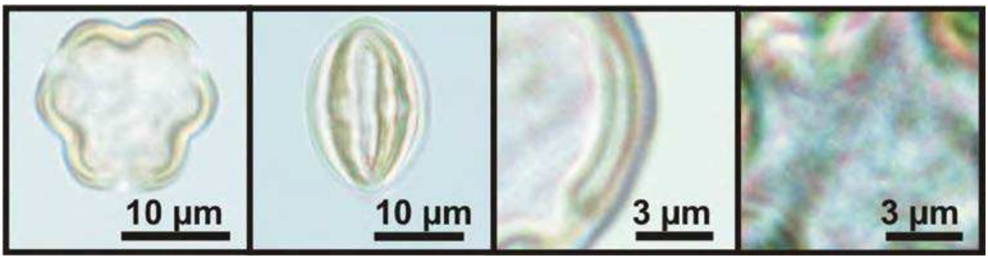
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1173
Pollen catalog number: PBEAS 16
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: cruciform
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small, P = 20.80 ± 0.91 (18.85-22.65), E = 17.80 ± 1.01 (14.80-19.52), radial, isopolar, circular amb, prolate spheroidal to prolate, P/E = 1.17 ± 0.08 (1.07-1.34), tricolporate, tripseudocolpate, colpus long, heteroaperturate, margo, pore circular. Exine psilate, Exi = 1.99 ± 0.37 (1.40-3.21).



Melastomataceae

Clidemia hirta D.Don

"PIXIRICA"

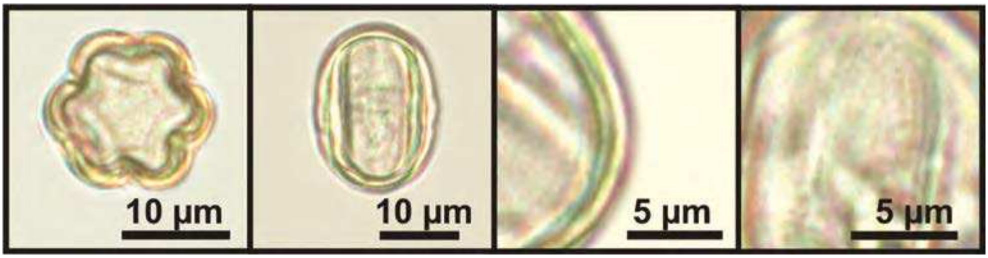
Vegetation: Amazon forest
INPA catalog number: INPA 278119
Pollen catalog number: PALIIBUSP 2
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: nocturnal
Anther dehiscence: poricidal
Scent: presence of odor
Floral resource: pollen

Pollen description

Monad, small, P = 21.92 ± 1.21 (20.24-23.78), E = 16.01 ± 1.19 (14.17-18.63), radial, isopolar, circular amb, subprolate to prolate, P/E = 1.37 ± 0.07 (1.25-1.51), tricolporate, tripseudocolpate, colpus long, heteroaperturate, pore lalongate. Exine microreticulate, Exi = 1.79 ± 0.34 (1.20-2.44).



Melastomataceae

Tibouchina granulosa (Desr.) Cogn.
"QUARESMEIRA"

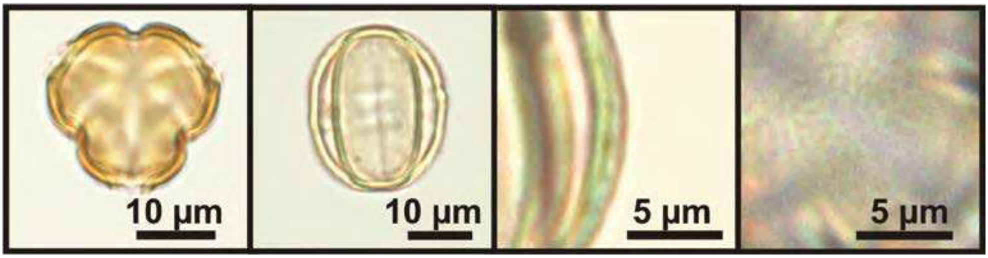
Vegetation: Urban area
SPF catalog number: F.Y.S. Arakaki 27
Pollen catalog number: PALIIBUSP 218
Habit: arboreal
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: large
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: purple
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: presence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 24.43 ± 1.26 (22.42-26.85), E = 22.04 ± 0.99 (20.53-24.82), radial, isopolar, circular amb, prolate spheroidal to subprolate, P/E = 1.11 ± 0.03 (1.06-1.17), tripseudocolpate, tricolporate, colpus long, heteroaperturate, pore lalongate. Exine rugulate, Exi = 1.66 ± 0.26 (1.20-2.21).



Myrtaceae

Eucalyptus globulus Labill.
“EUCALIPTO”

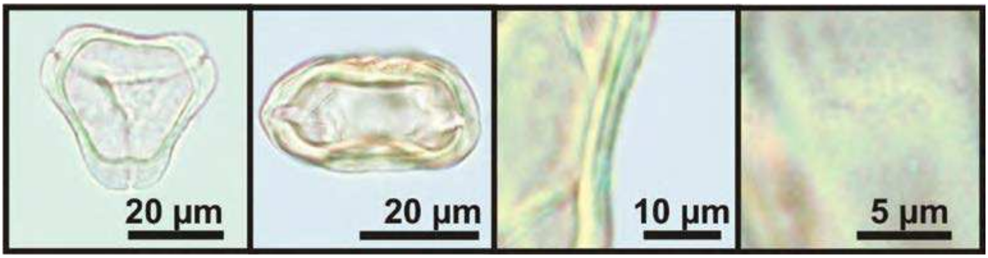
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1202
Pollen catalog number: PBEAS 92
Habit: arboreal
Origin: exotic

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 22.59 ± 2.33 (17.02-26.67), E = 37.47 ± 2.53 (33.72-43.48), radial, isopolar, triangular amb, oblate, P/E = 0.60 ± 0.05 (0.50-0.71), tricolporate, colpus long, parasyncolporate, pore lalongate, fastigium. Exine scabrate, Exi = 4.10 ± 0.80 (2.80-6.01).



Nyctaginaceae

Bougainvillea spectabilis Willd.
"PRIMAVERA"

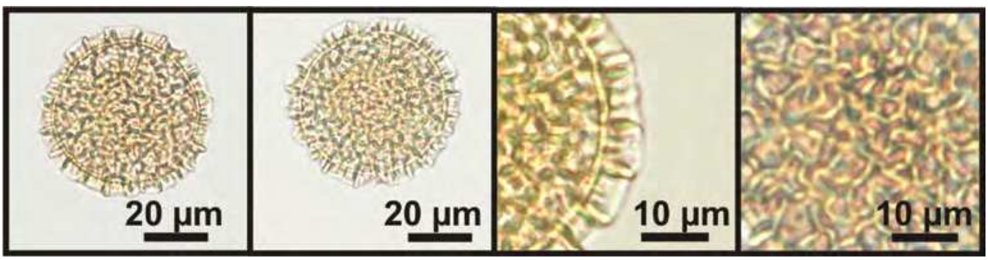
Vegetation: Urban area
SPF catalog number: F.Y.S. Arakaki 30
Pollen catalog number: PALIIBUSP 221
Habit: shrubby
Origin: native

Flower features

Pollination system: by birds and by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: salverform (hypocrateriform)
Flower symmetry: actinomorphous
Flower color: yellow, pink and red
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, medium to large, D = 54.70 ± 2.88 (49.70-63.38), radial, isopolar, subcircular amb, spheroidal, tricolpate, colpus short, pore absent. Exine reticulate, heterobrochate, Exi = 6.23 ± 0.65 (5.01-8.52).



Plantaginaceae

Digitalis purpurea L.
"DIGITALIS AND DEDALERA"

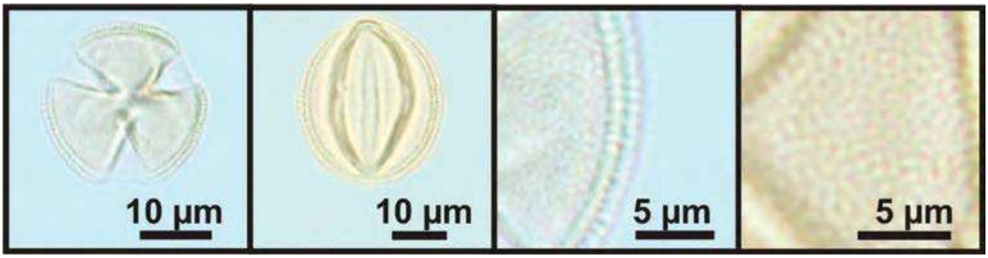
Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 1357
Pollen catalog number: PBEAS 25
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: medium
Flower shape: campanulate
Flower symmetry: zygomorphous
Flower color: purple and white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, small to medium, P = 31.97 ± 2.38 (28.04-36.92), E = 23.52 ± 2.32 (19.48-27.84), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 1.36 ± 0.18 (1.06-1.64), tricolporate, colpus long, pore circular. Exine microreticulate, Exi = 2.44 ± 0.34 (1.81-2.87).



Poaceae

Zea mays L.

“MAÍZ”

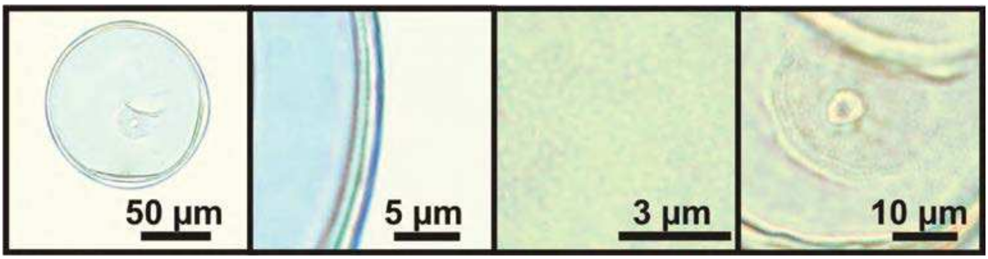
Vegetation: Urban area
UMNG-H catalog number: UMNG-H 120
Pollen catalog number: PBEAS 114
Habit: herbaceous
Origin: cultivated

Flower features

Pollination system: by wind
Attraction unit: inflorescence
Flower sexuality: unisexual
Flower size: small
Flower shape:
Flower symmetry:
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen

Pollen description

Monad, large to very large, D = 118.85 ± 10.92 (99.33-141.02), radial, heteropolar, circular amb, spheroidal, monoporate, pore circular, annulus. Exine microechinate, Exi = 2.08 ± 0.36 (1.61-2.81).



Portulacaceae

Talinum fruticosum (L.) Juss.
"BELDROEGA GRAUDA"

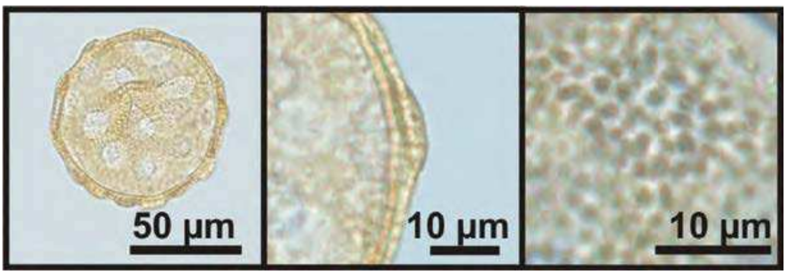
Vegetation: Crop area
EAC catalog number: EAC 59081
Pollen catalog number: PALIUFC 279
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: pink
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large to very large, D = 81.94 ± 12.84 (50.40-116.87), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine microreticulate, Exi = 4.46 ± 1.05 (2.72-5.85).



