Ciência e Natura
ISSN: 0100-8307
cienciaenaturarevista@gmail.com
Universidade Federal de Santa Maria
Brasil

Miranda Leão, Victor; Araujo Lucas, Flavia Cristina; Cajueiro Gurgel, Ely Simone
Herbaria as patrimony: the contribution of the MFS collection in the conservation of Amazonian biodiversity
Ciência e Natura, vol. 39, núm. 3, septiembre-diciembre, 2017, pp. 467-483
Universidade Federal de Santa Maria
Santa Maria, Brasil

Artigo Original

DOI:10.5902/2179460X27080

Ciência e Natura, Santa Maria v.39 n.3, 2017, Set - Dez, p. 467 – 483
Revista do Centro de Ciências Naturais e Exatas - UFSM
ISSN impressa: 0100-8307 ISSN on-line: 2179-460X

CIÊNCIA e NATURA

Herbaria as patrimony:

the contribution of the MFS collection in the conservation of Amazonian biodiversity

Victor Miranda Leão[1], Flavia Cristina Araujo Lucas[2] e Ely Simone Cajueiro Gurgel[3]

[1,2] Universidade do Estado do Pará
victor_mirandaleao@yahoo.com.br; copaldoc@yahoo.com.br

[3]Museu Paraense Emilio Goeldi
esgurgel@museu-goeldi.br

Abstract

Herbaria and living collections play an indispensable role in species conservation strategies. The objective of this work is to discuss the formation of the MFS - Marlene Freitas da Silva herbarium, at the Universidade do Estado do Pará, with the goals of helping new Brazilian herbaria and motivating educational institutions, professors and students. The process involved in creating a botanical collection is described (e.g., establishing partnerships, training technicians, curating collections, processing field data, taking images, and making data available online). Presently, MFS has 6083 dried collections, including angiosperms (5111 spp.), bryophytes (863 spp.), lycophytes and ferns (18 spp.), and fungi (91 spp.). In addition, there are associated collections of seedlings (15 spp.), flowers (47 spp.), fruits and seeds (187 spp.), and an ethnobotanical collection (56). The increasing growth of the MSF collection is a result of many interdisciplinary studies in botany that are invested in the social and environmental value of biodiversity. MFS is an important academic space and reference for researchers and students because it allows botanical material to be identified, and is a resource of historical, sociocultural and economic information about plants of a distinct and unique region of the world.

Keywords: *Exsiccatae · Taxonomy · Database · Extension*

Recebido: 09/05/2017 Aceito: 14/08/2017

1 Introduction

In the mid-twentieth century, the environment became an agenda of international conferences, primarily because of biological and ecological studies that suggested alarming rates of loss of biodiversity (Fonseca–Kruel and Pereira 2009). Subsequently, the Convention on Biological Diversity acknowledged this biodiversity loss as a key element of the environmental crisis, which was directly related to ecosystem loss and the effect of climate change, and resulted in introducing concepts of sustainable use and development (Vieira et al. 2014).

In addition to the highest diversity of plants in the world, Brazil has high sociobiodiversity that has been the target of international greed (Stefanello and Dantas 2014; Fioravante 2015). Natural Amazonian areas consisting of native matrices formed by immense rivers, in the largest hydrographic basin on Earth, have resulted in high rates of endemism and the largest body of rain forest on the planet (Albagli 2001; Imazon 2011).

Despite impressive biodiversity numbers, data published by the Sistema de Desmatamento da Amazônia/SAD – Imazon (2016) show that large areas of Amazonia are threatened (mainly public land that is being used legally and illegally, and privately owned land). This can be explained by the accelerated growth of the agricultural sector and illegal logging that is mostly concentrated in the states of Mato Grosso and Pará; the latter is responsible for 28% of the deforested area (330 km²). Between August 2015 and November 2015, the area deforested in Pará was the second largest in Amazonia (Imazon 2016).

Presently in Amazonia, more specifically Pará, herbaria and living collections play an important role, and have been classified by Záchia (2014) as indispensable for conducting inventories and proposing and implementing species conservation strategies. This author interprets the role of inventories as the effort to collect specimens from their natural environments and make them available to humanity as a gesture of solidarity, which shows the value of biodiversity as a historical patrimony and an instrument of social transformation. According to Bridson and Forman (1998), herbaria are libraries of local biodiversity that function as research laboratories of systematics, floristics, taxonomy, phylogeny, palynology, phenology, ethnobotany and related fields (e.g., medicine, phytochemistry, pharmacology, ecology, anthropology, biogeography and pedagogy). The actions developed by herbaria are not only indispensable for preservation, but also contribute to the development of management plans and recovery of degraded areas because the collections contain important ecosystem and phytogeographic data about environments (Lima et al. 2009).

The protection of species in threatened areas is lacking in the North Region of Brazil, and there is a need for specialists that can, for example, collect and identify specimens. Based on data from HI (*Index Herbariorum*) and Specieslink, Vieira (2015) reported worrisome data about the collection index for the country and that the North Region has less than 0.3 records per Km²

To start a scientific collection and join the effort to catalog data, and consequently conserve the Amazonian flora, in 2011 the Marlene Freitas da Silva herbarium (MFS) at the Universidade do Estado do Pará (UEPA) was established. This was the result of the "Coleção de frutos, sementes e plântulas amazônicas: conhecimento e conservação do patrimônio genético natural" project approved in 2009 (notice Nº. 56/2008) by the Fundação de Amparo à Pesquisa do Estado do Pará (FAPESPA). MFS contains collections of various plant groups and acts as an important, interdisciplinary, academic consultation and reference space for researchers and students, allowing botanical material to be identified and contributing historical, sociocultural and economic information about the field of botany of a specific region.

This space was constructed based on the discussion of collections as scientific instruments, and has the mission of conservation, research, communication, information management, training students and, especially, to bring science closer to society. Therefore, the objective of this work is to discuss how the MFS was created, at the Universidade do Estado do Pará, with the goals of helping new Brazilian herbaria and motivating educational institutions, professors and students.

2 Material and Methods

Initial activities: partnerships and training

The approval of a research project in 2009, which had the objective of establishing an archive of fruits, seeds and seedlings, was the first step in the formation of a didactic collection at the university. The initial collection, which had approximately 200 samples, was then expanded by acquiring new botanical specimens. In addition, partnerships were formed with other herbaria that resulted in the acquisition of duplicates and support for fieldwork.

The expansion of the collection required a new physical space and better prepared students that were trained in basic collection, organization and database procedures needed to process the material. For this, Embrapa Amazônia Oriental and the Museu Paraense Emílio Goeldi (Belém, Pará) were contacted, and through interagency partnerships space and human resources were provided to conduct short courses and workshops that included the following: plant morphology, plant taxonomy, collecting techniques and management of botanical material, field equipment, processing collected material (pressing, drying and archiving), treatment of specimens (including fumigation) and identification and organizing field expeditions. In

addition, training related to collection management was conducted at the Jardim Botânico do Rio de Janeiro (JBRJ) and The New York Botanical Garden (NYBG).

With the consolidation of the space and an identity, it was possible to become officially recognized by the Rede de Herbários do Brasil (http://www.botanica.org.br/rbh) that allowed for meetings with representatives and curators of other collections to share experiences and discuss problems and solutions, as well as to exchange botanical material with herbaria throughout the country.

