

Use, Perception, and Local Management of *Copernicia Prunifera* (Miller) H. E. Moore in Rural Communities in the Brazilian Savanna

José Afonso Santana Almeida

Universidade Federal do Piauí

Nágila Alves Feitosa

Universidade Federal do Piauí

Leilane Carvalho Sousa

Universidade Federal do Piauí

Raimundo Nonato Oliveira Silva

Universidade Federal do Piauí

Rodrigo Ferreira Morais

Universidade Estadual do Piauí

Julio Marcelino Monteiro

Universidade Federal do Piauí

Jose Ribamar Sousa Junior (✉ sousajr@ufpi.edu.br)

Universidade Federal Rural de Pernambuco <https://orcid.org/0000-0002-8952-6441>

Research

Keywords: Ethnobotany, Artificial Selection, Brazilian Savanna, Caatinga, and Palm Wax

Posted Date: September 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-65335/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at Journal of Ethnobiology and Ethnomedicine on March 22nd, 2021. See the published version at <https://doi.org/10.1186/s13002-021-00440-5>.

Abstract

Background

Copernicia prunifera is a species native to the northeastern region of Brazil and is economically important as a source of income for many human populations in the region that carry out intense extractive activity on the species. This study aimed to evaluate the uses, management, and perception of the species by local extractors.

Methods

Two communities were studied, *Bem Quer*, where 15 extractors were interviewed, and *Cana*, where 21 extractors considered specialists were interviewed, totaling a sample of 36 informants. A regression analysis was used to explore the relationships between social variables (age, time in extractive activity, and income obtained from extraction) with the number of leaves exploited. The relationship between time of extraction, and time of residence in the community was also analyzed.

Results

The leaf was indicated as the most used part, from which an important powder is extracted for the production of wax. In addition, the leaf was also indicated for fertilization and construction. Uses were also indicated for the stem (construction) and fruit (forage). The relationship between the socioeconomic variables, income obtained through extraction and the amount of leaves extracted (in thousands) was significant ($R^2 = 0.73$ and $p < 0.001$). However, the other variables analyzed in this study, such as the time spent extracting leaves and the amount of time residing in the community ($R^2 = 0.03$ and $p > 0.05$), the number of leaves extracted and the age of informants ($R^2 = 0.05$ and $p > 0.05$) and number of leaves extracted and time of extraction ($R^2 = 0.04$ and $p > 0.05$) did not indicate a relationship.

Conclusion

C. prunifera was had a great economic and cultural importance for studied communities. It is possible that the economic factor is the preponderant force that directs the management strategies of native species.

Background

The management of tree species has been a very common practice in local communities, and studies are necessary in order to understand the role of this human action on plant populations. In this context, ethnobotany is a science that has contributed to understanding the interrelationships between humans

and plants, which allows us to understand their benefits [1, 2], in addition to the inherent processes of this interaction. Thus, several ethnobotanical studies have addressed the management of plant species, especially trees, in order to understand the interaction between people and plants [3, 4] from a local management perspective, which can be defined as practices which aim to transform and/or adapt ecosystems, their natural components, as well as the processes involved in this relationship [5].

According to [6], plant management can also be defined as actions or practices carried out by people directly or indirectly on populations or individuals within communities, aiming to favor the availability of a specific characteristic [7]. Additionally, two plant aspects are taken into account for this definition: the selective (when individual plants are favored through human manipulation) and the non-selective (when plant individuals are opportunistically managed); moreover, these practices are carried out in several different environments, from the natural to anthropogenic regions [6]. Another important concept that is often related to traditional management is that of artificial selection, which consists of selective practices that aim to increase and guarantee the availability of individuals with desirable characteristics, and sometimes there may even be the elimination of undesirable phenotypes [6].

In recent years, some studies have addressed the management of tree species, as well as management of cacti in Mesoamerica, which identified levels of management of plant populations by local communities: collection, *incipient* management, and cultivation [8, 6, 7]. Within incipient management, the following types also stand out: tolerance (maintenance of individuals in areas destined for agriculture/livestock); protection (elimination of competitors and/or predators); promotion (increase in population density), and *ex situ* cultivation (propagation of plants in anthropogenic areas) [6].

Likewise, among the main examples of tree species studied in Brazil, is the umbuzeiro (*Spondias tuberosa* Arruda), whose fruit is the most used part and presents a desirable selection tendency in relation to size [7, 9, 10]. Another Brazilian example is the fruit of the Goiabinha serrana (*Acca selowiana* (O. Berg)), whose weight is a characteristic with tendency to be selected among others [7, 9]. Furthermore, the Brazilian pine (*Araucaria angustifolia* (Bertol)) also presents a larger fruit size as a tendency for selection [11, 7]. Another Brazilian species worth mentioning is the Pequi (*Caryocar coriaceum* Wittm), featuring a variation in fruit morphology, where size is indicated as the most desired characteristic [12]. Moreover, the fruit is characterized as being fleshy (yellow colored pulp) [12, 13].

Still within this approach, the Arecaceae family has characteristics, especially the fruit that are targets for management and artificial selection. Açaí (*Euterpe oleraceae* Mart.), for example, has peculiar characteristics, such as fruit color and purplish coloration, which are traits resulting from changes [7, 14]. In turn, the selective characteristic for the pupunha (*Bactris gasipaes*) is size and increase of fruit production, a trait that has changed through artificial selection [7, 15–17]. Despite the various records for the fruit as the morphological structure targeted for selection, many other plant parts are often relevant. For example, unlike the species mentioned above, Butiá (*Butia capitata*) combines all the characteristics of selection in a single resource, the leaf. Although the study did not focus on management, a study on

Ouricuri (*Syagrus coronata*) indicated its leaves as an important resource used by the indigenous Fulni-ô people in Northeastern Brazil [18].

In this framework, the carnaubeira (*C. prunifera* (Miller) HE Moore), an endemic palm of the semi-arid Northeast belonging to the Arecaceae Family, has been used historically by people from the northeast region of Brazil as a source of income due to its economic and cultural importance. The extraction of the ceriferous powder from its leaves is an extractive activity responsible for the sustenance of several families during the drought period, which extends from July to December [19–21].

Thus, the present work aimed to conduct an ethnobotanical study on carnaúba, in order to characterize the uses and management conducted by local extractors, as well as to highlight the strategies of collection and local management. This study was designed to answer the following questions: What factors favor the management of carnaúba in the studied community? Do local extractors perceive morphological variations in carnaúba that can determine management strategies? Which aspects identified in the management of the leaves are most important for the amount collected?

