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*Original article*

# Contact with natural areas influences Brazilian high school students' ability to recognize native plant species

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## ABSTRACT

Limited experiential contact to natural environment can affect the knowledge of the local flora and, consequently, the intentions to conserve it. Therefore, this study aims to analyze whether high school students from Teresina (PI-Brazil) can identify more species of native than exotic plants and the factors that can affect this ability. 333 students from state public schools were interviewed through semi-structured questionnaires and with printed images of 20 species of plants found in the region. The data were analyzed using univariate non-parametric statistics. The results show that living in the countryside positively influenced the identification of local flora, but there was no significant difference in the number of identified plants between students who attended botany classes and those who did not. Two native plants (cashew-96.7% and pitomba-91.9%) and three exotic plants (mango-90.7%, guava-94.9% and acerola-82.0%) stood out among the most identified plant species. It was also found that, for two species of native plants very important for the State of Piauí, the caneleiro (0.6%) and the carnauba (26.7%), the identification rates were scarce. Thus, it is necessary to use Environmental Education and the teaching of Botany to prioritize native plant species, valuing local ecology and ensuring their protection.

**Keywords:** Teaching botany. Plant unawareness. Environmental conservation. Local Plant Species. Teresina (PI).

## Introduction

Population growth, urban sprawl, and its economic practices are highlighted as the leading causes for changes in vegetation, bringing inevitable consequences to biodiversity (Proença *et al*. 2011). Authors such as Buczkowski and Richmond (2012) believe that the lack of "contact with natural environment" makes this situation more chaotic. Distancing from the natural environment occurs primarily due to the lifestyle of modern society, which has become an obstacle to practices aimed at natural environment protection. The lack of contact with the natural environment of young people is pointed out by Louv (2005), and the

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generalization of environment knowledge is demonstrated by Driessnack (2009). Both of these aspects when added to the physical impacts of environment degradation, such as fragmentation of habitats, impact on the environment richness and abundance of fauna and flora, as well as the decrease and extinction of native species (Connor *et al.* 2002; Morini *et al.* 2007; Sanford *et al.* 2008; Buczkowski & Richmond 2012; Lutinski *et al.* 2014) aggravate the process of disconnection with the natural environment.

In Brazil, the distance from natural environment may contribute to the little knowledge about native flora, which represents one of the world's most exceptional biodiversity of flora. However, the distance from natural environment may contribute to the little knowledge about its native flora, especially for future generations. For example, studies suggest that Brazilians might frequently identify exotic plants because they are part of Brazilians' daily life either as a nutrition source (fruits and vegetables) or as reforestation projects (Itii & Campos 2012; Santos Junior 2013; Soares Filho 2017). Although Brazil has plant species with food potential, few are produced on a large scale and are hardly commercialized in supermarkets (Santos Junior 2013). Many plant species widely used as food in the country are considered naturalized exotic species, once their survival and reproduction occur naturally in the regions where they are now found (Richardson *et al.* 2008), making it difficult to identify their origin.

The diffusion of exotic species in the daily lives of populations, the growing urbanization, and the distance from green areas may reflect the little knowledge children and young people have of native species and their local environment. These factors can affect the understanding of the importance of environmental conservation and the feeling of belonging to the environment in which they live. According to Proença *et al.* (2017), the recognition of the local environment enables relevant parameters, such as the local culture, to be included in educational strategies making students understand the social and educational importance of native species.

Thereby, this devaluation of local plant species is reflected in the school context. Youngsters can define global warming, the forest, and the impact of Amazon's deforestation. However, they do not know how plants grow in their backyards (Driessnack 2009), which suggests the lack of connection with the place where they live. Research applied to Brazilian Primary School students demonstrated that exotic plant species are mentioned among the native plant species (Silveira & Farias 2009; Miyazawa *et al.* 2015; Proença *et al.* 2017; Agrizzi *et al.* 2020). This happens, mainly, due to the low quantity of native flora examples in Brazilian textbooks (Sales & Landim 2009; Marinho *et al.* 2015; Purificação & Lopes 2018), media (television broadcasts, cartoons, TV series), Botany classes (Towata *et al.* 2010) or a utilitarian vision of natural environment for example (Bitencourt *et al.* 2011). Besides, this fact is probably consistent with both urbanization and substitution of the native by exotic species and can be a consequence of the native diversity's undervalue.

Silveira and Farias (2009) report that students have good prior knowledge about plants, especially exotic ones. Some factors may be related to this conclusion. One of them is how Botany courses are understood locally. Mostly, Botany courses in high schools are understood as something superfluous and students are not incentivized. Further, they are decontextualized from students' reality (Salatino & Buckeridge 2016). Due to this situation, students, mainly high school students, have an insufficient understanding of biodiversity (García & Hernández 2004).

