

# Wild Plants and the Food-medicine Continuum – An Ethnobotanical Survey in Chapada Diamantina (Northeastern Brazil)

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## Research

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# Abstract

**Background:** Ethnobotanical research has demonstrated that several wild food plants (WFP) are used for medicinal purposes. Therefore, in addition to constituting an important source of nutrients, WFP can be used to help treat and avoid health problems. This study sought to characterize the traditional use of plants considered simultaneously as food and medicine by local specialists in the community of Caeté-Açu, which borders Chapada Diamantina National Park (NE Brazil). We also sought to identify the drivers of species' cultural importance.

**Methods:** We selected local specialists based on a snowball sample and used a free-listing technique to register the wild plants they knew that are both edible and medicinal. Then, we asked the specialists to rank each plant component cited according to the following attributes: (1) ease of acquisition, (2) taste, (3) smell, (4) nutritional value, and (5) medicinal value. We used multiple regression to determine the drivers of popularity and frequency of use.

**Results:** The most culturally salient species was *Anredera cordifolia* (Ten.) Steenis. The main medicinal effects associated with this species were related to body strengthening, intestinal regulation, and stomach issues. The most salient used species were those that were easiest to acquire and had the highest perceived nutritional values.

**Conclusion:** It is likely that the sociocultural backgrounds of the respondents (elders, former miners or descendants of miners) and the historical importance of wild food plants to local diets increased the predictive power of the perceived nutritional potential and ease of acquisition of these plants.

## 1. Background

In many cases, medicinal and food uses of natural resources are so interconnected that it is difficult to establish when one use ends and the other begins [1]. Ethnobotanical studies have addressed this food-medicine continuum by evaluating the overlap between medicinal and edible uses in several social-ecological systems [2–5]. Although a large number of species are exclusively medicinal or exclusively edible, investigations have discovered outstanding intersections, which have been sufficient to relativize previous ideas of the separation between them.

Different forms of interactions between food and medicine may emerge in social-ecological systems. Pieroni and Quave [6], in a study including Albanians and Italians in Lucania (Southern Italy), synthesized such relations in three possible contexts: (1) a given plant is used both as medicine and food but without any further association between the two (e.g., the plant component used for medicinal purposes is different from the part consumed as food); (2) a food plant is considered healthy but without a unique or specific medicinal target (a so-called “functional food” according to some definitions); and (3) a plant is consumed to obtain a specific medicinal effect (a medicinal food or food medicine).

Although several ethnobotanical studies have directed efforts to understand this food-medicine continuum, there is a lack of investigations dedicated to finding the main drivers of species' local importance in such a

context. Most studies are focused on eliciting the reasons behind the maintenance and abandonment of the traditional uses of these products as a whole and do not focus on specific differences in importance among plants. Such studies have indicated sociocultural aspects, health claims and availability as important drivers [7, 8].

In regard to the differences in importance among species, research on food plants in general has elucidated the relevance of several influential variables, such as taste [9, 10], availability in time or space/ease of acquisition [10, 11], nutritional value [10, 12], easiness to process [12] and associated uses – including medicinal uses [10]. Studies on medicinal plants have also indicated the role of their organoleptic properties [13–15] and availability [15, 16] as well as the importance of their therapeutic efficiency or the presence of certain compounds [15, 17, 18].

Most studies on medicinal and food uses access this information by directly asking respondents the reasons why they consume (or have abandoned the consumption of) certain species [9, 11]. This approach has provided evidence of important aspects of interactions between people and plants and is a powerful tool in the elucidation of cultural and context-specific drivers of changes in species' local importance.

An alternative approach uses predictive models to find a possible causal relation between one (or several) explanatory variable(s) and a response variable. In such cases, the response variable is often an indicator of the species' importance (knowledge or use), and the explanatory variables are attributes that can be measured with ecological tools (e.g., availability as measured using data from plant inventories) or chemical tools (e.g., therapeutic efficiency as measured by the presence of certain bioactive compounds) or are based on people's perception [10, 15–17]. While this approach neglects the direct opinions of respondents, it has the advantage of capturing drivers that may operate unconsciously or even drivers that are culturally rooted but have environmental or biological meaning (e.g., when people mention that some plants are more important because of tradition, but those plants are those with a higher energy content).

