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Medical Ethnobiology and Ethnopharmacology in Latin America

Guest Editors: Ulysses Paulino Albuquerque, Edwin L. Cooper,
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Editorial Board

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Editorial

Medical Ethnobiology and Ethnopharmacology in Latin America

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Through their long exposure and experience with natural resources, many local communities in Latin America have developed health care practices. Thousands of years of observation and experimentation have helped in developing different empirical medical systems, as well as knowledge of plants, animals, and minerals. Such knowledge is the subject of medical ethnobiology and ethnopharmacology, disciplines that before being exclusive actually complemented each other. In the broadest sense, both medical ethnobiology and ethnopharmacology attempt to make sense and to understand traditional medical systems: the first from perceptions, healing strategies, natural resources used to fight diseases or maintain health; the second from traditional medicines, either plants, animals, or minerals.

We can find new and different types of approaches and theoretical and methodological developments such as ethnopharmacological evaluations of traditional drugs unknown so far; the inclusion of historical perspective in ethnopharmacological studies; the migration influence on traditional medical systems both in industrialized countries and remote locations, or a greater focus on urban contexts in ethnopharmacology. Moreover, the integrative aspect is noteworthy; it includes medical ethnobotany and zootherapy (the treatment of human diseases using drug-based therapies derived from animals).

Recent developments in methods and theory, like any evolving discipline, promote discussions of theoretical scenarios and help us understand the contexts of traditional medical systems as well as methods and techniques that enable access to these systems. Perhaps, a very common approach has been the development of quantitative techniques to access information about animals and plants used in these medical systems, in order to constitute a way to objectively select resources for phytochemical and pharmacological studies. Ethnopharmacological evaluations of traditional drugs is perhaps an approach that concentrates most investigations, focusing on an assessment of traditional preparations regarding their effectiveness. Both animals and plants provide extensive resources for new Complementary and Alternative Medicine (CAM) approaches which may prove important for future applications. Despite criticism about errors in experimentation and data interpretation this approach has proven useful.

The historical perspective of ethnopharmacology has focused on the medicinal use of natural products that has preceded recorded human history probably by thousands of years. Surveys of those medicaments used in the past show that whereas compounders of medicines have invariably used vegetable, animal, and mineral substances, animals are less prevalent than herbs, and more prevalent than minerals. Historical texts showed that the treatment of illnesses using animal-based remedies is an extremely old practice. Animal-based remedies have constituted part of the inventory of medicinal substances used in various cultures since ancient times. Until now, studies concerning diversity of plants and animals used in medical systems of immigrants have occupied little space in the ethnopharmacological literature. Thus there has been influence of migration on traditional medical systems. Ethnobiological studies have shown that the natural product diversity used by people arises from a number of learning strategies, both simple and complex and that sophisticated social learning in particular plays a key role in transmitting variation in behavior between generations.

Medical ethnobotany and zootherapy constitutes an important alternative among many other known therapies practiced worldwide. There is growing recognition that people in different parts of the world still use animal- and plant-based remedies as primary or complementary medicine. Probably the most famous of these are the Chinese, who use animals for a variety of ailments. Lesser known and studied, though just as varied and rich is Latin America's and Africa long tradition of animal remedies for all kinds of ailments. For example, in Traditional Chinese Medicine, more than 1500 animal species have been recorded to be of some medicinal use. In Brazil, at least 326 medicinal animals have been recorded, and at least 584 animal species, in Latin America. Using plants and animals for medicinal purposes is part of a body of traditional knowledge which is becoming increasingly more relevant to discussions on conservation biology, public health policies, and sustainable management of natural resources, biological prospection, and patents. Ethnopharmacology in urban contexts while expanding in most of the world continue to supplement limited public health facilities and more expensive commercially produced medications with popular remedies; this has led to an increasing demand for wildlife products for medicinal purposes in urban areas. A reflection is the widespread trade in medicinal plants and animals, mainly concentrated in local and traditional market in urban areas.

This Special Issue of 22 peer-reviewed papers include in this collection various dimensions of the constitutional process of healing practices through the use of plants and animals that local communities in Latin America developed over centuries of experimentation. The papers explore different aspects of the empirical use of natural resources including the cultural dimensions that influence the extraction of natural products, evaluation of medicinal efficacy of these products; intermedical character of traditional medical systems; application of fossils in folk medicine. All these researches highlight the importance of local perceptions and knowledge as potential information that can contribute to future applications and therefore as a new source of medicines from natural products.

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Research Article

Ethnopharmacology of Medicinal Plants of the Pantanal Region (Mato Grosso, Brazil)

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Traditional knowledge is an important source of obtaining new phytotherapeutic agents. Ethnobotanical survey of medicinal plants was conducted in Nossa Senhora Aparecida do Chumbo District (NSACD), located in Poconé, Mato Grosso, Brazil using semi-structured questionnaires and interviews. 376 species of medicinal plants belonging to 285 genera and 102 families were cited. Fabaceae (10.2%), Asteraceae (7.82%) and Lamaceae (4.89%) families are of greater importance. Species with the greater relative importance were *Himatanthus obovatus* (1.87), *Hibiscus sabdariffa* (1.87), *Solidago microglossa* (1.80), *Strychnos pseudoquina* (1.73) and *Dorstenia brasiliensis*, *Scoparia dulcis* L., and *Luehea divaricata* (1.50). The informant consensus factor (ICF) ranged from 0.13 to 0.78 encompassing 18 disease categories,of which 15 had ICF greater than 0.50, with a predominance of disease categories related to injuries, poisoning and certain other consequences of external causes (ICF = 0.78) having 65 species cited while 20 species were cited for mental and behavioral disorders (ICF = 0.77). The results show that knowledge about medicinal plants is evenly distributed among the population of NSACD. This population possesses medicinal plants for most disease categories, with the highest concordance for prenatal, mental/behavioral and respiratory problems.

1. Introduction

Despite the fact that modern medicine, on the basis of the complex pharmaceutical industry, is well developed in most part of the world, the World Health Organization (WHO) through it Traditional Medicine Program recommends its Member States to formulate and develop policies for the use of complementary and alternative medicine (CAM) in their national health care programmes [1]. Among the components of CAM, phytotherapy practiced by the greater percentage of the world population through the use of plants or their derivatives, occupies a significant and unique position [2].

In this sense, documentation of the indigenous knowledge through ethnobotanical studies is important in the conservation and utilization of biological resources [3].

Brazil is a country with floral megadiversity, possessing six ecological domains, namely, Amazonian forest, Caatinga, Pampas, Cerrado, Atlantic Forest, and the Pantanal [4]. Mato Grosso region is noteworthy in this regard, as it occupies a prominent position both in the national and international settings, for it presents three major Brazilian ecosystems (the Pantanal, Cerrado, and Amazonian rainforest). Besides this, it also hosts diverse traditional communities in its territories, namely, the Indians descents (Amerindians), African descents, and the white Europeans. However, due to the mass migration from the rural areas and technological development, coupled with globalization of knowledge by the dominant nations, cultural tradition concerning the use of medicinal plants is in the major phase of declining [5].

The Pantanal is distinguishably the largest wetland ecosystem of the world, according to the classification by UNESCO World Heritage Center (Biosphere Reserve) [4]. The Pantanal vegetation is a mosaic consisting of species of the Amazonian rainforest, Cerrado, Atlantic forest, and Bolivian Chaco, adapted to special conditions, where there is alternations of both high humidity and pronounced dryness during the time of the year [4]. The presence in the Pantanal of the traditional populations that use medicinal plants for basic health care makes this region an important field for the ethnobotanical and ethnopharmacological studies [6, 7].

Because of the fact that the Pantanal communities are relatively isolated, they have developed private lives that involved much reliance on profound knowledge of the biological cycles, utilization of natural resources, and traditional technology heritage [8].

As a result of the aforementioned, this study aimed to systematically and quantitatively evaluate the information gathered from these Pantanal communities, highlight the relevance of the ethnobotanical findings, and cite and discuss relevant literatures related to medicinal plants with greater relative importance (RI) and high informant consensus factor (ICF) values obtained in the study.

2. Materials and Methods

2.1. Study Area. For the choice of study area, literature search was conducted to identify the Pantanal region in Mato Grosso, consisting of traditional communities where such studies have not yet been conducted and/or there were no ethnobotanical survey publications. The study design was cross-sectional and was conducted between the period of November, 2009 and February, 2010. The study setting chosen was NSACD located in the Poconé municipality, Mato Grosso State, Central West of Brazil (Figure 1) with coordinates of 16° 02′ 90′′ S and 056° 43′ 49′′ W. Poconé is located within the region of Cuiabá River valley, with an altitude of 142 m, occupies a territorial area of 17,260.86 km^2, and of tropical climate. The mean annual temperature is 24°C (4–42°C) and the mean annual rainfall is 1,500 mm with rainy season occurring between December and February. The municipality is composed of 2 Districts (NSAC and Cangas), 5 villages, 11 settlements, 14 streets, and 72 communities (countryside) [9]. The population of NSACD is estimated to be 3,652 inhabitants, representing 11.5% of Poconé municipality [10]. The principal economic activities are mainly livestock farming, mining, and agriculture with great tourism potentials, because Poconé municipality is the gateway to the Pantanal region [9].

2.2. Consent and Ethical Approval. Authorization and ethical clearance were sought from the relevant government (Health authority of Poconé and the National Council of Genetic Heritage of the Ministry of Environment (CGEN/MMA), Resolution 247 published in the Federal Official Gazette, in October, 2009, on access to the traditional knowledge for scientific research and Federal University of Mato Grosso and Júlio Muller Hospital Research Ethical Committees, Protocol 561/CEP-HUJM/08 authorities. Previsits were made to each community of NSACD to present the research project as well as to seek the consent of each potential informant.

2.3. Data Collection and Analysis. In this present study, sampling was done using probabilistic simple randomization and stratified sampling techniques [10, 11].

The population studied consists of inhabitants of 13 communities of NSACD, Mato Grosso State, considering an informant per family. The criteria for each informant chosen were age of 40 and above, residing in NSACD for more than 5 years (because there is large migration into the area because of the presence of ethanol producing factory).

These criteria are in line with the study objective coupled with the information gathered from the local authority [12].

In order to determine the estimated sample size (n), in this case, the number of families to be sampled per communities being considered, the following formula was utilized [11, 13]:

$$n = \frac{Np(1-p)}{(N-1)(d/z_{\alpha/2})^2 + p(1-p)}. \quad (1)$$

This study considered the population size of 1,179 families ($N = 1,179$), confidence coefficient of 95% ($z/2 = 1.96$), sampling error of 0.05 ($d = 0.05$), a proportion of 0.5 ($P = 0.5$). It should be noted that the $P = 0.5$ was assigned due to nonexistence of previous information about this value as is usual in practice, to obtain conservative sample size which is representative at the same time.

In determining the sample size for the microarea, 5% error and 10% loss in sample were considered. To determine the sample size in each microarea, the sample size (290) was multiplied by the sampling fraction of each microarea and dividing the total number of families of the same microarea with the total number of families of all the microareas (1,179), thereby arriving at the sample sizes for each area as shown in Table 1.

The interviews were conducted with the help of 12 trained applicators, under the supervision of the respective investigator. Data collected included sociodemographic details, vernacular names of the plant species with their medicinal uses, methods of drug preparation, and other relevant information. The ethnobotanical data were organized using the Microsoft Office Access 2003 program and statistically analyzed using SPSS, version 15 for Windows (SPSS Inc., Chicago, Illinois, USA).

2.4. Plant Collection, Identification, and Herborization. The collection of plant materials were done in collaboration with the local specialists, soon after the interviews. Both indigenous and scientific plant names were compiled. The plant materials collected during the study period were herborized, mounted as herbarium voucher specimens, and deposited for taxonomic identification and inclusion in the

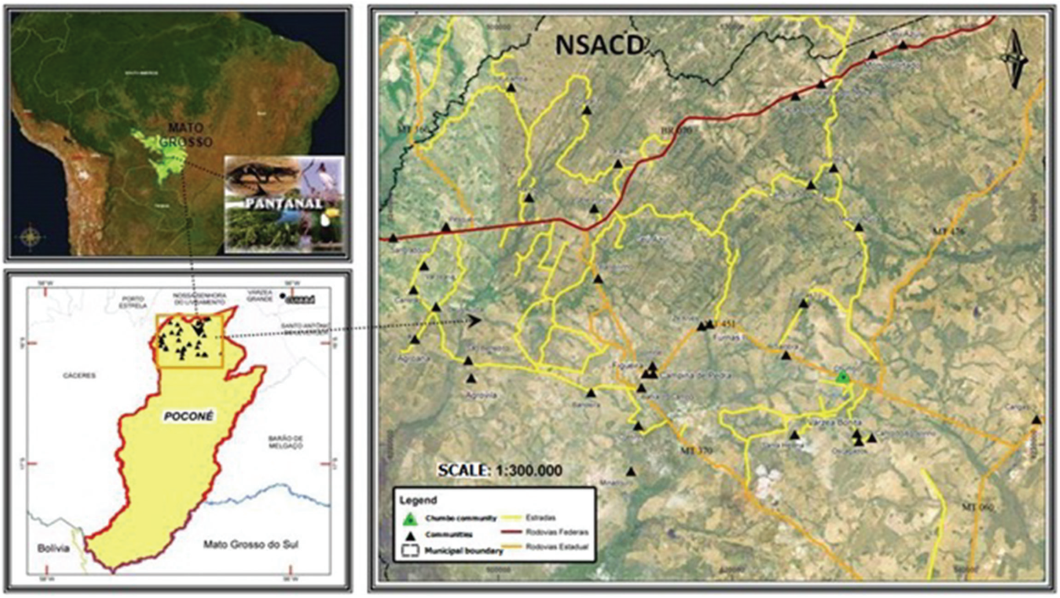

Figure 1: Location of the study area. Poconé, Mato Grosso, in Midwest of Brazil.

Table 1: Distribution of the 13 communities of Nossa Senhora Aparecida do Chumbo District.

ID	COMMUNITY	Total number of individuals	Total number of families	Sample fraction	Sample size
1	Chumbo	946	216	0.1832	52
2	Canto do Agostinho, Santa Helena, Os Cagados, Várzea bonita	179	52	0.0441	15
3	Furnas II, Salobra, Zé Alves	165	59	0.0500	15
4	Campina II, Furnas I, Mundo Novo, Rodeio	279	81	0.0687	20
5	Campina de Pedra, Imbé	188	67	0.0568	16
6	Barreirinho, Coetinho, Figueira	253	95	0.0806	23
7	Bahia de Campo	257	74	0.0628	18
8	Agrovila, São Benedito	184	66	0.0560	16
9	Agroana	372	178	0. 1510	44
10	Bandeira, Minadouro	248	82	0.0696	20
11	Carretão, Deus Ajuda, Sangradouro, Pesqueiro, Varzearia	216	77	0.0653	19
12	Chafariz, Ramos, Sete Porcos, Urubamba	208	67	0.0568	16
13	Céu Azul, Capão Verde, Morro Cortado, Passagem de Carro, Varal	157	65	0.0551	16
	Total	3,652	1,179	1.0000	290

ID = identification of the microarea.

collection of Federal University of Mato Grosso and CGMS Herbarium of Federal University of Mato Grosso do Sul, Brazil.

Plant species were identified according to standard taxonomic methods, based on floral morphological characters, analytical keys, and using, where possible, samples for comparison, as well as consultations with experts and literature [6, 7, 14–19]. The plant species obtained were grouped into families according to the classification system of Cronquist [20], with the exception of the Pteridophyta and Gymnospermae. For corrections of scientific names and families, the official website of the Missouri Botanical Garden was consulted [21].

2.5. Quantitative Ethnobotany. The relative importance (RI) of each plant species cited by the informants was calculated according to a previously proposed method [22]. In order to calculate RI, the maximum obtainable by a species is two was calculated using (2) according to Oliveira et al. [23]

$$RI = NCS + NP, \quad (2)$$

where RI: relative importance; NCS: number of body systems. It is given by the number of body systems, treated by a species (NSCS) over the total number of body system treated by the most versatile species (NSCSV): NCS = NSCS/NSCSV; NP: number of properties attributed to a specific species

(NPS) over the total number of properties attributed to the most versatile species (NPSV): NP = NPS/NPSV.

We sought to identify the therapeutic indications which were more important in the interviews to determine the informant consensus factor (ICF), which indicates the homogenity of the information [23].

The ICF will be low (close to 0), if the plants are chosen randomly, or if the informants do not exchange information about their uses. The value will be high (close to 1), if there is a well defined criterion of selection in the community and/or if the information is exchanged among the informants [23].

ICF was calculated using the number of use citations in each category of plant disease (n_{ur}), minus the number of species used (n_t) divided by the number of use citations in each category minus one on the basis of (3):

$$\text{ICF} = \frac{n_{ur} - n_t}{n_{ur} - 1}. \quad (3)$$

The citations for therapeutic purposes were classified using the 20 categories of the International Classification of Diseases and Related Health Problems, 10th edition-CID [24]: injuries, certain infectious, and parasitic diseases (I); neoplasms-tumors (II), diseases of blood and blood-forming organs and certain disorders involving the immune mechanism (III), endocrine, nutritional and metabolic diseases (IV) mental and behavioral disorders (V), nervous system (VI), diseases of eye and adnexa (VII), diseases of the ear and mastoid process (VIII), diseases of the circulatory system (IX), respiratory diseases (X), digestive diseases (XI), diseases of the skin and subcutaneous tissue (XII), diseases of the musculoskeletal system and connective tissue (XIII), genitourinary diseases (XIV), pregnancy, childbirth and (XV), certain conditions originating during the perinatal period (XVI), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (XVIII) and injury, poisoning and certain other consequences of external causes (XIX).

We selected for further discussion species that presented RI ≥ 1.5, and are in a category with high ICF. We conducted literature review using among others, the databases of Web of Science, MEDLINE, SciELO and including nonindexed works. We also searched national data bases for dissertations and theses.

3. Results

A total of 262 informants were interviewed, representing 7.17% of the population of NSACD, 22.22% of the population aged ≥40 years and residing in the District for over five years. Of the respondents, 69% were female and 31% male, aged 40–94 years (median 55). 68% were born in the city of Poconé, and 62% have been residents for over 20 years in the District (Table 2).