According to the National Curriculum Guidelines for Secondary Education (PCN - Resolution CBE/CNE nº 03/1998), students should learn Botany with an evolutionary-ecological approach. This approach is the geological history of life (Brasil 2000), which is a very specific context. The combination of this curriculum specificity with the socio-environmental problems seen in the country (Arrais & Bizerril 2020) affects teaching and Environmental Education (EE), once teachers focus on these environmental problems and not on subsidizing Botany courses in public schools. Botany classes should be a tool for understanding environmental problems and identifying that plants form the main ecosystems' components (Vilas Boas 2015).

Thus, obtaining information about the plant species known by young students and the affecting factors of this knowledge is essential to guide methodologies in teaching Botany. Although researchers have investigated the study of Botany in the school environment (see Bitencourt *et al.* 2011; Silva & Ghilardi-Lopes 2014; Agrizzi *et al.* 2020), little is known about how the contact with natural environment and television programs dedicated to Botany, for example, can influence Brazilian students' capacity to recognize species. Moreover, different European and North American authors suggest that the species' identification (referred here as recognition), of either flora or fauna, is a viable teaching strategy, considering that students tend to identify a plant or animal (from visual stimuli) rather than mention their name spontaneously (Palmberg *et al.* 2015; Rosalino *et al.* 2017; Aruguete *et al.* 2019; Hooykaas *et al.* 2019). This recognition contributes to the respect for the local fauna and flora, which increases the identity with native landscapes and biodiversity, and consequently, the concern to conserve them (Bizerril 2004).

Thus, the objective of this research was to evaluate the ability of high school students in the city of Teresina (PI), Brazil, to recognize native plant species, the part of the plant that they use to recognize, and the factors that can influence the recognition of plant species. The main factors considered as variables were conviviality with rural areas and agricultural practices, botany classes and means of information by television programs on botanical issues, and if students can differentiate native and exotic plant species,

beyond its purposes. Accordingly, this research's hypotheses tested were the following: (a) there are significant differences between the recognition of exotic and native species; (b) factors such as living in or contact with rural areas, Botany classes, TV programs, and knowing how to conceptualize exotic and native species influence the recognition of plants by students. The research area chosen is the municipality of Teresina, Piauí, northeastern Brazil, due to the high urbanization and the existence of high schools distributed in different areas, which serve students not only from urban areas but also rural areas.

## Materials and methods

### *Target region and students*

The research took place in Teresina (05°5'20" S and 42°48'07" W), Piauí State capital, in the Northeast of Brazil. The city has 814.230 inhabitants (IBGE 2010), of which 94,3% live in urban areas (Pnud 2013). The city has a tropical savanna climate, with a six-month dry season, with an average annual temperature of 26 °C and precipitation in between 1300 mm and 1600 mm (Alvares *et al.* 2013). The natural vegetation consists of mixed secondary deciduous tropical forest, babassu palms, and cerrado (Brazilian savanna) (Cepro 2010).

Data collected refer to answers given by High School students of the Public-School System of the State of Piauí (Brazil). The total number of schools was surveyed based on data obtained from the website Qedu (http://www.qedu.org.br/), which include schools across the country based on the 2016 School Census, besides the documents made available by Secretary of Education and Culture of the State of Piauí (SEDUC). Teresina has a substantial number of schools in relation to other municipalities in the State, totaling 106 high schools (Qedu 2016). In this research, students from 13 schools were included, which were chosen randomly by sortition and classified by city zones: Center, Southeast, South, Northeast, and North (classification proposed by SEDUC) (Fig. 1). Two schools were drawn in each zone, and for those zones that had few students in the classes, another school was drawn (Center, North, and Northeast). With this classification, it was possible to identify central areas of the city (for example, Center-North, Southeast) that concentrate the essential educational and health services. Further, they often attract the rural population of the municipality (Cruz *et al.* 2016; Lima *et al.* 2017).

A total of 333 third grade students participated in this study. Students from this grade level were preferably selected because it is the concluding level of the secondary school in Brazil, according to the National Educational Guidelines and Framework Law (nº 9,393/1996 - LDB) and the National Curriculum Guidelines for Secondary Education (PCN - Resolution CBE/CNE nº 03/1998). This legal determination makes it conceivable to investigate the acquired knowledge about biodiversity in this formal educational level (Brasil 2013).

Also, as the research involves the collection of data based on the interview of people the rule imposed by Resolution nº 466/12 of the National Research Ethics Committee was followed. This work is linked to the project registered at Plataforma Brazil, approved under protocol nº 2.763.982 by the Research Ethics Committee (CEP) of the Federal University of Piauí (UFPI). For participants over the age of 18, the Free and Informed Consent Form for Qualitative Studies was issued in two copies, one being filed by the student and the other by the researcher. For cases of respondents under the age of 18, parents were given a Consent Form, also drawn up in two copies, authorizing the participation of their sons and daughters in the study.

### *Data collection and analysis*

For data collection, semi-structured questionnaires were used. The questions addressed aspects such as age and gender, along with the variables: (a) conviviality with less urbanized areas (rural area); (b) if they attended botany classes; (c) TV programs that address botanical issues (forests and other ecosystems, gardening, cooking, camping); (d) knowledge of the concepts of native and exotic plant species. The variable (a) concerns the fact that both urban and rural students attend the schools, where the researchers applied the questionnaires (they move/travel in search of employment, education, and health) (Lima *et al.* 2017). Concerning conviviality in less urbanized areas, the questionnaire presented three options: 1. Do you live in the countryside? 2. Do you frequently travel to the countryside? and 3. Have you ever been engaged in or are you engaged in any agricultural activity? These three questions were grouped into a single variable (conviviality with rural area).