Rubiaceae

Ixora chinensis Lam.

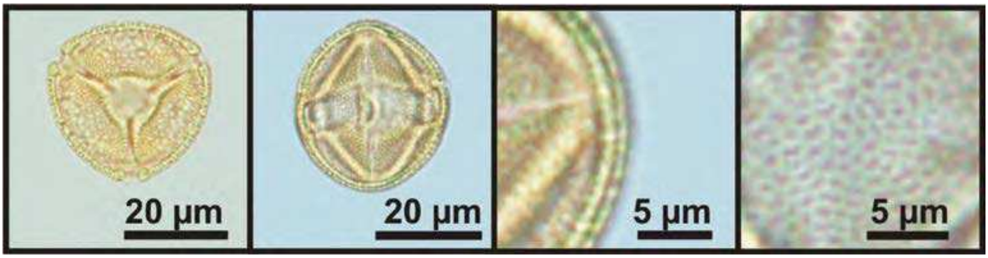
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59141
Pollen catalog number: PALIUFC 345
Habit: herbaceous and shrubby
Origin: cultivated

Flower features

Pollination system: by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: salverform (hypocrateriform)
Flower symmetry: actinomorphous
Flower color: red
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: absence of odor
Floral resource: nectar

Pollen description

Monad, medium, P = 33.72 ± 2.52 (29.28-39.91), E = 32.11 ± 2.19 (27.49-35.71), radial, isopolar, subcircular amb, oblate spheroidal to prolate spheroidal, P/E = 1.05 ± 0.05 (0.96-1.14), tricolporate, sincolporate, endocingulum, colpus long, pore lalongate, annulus. Exine reticulate, heterobrochate, Exi = 2.06 ± 0.40 (1.42-3.00).



Rubiaceae

Morinda citrifolia L.
"NONI"

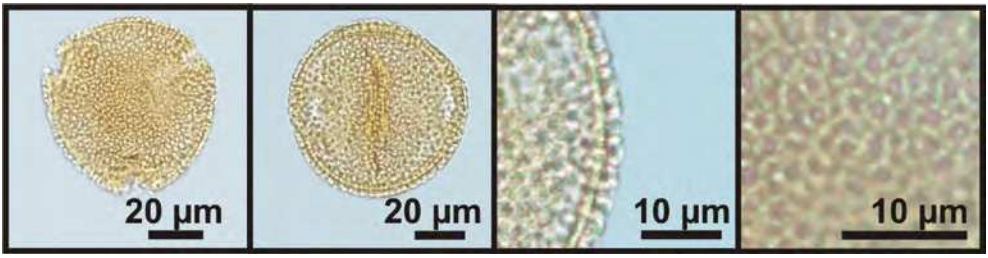
Vegetation: Semi-deciduous lowland forest
EAC catalog number: EAC 59143
Pollen catalog number: PALIUFC 276
Habit: arboreal
Origin: cultivated

Flower features

Pollination system: by butterflies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: salverform (hypocrateriform)
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, large, P = 72.34 ± 4.87 (60.40-78.97), E = 64.41 ± 5.92 (57.04-79.52), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.12 ± 0.11 (0.96-1.30), tricolporate, colpus long, pore lolongate. Exine reticulate, heterobrochate, Exi = 3.71 ± 0.69 (2.66-4.81).



Rubiaceae

Spermacoce alata Aubl.
“ERVA-QUENTE”

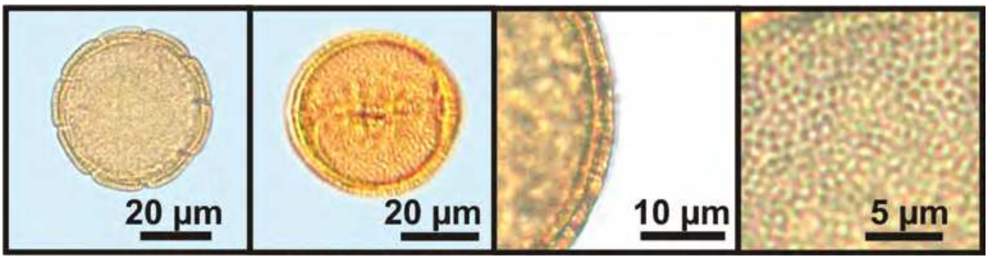
Vegetation: Amazon forest
INPA catalog number: INPA 278132
Pollen catalog number: PALIIBUSP 15
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: nectar

Pollen description

Monad, medium to large, P = 44.54 ± 3.19 (37.17-48.90), E = 46.16 ± 3.32 (39.90-53.28), radial, isopolar, circular amb, suboblate to prolate spheroidal, P/E = 0.96 ± 0.03 (0.87-1.04), 8-colporate and 9-colporate, colpus long, pore lalongate. Exine microreticulate, Exi = 3.13 ± 0.32 (2.61-3.80).



Rubiaceae

Spermacoce verticillata L.
"VASSOURINHA-DE-BOTÃO"

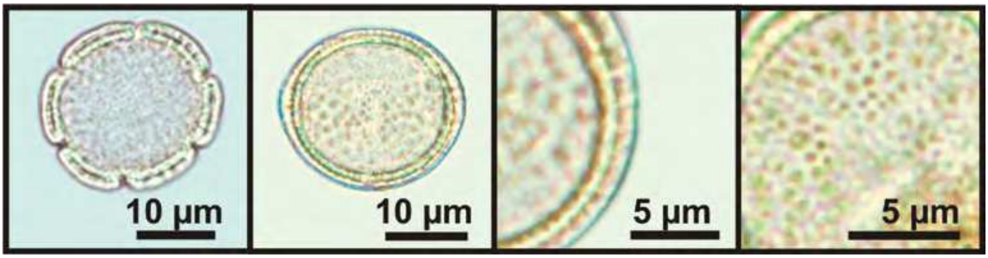
Vegetation: Brazilian dry forests and Amazon forest
MOSS catalog number: MOSS 13903
Pollen catalog number: PALIASA 20
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees and by flies
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: infundibular
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, small to medium, P = 21.54 ± 2.90 (16.89-28.35), E = 23.73 ± 2.97 (19.17-31.88), radial, isopolar, circular amb, suboblate to oblate spheroidal, P/E = 0.91 ± 0.03 (0.83-0.98), pentacolpate, hexacolpate, colpus short. Exine microreticulate, Exi = 2.33 ± 0.50 (1.60-4.02).



Solanaceae

Solanum americanum Mill.
"YERBA MORA"

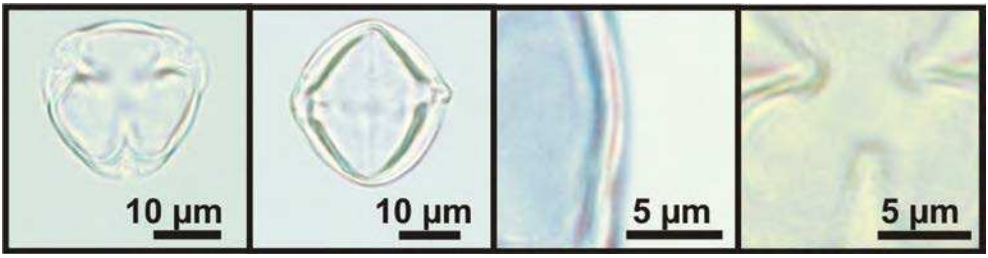
Vegetation: Intervened area and Low montane dry forest
UMNG-H catalog number: UMNG-H 1292
Pollen catalog number: PBEAS 91
Habit: herbaceous
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: rotate
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 27.51 ± 1.94 (24.49-32.73), E = 25.41 ± 2.06 (20.69-28.44), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.08 ± 0.08 (0.95-1.27), tricolporate, colpus long, pore lalongate. Exine psilate, Exi = 1.41 ± 0.30 (1.00-1.90).



Solanaceae

Solanum lycopersicum L.
"TOMATE"

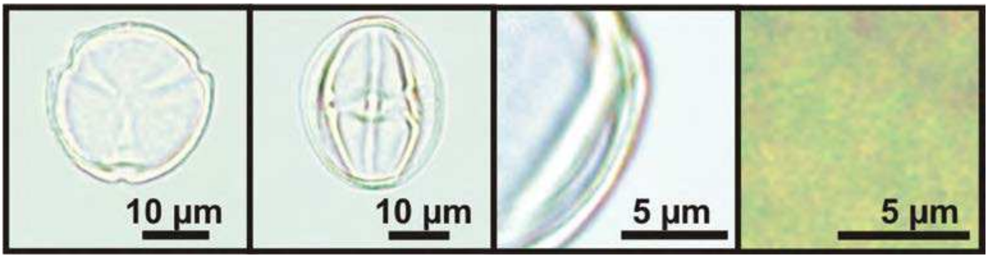
Vegetation: Intervened area and Pampa
UMNG-H catalog number: UMNG-H 117
Pollen catalog number: PBEAS 111
Habit: herbaceous
Origin: cultivated

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: rotate
Flower symmetry: actinomorphous
Flower color: yellow
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 29.00 ± 1.99 (25.91-32.49), E = 25.57 ± 2.27 (21.39-29.15), radial, isopolar, subtriangular amb, oblate spheroidal to prolate, P/E = 1.13 ± 0.11 (0.98-1.52), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 1.40 ± 0.25 (1.00-1.81).



Solanaceae

Solanum paniculatum L.
"JURUBEBA"

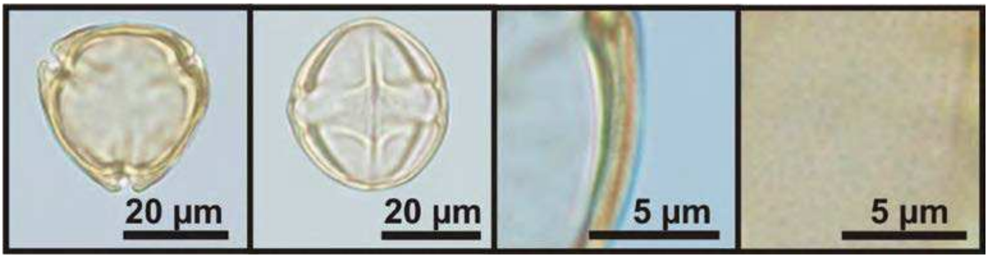
Vegetation: Amazon forest and Semi-deciduous lowland forest
EAC catalog number: EAC 59147
Pollen catalog number: PALIUFC 305
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: inflorescence
Flower sexuality: bisexual
Flower size: small
Flower shape: rotate
Flower symmetry: actinomorphous
Flower color: white
Anthesis: diurnal
Anther dehiscence: poricidal
Scent: absence of odor
Floral resource: pollen

Pollen description

Monad, small to medium, P = 35.67 ± 2.94 (25.89-39.80), E = 33.29 ± 2.52 (24.34-37.05), radial, isopolar, triangular amb, oblate spheroidal to subprolate, P/E = 1.07 ± 0.05 (0.94-1.17), tricolporate, colpus long, costa, pore lalongate, vestíbulo, endocíngulo. Exine microreticulate, Exi = 1.51 ± 0.30 (0.83-2.09).