Of the 262 respondents, 259 (99.0%) reported the use of medicinal plants in self health care, with a minimum of 1 plant and a maximum of 250 plants among the female respondents and a minimum of 2 plants and a maximum of 54 among the male respondents. A total of 3,289 citations were recorded corresponding to 376 different plant species which belong to 285 genera and 102 families. Fabaceae (10.2%), Asteraceae (7.82%), and Lamaceae (4.89%) families were the most representative in this study (Table 3).

3.1. Relative Importance (RI). The RI of the species cited by 262 respondents from NSACD ranged from 0.17 to 1.87. A total of 261 species had RI ≤ 0.5; 80 species, RI from 0.51 to 1.0; 30 species, RI from 1.1 to 1.5, and 4 species with RI from 1.51 to 2.0, among the latter, three species were native to Brazil. The species with RI ≥ 1.5, were *Himatanthus obovatus* (Müll. Arg.) Woodson (1.87), *Hibiscus sabdariffa* L. (1.87), *Solidago microglossa* DC. (1.80), *Strychnos pseudoquina* A. St.-Hil. (1.73), *Dorstenia brasiliensis* Lam., *Scoparia dulcis* L., and *Luehea divaricata* Mart. (1.50 each), as shown in Table 4.

3.2. Informant Consensus Factor (ICF). In the disease categories according to CID, 10th ed., we observed that ICF values ranged from 0.43 to 0.77, with the exception of disease category included in CID VI (diseases of the nervous system), which was 0.13. The ICF for CID VI ranged between 0.13 and 0.78 (mean = 0.62, SD = 0.16, 95% CI: 0.53–0.70). The highest consensus value obtained was for the category related to injuries, poisoning, and some other consequences of external causes (ICF = 0.78), with 65 species and 286 citations. Three species were more common, namely, *S. dulcis* and *S. microglossa* ("Brazilian arnica"), with 49 citations each and *L. pacari* (manga-brava) with 42 citations. The main ailments addressed in this category were inflammation, pain, and gastric disorders.

Out of 20 disease categories, there were citations for 18 therapeutic indications, as shown in Table 5.

4. Discussion

In the present study, almost all the respondents (99%) claimed to know and use medicinal plants. Surveys conducted in other countries had reported values ranging from 42% to 98% depending on the region and country of the study [25–27]. Due to the low level of knowledge of traditional medicine in national capitals, ethnobotanical surveys in many developing countries including Brazil, primarily prefer to evaluate small communities or rural hometowns, whose population having knowledge and practical experience with traditional medicine are proportionately higher (between 80 and 100%) [28–30].

The high percentage of folk knowledge of medicinal plants identified in Brazil may be due to factors such as lower influence of the contemporary urban lifestyle and the strength of cultural traditions in the rural communities [31]. In fact, with the process of industrialization and migration to the cities, a significant part of traditional culture is maintained more in the communities farther from the metropolis via oral transmission of the knowledge of CAM and family traditions. Transmission and conservation of CAM knowledge is more pronounced in Brazil due to high degree of biodiversity.

One of the most important aspects of this research is the documentation of high number of taxa (285 genera and

Table 2: Distribution of the 13 communities of Nossa Senhora Aparecida do Chumbo District, Poconé, Mato Grosso, Brazil.

ID	Comunity	Population	Number of individuals[a]	Sample fraction	Sample size	N	Plant citations
1	Chumbo	946	216	0.1832	52	50	827
2	Canto do Agostinho, Santa Helena, Os Cagados, Várzea bonita	179	52	0.0441	15	10	131
3	Furnas II, Salobra, Zé Alves	165	59	0.050	15	10	99
4	Campina II, Furnas I, Mundo Novo, Rodeio	279	81	0.0687	20	11	179
5	Campina de Pedra, Imbé	188	67	0.0568	16	12	173
6	Barreirinho, Coetinho, Figueira	253	95	0.0806	23	23	213
7	Bahia de Campo	257	74	0.0628	18	13	461
8	Agrovila, São Benedito	184	66	0.056	16	16	141
9	Agroana	372	178	0.151	44	38	349
10	Bandeira, Minadouro	248	82	0.0696	20	22	171
11	Carretão, Deus Ajuda, Sangradouro, Pesqueiro, Varzearia	216	77	0.0653	19	23	180
12	Chafariz, Ramos, Sete Porcos, Urubamba	208	67	0.0568	16	16	200
13	Céu Azul, Capão Verde, Morro Cortado, Passagem de Carro, Varal	157	65	0.0551	16	18	165
	N	3,652	1,179	1.000	290	262	3,289

ID: Identification of the microarea; N: Sample size; [a]Informants with age ≥ 40 years and period of residing ≥ 5 years.

102 families) and species (376) mentioned by the informants as medicinal. These findings confirmed the existence of the great diversity of plants used for therapeutic purpose and preserved traditional culture, as stated by Simbo [32]. It is worth mentioning here the presence of 8 (eight) local medicinal plant expert informants/healers among the 262 respondents in this study. These local expert informants/healers account for a significant number of citations (43 to 250) in this study. In Brazil, as in other countries, rural communities have developed knowledge about the medicinal and therapeutic properties of natural resources and have contributed to the maintenance and transmission of the ethnopharmacological knowledge within the communities.

The most representative plant families are Fabaceae (10.2%), Asteraceae (7.82%), and Lamiaceae (4.89%). These results are in accordance with other ethnobotanical surveys conducted in the tropical regions [33, 34] including Brazil [7, 35]. Furthermore, the results from our study are also in conformity with the findings of the most comprehensive ethnobotanical survey conducted by V. J. Pott and A. Pott in the Brazilian Pantanal region [19].

Featuring greater potential for bioprospecting are 231 (61.6%) species indicated for the treatment of at least two diseases, and RI between 0.17 and 1.87 (mean = 0.46, SD = 0.357, 95% CI: 0.4250–0.4973). The seven species with the highest RI were *H. obovatus* (Müll. Arg.) Woodson (13 therapeutic indications and RI = 1.87, *H. sabdariffa* L. (12 therapeutic indications and RI = 1.87); *S. microglossa* DC. (9 therapeutic indications and RI = 1.80) *S. pseudoquina* A. St. - Hil. (14 therapeutic indications and RI = 1.73) and *D. brasiliensis* Lam., *S. dulcis* L., and *L. divaricata* Mart. (12, 10, and 12 therapeutic indications respectively with RI = 1.50) (Table 4). For the sake of brevity, we will focus most of our discussion on these seven most cited medicinal plants highlighting the most important available literature on them and including *L. pacari*. It should be noted that although 146 (39%) species presented RI below 0.17, with just a single indication, they cannot be considered as of lower pharmacological potential or importance, because as Albuquerque et al. [36] have noted elsewhere, these may be species of recent introduction in the culture of the community under study but might have been validated by the customary use in other social groups.

A total of 105 different folkways, including 18 disease categories, according to Brasil [24], were codified as shown in Table 5. The highest frequencies in decreasing magnitude were indications for the treatment of pain and inflammation (10.8%), kidney disease (7.6%), and wound healing (6.8%). In part, these data can be explained by the characteristics of the informants (elderly, rural activity, low level of education, and poor sanitation at home) with higher frequency of chronic, inflammatory, and infectious diseases. In addition, the search for natural treatments for infected wounds is very common in populations of agrarian labor or menial worker as stated by Akerreta et al. [37]. As ICF values were generally close to 1.0, it may be presumed that there is certain homogeneity in knowledge of medicinal plants among the population of NSACD.

4.1. Literature Survey and Discussions on the Selected Species with Higher Relative Importance. *Himatanthus obovatus*, var. *obovatus* had the highest relative importance, being cited for 13 different ailments that fall into 11 categories of CID, 10th ed. with a total of 29 citations. The most commonly mentioned of these indications for this plant were its

Table 3: Relation of the relative importance of the plant species mentioned by informants of Nossa Senhora Aparecida do Chumbo District, Poconé, Mato Grosso, Brazil.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
1. ACANTHACEAE							
1.1. *Justicia pectoralis* Jacq.	Anador	pain, fever, laxative, and muscle relaxant	Infusion (I)	36	2	3	0.40
2. ADOXACEAE							
2.1. *Sambucus australis* Cham. & Schltdl.	Sabugueiro	Fever and measles	Infusion (I, E)	24	2	2	0.33
3. ALISMATACEAE							
3.1. *Echinodorus macrophyllus* (Kuntze.) Micheli	Chapéu-de-couro	blood cleanser, stomach, rheumatism, and kidneys		43	4	4	0.67
4. AMARYLLIDACEAE							
4.1. *Allium cepa* L.	Cebola	wound healing	Infusion (I)	1	1	1	0.17
4.2. *Allium fistulosum* L.	Cebolinha	Flu	Infusion (I)	1	1	1	0.17
4.3. *Allium sativum* L.	Alho	hypertension	Infusion (I)	7	1	1	0.17
5. AMARANTHACEAE							
5.1. *Alternanthera brasiliana* (L.) Kuntze	Terramicina	wound healing, itching, diabetes, pain, bone fractures, throat, flu, inflammation uterine, and relaxative muscular	Infusion (I, E)	41	6	9	1.20
5.2. *Alternanthera dentata*(Moench) Stuchlik ex R.E. Fr.	Ampicilina	wound healing and kidneys	Infusion (I, E)	7	2	2	0.33
5.3. *Alternanthera ficoide* (L.) P. Beauv.	Doril	muscular relaxative	Infusion (I, E)	3	1	1	0.17
5.4. *Amaranthus* aff. *viridis* L.	Caruru-de-porco	wound healing, pain, and kidneys	Infusion (I)	4	3	3	0.50
5.5. *Beta vulgaris* L.	Beterraba	anemia	Infusion (I)	1	1	1	0.17
5.6. *Celosia argentea* L.	Crista-de-galo	kidneys		5	3	3	0.50
5.7. *Chenopodium ambrosioides* L.	Erva-de-santa-maria	wound healing, heart, diabetes, bone fractures, flu, kidneys, cough, and worms	Infusion (I, E)	102	7	8	1.23
5.8. *Pfaffia glomerata* (Spreng.) Pedersen	Ginseng-brasileiro	Obesity	Infusion (I)	2	1	1	0.17
6. ANACARDIACEAE							
6.1. *Anacardium humile* A. St.– Hil.	Cajuzinho-do-campo	diabetes, dysentery, and hepatitis	Infusion (I, E)	5	3	3	0.50
6.2. *Anacardium occidentale* L.	Cajueiro	abortive, wound healing, cholesterol, teeth, blood cleanser, diabetes, diarrhea, dysentery, and pain	Infusion (I, E)	30	6	9	1.20
6.3. *Astronium fraxinifolium* Schott ex Spreng	Gonçaleiro	flu, hemorrhoids, and cough	Infusion and maceration (I, E)	8	3	3	0.50

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
6.4. *Mangifera indica* L.	Mangueira	Bronchitis, flu, and cough	Infusion and maceration (I, E)	11	2	3	0.40
6.5. *Myracrodruon urundeuva* (Allemão) Engl.	Aroeira	anemia, bladder bronchitis cancer, wound healing, blood cleanser, bone fractures, hernia, uterine inflammation, muscular relaxative, and cough	Infusion, maceration, and decoction (I, E)	84	7	11	1.43
6.6. *Spondias dulcis* Parkinson	Caja-manga	scabies	Infusion (I, E)	2	1	1	0.17
6.7. *Spondias purpurea* L.	Seriguela	wound healing and hepatitis	Infusion (I, E)	2	2	2	0.33
7. ANNONACEAE							
7.1. *Annona cordifolia* Poepp. ex Maas & Westra	Araticum-abelha	Diabetes and bone fractures	Infusion and decoction (I, E)	3	2	2	0.33
7.2. *Annona crassiflora* Mart.	Graviola	diabetes	Infusion (I, E)	11	1	1	0.17
7.3. *Duguetia furfuracea* (A. St.- Hil.) Saff.	Beladona-do-cerrado	pain	Infusion (I, E)	1	1	1	0.17
8. APIACEAE							
8.1. *Coriandrum sativum* L.	Coentro	flu	Infusion (I)	1	1	1	0.17
8.2. *Eryngium* aff. *pristis* Cham. & Schltdl.	Lingua-de-tucano	Tooth and muscular relaxative	Infusion (I)	3	2	2	0.33
8.3. *Petroselinum crispum* ((Mill) Fuss	Salsinha	flu	Infusion (I)	1	1	1	0.17
8.4. *Pimpinella anisum* L.	Erva-doce	pain soothing, constipation, and kidneys	Infusion (I, E)	12	3	3	0.50
9. APOCYNACEAE							
9.1. *Aspidosperma polyneuron* (Müll.) Arg.	Péroba	Stomach and laxative	Infusion and decoction (I, E)	5	1	2	0.23
9.2. *Aspidosperma tomentosum* Mart.	Guatambu	gastritis	Infusion (I)	4	1	1	0.17
9.3. *Catharanthus roseus* (L.) G. Don	Boa-noite	mumps fever and kidneys	Infusion (I)	8	3	3	0.50
9.4. *Geissospermum laeve* (Vell.) Miers	Pau-tenente	Diabetes and pain	Infusion (I)	6	2	2	0.33
9.5. *Hancornia speciosa* var. *gardneri (*A. DC.) Müll. Arg.	Mangava-mansa	itching, diarrhea, and stomach	Decoction and maceration (I, E)	8	3	3	0.50
9.6. *Himatanthus obovatus* (Müll. Arg.) Woodson	Angélica	anemia, wound healing, cholesterol, blood cleanser, pain, nose bleeding, hypertension, uterine inflammation, labyrinthitis, pneumonia, relaxative muscular, worms, and vitiligo	Maceration (I)	45	10	13	1.87

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
9.7. *Macrosiphonia longiflora* (Desf.) Müll. Arg.	Velame-do-campo	hearth, blood cleanser, stroke, diuretic, pain, throat, muscular relaxative, and vitiligo	Decoction (I)	5	6	8	1.13
9.8. *Macrosiphonia velame* (A. St.-Hil.) Müll. Arg.	Velame-branco	flu	Decoction (I)	73	1	1	0.17
10. ARACEAE							
10.1 *Dieffenbachia picta* Schott	Comigo-ninguém-pode	pain	Maceration (E)	2	1	1	0.17
10.2. *Dracontium* sp.	Jararaquinha	snakebite	Infusion (I)	10	1	1	0.17
11. ARECACEAE							
11.1. *Acrocomia aculeata* Lodd. ex. Mart.	Bocaiuveira	heart, hepatitis, hypertension, and kidneys	Decoction and syrup (I)	20	4	4	0.67
11.2. *Cocos nucifera* L.	Cocô-da-bahia	kidneys	Maceration (I)	2	1	1	0.17
11.3. *Orbignya phalerata* Mart.	Babaçu	inflammation	Decoction (I)	8	1	1	0.17
11.4. *Syagrus oleracea* (Mart.) Becc.	Guariroba	kidneys	Maceration (I)	2	1	1	0.17
12. ARISTOLOCHIACEAE							
12.1. *Aristolochia cymbifera* Mart & Zucc.	Cipó-de-mil-homem	dengue, blood cleanser, stomach, kidneys, and digestive	Infusion (I)	11	4	5	0.73
12.2. *Aristolochia esperanzae* Kuntze	Papo-de-peru	wound healing	Infusion (I)	3	1	1	0.17
13. ASTERACEAE							
13.1. *Acanthospermum australe* (Loefl.). Kuntze	Carrapicho, beijo-de-boi	colic, kidneys, and runny cough	Infusion (I)	31	2	3	0.40
13.2. *Acanthospermum hispidum* DC.	Chifre-de-garrotinho	Gonorrhea and kidneys	Infusion (I)	5	2	3	0.40
13.3. *Achillea millefolium* L.	Dipirona, Novalgina,	pain, flu, and muscular relaxative	Infusion (I)	13	3	4	0.57
13.4. *Achyrocline satureioides* (Lam.) DC.	Macela-do-campo	diarrhea, pain, stomach, gastritis, flu, and hypertension	Infusion (I)	13	5	6	0.90
13.5. *Ageratum conyzoides* L.	Mentrasto	pain, labor pain, stomach, swelling in pregnant woman, rheumatism, and cough	Infusion (I)	18	5	6	0.90
13.6. *Artemisia vulgaris* L.	Artemisia	insomnia	Infusion (I)	3	1	1	0.17
13.7. *Artemisia absinthium* L.	Losna, nor-vômica	pain, stomach, liver, hernia, and muscular relaxative	Infusion (I)	39	4	5	0.73
13.8. *Baccharis trimera* (Less.) DC.	Carqueja	cancer, cholesterol, diabetes, diuretic, stomach, flu, and obesity	Infusion (I)	31	5	7	0.97
13.9. *Bidens pilosa* L.	Picão-preto	hepatitis, enteric, and kidneys	Infusion (I, E)	20	3	3	0.50