Variables (b) and (d) were chosen because this research is based on the premise that in Botany (Science and Biology) subjects students experience content that favors the recognition of plant biodiversity, as well as concepts, threats, and effects of human activity on this biodiversity (as is the case with the introduction of species).

In order to obtain the information about the species recognition, it was adopted 20 questions related to the identification of plants in printed images and their uses (Supplementary Data). The presentation order of the printed images was carried out randomly and did not present any identification regarding the name of the species (scientific or common names) and its origin (native or exotic). It was considered that students knew the plant when they correctly refer to the species' common name.

For the 20 questions that referred to the identification of plant species, visual stimulus (printed images) were used. They showed high-resolution photographs (≥ 3 Megapixel) of native plant species, belonging to the study region, and naturalized exotic plant species (Supplementary Data). The species were selected based on the following criteria:

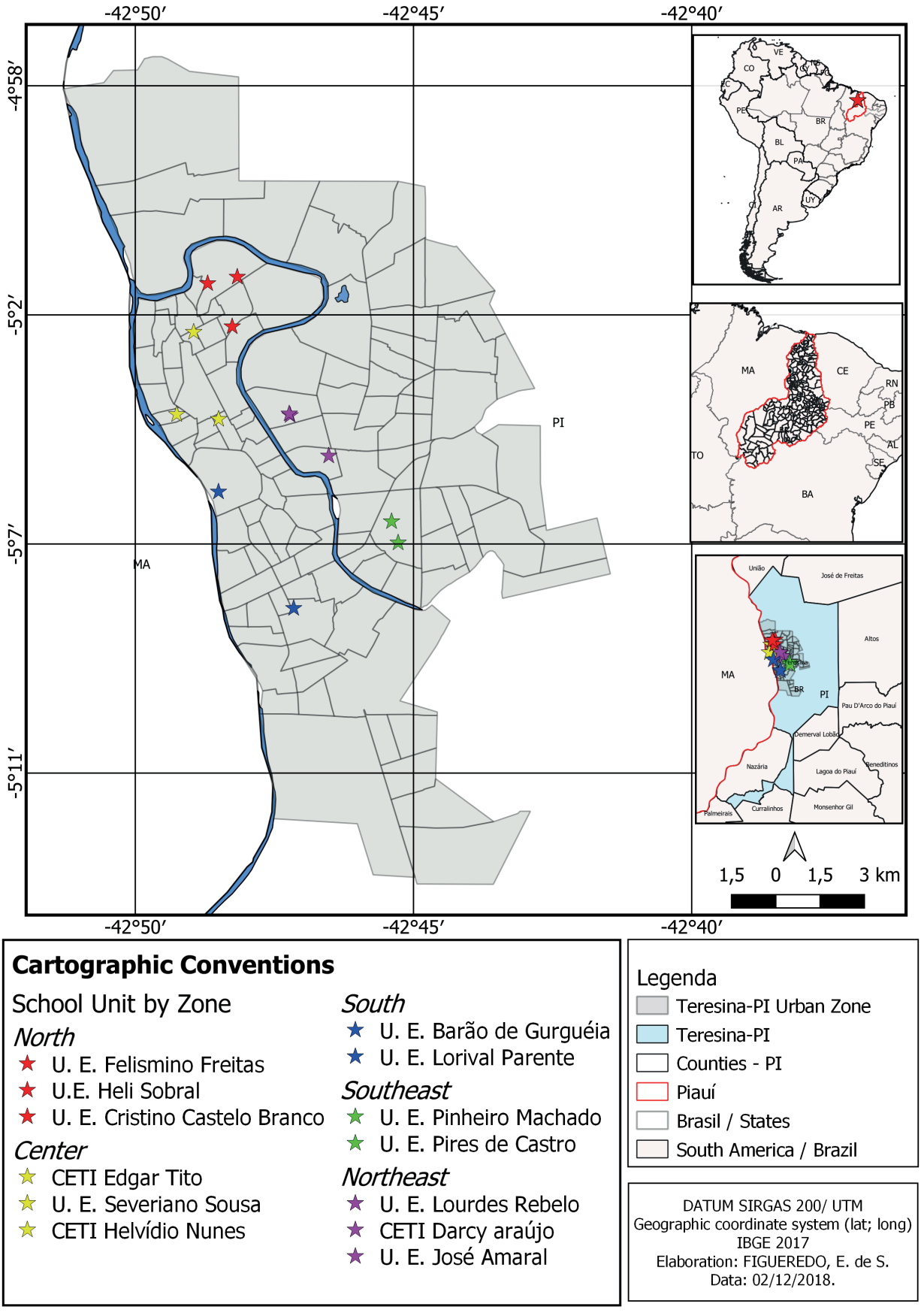


**Figure 1.** Distribution of public high schools in the city of Teresina, Piauí, which participated in this research.

native - to be known locally and to have importance in the daily lives of local populations; exotic - having significant commercialization and being well-portrayed in teaching materials and the media (TV programs). The researchers obtained the images used in the research from their private resources, from specific educational materials related to the research area (Lorenzi 2008; 2009), and from databases (e.g., Flickr ©, Google ™ Images ©) with a public license for non-commercial use. From the 20 plant species that were selected and displayed on the planks, 12 were native, and 8 were exotic (Table 1).

