






## Tracking knowledge: tree survey and botanics teaching on the trail in Alto Solimões

### Trilhando conhecimento: levantamento arbóreo e ensino de botânica na trilha no Alto Solimões

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#### ABSTRACT

The main objective of this research was to carry out a qualitative-quantitative survey of the tree diversity of the ecological trail of the Institute of Nature and Culture (*Instituto de Natureza e Cultura - INC/UFAM*) from the point of view of its pedagogical value for the teaching of botany. From the information obtained, didactic tools for the teaching of botany were elaborated in order to investigate the potential of the trail as a pedagogical tool. The tree survey of the sampling area resulted in 41 species, 39 genera and 27 botanical families distributed among tree species and palm trees. From this developed an illustrated guide with the species found, a glossary with botanical terms and a key to identify the characteristics of the leaves and fruits. The students expressed satisfaction with the practice conducted, reflected in its massive and attentive participation in the activity of key identification, in which it showed that the track has pedagogical potential in the teaching of botany.

#### RESUMO

A presente pesquisa teve como objetivo principal realizar um levantamento quali-quantitativo da diversidade arbórea da trilha ecológica do Instituto de Natureza e Cultura INC/UFAM do ponto de vista do seu valor pedagógico para o ensino de botânica. A partir das informações obtidas elaborou-se ferramentas didáticas para o ensino de botânica com a finalidade de investigar o potencial da trilha enquanto ferramenta pedagógica. O levantamento arbóreo da área amostral resultou em 41 espécies, 39 gêneros e 27 famílias botânicas distribuídas entre espécies arbóreas e palmeiras. A partir deste desenvolveu-se um guia ilustrado com as espécies encontradas, um glossário com termos botânicos e uma chave de identificação das características das folhas e frutos. Os estudantes expressaram satisfação com a prática conduzida, refletida em sua massiva e atenta participação na atividade da identificação da chave, na qual mostrou que a trilha possui potencial pedagógico no ensino de botânica.

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Trilha ecológica, Chave de identificação, Estratégias didáticas, Educação Sustentável.

## **Introduction**

An arboreal survey seeks to list all the species existing in a given area and allows us to classify these species as to their origin; that is, if they are native to the Brazilian territory or if they are exotic, introduced and cultivated in the territory, but coming from other countries. The survey also aims at the knowledge of the history and economic development of the region studied, since the tree species implanted are closely linked to the landscape design of the current time (LORENZI, 2008).

It's also noticed that the surveys have been used in several Brazilian university campuses for the elaboration of interpretive trails that work on environmental awareness, as is the case of the research of from Oliveira; Correia (2015) in a study whose objective was to investigate the effect of field classes on the environmental awareness of high school students, using logbooks as teaching and learning instruments, highlighting the use of this technique demonstrated to be a positive mechanism for the teaching and learning process as well as for reports of information about an environment.

This range of activities shows the potential and importance of what can be achieved, through the tree survey proposed on the trail of the Institute of Nature and Culture (*Instituto de Natureza e Cultura - INC*) of the Federal University of Amazonas (*Universidade Federal do Amazonas*), Alto Solimões campus, which has a course of 1,300 m and presents an excellent potential for the implementation of activities aimed at environmental education and also to function as a "living laboratory" for the teaching of botany.

In this context, the work aimed to carry out a qualitative-quantitative survey of the tree flora of the ecological trail of the Institute of Nature and Culture (Instituto de Natureza e Cultura - INC/UFAM).

## **Methodological procedure**

The study was developed in the county of Benjamin Constant (Figure 1), located in the Alto Solimões region of the State of Amazonas, Brazil, at the Institute of Nature and Culture (*Instituto de Natureza e Cultura - INC*) of the Federal University of Amazonas (*Universidade Federal do Amazonas - UFAM*).

