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Life strategy and chemical composition as predictors of the selection of medicinal plants from the *caatinga* (Northeast Brazil)

C.F.C.B.R. de Almeida[a], T.C. de Lima e Silva[b], E.L.C. de Amorim[b], M.B. de S. Maia[c], U.P. de Albuquerque[d,*]

[a]*Departamento de Botânica, Programa de Pós-graduação em Biologia Vegetal, Universidade Federal de Pernambuco, Brasil*

[b]*Laboratório de Química Farmacêutica, Departamento de Ciências Farmacêuticas, Universidade Federal de Pernambuco, Brasil*

[c]*Laboratório de Farmacologia e Produtos Naturais, Departamento de Fisiologia e Farmacologia, Universidade Federal de Pernambuco, Brasil*

[d]*Laboratório de Etnobotânica Aplicada, Área de Botânica, Departamento de Biologia, Universidade Federal Rural de Pernambuco Rua Dom Manoel de Medeiros s/n, Dois Irmãos, Recife, Pernambuco 52171-030, Brasil*

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Abstract

An ethnobotanical study was undertaken in conjunction with a phytochemical approach to the medicinal flora of the *caatinga*, popularly used in communities of the Xingó region (Northeast Brazil); the focus was on applying the apparency theory to explain the choice and use of these plants. Initially, an ethnobotanical study was carried out to survey the medicinal plants used in the region in which 339 people were interviewed using standardized questionnaires. To eliminate the effect of cultural interference, exotic plants cultivated intentionally were not considered, which resulted in a total of 41 species. In the field, data was obtained on the types of life strategies and habit for each species and plant parts indicated for medicinal use were collected. A phytochemical study was undertaken with five classes of chemical compounds for the species collected. Significant differences were found in the number of positive occurrences for each of the compound classes in relation to life strategy

*Corresponding author. Tel.: +55 81 3302 1350; fax: +55 81 3302 1360.
E-mail address: upa@ufrpe.br (U.P. de Albuquerque).

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and habit. Strategist-*K* plants had a greater number of occurrences than strategist-*r* plants. In general, trees were more diversified than herbs and bushes in relation to the presence of compound classes. The scores (local relative importance) obtained for each plant are independent from compound classes found, habit, life strategy, and plant part used. Nevertheless, strategist-*K* species obtained the highest averages.

Keywords: Phytochemistry; Dry forest; *Caatinga*; Ethnobotany; Apparency theory

1. Introduction

Several researchers have drawn attention to the use of medicinal plants in tropical regions, discussing different hypothesis to explain the usage patterns found (Voeks, 1996; Stepp and Moerman, 2001; Stepp, 2004). The information available today makes clear the role of plants' life form and ecologic biochemistry for the local use and knowledge of medicinal resources. Stepp and Moerman (2001) and Stepp (2004), for example, observed a high frequency of herbs and weeds used as medicinal in several parts of the world, suggesting that this preference might be related with chemical and ecological aspects. However, cultural factors, in conjunction with the previously cited usage patterns, strongly influence the selection and use of medicinal plants (cf. Nolan and Robbins, 1999; Amorozo, 2004; Vandebroek et al., 2004).

As a model, the authors above suggest the apparency (Feeny, 1976) and resource availability theories (Coley et al., 1985), initially used in herbivory studies. Both have some predictions in common, supported by the idea that weeds and herbs are high in strongly active secondary compounds. In reality, these theories are complementary and share some predictions (Howe and Westley, 1988). Rhoades and Cates (1976) postulate that there is a greater investment in defense in apparent plants and that these plants developed chemical defenses that are either quantitative or that act as digestibility reducers (tannins, for example); non-apparent plants, however, would accumulate qualitative defenses (glycosides, for example), present in low concentrations in tissues and with low metabolic cost (Piazzamiglio, 1991).