Turneraceae

Turnera subulata Sm.
"CHANANA, ONZE-HORAS AND BOA-NOITE"

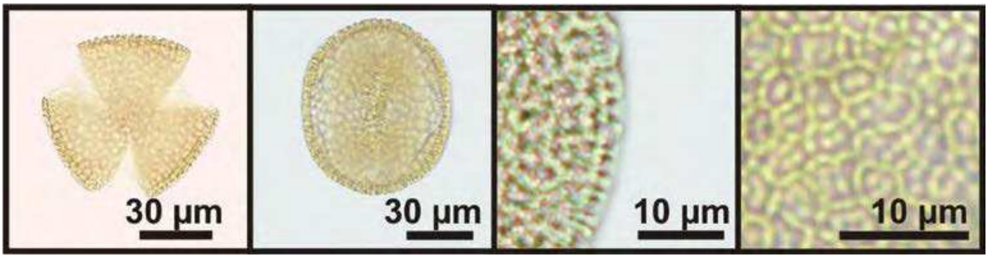
Vegetation: Brazilian dry forests
MOSS catalog number: MOSS 13876
Pollen catalog number: PALIASA 1
Habit: shrubby
Origin: native

Flower features

Pollination system: by bees
Attraction unit: flower
Flower sexuality: bisexual
Flower size: very small
Flower shape: actinomorphic
Flower symmetry: actinomorphous
Flower color: cream
Anthesis: diurnal
Anther dehiscence: longitudinal
Scent: presence of odor
Floral resource: pollen and nectar

Pollen description

Monad, large, P = 78.81 ± 4.56 (74.93-90.28), E = 73.41 ± 2.87 (68.91-79.04), radial, isopolar, subtriangular amb, prolate spheroidal, P/E = 1.07 ± 1.59 (1.09-1.14), tricolporate, colpus long, pore circular. Exine reticulate, heterobrochate, Exi = 3.50 ± 0.68 (2.69-4.57).

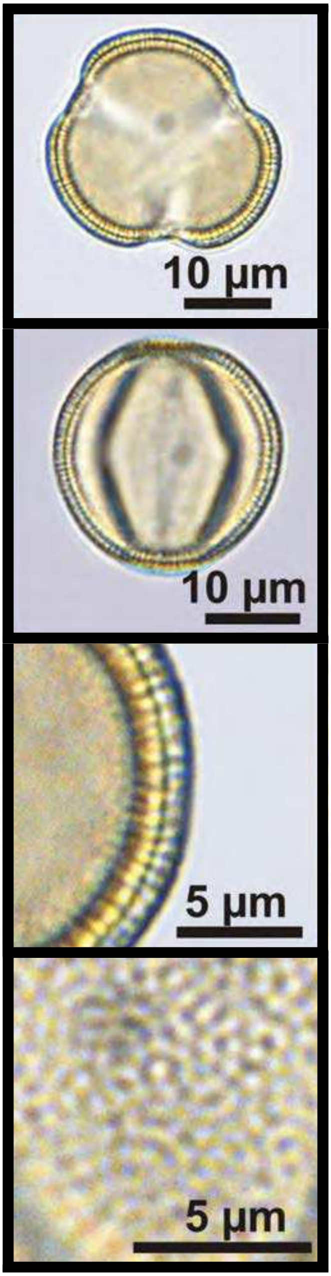


Palynotaxonomy

Acanthaceae

Elytraria imbricata (Vahl) Pers.

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B601 (UTMC)
Pollen catalog number: CBUMAGPALI 0002
Origin: native



Pollen description

Monad, small to medium, P = 27.66 ± 2.71 (23.48-33.37), E = 26.91 ± (23.06-31.75), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.03 ± 0.09 (0.88-1.23), tricolpate, colpus long. Exina microreticulate, Exi = 2.01 ± 0.12 (1.72-2.30).

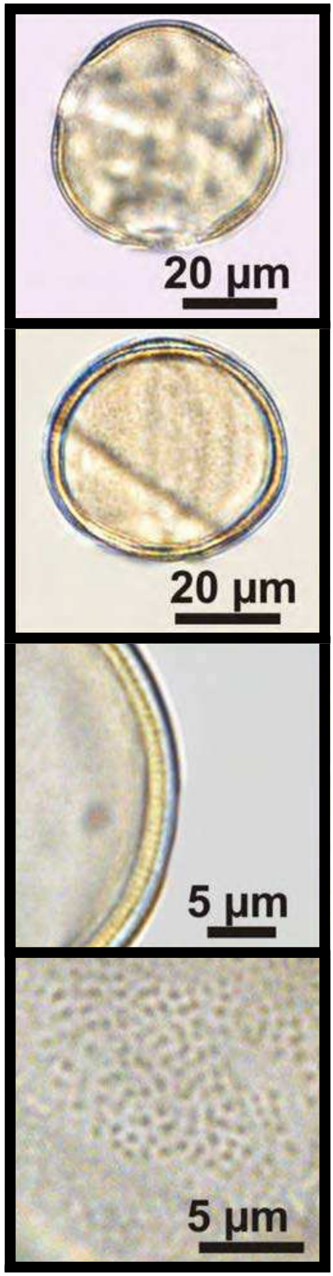
Aizoaceae

Trianthema portulacastrum L.

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B594 (UTMC)
Pollen catalog number: CBUMAGPALI 0003
Origin: native

Pollen description

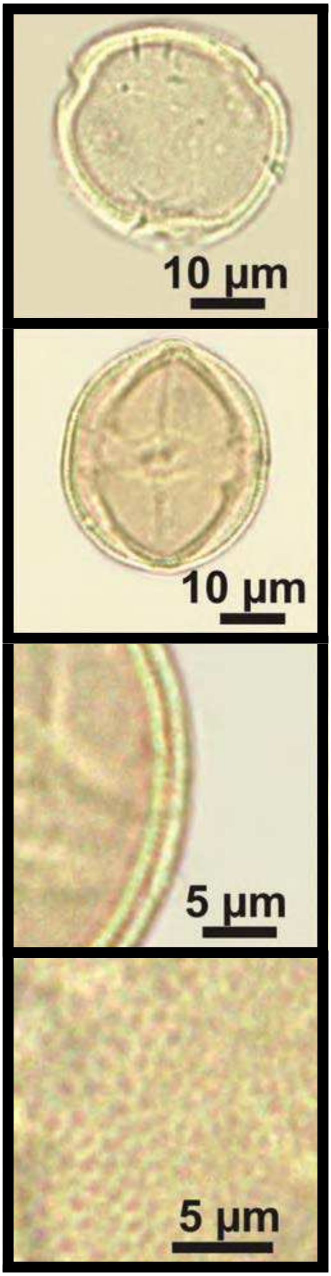
Monad, medium, P = 40.88 ± 1.90 (37.14-43.55), E = 45.19 ± 2.15 (41.06-48.64), radial, isopolar, subcircular amb, suboblate to oblate spheroidal, P/E = 0.91 ± 0.03 (0.84-0.97), tricolpate, colpus long. Exina microreticulate, Exi = 2.03 ± 0.29 (1.45-2.58).



Anacardiaceae

Schinus terebinthifolia Raddi
"AROEIRA-VERMELHA"

Vegetation: Tropical rain forest, Pampa e Urban area
MBM catalog number: FCGW 085
Pollen catalog number: PALIUFPR 31
Origin: native



Pollen description

Monad, medium, P = 36.78 ± 2.33 (30.30-41.04), E = 32.82 ± 2.64 (28.88-37.82), radial, isopolar, subtriangular amb, prolate spheroidal to subprolate, P/E = 1.12 ± 0.07 (1.01-1.25), tricolporate, colpus short, pore lalongate. Exine reticulate, striate, Exi = 2.91 ± 0.32 (2.21-3.40).

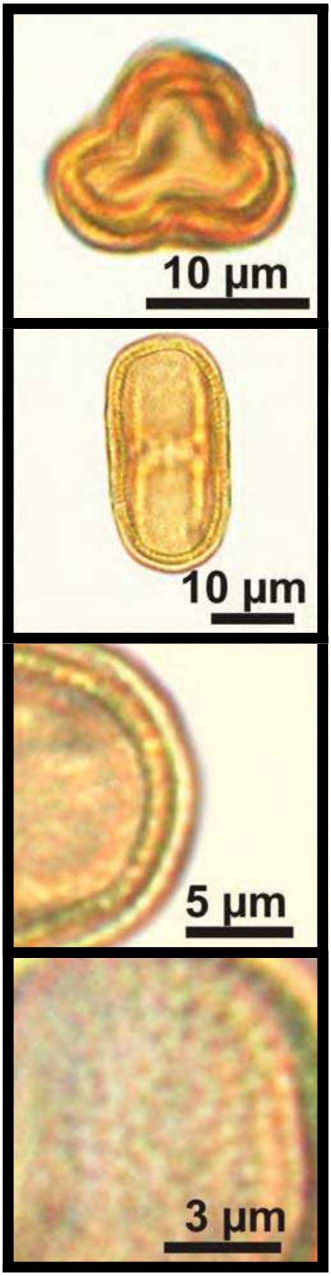
Apiaceae

Foeniculum vulgare Mill.
"FENNEL"

Vegetation: Urban area
TRT catalog number: TRT 122911
Pollen catalog number: PALYTRT 10
Origin: introduced

Pollen description

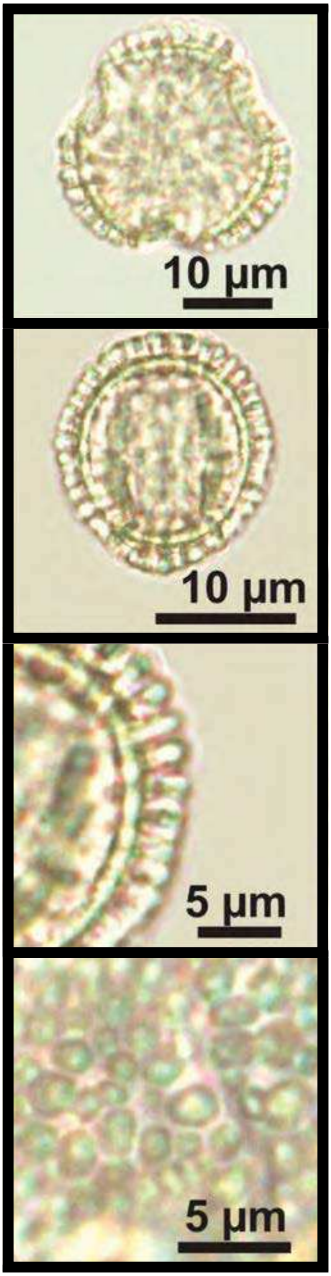
Monad, very small to medium, P = 27.71 ± 1.78 (24.43-31.43), E = 15.42 ± 1.32 (13.59-18.66), radial, isopolar, subtriangular amb, prolate to perprolate, P/E = 1.80 ± 0.13 (1.50-2.02), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.60 ± 0.31 (1.85-3.26).