**Figure 1.**  
*Location of the Institute of Nature and Culture (INC/UFAM).*



*Source: Satellite view obtained by Google Earth (2021).*

The study was based on the identification of tree species on the trail. Species that were up to 3 m from the edges of the trail were inventoried. The numbering of the individuals consisted of the arrangement of numbered aluminum plates, fixed at a height of approximately 1.3 m in the bark of the tree with the aid of nylon wires so as not to damage the trunk. The identification with the aluminum plate is a measurement protocol used by studies of vegetative survey that can not be characterized as damage in vegetation (HOLLAND, 2016).

The identification was performed by consulting the literature available in Lorenzi (2008) and Lorenzi et al. (2003). Information regarding the origin of the species was obtained from Lorenzi et al. (2003) and Souza and Lorenzi (2008). The specimens were photographed with a digital camera so that the images obtained at the end of the collections could support the elaboration of a guide, with the best possible resolution, of digital media for didactic purposes.

The specimens present during the trail were georeferenced through the Garmin Global Position System (GPS) so that these data can subsidize future work on campus, as well as assist management plans such as pruning and suppression of specimens, since it will have the exact location of each individual, as well as the distribution of trees along the trail.

On occasions when it's not possible to identify the plant species, it consisted of collection for the manufacture of pressed (exsiccate), to be compared with the collection of the Herbarium of the National Institute of Amazonian Research (*Instituto Nacional de Pesquisas da Amazônia* - INPA) and with the MOBOT website. The sequence of assembly of the pressed assembly is based on: sheet of cardboard, sheet of newspaper containing the botanical material

and sheet of cardboard. This sequence repeated the number of times the press holds the specimens. After the material was pressed, it dried at a temperature of 50°C for 48 hours.

After being dried in a greenhouse, each individual was sewn by stitches, with thread and needle and attached with adhesive tape in white cardboard of size 30 cm high and 45 cm wide. The size of the cardboard, in addition to allowing a safer handling of the material, represents a standardized dimension, which allows the exsiccates to be donated, exchanged or even sent for identification worldwide. The fruits or flowers that may have been released from the collected material were affixed in small envelopes to the upper left corner of the cardboard. After the exsiccates were made, they received, in the lower right corner of the sheet of paper, a label with their identification.

In order to investigate the potential of botanical identification in the track as a pedagogical tool, we counted on the participation of a group of INC students of the Degree Course in Sciences: Biology and Chemistry.

Then, the groups were led to the trail so that they could try to identify botanical species, genera and families. To this end, the participating groups had access to the study material from the survey now carried out regarding the plant species identified in the INC track. The material consisted of an illustrated guide of the species present in the trail, as well as information regarding these species, along with a glossary containing botanical terminology and a key for identifying the morphology of leaves and fruits.

Ten species were chosen (Chart 1) to compose the path of the trail. These species were selected based on the following requirements:

- Degree of representativeness (higher frequency) on the trail;
- Added value by being a supplier of hardwood;
- Added value for being a fruitful species;
- Added value for being a medicinal species according to popular knowledge.

**Chart 1**  
*Species proposed for the dichotomous key.*

| Criterion | Popular name     | Scientific name                    | Point |
|-----------|------------------|------------------------------------|-------|
| Fruitful  | Abiu             | <i>Pouteria caimito</i> Radlk.     | 01    |
| Fruitful  | Avocado          | <i>Persea americana</i> Mill.      | 02    |
| Fruitful  | Soursop          | <i>Annona mucosa</i> Jacq          | 03    |
| Medicinal | Red-lace         | <i>Vismia guianenses</i> Aubl.     | 04    |
| Hardwood  | Angelim          | <i>Andira anthelmia</i> Vell.      | 05    |
| Fruitful  | Inga             | <i>Inga edulis</i> Benth.          | 06    |
| Fruitful  | Mapati           | <i>Zanthoxylum rhoifolium</i> Lam. | 07    |
| Medicinal | Pariparoba       | <i>Piper crassinervium</i> Kunth   | 08    |
| Hardwood  | Mamica de cadela | <i>Zanthoxylum rhoifolium</i> Lam. | 09    |
| Fruitful  | Tucuman          | <i>Astrocarium chambira</i> Burret | 10    |

The key for identifying the structures related to the species mentioned in Table 1 contains the fundamental categories of fruits: simple, multiple, fruiting, consistency, dehiscence and number of seeds. In addition to the parts that constitute the leaf as: division, shape, cutout, ribbing and disposition.