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
13.10. *Brickellia brasiliensis* (Spreng.) B.L. Rob.	Arnica-do-campo	wound healing, uterine inflammation, and kidneys	Infusion (I)	13	2	3	0.40
13.11. *Calendula officinalis* L.	Calêndula	anxiety	Infusion (I)	6	1	1	0.17
13.12. *Centratherum* aff. *punctatum* Cass.	Perpétua-roxa	muscular relaxative, and hearth	Infusion (I)	3	2	2	0.33
13.13. *Chamomilla recutita* (L.) Rauschert.	Camomila	soothing colic, pain, stomach, fever, and flu	Infusion (I)	78	5	6	0.90
13.14. *Chaptalia integerrima* (Vell.) Burkart	Lingua-de-vaca	worms	Infusion (I)	6	1	1	0.17
13.15. *Chromolaena odorata* (L.) R.M. King & H. Rob	Cruzeirinho	colic, pain, bone fractures, pain, bone fractures, and kidneys	Infusion (I)	7	3	4	0.57
13.16. *Conyza bonariensis* (L.) Cronquist	Voadeira	cancer itching, blood cleanser, leukemia, and worms	Infusion (I)	15	4	5	0.73
13.17. *Elephantopus mollis* Kunth	Sussuaiá	blood cleanser, pain, and uterine inflammation	Infusion (I)	11	2	3	0.40
13.18. *Emilia fosbergii* Nicolson	Serralha	conjunctivitis	Infusion (I)	6	1	1	0.17
13.19. *Eremanthus exsuccus* (DC.) Baker	Bácimo-do-campo	wound healing, stomach, bone fractures, and skin	Infusion and maceration (I, E)	11	3	4	0.57
13.20. *Eupatorium odoratum* L.	Arnicão	wound healing, muscular relaxative, and kidneys	Infusion (I, E)	10	3	3	0.50
13.21. *Mikania glomerata* Spreng.	Guaco	bronchitis cough	Infusion (I)	14	2	2	0.33
13.22. *Mikania hirsutissima* DC.	Cipó-cabeludo	diabetes	Infusion (I)	10	1	1	0.17
13.23. *Pectis jangadensis* S. Moore	Erva-do-carregador	blood cleanser and diabetes	Infusion (I)	4	2	2	0.33
13.24. *Porophyllum ruderale* (Jacq.) Cass.	Picão-branco	Hepatitis and kidneys	Infusion (I)	11	2	2	0.33
13.25. *Solidago microglossa* DC.	Arnica-brasileira	wound healing, blood cleanser, pain, bone fractures, hypertension, uterine inflammation, muscular relaxative, kidneys, worms, pain, stomach, hypertension, pneumonia, constipation, and relaxative muscular	Infusion (I, E)	82	8	15	1.80
13.26. *Spilanthes acmella* (L.) Murray	Jambú	liver	Infusion (I)	5	1	1	0.17
13.27. *Tagetes minuta* L.	Cravo-de-defunto	Dengue and flu	Infusion (I)	3	2	2	0.33

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
13.28. *Taraxacum officinale* L.	Dente-de-leão	blood cleanser	Infusion (I)	18	1	1	0.17
13.29. *Tithonia diversifolia* (Hemsl.) A. Gray	Flor-da-amazônia	alcoholism, stomach, kidney, and constipation	Infusion (I)	16	3	3	0.50
13.30.*Vernonia condensata* Baker	Figatil-caferana	cancer stomach and liver	Infusion (I)	48	2	3	0.40
13.31. *Vernonia scabra* Pers.	Assa-peixe	bronchitis blood cleanser, fever, flu, pneumonia, cold, and cough	Infusion and syrup (I)	38	2	7	0.67
13.32. *Zinnia elegans* Jacq.	Jacinta	pain	Infusion (I)	1	1	1	0.17
14. BERBERIDACEAE							
14.1. *Berberis laurina* Billb.	Raiz-de-são-joão	blood cleanser and diarrhea	Decoction and bottle (I, E)	6	2	2	0.33
15. BIGNONIACEAE							
15.1. *Anemopaegma arvense* (Vell.) Stellfeld & J.F. Souza	Verga-teso, Alecrim-do-campo, Catuaba	anxiety soothing kidneys	Decoction and bottle (I, E)	13	2	3	0.40
15.2. *Arrabidaea chica* (Humb. & Bonpl.) B. Verl.	Crajirú	wound healing and blood cleanser	Infusion (I)	6	2	2	0.33
15.3. *Cybistax antisyphilitica* (Mart.) Mart.	Pé-de-anta	fever, flu, relaxative muscular, and worms	Infusion (I)	13	4	4	0.67
15.4. *Jacaranda caroba* (Vell.) A. DC.	Caroba	wound healing	Decoction and bottle (I, E)	3	1	1	0.17
15.5. *Jacaranda decurrens* Cham.	Carobinha	allergy cancer wound healing, blood cleanser, diabetes, leprosy, hemorragia no nariz, inflammation uterina, and kidneys	Decoction and bottle (I, E)	94	8	9	1.40
15.6. *Tabebuia aurea* (Silva Manso) B. & H. f. ex S. Moore	Ipê-amarelo	worms	Decoction and bottle (I)	2	1	1	0.17
15.7. *Tabebuia caraiba* (Mart.) Bureau	Para-tudo	prostate cancer anemia, bronchitis cancer blood cleanser, diarrhea, pain, stomach, cough, and worms	Decoction and bottle (I, E)	67	6	10	1.27
15.8. *Tabebuia impetiginosa* (Mart. ex DC.) Standl.	Ipê-roxo	prostate cancer cough	Decoction and bottle (I)	8	2	2	0.33
15.9. *Tabebuia serratifolia* Nicholson	Piúva	prostate cancer	Decoction and bottle (I, E)	3	1	1	0.17
15.10. *Zeyhera digitalis* (Vell.) Hochn.	Bolsa-de-pastor	Stomach	Decoction and bottle (I)	9	1	1	0.17
16. BIXACEAE							
16.1. *Bixa orellana* L.	Urucum	cholesterol, stroke, bone fractures, and measles	Infusion (I)	11	4	4	0.67

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
16.2. *Cochlospermum regium* (Schrank) Pilg.	Algodãozinho-do-campo	blood cleanser, stomach, bone fractures, inflammation uterina, syphilis, vitiligo, gonorrhea, and ringworm	Infusion (I)	37	6	9	1.20
17. BOMBACACEAE							
17.1. *Pseudobombax longiflorum* (Mart. Et Zucc.) Rob.	Embiriçu-do-cerrado	pneumonia, cough, and tuberculosis	Infusion (I)	17	3	3	0.50
17.2. *Eriotheca candolleana* (K. Schum.)	Catuaba	prostate cancer		1	1	1	0.17
18. BORAGINACEAE							
18.1. *Cordia insignis* Cham.	Calção-de-velho	cough	Infusion (I)	5	1	1	0.17
18.2. *Heliotropium filiforme* Lehm.	Sete-sangria	thooth, blood cleanser, hypertension, and tuberculosis	Infusion (I)	43	4	4	0.67
18.3. *Symphytum asperrimum* Donn ex Sims	Confrei	wound healing, heart, throat, and obesity	Infusion (I, E)	10	4	4	0.67
19. BRASSICACEAE							
19.1. *Nasturtium officinale* R. Br.	Agrião	bronchitis	Infusion (I)	2	1	1	0.17
20. BROMELIACEAE							
20.1. *Ananas comosus* (L.) Merr.	Abacaxi	diuretic and cough	Infusion (I)	9	2	2	0.33
20.2. *Bromelia balansae* Mez	Gravatá	cough and bronhitis	Infusion (I)	2	2	2	0.33
21. BURSERACEAE							
21.1. *Commiphora myrrha* (T. Nees) Engl.	Mirra	Menstruation and rheumatism	Infusion (I)	3	2	2	0.33
21.2. *Protium heptaphyllum* (Aubl.) Marchand	Almésica	blood cleanser, stroke, pain, muscular relaxative, rheumatism, and cough		23	3	6	0.70
22. CACTACEAE							
22.1. *Cactus alatus* Sw.	Cacto	Colic and guard delivery	Infusion (I, E)	10	2	2	0.33
22.2. *Opuntia* sp.	Palma	column		2	1	1	0.17
22.3. *Pereskia aculeata* Mill.	Oro-pro-nobis	anemia	Infusion (I)	2	1	1	0.17
23. CAPPARACEAE							
23.1. *Crataeva tapia* L.	Cabaça	cough	Infusion (I)	2	1	1	0.17
23.2. *Cleome affinis DC.*	Mussambé	diarrhea		1	1	1	0.17
24. CARICACEAE							
24.1. *Carica papaya* L.	Mamoeiro	worms, thooth, stomach, hepatitis, muscular relaxative, and cough	Infusion (I)	17	4	6	0.80

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
25. CARYOCARACEAE							
25.1. *Caryocar brasiliense* A. St.-Hil.	Pequizeiro	diabetes, hypertension, labyrinthitis, and obesity		11	4	4	0.67
26. CELASTRACEAE							
26.1. *Maytenus ilicifolia* Mart.ex Reissek	Espinheira-santa	uric acid, bronchitis diarrhea, stomach, gastritis, flu, and cough	Infusion (I)	8	5	7	0.97
27. CECROPIACEAE							
27.1. *Cecropia pachystachya* Trécul	Embaúba	cholesterol, blood cleanser, diabetes, pain, hypertension, leukemia, pneumonia, kidneys, and cough	Infusion (I)	38	6	9	1.20
28. CLUSIACEAE							
28.1. *Kielmeyera* aff. *grandiflora* (Wawra) Saddi	Pau-santo	anemia		1	1	1	0.17
29. COMBRETACEAE							
29.1. *Terminalia argentea* Mart.	Pau-de-bicho	itching, diabetes, and cough		8	3	3	0.50
29.2. *Terminalia catappa* L.	Sete-copa	conjunctivitis	Infusion (I, E)	2	1	1	0.17
30. COMMELINACEAE							
30.1. *Commelina benghalensis* L.	Capoeraba	hemorrhoids	Infusion (I)	1	1	1	0.17
30.2. *Commelina nudiflora* L.	Erva-de-santa-luzia	wound healing and conjunctivitis	Infusion (I)	3	2	2	0.33
30.3. *Dichorisandra hexandra* (Aubl.) Standl.	Cana-de-macaco	flu, hypertension, and kidneys	Infusion (I)	1	3	3	0.50
31. CONVOLVULACEAE							
31.1. *Cuscuta racemosa* Mart.	Cipó-de-chumbo	pain	Infusion (I)	1	1	1	0.17
31.2. *Ipomoea batatas* (L.) Lam.	Batata-doce	hearth	Infusion (I)	1	1	1	0.17
31.3. *Ipomoea* (Desr.) Roem. & asarifolia Schult	Batatinha-do-brejo	Stomach and worms	Infusion (I)	4	2	2	0.33
32. COSTACEAE							
32.1. *Costus spicatus* (Jacq.) Sw.	Caninha-do-brejo	bladder diuretic, inflammation uterina, muscular relaxative, and kidneys	Infusion (I)	40	3	5	0.63
33. CRASSULACEAE							
33.1. *Kalanchoe pinnata* (Lam.) Pers.	Folha-da-fortuna	allergy, bronchitis blood cleanser, and flu	Infusion and juice (I)	11	2	4	0.47
34. CUCURBITACEAE							
34.1. *Cayaponia tayuya* (Cell.) Cogn.	Raiz-de-bugre	blood cleanser, pain, and hepatitis	Infusion (I)	17	2	3	0.40
34.2. *Citrullus vulgaris* Schrad.	Melância	bladder colic	Infusion (I)	2	1	2	0.23
34.3. *Cucumis anguria* L.	Máxixe	anemia	Infusion (I)	1	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
34.4. *Cucumis sativus* L.	Pepino	hypertension	Maceration (I)	1			
34.5. *Cucurbita maxima* Duchesne ex Lam.	Abóbora	Pain and worms	Infusion (I)	4	2	2	0.33
34.6. *Luffa* sp	Bucha	Anemia and kidneys	Infusion (I)	7	2	2	0.33
34.7. *Momordica charantia* L.	Melão-de-são-caetano	bronchitis dengue, stomach, fever, flu, hepatitis, swelling in pregnant woman, malaria, muscular relaxative, and worms	Infusion (I)	50	6	10	1.27
34.8. *Siolmatra brasiliensis* (Cogn.) Baill.	Taiuá	Ulcer	Infusion (I)	6	1	1	0.17
35. CYPERACEAE							
35.1. *Bulbostylis capillaris* (L.) C.B. Clarke	Barba-de-bode	diuretic, stomach, kidneys, and worms	Infusion (I)	12	3	4	0.57
35.2. *Cyperus rotundus* L.	Tiririca	Pain	Infusion (I)	1	1	1	0.17
36. DILLENIACEAE							
36.1. *Curatella americana* L.	Lixeira	wound healing, colic, diarrhea, flu, kidneys, and cough	Infusion (I, E)	24	5	6	0.90
36.2. *Davilla elliptica* A. St.-Hil.	Lixeira-de-cipó	kidneys		3	1	1	0.17
36.3. *Davilla nitida* (Vahl.) Kubitzki	Lixeirinha	delivery help, liver, hernia, and kidneys	Infusion (I)	10	3	4	0.57
37. DIOSCOREACEAE							
37.1. *Dioscorea* sp.	Cará-do-cerrado	boil	Infusion (I)	25	1	1	0.17
37.2. *Dioscorea trifida* L	Cará	blood cleanser	Infusion (I)	6	1	1	0.17
38. EBENACEAE							
38.1. *Diospyros hispida* A. DC.	Olho-de-boi	Pain and leprosy	Infusion (I)	5	2	2	0.33
39. EQUISETACAE							
39.1. *Equisetum arvense* L.	Cavalinha	gastritis and kidneys	Infusion (I)	8	2	2	0.33
40. ERYTHROXYLACEAE							
40.1 *Erythroxylum* aff. *Daphnites* Mart.	Vasoura-de-bruxa	syphilis	Infusion (I)	1	1	1	0.17
41. EUPHORBIACEAE							
41.1. *Croton antisyphiliticus* Mart.	Curraleira	Hypertension and uterine inflammation	Infusion (I)	6	2	2	0.33
41.2. *Croton* sp.	Curraleira-branca	uterine inflammation	Infusion (I)	3	1	1	0.17
41.3. *Croton urucurana* Baill.	Sangra-d'água	cancer prostate cancer healing, diabetes, stomach, gastritis, uterine inflammation, kidneys, and ulcer	Maceration (I)	37	5	9	1.10
41.4. *Euphorbia* aff. *Thymifolia* L.	Trinca-pedra	kidneys	Infusion (I)	3	1	1	0.17
41.5. *Euphorbia prostrata* Aiton	Fura-pedra	kidneys	Infusion (I)	4	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
41.6. *Euphorbia tirucalli* L	Aveloz	cancer uterine inflammation	Maceration (I)	3	2	2	0.33
41.7. *Jatropha* sp.	Capa-rosa	diabetes	Infusion (I)	10	1	1	0.17
41.8. *Jatropha elliptica* (Poh) Oken	Purga-de-lagarto	allergy	Infusion (I)	38	1	1	0.17
41.9. *Jatropha* aff. *Gossypiifolia* L.	Pinhão-roxo	wound healing, prostrate cancer, itching, blood cleanser, stroke, snakebite, syphilis, worms, and vitiligo	Maceration(I, E)	7	6	10	1.27
41.10. *Jatropha urens* L.	Cansansão	diabetes	Maceration (I, E)	6	1	1	0.17
41.11. *Manihot esculenta* Crantz	Mandioca-braba	itching	Maceration (I, E)	2	1	1	0.17
41.12. *Manihot utilissima* Pohl.	Mandioca	itching	Maceration (I, E)	7	1	1	0.17
41.13. *Ricinus communis* L.	Mamona	wound healing and blood cleanser	Maceration (I, E)	8	2	2	0.33
41.14. *Synadenium grantii* Hook. f.	Cancerosa	gastritis, prostate cancer stomach, and pneumonia	Maceration (I, E)	12	3	4	0.57
42. FABACEAE							
42.1. *Acosmium dasycarpum* (Volgel) Yakovlev	Cinco-folha	column, blood cleanser, pain, and kidneys	Infusion (I)	19	2	4	0.47
42.2. *Acosmium subelegans* (Mohlenbr.) Yakovlev	Quina-gensiana	wound healing, blood cleanser, pain, liver, uterine inflammation, delivery relapse, and kidneys	Decoction (I)	16	5	7	0.97
42.3. *Albizia niopoides* (Spr. ex Benth.) Burkart.	Angico-branco	bronhitis	Decoction (I)	1	1	1	0.17
42.4. *Amburana cearensis* (Allemão) A. C. Sm.	Imburana	cough	Decoction (I)	13	1	1	0.17
42.5. *Anadenanthera colubrina* (Vell.) Brenan	Angico	asthma, wound healing, expectorant, uterine inflammation, pneumonia, and cough	Decoction (I)	12	5	6	0.90
42.6. *Andira anthelminthica* Benth.	Angelim	diabetes	Decoction (I)	3	1	1	0.17
42.7. *Bauhinia variegata* L.	Unha-de-boi	kidneys	Decoction (I)	4	1	1	0.17
42.8. *Bauhinia ungulata* L.	Pata-de-vaca	diabetes	Infusion (I)	11	1	1	0.17
42.9. *Bauhinia glabra* Jacq.	Cipó-tripa-de-galinha	diarrhea, dysentery, and pain	Infusion (I)	7	3	3	0.50
42.10. *Bauhinia rubiginosa* Bong.	Tripa-de-galinha	kidneys	Infusion (I)	2	1	1	0.17
42.11. *Bauhinia rufa* (Bong.) Steud.	Pata-de-boi	diabetes	Infusion (I)	1	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
42.12. *Bowdichia virgilioides* Kunth	Sucupira	blood cleanser, paom, stomach, nose bleeding, cough, and worms	Bottle (I)	20	4	6	0.80
42.13. *Caesalpinia ferrea* Mart.	Jucá	wound healing, stomach, bone fractures, and inflammation of uterine	Maceration (I, E)	15	3	4	0.57
42.14. *Cajanus bicolor* DC.	Feijão-andu	diarrhea, stomach and worms	Infusion (I)	8	2	3	0.40
42.15. *Cassia desvauxii* Collad.	Sene	constipation, pain, fever, uterine inflammation, and labyrinthitis	Infusion (I)	18	4	5	0.73
42.16. *Chamaecrista desvauxii* (Collad.) Killip	Sene-do-campo	constipation, blood cleanser, pain, and fever	Infusion (I)	10	2	4	0.47
42.17. *Copaifera* sp.	Pau-d'óleo	wound healing, kidneys, ulcer	Infusion (I)	8	3	3	0.50
42.18. *Copaifera langsdorffii* var. *glabra* (Vogel) Benth.	Copaiba	bronchitis prostate cancer stroke, pain, throat, and tuberculosis	Maceration and syrup (I)	13	5	6	0.90
42.19. *Copaifera marginata* Benth.	Guaranazinho	ulcer	Infusion (I)	4	1	1	0.17
42.20. *Desmodium incanum* DC.	Carrapicho	bladder itching, diarrhea, pain, hepatitis, and kidneys	Infusion (I)	18	5	6	0.90
42.21. *Dimorphandra mollis* Benth.	Fava-de-santo-inácio	bronchitis wound healing, pain, flu, hypertension, pneumonia, rheumatism, cough, and worms	Infusion (I)	21	6	9	1.20
42.22. *Dioclea latifolia* Benth.	Fruta-olho-de-boi	stroke	Infusion (I)	3	1	1	0.17
42.23. *Dioclea violacea* Mart. Zucc.	Coronha-de-boi	osteoporosis	Infusion (I)	6	2	2	0.33
42.24. *Dipteryx alata* Vogel	Cumbarú	stroke bronchitis cicartrizante, diarrhea, dysentery, pain, throat, flu, snakebite, and cough	Infusion (I)	43	4	9	1.00
42.25. *Galactia glaucescens* Kunth	Três-folhas	column, pain, bone fractures, and kidneys	Infusion (I)	8	4	4	0.67
42.26. *Hymenaea courbaril* L.	Jatobá-mirim	bladder bronchitis flu, pneumonia, and cough	Syrup and decoction (I)	36	3	5	0.63