Methods

Study area

This study was conducted in two communities from the municipality of Barão de Grajaú, MA in the Bem Quer community and the Cana community. Both communities are located in the eastern region of Maranhão and the Chapada do Alto Itapecuru microregion, neighboring municipalities of São João dos Patos, Sucupira do Riachão, São Francisco do Maranhão (located in the state of Maranhão), and Amarante, Jerumenha, and Floriano (located in the state of Piauí) [22]. Additionally, the predominant vegetation type in the region is a typical transition between cerrado (savannah forest) and caatinga, also containing riparian vegetation along the Parnaíba riverbed close to the communities, and carnaúba forests (also known as carnaubais).

With an altitude of 108 meters and caatinga and cerrado vegetation, the Bem Quer community has about 56 families according to information from local health agents, some of which are characterized as extractors of carnaúba. The Cana community has a smaller number of people, about 30 families and 99 inhabitants, according to data from local health agents. The Cana community is 15 km away from the first community and has similar phytosociological characteristics with a main group of active carnaúba extractors active (Fig. 1). In both communities, the main economic activity is agriculture, especially rice, manioc, corn, beans, squash, and watermelon, in addition to fishing activity by some extractors.

Data collection

Traditional knowledge is considered a national heritage in Brazil. In order to access local knowledge about *C. prunifera*, collaborators (people from the communities) were asked to give their consent by signing the free informed consent form in accordance with resolution No. 292 of 08/ 07/1999. Thus, this

research project was submitted and approved under CAAE registration number: 93417517.3.0000.5660, by the Research Ethics Committee of the Federal University of Piauí (UFPI-CAFS), following the ethical and legal aspects based on resolutions 466/12, and 510/2016 of the National Health Council (CNS).

In order to characterize the knowledge, use, and local management of *C. prunifera*, we used ethnobiological investigation methods based on quantitative and qualitative approaches. Thus, before beginning data collection, we held meetings with members of the target community, in order to clarify the intentions of the study to be developed.

We performed snowball sampling, an intentional non-probabilistic sampling, considering that the people interviewed from the communities were those who maintained the greatest contact (specialists) with the carnaúba (*C. prunifera*) [23]. This sampling was applied at the end of each interview, where we asked if the interviewee knew another person in the community who has a more comprehensive knowledge about *C. prunifera*. The interviews were based on semi-structured scripts [24], which contained the following questions: 1) What are the uses of the carnaúba palm? 2) Which parts are used? 3) What are the straws (leaves) used for? 4) Are there different types of straw? 5) How many straws (leaves) are needed to obtain one kilogram of wax powder? What is the powder used for? 6) How much straw is collected and how much is sold? 7) How much powder is extracted and how much is sold? 8) How much was your income during the last harvest (or the last time that you extracted powder)? These questions were asked to both communities, in addition to other questions about socioeconomic data. Considering the specialist characteristic of the Cana community, where the extractors organize themselves in groups, other questions were only deepened with them, such as 9) Do you notice morphological variation in the leaves of the carnaúba? 10) During the collection, do you perform leaf selection? 11) Do you perform any type of management (a - simple collection; b - tolerance of arboreal individuals; c - pruning; d - protection against other organisms)? 12) How long have you been engaged in extractive activities?

This work was conducted during two distinct moments. The first moment was during the 2018 harvest season (July to November), when the residents of the Bem Quer community were interviewed and the activity seemed to be in sharp decline. During the second instance, throughout the 2019 harvest (July to November), we interviewed informants based on the indications of the interviews made in the aforementioned community, and we also interviewed the specialist extractors who organize themselves into groups in the Cana community. Apparently, the activity of extracting the carnaúba leaves in the region is predominantly performed by men.

In addition, we noticed a difference between the two communities regarding the extraction of leaves. Bem Quer community presented informants who carried out the collection individually (including some who no longer conduct the activity), while in the Cana community there extractors are organized into groups, with a group coordinator for activities carried out throughout the harvest. The groups in this community are divided into two: one with 10, and the other with 11 local extractors. Thus, 36 interviews were carried out in total, 15 with *C. prunifera* extractors in the Bem Quer community (where the average age was 42.3),

and 21 interviews with extractors in the Cana community (where the average age of specialists was 33.8).

Data analysis

The data were tabulated in Microsoft Excel. Data analysis was performed from simple proportions using the Microsoft Excel. Additionally, for the specialist community, a regression analysis was used to explore the relationships between social variables (age, time in extractive activity, and income obtained from extraction) with the number of leaves exploited. The relationship between time of extraction, and time of residence in the community was also analyzed. For these analyses a $p < 0.05$ was adopted and conducted in Software R 3.6.1 (R Development Core Team 2011).

Results

Socioeconomic data, knowledge, and use of *C. prunifera*

All interviews indicated the use of carnaúba (*C. prunifera*), the leaf (straw) being the plant structure with more use indications and management, that is, the main part of the plant, followed by the stem (stipe) and then the fruit. The use of the leaf was the most important and expressive (84.09% of the citations), with the main uses cited as fertilization, artisanal crafts, construction (mainly covering houses), and extraction of wax powder (Fig. 2). The straw powder is related to its economic importance, since it produces a type of wax, used to manufacture various objects such as candles, chips, medicine capsules, among other diverse applications, according to the interviews. Besides the use of the leaf (straw), the stem (stipe) of the carnaúba was the second part of the plant (11.36%) with more indications of uses, mainly for the construction of houses (mud houses), fences, and corrals. However, according to the informants, this use is in decline. The fruit, in turn, serves as food for animals (4.55%).

As for socioeconomic data, the interviews indicated that there is no relationship between the time the informant extracts the leaves and the time of residence in the community ($R^2 = 0.03$ and $p > 0.05$), between the number of leaves extracted and the age of the informants ($R^2 = 0.05$ and $p > 0.05$), and between quantity of leaves extracted and extraction time ($R^2 = 0.04$ and $p > 0.05$). On the other hand, the relationship between income obtained through extraction and the amount of leaves extracted (in thousands) was significant ($R^2 = 0.73$ and $p < 0.001$) (Fig. 3).

Local management and morphological perception of *C. prunifera*

All informants claimed to perceive some morphological variation in the leaves of the carnaúba, among which the straw color stood out, with the green color being the most mentioned (42.5% of the total citations), followed by the "dry" color (30%), and lastly, yellow (27.5%). Apparently, the "dry" color, which the interviewees mentioned, is a physiological state of the leaf or a consequence of the action of microorganisms. According to the interviews, it was possible to note that leaf coloring is important for

extractors, because, according to them, it influences the production of powder, with green leaves being the most favorable since they produce the most powder.

As for the management of *C. prunifera*, all informants indicated to perform selection at the time of extraction, with the separation of the "eye" from the carnaúba being the main selective action performed by them. In addition, 100% of respondents reported that, when collecting, they eliminate dry straws because they do not produce powder, which is the main extraction product. In addition to the collection, tolerance of plants (maintenance of individuals in agricultural plantation areas, backyards, and farms due to their economic importance) was indicated by all informants as a common practice, that is, they stated that they did not cut down the carnaúba, except when the arboreal individuals die, and in this case, the wood is used for construction. Moreover, in relation to the types of management, fire protection was indicated by 85.7% of the interviewees as a deliberate action to prevent burning from causing damage to carnaúba trees (carnaúba forests). However, according to the interviews, the extractors indicated greater concern regarding fires during the collection period, since, in this instance, the collected straws are arranged on the floor for drying and subsequent powder removal, and, in this sense, the burned in the region would destroy all the collection work carried out.