Species availability has been a strong driver of plant knowledge and use for different purposes, especially woody uses [19], but has been a weak predictor of the importance of plants for medicinal purposes [19] and an even weaker predictor of food uses [20, 21]. However, for both medicinal and food purposes, recent studies using the local perception of availability instead of conventional ecological tools have found that availability may not be disregarded in regard to predicting species' relevance for medicinal and food purposes [10, 15].

In many cases, people usually attribute greater importance to organoleptic characteristics (particularly taste) than other characteristics when choosing which food plants to consume [7, 22, 23]. Taste and smell may also provide cues for identifying the therapeutic potential of plant species, which is an important influencer of the use of plants for medicinal purposes [24, 25]. Taste also plays an important role in indicating the medicinal properties of a given food. For example, some studies have found that bitter food medicines are often consumed to treat diabetes as the bitter taste counterbalances the sweetness of the disease [26, 27].

Studies have also displayed great variation in terms of the main drivers of popularity and use frequency of plants. Therefore, we need to increase case studies focusing on searching for such drivers to better understand situations in which each driver gains or loses predictive power over the species' importance. Considering the specific group of plants for which medicinal and food uses overlap, much work remains to be performed to discover whether therapeutic or nutritional value is primary when deciding which plants to consume.

For this reason, we aimed to characterize the traditional use of wild plants that are both food and medicine by local specialists in a rural community bordered by Chapada Diamantina National Park (NE Brazil). We also chose four criteria described in the scientific literature (smell, taste, nutritional potential and medicinal potential) to determine possible drivers of the cultural salience of such species.

## 2. Methods

### 2.1. Study area

We conducted this study in the rural community of Caeté-Açu (also known as the Capão Valley). The valley is located in the Palmeiras municipality (south-central Bahia State, Northeastern Brazil) (Fig. 1). It is situated in the geographical region of Chapada Diamantina ("Plateau of Diamonds") and surrounds Chapada Diamantina National Park.

This region has a rugged relief; its altitude varies from 200 to 2,033 m above sea level, and it is 500 m above sea level (Franca Rocha et al. 2005). In most of Chapada Diamantina, the climate is humid tropical with dry winters and temperate summers (Cwb climate according Köopen's classification) [28]. Most of the annual rainfall is concentrated in summer.

The ecosystems of Chapada Diamantina form a mosaic of different vegetation types, such as *campos rupestres*, submontane to montane forests (including riparian forests), Cerrado (a Brazilian savanna), Caatinga, and wetlands. *Campo rupestre* is open vegetation composed of sclerophyllous and evergreen shrubs or subshrubs and small trees, situated at the highest altitudes [29]. The submontane to montane forests include vegetation with high continuous canopies (ranging from 8.5 to 20 m high), a lower canopy with shrubs and small trees, and an open understory with rare epiphytes [30]. The Cerrado is characterized by a discontinuous arboreal layer up to 10 m tall, with twisted branches and thick tree bark. The ground layer is usually continuous, composed mainly of grasses, sedges and numerous subshrubs [29]. Caatinga vegetation is highly xeromorphic with a predominance of profusely branched low trees and shrubs. Most of the plants in the Caatinga areas have small leaves, spines, thick bark, and a well-developed root system often bearing tubers [29]. The wetlands are permanently or periodically inundated or boggy areas [29].

Habitat heterogeneity and anthropogenic disturbances are factors that generate high floristic heterogeneity in the local ecosystems [31, 32]. Therefore, there is high beta diversity in the region (change in community composition along environmental gradients).

### 2.2. Sociocultural setting

Before the Portuguese colonization (century XVI), the Chapada Diamantina region (which at that time belonged to a region named *Sertão das Jacobinas*) was inhabited by different ethnic groups, such as the Payayá, Sapoiá, Tocó, Moritises, Maracás, Secaquerinhens, Cacherinhens, Caimbés, Pankararu, Ocren, Oris, Tamaquins, Araquenas, Anaiós and Topins [33]. As in other hinterland northeastern regions, the Portuguese colonization of the *Sertão das Jacobinas* was positively impacted by the livestock practice (Santos, 2011). In the middle of the XIX century, the discovery of diamonds in the region spurred an huge migration wave (including Europeans, enslaved Africans, and Brazilians from many regions, mainly from the southeast and northeast) and the establishment of large villages in Chapada Diamantina [34].