Therefore, *r*-strategist species, which colonize rapidly and have a short life cycle, tend to invest in the quality (mobile defenses) of the defense compounds and not on the quantity (Coley et al., 1985); there is a link between lifespan and type of defense, based on the fact that annual plants are more toxic than perennials—this toxicity is important in the species used as medicinal plants. One example is *Catharanthus roseus* (L.) G. Don., an annual species considered a weed, which produces vincristine and vinblastine, drugs used in chemotherapy to treat some types of cancer (Stepp and Moerman, 2001; Stepp, 2004).

These theories would explain the great number of herbs among medicinal floras. Considering the poorly investigated medicinal flora of seasonal dry forests, especially the *caatinga* of northeastern Brazil (for example, Almeida and Albuquerque, 2002; Albuquerque and Andrade, 2002), this study tested two hypotheses: (a) chemical compounds considered strongly bioactive tend to concentrate themselves in species of higher local relative importance; (b) the percentage of highly bioactive compounds is greater in medicinal herbs than in any other kind of habit. In this sense, an ethnobotanical study was undertaken in conjunction with a phytochemical approach to the medicinal flora of the *caatinga* popularly used in communities of the Xingó region (Northeast Brazil); the focus was on applying the apparency theory to explain the selection and use of medicinal plants.

2. Materials and methods

2.1. The caatinga and the study area

A total of 80% of the Brazilian Northeast is classified as semi-arid, with 80,000 km^2 of hectares of *caatinga*. The vegetation of the *caatinga* is made up of small woody and herbaceous deciduous, caducifolious, spiny species, where succulent, epiphytic, rupiculous, and saxiculous plants stand out (Drumond et al., 2002). Altitude varies from 0 to 600 m and temperature ranges from 24 to 28 °C (Drumond et al., 2002). The climate is semi-arid and hot, with scarce, badly distributed precipitation and long periods of drought. Annual precipitation reaches levels between 600 and 750 mm (Assis, 1999).

The name *caatinga* has been used exclusively for regions of northeastern Brazil and this has caused confusion (Prado, 2003). The *caatinga* definition includes areas such as the Chapada do Araripe, with corral (*cerrado*) vegetation and areas of humid forest (*brejo*), as well as areas that, despite being floristically part of the *caatinga* vegetation, are not considered *caatinga* as they are not part of this geographical region (for example, the dry valley of the Jequitinhonha River, in the state of Minas Gerais, and/or other regions of the Rio Grande Basin, in western Bahia) (Prado, 2003). According to Andrade-Lima (1966), the name used should be *caatingas*, in the plural, due to the several different vegetation physiognomies included (called mosaic).

The *caatinga* is submitted to a hot, dry, semi-arid climate, resulting in xerophyte vegetation. The *caatinga* and the other surrounding ecosystems have significant floristic diversity (Rodal and Sampaio, 2002). This ecosystem is under great pressure due to deforestation—it suffers as northeastern Brazil's main energy demand. In addition, irrational soil use causes erosion due to farming failures. This hinders the sustainability of forest resources, worsening the region's poverty by restraining family income and forage supply. Under a biodiversity conservation point of view, the *caatinga* needs priority action because it is home to flora and fauna with endemic species. Many of these species (*Schinopsis brasiliensis* Engl., *Myracroduon urundeuva* Fr. All., *Tabebuia aurea* (Manso) Benth. and Hook. F. ex S. Moore) have great medicinal potential, and extractivism has reduced their populations drastically.

The Xingó region, where this study took place, comprises the borders between the states of Pernambuco, Bahia, Alagoas, and Sergipe, and covers an area of 7845 km^2. Its central point is located at 09°36′96″ south latitude and 36°50′88″ east longitude. The region is cut by the São Francisco River, which runs through its central portion in a northwest/southeast direction (RADAMBRASIL, 1983). Following the domain concept, the following types of soils can be found: thin litholic soils, with medium to clayish texture, frequently stony; quartzarenic soils, a kind of soil that is not very developed; cambisoils and dystrophic podzolic soils, made up of clay minerals; the no-calcic brunisolic soils, little developed and very clayish; and planosols from the kaulinite-esmectite sub-domain (Jacomine et al., 1975).