The research used definitions by the National Environment Council (CONAMA) to analyze answers regarding concepts of native and exotic plant species. CONAMA's definition states that a native species "presents its natural populations within the limits of its geographic distribution participating in ecosystems where it presents its levels of interaction and demographic controls" and that an exotic species is "any species outside its natural area of geographic distribution" (Brasil 2011, p. 76). The classification as native or exotic plant species was confirmed using data from the website Plants of Brazil 2020 - Algae, Fungi, and Plants (http://floradobrasil.jbrj.gov.br/reflora/) and the document provided by CNIP – Northeastern Center of Information on Plants (http://www.cnip.org.br/).

The results were tabulated and analyzed using non-parametric univariate statistics (Mann-Whitney U test), as it has an independent distribution. The letter "U" represents the test value. The statistic differences are represented by the value of the mean rank and p, being significant when $p \leq 0.05$. In accordance with each variable (a, b, and c), the analyzes were made comparing groups of answers and their relations with plant species. For example: conviviality or not with rural areas or practicing agricultural activities influences the ability of recognition more plant species. All analyzes were performed using software R version 3.5.1. The level of significance adopted was 5% ($p \leq 0.05$) in all cases.

## Results

Within the students who took part in the research, 47.1% were male and 52.9% female, with ages varying from 15 to 25 (average age was 17.5). Among the students, 57.6%, mentioned conviviality with rural areas, 84.9% took Botany classes, 66.1% do not watch TV programs about

**Table 1.** Presentation order of planks with images of native and exotic plant species used in the research with students from Teresina - Piauí.

| Order | Cientific name | Popular name | Source |
|---|---|---|---|
| 1 | *Punica granatum* L. | Pomegranate | Exotic |
| 2 | *Copernicia prunifera* (Miller) H.E. Moore | Carnaúba* | Native |
| 3 | *Moquilea tomentosa* Benth. | Oiti* | Native |
| 4 | *Attalea speciosa* Mart. ex Spreng | Babaçu* | Native |
| 5 | *Azadirachta indica* A. Juss. | Neem/ Nim / Ninho* | Exotic |
| 6 | *Hibiscus rosa-sinensis* Linn. | Hibiscus | Exotic |
| 7 | *Delonix regia* (Hook.) Raf. | Flamboyant | Exotic |
| 8 | *Malpighia emarginata* DC. | Acerola* | Exotic |
| 9 | *Mangifera indica* L. | Mango | Exotic |
| 10 | *Spondias mombin* L. | Cajá* | Native |
| 11 | *Anacardium occidentale* L. | Caju* | Native |
| 12 | *Handroanthus serratifolius* (Vahl) S.O. Grose | Ipê-amarelo / Pau D´arco* | Native |
| 13 | *Talisia esculenta* (A.St.-Hil.) Radlk. | Pitomba* | Native |
| 14 | *Eucalyptus* sp | Eucalyptus | Exotic |
| 15 | *Cenostigma macrophyllum* Tul. | Caneleiro / canela-de-velho* | Native |
| 16 | *Bougainvillea spectabilis* Willd. | Bougainville / Primavera / Três Marias* | Native |
| 17 | *Caryocar coriaceum* Wittm. | Piqui* | Native |
| 18 | *Astronium urundeuva* (M.Allemão) Engl. | Aroeira* | Native |
| 19 | *Psidium guajava* L. | Guava | Exotic |
| 20 | *Anadenanthera colubrina* (Vell.) Brenan | Angico* | Native |

* Popular names in the city of Teresina.

botanical topics. Over 60% of students correctly reported the concepts of native and exotic plant species. These and other data are summarized in Table 2.

**Table 2.** Socioeconomic profile of interviewed students.

| Variables | n (%) |
|---|---|
| **Gender** | |
| Male | 157 (47.1%) |
| Female | 176 (52.9%) |
| **Conviviality with less urbanized areas (rural area)** | |
| Yes | 192 (57.6%) |
| No | 141 (42.4%) |
| **Students that attended botany classes** | |
| Yes | 283 (84.9%) |
| No | 50 (15.1%) |
| **Students that watched TV programs that address botanical issues** | |
| Yes | 113 (33.9%) |
| No | 220 (66.1%) |
| **Students that correctly answered about the concepts of native plant species** | |
| Yes | 212 (63.6%) |
| No | 121 (36.4%) |
| **Students that correctly answered about the concepts of exotic plant species** | |
| Yes | 207 (62.2%) |
| No | 126 (37.8%) |