Aquifoliaceae

Ilex dumosa Reissek
"CAÚNA"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 061
Pollen catalog number: PALIUFPR 3
Origin: native



Pollen description

Monad, small to medium, P = 31.66 ± 2.98 (26.05-37.47), E = 26.94 ± 1.92 (23.10-31.42), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.28 ± 0.08 (0.90-1.29), tricolporate, colpus long, margo, pore lalongate. Exine clavate, Exi = 4.27 ± 0.57 (2.98-5.02).

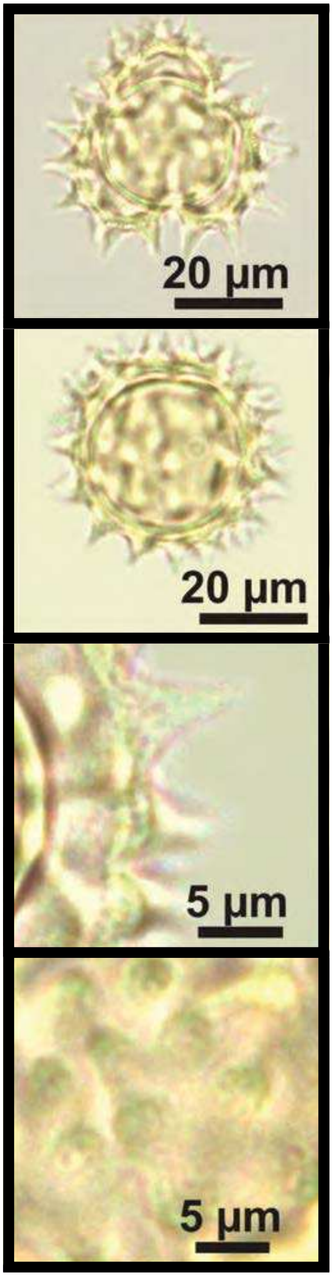
Asteraceae

Baccharis pseudovillosa Malag. & Vidal
"CARQUEJA-DAS-TURFEIRAS"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 078
Pollen catalog number: PALIUFPR 23
Origin: native

Pollen description

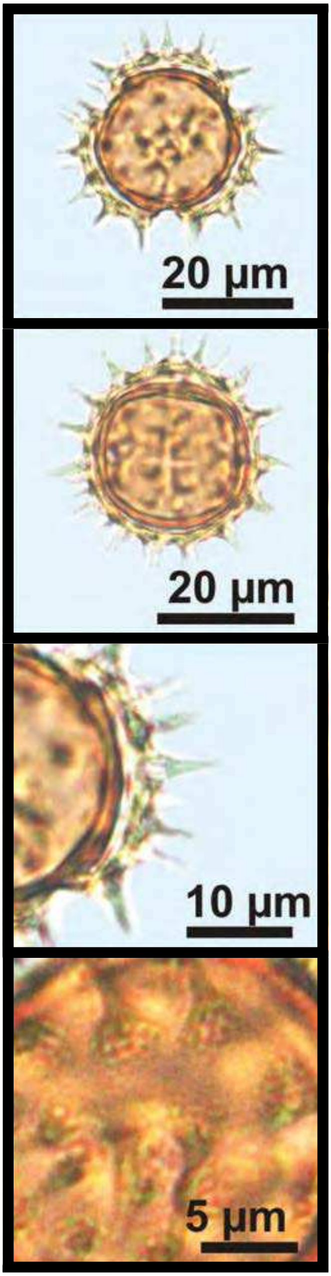
Monad, medium to large, P = 45.98 ± 7.58 (34.95-61.92), E = 46.71 ± 6.55 (37.15-61.92), radial, isopolar, subtriangular amb, suboblate to prolate spheroidal, P/E = 0.98 ± 0.06 (0.82-1.08), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 1.65 ± 0.56 (0.70-2.63).



Asteraceae

Coreopsis lanceolata L.
"LANCE-LEAVED-COREOPSIS"

Vegetation: Crop area
OAC Herbarium catalog number: OAC Herbarium 22943
Pollen catalog number: PALYUOFG 6
Origin: naturalized



Pollen description

Monad, medium, P = 35.51 ± 1.77 (32.23-39.64), E = 35.34 ± 1.98 (30.97-37.86), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.00 ± 0.04 (0.94-1.11), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.27 ± 0.34 (1.60-3.01).

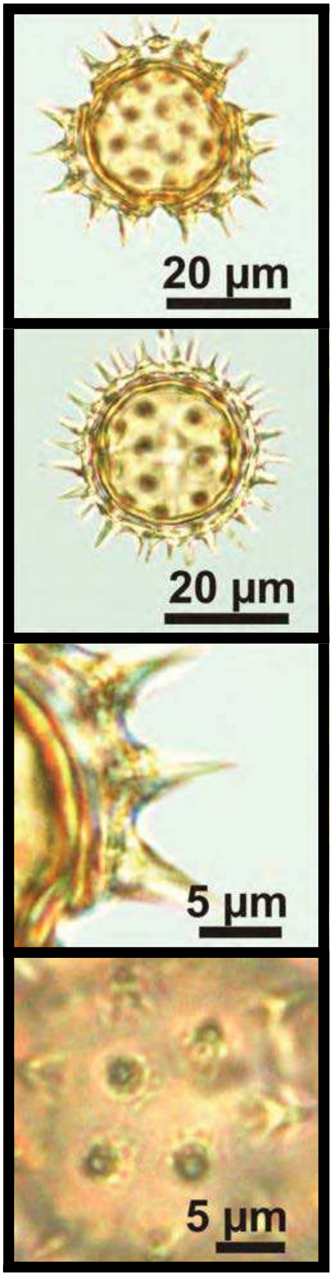
Asteraceae

Cosmos bipinnatus Cav.
“COSMOS”

Vegetation: Crop area
OAC Herbarium catalog number: OAC Herbarium 16305
Pollen catalog number: PALYUOFG 4
Origin: introduced

Pollen description

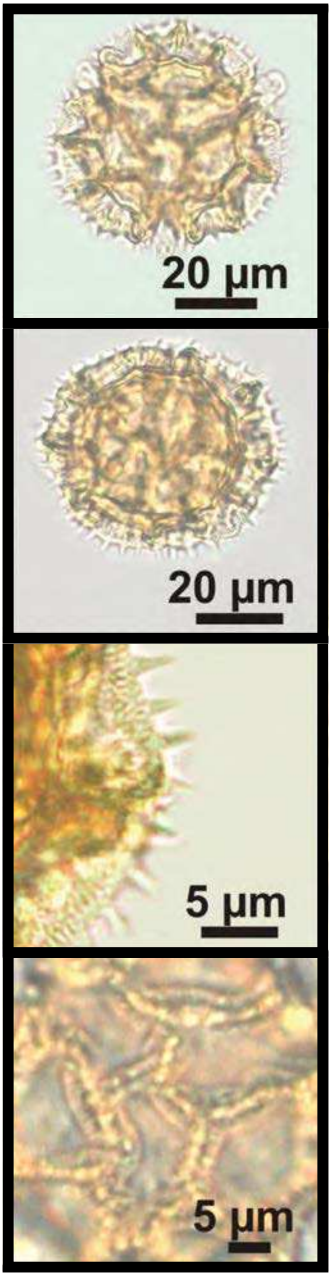
Monad, medium, D = 41.79 ± 2.65 (36.65-47.69), radial, isopolar, subtriangular amb, spheroidal, tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.68 ± 0.51 (2.00-3.74).



Asteraceae

Lessingianthus glabratus (Less.) H.Rob.
"ASSA-PEIXE-ROXO"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 065
Pollen catalog number: PALIUFPR 7
Origin: native



Pollen description

Monad, medium to large, P = 57.07 ± 5.30 (45.22-69.72), E = 59.62 ± 5.05 (48.85-72.11), radial, isopolar, subtriangular amb, suboblate to spheroidal, P/E = 1.80 ± 0.05 (0.87-1.00), triporate, colpus absent, pore circular. Exine echinolophate, Exi = 5.93 ± 1.05 (4.01-7.79).

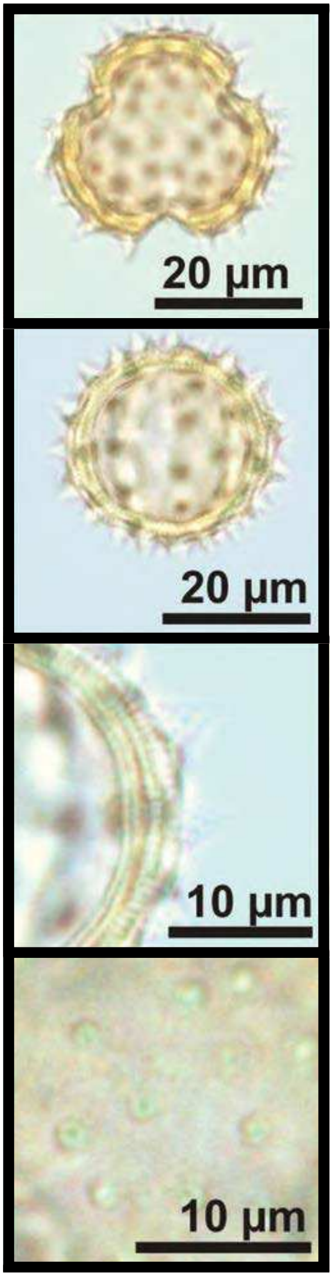
Asteraceae

Pentacalia ledifolia (Kunth) Cuatrec.
“HIERBA UVA”

Vegetation: Sub-paramo
UMNG-H catalog number: UMNG-H 971
Pollen catalog number: PBEAS 1
Origin: native

Pollen description

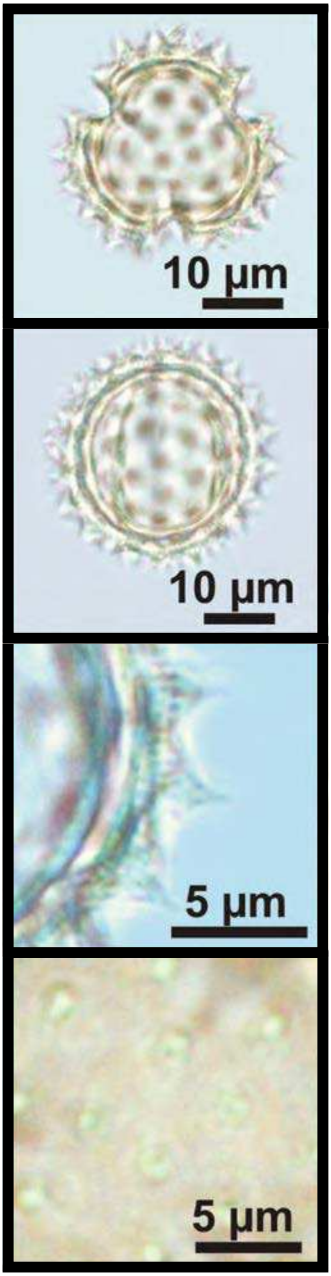
Monad, medium, P = 36.13 ± 2.66 (32.71-42.62), E = 34.46 ± 2.13 (31.51-40.87), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 1.05 ± 0.05 (0.97-1.14), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.80 ± 0.46 (2.06-3.63).