During the 1990s, the Xingó Program was implemented in the region of this study, a multidisciplinary initiative supported by the National Council of Scientific and Technologic Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico—CNPq), in conjunction with the São Francisco Hydroelectric Company (Companhia Hidro Elétrica do São Francisco—CHESF). With the participation of several institutions of higher education, several projects began to be developed in the areas of aquiculture, tourism, water resources, biodiversity, alternative energy, education, work management, archeology, and historical patrimony.

The ethnobotanical investigation reported here was undertaken in rural communities within the municipalities of Piranhas and Delmiro Gouveia, in the state of Alagoas, Brazil. These communities typically practice only subsistence agriculture, in a region marked by severe seasonal droughts and limited medical services. Isolated areas such as these tend to use remedies based on medicinal plants to a much greater extent than in regions where health stations and medical professionals are more easily available. A majority of the local population identifies themselves as Catholics.

2.2. Data collection

This study was part of a larger project, "Projeto Biodiversidade da Caatinga" (Caatinga Biodiversity Project), of the Xingó Program: the subproject Chemistry, Pharmacology, and Toxicology of Medicinal Plants of the Caatinga. Basically, the project aimed to "Diffuse *caatinga* medicinal plant usage technologies with the aim of propagating their rational use and establishing alternatives of pharmaceutical assistance for the population, considering that native vegetation can reveal a medicinal richness with an important and relatively unexplored therapeutic potential" (http://www.programa-xingo.gov.br). Initially, an ethnobotanical study was undertaken to survey the species of medicinal plants used in the region, based on interviews with standardized questionnaires. A number of basic questions were asked: do you use plants to treat or prevent illnesses? Which ones? Which parts of the plant are used, and in what quantities? How is the medicine prepared? A total of 339 local dwellers were interviewed in the municipalities of Piranhas and Delmiro Gouveia, state of Alagoas, which resulted in the documentation of 187 species from 64 families and 128 genera. Native or spontaneous species of the *caatinga* were selected from this list and a new list was obtained with 105 species.

In order to focus on the value of the local flora, exotic plants cultivated intentionally were not considered. All of the available medicinal plants cited were collected randomly, from February to September 2003, in a total of 41 species. The number of species collected reflects the availability of suitable botanical material during the period of this investigation. As such, the species investigated represent only an initial sampling. Due to the difficulty in obtaining an expressive number of species in the municipalities where the interviews took place, samples were collected (with the aid of local medicinal plant specialists) from the municipalities of Poço Redondo (9°48′S, 37°41′W) and Canindé de São Francisco (9°64′S, 37°78W), in the state of Sergipe, and Piranhas (9°37′S, 37°45′W), Olho d'Água do Casado (9°35′S, 37°83W), and Delmiro Gouveia (9°38′S, 37°99′W), in the state of Alagoas; all of these areas are located in the São Francisco River microregion.

Data on the types of life strategy and habit was obtained in the field for each species, and plant parts indicated for medicinal use were collected. Voucher material is deposited in the Xingó herbarium (Canindé do São Francisco, Sergipe, Northeast Brazil).

2.3. *Life strategies and habit*

The grouping of species according to type of life strategy (r and k) and habit (tree, bush, and herb) was necessary to define medicinal plant selection and use in the studied area. Life strategies were defined according to Begon et al. (1988), in which the letters r and k refer to logistic equation parameters: individuals selected as r have high rates of reproduction and growth and are a given area's most probable colonizers, while species belonging to the K group have a lower reproduction potential, but a greater ability to survive competitively under the density of the previous stages and are found in constant habitats.

The definition of Begon et al. (1988) was also adopted for the types of habit. The trees are perennial woody plants, generally with a single stem axis; the bushes are also perennial woody plants, but are shorter and typically have many branches; and the herbs are non-woody plants, with relatively small aerial components.