The key was made available to the students, along with the illustrated guide and the botanical glossary, in order to assist in the identification of the leaves and fruits. One of the contributors to the recognition of the plant was the nameplate, which helped the students not to waste time looking for the desired plant.

To answer the identification key they took out a branch containing the leaves and fruits, or only the leaves to answer the nine characteristics requested in the key.

Not only was the quantity of correct answers for each group used for the analysis of the didactic potential in question, but aspects related to the collective learning process proposed by the species identification activity were also analyzed descriptively.

During the course of the trail the students asked questions about the plant selected from the illustrated guide and when they had doubts about a botanical term, such as dehiscent and indehiscent, they resorted to the botanical glossary.

The qualitative analysis turned to the descriptions of the plant species existing on the campus of the INC/UFAM, and a database was carried out in an Excel spreadsheet, with all the records of the species including their location in the surroundings.

For the quantitative analysis, arithmetic means and percentage were used, and explanatory tables, graphs and tables were generated, which allowed comparisons of the data obtained. These data were analyzed with the aid of Microsoft Excel 2010 software.

Additionally, the combination of the information obtained with the quantitative analysis, articulated with the information annotated from the observation, field notebook and the specific literature allowed the qualitative analysis of the data.

## **Results and discussion**

The tree survey of the sampling area resulted in 41 species, 39 genera and 27 botanical families distributed among tree species and palm trees. The prepared exsiccatas are stored in the Botany laboratory of the Institute of Nature and Culture and available for consultation by teachers and students. The most representative families in number of species were: Arecaceae and Fabaceae (4 each), Malvaceae (3), Araliaceae, Euphorbiaceae, Hypericaceae, Meliaceae, Melastomataceae, Rubiaceae, Rutaceae and Urticaceae (2 each) and the other families found were represented by only one species each.

As for the families found, it's notable that Fabaceae stood out in number of individuals, as well as in species richness. According to Souza and Lorenzi (2012), this is the main family used in urban ornamentation, considered one of the largest botanical families and among the main ones from an economic point of view.

According to Sousa and Lima (2019), the Arecaceae family is very important to keep the ecosystem in balance, being considered the third most important family for humans. Most of these species are native to the Amazon.

The Arecaceae family together with the Fabaceae were represented by four distinct species and four genera, representing 9.75% of the species found in each family. The Malvaceae Family represented by three species and three genera making up 7.31% of the total species sampled. The Hypericaceae Family represents two species and one genus totaling 4.87%, thus representing 24.39% of the identified species. The remaining 44% is the 18 families containing only one species per family.

## **Didactic description of the survey**

For this subitem, a table (Table 1), a guide and an illustration board with the images with some sampled individuals were elaborated. All these elements were made with the purpose of subsidizing university activities. In this way, both the student and the teacher can understand, understand and transmit all the knowledge built in this study of tree survey. It was noteworthy that during the identification the group of students debated among themselves, about some characteristics that they already knew about the species, or debated about the shape of the leaf or about its phylotaxia.

Table 1 shows the main characteristics of the species with their respective data collected about: family, popular name, scientific name, origin, identification number and geographic coordinates. This last record serves to assist the researcher in the search for the desired species.