Asteraceae

Senecio madagascariensis Poir.
"SENECIO"

Vegetation: Sub-paramo and intervened area
UMNG-H catalog number: UMNG-H 975
Pollen catalog number: PBEAS 98
Origin: exotic



Pollen description

Monad, medium, P = 34.03 ± 2.18 (30.44-37.84), E = 31.99 ± 1.72 (29.77-35.50), radial, isopolar, subtriangular amb, spheroidal to subprolate, P/E = 1.06 ± 0.04 (1.00-1.16), tricolporate, colpus long, pore lalongate. Exine echinate, Exi = 2.10 ± 0.30 (1.60-2.83).

Boraginaceae

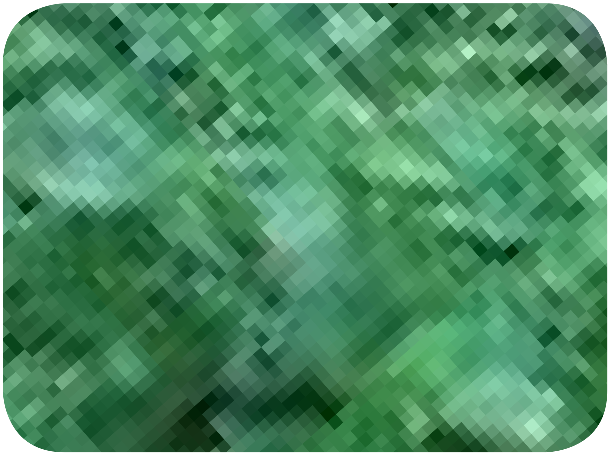
Heliotropium indicum L.

"CRISTA-DE-GALO"

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B094 (UTMC)
Pollen catalog number: CBUMAGPALI 0017
Origin: naturalized

Pollen description

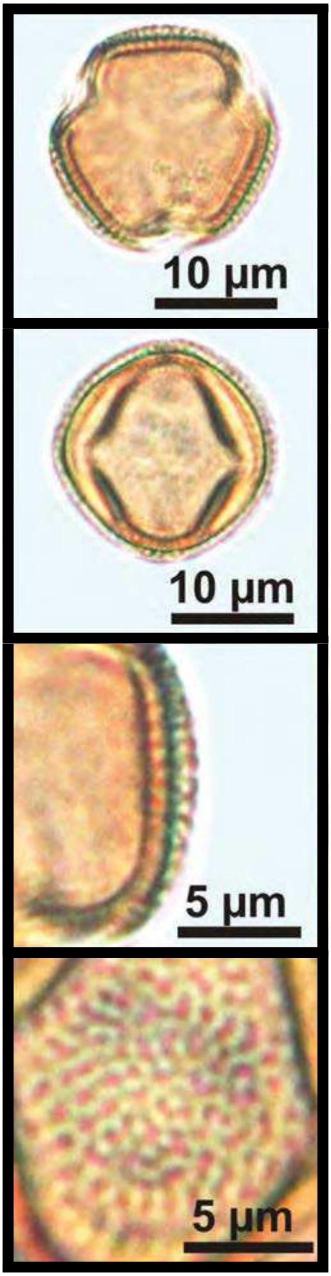
Monad, small to large, P = 51.45 ± 10.49 (35.45-75.25), E = 30.98 ± 4.05 (23.41-38.39), radial, isopolar, subcircular amb, prolate to perprolate, P/E = 1.65 ± 0.17 (1.37-2.11), tricolporate, colpus long, pore lalongate. Exina microreticulate, Exi = 1.44 ± 0.14 (1.16-1.65).



Caprifoliaceae

Sambucus canadensis L.
"CANADA ELDERBERRY"

Vegetation: Crop area
OAC Herbarium catalog number: OAC Herbarium 50522
Pollen catalog number: PALYUOFG 19
Origin: native



Pollen description

Monad, small, P = 19.79 ± 1.14 (17.82-22.11), E = 19.91 ± 0.97 (18.31-21.68), radial, isopolar, subtriangular amb, suboblate to subprolate, P/E = 0.99 ± 0.07 (0.87-1.17), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.15 ± 0.21 (1.80-2.61).

Commelinaceae

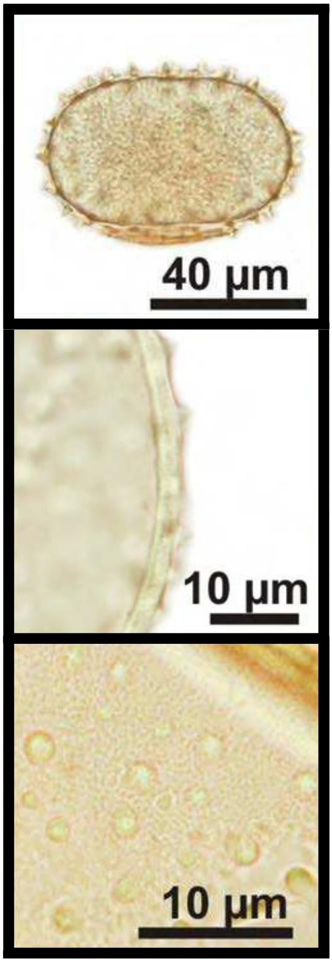
Commelina erecta L.

“ERVA-DE-SANTA-LUZIA, TRAPOERABA”

Vegetation: Urban area
SPFR catalog number: SPFR 14582
Pollen catalog number: PALIULBRA 1383
Origin: native

Pollen description

Monad, medium to large, P = 69.2 ± 5.27 (60.00-81.00), E = 54.84 ± 4.80 (44.00-61.00), bilateral, isopolar, circular amb, prolate spheroidal to prolate, P/E = 1.26 ± 0.10 (1.07-1.53), monosulcate, colpus absent, pore absent. Exine echinate, Exi = 3.2 ± 0.50 (2.00-4.00).



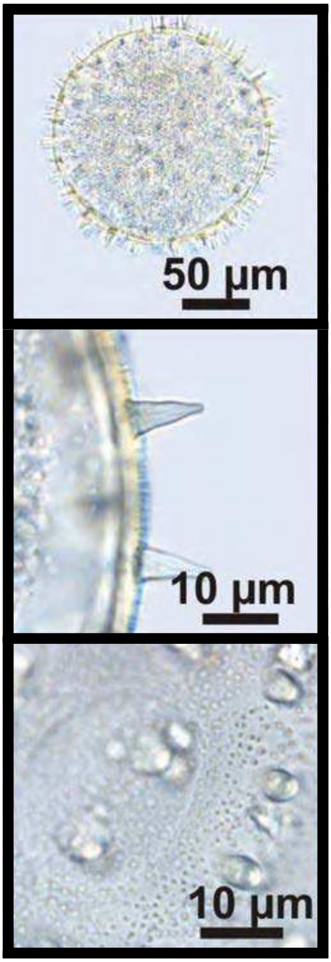
Cucurbitaceae

Cucurbita maxima Duchesne
"ABÓBORA, MORANGA AND JERIMUM"

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda C335 (UTMC)
Pollen catalog number: CBUMAGPALI 0026
Origin: naturalized

Pollen description

Monad, large to very large, D = 164.74 ± 18.85 (92.62-185.97), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 2.52 ± 0.35 (2.01-3.39).



Cucurbitaceae

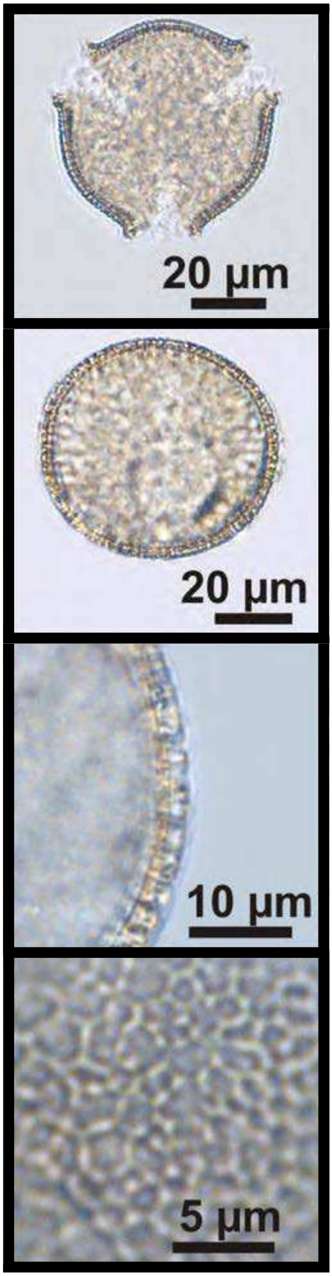
Momordica charantia L.

"MELÃO-DE-SÃO-CAETANO"

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B057 (UTMC)
Pollen catalog number: CBUMAGPALI 0027
Origin: naturalized

Pollen description

Monad, medium to large, P = 51.89 ± 7.50 (38.85-67.43), E = 55.80 ± 5.38 (45.42-64.49), radial, isopolar, subcircular amb, suboblate to prolate spheroidal, P/E = 0.93 ± 0.06 (0.85-1.06), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.64 ± 0.25 (2.20-2.98).



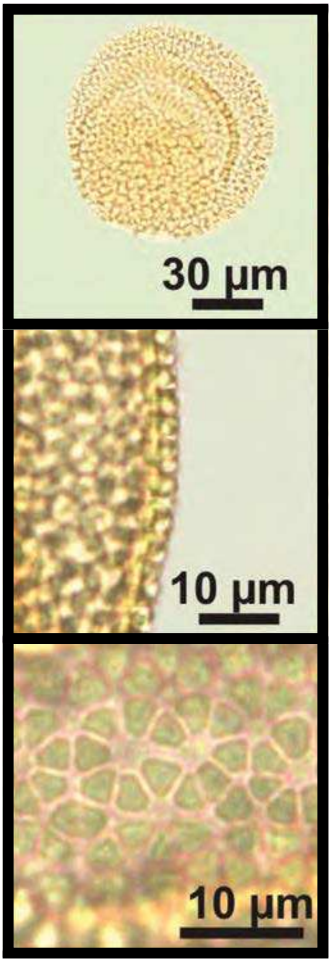
Euphorbiaceae

Croton ceanothifolius Baill.

Vegetation: Tropical rain forest
MBM catalog number: FCGW 088
Pollen catalog number: PALIUFPR 35
Origin: native

Pollen description

Monad, large to very large, D = 88.96 ± 17.99 (61.26-127.92), radial, apolar, circular amb, spheroidal, inaperturate. Exine Croton pattern, Exi = 4.74 ± 0.63 (3.23-6.33).