Furthermore, according to the interviews, the extractors indicated they perform selection according to the following criteria: color, shape, and size of the leaves (straw). Of the extractors, 38.5% indicated they perform leaf selection based on size, due to a relationship, according to them, between size and powder production ("the bigger the straw, the greater the powder production"); 30.8% indicated the shape of the leaf as a selection criterion during collection, and according to them the "opening" of the straw (fan shaped leaves) favors the best powder extraction; 26.9% indicated the color as a selection criterion for collection, and according to the interviews, the local specialists, said green was the most important criteria. Only one specialist reported not following any selection criteria when carrying out the collection, and he indicated that the most important thing is the production ("the more you collect, the better"). No informant indicated the characteristic "odor" or "texture" as selection criteria.

When asked if there were individuals of *C. prunifera* from whom nothing was removed, all respondents indicated that only the "eye" of carnaúba was the structure that they sometimes failed to remove. According to the interviews, extractors perceive three types of "eyes" (which correspond to new leaves) from the carnaúba tree as morphological structures that determine their extraction. From the three types (Fig. 4), the two largest "eyes" (larger new leaves) are removed due to the quality of the powder they produce, while the third eye (smaller new leaf) is kept in the carnaúba tree because, according to informants, it is from that "eye" all the leaves will regenerate in time for the next collection, which takes place within one year.

The powder extracted from the new leaf, or as it is locally called, carnaúba "eye" (leaves still closed and new in the canopy of the carnaúba), has a different color from the powder of the other leaves (open leaves that form the canopy of the carnaúba). A strong implication of this is the difference in the selling

price of each type. Although its production is lower, the powder from the carnaúba “eye” has a higher value than the powder from the straw leaves.

According to the interviews, the amount of straw leaves collected per year varies between 150 and 600 thousand leaves in the Bem Quer community and from 200 to 900 thousand in the Cana community (Table 1), depending on the collection effort of the extractor (or group of extractors), and the previous year's collection activity. The same goes for the amount of straw collected per day, which ranged on average between 20 to 30 thousand in the Bem Quer community, and 20 to 50 thousand in the Cana community. In order to extract 1 kg of powder from the carnaúba straw, 1,000 straws are needed in both communities, according to the interviews. The value of the powder varied between R \$ 2.50 to 6.00 in the Bem Quer community and R \$ 7.00 to 8.00 in the Cana community, and all products derived from it are produced by local manufacturers, which means the collectors are the first link in the production chain of the carnaúba wax powder. Currently, wax production is centered on some manufacturers in the region, but in the past local people used to produce it. The economic importance of *C. prunifera* is the main factor for the intense extraction and management of this species.

Table 1

Quantities and values of the products from the extraction of carnaúba (*Copernicia prunifera*) in two rural communities in the northeastern semiarid region

Quantity of straw leaves (in thousands of leaves)	Bem Quer community	Cana community
Extracted per year	150 to 600 thousand	200 to 900 thousand
Extracted per day	20 to 30 thousand	20 to 50 thousand
Quantity of leaves necessary to obtain 1 kg of powder	1000 leaves	1000 leaves
Values (R\$/US\$)		
Sale of the powder from the open leaves – each kilogram	R\$ 2.50 to 3.00 (US\$ 0.59 to 0.71)*	R\$ 5.00 (US\$ 1.20)*
Sale of the powder from closed leaves (carnaúba “eye”) – each kilogram	R\$ 5.50 to 6.00 (US\$ 0.76 to 1.44)*	R\$ 7.00 to 8.00 (US\$ 1.68 to 1.70)*
* dollar quote for November 2019		

Discussion

Socioeconomic data, knowledge, and use of *C. prunifera*

The carnaúba leaf (*C. prunifera*) was the most important part of the plant and had the most indications of uses. Although the leaf (straw) has had several indications of uses, the main category was economic,

that is, the pure extraction of straw leaves to remove the powder, and later commercialize it. This data corroborates the study by Vieira and Loiola [25] who indicated the economic importance of carnaúba straw by traditional artisans in the northern state of Piauí. The importance of the extraction powder, production wax and carnaúba leaves was also observed in the study by Sousa et al. [26], also indicating the fruit and stem as important parts of the species. The versatility in relation to the forms of use makes carnaúba a species of great economic and cultural importance in its occurrence region [27]. *C. alba* (Morong ex Morong and Britton), a co-genus of the carnaúba, also has similar characteristics regarding ethnobotanical aspects, such as the use of leaves for construction, crafts, and in animal feeding [28–31].

Furthermore, other tree species have also stood out economically for many local populations. For example, Sousa Júnior et al. [32] indicated the production of pequi oil (*Caryocar coriaceum* Wittm) from the fruit as a category with as much importance as food; its commercialization is so relevant because the oil can be stored during the period between harvests. Another species that has great economic relevance is the umbu (*Spondias tuberosa* Arruda), whose fruit commercialization guarantees income for many rural communities in the semiarid region [33]. In several regions of the world, species of the *Moringa* genus have different uses, from their leaves and fruits, and are economically important due to their applications in nutrition, industries, and medicine [34, 35].

In several ethnobotanical studies, the plant species studied are presented as having various categories of uses, according to the local people who use and manage them. In addition, depending on the species, the target part of extraction, use, and management may be the fruit (as the examples indicated above), the leaf, seeds, stem, tubers, etc. [7]. It is important to note that in many communities, people use different types of plants, some of which have a greater potential for treating diseases (medicinal use), others for subsistence or alternative food (food use), in the production of charcoal, construction of houses, or as wood for combustion (wood use). In a way, all of these categories mentioned above have implications in the socioeconomics of local populations.

However, it is important to note that some species have a greater economic appeal, either through their direct commercialization or from products extracted from it. Thus, the socioeconomic aspect may be one of the driving forces based on the economy [36] that directs the use and management of plant populations of human interest. On the other hand, the economic importance of a species can lead to overexploitation of the resource, harming its potential. Destructive practices in the fruit collection of *Mauritia flexuosa* Lf, a species of great cultural and economic importance, is an excellent example of this exploitation [37, 38]. Thus, showing the importance of studies that aim at understanding the socioeconomic factors related to the knowledge, uses, and management of plant species of economic importance, as well as their sustainable management.