Mining began to decrease in the area near the end of the XIX century, and many people migrated to Southern and Southeastern Brazil to work in coffee cultivation (Matta, 2006). However, local livelihoods were so strongly linked to the mining activity that some people migrated to the state of Mato Grosso do Sul searching for other diamond mines, while others continued to mine in Chapada Diamantina against all odds [35].

In the 1980s, Capão began to be a common site for ecotourism [36]. Then, strong migration took place in the valley, mainly by people seeking to live in contact with nature and who were looking for a healthy lifestyle [36]. The valley is currently inhabited by people from several countries (in particular, from Latin America and Europe) and provinces [36]. These people coexist with native people, mostly descendants of miners [36]. Natives and migrants currently work in tourism (as guides, or in related services – restaurants, bars, hotels, etc.), small-scale agriculture, and other services and commercial enterprises. Among the elders, many of the native residents are former miners who continued to mine even after the decrease in its productivity and that are currently retired.

According to the local health center, there were 693 families and 1,177 people living in the community of the Capão Valley in 2014. The main economic activities of these people are related to commerce and tourism, but small-scale agriculture is still common. People can access official medical facilities in downtown Palmeiras (21 km from Capão) and in neighboring cities (Seabra, Lençóis and Iraquara) [37]. A great diversity of religions and beliefs is found in Capão. Catholicism and Protestantism are predominant, although eastern religions (e.g., Buddhism and Shintoism) and Santo Daime are increasing [37].

## 2.3. Data collection

We conducted data collection between April and June 2014. We used the snowball technique to select local specialists. We identified a first local expert, and this expert indicated another one and so on until there was no other specialist mentioned (N = 13, nine men and four women). Therefore, our results may not be interpreted as a pattern for the whole community but rather as a tendency for local experts. This technique led to the inclusion of older native individuals who were former miners or descendants of former miners.

We explained to the key informants that we were interested in understanding their knowledge and opinions about the wild edible plants they knew that also had health benefits. Then, we used the free-listing technique to stimulate the informants to list the plants they knew and the plant parts they used. In some cases, the respondents cited more than one plant part for a single species, which is why we employed the

“plant-part” pairs for the other steps of our interview. The respondents indicated the medicinal benefit of each of the cited plant-part pairs. Then, we asked the interviewees to rank the plant-part pairs they cited according to the following criteria (one at a time): (1) ease of acquisition, (2) taste, (3) smell, (4) nutritional value, and (5) medicinal value. All of these criteria were evaluated based on the local experts’ perceptions. As we dealt with ranks, the interviewees attributed a value of 1 to the best species for a given attribute (e.g., the most frequently consumed, the most tasteful, etc.) and subsequent values to other species until the “worst” plant for a given attribute was assigned a rank  $n$  ( $n$  = total length of the respondent’s free list). We also permitted ties (e.g., when a respondent indicated the first and second most nutritive plant-part pairs and stated that the other four all had equal nutritive value, we considered the ranks as 1, 2, 3, 3, 3, 3). The rankings of all 13 respondents are available in Supplementary file 1.

We adapted our questions to the local context to avoid misinterpretations. For example, instead of asking respondents to rank species according to their nutritional value, we asked them to rank plants from those that provided more “sustenance” (*sustância*) to those that provided less sustenance. We chose the best emic terms based on our previous experience in the research area and informal interviews prior to our free lists.

We used “ethnospecies” as our research unit. Only the top 5 culturally salient species were identified. Vouchers were deposited in the Dárdano de Andrade Lima Herbarium (Empresa Pernambucana de Pesquisa Agropecuária) and in the Professor Vasconcelos Sobrinho Herbarium (Universidade Federal Rural de Pernambuco).