The herbarium code and homage

The MFS herbarium initials are in homage to Dr. Marlene Freitas da Silva (1937–2005). Dr. Marlene was born in the city of Manaus, on 12 August 1937, was considered one of the most important researchers at the Instituto Nacional de Pesquisas da Amazônia – INPA, and was an internationally renowned taxonomist. In addition to becoming a specialist in Amazonian Leguminosae, she studied Bignoniaceae, Cariocaraceae, Clusiaceae, Elaeocarpaceae, Euphorbiaceae, Podostemaceae, Rutaceae, Sapindaceae, Sapotaceae, Malvaceae and Styracaceae.

She was a curator at INPA (the Instituto Nacional de Pesquisas da Amazônia herbarium) between 1975 and 1992, and significantly contributed to many areas, such as systematics, biogeography, palynology, agronomy, morphology and phytosociology. In the nearly 50 years of life dedicated to botany she taught students, including undergraduate, master's, and doctorate courses. Dr. Marlene accomplished something few Brazilians have done by publishing in Flora Neotropica, in addition to being honored and immortalized by botanists that named new species after her, such as *Coupeia marlenei* Prance, *Heteropterys marleneae* W. R. Anderson, *Talisia mollis* Kunth **var**. marleneana G. Guarim Neto, *Connarus marleneae* Forero, *Cynometra marleneae* A. S. Tavares, *Licania marleneae* Prance and *Virola marleneae* W. A. Rodrigues. As a result of her studies in Amazonia, 25 new taxonomic arrangements have been proposed for science, which shows she was dedicated to the society in a region that was under heavy anthropogenic pressure (Souza 2005; Martins da Silva et al. 2007).

Treatment of botanical collections: methods and procedures

The collection and post-collection procedures are based on the guide *Coleta e identificação de espécimes botânicos* (Martins da Silva et al. 2014), published by Embrapa Amazônia Oriental, in Belém, Pará. After identifying and mounting the exsiccatae, the scientific names are checked, using the Lista de Espécies da Flora do Brasil (http://reflora.jbrj.gov.br, 2016) and Tropicos (http://www.tropicos.org, 2016), which are based on the Angiosperm Phylogeny Group IV classification (http://www.mobot.org/MOBOT/research/APweb/, 2016).

Management of field data: use of computer tools and applications

In the past, after returning from a collecting expedition, the data obtained (e.g., description of location with coordinates, habitat, collector name and number, morphological description of collection, common name if one exists, and identification of the species) was added to an Excel sheet. Recently, the data has been transferred to a collection management system. MFS uses the software *Botanical Research and Herbarium Management System* – BRAHMS (Figure 1 - A). BRAHMS integrates data and images of specimens, botanical studies, field observations, live collections, seed banks and literature (Figure 1 – B). It is available to download (http://herbaria.plants.ox.ac.uk/bol/) for free and can be used after registering on the BRAHMS website. The software has diverse tools to visualize, edit, select, consult, produce reports and maps, export and publish data. It also allows you to classify, filter, calculate, tabulate and analyze data in different ways, which makes it a functional database available to everyone.

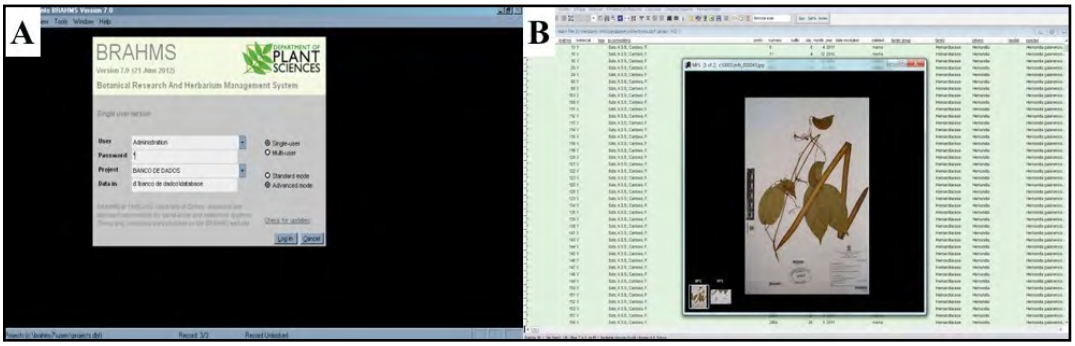

Figure 1 - A –BRAHMS Software. B – MFS database

To start using BRAHMS, data and images are added using Rapid Data Entry (RDE). The entire system can be configured based on the preferences of the user, allowing data to be added, edited, tabulated or published, and maps to be produced, when necessary. After adding data and/or images using RDE the records can be imported into the database, which has nearly all of the tools present in the RDE but is more secure and permits data to be edited directly without using the library (Brahms 2010). Data management using a computer system is noted by Jotta and Barbosa (2015) as a discipline that locates, organizes, treats and disseminates information that is accurate and is needed by an organization or institution.

Mounting and photographing exsiccatae

The exsiccatae are mounted according to the INCT (2013) herbarium manual. The dried specimens are glued or sewn to thick paper that includes an envelope for pieces of the specimen that fall off. After this, a label is added and the specimen is stamped to show the ownership by UEFP and to indicate it has been digitized in BRAHMS (Figure 2 - A). To avoid constant handling and to maintain the integrity of the material, the specimens are photographed after the steps above are complete. With a semiprofessional camera (Figure 2 – B), two images are taken, one of the specimen, with a ruler positioned laterally, and another of the label with the collection information. The images are added to the BRAHMS database and linked to the record.

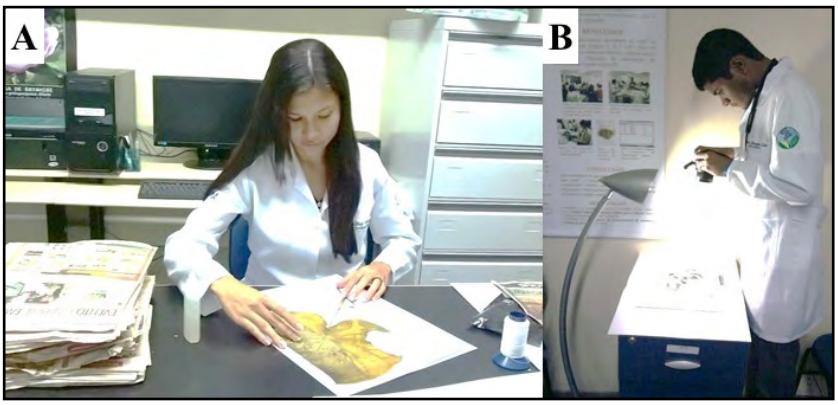

Figure 2 - A – Mounting exsiccatae; B – Photographing a specimen

Preservation and storage

Due to the high temperatures and humidity in Amazonia, some preventative measures are taken against fungi and other biological agents to protect the samples. According to Guerra et al. (2012), the proliferation of biological agents, such as mold, disturb the preservation of organic material. For this reason, the collection is maintained in a room at 17ºC and approximately 30% humidity, which is controlled with a central air conditioner/dehumidifier.

To control insects, 712mg pharmaceutical camphor (Anvisa 2010) and cloves (Andrade et al. 2013) are used. In addition, every two years the herbarium is chemically fumigated with GASTOXIN B57, a strong insecticide with an aluminum phosphide (570g/Kg) base (Adapar 2014). The specimens are stored in sealed, steel cabinets (exsiccatae, fruits and fungi) and steel drawers (bryophytes), and arranged alphabetically by family, genus and species.