Therefore, some studies sought to understand the influence of socioeconomic factors on the knowledge and uses of plants, and some made various types of associations, beginning with general plant use [39–41] to categories of specific uses, such as medicinal [42–44] and food [45]. In general, studies on this focus have varied according to the approach of each researcher. Income and education have been

addressed in studies on useful plants in general, which suggest that knowledge decreases with the increase in schooling [46, 47] and increased income [41, 48, 49]. Our data, however, did not show a relationship between socioeconomic variables (length of residence, time in extractive activity, and age) with the extraction of carnaúba straw, with the exception of the income obtained from extraction and the number of leaves extracted, which had a significant relationship, indicating an effort to maximize straw collection, including through group organization, according to local extractors. This analysis reinforced the economic importance of carnaúba leaves as one of the factors that drive the use and management of this species locally. Sousa Júnior et al. [12] found a similar situation for *C. coriaceum*, which showed a great economic importance from the nutritional use of its fruit, the pequi. The same was observed for *S. tuberosa* through the study by Lins Neto et al. [50], which demonstrated the commercial importance of the umbu fruit as a factor that influences the management of this species. In the case of carnaúba, what is strongly different is the target of human selection (the leaf) compared to other studies in which the tendency has been for fruits as targets for selection. This can indicate the economic factor as the predominant force that directs the management of native plant species in socio-ecological systems.

In regards to age, according to the results, we did not observe an influence of this variable on the use and management of carnaúba straw. Similarly, Sousa et al. [41] demonstrated that the local importance of species from the region of Floresta do Araripe, in Ceará, was not influenced by socioeconomic factors, with the exception of a smaller number of species which had age as a factor that explained the importance of some culturally salient species. Moreover, according to these authors, younger people were motivated mainly by the commercial potential of some of the native forest resources, giving them greater local importance. Unlike other studies, this present study was carried out with only one species (carnaúba) that suffers from intense extractivism, with a focus on the use and management of its leaves. In addition, this study observed that only men perform extractive activities of carnaúba in the communities studied, which did not allow for gender analysis.

Local management and morphological perception of *C. prunifera*

Data on the perception of extractors are in line with the main results found for native plant species where local people exercise some type of management. The perception of morphological and organoleptic characteristics is an important resource that allows people to manage species of interest, favoring those characteristics that vary between plant populations [12, 50], and thus constituting the basic principle of the artificial selection process [7, 51, 52]. Thus, artificial selection is a criterion that can be based on the perception of characteristics preferred by people; consequently, reflecting on the management practices that drive the morphological and genetic divergences between natural and managed populations [53, 54]. The color and size of fruits, for example, are target characteristics of human selection, a trend observed in several studies [9, 12, 50, 54, 55].

Another morphological structure of plants that has been analyzed from this perspective is the leaf [56, 57] indicated that the color and size and arrangement of the *Agave* leaves are an important attribute of the species that help producers of “pulque” (a drink prepared with *Agave* sap in Mexico) in different stages of

production. Although the tuberous root is predominantly the target of selection, the leaves of *Manihot esculenta* ssp. *esculenta* (Euphorbiaceae), can be the target [7, 58]. One of the main studies on leaf management of the Arcaecae family was the influence of leaf management on individuals of butiá (*Butia capitata* Martius) in southern Brazil [59]. According to this authors, traditional management seems to be the most interesting both from the point of view of the response of the palm, and also from the productivity of leaves for exploitation. Moreover, according to that study, the artisans of the butiá recognize three distinct types of leaves: new apex leaves, which must remain on the plant, while the rest may be extracted; new leaves for making artisanal products; and discarded leaves, as they are not suitable for handicrafts (either due to their rigidity, stains, or dryness) [59].

These data reinforce the importance of the perception that local extractors have about the resources they manage in different locations. Similar to the study by [59], in this present study on carnaúba (*C. prunifera*), the interviews also indicated that extractors perceive different types of leaves, which are locally called "eye of the carnaúba," two larger (larger new leaves) and one smaller (new leaf that is left on the plant to assist in its regeneration). Our hypothesis that people would perceive morphological diversity in carnaúba, therefore, has been confirmed. Thus the local perception, especially of morphological characteristics of interest, may indicate the important role of intentional human action in the selection criteria, use (and preferences), and management of plant species of economic importance, especially by having a more conscious (intentional) selection [12, 60]. A logical consequence of this understanding is that the management of species of economic importance in socio-ecological systems (integration of socioeconomic and biophysical processes and components) [61], is the driving force behind targeting characteristics of human interest [12].

Some studies already carried out on the carnaúba itself indicate the great importance that this species presents, thus justifying the intense management exercised over it in a large part of northeastern Brazil. Ferreira et al. [21] evaluated the effect of different leaf cutting management strategies on a natural population of carnaúba and showed that leaf age has greater relevance on the exploitation, and that the best leaf cutting management strategy is a single annual cut in the month of December. Despite not focusing on the human aspect, through an ethnobiological perspective, this data on management found by Ferreira et al. [21], in which a single cut is the best strategy, can be an indication of possible strategies for the sustainable extraction of *C. prunifera* straw. In addition, our interviews indicated another mechanism that can also be evaluated as another management strategy: not removing any leaves from some individuals of *C. prunifera* during one year so that they have more leaf straws with powder the following year. This mechanism is related to the extraction product of the leaves, which is the wax powder. The differences in prices observed from the interviews indicate that the handling of the leaves also aims at a better quality powder. According to the interviews, the powder from the "eye" of the carnaúba straw (closed leaves and new ones existing in the canopy of the carnaúba) has higher quality and therefore higher market value than the powder from the rest of the straws (open leaves that form the carnaúba canopy). According to Sousa et al. [26], the price of powder extracted from the "eye" of carnaúba was estimated at R\$ 7.00 (thereabout US\$ 1.68 based on the month of November 2019), while

the powder removed from ripe straws cost around R\$ 5.00 (thereabout US\$ 1.20 based on the month of November 2019). Similar data were observed in our study.

Another interesting fact about the carnaúba was the positive correlation between the amount of straw collected and the income obtained, which proved to be strong and positive. That is, the more you collect, the more you earn in that activity. The correlation analysis corroborates the interviewees' own view, recognizing that, despite the morphological preferences for larger leaves and powder extracted from new leaves (the carnaúba eye), the important thing is to have a large number of leaves collected over the period harvest. A possible consequence of this is the variation in prices of leaves and powder caused by the increased supply of those products, resulting from intensive collection activities. Thus, extractivists may have their income impaired due to the fall in product prices at the beginning of the production chain [62]. Another possible negative impact is the ecological effects on the resource [63]. One of the implications of this is the importance of seeking strategies for the sustainable use of biodiversity resources of economic importance, such as the carnaúba leaf, in order to match the conservation of natural resources with income for human populations that use such resources [64, 65].