## 2.4. Data analysis

Before statistical analysis, we excluded plant-part pairs cited by fewer than three local experts to avoid biases from idiosyncratic information, leaving twenty-one plant-part pairs. We summarized each of the aforementioned attributes according to the mean value (the sum of the ranks attributed to the plant-parts divided by the number of interviewees that mentioned the plant). Given that a respondent could not provide information about a species he/she did not mention, the number of respondents used to calculate the mean values for an ethnospecies was exactly the number of individuals who mentioned it.

We used a multiple regression model to assess the additive effects of the predictor variables (ease of acquisition, taste, smell, and nutritional and medicinal values) on cultural salience. Salience was calculated according to Smith and Borgatti [38]. We used a stepwise approach to include in each final model only the variables that provided the lowest AIC value for the model. We used the ‘vif’ function in the R package ‘car’ to detect multicollinearity. This function returned the Variance Inflation Factor (VIF) for our explanatory variables, and all the values were  $< 5$ , indicating the absence of strong multicollinearity.

We standardized the final model by centering and scaling the data. This procedure allowed for better comparisons among the coefficients.

### 3. Results

We identified 57 plant parts and 46 ethnospesies in the intersection between medicinal and food plants in the region. From these, 21 plant-part pairs from 20 ethnospesies were cited by three or more respondents (Supplementary file 1).

Regarding the plant parts used, the respondents mentioned fruits for 47.8% of the ethnospesies, followed by leaves (39.1%), roots (21.7%) and other parts (15.2%). Most of these foods are consumed *in natura*, as juices, in salads, as sweets or as condiments. Respondents considered a wide range of health benefits of wild foods. The medicinal indication associated with the highest number of ethnospesies was body strengthening (52.2% of the ethnospesies), followed by intestinal regulation (37%), treatment of stomach issues (26.1%), improvement of kidney function (13.0%) and calming properties (10.9%). The position of body strengthening as the health benefit associated with the most species indicates that functional foods are highly valued among local experts. However, among the top 5 most salient species, the main medicinal indications were target-specific (intestinal regulation and calming properties), which shows that to achieve high importance in the food-medicine system a specific medicinal effect is often required.

The species with the highest value for cultural salience was *Anredera cordifolia* (Ten.) Steenis, followed by *Passiflora edulis* Sims, *Ipomoea serrana* Sim-Bianch. & L.V.Vasconcelos, *Passiflora cincinnata* Mast. and *Piper umbellatum* L (Table 1). Interestingly, four of the top 5 species are vines.

Table 1

Functional and medicinal foods with the highest values for cultural salience as mentioned by local experts in the rural community of Caeté-Açu. NE Brazil. Med = Main medicinal target.

TOP-5 Salience	Family	Popular name	Life form	Used part	Salience	Med	Voucher n°
<i>Anredera cordifolia</i> (Ten.) Steenis	Basellaceae	Quiabinho	Vine	Leaf	0.48	Intestine	*
<i>Passiflora edulis</i> Sims	Passifloraceae	Maracujina	Vine	Fruit	0.48	Calming	IPA 90073
<i>Ipomoea serrana</i> Sim-Bianch. & L.V.Vasconcelos	Convolvulaceae	Batata da serra	Vine	Root	0.43	Intestine	*
<i>Passiflora cincinnata</i> Mast.	Passifloraceae	Maracujá do mato	Vine	Fruit	0.39	Calming	IPA 90036
<i>Piper umbellatum</i> L.	Piperaceae	Capeba	Sub-shrub	Leaf	0.37	Liver	IPA 90188
*Not deposited (unfertile material)							

The stepwise approach retained the variables nutritional value and ease of acquisition in the final model.

The model explained an intermediate amount of variation in the response variable ( $R^2 = 0.47$ ; Adjusted  $R^2 =$

0.41), and the AIC value was low (-36.2). Both variables exerted a significant influence on cultural salience, but ease of acquisition exhibited a slightly higher effect (Table 2).

Table 2  
Predictors of the cultural salience of functional and medicinal foods known by local experts in the rural community of Caté-Açu, Chapada Diamantina, NE Brazil.