Euphorbiaceae

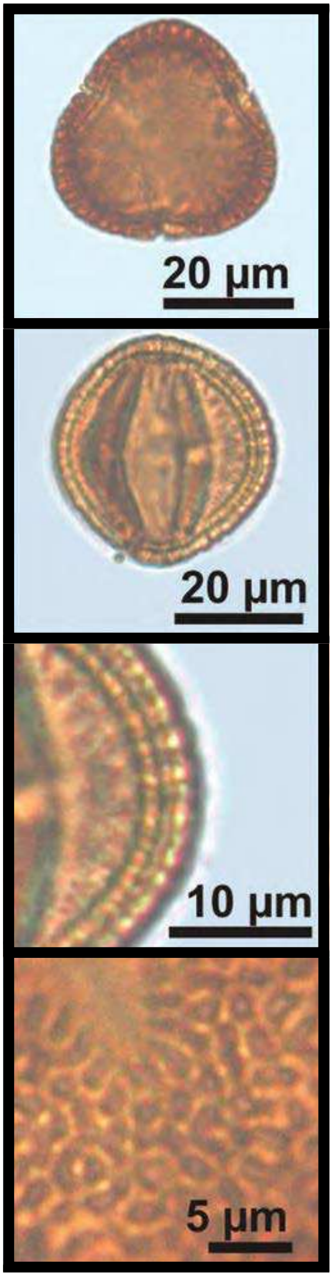
Euphorbia pulcherrima Willd. ex Klotzsch

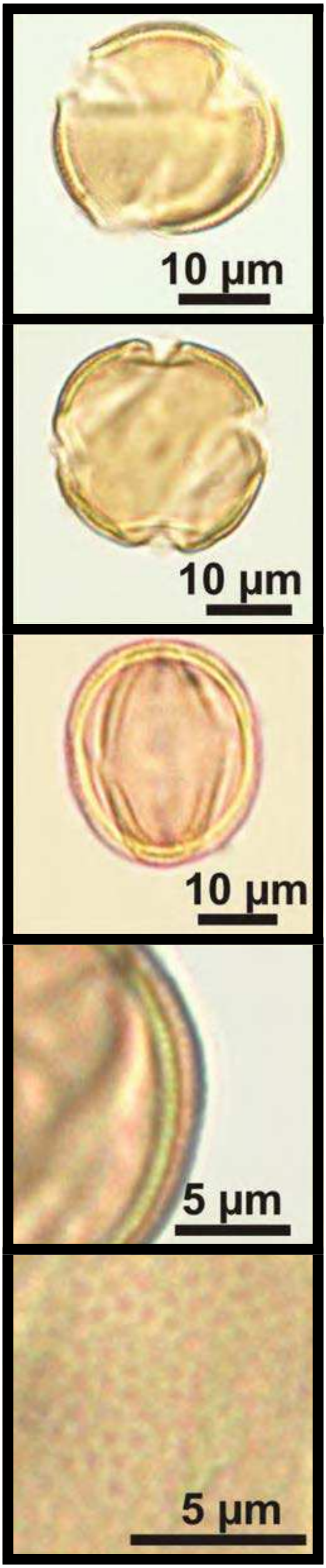
“POINSÉTIA”

Vegetation: Urban area
SPF catalog number: J.A. Pissolato 11
Pollen catalog number: PALIIBUSP 112
Origin: exotic

Pollen description

Monad, medium, P = 37.22 ± 2.65 (27.65-41.48), E = 35.74 ± 2.49 (29.43-39.25), radial, isopolar, subtriangular amb, oblate spheroidal to subprolate, P/E = 1.04 ± 0.05 (0.94-1.22), tricolporate, colpus long, pore lalongate. Exine reticulate, heterobrochate, Exi = 4.04 ± 0.59 (2.67-4.91).





Hypericaceae

Hypericum rigidum A.St.-Hil.

"ORELHA-DE-GATO"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 079
Pollen catalog number: PALIUFPR 25
Origin: native

Pollen description

Monad, small to medium, P = 30.84 ± 3.03 (24.72-39.90), E = 25.33 ± 2.92 (19.30-32.35), radial, isopolar, subtriangular amb, quadrangular, prolate spheroidal to prolate, P/E = 1.22 ± 0.12 (1.08-1.45), tricolporate, tetracolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 2.25 ± 0.35 (1.65-3.20).

Lamiaceae

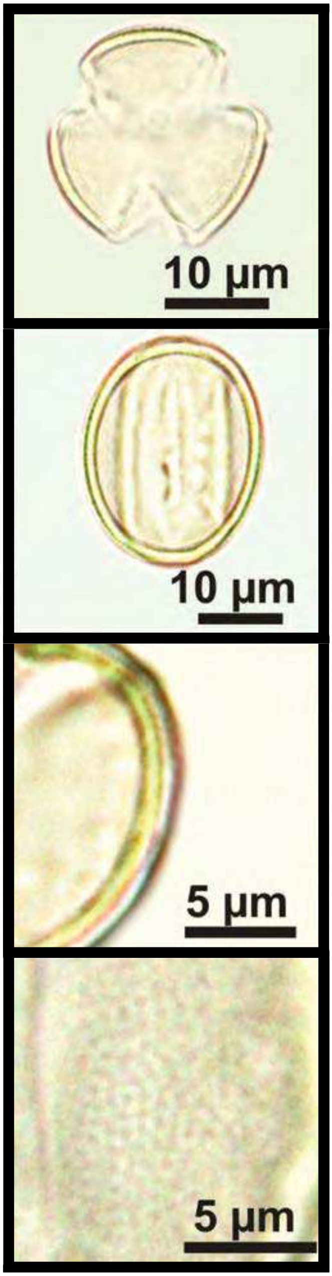
Leonurus cardiaca L.

"MOTHERWORT"

Vegetation: Crop area
OAC Herbarium catalog number: OAC Herbarium fresh specimen
Pollen catalog number: PALYUOFG 64
Origin: introduced

Pollen description

Monad, small to medium, P = 28.32 ± 2.09 (24.26-34.76), E = 21.55 ± 1.24 (18.27-22.94), radial, isopolar, subtriangular amb, subprolate to prolate, P/E = 1.31 ± 0.10 (1.16-1.52), tricolpate, colpus long, pore absent. Exine microreticulate, Exi = 1.74 ± 0.33 (1.20-2.67).

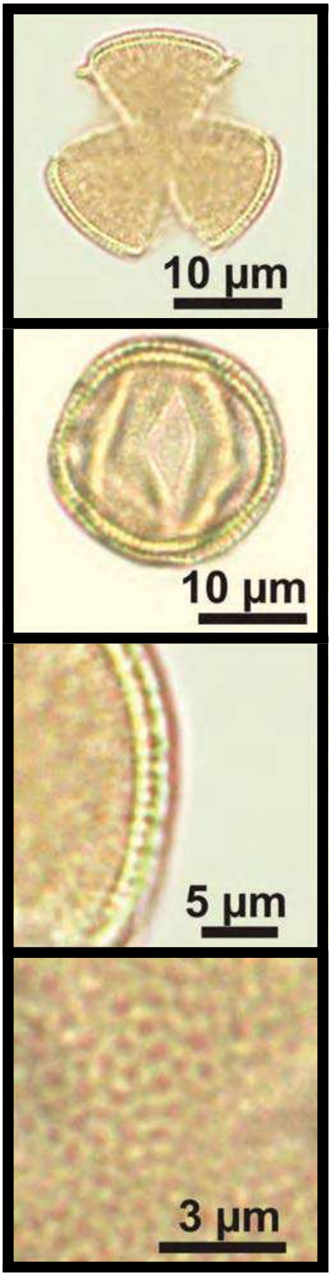


Lamiaceae

Vitex megapotamica (Spreng.) Moldenke

“TARUMÃ”

Vegetation: Tropical rain forest
MBM catalog number: FCGW 092
Pollen catalog number: PALIUFPR 40
Origin: native



Pollen description

Monad, small to medium, P = 29.25 ± 4.89 (22.81-38.44), E = 22.46 ± 2.45 (17.48-26.50), radial, isopolar, subtriangular amb, prolate spheroidal to prolate, P/E = 0.79 ± 1.30 (1.10-1.70), tricolpate, colpus long, pore absent. Exine microreticulate, Exi = 2.94 ± 0.51 (2.24-4.01).

Lythraceae

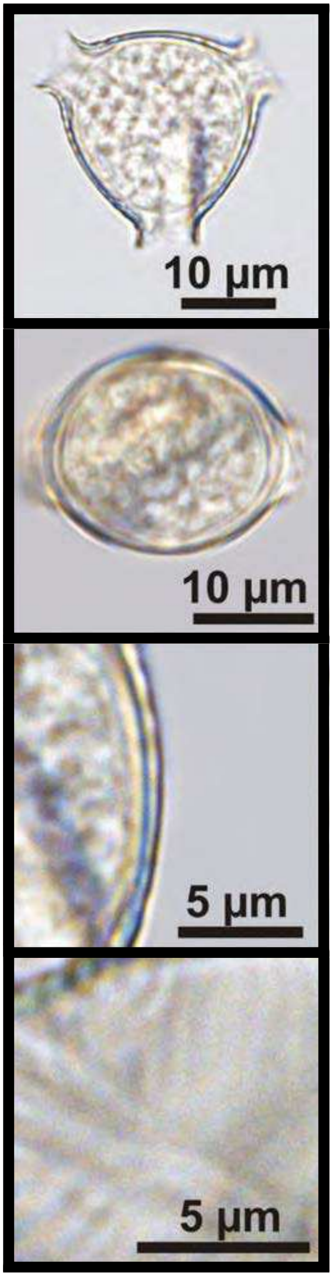
Cuphea carthagenensis (Jacq.) J.F.Macbr.

"SETE-SANGRIAS"

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B062 (UTMC)
Pollen catalog number: CBUMAGPALI 0039
Origin: S.I

Pollen description

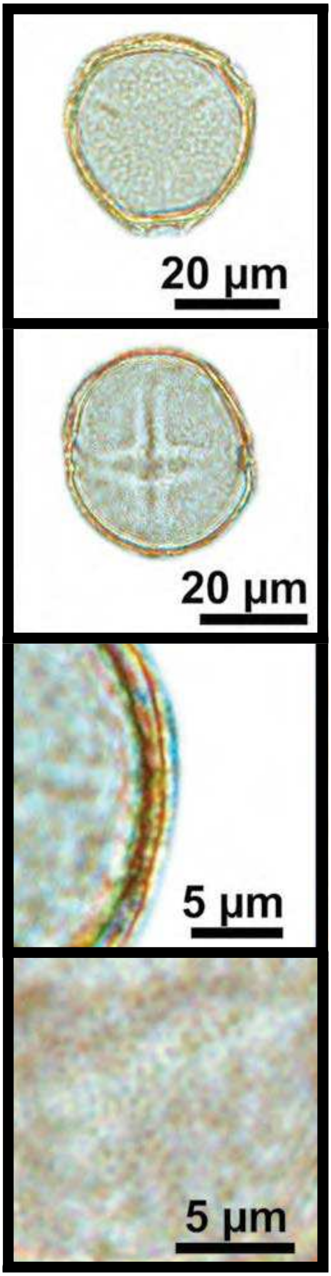
Monad, small, P = 17.20 ± 1.12 (14.69-19.64), E = 20.70 ± 0.93 (18.14-22.45), radial, isopolar, subtriangular amb, suboblate to oblate spheroidal, P/E = 0.83 ± 0.03 (0.75-0.90), tricolporate, colpus long, pore lalongate. Exine striate, Exi = 1.07 ± 0.14 (0.89-1.49).