Therefore, it is important to emphasize that correlation analysis further reinforces the economic importance of carnaúba leaves as one of the factors that guides the use and management of this species. Sousa Júnior et al. [12] found a similar situation for *C. coriaceum*, which had a great economic importance from the nutritional use of its fruit, the pequi. For carnaúba, what is strongly different is the target of human selection, which in this case is the leaf, compared to other studies in which the tendency has been for fruits as targets of selection. This can indicate the economic factor as the predominant force that directs the management of native plant species in socio-ecological systems. Nevertheless, it is necessary to develop studies that seek to ascertain this hypothesis, as well as the production chain associated with other socio-cultural factors that may be related to the use and management of carnaúba.

Conclusions

Copernicia prunifera (carnaúba) demonstrated relevant economic and cultural importance for the local populations in the communities of southern Maranhão, Northeastern Brazil. The management of the species is associated with its leaves strong economic value, due to the wax powder extracted from the carnaúba straw. The amount of leaves extracted is related to the income obtained due to the extraction and commercialization of the powder for wax production. The straw collection involved the formation of groups of collectors in one of the communities, in which the extractors were the specialists. The collection and protection of *C. prunifera* individuals were the main forms of management indicated by the extractors. Despite the indication to collect all the leaves, one of the management strategies indicated by the carnaúba interviewers was to stop collecting leaves from some individuals so that they would have leaves with greater powder production. It is possible that the importance of the economic value of many native species is the predominant factor in their management strategies, as was observed for carnaúba.

Declarations

Acknowledgements

The authors would like to thank the residents of the Bem Quer and Cana communities. We would also like to thank the Federal University of Piauí (UFPI). Lastly, we would like to thank the *Campus* Amílcar Ferreira Sobral (CAFS/UFPI), Floriano, PI, for logistical support in our fieldwork.

Authors' contributions

JRSJ conceived the work and processed the data; JASA, NAF and LCS collected the data and write; RFM performed the statistical analyses; JASA, JRSJ, RNOS, JMM, RFM drafted the manuscript with contribution of NAF and LCS. JRSJ supervised the work. All authors read and approved the final manuscript.

Funding

This research was not supported by a financing project, having only the support of the Federal University of Piauí through logistical support for fieldwork.

Availability of data and materials

The datasets used and/or analyzed in the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Individual consent to participate in the study was obtained prior to the administration of the questionnaire. Only people that consented to participate in the study were considered. This study was approved by the Research Ethics Committee of the Federal University of Piauí, under CAAE registration number 93417517.3.0000.5660.

Consent for publication

Individual free informed consent was obtained according to the Research Ethics Committee of Federal University of Piauí (CEP/UFPI). A copy of the form used is available under request.

Competing interests

The authors declare that they have no competing interests.

Author details

¹ Federal University of Piauí / *Campus* Amílcar Ferreira Sobral (UFPI/CAFS), Ethnobiology and Conservation Laboratory, BR 343, km 3.5 s/n Meladão, Floriano, Piauí, Brazil Postal code: 64808-605. ² State University of Piauí (UESPI) / Coordination of Biological Sciences, Botany Laboratory. *Campus* of Corrente, Av. Dom Pedro II, 629, Corrente, Piauí, Brazil. Postal code: 64980-000.

References

1. Alcorn JB. The scope and aims of ethnobotany in a developing world. In: Schultes RE, Reis SV. (Orgs.). *Ethnobotany: evolution of a discipline*. Cambridge: Timber Press; 1995.
2. Rocha JA, Bocolo OH, Fernandes LRRMV. Etnobotânica: um instrumento para valorização e identificação de potenciais de proteção do conhecimento tradicional – Interações. 2015; 16:67–74.
3. Nascimento NA, Carvalho JOP, Leão NVM. Distribuição espacial de espécies arbóreas relacionadas ao manejo de florestas naturais – Revista de Ciências Agrárias. 2002; 37: 175–194.
4. Prado ACC, Rangel EB, Sousa HC, Messias MCTB. Etnobotânica como subsídio à gestão socioambiental de uma unidade de conservação de uso sustentável. *Rodriguésia*. 2019;70:1–10.
5. Blancas J, Casas A, Salicrup DP, Caballero J, Vega E. Ecological and socio-cultural factors influencing plant management in Náhuatl communities of the Tehuacán Valley, Mexico -. *J Ethnobiol Ethnomed*. 2013;9:1–22.
6. González-Insuasti MS, Caballero J. Managing plant resources: how intensive can it be? *Human Ecology*. 2007;35:303–14.
7. Lins Neto EMF, Peroni N, Casas A, Parra F, Aguirre X, Guillén S, Albuquerque UP. Brazilian and Mexican experiences in the study of incipiente domestication. *J Ethnobiol Ethnomed*. 2014;10:33.
8. Casas A, Valiente-Banuet A, Viveros JL, Caballero J, Cortés L, Dávila P, Lira R, Rodriguez I. Plant Resources of the Tehuacán-Cuicatlán Valley, México. *Econ Bot*. 2001;55:129–66.
9. Santos KL, Peroni N, Guries RP, Nodari RO. Traditional Knowledge and Management of Feijoa (*Acca sellowiana*) in Southern Brazil. *Econ Bot*. 2009;63:204–14.
10. Tinoco A, Casas A, Luna R, Oyama K. Population genetics of *Escontria chiotilla* in wild and silvicultural managed populations in the Tehuacán Valley, Central México. *Genet Resour Crop Evol*. 2005;52:525–38.
11. Silva CV, Reis MS. Produção de pinhão na região de Caçador SC: Aspectos da obtenção e sua importância para comunidades locais. *Ciência Florestal*. 2009;19:365–76.
12. Sousa Júnior JR, Collevatti RG, Lins Neto EMF, Peroni N, Albuquerque UP. Traditional management affects the phenotypic diversity of fruits with economic and cultural importance in the Brazilian Savana. *Agrofor Syst*. 2018;92:11–21.
13. Ramos KMC, Souza VAB. Características físicas e químicos –nutricionais de frutos de pequi (*Caryocar coriaceum* Wittm.) em populações naturais da região Meio-Norte do Brasil. *Revista Brasileira de Fruticultura*. 2011;33:500–8.
14. Standley PC. *Trees and shrubs of Mexico*. Contrib United States National Herbarium. 1924;23:1–1721.
15. Clement CR, Cristo-Araújo M, D’eeckenbrugge GC, Pereira AA, Picanço-Rodrigues D. Origin and Domestication of Native Amazonian Crops. *Diversity*. 2010;2:72–106. <https://doi.org/10.3390/d2010072>.
16. Morton JF. *Fruits of Warm Climates*. Miami: Curtis F. Downing; 1987.