Variable	Estimate	S.E.	t-value	p
Intercept	0.26	0.02	13.04	0.00
Mean ranking for ease of acquisition	-0.06	0.02	-2.58	0.02
Mean ranking for nutritional value	-0.05	0.02	-2.18	0.04
AIC	- 36.2			
R <sup>2</sup>	0.47			
Adjusted R <sup>2</sup>	0.41			

For the two variables, there was an inverse relationship, meaning that lower values for the mean ranks led to higher salience values. Lower values (close to one) of the mean ranks indicated that species were often cited in the first positions. Therefore, a higher perceived nutritive value and ease of acquisition were positively associated with cultural salience.

## 4. Discussion

This study strengthens the notion of a food-medicine continuum by indicating a large number of plants involved in this intersection. However, in terms of use patterns, the plants within the continuum are more closely related to the food domain than the medicine domain. The status of fruit as the major plant part follows a pattern common for wild food plants in the tropics [39–41] and in other areas. Moerman [3], for example, in a study on food and medicinal plants used by Native North Americans, found that “Fifty-eight percent of food uses are of fruits, while only 8% of medical uses are of fruits.” Such results provide evidence that different plant parts can be used for different purposes in the same region. For medicinal plants in Chapada Diamantina, the most common pattern is the outstanding presence of leaves and barks, with a low representation of fruits [42, 43].

Our findings demonstrate that ease of acquisition and nutritional potential are the most important determinants of the knowledge and consumption of wild functional and medicinal foods by local experts from the community of Caeté-Açu. Ease of acquisition is important not only in terms of specific differences in plant importance but also in terms of explaining the abandonment of a whole set of wild foods and medicines [7], as in many regions deforestation is distancing people from natural resource areas.

Studies using ecological indicators of availability to test their relationships with species’ importance have not indicated ease of acquisition as an important predictor [20, 21]. Our study strengthens the idea that accessing people’s perceptions of availability instead of ecological data may provide evidence of certain

patterns not highlighted by the latter technique, which may happen because incorporating perceptions of local people allows for a wider number of plants in the analyses, given that wild species occurring outside of forest areas may also be included, as well as species with different life forms. Studies including ecological data commonly focus on specific life forms – more often on woody plants [20, 21]. Furthermore, high values of ecological abundance or frequency do not necessarily ensure that the plants are easy to acquire since they can occur in areas difficult to access. At the same time, low values of ecological abundance or frequency may not indicate that the species is difficult to acquire, as it may occur precisely on people`s common pathways.

However, such arguments do not intend to infer that local perception is a better indicator of species availability/ease of acquisition. Under some circumstances, ecological indexes are related to plant use while local perception of availability is not. In a case study on the drivers of fuelwood use, Hora et al. [44] encountered this situation and inferred that most of their interviewees were older people who were no longer accessing forest areas and acquired fuelwood from younger community members. Therefore, their perceptions of availability could be strongly related to a past landscape, which could weaken the relationship between perceived availability and fuelwood use. Therefore, we need to perform more studies to understand which portions of availability each technique (ecological indicators vs local perception) is specifically capturing.

Nutritional value has proven to be an important driver of wild food plant importance in other contexts [10, 12]. The fact that nutritional value remained in the final model, while medicinal value did not, shows that, although local experts recognize the important of medicinal attributes in wild food plants, nutritional aspects are more relevant for designating culturally important plants in the food-medicine continuum than medicinal properties.

Our results are consistent with the social-ecological theory of maximization. One of the theory`s assumptions is that the most important natural resources to local people are those that afford the maximum return, considering the balance among different explanatory variables that affect resource use [45]. This maximum return is the best possible achievement from the combination of different variables driving the use of a natural resource [45]. Additionally, the most important drivers as evidenced by our research are also among those deeply studied in the context of optimal foraging theory [46] – in which nutritional value is analogous to energy intake and ease of acquisition is analogous to energy spent during foraging. Therefore, a balance between the costs of acquiring a plant and the nutritional benefits of consuming it seems to influence cultural relevance in the intersection between food and medicine.