The total number of plant species recognized by the young students showed significant differences. They recognized more native plants (Mann–Whitney U test = 49777; mean $rank_{native}$ = 175.26; mean $rank_{exotic}$ = 158.24; $p$ = 0.0184). Of the 20 species showed, five were better identified, with a percentage higher than 80%, being: cashew (*Anacardium occidentale*), guava (*Psidium guajava*), pitomba (*Talisia esculenta*), mango (*Mangifera indica*) and acerola (*Malpighia emarginata*), two native and three exotic plant species (Fig. 2). The plant species that were lesser recognized showed percentages < 2%. They are oiti (*Moquilea tomentosa*), caneleiro (*Cenostigma macrophyllum*), flamboyant (*Delonix regia*), bouganville, or três-marias (*Bougainville spectabilis*), aroeira (*Astronium urundeuva*) and angico (*Anadenanthera colubrina*). In this list, five are native plant species, and only one is exotic (Fig. 2).

It should be noted that the five plant species with the highest percentage of identification are fruit trees, and of all the suggested parts (whole plant, stem, leaf, flower, fruit, and seed), the fruit was the plant part that helped most in the process of recognition (Table 3). Students could point out the plant species whose primary utility is food, and in this case, these species were the most easily identified by them (Table 4).

Among the variables analyzed in this study, the results demonstrate that the students who have conviviality with rural areas tend to recognize more plant species (Table 5). Additionally, these students have wider recognition of native species and can recognize more exotic plants than those

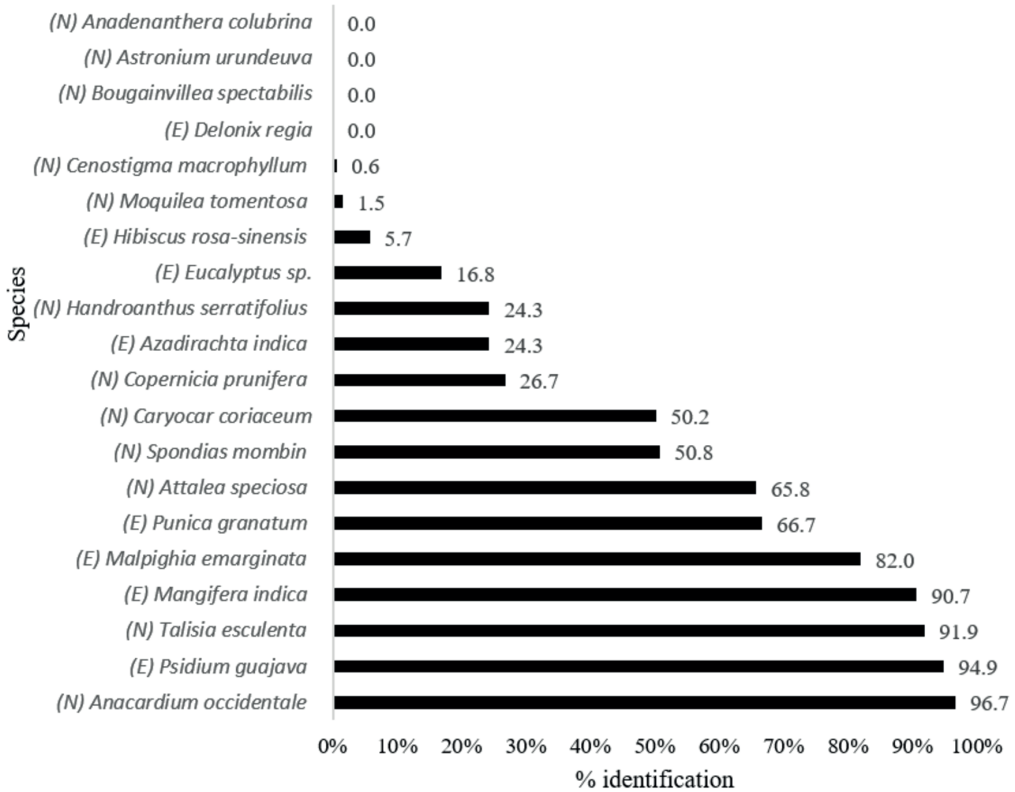


**Figure 2.** Percentage of identification of native (N) and exotic (E) plant species by Grade 3 students from Teresina - PI.