17. Smith NJH, Willians JT, Plucnett DL, Talbot J. Tropical Forests and Their Crops. Cornell University.1992.
18. Campos JLA, Araújo EL, Gaoue OG, Albuquerque UP. Socioeconomic factors and cultural changes explain the knowledge and use of Ouricuri Palm (*Syagrus coronata*) by the Fulni-ô Indigenous People of Northeast Brazil. *Econ Bot.* 2019;73:187–99.
19. Gomes JMA, Nascimento LW. Visão sistêmica da cadeia produtiva da carnaúba. In: Gomes JMA, Santos KB, Silva MS. (Orgs.). Cadeia produtiva da cera de carnaúba: Diagnóstico e cenários. Eds. Teresina: EDUFPI; 2006. 190 p.
20. Holanda SJR, Araújo FS, Gallão MI, Medeiros Filho S. Impacto da salinidade no desenvolvimento e crescimento de mudas de carnaúba (*Copernicia prunifera* (Miller) H. E. Moore). *Revista Brasileira de Engenharia Agrícola e Ambiental.* 2011;15:47–52.
21. Ferreira CS, Nunes JAR, Gomes RLF. Manejo de cortes das folhas de *Copernicia prunifera* (Miller) H. E. Moore no Piauí. *Revista Caatinga.* 2013;26:25–30.
<https://periodicos.ufersa.edu.br/index.php/caatinga/article/view/2839>. Available.
22. IBGE – Instituto Brasileiro de Geografia e Estatística. 2019. Available in:
<https://cidades.ibge.gov.br/brasil/ma/barao-de-grajau/panorama> consultado 14/05/2019.
23. Bailey K. *Methods of social research.* New York: The Free Press; 1994. 591 p.
24. Albuquerque UP, Lucena RFP, Alencar NL. Métodos e técnicas para coleta de dados etnobiológicos. In: Albuquerque UP, Lucena RFP, Cunha LVFC. (Orgs.). Métodos e Técnicas na Pesquisa Etnobiológica e Etnoecológica. Recife: NUPEEA; 2010. pp. 39–64.
25. Vieira IR, Loiola MIB. Percepção ambiental das artesãs que usam as folhas de carnaúba (*Copernicia prunifera* H.E.Moore, Arecaceae) na Área de Proteção Ambiental Delta do Parnaíba, Piauí, Brasil. *Sociedade Natureza.* 2014;26:63–76.
26. Sousa RF, Silva RAR, Rocha TGF, Santana JAS, Vieira FA. Etnoecologia e etnobotânica da palmeira carnaúba no semiárido brasileiro. *Cerne.* 2015;21:587–94.
27. Rodrigues LC, Silva AA, Silva RB, Oliveira AFM, Andrade LHC. Conhecimento e uso da carnaúba e da algaroba em comunidades do sertão do Rio Grande do Norte, nordeste do Brasil. *Revista Árvore.* 2013;37:451–7.
28. Markley KS. Caranday: a source of palm wax. *Econ Bot.* 1955;9:39–52.
29. Grassía JA. Palmeras en la Ciudad de Resistencia. *Copernicia alba.* 2010. Available in:
<http://palmasenresistencia.blogspot.com/2010/09/copernicia-alba.html> Accessed in may 2020.
30. Negrelle RRB, Degen-Naumann RL. *Copernicia alba* Morong ex Morong & Britton: aspectos botânicos, ecológicos, etnobotânicos e agronômicos. *Visão Acadêmica.* 2012;13:60–71.
31. Arrúa RD, Negrelle RRB. Estructura poblacional, regeneración y producción potencial de cera de *Copernicia alba* Morong ex Morong & Britton en tres sitios de la región del Chaco, Paraguay. *Iheringia, Sér. Bot.* Porto Alegre. 2014;69:277–84.

32. Sousa Júnior JR, Albuquerque UP, Peroni N. Traditional Knowledge and Management of *Caryocar coriaceum* Wittm. (pequi) in the Brazilian Savanna northeastern Brazil. *Econ Bot.* 2013;67:225–33.
33. Lins Neto EMF, Oliveira IF, Britto FB, Albuquerque UP. Traditional knowledge, genetic and morphological diversity in populations of *Spondias tuberosa* Arruda (Anacardiaceae). *Genet Resour Crop Evol.* 2013;60:1389–406.
34. Dawit S, Regassa T, Mezgebu S, Mekonnen D. Evaluation of two *Moringa* species for adaptability and growth performance under Bako conditions. *Journal of Natural Sciences Research.* 2016;6:76–82.
35. Rani EA, Arumugam T. *Moringa oleifera* (Lam) – a nutritional powerhouse. *Journal of Crop Weed.* 2017;13:238–46.
36. Bürgi M, Hersperger AM, Schneeberger N. Driving forces of landscape change – current and new directions. *Landscape Ecol.* 2004;19:857–68.
37. Delgado C, Couturier G, Mejia K. *Mauritia flexuosa* (Arecaceae: Calamoideae), an Amazonian palm with cultivation purposes in Peru. *Fruits.* 2007;62:157–69.
38. Horn CM, Gilmore MP, Endress BA. Ecological and socio-economic factors influencing aguaje (*Mauritia flexuosa*) resource management in two indigenous communities in the Peruvian Amazon. *For Ecol Manage.* 2012;267:93–103.
39. Souto T, Ticktin T. Understanding interrelationships among predictors of local ecological knowledge. *Econ Bot.* 2012;66:149–64.
40. Beltrán-Rodríguez L, Ortiz-Sánchez A, Mariano N, Maldonado-Almanza B, Reyes-García V. Factors affecting ethnobotanical knowledge in a mestizo community of the Sierra de Huautla Biosphere Reserve, Mexico. *J Ethnobiol Ethnomed.* 2014;10:1–18.
41. Sousa RS, Medeiros PM, Albuquerque UP. Can socioeconomic factors explain the local importance of culturally salient plants in a social-ecological system? *Acta Botanica Brasilica.* 2019;33:283–91.
42. Hanazaki N, Tamashiro JY, Leitao-Filho H, Begossi A. Diversity of plant uses in two Caiçara communities from the Atlantic Forest coast, Brazil. *Biodivers Conserv.* 2000;9:597–615.
43. Voeks RA. Are women reservoirs of traditional plant knowledge? Gender, ethnobotany and globalization in northeastern Brazil. *Singap J Trop Geogr.* 2007;28:7–20.
44. Vandebroek I, Balick MJ. Globalization and loss of plant knowledge: challenging the paradigm. *Plos One.* 2012; 7: e0037643. doi: 10.1371/ journal.pone.0037643.
45. Ladio AH, Lozada M. Patterns of use and knowledge of wild edible plants in distinct ecological environments: a case study of a Mapuche community from Northwestern Patagonia. *Biodivers Conserv.* 2004;13:1153–73.
46. Benz BF, Cevallos J, Santana F, Rosales J, Graf S. Losing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico. *Econ Bot.* 2000;54:183–91.
47. Saynes-Vásquez A, Caballero J, Meave JA, Chiang F. Cultural change and loss of ethnoecological knowledge among the Isthmus Zapotecs of Mexico. *J Ethnobiol Ethnomed.* 2013;9:40.