The collections: exsiccatae and associated and thematic collections

According to the Rede Brasileira de Herbários and GIBIF, of the 30 herbaria active in the Amazonian region, 21 are listed in *Index Herbariorum*, nine have type collections and only six have at least one type of associated collection (Table 1). Thus, MFS decided from the beginning to have a diverse collection to give users access to the Amazonian flora. Besides exsiccatae, other plant parts, as well as products made from raw plant material, are included in the collection, which are all recorded in the MFS database generated in BRAHMS. Examples of the kinds of collections are in Figure 3.

Table 1: Indexed Amazonian herbaria with types and/or associated collections (based on the Rede Brasileira de Herbários and GIBIF)

Herbarium	State	Curator	N° of specimens	Collections	Type material
IAN – HERBÁRIO DA EMBRAPA AMAZÔNIA ORIENTAL	PA	Helena Joseane Raiol Souza	194,000	Wood, Flowers, Fruits, Seeds, Seedlings.	3,000
MFS – MARLENE FREITAS DA SILVA	PA	Flávia Cristina Araújo Lucas	6,083	Bryophytes, Fungi, Flowers, Fruits, Seeds, Seedling, Ethnobotanical.	0
MG - MUSEU PARAENSE EMILIO GOELDI	PA	Pedro Lage Viana (general curator); Anna Luiza Ilkiu-Borges (bryophyte curator); Hélen Sótão (fungi curator)	211,000	Bryophytes, Fungi and lichens, Wood, Fruits, Pollen, Seedlings.	3,031
INPA – HERBÁRIO DO INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA	AM	Michael Hopkins	270,700	Bryophytes, Fungi, Wood, Flowers, Fruits, Seeds, Pollen.	2,000
HERBAM - HERBÁRIO DA AMAZÔNIA MERIDIONAL	MT	Célia Regina Araújo Soares Lopes	13,000	Wood, Flowers, Fruits, Seeds.	5
HPAN - HERBÁRIO DO PANTANAL VALI JOANA POTT	MT	Maria Antonia Carniello	10,000	Bryophytes, Ethnobotanical.	0
NX - HERBÁRIO NOVA XAVANTINA	MT	Beatriz Schwantes Marimon (phanerogams) and Francisco de Paula Athayde Filho (cryptogams)	16,000	Bryophytes	1
SLUI - HERBÁRIO ROSA MOCHEL	MA	Francisca Helena Muniz	5,500	Bryophytes, Fungi, Algae, Wood, Fruits, Seeds, Pollen.	0

Figure 3 - MFS collections. A – Exsiccatae. B – Flowers. C - Fruits. D – Seedlings. E – Fungi. F – Ethnobotanical. G – Bryophytes

Exsiccatae

Exsiccatae are fundamental to an herbarium. They are records that compile information from a locality and the specimens are called voucher material (Monteiro and Siani 2009). They are dried plant samples, which are treated and preserved following specific techniques of the INCT (2013) (Figure 4). Exsiccatae are fundamental for taxonomic and systematic studies, and essential for comparative analyses to identify species (Martins da Silva 2002). In addition, they contribute to management, conservation and productivity studies used and to create public policies for environmental conservation.

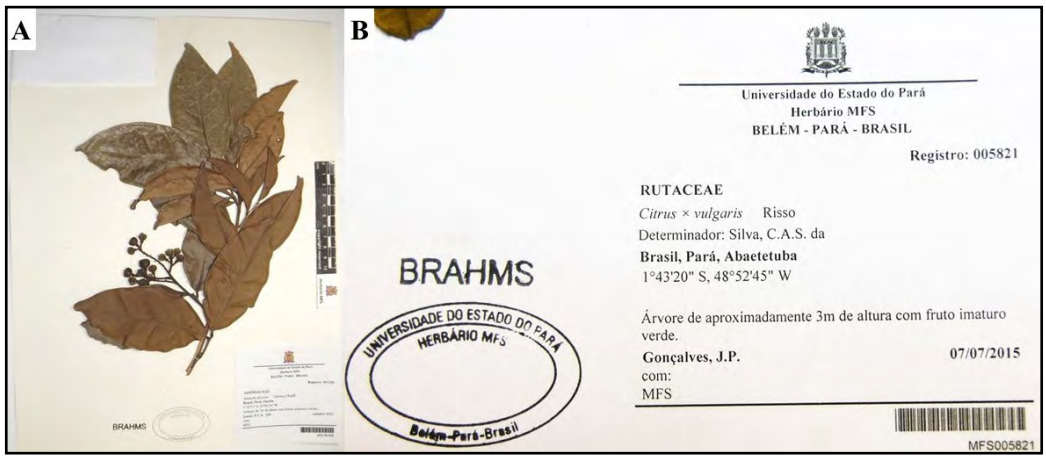

Figure 4 - Exsiccatae. A. Exsiccatae of Matayba discolor (Spreng.) Radlk. B – Image of label of Citrus x vulgaris Risso, generated by BRAHMS, with taxonomic information, locality, description of the collection, collection date, collector, determiner, coordinates and herbarium/accession number of the collection

Associated collections add information to exsiccatae, include different parts of the same collection, and provide data for diverse taxonomic, floristic, anatomical and ecological studies (Fonseca et al. 2005; Peixoto et al. 2003). This material is registered, in association with the number of the corresponding exsiccatae voucher, according to its category (flower, fruit and seed, and seedling). The system generates a label containing both records, the voucher and associated material, the scientific and common names, and field information. At MFS there are four types of associated collections, flowers, fruits, seeds and seedlings, which are discussed below.

Collections of Flowers

As plant components with elaborate architectures, which can be both delicate and enormously complex, flowers are intimately linked to the reproductive process (Ramalho and Rosa 2010). Flowers are essential elements used in taxonomy to identify many species, because they often have unique and peculiar characteristics, and are important in studies about pollinators involved in ecosystem services (Imperatriz-Fonseca 2012).

Flowers are collected in large quantities and stored in paper bags, or in a liquid medium during longer field trips, until they reach the laboratory. Notes (color, odor, morphological characteristics) and images of the flowers are made in the field. In the herbarium, the flowers are preserved in a liquid medium containing 70% alcohol, distilled water and glycerin (proportion 2:2:1), and stored in glass jars (Figure 5).

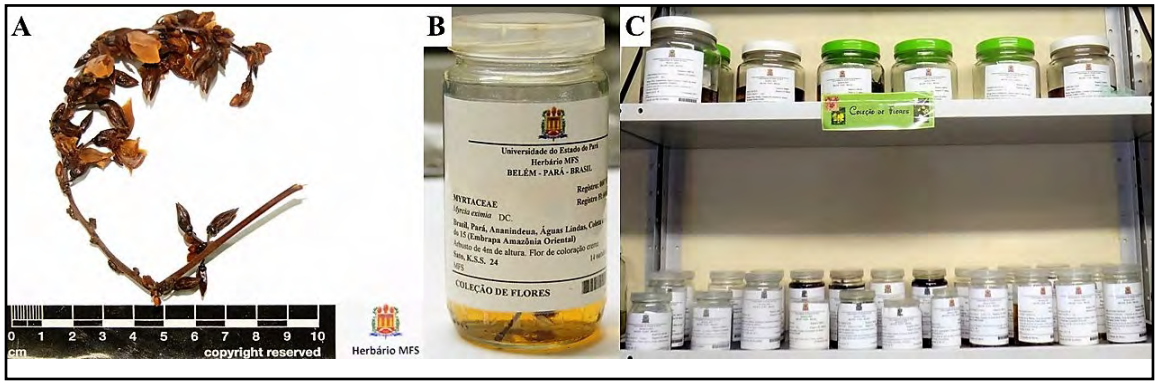

Figure 5 - A – Collected inflorescence (Clitoria sp.). B – Flower in liquid medium (Myrcia eximia DC.). C – Jars on shelves

Fruits and seeds

Fruits and seeds have unique characteristics that can be used to identify species, which are often listed on the labels of these associated collections but not mentioned on the labels of the exsiccatae (Oliveira and Souza 2014). Lorenzi (2006) noted the importance of studying fruit diversity, in addition to chemical, food, economic and ecological potential, so that management and conservation plans involve the conscious exploitation of these resources.