2.4. *Phytochemical analysis*

Phytochemical tests were undertaken for the following compounds classes: phenols and tannins (quantitative compounds); alkaloids, triterpenes, and quinones (qualitative compounds), selected due to their strong biological activity (Matos, 1997; Carvalho et al., 2002; Falkenberg, 2002; Henriques et al., 2002; Santos and Mello, 2002) and due to the need of working with compounds qualitative and quantitative, as professed by the apparency theory (cf. Feeny, 1976).

Selection was done using ethanol extracts of parts used medicinally as indicated during the ethnobotanical survey. Chemical complexity tests were undertaken adopting the procedures suggested by Matos (1997): phenols and tannins were detected with an alcoholic solution of iron chloride; for alkaloids, specific precipitation reagents were used: Hager, Mayer, and Dragendorff; for triterpenes, extracts were treated with acetic anhydride and concentrated sulfuric acid; and for quinones, the extract was treated with a solution of aluminum hydroxide. All positive results were confirmed by thin layer chromatography, using 0.2 mm thick

Merck silica gel 60 chromatoplates with F_{254} fluorescence indicators and elution systems, and a specific developer for each of the classes investigated (Wagner and Bladt, 1996; Harbone, 1982).

2.5. Data analysis

The *G* test (Sokal and Rholf, 1995) was used to verify the percentage of species with positive results, in relation to life strategy and habit, for each of the chemical compound classes. Additionally, the Kruskal–Wallis test, a non-parametric analysis, was used (Sokal and Rholf, 1995) to check whether the species' local relative importance is associated with life strategy, habit, chemical composition, and plant part used. Relative importance (RI) was calculated according to Bennett and Prance (2000). Species that obtained the highest values are considered the most versatile, and will have a greater number of properties and number of corporeal systems treated. In using this technique, we are assuming that a plant is more important when it is most versatile (Silva and Albuquerque, 2004). This analysis has some limitations however, for a plant with few uses, but which is used frequently by many people, would tend to be awarded only low values. Nonetheless, this quantitative technique, as are many others found in the ethnobotanical literature (cf. Silva and Albuquerque, 2004), are measures of folk knowledge, and interpretations of their use must be carefully made. The RI Index is calculated by the following:

$$\mathbf{RI} = \mathrm{NCS} + \mathrm{NP},$$

where **RI** is the relative importance; **NCS** is number of corporeal systems. It is given by the number of corporeal systems treated by a species (NSCS) over the total number of corporeal systems treated by the most versatile species (NSCSV):

$$\mathbf{NCS} = \frac{\mathrm{NSCS}}{\mathrm{NSCSV}}.$$

NP is the number of properties attributed to a specific species (NPS) over the total number of properties attributed to the most versatile species (NPSV):

$$\mathbf{NP} = \frac{\mathrm{NPS}}{\mathrm{NPSV}}.$$

3. Results

3.1. Compound classes vs. habit

Of the 41 species studied, 29.27% are herbs, 24.39% are bushes, and 46.34% are trees. In relation to their life strategy, 29.27% are annual and 70.73% are considered perennial. All of the species of herbs were considered *r*-strategists and all trees and bushes were considered *K*-strategists. The species analyzed belong to 24 families, from which Cactaceae, Caesalpiniaceae, and Euphorbiaceae stand out (Table 1).

All of the species studied had at least one of the five compound classes; phenols were found in all species and tannins in 56%. In the analysis for alkaloids, only two species had positive results, *Aspidosperma pyrifolium* Mart. and *Mimosa tenuiflora* (Willd.) Poir. Triterpenes were detected in 46.34% of the species and 34.14% of the species had quinones.

Significant differences were found in the number of positive occurrences for each compound class in relation to life strategies and habit (Table 2). *K*-strategist plants had a greater number of occurrences than the *r*-strategists ($G = 27.72$; df $= 3$; $P < 0.01$). In general, trees were more diversified in relation to the presence of the compound classes studied than herbs ($G = 38.27$; df $= 3$; $P < 0.01$) and bushes ($G = 18.56$; df $= 3$; $P < 0.01$). Differences were also significant when comparing herbs and bushes ($G = 9.05$; df $= 3$; $P < 0.05$). *K*-strategist plants showed a larger number of occurrences of both qualitative and quantitative compounds than did *r*-strategist species ($G = 40.38$; df $= 2$; $P < 0.01$).