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
42.27. *Hymenaea stigonocarpa* Mart. ex Hayne	Jatoba-do-cerrado	bronchitis prostate cancer pain, fertilizer, flu, and cough	Syrup and decoction (I)	31	5	6	0.90
42.28. *Indigofera suffruticosa* Mill.	Anil	ulcer	Infusion (I)	2	1	1	0.17
42.29. *Inga vera* Willd.	Ingá	Laxative and kidneys	Infusion (I)	5	2	2	0.33
42.30. *Machaerium hirtum* (Vell.) Stellfeld	Espinheira-santa-nativa	ulcer	Infusion (I)	2	1	1	0.17
42.31. *Melilotus officinalis* (L) Pall.	Trevo-cheiroso	bone fractures and thyroid	Infusion (I)	5	2	2	0.33
42.32. *Mimosa debilis* var. vestita (Benth.) Barneby	Dorme-dorme	soothing	Infusion (I)	2	1	1	0.17
42.33. *Mucuna pruriens* (L.) DC.	Macuna	stroke	Infusion (I)	2	1	1	0.17
42.34. *Peltophorum dubium* (Spreng.) Taub.	Cana-fistula	gastritis	Infusion (I)	5	1	1	0.17
42.35. *Platycyamus regnellii* Benth.	Pau-porrete	anemia	Infusion (I)	1	1	1	0.17
42.36. *Pterodon pubescens* (Benth.) Benth.	Sucupira-branca	worms, pain, and stomach	SYRope, decoction and maceration (I)	2	3	3	0.50
42.37. *Senna alata* (L.) Roxb.	Mata-pasto	throat, worms, and vitiligo	Infusion (I)	6	3	3	0.50
42.38. *Senna occidentalis* (L.) Link	Fedegoso	blood cleanser, pain, flu, cough, and worms	Infusion (I)	42	3	5	0.63
42.39. *Stryphnodendron obovatum* Benth.	Barbatimão 1	wound healing	Syrup and decoction (I, E)	57	1	1	0.17
42.40. *Stryphnodendron adstringens* (Mart.) Coville	Barbatimão 2	bladder bronchitis, colic, stomach, bone fractures, uterine inflammation, relaxative muscular, and ulcer	Syrup and decoction (I, E)	15	4	9	1.00
42.41. *Tamarindus indica* L.	Tamarindo	anxiety pain, thooth, laxative, osteoporosis, syphilis, and worms	Maceration and juice (I)	30	6	7	1.07
43. FLACOURTIACEAE							
43.1. *Casearia silvestris* Sw.	Guaçatonga	Epilepsy and kidneys	Infusion (I)	3	2	2	0.33
44. GINKGOACEAE							
44.1. *Ginkgo biloba* L.	Ginco-biloba	vertebral	Infusion (I)	1	1	1	0.17
45. HERRERIACEAE							
45.1. *Herreria salsaparilha* Mart.	Salsaparilha	column, blood cleanser, muscular relaxative, and kidneys	Infusion (I)	12	3	4	0.57
46. HIPPOCRATEACEAE							
46.1. *Salacia* aff. *elliptica* (Mart. ex Schult.) G. Don	Saputa-do-brejo	pain	Infusion (I)	6	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
47. IRIDACEAE							
47.1. *Eleutherine bulbosa* (Mill.) Urb.	Palmeirinha	pain, hemorrhoids, cough, and blood cleanser	Infusion (I)	11	2	4	0.47
48. LAMIACEAE							
48.1. *Hyptis* cf. *hirsuta* Kunth	Hortelã-do-campo	diabetes, stomach, flu, cough, and worms	Infusion (I)	23	5	5	0.83
48.2. *Hyptis paludosa* St.-Hil.ex Benht.	Alevante	cold	Infusion (I)	4	1	1	0.17
48.3. *Hyptis* sp.	Hortelã-bravo	Diabetes and cough	Infusion (I)	6	2	2	0.33
48.4. *Hyptis suaveolens* (L.) Poit.	Tapera-velha	pain, stomach, flu, constipation, kidneys, and worms	Infusion (I)	42	5	6	0.90
48.5. *Leonotis nepetifolia* (L.) R. Br.	Cordão-de-são-francisco	column, hearth, blood cleanser, stomach, fever, gastritis, flu, hypertension, labyrinthitis, muscular relaxative, and kidneys	Infusion (I)	38	7	11	1.43
48.6. *Marsypianthes chamaedrys* (Vahl) Kuntze	Alfavaca/Hortelã-do-mato	flu, hypertension, and cough	Infusion (I)	8	3	3	0.50
48.7. *Melissa officinalis* L	Melissa	soothing	Infusion (I)	2	1	1	0.17
48.8. *Mentha crispa* L.	Hortelã-folha-miuda	anemia, liver, cough, and worms	Infusion (I)	16	4	4	0.67
48.9. *Mentha pulegium* L.	Poejo	bronchitis soothing fever, flu, cold, and cough	Infusion (I)	59	3	6	0.70
48.10. *Mentha spicata* L.	Hortelã-vicki	bronchitis flu, wound healing, stomach, and worms	Infusion (I)	24	4	5	0.73
48.11. *Mentha* x *piperita* L.	Hortelã-pimenta	bronchitis flu, cough and worms	Infusion (I)	42	3	4	0.57
48.12. *Mentha x villosa* Huds.	Hortelã-rasteira	stomach, flu, cold, and worms	Infusion (I)	86	3	4	0.57
48.13. *Ocimum kilimandscharicum* Baker ex Gürke	Alfavacaquinha	flu	Infusion (I)	2	1	1	0.17
48.14. *Ocimum minimum* L.	Manjericão	kidneys, sinusitis, and worms	Infusion (I)	7	3	3	0.50
48.15. *Origanum majorana* L.	Manjerona	heart	Infusion (I)	4	1	1	0.17
48.16. *Origanum vulgare* L.	Orégano	cough	Infusion (I)	1	1	1	0.17
48.17. *Plectranthus amboinicus* (Lour.) Spreng.	Hortelã-da-folha-gorda	bronchitis flu, uterine inflammation, and cough	Infusion and syrup (I)	7	3	4	0.57
48.18. *Plectranthus barbatus* Andrews	Boldo-brasileiro	pain, stomach, liver, and malaise	Maceration (I)	99	2	4	0.47
48.19. *Plectranthus neochilus* Schltr.	Boldinho	stomach	Maceration (I)	1	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
48.20. *Rosmarinus officinalis* L.	Alecrim	anxiety soothing hearth, pain, hypertension, insomnia, labyrinthitis, sluggishness memory, tachycardia, and vitiligo	Infusion and maceration (I)	31	6	10	1.27
49. LAURACEAE							
49.1. *Cinnamomum camphora* (L.) Nees & Eberm.	Cânfora	pain	Infusion and maceration (I)	1	1	1	0.17
49.2. *Cinnamomum zeylanicum* Breyne	Canela-da-india	aphrodisiac, tonic, obesity, and cough	Infusion (I)	11	3	4	0.57
49.3. *Persea americana* Mill.	Abacateiro	diuretic, hypertension, and kidneys	Infusion and maceration (I)	31	3	3	0.50
50. LECYTHIDACEAE							
50.1. *Cariniana rubra* Gardner ex Miers	Jequitibá	bladder wound healing, colic, pain, uterine inflammation, rheumatism, cough, and ulcer	Infusion and maceration (I)	49	5	8	1.03
51. LOGANIACEAE							
51.1. *Strychnos pseudoquina* A. St.-Hil.	Quina	anemia, wound healing, cholesterol, blood cleanser, pain, stomach, bone fractures, flu, uterine inflammation, pneumonia, muscle relaxant, cough, ulcer, and worms	Decoction and maceration (I, E)	107	8	14	1.73
52. LORANTHACEAE							
52.1. *Psittacanthus calyculatus* (D.C.) G. Don	Erva-de-passarinho	stroke, pain, flu, and pneumonia	Infusion and maceration (I)	14	3	4	0.57
53. LYTHRACEAE							
53.1. *Adenaria floribunda* Kunth	Veludo-vermelho	kidneys		3	1	1	0.17
53.2. *Lafoensia pacari* A. St.-Hil.	Mangava-braba	wound healing, diarrhea, pain, stomach, gastritis, kidneys, and ulcer	Decoction and maceration (I, E)	73	5	7	0.97
54. MALPIGHIACEAE							
54.1. *Byrsonima orbignyana* A. Juss.	Angiquinho	wound healing	Decoction and maceration (I)	2	1	1	0.17
54.2. *Byrsonima* sp.	Semaneira	pain	Infusion (I)	1	1	1	0.17
54.3. *Byrsonima verbascifolia* (L.) DC.	Murici-do-cerrado	column	Infusion (I)	3	2	2	0.33

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
		uterine inflammation					
54.4. *Camarea ericoides* A. St.-Hil.	Arniquinha	wound healing	Infusion (I)	11	1	1	0.17
54.5. *Galphimia brasiliensis* (L.) A. Juss.	Mercúrio-do-campo	wound healing, itching, thooth, and bone fractures	Infusion (I)	7	3	4	0.57
54.6. *Heteropterys aphrodisiaca* O. Mach.	Nó-de-cachorro	brain, wound healing, blood cleanser, impotence, muscular relaxative, and rheumatism	Decoction (I)	23	5	6	0.90
54.7. *Malpighia emarginata* DC.	Cereja	wound healing	Infusion (I)	5	1	1	0.17
54.8. *Malpighia glabra* L.	Aceroleira	bronchitis dengue, stomach, fever, and flu	Infusion (I)	24	4	5	0.73
55. MALVACEAE							
55.1. *Brosimum gaudichaudii* Trécul	Mama-cadela	stomach	Infusion (I)	13	1	1	0.17
55.2. *Gossypium barbadense* L.	Algodão-de-quintal	blood cleanser, stomach, vitiligo, inflammation, and gonorrhea	Infusion (I)	47	5	5	0.83
55.3. *Guazuma ulmifolia* var. *tomentosa* (Kunth) K. Schum.	Chico-magro	diarrhea, kidneys, bronchitis wound healing	Infusion and decoction (I)	10	4	4	0.67
55.4. *Hibiscus pernambucensis* Bertol.	Algodão-do-brejo	wound healing, colic, flu, and uterine inflammation	Infusion (I)	2	3	4	0.57
55.5. *Hibiscus rosa-sinensis* L.	Primavera	pain	Infusion (I)	2	1	1	0.17
55.6. *Hibiscus sabdariffa* L.	Quiabo-de-angola, Hibisco	anxiety hearth, flu, tachycardia, kidneys, colic, runny, diarrhea, pain, uterine inflammation, labyrinthitis, snakebite, and pneumonia	Infusion (I)	18	10	13	1.87
55.7. *Helicteres sacarolha* A. St.-Hil.	Semente-de-macaco	Hypertension and ulcer	Infusion (I)	2	2	2	0.33
55.8. *Malva sylvestris* L.	Malva-branca	wound healing, conjunctivitis, runny, blood cleanser, diuretic, boil, uterine inflammation, and rheumatism	Infusion (I)	31	7	8	1.23
55.9. *Malvastrum corchorifolium* (Desr.) Britton ex Small	Malva	tonsillitis wound healing, pain, and uterine inflammation	Infusion (I)	13	4	4	0.67
55.10. *Sida rhombifolia* L.	Guaxuma	obesity	Infusion (I)	5	1	1	0.17
56. MELASTOMATACEAE							
56.1. *Leandra purpurascens* (DC.) Cogn.	Pixirica	rheumatism	Infusion (I)	1	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
56.2. *Tibouchina clavata* (Pers.) Wurdack	Cibalena	pain	Infusion (I)	3	1	1	0.17
56.3. *Tibouchina urvilleana* (DC.) Cogn.	Buscopam-de-casa	stomach	Infusion (I)	1	1	1	0.17
57. MELIACEAE							
57.1. *Azadirachta indica* A. Juss.	Neem	diabetes	Infusion and decoction (I, E)	1	1	1	0.17
57.2. *Cedrela odorata* L.	Cedro	wound healing	Infusion (I)	3	1	1	0.17
58. MENISPERMACEAE							
58.1. *Cissampelos* sp.	Orelha-de-onça	Column and kidneys	Infusion (I)	3	2	2	0.33
59. MORACEAE							
59.1. *Artocarpus integrifolia* L.f.	Jaca	diuretic	Infusion (I)	1	1	1	0.17
59.2. *Chlorophora tinctoria* (L.) Gaudich. ex Benth.	Taiúva	osteoporosis and muscular relaxative	Infusion (I)	2	2	2	0.33
59.3. *Dorstenia brasiliensis* Lam.	Carapiá	wound healing, colic, thooth, blood cleanser, dysentery, pain, flu, laxative, menstruation, pneumonia, relapse delivery, and kidneys	Infusion (I)	41	7	12	0.50
59.4. *Ficus brasiliensis* Link.	Figo	gastritis	Infusion (I)	4	1	1	0.17
59.5. *Ficus pertusa* L. f.	Figueirinha	stomach	Infusion (I)	5	1	1	0.17
60. MUSACEAE							
60.1. *Musa x paradisiaca* L.	Bananeira-de-umbigo	bronchitis anemia and pain	Infusion and syrup (I)	9	3	3	0.50
61. MYRTACEAE							
61.1. *Eucalyptus citriodora* Hook.	Eucálipto	bronchitis diabetes, fever, flu, sinusitis, and cough	Infusion and syrup (I)	22	3	6	0.70
61.2. *Eugenia pitanga* (O. Berg) Kiaersk.	Pitanga	pain, throat, flu, and kidneys	Infusion (I)	10	3	4	0.57
61.3. *Psidium guajava* L.	Goiabeira	diarrhea	Infusion (I)	19	1	1	0.17
61.4. *Psidium guineense* Sw.	Goiaba-áraça	pain, diarrhea, and hypertension	Infusion (I)	11	3	3	0.50
61.5. *Syzygium aromaticum* (L.) Merr. & L. M. Perry	Cravo-da-india	Throat and cough	Infusion (I)	5	1	2	0.23
61.6. *Syzygium jambolanum* (Lam.) DC.	Azeitona-preta	cholesterol	Decoction (I, E)	4	1	1	0.17
62. NYCTAGINACEAE							
62.1. *Boerhavia coccinea* L.	Amarra-pinto	bladder icterus, inflammation uterina, and kidneys	Infusion (I)	22	2	4	0.47
62.2. *Mirabilis jalapa* L.	Maravilha	heart, pain, and hypertension	Infusion (I)	8	2	3	0.40
63. OLACACEAE							
63.1. *Ximenia americana* L.	Limão-bravo	Trush and diuretic	Infusion (I)	4	2	2	0.33
64. OPILIACEAE							
64.1. *Agonandra brasiliensis* Miers ex Benth. & Hook f.	Pau-marfim	uterine inflammation	Decoction (I, E)	1	1	1	0.17

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
65. ORCHIDACEAE							
65.1. *Vanilla palmarum* (Salzm. ex Lindl.) Lindl.	Baunilha	hypertension	Infusion (I)	2	1	1	0.17
65.2. *Oncidium cebolleta* (Jacq.) Sw.	Orquidea	pain	Infusion (I)	2	1	1	0.17
66. OXALIDACEAE							
66.1. *Averrhoa carambola* L.	Carambola	hypertension	Infusion (I)	8	1	1	0.17
66.2. *Oxalis* aff. *hirsutissima* Mart. ex Zucc.	Azedinha	obesity	Infusion (I)	9	1	1	0.17
67. PAPAVERACEAE							
67.1. *Argemone mexicana* L.	Cardo-santo	hypertension	Infusion (I)	8	1	1	0.17
68. PASSIFLORACEAE							
68.1. *Passiflora alata* Curtis	Maracujá		Infusion (I)	9	1	1	0.17
68.2. *Passiflora cincinnata* Mast.	Maracujá-do-mato	soothing hypertension	Infusion (I)	5	2	2	0.33
69. PEDALIACEAE							
69.1 *Sesamum indicum* L.	Gergelim	stomach, liver, gastritis, ulcer, and worms	Infusion and maceration (I)	12	2	5	0.53
70. PHYLLANTHACEAE							
70.1. *Phyllanthus niruri* L.	Quebra-pedra	kidneys	Infusion (I)	32	1	1	0.17
71. PHYTOLACCACEAE							
71.1. *Petiveria alliacea* L.	Guiné	rheumatism	Infusion (I, E)	4	1	1	0.17
72. PIPERACEAE							
72.1. *Piper callosum* Ruiz & Pav	Ventre-livre/elixir paregórico	kidneys	Infusion (I)	1	1	1	0.17
72.2. *Piper cuyabanum* C. DC.	Jaborandi	pain, stomach, and loss of hair	Infusion (I, E)	10	3	3	0.50
72.3. *Pothomorphe umbellata* (L.) Miq.	Pariparoba	blood cleanser, stomach, liver, and pneumonia	Infusion (I)	11	3	3	0.50
73. PLANTAGINACEAE							
73.1. *Plantago major* L.	Tanchagem	heart, pain, and laxative	Infusion (I)	16	3	3	0.50
74. POACEAE							
74.1. *Andropogon bicornis* L.	Capim-rabo-de-lobo	uterine inflammation	Infusion (I)	3	1	1	0.17
74.2. *Coix lacryma-jobi* L.	Lácrimas-de-nossa-senhora	kidneys	Infusion (I, E)	4	1	1	0.17
74.3. *Cymbopogon citratus* (DC.) Stapfc	Capim-cidreira	soothing blood cleanser, pain, stomach, expectorant, fever, flu, hypertension, muscular relaxative, kidneys, tachycardia, and cough	Infusion and juice (I)	49	5	12	1.30
74.4. *Cymbopogon nardus* (L.) Rendle.	Capim-citronela	flu, cough, and tuberculosis	Infusion (E)	11	2	2	0.33
74.5. *Digitaria insularis* (L.) Mez ex Ekman	Capim-amargoso	wound healing, stomach, bone fractures, and rheumatism	Infusion (I)	14	3	4	0.57