Malvaceae

Luehea divaricata Mart.
"AÇOITA-CAVALO"

Vegetation: Pampa
SPFR catalog number: SPFR 13675
Pollen catalog number: PALIULBRA 1404
Origin: native



Pollen description

Monad, medium, P = 40.40 ± 1.50 (37.00-43.00), E = 36.64 ± 1.58 (34.00-40.00), radial, isopolar, subcircular amb, prolate spheroidal to prolate, P/E = 1.10 ± 0.05 (1.03-1.21), tricolporate, colpus medium, costa, pore lalongate. Exine reticulate, heterobrochate, Exi = 2.04 ± 0.20 (2.00-3.00).

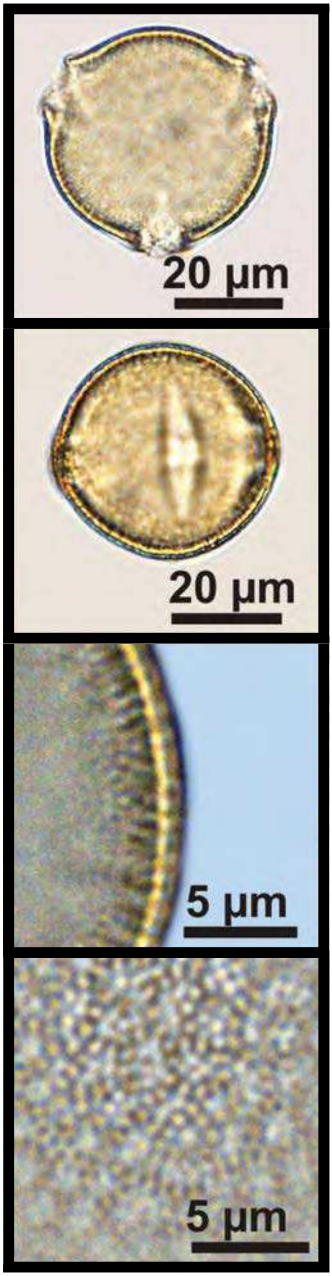
Malvaceae

Melochia parvifolia Kunth

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda C015 (UTMC)
Pollen catalog number: CBUMAGPALI 0044
Origin: native

Pollen description

Monad, medium, P = 40.07 ± 1.91 (36.80-45.03), E = 41.03 ± 2.64 (37.89-48.59), radial, isopolar, subtriangular amb, oblate spheroidal to prolate spheroidal, P/E = 0.98 ± 0.05 (0.89-1.09), tricolporate, colpus long, pore lalongate. Exine microreticulate, Exi = 1.84 ± 0.16 (1.53-2.17).



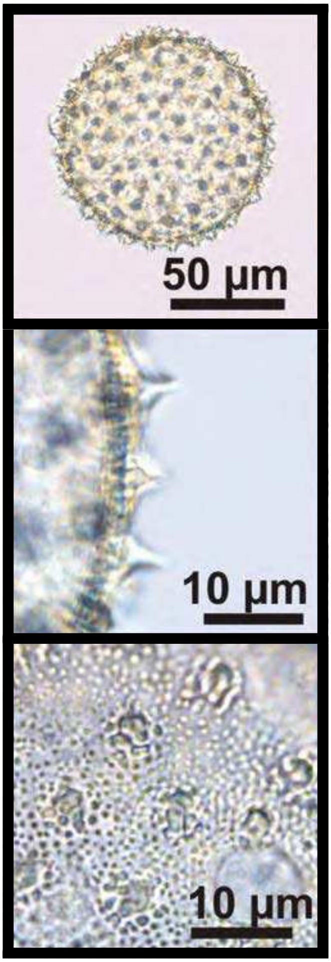
Malvaceae

Sida rhombifolia L.
"GUANXUMA AND VASSOURINHA"

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B463 (UTMC)
Pollen catalog number: CBUMAGPALI 0049
Origin: native

Pollen description

Monad, large to very large, D = 81.55 ± 19.23 (51.29-108.14), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 2.67 ± 0.48 (1.86-3.68).



Myrtaceae

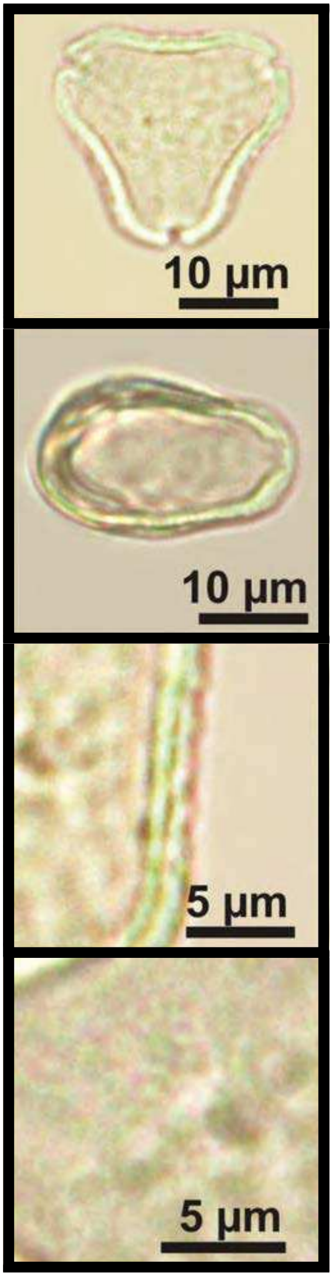
Myrceugenia euosma (O.Berg.) D.Legrand

"GUAMIRIM"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 060
Pollen catalog number: PALIUFPR 2
Origin: native

Pollen description

Monad, small to medium, P = 12.17 ± 1.29 (10.01-15.14), E = 24.16 ± 1.84 (21.30-29.40), radial, isopolar, triangular amb, peroblate to oblate, P/E = 0.50 ± 0.06 (0.41-0.66), tricolporate, colpus long, parasyncolporate, pore circular, fastigium. Exine microreticulate, Exi = 2.38 ± 0.32 (1.65-2.89).

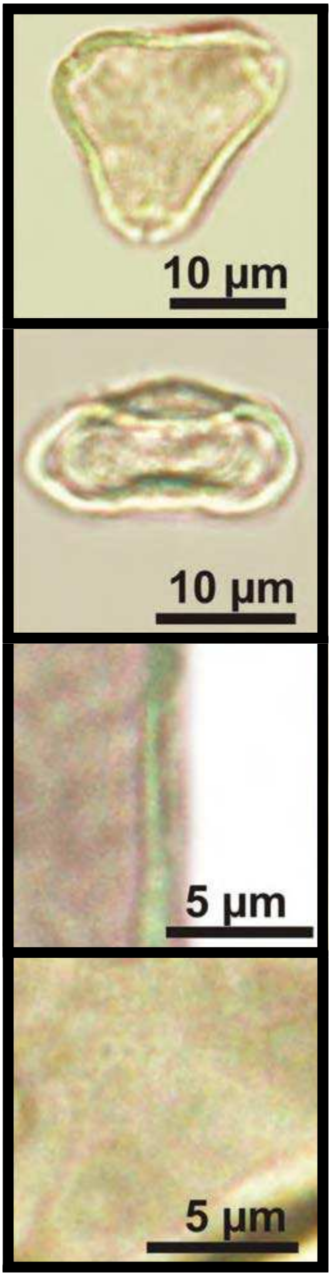


Myrtaceae

Myrcia selloi (Spreng.) N.Silveira

"CAMBUÍ"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 062
Pollen catalog number: PALIUFPR 4
Origin: native



Pollen description

Monad, very small to small, P = 10.69 ± 1.27 (8.80-12.69), E = 20.79 ± 1.26 (18.22-24.00), radial, isopolar, triangular amb, peroblate to oblate, P/E = 1.28 ± 0.51 (0.40-0.64), tricolporate, colpus long, pore circular. Exine microreticulate, Exi = 1.83 ± 0.33 (1.40-2.79).

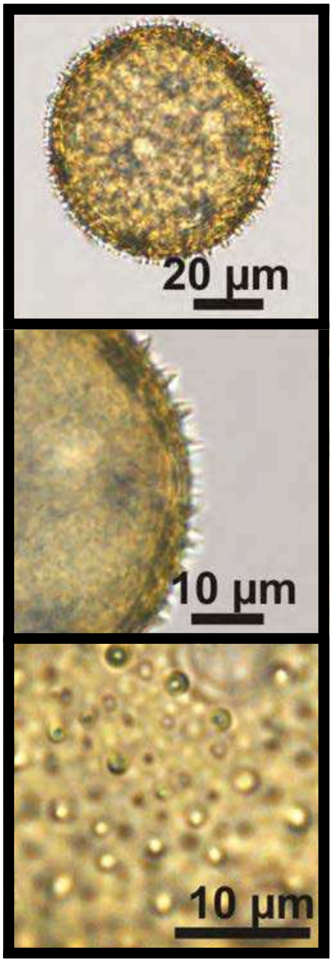
Nyctaginaceae

Boerhavia erecta L.

Vegetation: Crop area
UTMC catalog number: K. miranda & G. Tejeda B126 (UTMC)
Pollen catalog number: CBUMAGPALI 0054
Origin: native

Pollen description

Monad, medium to large, D = 54.51 ± 9.94 (34.28-68.58), radial, apolar, circular amb, spheroidal, pantoporate, pore circular. Exine echinate, Exi = 3.67 ± 0.52 (2.88-4.94).



Onagraceae

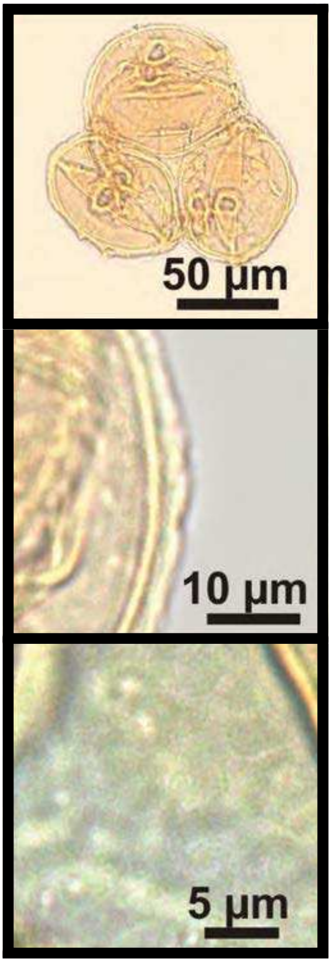
Ludwigia sericea (Cambess.) H.Hara

"CRUZ-DE-MALTA"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 084
Pollen catalog number: PALIUFPR 30
Origin: native

Pollen description

Tetrad, very large, D = 123.83 ± 6.41 (106.93-134.02), subtriangular amb in front view, spheroidal, triporate, pore circular. Exine areolate, Exi = 4.94 ± 0.94 (3.40-7.11).