**Table 3.** Percentage of plant parts from known species that helped the correct identification by Grade 3 students from Teresina - PI.

| Scientific name | Whole plant | Stalk | Leaf | Flower | Fruit | Seed |
|---|---|---|---|---|---|---|
| (E) *Punica granatum* | 10.2% | 2.4% | 3.3% | 8.7% | 64.3% | 22.5% |
| (N) *Copernicia prunifera* | 33.9% | 10.8% | 20.1% | 2.7% | 32.4% | 6.3% |
| (N) *Moquilea tomentosa* | 6.6% | 2.1% | 3.6% | 4.2% | 25.8% | 3.6% |
| (N) *Attalea speciosa* | 46.8% | 6.3% | 11.7% | 3% | 39.6% | 6.6% |
| (E) *Azadirachta indica* | 21.6% | 5.1% | 14.7% | 5.7% | 13.2% | 3.6% |
| (E) *Hibiscus rosa-sinensis* | 9.3% | 1.2% | 5.1% | 31.2% | 0.3% | 0% |
| (E) *Malpighia emarginata* | 44.1% | 5.7% | 10.2% | 13.5% | 47.1% | 18.6% |
| (E) *Mangifera indica* | 52.9% | 6.3% | 10.8% | 10.5% | 47.1% | 10.2% |
| (N) *Spondias mombin* | 30.6% | 6.6% | 6% | 3.9% | 60.1% | 14.7% |
| (N) *Anacardium occidentale* | 55% | 4.8% | 12% | 11.4% | 49.5% | 20.4% |
| (N) *Handroanthus serratifolius* | 9.9% | 3.6% | 5.4% | 16.5% | 2.7% | 1.2% |
| (N) *Talisia esculenta* | 33.3% | 3.9% | 8.1% | 6% | 64.3% | 13.8% |
| (E) *Eucalyptus sp.* | 9.9% | 5.4% | 4.5% | 2.7% | 6.6% | 1.8% |
| (N) *Cenostigma macrophyllum* | 2.4% | 3% | 3.3% | 2.1% | 4.2% | 2.1% |
| (N) *Caryocar coriaceum* | 12.9% | 3.3% | 5.4% | 4.5% | 45.6% | 8.4% |
| (E) *Psidium guajava* | 48.9% | 9.6% | 12% | 9.6% | 55.6% | 14.7% |

**Table 4.** Percentage of the uses of the five plant species most easily identified by Grade 3 students in Teresina - PI.

| Specie | Timber | Food | Medicine | Ornamental |
|---|---|---|---|---|
| *Anacardium occidentale* | 4.2% | 96.7% | 8.7% | 3% |
| *Psidium guajava* | 2.4% | 96.4% | 11.7% | 1.8% |
| *Talisia esculenta* | 0.3% | 93.3% | 4.2% | 3% |
| *Mangifera indica* | 6% | 91.8% | 4.5% | 1.5% |
| *Malpighia emarginata* | 0.6% | 85.2% | 7.2% | 1.8% |

**Table 5.** Variables that influenced the recognition of general, native and exotic plant species, with $p < 0.05$.

| Variables | Mann-Whitney U test | Mean ranking | *p* Value |
|---|---|---|---|
| Conviviality with rural areas (No X Yes) | U = 10542 | Mean $rankin_{sim}$ = 105.28<br>Mean $rankin_{não}$ = 61.72 | *p = 0.0005* |
| Conviviality with rural areas (No X Yes) natives sp. | U = 10789 | Mean $rankin_{sim}$ = 104.54<br>Mean $rankin_{não}$ = 62.46 | *p = 0.0013* |
| Conviviality with rural areas (No X Yes) exotics sp. | U = 10922 | Mean $rankin_{sim}$ = 104.14<br>Mean $rankin_{não}$ = 62.86 | *p = 0.0016* |
| Conviviality with rural areas (Yes) general sp. | U = 16118 | Mean $rankin_{nativa}$ = 102.28<br>Mean $rankin_{exótica}$ = 90.22 | *p = 0.0308* |
| TV programs<br>(Yes X No) | U = 10470 | Mean $rankin_{sim}$ = 62.56<br>Mean $rankin_{não}$ = 104.44 | *p = 0.0182* |
| TV programs<br>(Yes X Não) natives sp. | U = 10636 | Mean $rankin_{sim}$ = 62.06<br>Mean $rankin_{não}$ = 104.94 | *p = 0.0278* |
| TV programs<br>(Yes X No) exotics sp. | U = 10492 | Mean $rankin_{sim}$ = 62.49<br>Mean $rankin_{não}$ = 104.51 | *p = 0.0178* |
| Correct answer about the native species concept<br>(Yes) general sp. | U = 19899 | Mean $rankin_{nativa}$ = 112.32<br>Mean $rankin_{exótica}$ = 100.18 | *p = 0.0361* |
| Correct answer about the exotic species concept<br>(Yes X No) | U = 11105 | Mean $rankin_{sim}$ = 109.63<br>Mean $rankin_{não}$ = 57.374 | *p = 0.0204* |
| Correct answer about the exotic species concept (Yes X No)<br>natives sp. | U = 11052 | Mean $rankin_{sim}$ = 109.79<br>Mean $rankin_{não}$ = 57.215 | *p = 0.0196* |
| Correct answer about the exotic species concept<br>(Yes) general sp. | U = 18246 | Mean $rankin_{nativa}$ = 111.43<br>Mean $rankin_{exótica}$ = 96.072 | *p = 0.0087* |

who do not have contact with such areas (Table 5), showing that the experience of life in the field positively influences students' ability to identify plant species. However, by comparison, the number of native and exotic plants known by students who have no contact with rural areas did not show significant differences (Mann–Whitney U test = 9190, $p > 0.05$).