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
74.6. *Eleusine indica* (L.) Gaertn.	Capim-pé-de-galinha	Hypertension and swelling in pregnant woman	Infusion (I)	6	2	2	0.33
74.7. *Imperata brasiliensis* Trin.	Capim-sapé	diabetes, pain, hepatitis, kidneys, and vitiligo	Infusion (I)	12	5	5	0.83
74.8. *Melinis minutiflora* P. Beauv.	Capim-gordura	dengue, blood cleanser, stroke, flu, kidneys, sinusitis, cough, and tumors	Infusion (I)	31	7	8	1.23
74.9. *Oryza sativa* L.	Arroz	bladder	Infusion (I)	1	1	1	0.17
74.10. *Saccharum officinarum* L.	Cana-de-açúcar	kidneys, anemia, and hypertension	Infusion (I)	2	3	3	0.50
74.11. *Zea mays* L.	Milho	bladder kidneys	Infusion (I)	3	2	2	0.33
75. POLYGALACEAE							
75.1. *Polygala paniculata* L.	Bengué	rheumatism	Infusion (I)	6	1	1	0.17
76. POLYGONACEAE							
76.1. *Coccoloba cujabensis* Wedd.	Uveira	diuretic	Infusion (I)	1	1	1	0.17
76.2. *Polygonum* cf. *punctatum* Elliott	Erva-de-bicho	wound healing, dengue, stomach, fever, flu, and hemorrhoids	Infusion (I)	41	5	6	0.90
76.3. *Rheum palmatum* L.	Ruibarbo	blood cleanser, dysentery, pain, and snakebite	Infusion (I)	6	4	4	0.67
76.4. *Triplaris brasiliana* Cham.	Novatero	diabetes	Infusion (I)	1	1	1	0.17
77. POLYPODIACEAE							
77.1. *Phlebodium decumanum* (Willd.) J. Sm.	Rabo-de-macaco	diuretic, hepatitis, and kidneys	Infusion (I)	9	2	3	0.40
77.2. *Pteridium aquilinum* (L.) Kuhn	Samambaia	colic, blood cleanser, and rheumatism	Infusion (I)	8	3	3	0.50
77.3. *Pteridium* sp.	Samambaia-de-cipo	rheumatism	Infusion (I)	1	1	1	0.17
78. PONTEDERIACEAE							
78.1. *Eichhornia azurea* (Sw.) Kunth	Aguapé	ulcer	Infusion (I)	3	1	1	0.17
79. PORTULACACEAE							
79.1. *Portulaca oleracea* L.	Onze-horas	hypertension	Infusion (I)	3	1	1	0.17
80. PROTEACEAE							
80.1. *Roupala montana* Aubl.	Carne-de-vaca	muscular relaxative	Infusion (I)	2	1	1	0.17
81. PUNICACEAE							
81.1. *Punica granatum* L.	Romã	colic, diarrhea, pain, throat, inflammation uterina, and kidneys	Infusion and maceration (I, E)	41	3	6	0.70
82. RHAMNACEAE							
82.1. *Rhamnidium elaeocarpum* Reissek	Cabriteiro	anemia, diarrhea, diuretic, pain, stomach, and worms	Infusion (I)	37	5	6	0.90

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
83. ROSACEAE							
83.1. *Rosa alba* L.	Rosa-branca	wound healing, pain, and uterine inflammation	Infusion and maceration (I, E)	6	3	3	0.50
83.2. *Rosa graciliflora* Rehder & E. H. Wilson	Rosa-amarela	pain	Infusion and maceration (I, E)	1	1	1	0.17
83.3. *Rubus brasiliensis* Mart.	Amoreira	cholesterol, hypertension, labyrinthitis, menopause, obesity, osteoporosis, and kidneys	Infusion and tintura (I)	38	6	7	1.07
84. RUBIACEAE							
84.1. *Chiococca alba* (L.) Hitchc.	Cainca	pain, flu, and rheumatism	Infusion (I)	8	3	3	0.50
84.2. *Cordiera edulis* (Rich.) Kuntze	Marmelada	worms	Maceration and syrup (I)	3	1	1	0.17
84.3. *Cordiera macrophylla* (K. Schum.) Kuntze	Marmelada-espinho	worms	Maceration and syrup (I)	1	1	1	0.17
84.4. *Cordiera sessilis* (Vell.) Kuntze	Marmelada-bola	Flu and worms	Maceration and syrup (I)	4	2	2	0.33
84.5. *Coutarea hexandra* (Jacq.) K. Schum.	Murtinha	diarrhea	Infusion (I)	1	1	1	0.17
84.6. *Genipa americana* L.	Jenipapo	appendicitis bronchitis diabetes and kidneys	Infusion and syrup (I)	8	4	4	0.67
84.7. *Guettarda viburnoides* Cham. & Schltdl.	Veludo-branco	blood cleanser and ulcer	Infusion (I)	5	2	2	0.33
84.8. *Palicourea coriacea* (Cham.) K. Schum.	Douradinha-do-campo	prostate cancer hearth, blood cleanser, diuretic, flu, hypertension, insomnia, relaxative muscular, and kidneys	Infusion (I)	62	7	9	1.30
84.9. *Palicourea rigida* Kunth	Doradão	Kidneys and cough	Infusion and decoction (I)	5	2	2	0.33
84.10. *Rudgea viburnoides* (Cham.) Benth.	Erva-molar	column, thooth, blood cleanser, dysentery, rheumatism, and kidneys	Infusion (I)	44	5	6	0.90
84.11. *Tocoyena formosa* (Cham. & Schltdl.) K. Schum.	Jenipapo-bravo	kidneys	Infusion (I)	1	1	1	0.17
84.12. *Uncaria tomentosa* (Willd. ex Roem. & Schult.) DC.	Unha-de-gato	intoxication, rheumatism, and kidneys	Infusion (I)	10	3	3	0.50
85. RUTACEAE							
85.1. *Citrus aurantiifolia* (Christm.) Swingle	Lima	soothing hearth, and hypertension	Infusion (I)	8	2	3	0.40
85.2. *Citrus limon* (L.) Osbeck	Limão	colic, diabetes, pain, liver, flu, hypertension, and cough	Infusion (I)	17	5	7	0.97

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
85.3. *Citrus sinensis* (L.) Osbeck	Laranja	soothing wound healing, fever, flu, pneumonia, and thyroid	Infusion (I)	30	4	6	0.80
85.4. *Ruta graveolens* L.	Arruda	colic, conjunctivitis, pain, stomach, fever, gastritis, nausea, and laxative muscular	Infusion (I)	57	4	8	0.93
85.5. *Spiranthera odoratissima* A.St.-Hil.	Manacá	rheumatism	Infusion (I)	6	1	1	0.17
85.6. *Zanthoxylum* cf. *rhoifolium* Lam.	Mamica-de-porca	diabetes, diarrhea, hemorrhoids, and muscular relaxative	Decoction (I, E)	12	4	4	0.67
86. SALICACEAE							
86.1. *Casearia silvestris* Sw.	Chá-de-frade	blood cleanser, pain, and fever	Infusion (I)	10	1	3	0.30
87. SAPINDACEAE							
87.1. *Dilodendron bipinnatum* Radlk.	Mulher-pobre	bone fractures	Infusion (I)	5	2	2	0.33
87.2. *Magonia pubescens* A. St.-Hil.	Timbó	uterine inflammation wound healing, pain, and cough	Maceration (I, E)	7	2	3	0.40
87.3. *Serjania erecta* Radk.	Cinco-pontas	column, muscular relaxative, and kidneys	Infusion (I)	9	2	3	0.40
87.4. *Talisia esculenta* (A. St.-Hil.) Radlk.	Pitomba	column, pain, and rheumatism	Infusion (I)	6	2	3	0.40
88. SAPOTACEAE							
88.1. *Pouteria glomerata* (Miq.) Radlk.	Laranjinha-do-mato	fever	Infusion (I)	1	1	1	0.17
88.2. *Pouteria ramiflora* (Mart.) Radlk.	Fruta-de-viado	Ulcer and kidneys	Infusion (I)	1	2	2	0.33
89. SCROPHULARIACEAE							
89.1. *Bacopa* sp.	Vicki-de-batata	kidneys	Infusion (I)	2	1	1	0.17
89.2. *Scoparia dulcis* L.	Vassorinha	bladder wound healing, hearth, blood cleanser, diabetes, pain, bone fractures, swelling in pregnant woman, pneumonia, kidneys, syphilis, and cough	Infusion (I)	81	7	12	1.50
90. SIMAROUBACEAE							
90.1. *Simaba ferruginea* A. St.-Hil.	Calunga	anemia, wound healing, diabetes, digestive, pain, stomach, obesity, ulcer, and worms	Maceration (I)	31	7	9	1.30
90.2. *Simarouba versicolor* A. St.-Hil.	Pé-de-perdiz	wound healing and uterine inflammation	Decoction (I, E)	4	2	2	0.33

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
91. SIPARUNACEAE							
91.1. *Siparuna guianensis* Aubl.	Negramina	pain, fever, and flu	Infusion (I)	20	2	3	0.40
92. SMILACACEAE							
92.1. *Smilax* aff. *brasiliensis* Spreng.	Japecanga	Column and rheumatism	Infusion (I)	5	1	2	0.23
93. SOLANACEAE							
93.1. *Capsicum* sp.	Pimenta	Pain and hemorrhoids	Infusion (I, E)	14	2	2	0.33
93.2. *Nicotiana tabacum* L.	Fumo	thyroid	Infusion (I, E)	2	1	1	0.17
93.3. *Physalis* sp.	Tomate-de-capote	hepatitis	Infusion (I)	1	1	1	0.17
93.4. *Solanum americanum* Mill.	Maria-pretinha	worms	Infusion (I)	3	1	1	0.17
93.5. *Solanum lycocarpum* A. St.-Hil.	Fruta-de-lobo	Gastritis and ulcer	Infusion and maceration (I)	6	1	2	0.23
93.6. *Solanum* sp.	Jurubeba	column, stomach, and liver	Infusion (I)	8	2	3	0.40
93.7. *Solanum* sp.	Urtiga	boi	Infusion (I)	1	1	1	0.17
93.8. *Solanum melongena* L.	Berinjela	cholesterol	Infusion and maceration (I)	2	1	1	0.17
93.9. *Solanum tuberosum* L.	Batata-inglesa	Pain and gastritis	Infusion and maceration (I, E)	13	2	2	0.33
93.10. *Solanum viarum* Dunal.	Joá-manso	Hemorrhoids	Infusion (I)	7	1	1	0.17
94. TILIACEAE							
94.1. *Apeiba tibourbou* Aubl.	Jangadeira	liver	Decoction (I, E)	1	1	1	0.17
94.2. *Luehea divaricata* Mart.	Açoita-cavalo	uric acid, column, blood cleanser, throat, flu, hemorrhoids, intestine, pneumonia, muscular relaxative, kidneys, cough, and tumors	Decoction and syrup (I)	58	7	12	1.50
95. ULMACEAE							
95.1. *Trema micrantha* (L.) Blume	Piriquiteira	wound healing	Decoction (I, E)	1	1	1	0.17
96. VERBENACEAE							
96.1. *Casselia mansoi* Schau	Saúde-da-mulher	thooth, blood cleanser, uterine inflammation, and menstruation	Infusion (I)	9	3	4	0.57
96.2. *Duranta repens* L.	Pingo-de-ouro	diabetes	Infusion (I, E)	3	1	1	0.17
96.3. *Lantana camara* L.	Cambará	cold and cough	Decoction (I)	22	2	2	0.33
96.4. *Lippia alba* (Mill.) N. E. Br. ex Britton & P. Wilson	Erva-cidreira	soothing hearth, thooth, blood cleanser, pain, flu, hypertension, tachycardia, and cough	Infusion (I)	75	5	9	1.10

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
96.5. *Phyla* sp.	Chá-mineiro	conjunctivitis, blood cleanser, pain, fever, muscular relaxative, rheumatism, and kidneys	Infusion (I)	19	4	7	0.87
96.6. *Priva lappulacea* (L.) Pers.	Pega-pega	Stomach and sinusitis	Infusion (I)	2	2	2	0.33
96.7. *Stachytarpheta* aff. *cayennensis* (Rich.) Vahl	Gervão	bronchitis blood cleanser, stomach, liver, bone fractures, gastritis, flu, constipation, relaxative muscular, cough, and worms	Infusion (I)	80	6	11	1.33
96.8. *Stachytarpheta* sp.	Rabo-de-pavão	relaxative muscular	Infusion (I)	3	1	1	0.17
96.9. *Vitex cymosa* Bert.ex Spregn.	Tarumeiro	blood cleanser, diarrhea, pain, and stomach	Infusion (I)	8	3	4	0.57
97. VIOLACEAE							
97.1. *Anchietea salutaris* A. St.-Hil.	Cipó-suma	column, blood cleanser, fever, intoxication, and vitiligo	Infusion (I)	18	4	5	0.73
97.2. *Hybanthus calceolaria* (L.) Schulze-Menz.	Poaia-branca	cough	Infusion (I)	1	1	1	0.17
98. VITACEAE							
98.1. *Cissus cissyoides* L.	Insulina-de-ramo	diabetes	Infusion (I)	10	1	1	0.17
98.2. *Cissus gongylodes* Burch. ex Baker	Cipó-de-arráia	relaxative muscular	Infusion (I)	1	1	1	0.17
98.3. *Cissus* sp.	Rabo-de-arráia	hypertension	Infusion (I)	3	2	2	0.33
98.4. *Cissus* sp.	Sofre-do-rim-quem-quer	inflammation uterina, relaxative muscular, and kidneys	Infusion (I)	5	3	3	0.50
99. VOCHYSIACEAE							
99.1. *Callisthene fasciculata* Mart.	Carvão-branco	Hepatitis and icterus	Decoction (I, E)	10	2	2	0.33
99.2. *Qualea grandiflora* Mart.	Pau-terra	Diarrhea and pain	Decoction (I, E)	5	2	2	0.33
99.3. *Qualea parviflora* Mart.	Pau-terrinha	diarrhea		1	1	1	0.17
99.4. *Salvertia convallariodora* A. St.-Hil.	Capotão	diarrhea, diuretic, hemorrhoids, and relaxative muscular	Decoction (I, E)	4	4	4	0.67
99.5. *Vochysia cinnamomea* Pohl	Quina-doce	flu		3	1	1	0.17
99.6. *Vochysia rufa* Mart.	Pau-doce	blood cleanser, diabetes, diarrhea, laxative, obesity, kidneys, cough, and worms	Decoction, Infusion (I, E)	25	6	8	1.13

Table 3: Continued.

Family/species	Vernacular name	Application	Preparation (administration)	Uses listed	NCS	NP	RI
100. LILIACEAE							
100.1. *Aloe barbadensis* Mill.	Babosa	Cancer, prostate cancer, wound healing, diabetes, stomach, bone fractures, gastritis, hepatitis, laxative, and rheumatism	Syrup and maceration (I, E)	87	5	9	1.10
101. ZAMIACEAE							
101.1. *Zamia boliviana* (Brongn.) A. DC.	Maquiné	stomach	Infusion (I)	2	1	1	0.17
102. ZINGIBERACEAE							
102.1. *Alpinia speciosa* (J. C. Wendl.) K. Schum.	Colônia	soothing hearth, fever, flu, and hypertension	Infusion (I)	36	4	5	0.73
102.2. *Curcuma longa* L.	Açafrão	column, diuretic, pain, stomach, and hepatitis	Infusion and maceration (I)	18	4	5	0.73
102.3. *Zingiber officinale* Roscoe	Gengibre	pain, flu, sinusitis, and cough	Infusion and maceration (I)	26	2	4	0.47

I: Internal, E: External; NSC: Number of body systems treated by species; NCS: number of body systems. NP: Number of properties of the species; RI: Relative importance of the species.

Table 4: Species with the highest values of relative importance.

Family	Species	Application/citation	RF	RI
Apocynaceae	*Himatanthus obovatus* (Müll. Arg.) Woodson	anemia (1), wound healing (7), cholesterol (3), blood cleanser (9), pain (4), nose bleeding (1), hypertension (4), uterine inflammation (5), labyrinthitis (6), muscle relaxant (2), worms (1), vitiligo (1), and pneumonia (1)	45	1.87
Malvaceae	*Hibiscus sabdariffa* L	anxiety/heart (1), flu (1), tachycardia (1), kidneys (1), cramps (3), discharge (1), diarrhea (1), pain (1), inflammation uterine (2), labyrinthitis (3), snakebite (1), and pneumonia (2)	18	1.87
Asteraceae	*Solidago microglossa* DC.	wound healing (53), blood cleanser (11), pain (2), bone fractures (1), hypertension (1), uterine inflammation (3), muscle relaxant (6), kidneys (3), and worms (2)	82	1.8
Loganiaceae	*Strychnos pseudoquina* A. St.-Hil.	anemia (46), wound healing (3), cholesterol (1), blood cleanser (16), pain (13), stomach (3), bone fractures (1), flu (2), uterine inflammation (1), pneumonia (1), muscle relaxant (1), cough (10), ulcer (1), and worms (8)	107	1.73
Moraceae	*Dorstenia brasiliensis* Lam.	wound healing (1), colic (1), tooth ache (1), blood cleanser (4), dysentery (1), pain (7), flu (2), laxative (3), menstruation (1), pneumonia (6), relapse delivery (13), and kidneys (1)	41	1.5
Plantaginaceae	*Scoparia dulcis* L.	heart (6), blood cleanser (1), diabetes (1), pain (16), bone fractures (47), swelling in pregnant woman (4), pneumonia (1), kidneys, (1) syphilis (3), and cough (1)	55	1.5
Malvaceae	*Luehea divaricata* Mart.	uric acid (18), vertebral column (2), blood cleanser (1), throat (1), flu (1), hemorrhoids (7), intestine (1), pneumonia (8), muscle relaxant (2), kidneys (3), cough (10), and tumors (4)	58	1.5

RF: Relative frequency; RI: Relative importance of the species.

traditional use as a blood cleansing, wound healing, and other conditions associated with infections, which seems to point to its possible antibiotic activity. Indeed, some studies have demonstrated the *in vitro* activity of its different extracts against promastigotes of *Leishmania donovani* [38]. A few others also showed experimentally its antiviral, antitumor activities, cellular proliferation activities, and inflammatory and immune response [39, 40]. On the basis of these aforementioned, it is possible that its use in the folk medicine may be related to its ability to modulate the immune system, which may enhance physiological mechanisms involved in resolving inflammation, pain, and wound healing.