3.2. Species' relative importance

Species with highest relative importance are trees and bushes, where *Senna splendida* (Vogel.) H.S. Irwin and Barneby (2.00), *Capparis jacobinae* Moric. (1.71), *Caesalpinia ferrea* Mart. ex Tul. (1.57), *Bauhinia cheilantha* (Bong.) Stend. (1.42), *Ruellia asperula* (Ness) Lindau (1.28), and *Zizyphus joazeiro* Mart. (1.28) stand out.

The scores (relative importance) obtained for each plant are independent from the compound classes present, the habit, the life strategies, and the plant part used (Table 3). Nevertheless, *K*-strategist species obtained the highest averages. In relation to the compound classes, phenols and tannins stood out, followed by the triterpenes.

4. Discussion

The idea that guided this study is based on the fact that plants developed strategies against herbivory, where compounds highly active in low concentrations, such as alkaloids and quinones, would be predominant in species with short life cycles (Stepp and Moerman, 2001). Therefore, from a chemical point of view, we expected to find more positive results for alkaloids and quinones, for example, among the *caatinga* native medicinal species analyzed, in order to satisfy the hypothesis' predictions. The population would have selected these plants exactly because of this type of defense, species with a low life cycle and rich in highly bioactive compounds with low molecular weight. The results obtained in this study do not completely support the apparency theory. Different from what was expected, of the group of plants analyzed, highly bioactive compounds should concentrate themselves in plants with short life cycles and would tend to occur in species with higher relative importance. However, *K*-strategist plants demonstrated a higher number of occurrences of quantitative compounds, in agreement with the apparency hypothesis.

Table 1
Medicinal plants studied

Scientific/family	Common name	Popular indications	Chemical compounds	Used part	Habit	Life strategy	IR	Voucher
ACANTHACEAE								
Ruellia asperula (Ness) Lindau	Camará candeia	Bronchitis, asthma, flu, febre, uterus inflammation	F	Leaf	Bushe	*K*	1.285	398
ANACARDIACEAE								
Myracroduon urundeuva Fr. All. et Rowl	Aroeira	Inflammation	F, T, TR, Q	Inner bark	Tree	*K*	0.286	411
Schinopsis brasiliensis Engl.	Baraúna	Inflammation, sexual impotence	F, T, TR, Q	Inner bark	Tree	*K*	0.570	410
Spondias tuberosa Arr. Cam	Umbuzeiro	Diabetes	F, T, TR, Q	Inner bark	Tree	*K*	0.286	408
APOCYNACEAE								
Allamanda blanchetii A. DC	Sete patacas roxas	Heart, high blood pressure	F	Leaf	Bushe	*K*	0.488	420
Aspidosperma pyrifolium Mart	Pereiro	Diarrhea, sedative, heart	F, T, AL, TR, Q	Inner bark	Tree	*K*	0.856	421
ARACEAE								
Anthurium affine Schott	Palmeirão brabo	Diabetes, heart, flu, blood make fine	F	Leaf	Herb	*r*	1.142	427
ASCLEPIADACEAE								
Calotropis procera (Willd.) R. Br.	Algodão de seda	Diarrhea, worm	F	Flower	Bushe	*K*	0.570	430
ASTERACEAE								
Acanthospermum hispidum DC.	Espinho de cigano	Bronchitis, asthma, pneumonia, inflammation, cancer	F	Leaf	Herb	*r*	1.142	441
Argyronermonia harleyi (H. Rob.) Macheish.	Moricica	Gastritis, ulcerous	F, TR, Q	Leaf	Herb	*r*	0.429	449