**Table 1.**

Description of the individuals sampled in the shrub-tree floristic survey of the Institute of Nature and Culture - INC/UFAM, in Benjamin Constant - AM, Brazil.

| Family          | Popular name     | Scientific name                                | Origin |
|-----------------|------------------|--|--------|
| MELIACEAE       | Red cedar        | <i>Cedrela fissilis</i> Vell.                  | Native |
| ARECACEAE       | Acai berry       | <i>Euterpe oleracea</i>                        | Native |
| LAURACEAE       | Avocado          | <i>Persea americana</i> Mill.                  | Exotic |
| ANNONACEAE      | Soursop          | <i>Annona muricata</i> L.                      | Native |
| EUPHORBIACEAE   | Alcornia         | <i>Alchornea discolor</i> Poepp.               | Native |
| LECYTHIDACEAE   | Sombrero         | <i>Gustavia longifolia</i> Poepp. ex O. Berg   | Native |
| FABACEAE        | Stinky Herb      | <i>Cassia grandis</i> L.                       | Native |
| VOCHYSIACEAE    | Maubarana        | <i>Vochysia maxima</i> Ducke                   | Native |
| ASTERACEAE      | Roast-fish       | <i>Vernonia polysphaera</i>                    | Native |
| PIPERACEAE      | Pariparoba       | <i>Piper crassinervium</i> Kunth               | Native |
| ARALIACEAE      | Bay leaf         | <i>Schefflera morototoni</i>                   | Native |
| MORACEAE        | Caxinguba        | <i>Ficus insipida</i>                          | Native |
| BIXACEAE        | Parakeet         | <i>Cochlospermum orinocense</i> (Kunth) Steud. | Native |
| FABACEAE        | Angelin          | <i>Andira anthelmia</i>                        | Native |
| HYPERICACEAE    | Red seal         | <i>Vismia guianensis</i> (Aubl.) Pers.         | Native |
| HYPERICACEAE    | White seal       | <i>Vismia cayennensis</i> (Jacq.)              | Native |
| SAPOTACEAE      | Abiu             | <i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.   | Native |
| ARECACEAE       | Tucuman          | <i>Astrocaryum chambira</i> Burret             | Native |
| MALVACEAE       | Pau-de-balsa     | <i>Ochroma pyramidale</i> (Cav. ex Lam.) Urb.  | Native |
| ARECACEAE       | Palm             | <i>Elaeis guineensis</i> Jacq.                 | Exotic |
| MELASTOMATACEAE | Pau-de-capoeira  | <i>Miconia</i> sp. Ruiz & Pav.                 | Native |
| ARALIACEAE      | Laurel Baboso    | <i>Schefflera morototoni</i>                   | Native |
| RUTACEAE        | Lemon-clove      | <i>Citrus X limonia</i> (L.)                   | Native |
| ARECACEAE       | Moriche palm     | <i>Mauritia flexuosa</i> L.                    | Native |
| MELASTOMATACEAE | Antwren guava    | <i>Bellucia imperialis</i> Saldanha & Cogn.    | Native |
| ANACARDIACEAE   | Mango            | <i>Mangifera indica</i> L.                     | Exotic |
| SMILACACEAE     | Espinho-de-judeu | <i>Smilax</i> sp. L.                           | Native |
| FABACEAE        | Ingá-cipó        | <i>Inga edulis</i> Benth.                      | Native |
| BIGNONIACEAE    | Ipê-yellow       | <i>Handroanthus riococensis</i>                | Native |
| RUBIACEAE       | Amarelinho       | <i>Chimarrhis barbata</i>                      | Native |
| APOCYNACEAE     | Sucuuba          | <i>Himatanthus sucuuba</i>                     | Native |
| CLUSIACEAE      | Beach mango      | <i>Clusia fluminensis</i>                      | Exotic |
| SACALICACEAE    | Caferana         | <i>Casearia</i> sp. Jacq.                      | Native |
| RUBIACEAE       | Macawtail        | <i>Kerianthera preclara</i>                    | Native |
| RUTACEAE        | Mamica de cadela | <i>Zanthoxylum rhoifolium</i> Lam.             | Native |
| URTICACEAE      | Mapati           | <i>Pourouma cecropiifolia</i> Mart.            | Native |
| URTICACEAE      | Red Embaúba      | <i>Cecropia glaziovii</i> Sneathl.             | Native |
| MYRTACEAE       | Guabiroba        | <i>Campomanesia eugenioides</i>                | Native |
| MALVACEAE       | Cocoa            | <i>Theobroma cacao</i> L.                      | Native |
| MALVACEAE       | Sapota           | <i>Matisia cordata</i> Bonpl.                  | Native |
| FABACEAE        | Mata-pasto       | <i>Senna alata</i> (L.) Roxb.                  | Native |

For the photographic record, the standard procedure was to record the part of the plant in which the metallic numbering plate was arranged and, to facilitate its recognition, the leaves were arranged next to the plate to identify the botanical species in question.