Contrary to other studies, attributes such as taste did not explain plants` importance. The higher importance of nutritional and availability issues compared to taste may be explained by the sociocultural background of the community. Most of the elders (including those from our sample) are former miners or descendants of former miners. In the region, miners worked for extended periods, forcing them to spend much time in natural areas, which were often far from settlements. Wild plants therefore constituted an important source of food in the mining context with a better return for miners implicit in the consumption of nutritionally rich, widely available species. This process probably influenced the importance of plant

species, which was transmitted culturally to the miners' descendants. For this reason, nutritional value and ease of acquisition remain important drivers of plant importance even now when these inhabitants do not rely much on wild foods as an important source of daily energy intake.

However, we need to conduct further studies including nonspecialists (particularly the younger members of the community) to provide evidence for the main drivers of plants' importance in the intersection between food and medicine. It is possible that the culturally mediated effects of nutritional value and ease of acquisition lose strength among younger dwellers, who are mostly unfamiliar with mining activity and never consumed wild plants as an important source of energy intake. Among people who consume wild plants as a supplementary source of food, taste may be more important, considering that their energy intake is probably being fulfilled by other (nonwild) foods. However, this claim needs to be tested using proper research designs.

Several other variables that were not included in our research may be important drivers of plants' importance in this food-medicine system. Moreover, qualitative aspects that we did not access can affect the use of food items. People have emotional links (both positive and negative) to food related to childhood memories, family togetherness, sharing care through foods, amusing cooking times or mealtimes, anxiety or sadness [47]. These memories may act as bridges between past individual experiences and present life, affecting the way an individual approaches food [47]. For some individuals from rural communities, eating wild foods can elicit positive memories related to early childhood or can cause them to feel more connected to nature (Cruz et al., 2014; Hora et al., 2020). In such cases, certain food/medicine items may be culturally important because people can experience strong emotional ties to them. Such aspects may not be properly captured by our research design, which is definitely a limitation of our study.

This study has some other limitations. The investigation would have been a stronger tool for finding drivers of plant use if the conventional approach (of directly asking people their reasons for preferring/consuming certain items) had been combined with our statistical model. Therefore, we strongly recommend this combination of approaches for future studies on this subject. Additionally, our sample of ethnospecies was small, which makes our model with two independent variables not as reliable as it would have been if it had included a high number of plants. Finally, other options to classify plants by the attributes would have been preferable over ranking. We obtained a high number of ties (i.e., people stating that several species occupied the same position in terms of taste, for example). When ties are common, scoring exercises [10] are much better options than rankings.

## 5. Final Remarks

Our findings demonstrate that for local experts in Chapada Diamantina, the importance of particular plants in the intersection between food and medicine follows a logic of maximum return, so that species with better returns in terms of ease of acquisition and nutritional value have been culturally appropriated and rooted. Furthermore, even considering the intersection between food and medicine, the evaluation of use patterns (e.g., the major use of fruits) and the drivers of importance (e.g., nutritional instead of medicinal

potential) indicate that this group of plants is more culturally associated with the domain of food than the domain of medicine. Finally, additional studies are needed to accurately place the food-medicine intersection within social-ecological systems.

## **6. List Of Abbreviations**

WFP – Wild food plants

NE – Northeast

AIC – Akaike Information Criterion

## **7. Declarations**

### **7.1 Ethics approval and consent to participate**

This study was part of a wider project entitled “Knowledge, use and local representations of plant resources in central and western Bahia: theoretical and conservational issues”. We conducted this research in accordance with the National Health Counsel guidelines established by the Research Ethics Committee (Resolution 196/96), and the protocol was approved by this committee (44962515.5.0000.5026). Before data collection, we described the goals of this research to local informants and asked them to sign a Free and Informed Consent Term. We were authorized to collect plant specimens by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), using the Sistema de Autorização e Informação em Biodiversidade (SISBIO) platform (42624-1.).

### **7.2 Availability of data and materials**

Raw data is available in the Supplementary file 1.

### **7.3 Competing interests**

The authors declare that they have no competing interests” in this section.

### **7.4 Funding**

CNPq (grant number 302786/2016-3).