BIGNONIACEAE								
Tabebuia aurea (Manso) Benth. and Hook. F. ex S. Moore	Craibeira	Uterus inflammation, worm	F, T	Inner bark	Tree	*K*	0.570	455
BOMBACACEAE								
Chorisia glaziovii (O. Kuntze.)	Barriguda de espinho	Heart, high blood pressure	F, T, TR, Q	Inner bark	Tree	*K*	0.429	459
BROMELIACEAE								
Tillandsia loliacea Mart. ex Schult.	Barba de bode pequeno	Uterus hemorrhage, ulcerous	F, T	Whole plant	Herb	*r*	0.570	479
Tillandsia recurvata (L.) L.	Barba de bode pequeno	Bloodshed	F	Whole plant	Herb	*r*	0.286	475
CACTACEAE								
Arrojadoa rhodantha (Guerke) Br. Et Rose	Rabo de raposa	Heart, gastritis, spleen	F, TR	Stem	Herb	*K*	0.714	487
Cereus jamacaru DC.	Mandacaru	Liver, kidneys infection	F	Stem	Tree	*K*	0.570	486
Opuntia palmadora Br. et Rose	Quipá	Asthma, worm, inflammation	F, TR	Stem	Bushe	*K*	0.856	488
Pilosocereus gounellei (Weber) Byl. Et Rowl.	Xique xique	Kidneys infection	F, TR	Stem	Bushe	*K*	0.429	485
CAESALPINIACEAE								
Bauhinia cheilantha (Bong.) Stend.	Mororó	Diabetes, inflammation, blood make fine, sedative, rheumatism	F, T, TR, Q	Leaf	Tree	*K*	1.428	507
Caesalpinia ferrea Mart. ex Tul.	Pau ferro	Sore throat, bronchitis, bloodness, swell, scar	F, T, Q	Fruit	Tree	*K*	1.571	510
Caesalpinia pyramidalis Tul.	Catingueira	Gases, bad digestion	F	Leaf	Tree	*K*	0.429	491
Parkinsonia aculeata L.	Turco	Flu, asthma, diabetes, high blood pressure	F	Flower	Tree	*K*	1.142	500
Senna splendida (Vogel.) H. S. Irwin and Barneby	Feijão brabo	Kidneys infection, bronchitis, rheumatism, migraine, diarrhea, inflammation, heart	F, T, TR	Leaf	Bushe	*K*	2.000	830

Table 1. (*continued*)

Scientific/family	Common name	Popular indications	Chemical compounds	Used part	Habit	Life strategy	IR	Voucher
CAPPARACEAE								
Capparis jacobinae Moric.	Icó verdadeiro	Intoxication, fever, diabetes, diarrhea, pneumonia, bronchitis, heart	F, T	Leaf	Bushe	*K*	1.714	526
CELASTRACEAE								
Maytenus rigida Mart.	Bom nome	Sexual impotence, rheumatism	F, TR, Q	Inner bark	Tree	*K*	0.570	533
EUPHORBIACEAE								
Cnidoscolus obtusifolius Pohl.	Faveleira	Cancer, tumor, liver, uterus inflammation	F	Leaf	Tree	*K*	1.000	582
Croton rhamnifolius Humb. Bomplan & Kunth.	Velame	Diabetes, inflammation	F, Q	Leaf	Bushe	*K*	0.570	581
Jatropha mollissima (Pohl.) Baill.	Pinhão Branco	Kidneys infection, appetite	F, TR	Leaf	Bushe	*K*	0.570	589
Manihot glaziovii Muell. Arg.	Maniçoba	Headache, kidneys infection, bloodness	F	Inner bark	Tree	*K*	0.856	591
FABACEAE								
Erythrina velutina Willd.	Mulungu	Headache, fever, sedative, galactogoge	F, T	Inner bark	Tree	*K*	1.000	619
LAMIACEAE								
Leonotis nepetaefolia (L.) R. Br.	Cordão de frade	Urinate keep	F, T, TR	Leaf	Herb	*r*	0.286	630
Ocimum tenuiflorum L.	Alfavaca	Cholesterol, high blood pressure	F, T	Leaf	Herb	*r*	0.286	626