48. Varughese G, Ostrom E. The contested role of heterogeneity in collective action: some evidence from community forestry in Nepal. *World Dev.* 2001;29:747–65.
49. Holmes C. Assessing the perceived utility of wood resources in a protected area of western Tanzania. *Biol Cons.* 2003;111:179–89.
50. Lins Neto EMF, Peroni N, Albuquerque UP. Traditional knowledge and management of umbu (*Spondias tuberosa*, Anacardiaceae): Na endemic species from the Semi-Arid Region of Northeastern Brazil. *Econ Bot.* 2010;64:11–21.
51. Darwin C. *The Variation of Animals and Plants under Domestication*. London: John Murray. 1868.
52. Gregory TR. *Artificial Selection and Domestication: Modern Lessons from Darwin's Enduring Analogy*. Evolution: Education Outreach. 2009;2:5–27.
53. Ruenes-Morales MR, Casas A, Jiménez-Osornio JJ, Caballero J. Etnobotânica de *Spondias purpurea* L. (Anacardiaceae) en la Península de Yucatán. *Interciencia.* 2010;35:247–54.
54. Aguirre-Dugua X, Eguiarte LE, González-Rodríguez A, Casas A. Rounde and large: morphological and genetic consequences of artificial selection on the gourd tree *Crescentia cujete* by the Maya of the Yucatan Peninsula, Mexico. *Ann Bot.* 2012;109:1297–306.
55. Casas A, Cruse-Sanders J, Morales E, Otero-Arnaiz A, Valeinte-Banuet A. Maintenance of phenotypic and genotypic diversity in managed populations of *Stenocereus stellatus* (Cactaceae) by indigenous peoples in Central Mexico. *Biodivers Conserv.* 2005;15:879–98.
56. Smart J, Simmonds NW. *Evolution of crop plants*. New York: Longman Scientific and Technical; 1995.
57. Álvarez-Ríos GD, Pacheco-Torres F, Figueredo-Urbina CJ, Casas A. Management, morphological and genetic diversity of domesticated agaves in Michoacán, México. *J Ethnobiol Ethnomed.* 2020;16:1–17.
58. Pujo B, Mühlen GS, Garwood N, Horoszowski Y, Douzery EJP, McKey D. Evolution under domestication: contrasting functional morphology of seedlings in domesticated cassava and its closest wild relatives. *New Phytol.* 2005;166:305–18.
59. Maurmann K. Como o manejo tradicional da folha de *Butia capitata* (Martius) Beccari pode promover a conservação dos butiazais? Trabalho de conclusão de curso. Instituto de Biociências. UFRGS. 2010. Available in: <http://hdl.handle.net/10183/35275>.
60. Zohary D. Unconscious selection and evolution of domesticated plants. *Econ Bot.* 2004;58:5–10.
61. Berkes F, Folke C. *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*, Cambridge University Press, Cambridge, UK. 1998. ISBN: 0521785626.
62. Belcher B, Kusters K. Non-timber forest product commercialization: development and conservation lessons. In: Kusters K, Belcher B. (Orgs.). *Forest products, livelihoods and conservation: case studies of non timber forest product systems*. 1. Indonésia: Ásia, Center for International Forestry Research (CIFOR); 2004. pp. 1–22.

63. Varghese A, Ticktin T. Regional variation in non-timber forest product harvest strategies, trade, and ecological impacts: the case of black dammar (*Canarium strictum* Roxb.) Use and conservation in the Nilgiri Biosphere Reserve, India. *Ecology and Society*. 2008; 13: 11. <https://www.ecologyandsociety.org/vol13/iss2/art11/> Accessed in 20 april 2020.
64. Souza GC, Kubo R, Guimarães L, Elisabetsky E. An ethnobiological assessment of *Rumohra adiantiformis* (samambaia-preta) extractivism in Southern Brazil. *Biodivers Conserv*. 2006;15:2737–46.
65. Jensen A. Valuation of non-timber forest products value chains. *Forest Policy Economics*. 2009;11:34–41.