When analyzing whether there is a difference regarding the ability of identification of plants by students who had taken Botany classes and the ones who have not, the research found that this variable did not influence, as there were no meaningful differences in the analyzes performed. Comparisons between the students who had and students who had not had Botany classes as well as differences between the recognition of exotic and native plants were not significant, that is, $p > 0.05$ in all cases. But watching or not watching TV programs regarding botanical topics influenced the recognition of native and exotic species (Table 5). The results demonstrate that students who do not watch any television material about plant species know more native and exotic plants than students who watch. As for the total number of recognized plant species, students who do not watch any specific TV program on botanical issues ended up identifying a higher number of plants than those who watch some specific TV program on botanical issues (Table 5).

Regarding the influence of the correct concept of native species on plant recognition, the results indicate one difference: students who got the concept of native plants right could identify more native plant species than exotic ones (Table 5). Thus, no significant differences were found in the total number of plants recognized by students and for exotic and native plants recognized by students who did not get the concept right, with $p > 0.05$ in all cases. Students who correctly answered the proposed concept for exotic plants could identify more native than exotic plants (Table 5). Similarly, students who correctly answered the proposed concept recognized more native species than those who didn't, as well as recognizing more plants in general (Table 5).

## Discussion

In this study, the students' contact with the natural environment may have contribuited them to identify a significantly greater number of flora species. Zhang *et al.* (2014) suggest that contact with less urbanized areas increased the biophilia and decreased the biophobia of urban and rural children in different cities in China, providing more interest in conserving animal and plant species. Similarly, Sampaio *et al.* (2018) found that Brazilian children who have contact with a forest or proximity to a natural area, even in urban areas, had more knowledge about local biodiversity.

The plant species best known by students are those that are close to them and which their fruits are consumed in their diet, in accordance with authors, reinforcing the importance of direct experience to acquire knowledge about plants and animals (Campos *et al.* 2012; Patrick *et al.* 2013; Agrizzi *et al.* 2020). For example, cashew (*A. occidentale*), pitomba (*T. esculenta*), guava (*P. guajava*), mango (*M. indica*), and acerola (*M. emarginata*), which were the most recognized, likely because the students have personal experience with them, either through their inclusion in the diet (such as fresh fruits, nuts, pseudo fruits, juices, pulps, sweets, beverages, jellies, among others) (Vieira & Gusmão 2006; Sebrae Nacional 2016; Serrano & Pessoa 2016), through backyard cultivation, or the reforestation of public roads (Moraes *et al.* 2016a; b; Prefeitura Municipal de Teresina 2017). Direct experience, characterized by physical engagement with natural environments and interactions with non-human species, constitutes one of the three categories of nature encounters that profoundly influence children's development. Kellert (2002) emphasize the significance of children's direct engagement with diverse natural systems during their formative years, alongside indirect and symbolic/vicarious experiences, in fostering their overall maturation.

Some native species from Northeastern Brazil, such as oiti (*M. tomentosa*), caneleiro (*C. macrophyllum)*, angico (*A. colubrina*), and aroeira (*A. urundeuva*), were not recognized by the students in this study. This supports the hypothesis that students are more likely to recognize plant species that they are familiar with, i.e., those that are part of their diet. Even though they are part of the central public roads (Machado *et al.* 2006; Moraes *et al.* 2016a), the students were unable to notice them in these environments. Accordingly, we highlight the use of visual aids (such as the printed images used here) to help develop the ability to recognize floristic species in the environment minimizing "plant unawareness" (Ursi & Salatino 2022; formerly "plant blindness" sensu Wanders & Schussler 1998) in schools and the daily lives of students. This approach is especially important for native plants of cultural significance, such as the *C. macrophyllum* (plant species symbol of municipality of Teresina, according to the Municipal Decree nº 2.407, of 13th of August 1993 – Soares 2001).

In this context, the contact with plant species can contribute to the knowledge of the local flora, as students are more likely to identify species that are efficiently present in their daily lives, especially as food, which is commonly represented by exotic plant species. Thus, it is imperative that the population, especially the youngest, get to know native plant species to protect them (Scherer *et al.* 2015). Engagement in the field of conservation is of great value, especially in urban areas where perceptions, values, and personal participation in the protection of biodiversity are necessary (Borg *et al.* 2014). Therefore, this study highlights the importance of schools to encourage the contact of

children and adolescents with native forests, which can contribute to more excellent knowledge of native flora and greater connectedness to natural environments, besides assisting in the learning process of the school content on Biology. Educational strategies can be used to improve this contact, such as theoretical-practical classes (Melo 2010) and field classes, which can stimulate feelings and emotions in students, which help in the process of understanding phenomena and learning, as well as in the development of affection for ecosystems (Seniciato & Cavassan 2004), and pro-ecological behaviors to protect them.