Table 5: Categories of diseases, indications, form of use, preparation and the informant consensus factor of the main medicinal plants from Nossa Senhora Aparecida do Chumbo District, Poconé, Mato Grosso, Brazil.

Disease category/CID, 10th ed.	Medicinal plants	Main indications	Main forms of use	Part utilized/ State of the plant	Species/citations	ICF
Injuries, poisoning, and certain other consequences of external causes— XIX	*Scoparia dulcis* L. *Solidago microglossa* D. C *Lafoensia pacari* A. St.-Hil.	inflammation and pain	Inf, Dec, Mac, and Tin	L, Wp, Rt (Fr, Dr)	65/286	0.78
Mental and behavioural disorders —V	*Chamomilla recutita* (L.) Rauschert.	soothing	Dec and Inf	L (In, Sc)	20/85	0.77
Symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified—XVIII	*Macrosiphonia longiflora* (Desf.) Müll. Arg.	blood depurative	Inf, Dec, and Mac	Rz (Fr, Dr)	176/713	0.75
Diseases of the genitourinary system —XIV	*Palicourea coriacea* (Cham.) K. Schum.	Kidneys and diuretic	Inf, Dec, and Syr	L (Fr, Dr)	132/533	0.75
Diseases of the digestive system—XI	*Plectranthus barbatus* Andrews	stomach, pain, liver, and malaise	Dec, Inf, Mac, and Juc	L (Fr, Dr)	113/428	0.74
Other infectious and parasitic diseases—I	*Chenopodium ambrosioides* L.	verminose	Inf, Mac, and Juc	L (Fr,Dr)	82/300	0.73
Diseases of the respiratory system—X	*Mentha pulegium* L.	flu, bronchitis, colds, and cough	Dec, Inf, Mac, and Syr	L (Fr, Dr)	88/303	0.71
Pregnancy, childbirth, and the puerperium—XV	*Dorstenia brasiliensis* Lam.	childbirth	Dec, Inf, and Syr	Rz (Fr, Dr)	9/28	0.70
Diseases of the circulatory system—IX	*Alpinia speciosa* (J. C. Wendl.) K. Schum.	Hypertension and heart	Inf and Mac	L (Fr, Dr)	56/180	0.69
Some disorders originating in the perinatal period—XVI	*Bidens pilosa* L.	Hepatitis and enteric	Dec and Inf	L (In, Sc)	3/7	0.67
Diseases of blood and blood forming organs and certain disorders involving the immune system—III	*Strychnos pseudoquina* A. St.-Hil.	anemia	Inf, Mac, and Syr	B (Fr, Dr)	15/38	0.62
Diseases of the eye and the surrounding structures—VII	*Malva sylvestris* L.	Discharge and conjuctivitis	Inf and Tin	L (Fr, Dr)	6/14	0.61
Diseases of endocrine of nutritional and metabolic origins—IV	*Cissus cissyoides* L.	diabetes	Inf	L (Fr, Dr)	47/109	0.57
Diseases of the ear and mastoid process—VIII	*Himatanthus obovatus* (Müll. Arg.) Woodson	labyrinthitis	Inf	L (Fr, Dr)	7/15	0.57
Diseases of musculoskeletal and connective tissue—XIII	*Solidago microglossa* DC.	bone fractures	Dec, Inf, Mac, and Tin	L (Fr, Dr)	70/146	0.52
Diseases of the skin and subcutaneous tissue—XII	*Dioscorea brasiliensis* Willd.	furuncules	Dec, Inf, Mac, Tin, and Out	Rz (Fr, Dr)	29/51	0.44
Neoplasia (tumors)—II	*Aloe barbadensis* Mill.	wound healing	Dec, Inf, Mac, Tin, and Out	L (Fr, Dr)	22/38	0.43
Diseases of the nervous system—VI	*Macrosiphonia longiflora* (Desf.) Müll. Arg.	leakage	Inf		14/16	0.13

CID, 10th ed. categories of diseases in chapters according to International Classification of Diseases and Related Health Problems, 10th. edition [25]; ICF: informant consesus factor; Inf: infusion, Dec: decoction, Syr: syrup, Mac: maceration, Sal: salad, Tin: tinture, Juc: juice, Out: others (compression and bath). L: leave; Wp: whole plant; Rt: root; Rz: rhizome; B: bark. State of the plant: Fr: fresh; Dr: dried.

We did not encounter any literature pertaining to its use in anemia, nosebleeding, muscle relaxant, deworming, or vitiligo treatment. Its indications as a blood cleansing and as antihypercholesterolemic are important targets for future biomedical research.

Hibiscus sabdariffa calyces are used in many parts of the world to make cold and hot drinks as well as in folk medicine [41]. Due to its many health-enhancing benefits, extensive works have been carried to validate its traditional therapeutic claims. In fact, its medicinal importance is widely acknowledged in many traditional herbal systems [42].

The benefits associated with the use of *H. sabdariffa* may in part be due to its high content of beneficial phytochemical constituents. These include alkaloids, L-ascorbic acid, anisaldehyde, anthocyanin, β-carotene, β-sitosterol, citric acid, cyanidin-3-rutinoside, delphinidin, galactose, gossypetin, hibiscetin, mucopolysaccharide, pectin, protocatechuic acid, polysaccharide, quercetin, stearic acid, and flavonoids [42, 43]. Studies have highlighted the role of polyphenol acids, flavonoids, and anthocyanins that may act as antioxidants or through other mechanisms that may contribute to its cardioprotective activity [44, 45].

In additions to folkloric use of *H. sabdariffa* noted in this study, other previous reports have indicated its use in the treatment of liver disease, hypocholesterolemic, antispasmodic, intestinal antiseptic, sedative, and as mild laxative [42, 46]. The most extensively studied is its antihypertensive activity. This effect was confirmed in several *in vitro* and animal studies [47–49]. The hypotensive effect of *H. sabdariffa* and its constituents may be mediated, at least partially, by a cholinergic and/or histaminergic mechanism and it has been confirmed to act via inhibitiory action on angiotensin I converting enzyme, vasorelaxation [50], and diuretic action [51]. For detailed review on this aspect, see [41]. In addition to literature reports on the medicinal uses of this plant, we also report here its indications in the treatment of anxiety and labyrinthitis and as anti-snake venom. To the best of our knowledge, these indications remained to be proven experimentally.

In concordance with the traditional use of *H. sabdariffa* in the treatment of uterine inflammation and pain, its aqueous ethanol extract was shown experimentally to presents anti-inflammatory, uterine antispasmodic activities, and attenuation of intestinal spasm [52–54]. In addition to its confirmed pharmacological activities, its antiobese/weight-reducing [50, 55], hepatoprotective [56–58], anticancer [46, 59, 60], free-radical scavenging [61], antioxidant [42], immunomodulatory [62], lipid-lowering [43, 63] effects and attenuation of oxidants-mediated complications in diabetes [64] have been well documented. Besides, the plant extract is characterized by a very low degree of toxicity [41]. Moreover, apart from its medicinal uses, the plant seed oil was also shown to be a good source of lipidsoluble antioxidants, particularly γ-tocopherol, thus it could have important industrial applications [65].

Solidago microglossa is popularly known in Brazil as "arnica," "arnica-do-mato," "arnica-silvestre," "erva-federal," "arnica-vulgar," "erva-lanceta," and "rabo-de-rojão" [66]. It is usually confused with *Arnica montana* L., a native of the mountainous regions of Europe, due to the similarity in their medicinal flowers and having the same color (yellow), *S. microglossa* is not cultivated in Brazil due to it low adaptation to the tropical conditions [66]. In our study, *S. microglossa* was indicated for treatment of 15 different diseases corresponding to 8 classes of CID, 10th ed. and had a total of 49 citations. The key citations for this plant were its use in wound healing and blood cleansing. Other popular indications found in this study were similar to those previously reported, especially its use in the treatment of wounds, acne, bruises, and stomach-related ailments [67].

Several classes of compounds and metabolites have been isolated from *S. microglossa*, especially phenols, acetophenones, carotenoids, lactones (helenalin and dihydrohelenalin) [68, 69], flavonoids [70, 71] saponins [72], and polyacetylenes [70]. The cicatrizant activity of the plant's extract has been confirmed experimentally [73]. Although not mentioned directly by respondents in this study, some lines of evidence suggest important antibiotic activity with the use of *S. microglossa*, which can justify its indication for uterine inflammation. Morel et al. [74] showed that the essential oil of *S. microglossa* and three of its components (quercetrin, α-espinasterol, and solidagenone) are capable of significantly inhibiting the growth of *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, *Escherichia coli*, *Salmonella setubal*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Saccharomyces cerevisiae,* and *Candida albicans* [74]. In addition, cicatrizant activity was observed with the administration of the plant's extract [73]. Its use in ameliorating renal ailments, blood cleansing, and hypotensive and antiparasitic activities may be associated with the presence in high concentrations of tannins [75, 76] and flavonoids in this species [76–79]. Its indication for muscle relaxation may also derive from its antispasmodic effect [80]. Further studies are warranted in these regards.

Other pharmacological properties not mentioned here, but have been established in preclinical studies, include hypoglycemic effect [81] and antitumor activity. In fact, the latter effect has attracted intense interest in the discovery of new chemotherapeutic agents. The extract of *S. microglossa* demonstrated antiproliferative effect (but not mutagenic) against young shoot cells of onion (*Allium cepa*) strain [82]. Some of these activities may be related to the presence of secondary metabolites such as helenalin [83].

Although *Strychnos pseudoquina* is referred to locally as "quinas", similar to the local name used for species such as *Cinchona* sp. (source of quinine), it has been shown to be inactive against *Plasmodium berghei* [84] contrary to its popular use in folk medicine elsewhere [84]. Theoretically, some of the indications may result from the classification bias in the community due to an erroneous popular cultural belief that plants referred to as "quinas" are useful for "anemic" patients infected with malaria parasite. This perhaps helps to explain why the highest indication for this plant in our study was to treat anemia.

Among the components isolated from *S. pseudoquina* metabolites are isoramnetin, strychnobiflavone, and 11-diaboline metoxidiaboline [85]. Silva et al. [86] demonstrated the gastroprotective effect of *S. pseudoquina* in models of gastric lesions induced by nonsteroidal anti-inflammatory agents and some necrotizing agents, thus confirming its indication for gastric ulcer and stomach disorders as noted in this present study. On the other hand, its indication in wound healing has not been experimentally confirmed at least in the diabetic wound model in rats [87] or in local hemorrhage induced by *Bothrops jararaca* venom [88]. Other medicinal uses indicated like "blood depurative" and analgesic effect may be subject of future investigation as a potential agent with antinociceptive and metabolic disorders ameliorating effects. Regarding its toxicity, Santos et al. [81] showed that only the methanol extract (but not dichloromethane) from the leaves of *S. pseudoquina* have mutagenic effect in *Salmonella* strains TA98 (−S9) and TA100 (+ S9, −S9) and that it induces formation of micronuclei after acute treatment [81].

Dorstenia brasiliensis, known as "Carapiá" is a perennial herb of the early geological point of view, typical of the fields in southern Brazil, Paraguay, Uruguay, and Argentina [89, 90]. Phytochemical analysis of roots of *D. brasiliensis* indicated the presence of dorstenic acid A and B (triterpenoids), isopimarane-type diterpenoid, and six different types of coumarins. The two triterpenoids showed moderate cytotoxicity against leukemia cells (L-1210 and HL-60) [91]. Furthermore, some authors have suggested that its use in cutaneow disease (such as psoriases and vitiligo) may be associated with the presence of furanocoumarins in the species of *Dorstenia* [92]. Bartericin A and B, stigmasterol, isobavachalcone, 4-hydroxylonchocarpin, dorsmanin F, 6,8-diprenyleridictyol, quercetin, quercitrin, amentoflavone [93], psoralen, bergapten (from rhizome), and umbelliferone [94] are some of the compounds isolated this medicinal plant.

Some few pharmacological studies have demonstrated analgesic and anti-inflammatory activities of *D. brasiliensis* in animal models [95]. These data corroborated the popular use of *D. brasiliensis* as an analgesic. There is dearth of information confirming its use in the popular medicine use as an anti-inflammatory agent. Moreover, *D. brasiliensis* may possesses some biologically active compounds similar to other *Dorstenia* species from the same genus and may thus share similar pharmacological profile. The following compounds and pharmacological activities have been reported in other *Dorstenia* species: chalcones (*D. prorepens* and *D. zenkeri*) [96], furocoumarins (*D. bahiensis* and *D. bryoniifolia*), triterpenes (*D. bahiensis, D. bryoniifolia*, *D. carauntae, D. cayapiaa,* and *D. heringerii*) [97]. This is a point to be noted for future research. Some authors have investigated its potential use as antivenom, antiinfective, anti-rheumatic [96, 97] while others established its antitrichomonal [93], antitussive [98], antioxidant [93, 99] and antileishmanial [100] activities.

Scoparia dulcis, popularly known as "vassourinha", grows wild in backyards, gardens, and fields in Brazil. Phytochemical studies have identified the presence of more than 12 interesting pharmacologically active compounds in this species, namely, scoparic acid A [101], iso-dulcinol, 4-epi-scopadulcic acid B, dulcidiol, scopanolal, dulcinol/scopadulciol, scopadiol [102], scoparinol [103], scopadulcic acid B [104–106], glutinol [107] and scopadulin [105]. Scopadulcic acid B inhibited the effects of tumor promoter 12-O-tetradecanoylphorbol-13-acetate (TPA) *in vitro* and *in vivo*, and also suppressed the promoting effect of TPA on skin tumor formation, demonstrating stronger effect than antitumor-promoting terpenoids, such as glycyrrhetinic acid [104]. In fact, its cytotoxicity has been investigated against antitumor activity [102] and nerve growth factor-mediated neurite outgrowth and neurodegenerative disorders [103, 108].

The analgesic and anti-inflammatory activities of ethanol extracts of *S. dulcis* and glutinol have been demonstrated in writhing induced by acetic acid and carrageenan-induced paw edema, respectively [107]. However, *S. dulcis* extracts were ineffective in the central pain models (tail flick) and paw edema induced by dextran. Another secondary metabolite, scoparinol, also showed significant analgesic and anti-inflammatory activity [109]. In regard to its toxicological effects, it is worthwhile to mention that glutinol and scoparinol markedly potentiated pentobarbital-induced sedation and duration of sleeping time in these two studies mentioned above.

In contrast to its toxicity, *S. dulcis* seems to possess potential hepatoprotective activity in different models, which have been attributed to its free-radical scavenging potential activities [110–113]. Corroborating with antibiotic use for some infections (like gonorrhea), some authors have investigated inhibition of multidrug resistance (MDR) bacteria, fungi [114, 115], leishmanial parasite [116], and herpes simplex virus type 1 growths [96].

Paradoxically, despite the low citation in gastric ulcer and diabetes treatments in this study, the antiulcer and antihyperglycemic activities of this species are well documented. Inhibitory activities of *S. dulcis* extracts was demonstrated in pylorus ligature model, histamine- or bethanechol-stimulated gastric secretion, and acute gastric lesions induced by indomethacin [117, 118]. *S. dulcis* was also demonstrated to inhibit both proton pump (H^+, K^+-ATPase) and proton transport into gastric vesicles [105]. In regard to its antihyperglycemic effect, experimental evidences demonstrated that *S. dulcis* extracts reduced blood glucose, glycosylated haemoglobin, prevented decrease in the body weight, and improved glucose tolerance similarly with glibenclamide [119]. Even in the insulin resistance stage, *S. dulcis*-treated L6 myotubes were found to be more capable of stimulating glucose transport than insulin treatment [120]. In addition, scoparic acid D was able to stimulate insulin secretion and receptor binding in streptozotoci- (STZ-) induced diabetic rats [121].

Luehea divaricata is a native tree of the Brazilian Cerrado popularly known as "açoita-cavalo". Just as popularly indicated, some studies have reported the following pharmacological activities of *L. divaricata*: the leaves as used as diuretic, the stems as anti-inflammatory, the bark and aerial parts are used for healing skin wounds, pimples, and for vaginal washes [122, 123].

Phytochemical screening of *L. divaricata* reported the presence of flavonoids, tannins and saponins and afforded the presence of 3b-*p*-hydroxybenzoyl-tormentic acid [124], maslinic acid [122], vitexin and glucopyranosylsitosterol, and (−)-epicatechin [123].

The presence of flavonoids and metabolites such as the vitexin [125, 126] and maslinic acid [127, 128] may be associated with the popular indication of its anti-inflammatory properties formation of urate (18) and anti-tumor (4). Extracts of *L. divaricata* has been shown to have antioxidant activity and analgesic property [129], lack toxicity *in vivo* [130], or mutagenicity [131]. Its extract also showed cytotoxicity against tumor cell lines [123]. Due to the high level of citation for the treatment of urate aleviation (18), we believe that its antigout or uricosuric activity may be an important target of pharmacological interest. Another indication prominently cited by the respondents is the use of *L. divaricata* in the treatment of lung diseases and upper airway. However, there is no scientific evidence on its regulatory activity on cough, while its antibiotic properties also vary. Some authors have demonstrated its inhibitory effect on the growth of dermatophytes [132] but not in other fungi species [123, 129]. In addition, the extract of *L. divaricata* was shown to strongly inhibit the growth of *S. aureus, S. epidermitis, K. pneumonia,* and *E. coli* in a study [129] but showed only moderately in another study elsewhere [123].

It is worth mentioning that although *Lafoensia pacari* A.St.-Hil. had low relative importance value, all the same, it is among the three plants with the highest informant consesus factor in addition to being a native plant in the region. The other two (*S. dulcis* and *S. microglossa*) have been discussed previously.