Fruits and seeds are collected in paper bags and dehydrated in a plant drier at approximately 60°C. The time in the drier varies according the type of fruit, which can be dry or fleshy. After they are dry, the fruits and seeds are stored in thick plastic bags (Ziplog ®) that are heat sealed; succulent specimens should be stored in a liquid medium. A different label (similar to exsiccatae) is used for fruits, which has a description (type, color, texture, consistency, location, dehiscence and pericarp indument) that is based on specialized literature (Figure 6).

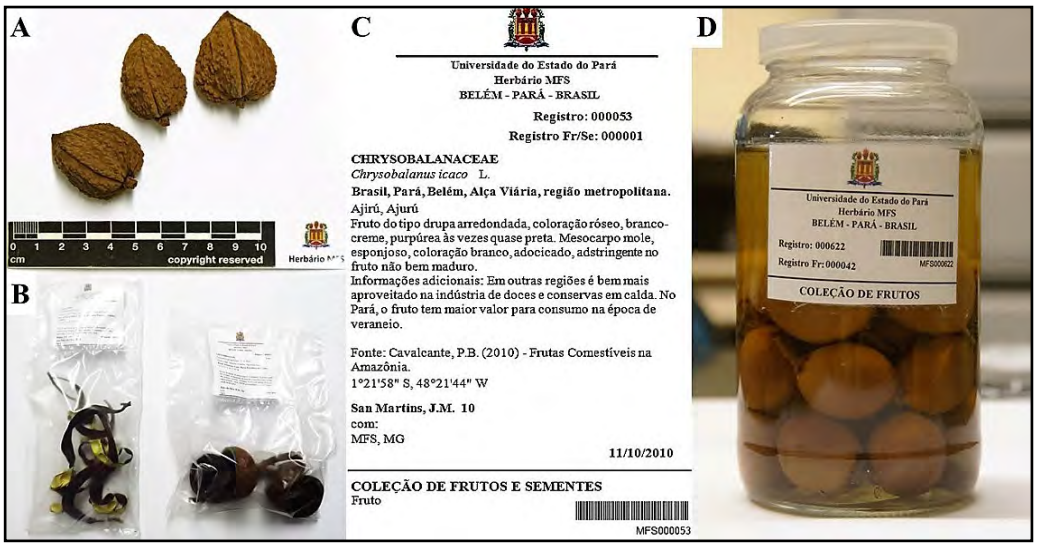

Figure 6 - A – Fruits dehydrated in a drier (Caraipa grandifolia Mart.). B – Dry fruits sealed in plastic bags. C – Example of a label with the typology. D – Fleshy fruit stored in liquid medium (Pouteria grandiflora (A.DC.) Baehni)

Seedling collections

Seedling collections consist of plant specimens at initial stages of development and can be very useful when identifying species. According to Gurgel et al. (2012), the study of seedling morphology is based on observations that start before germination and end with the development of the young plant. This information supports systematic studies and management and conservation proposals, and is useful in identification manuals.

To obtain seedlings, MFS has adopted the methodology reported by Gurgel et al. (2006), where seeds of species are collected from fruits, germinated in plastic containers (80 x 40 x 20 cm) containing a substrate of sand and sawdust (1:1), stored outside in a shady area under natural environmental conditions, and watered (to keep the substrate humid) when needed. A sample of the collection is made at each stage of development, from the protrusion of the root to the production of eophylls (seedling) and metaphylls (young plant).

Subsequently, the young plants are placed in jars with a liquid medium of alcohol and glycerin (Carvalho et al. 2013), which are identified with a label containing the scientific name, common name, locality (including coordinates), description of the seedling and germination (substrate used), and collector (Figure 7).

Figure 7 - A – Seedlings at different stages of development collected from the same germination lot (Annona mucosa Jacq.). B – Seedling in liquid medium. C – Jars of seedlings stored on shelves

Thematic collections

In addition to the exsiccatae and associated collections, an herbarium can have other sources of plants used in studies. Leadlay and Greene (1999) show how natural resources can be conserved as live collections and in herbaria. In this publication, the authors cite illustrations and images, plant tissues, wood, medicinal species, aromatics, oleaginous plants, ethnobotanical products and material, paleobotanical fossils, DNA and vulnerable species, among others, as collections that are related to more specific issues that are different from the larger central theme of the exsiccatae. The authors point out that thematic collections require a deeper knowledge to interpret the material.

The bryophyte collection comprises a group of plant species that share very peculiar morphophysiological characteristics, and houses part of the large and unknown diversity that is found in Amazonian forests (Vaderpoorten and Goffinet 2009). The collection is important in the support of taxonomic studies and richness analyses of the Amazonian bryoflora and contributes to ecosystem, microbiota and environmental impact analyses, as reported by Garcia et al. (2014) and Pantoja et al. (2015). Initiated in 2013, based on a partnership with the bryology group at Museu Paraense Emílio Goeldi and researchers at the Universidade do Estado do Pará, this collection has a significant number of species and is growing based on new collections made by students with fellowships for MFS research projects.

The field collections are stored in paper bags, dehydrated outdoors, under the sunlight, and identified by comparing them with other specimens and with the aid of literature (Câmara and Vital 2004). The specimens are archived in envelopes made with Kraft paper® (28cm²) (Yano 1984) and the information about the collection, and the environment and substrate where it was found, is recorded on the label. Seeing that a single substrate may have various associated species, as well as different families, there is an additional field to list this information on the label (Figure 8 - B). The envelopes are stored in steel drawers and alphabetically arranged by family and genus.