Figures

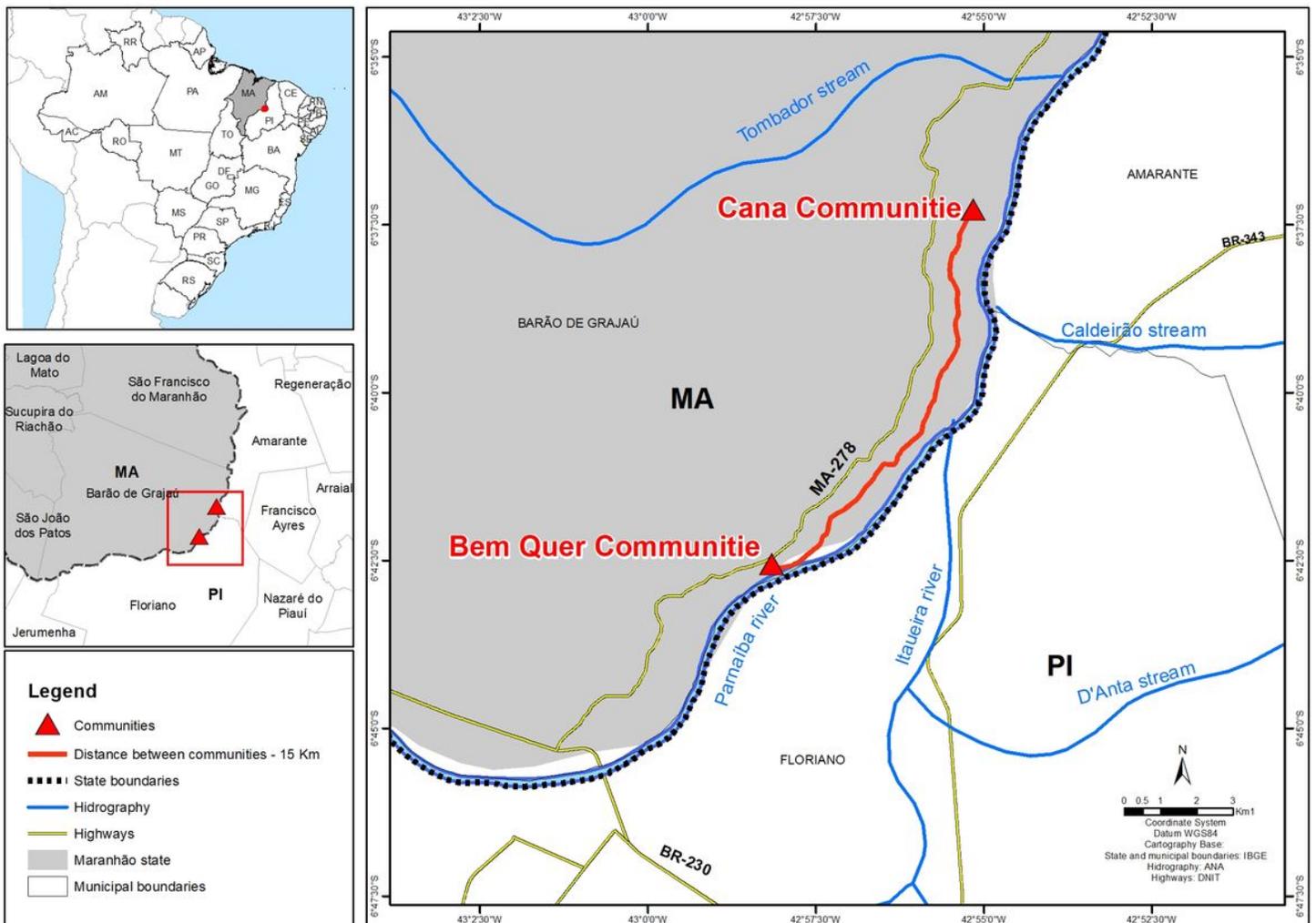


Figure 1

Location of study area, municipality of Barão de Grajaú, Maranhão, Brazil.

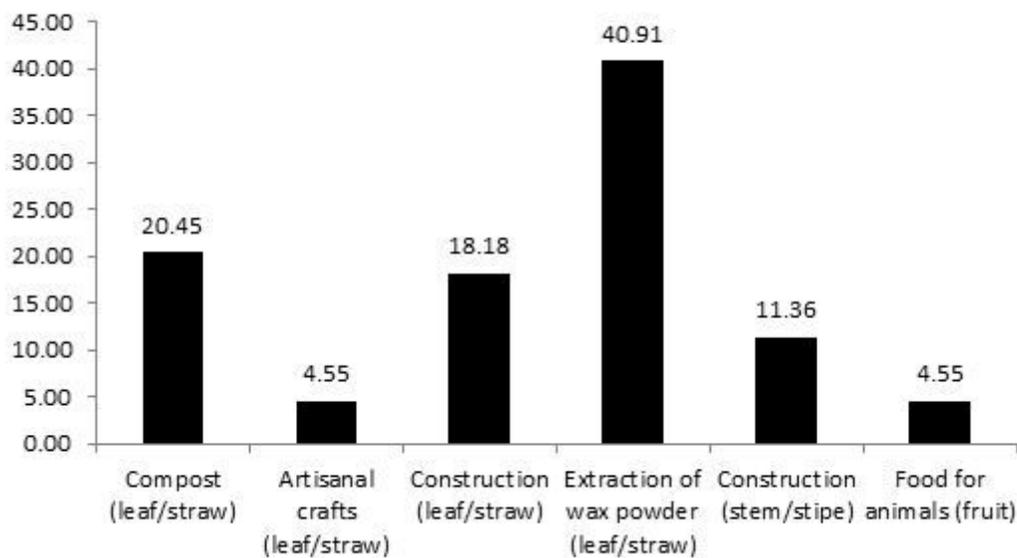


Figure 2

Percentages by use category indicated for *Copernicia prunifera*, Maranhão, Brazil

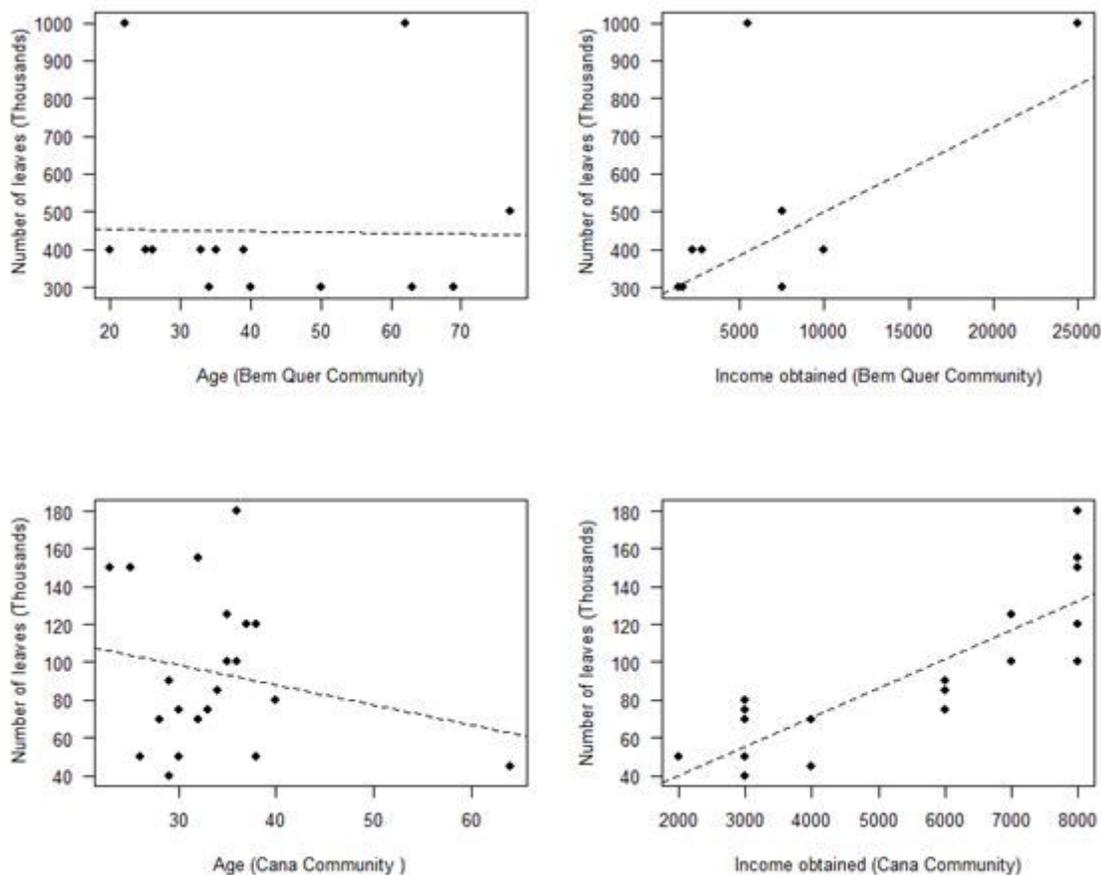


Figure 3

Correlation analysis between socioeconomic data



Figure 4

“Types” of carnaúba eyes (new leaves) cited by extractors. Photos: José Afonso S. Almeida

Supplementary Files

This is a list of supplementary files associated with this preprint. [Click to download.](#)

- Coperniciaprunifera.jpeg
- personandplant.jpeg
- renamedc8c5d.jpeg
- image02suggestionfophotographforthecover.png
- image01suggestionfophotographforthecover.png