### **7.5 Authors contributions**

PMM idealized the index and wrote parts of the MS

WSFJ helped with the literature review and wrote parts of the MS

FSQ performed the statistical analyses and wrote parts of the MS

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## 7.7 Consent for publication

Not applicable

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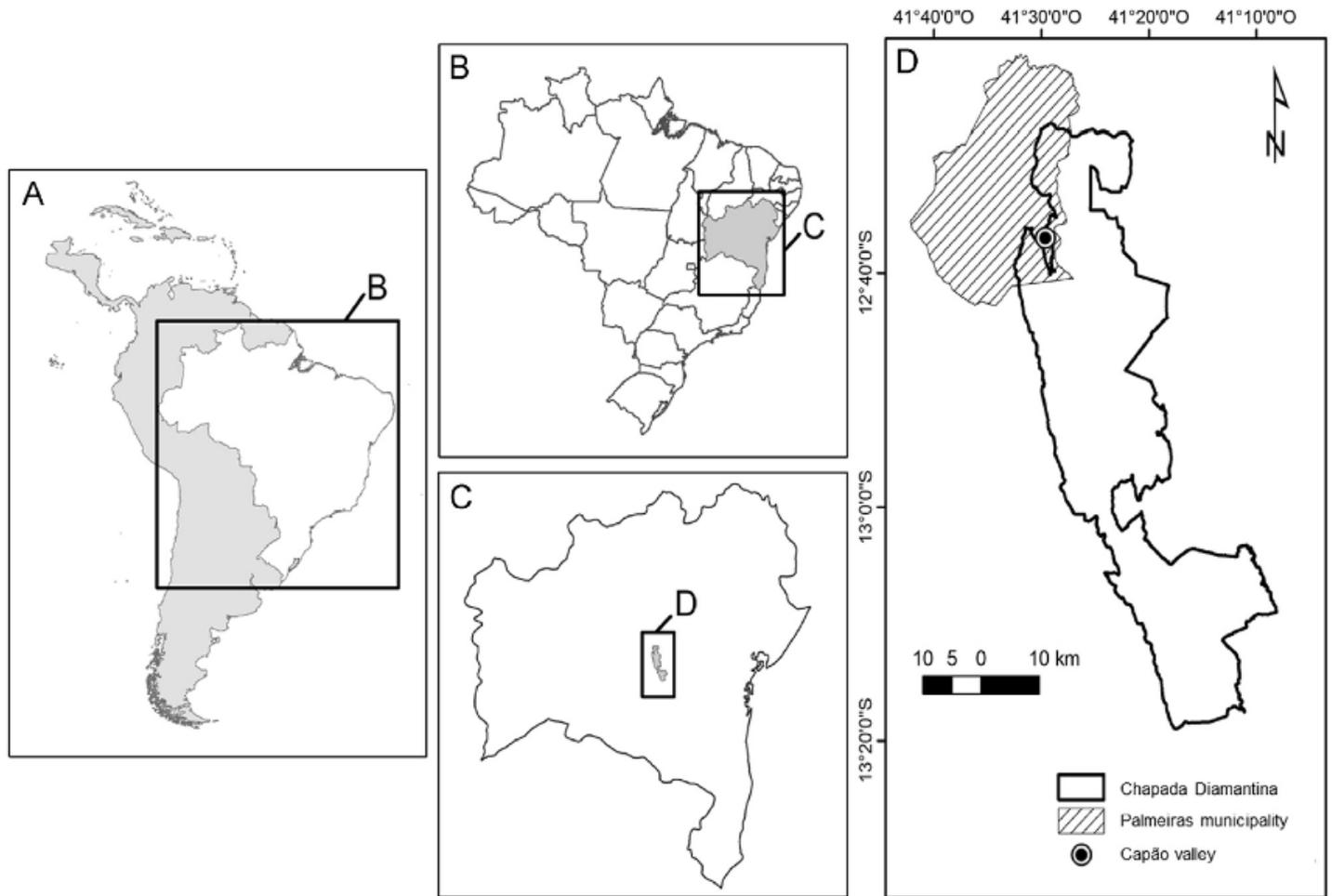
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## Figures



**Figure 1**

Location of the Capão Valley, adjacent to Chapada Diamantina National Park, south-central Bahia State, Northeastern Brazil. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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