Many of the botanical species identified from the campus trail originate from Brazil, 90% of them native species. The other 10% of the species are exotic, that is, they are not native to the country where they live, but have adapted very well in tropical climates.

The predominance of native species over exotic species is also found in other university campuses that have had their landscaping implemented, as is the case of the Federal University of Rio Grande do Norte (*Universidade Federal do Rio Grande do Norte*) (MACÊDO et al., 2012), Federal Technological University of Paraná Pato Branco campus (OLIVEIRA et al., 2009) and Federal University of Viçosa (EISENLOHR et al., 2008).

In some cases, depending on the region, there is a predominance of exotic species over native species, due to the practice found in Brazilian landscaping since colonial times, in which the use of plants from other regions stood out from the autochthonous ones, due to the lack of information for the use of native species in landscape projects (HOEHNE, 1930 apud HEIDEN et al., 2006).

The tree survey of the trail can serve as a subsidy for future vegetation management plans on campus, since in addition to the identification of the species, the geographical coordinates of each specimen and their georeferencing were also raised, as well as the tree enrichment with native species, a practice that has been encouraged in recent years by the Municipal Secretariat of Green and Environment (Secretaria Municipal do Verde e Meio Ambiente - SVMA) (1993).

### **Didactic strategies for the teaching of Botany**

Although the tree composition of the trail does not present a great diversity of tree species, these can be used for the implementation of educational activities of biology, especially botany.

From the tree survey developed an Illustrated Guide with the diversity of tree species found along the trail. The guide aims to popularize the knowledge of the tree species present in the trail, in order to promote the species present in it and provide information regarding it.

From the tree survey developed an Illustrated Guide with the diversity of tree species found along the trail. The guide aims to popularize the knowledge of the tree species present in the trail, in order to promote the species present in it and provide information regarding it.

The guide provides subsidies for the easy identification of plants through the use of photographs of their main identifying components. The included text provides information such as: family, scientific name, popular name, name in the Tikuna language, geographical positioning, as well as other information regarding the plant. Each species is presented on a single page where images and information about it are included.

The Tikuna language was used in this guide because it's an ethnic group present in the Alto Solimões region, where the Institute of Nature and Culture - INC/UFAM is located, and a small part of the students are indigenous.



The use of the illustrative guide, based on the tree survey, can have numerous purposes in botany classes such as the study of diversity, evolutionary relations, organization in groups, morphology, through the simple comparison and visual observation of the different specimens found on the trail.

Botanical collections are important in teaching, research and extension, helping the teaching-learning process of large groups of plants. In addition, the collection can also attract the attention of basic education students to encourage collections of plant material from that location, thus increasing the potential and recognizing its rich biodiversity (MOURA et al., 2021).

Another illustrative instrument for the teaching of Botany elaborated was a botanical glossary, this has terms used within the language of the same and its meaning. The glossary has illustrative images of the composition of the leaves, flowers and fruits. Using the available bibliography, the description of all botanical terms was made, condensed in a glossary, included in the dichotomous keys as well as in the descriptions of the various taxonomic categories.

This provides the student to know the terms of the Botanical language, being easy to use as a tool for teachers and students of secondary and university, as well as by amateur botanists. The glossary was also enriched with several illustrative drawings (scientific illustrations) referring to the arrangement and ribbing of the leaves, types of corolla and fruits, among others.

Didactic potential of botanical identification in the ecological trail.