MALPIGHIACEAE								
Byrsonima intermedia Juss.	Cipó de rego ou pitombinha	Gallstone, kidneys stone, prostate inflammation, bad digestion, worm	F, T, TR, Q	Leaf	Bushe	*K*	1.142	647
MIMOSACEAE								
Anadenanthera colubrina (Vell.) Brenan	Angico de caroço	Bronchitis, pneumonia, flu	F, T, TR, Q	Inner bark	Tree	*K*	0.714	675
Mimosa tenuiflora (Willd.) Poir.	Jurema Preta	Inflammation, fever, menstrual cramps	F, T, AL, TR, Q	Inner bark	Tree	*K*	0.714	670
PAPAVERACEAE								
Argemone mexicana L.	Cardo santo	Pneumonia, uterus inflammation	F	Leaf	Herb	*r*	0.570	694
PASSIFLORACEAE								
Passiflora foetida L.	Maracujá papoco	Heart, sedative	F, TR	Leaf	Herb	*r*	0.570	698
RHAMNACEAE								
Zizyphus Joazeiro Mart.	Juazeiro	Flu, tuberculosis, pneumonia, bronchitis, stomachache, bad digestion	F, T, TR	Fruit	Tree	*K*	1.286	728
SAPINDACEAE								
Cardiospermum corindum L..	Timbó	Ulcerous	F	Leaf	Herb	*r*	0.286	758
SAPOTACEAE								
Sideroxylum Obtusifolium (Roem & Schult.) Penn.	Quixaba	Gastritis, stroke, inflammation, genital inflammation	F, T, TR, Q	Inner bark	Tree	*K*	1.142	765
STERCULIACEAE								
Melochia tomentosa L.	Perpetua roxa	Flu, cold, bronchitis, pulmonary inflammation	F	Leaf	Herb	*r*	0.856	782

RI: relative importance, F: phenols, T: tannins, AL: alkaloids, TR: triterpenes, Q: quinones.

Table 2
Number of positive occurrences in relation to secondary compounds, life strategies, and habit of species selected for the study of medicinal plant use criteria and choice in seasonal dry forests (*caatinga*) in northeastern Brazil

Species group	Chemical compounds				
	Phenols	Tannins	Alkaloids	Triterpenes	Quinones
r	12 (100%)	4 (33.33%)	—	3 (25%)	1 (8.33%)
K	29 (100%)	19 (65.51%)	2 (7%)	16 (55.17%)	13 (45%)
Herbs	12 (100%)	4 (33.33%)	—	3 (25%)	1 (8.33%)
Bushes	10 (100%)	4 (40%)	—	5 (50%)	2 (20%)
Trees	19 (100%)	15 (79%)	2 (10.52%)	11 (58%)	11 (58%)

Table 3
Summary of the Kruskal–Wallis test based on relative importance and chemical compound classes, life strategies, and habit of species collected for the study of medicinal plant use criteria and choice in seasonal dry forests (*caatinga*) in northeastern Brazil

	Mean/standard deviation	Kruskal–Wallis test
Life strategy		$H = 3.43$ $P = 0.063$
r	0.59 ± 0.31	
K	0.86 ± 0.44	
Habit		$H = 3.69$ $P = 0.158$
Herbs	0.59 ± 0.31	
Bushes	0.96 ± 0.55	
Trees	0.81 ± 0.37	
Plant part		$H = 0.567$ $P = 0.451$
Leaf	0.85 ± 0.50	
Stem	0.66 ± 0.24	
Compound class		$H = 0.321$ $P = 0.956$
Phenols	0.78 ± 0.42	
Tannins	0.86 ± 0.49	
Alkaloids	0.78 ± 0.10	
Triterpenes	0.79 ± 0.45	
Quinones	0.76 ± 0.41	

However, a closer examination suggests that the observed behavior could be explained by considering resource availability hypothesis, given the singularities of the c*aatinga* environment. According to this hypothesis, plants that develop in rigorous environments have slower growth rates, and tend to invest in high molecular weight compounds. There is an important metabolic cost in the production of bioactive toxic compounds, even for plants of rapid growth (Coley et al., 1985; Barone and Coley, 2002). As such, in the case of *caatinga* plants with a short life cycle, there would tend to be a greater investment in growth in order to complete their life cycle that in the production of alkaloids, for example. As such, our results are in agreement with the predictions based on the resource availability hypothesis.