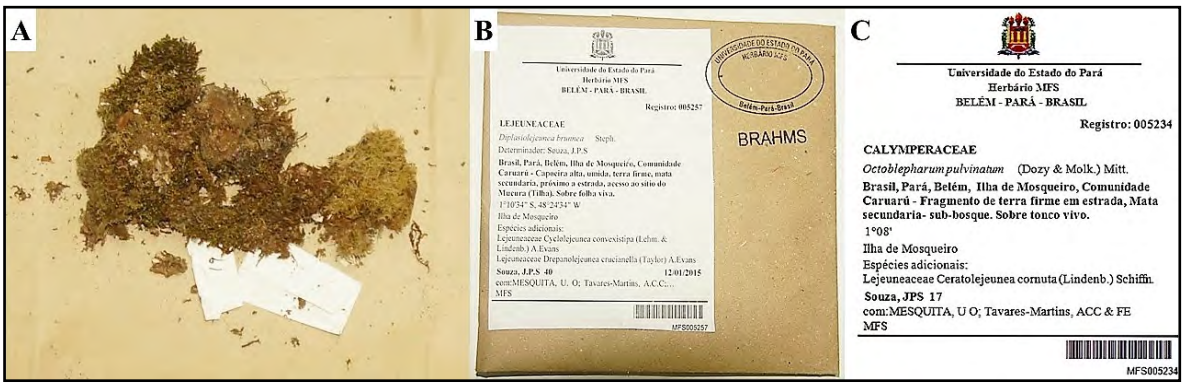

Figure 8 - A – Dried material with substrate. B – Kraft paper® envelope with label and BRAHMS and university stamps. C – Label with field for additional species

MFS catalogs macroscopic fungi, which are also important components of herbaria as research centers that promote the conservation of biology (Peixoto et al. 2009). For fungi, in addition to taxonomic and mycological information, ecological data are also collected because many of these organisms are involved in the cycling of material or occupy niches in symbiosis with other organisms. Pereira (2010) noted the importance of understanding the niche of fungi when developing fungi studies about medicine, food, and economics (in relation to their industrial utility).

Figure 9- A – Dehydrated fungus (Phellinus sp.). B – Material preserved in a Ziplog ® bag containing camphor. C – Kraft paper® envelope with label, and BRAHMS and university stamps

After collecting fungi, the material is dried. This process can be done in a plant drier, dehydrator or in the sun, depending on the type of fungus (Inct 2013). Subsequently, the material is identified by specialists and researchers at the Museu Paraense Emílio Goeldi and the Universidade do Estado do Pará. Information associated with each collection is recorded in BRAHMS, such as the collection number, collector, family, species, determiner, locality and description of the collection; for the latter, it is fundamental to include the substrate the fungus was growing on. Subsequently, the collection is put in a plastic bag (Ziplog ®) with camphor, and then in a Kraft paper® envelope that is similar to what is used for bryophytes (Fidalgo and Bononi 1989). The envelopes are then labeled, stamped, stored in steel cabinets, and arranged in alphabetical order by genus and species (Figure 9).

The ethnobotanical collection, another thematic collection in the herbarium, shows the traditional and cultural use of plants from a global perspective, for both the past and the present. Tools, utensils, fibers, medicinal plant drugs, among other artifacts and products made of raw plant material, constitute documented heritages of unquestionable anthropological value (Salick et al. 2014). In turn, these artifacts contribute to interdisciplinary studies that enable enforcement actions, which are aimed at local development in traditional communities and include the participation of these groups (Rocha et al. 2014).

Formed by products from work done within and outside of traditional communities (Figure 10 – A), this collection represents a wealth of sociocultural knowledge linked to products that come from plants in a dynamic system (Hanazaki 2013). Most of the material obtained was donated by researchers and students of the team, who had authorization to work in the communities. The information related to each product was collected using semi-structured forms used to question residents, as in Alburquerque et al. (2010).

Products such as basketry, dehydrated herbs, jewelry made from organic material, artisanal toys, musical instruments, and those for hunting and fishing, undergo a disinfection process using thermal shock (48h freezing, 48h thawing). Other products, such as oils, potions and ointments, are directly incorporated into the collection. Subsequently, collections are recorded in a Microsoft Office Excel database until authorization is received from the Ministério do Meio Ambiente on the Plataforma Brasil. The information is then transferred to BRAHMS and made available online, as done for the rest of the collection.

Data recorded for the material in this collection are the following: ethno registration number, name of object, origin of object or product, form of use, scientific name(s) of the species that comprise the material, donator (person that gave the product to the collection), date the product entered the collection, author (artisanal or industrial), additional information (from the producer or articles) and category of use. This profile of ethnobotanical information is based on the manual by Salick et al. (2014), which describes the methodological steps used to curate biocultural collections, and visits to the ethnobotanical collections at the Jardim Botânico do Rio de Janeiro (RB) and The New York Botanical Garden (NY) herbaria. For products acquired at fairs or open markets, where there was no contact with the communities, the literature is searched to find information that complements the use and properties, which is listed in an additional information field.

Figure 10 - Material belonging to the ethnobotanical collection. A – Products from traditional communities, fairs and commerce. B – Labeled ethnobotanical material. C – Label with information about a product

For products acquired with only a common name, descriptions, images and the literature are searched to identify the product to at least to the genus level. Rosso (2013) also discusses this problem because there is a wide divergence of consensus for identifications made using common names. Subsequently labels are elaborated with the record, name of the object, origin, use, scientific name, donator, date entered and category (Figure 10 - B) are tied to the product with cotton string (to make sure the collection maintains its integrity), as instructed by Viviane Stern da Fonseca-Kruel, the curator of the ethnobotanical collection at the Jardim Botânico do Rio de Janeiro (Figure 10 - C). The products are preserved in steel drawers and preventatively protected with camphor against attacks by biological agents.

The role of MFS and the availability of its data online

With the goal of integrating and sharing information among herbaria worldwide, to develop plans and measures that contribute to preserving global biodiversity, MFS is accredited in many virtual platforms that contain national and international collections. According to Záchia (2014), the collaboration of curators and taxonomists on herbarium networks promotes studies, preparations of lists and the identification of species, as well as cooperation and mutual planning of deadlines and conservation goals. In 2011, MFS was registered in the Rede Brasileira de Herbário (RBH), an initiative of the herbaria committee of the Sociedade Brasileira de Botânica (SBB), which has an online catalog of the collections of the national herbaria (http://www.botanica.org.br/rbh-catalogo) and has the objective of helping to develop these collections (Sbb 2016). Also in 2011, MFS joined the interdisciplinary research and multi-institutional network Instituto Nacional de Ciência e Tecnologia (INCT), through the project Herbário Virtual da Flora e dos Fungos, which uses information based on Specieslink to promote digital access of biodiversity information to the general public. This is a collaborative system that includes hundreds of national and international collections (Cria 2015).

Figure 11 - MFS site. MFS home page with the dedication of the herbarium code to Dr. Marlene Freitas da Silva (left) and herbarium page (right)

Figure 12. - MFS Facebook page

In 2014, MFS was added to the Sistema de Informação (SiBBr), another online platform that, in addition to making information about collections available, also provides information about creating projects, public policy development and decision making for managing natural resources. In 2015, MFS started sharing data with the Global Biodiversity Information Facility (GIBF), which includes data about all life forms on Earth and is working with various countries. This gives MFS greater visibility, which increases the possibilities of forming international research partnerships.

With the objective of offering information to the general public in the most accessible way, in 2015 a virtual herbarium was created that consists of a site (*paginas.uepa.br/herbariomfs/*) where professors, students and the public can find information about the collections, works conducted by academics and researchers, promoted activities and actions, and direct access to BRAHMS online (Figure 11). The content of the site is also shared on a social network to make the flow of information more dynamic (Figure 12).

The MFS database is compiled online with the help of BRAHMS and can be accessed on the MFS site. On the site, there are tools to search for information, and to make maps and graphs in a simple and practical way (Figure 13).