L. pacari popularly called "mangava-brava", belongs to the family Lythraceae, is a tree native to the Brazilian Cerrado [133]. It is commonly used for gastrointestinal disorders, wound healing, diarrhea, and kidney problems. In our study, it was referenced for the treatment of seven disorders distributed into five classes of CID, 10th ed. Preliminary phytochemical studies of methanol extract of the stem bark of *L. pacari* revealed the presence of free steroids, saponins, tannins catechins, pyrogalic tannins (in particular, ellagic acid), triterpenoids, simple phenols, strong and weak fixed acids, alkali, and quaternary amino acids [134–136]. Acute toxicity studies or subchronic oral administration of extracts of *L. pacari* did not indicate any harmful effects [137]. However, it is also indicated for its adverse reactions and used as an abortifacient, diarrheic, weight loss, and tachycardia. Among the 42 citations for *L. pacari*, 29 were for the treatment of ulcer, and four and two for gastritis and stomach, respectively. These indications have been confirmed with the use of methanol crude extract of *L. pacari* and its major active components, ellagic acid, in different experimental ulcer models [138–143]. In addition, the antiulcer activity of the methanol extract (capsules) of *L. pacari* was confirmed in the clinical trial with 55 patients with dyspepsia [144].

We did not encounter any studies concerning its activities in wound healing, antidiarrheal or alleviation of kidney disorders. This phenomenon of plant selection by local people for certain indications may be, for instance, to consolidate best practice of the medicinal properties of the plants at the expense of using other plants substitute for these indications. In fact, the broad community access to Amazon or Pantanal biome, and the close relationship with the indigenous native populations, promotes a variety of possibilities of ethnobotanical indications. Examples of other popular uses of *L. pacari* that have been experimentally confirmed includes weight loss [145], anorectic effect [142], antipyretic activity [146], anti-inflammatory [147], antiallergic [148], and analgesic property [149].

It is also worth mentioning other studies focused on the medicinal uses of *L. pacari*, including its potent antifungal activity [150], have demonstrated that the main compound responsible is found in the methanol extract of this plant. A patent application of lotion with the infusion prepared from the leaves of *L. pacari*, as a component of the formulation was also solicited [151]. To the best of our knowledge, there is currently no available literature concerning its claims as wound healing, antidiarrheal, or in kidney disorders.

5. Conclusions

The present study identified the several plant species and their medicinal uses in NSACD highlighting significant cultural diversity in the Pantanal region. In fact, one of the important components of this community is the contribution of Amerindian culture, which highlights its importance in the identification of indigenous popular knowledge relevance in the identification of native popular knowledge.

Analytically, the data were categorized according to the highest values of relative importance and consensus among informants, ensuring the best evidence for ethnobotanical bioprospecting of medicinal plants. Thus, we identified seven native species with the highest relative importance, which are *H. obovatus*, *H. sabdariffa*, *S. microglossa*, *S. pseudoquina* and *D.brasiliensis*, *S. dulcis,* and *L. divaricata* including *L. pacari.* The three plants with the highest value of consensus among informants were *S. dulcis*, *S. microglossa,* and *L. pacari.*

The preservation of local culture, the practice of traditional medicinal plant species themselves represent important strategies for sustenance of popular knowledge of CAM in the local systems of health care and environmental education. Moreover, ethnobotanical and pharmacological studies provide information essential for guidance in bioprospecting for new drugs of plant origin in the consolidation of therapeutic practices of the community.

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Review Article

Ichthyofauna Used in Traditional Medicine in Brazil

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Fish represent the group of vertebrates with the largest number of species and the largest geographic distribution; they are also used in different ways by modern civilizations. The goal of this study was to compile the current knowledge on the use of ichthyofauna in zootherapeutic practices in Brazil, including ecological and conservational commentary on the species recorded. We recorded a total of 85 species (44 fresh-water species and 41 salt-water species) used for medicinal purposes in Brazil. The three most commonly cited species were *Hoplias malabaricus, Hippocampus reidi,* and *Electrophorus electricus*. In terms of conservation status, 65% of species are in the "not evaluated" category, and 14% are in the "insufficient data" category. Three species are in the "vulnerable" category: *Atlantoraja cyclophora*, *Balistes vetula,* and *Hippocampus erectus*. Currently, we cannot avoid considering human pressure on the population dynamics of these species, which is an essential variable for the conservation of the species and the ecosystems in which they live and for the perpetuation of traditional medical practices.

1. Introduction

Nature offers various resources that people use to guarantee their survival [1] and to reproduce their ways of life and their practices. The use and management of these resources is intimately linked with the needs of various human populations. Among traditional populations, the use of plant and/or animal resources for medicinal purposes has been reported by various authors as an essential practice in traditional medical systems [2–13]. Natural resources have been used in traditional medical practices since ancient times, and their use is spreading in contemporary society [14]. One very old alternative therapy involves the use of animals and their derivatives in the production of zootherapeutic medications [15]. Zootherapy is an important alternative for cures in local populations; it can also be useful for the development of new drugs in modern medicine [4].

In Brazil, zootherapy appears well established; its broad biological diversity, along with its cultural complexity, drive production of zootherapeutic products [16]. In addition, the difficulty in accessing the main health system encountered by some populations increases the demand for traditional medicine [17].

Among the animal taxa used as medicinal resources, fish deserve special attention due to their strong representation in zootherapeutic surveys in Brazil [2, 7, 8, 12, 30, 42]. As a resource, fish are exploited in different ways by each culture [36]. Their medicinal applications include the use of both body parts and materials produced by the fish, along with live individuals [22].

Many of the animals used medicinally are found on the list of endangered species [7]; the risk of extinction is not only for the species but also for the benefits they offer. One of the benefits resulting from research in zootherapy is the discovery of new compounds that have pharmacological potential [21]. Given what has been stated above, this study aims to gather the current knowledge on ichthyofauna used in zootherapeutic practices in Brazil. By doing so, we expect to broaden the knowledge base through a compilation of species used to provide a first approximation of the wealth of these resources and their potential. Additionally, the study will evaluate whether the habitat of these species influences its versatility of use and if there are differences in the diversity of species cited for each body system.

The information compilation was based on bibliographic data. We considered bibliographic data from book chapters, in periodicals publications, and technical information available in online databases. We only considered a valid taxa the identified on species level, since the use of clades identified on the genus level, without its proper description, does not allow the technical-scientific accumulation of the taxon, which justifies this compilation with a fewer species number when compared to Costa-Neto and Alves [42] and R. R. N. Alves and H. N. Alves [13].

The database generated contains information on taxonomy, habitat, conservation status through the IUCN, the part of the animal used, therapeutic indications, and the Brazilian states where the species were cited. Species nomenclature, their habitats, and conservation status were confirmed and updated according to [43–45].

Though the locations sampled employed different methods and collection efforts, we counted the numbers of species used for zootherapeutic purposes by Brazilian region (state) and therapeutic indication. While it was not possible to perform a refined comparative analysis on the distribution of species use, this method allowed us to record the breadth of geographic distribution of the zootherapeutic indications and the study frequency by Brazilian regions and states.

We used the Index of Relative Importance (IR) [46] to measure the versatility of use of each species. This index takes into consideration the properties attributed and the body systems that are indicated for each species. This index varies from 0 to 2, with 2 indicating the most versatile species. We used the Kruskal-Wallis test to evaluate whether the relative importance of a species was related to its habitat (i.e., salt water or fresh water) and its conservation status. We also compared habitats relative to species wealth for each body system using the Kolmogorov-Smirnov test. BioEstat v.5.0 software was used for analysis [47].

Therapeutic indications were categorized according to body systems from [48]: digestive, respiratory, gynecological/urinary, circulatory, nervous, sensory, motor, puerperal, cutaneous, scarring, poisoning, neoplasia, hematopoietic, nutrition, infectious/parasitic, lack of sexual desire, antiabortive, and postpartum. Indications that could not be classified in these systems were grouped as "undefined pains/disorders."

2. Ichthyofauna in Traditional Medical Practices in Brazil

The inventory of ichthyofauna used in Brazilian zootherapy produced a list of 85 species, of which 44 are predominantly fresh water and 41 are predominantly salt water fishes; 22 are cartilaginous fish (Figure 1). The most commonly listed fish were *Hoplias malabaricus* (Bloch, 1794) ($N = 15$), followed by *Hippocampus reidi* Ginsburg, 1933 ($N = 13$), and *Electrophorus electricus* (Linnaeus, 1766) ($N = 10$) (Table 1). These three species are highly important for zootherapy due to their documented use in various regions of Brazil [24–26, 31, 36].

These most frequently used fish resources are part of the native fauna, demonstrating the importance of local fauna as a source for traditional remedies. According to R. Alves and H. Alves [13], the composition and availability of fauna are factors that directly affect the composition of the local zootherapeutic arsenal.

The dissemination of zootherapeutic knowledge is reflected in the population's contact with resources that, in principle, are not available locally. Some species that are restricted to the coast, such as the seahorse (*Hippocampus reidi*), are broadly disseminated throughout the interior of Brazil [24, 25, 27]. The use of this species was recorded for populations in the interior, such as the cities of Santa Cruz do Capibaribe-PE [24], Crato-CE [33], Queimadas-PB [25], and Caruaru-PE [26]. This situation may be explained by the existence of commercial routes for medicinal animals involving different cities in Brazil [49]. An exotic species such as the cod *Gadus morhua* Linnaeus, 1958, is available commercially in various states in Brazil for culinary purposes, but it is also used medicinally in states such as Paraíba and Bahia [2, 23].

Zootherapeutic practice involving ichthyofauna was recorded in 14 Brazilian states, representing the North, Northeast, Center-West, and Southeast regions. The state of Bahia (28 spp.) had the highest number of fishes used as traditional remedies, followed by the states of Tocantins (21 spp.), Paraíba (19 spp.), Maranhão (16 spp.), and Pará (9 spp.). This may not reflect the true situation regarding zootherapy in Brazil; the number is likely underestimated due to the concentration of studies in these regions (Figure 2).

The Northeast region was the best represented, with research performed in eight states: Piauí, Maranhão, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, and Bahia. This region has a significant presence of zootherapy in curing practices [7, 50]. Alves [12], while recording zootherapeutic practices in this region, did not perform studies in Ceará and Rio Grande do Norte; however, studies performed that same year [27, 33] and in the following year [28] demonstrated the medicinal use of animals in these two states. The North region was the second-most frequently represented, followed by the Southeast and Center-West regions, which accounted for 7% of the studies.

3. Therapeutic Indications for Ichthyofauna

Various therapeutic indications have been associated with ichthyofauna for medicinal use in Brazil, with 83 different diseases or illnesses recorded, particularly asthma, rheumatism, wounds, alcoholism, and bronchitis.

Hippocampus reidi and *Hippocampus erectus* stand out among the salt water species, with RI (relative importance) values of 1.73 and 0.98, respectively. The importance of

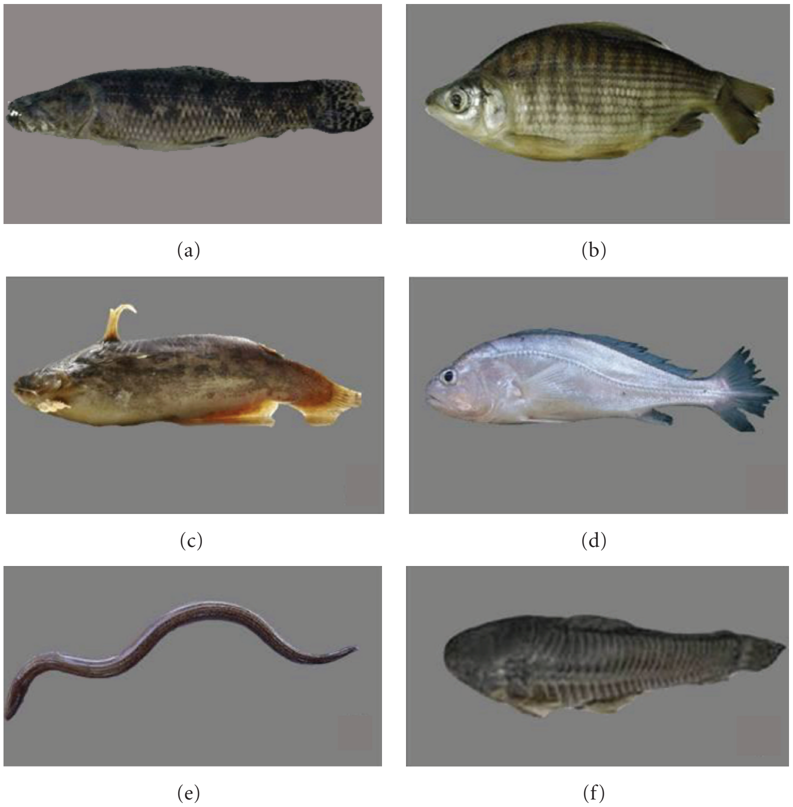

Figure 1: Species cited in the traditional medicine of Brazil ((a) *Hoplias malabaricus* (Bloch 1794) (Trahira/Traíra), (b) *Prochilodus argenteus* Spix and Agassiz, 1829 (curimatã), (c) *Trachelyopterus galeatus* (Linnaeus, 1766) (Driftwood catfishes/Cumbá), (d) *Plagioscion squamosissimus* (Heckel, 1840) (South American silver croaker/Corvina), (e) *Synbranchus marmoratus* Bloch, 1795 (marbled swamp eel/muçum), (f) *Callichthys callichthys* (Linnaeus, 1758) (cascudo/caboje)).

these species is also evident from the number of studies that reported them in their inventories, especially in Northeast Brazil.

Hoplias malabaricus scored highest on diversity among the predominantly fresh water species, with an RI of 2.00, the highest score among all the species in the inventory. This species also stood out regarding the number of parts of the fish that can be used in traditional remedies. *Electrophorus electricus* received the second-highest RI score (1.60). It was also evident that these species have regional importance, due to the fact that they are cited in various studies conducted in Northern and Northeast Brazil. There was no significant difference between the species regarding habitat, according to the Kruskal-Wallis test ($H = 1.213$; $P = 0.270$).

The therapeutic indications were grouped into 16 body systems (Figure 3). Of these, only two categories did not appear for the fresh water species: neoplasias and problems relating to pregnancy, birth, and puerperium. Two categories did not appear among salt water species: sensory system disorders and undefined pains/disorders.

The systems with the greatest diversity of species included disorders of the respiratory system (e.g., asthma, bronchitis, and pneumonia) and wounds, poisonings and other results from external causes (e.g., wounds caused by the fish itself, burns, and scarring). In spite of the fact that 57% of systems had greater diversity for fresh water than for salt water species, no significant differences in species wealth were observed ($P = 0.374$) between the two groups.

Often, a single species is the source of treatment for many diseases and infirmities [27]. Among the most versatile species are *Hoplias malabaricus, Electrophorus electricus, Hippocampus reidi, Hippocampus erectus, and Phractocephalus hemiliopterus*. The trahira (*Hoplias malabaricus*) was very versatile in treating 35% of therapeutic indications, ranging from bone and respiratory problems to alcoholism and snakebite. The electric eel (*Electrophorus electricus*) and the longsnout seahorse (*Hippocampus reidi*) treated 23% of indications each, and the redtail catfish (*Phractocephalus hemiliopterus*) and another species of seahorse (*Hippocampus erectus*) each treated 12%. It should be noted that seahorses and the trahira are heavily commercialized in Northeast Brazil [9, 51].

Although a particular species can be associated with various indications, these therapeutic uses may be associated with the use of different parts of the animal. The head of *Hoplias malabaricus* (trahira) is used for treatment of tetanus [38], while its scales are used to combat stroke [20], and the fat and skin secretion are indicated as a remedy for alcoholism [16, 27]. Another example of therapeutic versatility is found in *Electrophorus electricus* (electric eel),

Figure 2: Distribution of richness of ichthyofauna used in traditional medicine in Brazil.

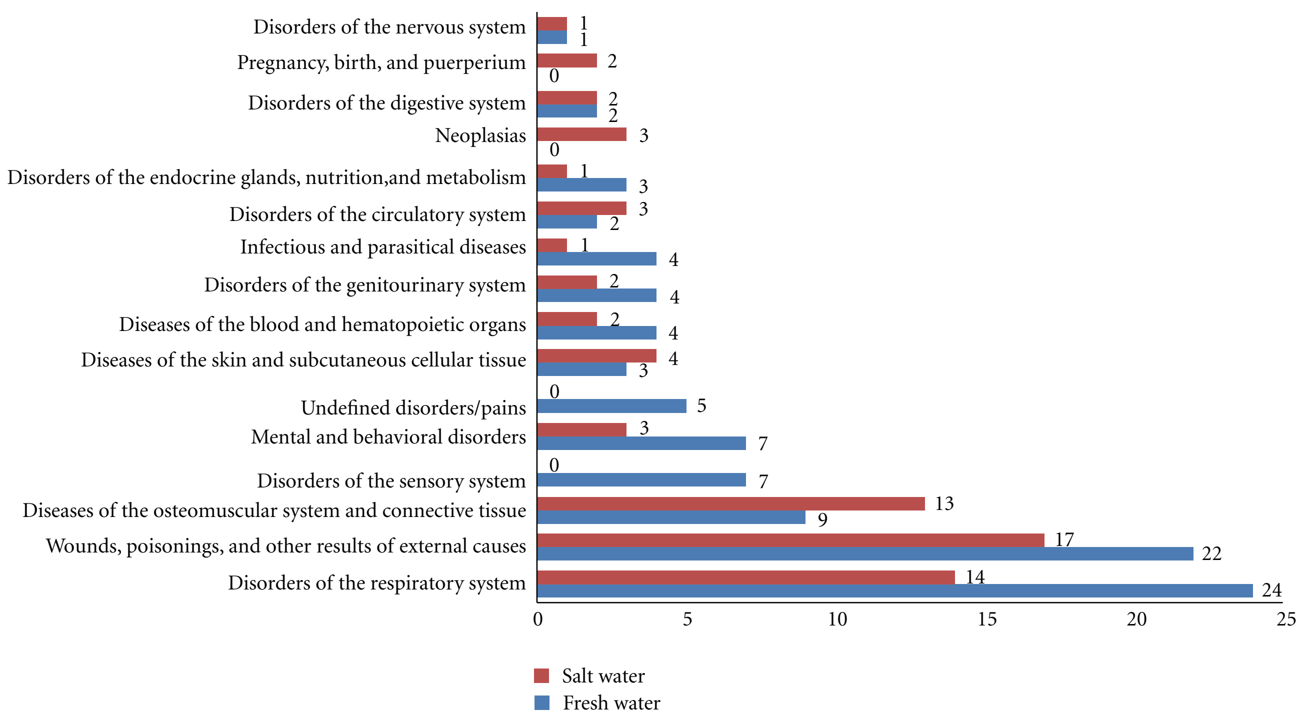

Figure 3: Body systems by fish species used in zootherapeutic practices in Brazil.