Considering each phytochemical class researched, alkaloids stand out due to their strong biological activity in low concentrations. Alkaloids are found more frequently in the angiosperms, where they have a wide array of biological activities, as in atropine (anticholinergic), quinine (antimalaria), vinblastine and vincristine (antitumor), morphine (analgesic), and caffeine (stimulant of the central nervous system) (Henriques et al., 2002), as well as cardiovascular and bronchodilator activities (Bruneton, 1991). Based on this study's presumptions, this compound class should stand out in relation to the others. Admitting the apparency theory for the specific case of alkaloids, their proportion should be greater in plants with short life cycles. Levin (1976), for example, ratified this hypothesis in a study of the flora of North America, in which the proportion of annual herbs that contained alkaloids was twice as much than the proportion of perennial plants. This author also notes that trees, as a general rule, are less likely to contain alkaloids. This data suggests that local people, in the studied area, tend to select their medicinal flora based on other criteria, as a greater occurrence of these compounds should be found in plants selected locally. A study by Hazlett and Sawyer (1997), on alkaloids in steppe vegetation, supports this idea; they found no differences in positive results between species with ethnobotanical records and species with no reported medicinal use. However, the results presented by this author are probably an exception to the rule, as many ethnobotanical studies have demonstrated the prevalence of alkaloids in species of the medicinal flora when compared to the general local vegetation (Stepp, 2004).

The same considerations can be applied to the quinones and terpenoids. Quinones are found in the xylem of some leguminous plants, which are toxic to termites and increase the wood's resistance, consequently augmenting their commercial value; this is the case of *C. ferrea*, which was positive for this class of compounds. Another function attributed to quinones is allelopathic activity. Naphtoquinones have been used the last few years with medicinal purposes, like the naphtoquinone trimer conocurvone, extracted from *Conospermum incurvum* Lindley (Proteaceae), which inhibits the replication of the HIV virus and is known throughout the world due to its laxative (Decosterd et al., 1993), antibacterial, antifungal, bronchospasmodic, and antispasmodic activity (Bruneton, 1991).

Triterpenes, on the other hand, are produced by plants to attract pollinators, to inhibit seed germination, to prevent water loss, etc. (Simões and Spitzer, 2002). They are known as essential oils and have antispasmodic, cardiovascular, locally anesthetic, antiseptic, antiinflammatory, and antitumor activity (Bruneton, 1991; Simões and Spitzer, 2002).

The phenols and the tannins were the classes that stood out the most in the phytochemical analysis, possibly due to their widespread distribution among angiosperms and, preferentially, among lignified plants (Carvalho et al., 2002), common in the *caatinga*. Phenols have been held responsible for several types of activity: antibacterial, antiviral, antioxidant, diuretic, antirheumatic, and against gastric and hepatic problems (Bruneton, 1991; Carvalho et al., 2002); tannins, on the other hand, have mainly astringent activity, and are used against diarrhea, as antiseptics, and as vasoconstrictors, and they also have antimicrobial and antifungal activity (Bruneton, 1991; Santos and Mello, 2002).

The great use of plants as medicine, rich in the classes mentioned above, suggests, in our opinion, that ecogeographic aspects also influence the selection of native plants. This means that the compounds of secondary metabolism have the same properties and occurrence frequency in groups of plants characterized ecogeographically, and despite environmental factors (such as herbivory, pollination, and seed dispersal) being the phytochemical propulsive force, they are not perceptible in the expression and diversification of the special metabolism (Gottlieb et al., 1996). For Gottlieb et al. (1996), a greater production of lignins is expected in equatorial regions, with their high incidence of solar energy, but, alternatively, ‘‘polyphenols would tend to substitute micromolecules and/or lignin precursors’’.

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