Students who reported having attended botany classes did not identify more plants than those who did not attend. This can be attributed to various factors, such as neglect of these contents and the lack of attention given to plant species, as reported by Scherer *et al.* (2015). However, this situation is not only present in Brazil, as studies conducted in European countries also report difficulties in teaching Botany (Palmberg *et al.* 2015; Kubiatko *et al.* 2021). It appears to be a vicious cycle where many teachers lack sufficient training in Botany, leading to a lack of stimulus and motivation for students to learn the content. As a result, students become disengaged and lose interest in the topic (Salatino & Buckeridge 2016).

Fonseca and Ramos (2018) also emphasize that the lack of botanical contextualization is present in teachers' training during University education. The authors indicate that undergraduate courses are focused on the absorption of trivial content and research. Further, more current themes are overvalued (such as genetics and ecology), and with little concern about how Botany will be taught and applied to the daily life of elementary and high school students. According to Figueiredo *et al.* (2012), educational programs and pedagogical practices used in Botany teaching reflect what happens in University education, creating a disconnect in the exchange of information between teacher and student.

Sales and Landim (2009) believe that teachers should emphasize the local biodiversity in their classes. Unfortunately, in Brazil, there is often a tendency to undervalue the teaching of local biological diversity, so the richness of regional species is not used to try to explain biodiversity (John 2006). Schroeder (2013) also mentions that, often, the scientific contents taught in schools is often disconnected from students' daily lives. A related issue is the biology textbook, which is frequently the only source of access to biological knowledge, mainly in public schools due to the low purchasing power of students and the precarious working conditions of teachers (Megid-Neto & Fracalanza 2003; Delizoicov *et al.* 2009; Bonotto & Semprebone 2010), besides poor public schools' infrastructures like the lack of complete and useful libraries with computers and organized book collections. In our specific area of study, Purificação and Lopes (2018) found that Science textbooks used in the 7th year of elementary school give little attention to specimens of native flora, both in terms of the images/illustrations and the text. We emphasize that this biological knowledge is essential not only as educational content but also for the formation of students as citizens who are aware of the reality around them (Silva & Cavassan 2005; Sales & Landim 2009; Proença *et al.* 2017).

The findings on watching television programs contradict those of García and Hernández (2004) and Scherer *et al.* (2015), who reported higher knowledge of exotic plant and animal species that are widely featured in such media. Possibly because both native and exotic species used for recognition are not circulating in the programs watched by students, since Cavassan *et al.* (2006, p. 7) emphasize that "most television programs, including films, cartoons, and documentaries watched by children are produced in the Northern Hemisphere". Moreover, only 33,1% of students reported watching TV programs focused on botanical topics. Thereby, television programs did not contribute significantly to the students' ability to identify Brazilian biodiversity, which reinforces the importance of the school in fulfilling this role.

Therefore, schools play an essential role in the acquisition of scientific concepts related to both exotic and native species. There is evidence that Brazilian teachers do not effectively approach these concepts with high school students, despite their presence in Botany content (Muller & Delazeri 2017; Santos & Oliveira 2017; Melo *et al.* 2021). Due to so many difficulties, teachers must seek and develop their materials and methodologies to adapt to this gap support them. Further studies are needed to emphasize the importance of native flora, raising awareness and appreciation (Carvalho 2019).

It is fundamental to discuss about Environmental Education and the conservation of plant species. They are responsible for providing food to herbivorous animals and boosting the entire food chain (Leme *et al.* 2016). Therefore, the consciousness of biodiversity protection is essential and it can be stimulated through knowledge of local species. Understanding the factors that affect knowledge can help to supporting Environmental Education actions more effectively. Moreover, the creation and application of Environmental Education programs contribute to students' knowledge about native and exotic species, emphasizing their contact with natural environment and seeking to value regional biodiversity (Scherer *et al.* 2015). The understanding of local fauna and flora can be utilized to foster an emotional connection with them, consequently promoting pro-environmental behaviors (Bizerril 2004).

When analyzing the variables mentioned above in this article, this study highlights the importance of contact with natural areas for the recognition of native species, which should be encouraged in schools through fieldwork classes or outdoor practices that stimulate contact with natural environment, especially for students living in urbanized

areas. The few contacts with natural environment have been occurring in the face of the intensification of the urbanization process, and also from a teaching that is decontextualized from the environment around them, and this can result in severe consequences for the conservation of the natural environment in the long term. Schools play a fundamental role in providing students with opportunities to contact with natural environments and learn about native diversity. This can be achieved not only through fieldwork but also by incorporating materials such as books, science texts, booklets, documentaries, and films that promote an appreciation of the local flora and fauna.

Lastly, this study indicates that there is a deficiency regarding the teaching of Biology in the municipality. To improve the situation, schools should develop approaches that provide methodological teaching strategies to support teachers in Botany classes. The use of native species can help students connect with the natural world and contextualize their learning to the local reality. This approach can promote recognition of native plant species and drive transformative processes for environmental conservation. It is important to believe that the school environment can effectively disseminate the importance of conserving native species and work with relevant agencies and society in general to achieve this goal.

## Supplementary material

Supplementary Data. Semi-structured questionnaire applied to high school students in Teresina - Piauí.

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