The teaching of Botany provides for the knowledge of the basic aspects of plant anatomy and physiology, valuing them as important components of the balance of the vital processes of the organisms studied (RAVEN et al. 2007). Learning is easier and more motivating when observing living specimens of the various plant groups, which is absolutely feasible in the Amazon region.

The methodology of field work has the differential of allowing the direct contact of the student with the fact, phenomenon or concept to be assimilated or modified in the structure of knowledge already existing in it. It was expected that the interaction between student/teacher and flora of the region (set of plants typical of the place) could promote a consistent acquisition of knowledge, by establishing exchange and active involvement among the participants.

It has long been necessary to seek alternatives that enable reflections on the relations between the human being and the environment and the environmental interpretation through

In this way, carrying out practical classes in non-formal spaces, in this case, in natural environments, should be a widespread practice in schools of different levels and spheres in the interior of the Amazon. Because we have in our hands a natural laboratory that in itself offers conditions to be explored in different approaches (FAVORETTI et al., 2020).

According to Mantovani (1985) one of the tools used to facilitate the identification of species in the field is the dichotomous key. This key can use vegetative and/or reproductive characters to facilitate their identification. The elaboration of an identification key for field use is of importance for students (undergraduate and graduate), researchers and professionals in the area, because it's used to carry out any study of the local flora (floristics, interactions, communities, extraction, feasibility of exploration, management plans, among others).

Thus, the proposal of an interpretative track with the use of the morphological identification key, testing the potential of the material now made for the purpose of serving as an educational tool in the teaching of Botany.

According to the graph above, it's remarkable the large number of correct answers based on the use of the identification key aimed at the species of the trail, and it can be said that it presented a huge potential for the use of practices related to the discipline of Botany, mainly focused on Botanical Systematics.

We can maintain that the survey carried out on the trail subsidizes the knowledge of some botanical species present in the region, although some species on the trail could be identified up to the genus level only. The choice of only ten species for the preparation of the identification key allowed the verification of its effectiveness in the track for the purpose of obtaining data for the writing of the present study. However, in order to add information about this method proposed to the results presented here, it's recommended that studies be dedicated in order to increase the number of species in the key, enhancing both its use for didactic purposes, as well as obtaining information to be increased in this resource proposed here.

It's also intended that future works of continuity to the methodological proposal of concomitant and interactive use of the key with the track take into account the insertion of technical sheets with striking information of each family (ZANATTA et al. 2015), enriching this valuable tool that proved to be the identification key. Richly illustrated with native species, the tool also fills part of the still existing gap of didactic resources in botany contributing to the teaching of this discipline and, extensively, to the quality of the studies carried out with this flora through access to the information contained in the material produced.

Finally, this survey provided the knowledge of many species existing on the trail, going against the still underuse of the same in methodological proposals in the teaching-learning of disciplines related to Botany taught in campus courses or in environmental education activities.

### **Final considerations**

The variety of botanical species obtained in the tree survey on the trail denotes the great potential existing in it with regard to the development of environmental interpretation activities that address integration methodologies and environmental and cultural analysis,

therefore and still extensive to the participation of society in an integrated way with the environment. Obviously, its value is emphasized within the scope of expanding botanical knowledge about native species on the trail.

The process of recognition and then systematization and availability of information - reflected in the elaboration of the guide and the key as a pedagogical proposal - requires dedication to studies that reinforce the informative potential of the material. This aspect not only implicitly brings its value as a subsidy to classes and future studies, but also to the realization of practices that bring students closer to the appropriation of knowledge, in addition to their insertion in a space that favors the discussion of other aspects related to elements that arise by the approximation with nature. It's the understanding of values that permeate intellectual knowledge, entering the scope of felt knowledge, which can be translated into the different ways of transcending knowledge about nature and its vital elements.

Therefore, the present work extends its value to the expansion of what can be applied pedagogically in order to embrace activities that presuppose the participation and interaction of the individual in the process of construction of botanical knowledge, beyond the simple content approach until then normally adopted in education, before the current and still unborn awakening to a felt and lived education.

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