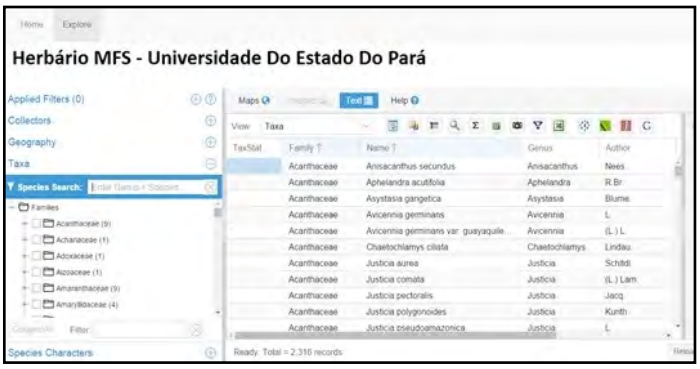

Figure 13 - MFS database made available online via BRAHMS

In 2016, MFS was registered in the Observatório de Ciência, Tecnologia & Inovação do Estado do Pará, a tool created to give visibility to the knowledge and services offered by laboratories of Pará State, which was developed to integrate this information into the decision making and formulation processes of public state policies. It has two virtual tools, a map of the Ciência Tecnologia e Informação - CT&I do Pará that shows the user the laboratories in the state and potential services, and a database that lists scientific publications from the region (Sect 2014).

3 Results and Discussion

Presently, MFS contains 6083 dried collections, including angiosperms (5111 spp.), bryophytes (863 spp.), lycophytes and ferns (18 spp.) and fungi (91 spp.). In addition, there are associated collections of seedlings (15 spp.), flowers (47 spp.), fruits and seeds (187 spp.), and an ethnobotanical collection (56). The three most representative families are Fabaceae (898 spp.), Rubiaceae (297 spp.) and Melastomataceae (246 spp.). The collections are mainly from the states of Pará, Amazonas and Santa Catarina (Figure 14). The increasing growth of this collection resulted in its institutionalization at the UEPA, which recognizes the herbarium as a laboratory of interdisciplinary studies in botany. In addition, in 2015 MFS was registered as the herbarium code in the international directory *Index Herbariorum*. The studies developed in these spaces are related to the science of biodiversity (also called a megascience), require the support of information technology, and involve diverse research activities, dissemination of knowledge and conservation and sustainable use actions (Imperatriz-Fonseca et al. 2012).

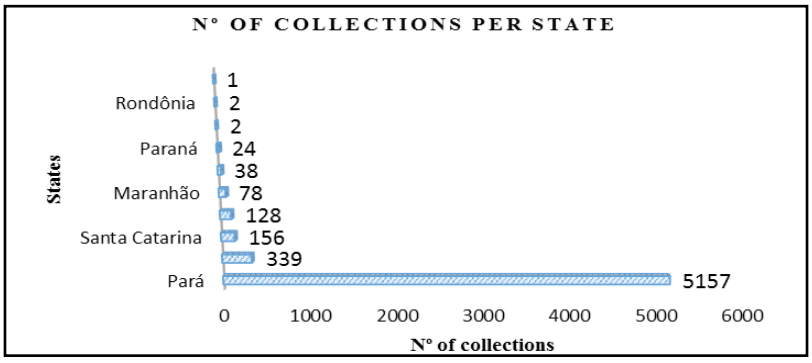

Figure 14 - Graph of the number of botanical collections per state

The logo and the research group

To identify MFS, a logo was created with an emblematic Amazonian plant: *Bertholletia excelsa* Bonpl. (Lecythidaceae, popularly called the Brazil nut, *castanha-do-pará*, *castanha-do-brasil* and *castanheira-da-amazônia*). This is a symbolic and abundant tree of Amazonian rain forest, and is also an example of a plant resource that corroborates the close relationship between humans and Amazonia, which has existed for a long time (Scoles 2011). The local and regional economy in most of Amazonia strongly depends on the harvest of Brazil nuts and this secular trade is unique because the seeds are collected exclusively from natural forest and traded internationally. The logo is a visual representation that defines the identity of the herbarium and is used in documents, publications and images (Byrne 2004). The symbol is a tree of this species with flowers and a fruit, as well as an agouti, which is the main disperser of the seeds (Figure 15).

Figure 15 - MFS logo

To consolidate the herbarium, the Interdisciplinary Studies in Botany (Estudos Interdisciplinares em Botânica) research group was founded in 2012. Since this time, the group has been developing various botanical projects, especially related to education, research and outreach. Students (undergraduate and graduate) and professors work together to write articles that focus on understanding the relationships between humans and nature, education, diversity of plants and the environment, and biotechnological processes in Amazonia. Institutional partnerships increase the production and quality of these studies. Since 2012, there have been 16 undergraduate students that were involved in Iniciação Científica (PIBIC and PIBIT) projects, 11 undergraduate students that finished their Trabalhos de Conclusão de Curso (TCC), 10 scientific articles have been published, and six articles, two long abstracts and 28 normal abstracts have been presented at national and international events. The postgraduate program collaborates with the Master's Degree in Environmental Sciences program (Curso de Mestrado Acadêmico em Ciências Ambientais) (five dissertations), and assists with fieldwork, plant identification, and research related to plant geography and ecology.

The herbarium in teaching, research and outreach

Plants and plant products comprise the material at MFS, which can be used by teachers, contributes to many educational spaces, such as schools, universities, museums, communities and botanical gardens, and helps to educate people of all ages. MFS has been providing this type of experience since 2015 when it was included in the Coordination of the Course of Natural Sciences (Coordenação do Curso de Ciências Naturais) as an environment to offer internships (called Estágio Supervisionado

Figure 16 - A – Teaching workshop about botanical collections with students from PARFOR. B – Practical herbarium workshop offered to the undergraduate students

I: Vivências em espaços não formais). As part of this, each year the herbarium receives the National Plan for Training Teachers in Basic Education (Nacional de Formação de Professores da Educação Básica, PARFOR), which supports classes and teaching workshops (Figure 16 – A).

In 2013, the university hosted a short Natural Science Degree Course, which lasted seven days, was given to 25 students, and was about herbarium practices. The course provided a booklet (illustrated) and discussed collections and the routine at herbaria (Figure 16 – B).

In 2014, a schedule of theoretical/practical activities about botanical collections was setup, which included the importance of collections as patrimony, basic herbarium procedures, collection types, database management, a course on fieldwork in natural areas (Área de Proteção Ambiental, Ilha do Combu), and fairs (Feira do Ver-o-Peso) (Figure 17).

Figure 17 - Activities by students in the internship program. A – Students conducting routine herbarium practices. B – Field course: Visit to the Ver-o-Peso fair. C – Field course: Excursion to the Área de Proteção Ambiental Ilha do Combu, Belém, Pará

The herbarium has exhibited at academic and commemorative events, such as National Botany Day, the UEPA anniversary, the Fauna and Flora Exhibition, and UEPA in the Communities (where the municipalities of Bujarú and Salvaterra, Pará, were visited).

The expositions have designed brochures and posters, display principal collections (exsiccatae), associated collections (flowers, fruits, seeds, seedlings), thematic collections (bryophytes, fungi and ethnobotany), basic collecting procedures, scientific works of the herbarium research groups, and species threatened with extinction, and have a tasting exposition of plant based products (sweets and drinks). A clothesline of exsiccatae and illustrated banners are also prepared, and there is an area to mount specimens, where visitors can choose a specimen, participate in the mounting process and take the plant as a memento

Figure 18 - Events and expositions where MFS has participated. A – UEPA in the communities (Bujarú). B – Centro de Ciências Sociais e Educação - CCSE – Campus I academic week. C – UEPA anniversary. D – Feira Municipal de Salvaterra

(Figure 18). Moreno (2007) explained the diverse roles that an herbarium can have in an informal, formal, patrimonial and museum education, through sharing information, designing projects and didactic material, and offering theoretical and practical training/workshops. Costa et al. (2016) portrayed the relevance of an herbarium as a multiuse laboratory that shares the idea of conservation/preservation in an interdisciplinary manner that combines scientific knowledge as a pedagogical strategy.