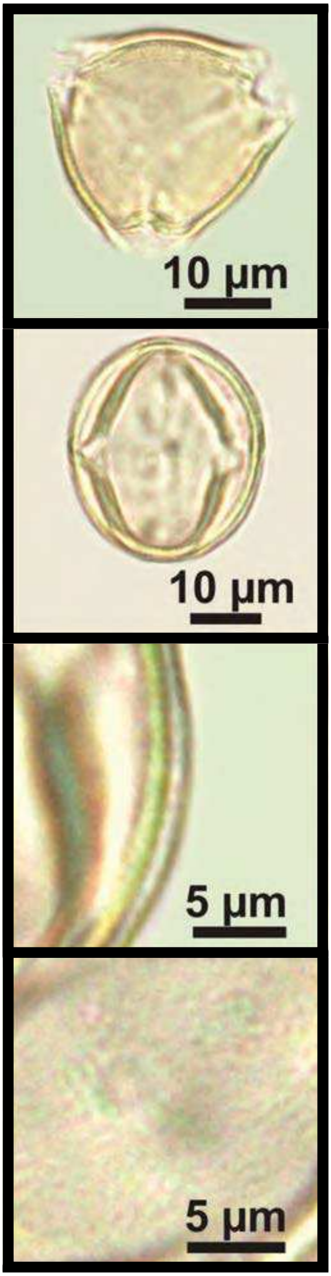
Rosaceae

Prunus myrtifolia (L.) Urb.
"PESSEGUEIRO-DO-MATO, PESSEGUEIRO-BRAVO"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 087
Pollen catalog number: PALIUFPR 34
Origin: native

Pollen description

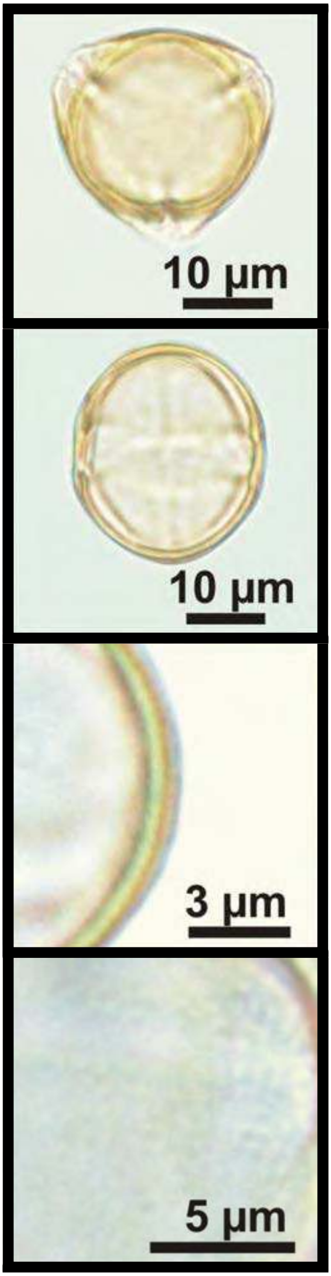
Monad, small to medium, P = 32.67 ± 3.48 (23.73-38.99), E = 28.45 ± 3.30 (22.05-38.04), radial, isopolar, subtriangular amb, circular, oblate spheroidal to prolate, P/E = 1.15 ± 0.10 (0.96-1.39), tricolporate, colpus long, pore lalongate. Exine striate, Exi = 2.37 ± 0.36 (1.61-3.00).



Solanaceae

Solanum quitoense Lam.
"LULO"

Vegetation: Intervened area
UMNG-H catalog number: UMNG-H 115
Pollen catalog number: PBEAS 109
Origin: native, cultivated



Pollen description

Monad, small to medium, P = 28.61 ± 1.89 (25.58-32.84), E = 25.44 ± 1.36 (22.95-28.21), radial, isopolar, triangular amb, prolate spheroidal to subprolate, P/E = 1.12 ± 0.05 (1.03-1.20), tricolporate, colpus long, pore lalongate, fastigium. Exine microreticulate, Exi = 1.34 ± 0.22 (1.00-1.80).

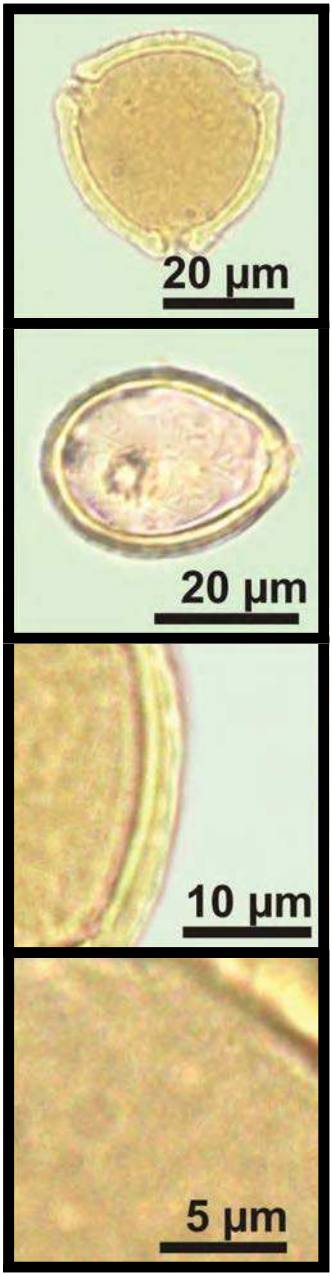
Symplocaceae

Symplocos glandulosomarginata Hoehne
"FALSA CANETA"

Vegetation: Tropical rain forest
MBM catalog number: FCGW 086
Pollen catalog number: PALIUFPR 32
Origin: native

Pollen description

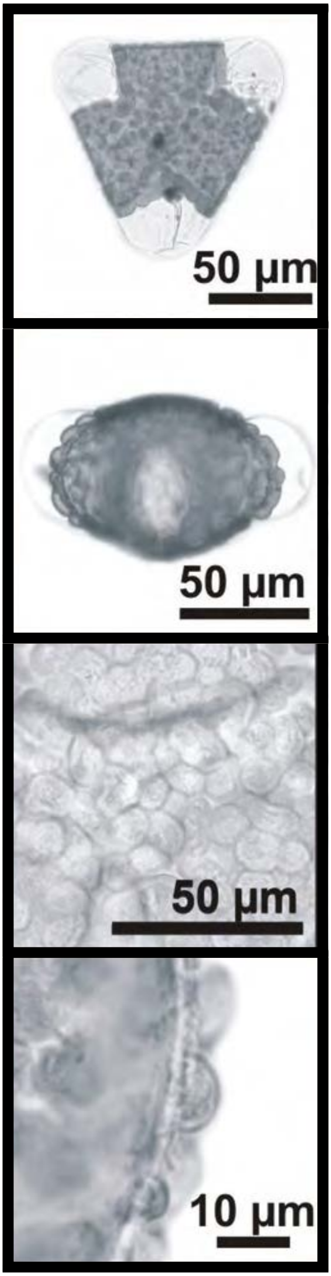
Monad, small to medium, P = 28.43 ± 3.49 (21.20-37.31), E = 35.05 ± 4.68 (23.60-43.32), radial, isopolar, subtriangular amb, quadrangular, oblate to oblate spheroidal, P/E = 0.81 ± 0.05 (0.71-0.90), tricolporate and tetracolporate, colpus short, pore circular, annulus. Exine microreticulate, Exi = 3.63 ± 0.74 (2.00-4.87).



Verbenaceae

Stachytarpheta cayennensis (Rich.) Vahl
"GERVÃO"

Vegetation: Amazon forest
SPFR catalog number: SPFR 14682
Pollen catalog number: PALIULBRA 1423
Origin: native



Pollen description

Monad, large to very large, P = 80.24 ± 3.91 (74.27-88.95), E = 111.35 ± 4.21 (104.37-119.05), radial, isopolar, subtriangular amb, oblate to suboblate, P/E = 0.72 ± 0.04 (0.66-0.80), tricolpate, colpus long. Exine verrucate, Exi = 3.40 ± 0.57 (2.00-4.00).

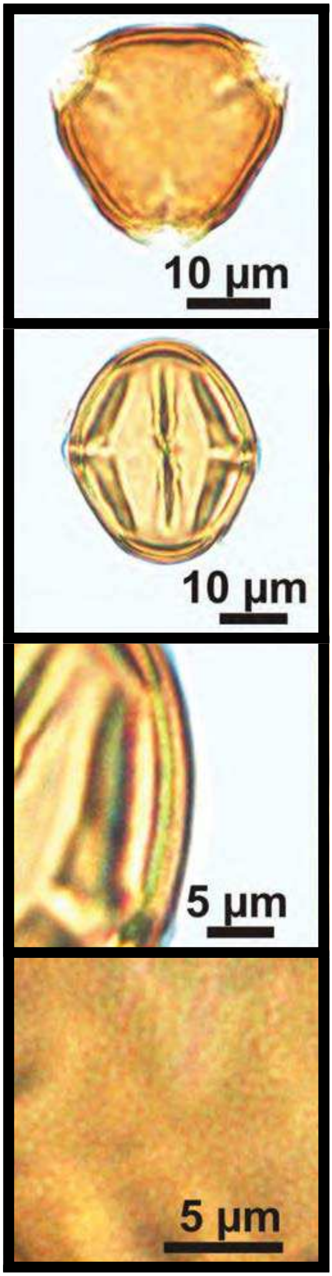
Verbenaceae

Verbena hastata L.
"BLUE VERVAIN"

Vegetation: Crop area
OAC Herbarium catalog number: OAC Herbarium 18910, OAC Herbarium 63275
Pollen catalog number: PALYUOFG 103
Origin: native

Pollen description

Monad, small to medium, P = 29.31 ± 2.43 (23.64-34.32), E = 28.26 ± 1.90 (23.24-32.15), radial, isopolar, triangular amb, oblate spheroidal to prolate, P/E = 1.04 ± 0.06 (0.91-1.34), tricolporate, colpus long, margo, pore lalongate. Exine microreticulate, Exi = 2.54 ± 0.32 (2.01-3.60).



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Hugo A. Sanchez-Marroquín: Biodiversity and Ecology of Wild Bees, Faculty of Applied Sciences, Nueva Granada University, Cajicá, Colombia. Hugo is a biologist who truly believes in the strength and interaction of the ecosystems. This idea was born due to studies about plant-pollinator and crops-society, from high Andean forests to dry forest ecosystems. Contribution: material collection, organization of the plant and pollen collections and photographs of pollen grains.

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The book "Atlas of pollen and plants used by bees" was prepared with great care with the data of researchers from Argentina, Brazil, Canada, and Colombia, who are collaborators of RCPol - Online Pollen Catalogs Network. RCPol was conducted during the development of the project entitled "Study of bee flora and pollen grains for the insertion of data in the Online Pollen Catalogs Network: subsidy for bee management and conservation", coordinated by researchers PhD. Cláudia Inês da Silva and PhD. Antônio Mauro Saraiva. On the RCPol website, data on more than 2,560 specimens of plants distributed in different plant formations are found, and in this book, information about 43 families, 101 genera, and 126 species from nine collections are presented. The organizers and authors of this book thank Bayer for the financial support for the publication of this work, and the Foundation for the Technological Development of Engineering (FDTE - 001505) for the logistical support. We would also like to thank the Asociación Latinoamericana de Paleobotánica y Palinología for sealing the book, the Department of Ecology at IBUSP (2015-2019), the Center for the Study of Social Insects at UNESP - Rio Claro campus (2019) and the Department of Environmental Sciences at Science and Technology Center for Sustainability at UFSCar - Sorocaba campus (2019-2020) for receiving the project during its development. We thank all the Institutions involved in the acquisition, processing and analysis of the data presented in this Atlas.

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