The closer the MFS collection is to the public that lacks access to research laboratories and institutions, the greater the chance the collection will continue to showcase, train, transform and be accessible. The socioeconomic and environmental facts exhibited in Brazil have put the country in an inevitable situation, and it is necessary to provide children with a quality education, educate the public about biodiversity (Palomera-García 2015), and invest in science and practices that bring the forest and knowledge together (Souza and Kindel 2014). As Bertha Becker once wisely said, "*o progresso da floresta virá da ciência".*

4 Conclusions

In the country with the biggest tropical forest in the world, it is urgent that herbaria acquire new deposited and cataloged specimens, especially from the Amazonian region where there are numerous collection gaps. Therefore, the acquisition of the 6,083 samples in the MFS collection demonstrates a responsibility to continue to collect and catalog an increasing number of samples, and confirms MFS is committed to environmental conservation amid a grave environmental crisis. Moreover, MFS has sought to present its scientific information in a simple way that is accessible to all of society, presenting its botanical resources as a free resource for everyone that also contributes to taxonomic, ecological, ethnobotanical and educational studies.

Referências

ADAPAR [Internet]. Agência De Defesa Agropecuária Do Paraná [cited 2016 mar 09]. Available from: http://www.adapar.pr.gov.br/.

ANVISA [Internet]. Agência Nacional De Vigilância Sanitária [cited 2016 mar 09]. Parecer Técnico nº 6, de 21 de dezembro de 2010. Available from: http://portal.anvisa.gov.br.

ALBAGLI S. Amazônia: fronteira geopolítica da biodiversidade. Parcerias estratégicas. 2001; (2): 5-19.

ALBUQUERQUE UP, LUCENA RFP, CUNHA LVFC. Métodos e técnicas na pesquisa etnobiológica e etnoecológica. NUPPEA (Coleção Estudos e Avanços). 2010.

ANDRADE LH DE, OLIVEIRA JV DE, LIMA IM DE M, SANTANA MF DE, BREDA M O. Efeito repelente de azadiractina e óleos essenciais sobre *Aphis gossypii* Glover (Hemiptera: Aphididae) em algodoeiro. Revista Ciência Agronômica. 2013; 44 (3): 628-634.

APG IV. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society. 2016; 181: 1-20.

BARATA FCA, CARREIRA LMM, MAUÉS MM. Biologia floral e morfologia polínica de *Q. amara* L. (Simaroubaceae). Boletim do Museu Paraense Emílio Goeldi. Série Botânica. 2002; 18 (1): 119-158.

BRAHMS online. BRAHMS – Botanical Research and Herbarium Mangement Sistem. Translation: Martins – da – Silva, R.C. Department of Plant Sciences. University of Oxford. 2010.

BRIDSON D, FORMAN L. The herbarium handbook. 3ªed, ilustrada, reimpressão. Royal Botanic Gardens. Kew. 1998.

BYRNE G. A marca e os novos negócios. Um guia para ajudar as empresas de médio e pequeno porte a desenvolver seu nome e logotipo. Empreendedores. HSM Management. 2004; 43.

CARVALHO YK, ZAVARIZE KC, MEDEIROS L DOS S, BOMBONATO PP. Avaliação do uso da glicerina proveniente da produção de biodiesel na conservação de peças anatômicas. Pesquisa Veterinária Brasileira. 2013; 33 (1): 115-118.

CGEN [Internet]. Ministério do meio ambiente [cited ago 2015]. Available from: http://www.mma.gov.br/patrimonio-genetico/conselho-de-gestao-do-patrimonio-genetico.

COSTA JCM, LUCAS FCA, GOIS MAF, LEAO VM, LOBATO GJM. Herbário virtual e universidade: biodiversidade vegetal para ensino, pesquisa e extensão. Scientia Plena. 2016; 10: 256.

CRIA [Internet]. Projetos [cited jun 20165]. Available from: http://www.cria.org.br/projetos.

FIDALGO O, BONONI VLR. Técnica de coleta, preservação e herborização de material botânico. Série Documentos. São Paulo. 2015: 62.

FIORAVANTI C A maior diversidade de plantas do mundo. Ciência Ecologia. Pesquisa Fapesp. 2015: 241.

FONSECA A, SOUZA JRC, VERÍSSIMO A [Internet] Boletim do desmatamento da Amazônia Legal. SAD Abril de 2015 [cited 2015 jun 06]. Belém: Imazon. Available from: http://site1378233601.provisorio.ws/publicacoes/boletim-do-desmatamento-da-amazonia-legal-abril-de-2015-sad/.

FONSECA CN, LISBOA PLB, URBINATI CV. A xiloteca (coleção Walter A. Egler) do Museu Paraense Emílio Goeld. Bol. Mus. Para. Emílio Goeldi, sér. Ciências Naturais. 2005; 1 (1): 65-140.

FONSECA-KRUEL VS, PEREIRA TS. A Etnobotânica e os Jardins Botânicos. Série Estudos e Debates. Recife, Nupeea / Sociedade Brasileira de Etnobiologia e Etnoecologia. 2009. p. 7-60.

GARCIA ET, TAVARES – MARTINS ACC, FAGUNDES DN. Diversidade florística de briófitas da Reserva Ecológica do Bacurizal, Salvaterra, Ilha de Marajó, Pará, Brasil. Enciclopédia Biosfera. 2014; 10 (19): 2168-2182.

GUERRA FL, CUNHA EG DE, SILVA ACS DE, KNOP S (2012) Análise das condições favoráveis à formação de bolor em edificação histórica de Pelotas, RS, Brasil. Ambiente Construído. 12 (4): 7-23.

GIBF [Internet]. What is GBIF? A short description of the Global Biodiversity Information Facility [cited 2016 mar 02]. Available from: http://www.gbif.org/whatisgbif.

GURGEL ESC, CARVALHO ACM, SANTOS JUM DOS, SILVA MF DA. *Virola surinamensis* (Rol. ex Rottb.) Warb. (Myristicaceae): aspectos morfológicos do fruto, semente, germinação e plântula. Bol. Mus. Para. Emilio Goeldi Cienc. Nat. 2006; 1 (2): 37-46.

GURGEL ESC, SANTOS JUM DOS, LUCAS FCA, BASTOS MNC. Morfologia de plântulas de Leguminosae e o potencial sistemático. Rodriguésia. 2012; 63(1): 65-73.

HANAZAKI N. Etnobotânica. Ecologia de Pescadores da Mata Atlântica e da Amazônia. RiMa editora, 2ª ed. Orga. Begossi, A. 2013

HOMMA AKO. Biodiversidade e biopirataria na amazônia: como reduzir os riscos? Passages de Paris. 2011; 6:111–128.

ICMBio [Internet]. Ministério do Meio Ambiente. Unidades de conservação [cites 2016 mai 15]. Available from: http://www.icmbio.gov.br/portal/unidadesdeconservacao/biomas-brasileiros.

IMAZON. Áreas Protegidas na Amazônia brasileira: avanços e desafios. Org. Adalberto Veríssimo [et al.]. Instituto Socioambiental. 2011.

IMAZON. Transparência Florestal. Amazônia Legal. Orgs. Fonseca, A.; JUSTINO, M.; SOUZA Jr, C; VERÍSSIMO, A. Relatório de desmatamento. 2016.

IMPERATRIZ-FONSECA VL, GONÇALVES LS, FRANCOY TM, NUNES-SILVA P. Desaparecimento das abelhas melíferas e a perspectiva do uso de outras abelhas na polinização. In. Documentos (Embrapa Semi-Árido. Online). 2012. p. 220-233.

INCT. Manual de procedimentos para herbários. Editora universitária da UFPE. Recife; 2013.

JOTTA CAR, BARBOSA C R. Gestão da informação, museus de ciência e tecnologia: mediação científica em coleções musealizadas. Revista Brasileira em Ciência da Informação e Biblioteconomia. 2015; 10 (1): 250-263.

LEADLAY E, GREENE J. Manual Técnico para Jardins Botânicos. Tradução de Monica Stawnitzer, Rio de Janeiro: Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rede Brasileira de Jardins Botânicos. 1999.

LIMA LF, LIMA PB, SOARES JÚNIOR RC, PIMENTEL RM DE M, ZICKEL CS. Diversidade de macrófitas aquáticas no estado de Pernambuco: levantamento em herbário. In. Revista de Geografia. UFPE – DCG/NAPA. 2009; 26 (3): 307-319.

LORENZI H. Frutas brasileira e exóticas cultivadas. Editora Plantarum, 1ª ed. 2006.

MARTINS-DA-SILVA RCV, CARREIRA LMM, BARATA FCA. Marlene Freitas da Silva 1937 – 2005. Rodriguésia – Revista do Jardim Botânico do Rio de Janeiro. 2007; 58 (2): 0-0.

MARTINS-DA-SILVA RCV, SILVA ASL DA, FERNANDES MM, MARGALHO FL. Noções morfológicas e taxonômicas para identificação botânica. Embrapa Amazônia Oriental. 2014.

MONTEIRO SS, SIANI AC. A Conservação de Exsicatas em Herbários: Contribuição ao Manejo e Preservação. In. Revista Fitos. 2009; 4 (02): 24-37.

MORENO EJ, TAMAYO HF. El herbario como recurso para el aprendizaje de la botánica. Acta bot. Venez. 2007; 30 (1):415-427.

OLIVEIRA RB DE, SOUZA MC DE. Diversidade de frutos da região do Alto Juruá, Acre, Brasil. Enciclopédia biosfera. 2014; 10(19): 2129-2140.

PALOMERA – GARCIA C, RIVERA – CERVANTES LE, GARCÍA – REAL E, GUZMÁM – HERNÁNDEZ L, RUAM – TAJEDA I. Las colecciones biológicas "itinerantes" como instrumentos de educación ambiental. Revista Iberoamericana para la Investigación y el Desarrollo Educativo. 2015; 6 (11): 109-119.

PANTOJA ACC, ILKIU – BORGES AL, TAVARES – MARTINS ACC, GARCIA ET. Bryophytes in fragments of Terra Firme forest on the great curve of the Xingu River, Pará state, Brazil. Braz. J. Biol.2015; 75 (3): 238-249.

PEIXOTO AL, MORIM MP. Coleções botânicas: documentação da biodiversidade brasileira. Ciência & Cultura. 2002; 55 (3): 21-48.

PEIXOTO AL, BARBOSA MRV, CANHOS DAL, MAIA LC. Coleções Botânicas: Objetos e Dados Para a Ciência. In: Granato, M. & Rangel, M. (Orgs). Cultura material e patrimônio da Ciência e Tecnologia. Museu da Astronomia e Ciências Afins. 2009.

PEREIRA LT. Diversidade e aspectos ecológicos de fungos gasteróides (Basidiomycota) em quatro áreas de mata atlântica no estado de Pernambuco, Brasil [dissertation]. Recife: Universidade Federal de Pernambuco; 2010.

RAMALHO M, ROSA JF. Ecologia da interação entre as pequenas flores de quilha de *Stylosanthes viscosa* Sw. (Faboideae) e as grandes abelhas *Xylocopa* (*Neoxylocopa*) *cearensis* Ducke, 1910 (Apoidea, Hymenoptera), em duna tropical. Biota Neotrop. 2010; 10 (3): 93-100.

ROCHA JA, BOSCOLO OH, FERNANDES LRRMV. Etnobotânica: um instrumento para valorização e identificação de potenciais de proteção do conhecimento tradicional. Interações. 2014; 16 (1): 67–74.

ROSSO CN. La etnobotánica histórica: el caso Mocoví em la Reducción de San Javier em el siglo XVIII. Etnobiología. 2013; 11 (3): 54-65.

SALICK J, KONCHAR K, NESBITT M. Curating Biocultural Collections: A Handbook. Kew Publishing. 2014.

SANTOS FS DOS. O herbário IFSR e sua importância científica e educacional. Revista Hipótese. 2015; 1 (1): 15-23.

SCOLES R. Do rio Madeira ao rio Trombetas: novas evidências ecológicas e históricas da origem antrópica dos castanhais amazônicos. Novos Cadernos NAEA. 2011; 14 (2): 265-282.

SECT. Observatório de CT&I do Pará. Ver-a-ciência. Revista de ciência, tecnologia e informação do estado do Pará. 6th ed. 2014.

SOUZA LAG DE. Marlene Freitas da Silva (1937-2005). Acta Amazonica. 2005; 35 (4): 0-0.

SOUZA CLP, KINDEL EAI. Compartilhando ações e práticas significativas para o ensino de botânica na educação básica. Experiências em Ensino de Ciências. 2014; 9 (3): 44-58.

STEFANELLO AGF, DANTAS FAC DE. Reflexões acerca da convenção sobre diversidade biológica no acesso e apropriação ao patrimônio genético da biodiversidade amazônica. Hiléia - Revista do Direito Ambiental da Amazônia. 2010; (8): 147-159.

SiBBr [Internet]. O que é o SiBBr? [cited 2016 jun 06]. Available from: http://www.sibbr.gov.br/internal/?area=osibbr.

VANDERPOORTEN A, GOFFINET B. Introduction to Bryophytes. New York: Cambridge University Press. 2009; p.294.

YANO O. Técnicas de coleta, preservação e herborização de Material botânico. Briófitas. O. Fidalgo (coord.). Instituto de Botânica, Série Documentos. 1984; p. 27-30.

ZÁCHIA RA. A evolução do conhecimento sobre a flora Rio-Grandense nos últimos 20 anos e a importância das coleções científicas no espaço acadêmico da universidade pública – os exemplos do herbário e do Jardim Botânico da Universidade Federal de Santa Maria. Ciência e Natura. 2014; 36: 294–30.

ZANIN EM, CHAVES AS, MIOLO LA. Herbário Padre Balduíno Rambo e suas contribuições ao estudo da botânica no sul do brasil. PERSPECTIVA Erechim. 2015; 39: 17-24.

VIEIRA AOS. Redes de Herbários e Herbários Virtuais no Brasil. Unisanta - Bioscience. Ed. especial 66º Congresso Nacional de Botânica 2015; 4 (7): 1-11.