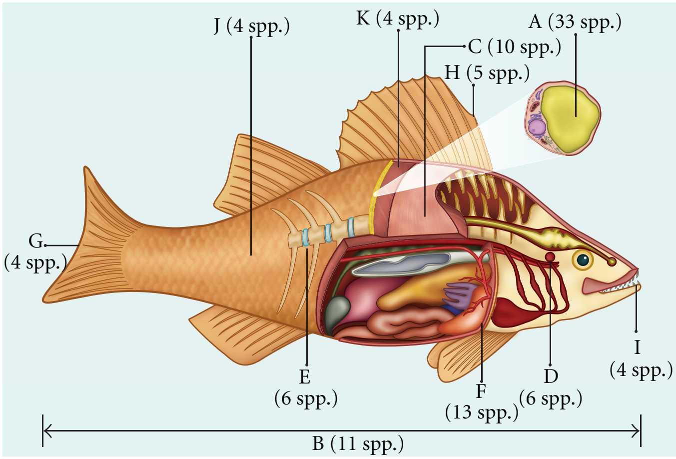

Figure 4: Richness of species according to the main body parts of fish used for therapeutic purposes in Brazil. (A: fat, B: entire, C: meat, D: otoliths, E: cartilage, F: liver, G: tail, H: spur, I: tooth, J: scale, K: skin).

Figure 5: Box in the Market of São José (Recife, Brazil) with seahorse to sell.

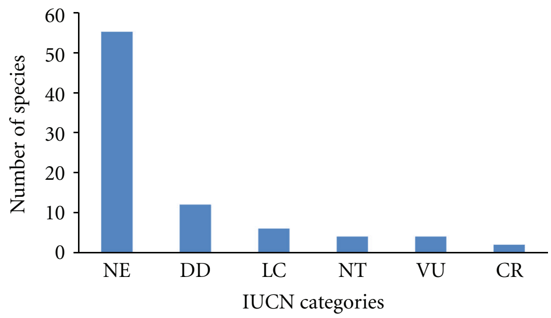

Figure 6: IUCN categories of fish species used for medicinal purposes in Brazil (EN: endangered, VU: vulnerable, LC: least concern, CR: critically endangered, NT: near threatened, NA: not available, DD: insufficient data).

whose bones are used to treat snakebite [31], while the fat is associated with other indications, such as pains [26, 28, 31], rheumatism [7–9, 17, 26, 27, 31, 37], colds [31], asthma [31, 37], and pneumonia [8, 37].

Among the fish parts most commonly employed for the production of zootherapeutic products, fat stood out with a 40% use occurrence. Fish fat is indicated for various infirmities and diseases. Its use recurs often in popular medicine [31]; fat has been documented as the most commonly used animal part in various studies [8, 35]. In India, the fat from various animals is indicated for combating all types of pain, impotence, burns, and paralysis [52]. The widespread use of fat can be related to the ease of its extraction. Additionally, it can be preserved at room temperature for long periods [29].

The use of various other parts of fish has also been recorded, including teeth, eyes, gall, liver, wattles, otoliths, fins, and stingers. Many fish parts used in zootherapy are not used for other purposes, such as scales and leathers, to maximize the use of local resources [35]. Another method for keeping therapeutic resources available are food taboos, through which the consumption of some of these species would lead to negative consequences, thereby keeping these animals available in case of necessity (Figure 4) [31].

In addition to dead animals and their parts, the use of living animals is a recurring practice in traditional medicine systems and is a part of the beliefs and "spells" in local systems [22]. A mystical use has been reported for the species *Synbranchus marmoratus* (marbled swamp eel) and *Callichthys callichthys* (armored catfish) [39] in the treatment of asthma; namely, one should spit in the mouth of a living animal, and then put it back in the river.

Another demonstration of aspects associated with popular medicine occurs when the morphology exhibited by the animal inspires its therapeutic application. Sometimes the morphology of the animal and/or the organs utilized is associated with the part of the human body to be treated

Table 1: Fish speciesused in traditional medicine in Brazil with local name, IUCN categories (EN: endangered, VU: vulnerable, LC: least concern, CR: critically endangered, NT: near threatened, NA: not available, DD: insufficient data), part used, therapeutic indication, number of bodily systems, state (occurrence), RI (relative importance), and reference.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
			Predominantly salt water				
Chondrichthyes							
Orectolobiformes							
Ginglymostomatidae							
Ginglymostoma cirratum (Bonnaterre, 1788) (Nurse shark/Cação-lixa)	DD	Cartilage	Rheumatism	1	MA, PB	0.138	[7, 9]
Carcharhiniformes							
Carcharhinidae							
Carcharhinus limbatus (Müller and Henle, 1839) (Blacktip shark/Sucuri-da-galha-preta)	NT	Cartilage, fat	Osteoporosis	1	MA	0.138	[7–9, 16]
Carcharhinus porosus (Ranzani, 1839) (Smalltail/Cação-do-salgado)	DD	Cartilage, fat	Asthma, rheumatism, wounds, inflammations, osteoporosis	3	MA, BA, PA	0.492	[7, 9]
Carcharhinus leucas (Muller and Henle, 1839) (Bull shark/Tubarão)	NT	—	—	—	PE	—	[3]
Galeocerdo cuvier (Péron and Lesueur, 1822) (Tiger shark/Jaguará)	NT	Cartilage, fat	Osteoporosis	1	MA, PI	0.138	[7, 9]
Rhizoprionodon lalandii (Müller and Henle, 1839) (Sharpnose shark/cação-frango)	DD	Cartilage, fat	Rheumatism	1	PB, BA	0.138	[7, 9, 16]
Rhizoprionodon porosus (Poey, 1861) (Caribbean sharpnose shark/Cação de praia)	LC	Cartilage, fat	Rheumatism	1	PB, BA	0.138	[7, 9, 16]
Sphyrnidae							
Sphyrna lewini (Griffith and Smith, 1834) (Scalloped hammerhead/Cação-martelo)	EN	Liver oil	Asthma, wounds, rheumatism	3	BA	0.415	[2]
Pristiformes							
Pristidae							
Pristis perotteti Muller and Henlle 1842 (Sawfish/Espadarte)	CR	Rostral expansion	Rheumatism, arthritis	1	PA	0.138	[9]
Pristis pectinata (Latham, 1794) Smalltooth sawfish/espadarte	CR	Rostral expansion	Asthma, rheumatism, arthritis	2	—	0.135	[18]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Rajiformes							
Narcinidae							
Narcine Braziliensis (Olfers, 1831) (Brazilian electric ray/Raia elétrica)	DD	Fat	Tooth pain	1	BA	0.138	[2, 4]
Rajidae							
Atlantoraja cyclophora (Regan, 1903) (Eyespot skate/Almofadinha/barata do mar)	VU	Eggs	Postpartum hemorrhage	1	RJ	0.138	[19]
Dasyatidae							
Dasyatis guttata (Bloch and Schneider, 1801) (Longnose stingray/Raia branca)	DD	Teeth, liver oil, tail, ventral mucus, liver	Asthma, wounds caused by the fish itself, burns on the skin	2	PB	0.315	[7, 9]
Dasyatis marianae Gomes, Rosa, and Gadig, 2000 (Brazilian large-eyed stingray/raia mariquita)	DD	Teeth, liver oil, tail, ventral mucus, liver	Asthma, wounds caused by the fish itself, burns on the skin	2	PB	0.315	[7, 9]
Myliobatidae							
Aetobatus narinari (Euphrasen, 1790) (Spotted eagle ray/raia-chita)	NT	Teeth, liver oil, tail, ventral mucus, liver	Asthma, wounds caused by the fish itself, burns on the skin, and hemorrhages	3	PA, PI, PB	0.453	[7, 9]
Urotrygonidae							
Urotrygon microphthalmum (Delsman, 1941) (small-eyed, round stingray/raia)	LC	Teeth, liver oil, tail, ventral mucus, liver	Asthma, wounds caused by the fish itself, burns on the skin	2	PB	0.315	[7, 9]
Actinopterygii							
Elopiformes							
Megalopidae							
Megalops atlanticus Valenciennes, 1847 (Tarpon/Camurupim/Cangurupim)	NE	Scale	Asthma, lack of air, headache, stroke	3	MA, PB, AL	0.454	[7–9, 20]
Anguilliformes							
Muraenidae							
Gymnothorax funebris Ranzani, 1840 (Green moray/moréia verde)	NE	Meat	Wounds	1	PB	0.138	[7, 9]
Gymnothorax moringa (Cuvier, 1829) (Spotted moray/moréia pintada)	NE	Meat	Wounds	1	PB	0.138	[7, 9]
Gymnothorax vicinus (Castelnau, 1855) (Purple mouth moray/moréia)	NE	Meat	Wounds	1	PB	0.138	[7, 9]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Clupeiformes							
Clupeidae							
Opisthonema oglinum (Lesueur, 1818) (Atlantic thread herring/sardinha)	NE	Entire	Alcoholism	1	PB	0.138	[7, 9]
Siluriformes							
Ariidae							
Bagre bagre (Linnaeus, 1758) (Coco sea catfish/bagre-fidalgo)	NE	Entire	Wounds caused by the fish itself	1	BA	0.138	[2, 21]
Genidens barbus (Lacepède, 1803) (White sea catfish/bagre-do-mar)	NE	Entire	Wounds caused by the fish itself	1	BA	0.138	[2, 21]
Genidens genidens (Valenciennes, 1840) (Guri sea catfish/Bagre)	LC	eye	Wounds caused by the fish itself	1	BA	0.138	[22]
Aspistor luniscutis (Valenciennes, 1840) (bagre-urutu)	NE	Entire	Wounds caused by the fish itself	1	BA	0.138	[2, 21]
Gadiformes							
Gadidae							
Gadus morhua Linnaeus, 1958 (Atlantic Cod, bacalhau)	VU	Fat, skin	Rheumatism, furuncle, back pain	2	PB, BA	0.315	[2, 23]
Batrachoidiformes							
Batrachoididae							
Thalassophryne nattereri (Steindachner, 1876) (niquim)	NE	meat, eye, and brain	Wounds caused by the fish itself	1	MA, PI, BA	0.138	[2, 7, 9]
Lophiiformes							
Ogcocephalidae							
Ogcocephalus vespertilio (Linnaeus, 1758) (Seadevil/Peixe morcego)	NE	Entire	Asthma, bronchitis, rheumatism, arthritis	2	MA, PB, RJ	0.354	[7–9, 19]
Beryciformes							
Holocentridae							
Holocentrus adscensionis (Osbeck, 1765) (Squirrelfish/Jaguariçá)	NE	Sting	Wounds	1	RJ	0.138	[19]
Gasterosteiformes							
Syngnathidae							
Hippocampus erectus Perry, 1810 (Lined seahorse/Cavalo-marinho)	VU	Entire	Alcoholism, thromboses, impotence, diabetes, osteoporosis, heart disease, bronchitis, cancer, asthma, and rheumatism	6	Brazil	0.985	[21]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Hippocampus reidi Ginsburg, 1933 (Longsnout seahorse/Cavalo-marinho)	DD	Entire	Edema, asthma, bronchitis, impotence, thromboses, hemorrhage, hemorrhage in women, postpartum disorders, gastritis, tuberculosis, epilepsy, alcoholism, increasing female fertility, osteoporosis, heart disease cancer, asthma, rheumatism, avoiding miscarriage	10	RJ, PE, RN, PB, CE, BA, MA, PI, Brazil	1.731	[1, 2, 4, 7–9, 19, 24–29]
Perciformes							
Centropomidae							
Centropomus undecimalis (Bloch, 1792) (Common snook/Robalo)	NE	Fat	Swollen legs, edema	1	BA	0.177	[2]
Sparidae							
Calamus penna (Valenciennes, 1830) (Sheepshead porgy/peixe-pena)	NE	Fin	Asthma	1	BA	0.138	[2]
Sciaenidae							
Cynoscion acoupa (Lacepède 1802) (Acoupa weakfish/Pescada amarela)	LC	Otoliths	Renal insufficiency	1	MA	0.138	[8]
Cynoscion leiarchus (Curvier 1830) (Smooth weakfish/Pescada branca)	NE	Otoliths, Head	Renal insufficiency, lack of air	1	MA, PB	0.177	[8, 30]
Micropogonias furnieri (Desmarest, 1823)	NE	Otoliths	Bronchitis	1	RJ	0.138	[29]
Trichiuridae							
Trichiurus lepturus (Linnaeus, 1758) (largehead hairtail/peixe espada)	NE	Tail	Asthma	1	—	0.138	[18]
Tetraodontiformes							
Balistidae							
Balistes vetula Linnaeus, 1758 (Queen-triggerfish/cangulo)	VU	Skin	Asthma, back pain	2	MA	0.277	[8]
Balistes capriscus Gmelin, 1789 (Grey-triggerfish/capucho)	NE	Skin	Bronchitis		RJ	0.138	[29]
Tetraodontidae							
Colomesus psittacus (Bloch and Schneider, 1801) (Banded puffer/Baiacú)	NE	Liver oil, bile	Breast cancer, back pain, warts	3	MA	0.415	[7, 9]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Sphoeroides testudineus (Linnaeus, 1758) (Checkered puffer/Baiacú)	NE	Fat	Rheumatism	1	BA	0.138	[1]
			Predominantly fresh water				
Chondrichthyes							
Rajiformes							
Potamotrygonidae							
Paratrygon ajereba (Walbaum, 1792) (Discus ray/raia)	DD	Spur, Fat	Asthma, cold, cough, ear pain, pneumonia, umbilical hernia, burns on the skin	3	TO	0.569	[31]
Plesiotrygon iwamae (Rosa, Castello and Thorson, 1987) (Long-tailed river stingray/Arraia)	DD	Fat	Wounds caused by the fish itself, cracks on the soles of feet, wounds	1	PA	0.138	[9]
Potamotrygon hystrix (Müller and Henle, 1841) (Porcupine river stingray/Raia)	DD	Spur, Fat	Asthma, cold, cough, ear pain, pneumonia, umbilical hernia, burns on the skin	3	TO	0.569	[31]
Potamotrygon motoro (Müller and Henle, 1841) (South American freshwater stingray/Raia)	DD	Spur, Fat	Asthma, cold, cough, ear pain, pneumonia, umbilical hernia, burns on the skin	3	TO	0.569	[31]
Potamotrygon orbignyi (Castelnau, 1855) (Smooth back river stingray/Arraia)	LC	Fat	Wounds caused by the fish itself	1	PA	0.138	[9]
Actinopterygii							
Osteoglossiformes							
Arapaimidae							
Arapaima gigas (Cuvier, 1829) (Arapaima/arapaima, pirarucu)	DD	scale	Asthma	1	PA	0.138	[8]
Osteoglossidae							
Osteoglossum ferreirai Kanazawa, 1966 (Black arawana/Aruanã) (Arapaima/arapaima, pirarucu)	LC	scale	Dermatological problems	1	AM	0.138	[32]
(Cruvina, Crumatá)		Fat, meat					
Prochilodus nigricans Agassiz 1829 (Black prochilodus/Curimatã, Papa-terra)	NE	Fat, gall, meat	Inflammations, cholesterol, burns on the skin, wounds, rheumatism, chilblains, malaria, whooping cough	5	CE, TO, Brazil	0.808	[27, 33, 34]
Anostomidae							
Leporinus piau Fowler, 1941 (Piau)	NE	Fat	Rheumatism	1	BA	0.138	[35]
Leporinus steindachneri Eigenmann 1907 (Piau)	NE	Fat	Cholesterol	1	CE	0.138	[27]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Schizodon knerii (Steindachner, 1875) (Piau branco)	NE	Fat	Edema, leukoma	2	AL	0.277	[20]
Characidae							
Brycon nattereri Günther, 1864 (Matrinchã)	NE	Meat	Flu	1	BA	0.138	[36]
Piaractus brachypomus (Cuvier, 1818) (Pirapatinga/Caranha)	NE	Fat	Scarring	1	TO	0.138	[37]
Serrasalmus brandtii Lütken, 1875 (White piranha/Piranha)	NE	Tail, gall, fat	Impotency, jaundice, edema, inflammations	3	BA, AL	0.454	[20, 22, 35]
Mylossoma duriventre (Cuvier, 1818) (Pacu manteiga)	NE	Fat	STDs	1	TO	0.138	[31]
Incertae sedis in Characidae							
Astyanax cf. bimaculatus (Linnaeus, 1758) (Two-spot astyanax/Piaba)	NE	Entire	Alcoholism	1	BA	0.138	[2]
Chalceus macrolepidotus Cuvier, 1818 (Pink tailed chalceus/Araripirá)	NE	Entire, eye	Asthma	1	AM	0.138	[11]
Paracheirodon axelrodi (Schultz, 1956) (Cardinal tetra/Cardinal)	NE	Entire	Asthma	1	AM	0.138	[11]
Salminus hilarii Valenciennes, 1850 (Dourado)	NE	Head	Memory	1	TO	0.138	[37]
Cynodontidae							
Hydrolycus scomberoides (Cuvier, 1819) (Payara/Cachorra)	NE	Fat	Ear pain	1	TO	0.138	[31]
Erythrinidae							
Erythrinus erythrinus (Bloch and Schneider, 1801) (Matroê)	NE	Entire	Asthma	1	AL	0.138	[20]
Hoplias lacerdae Miranda Ribeiro, 1908 (Trahira/Traírão)	NE	Fat	Rheumatism, "vilide"	2	BA	0.277	[35]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Hoplias malabaricus (Bloch 1794) (Trahira/Traíra)	NE	Fat, epidermal secretion, "bucho", entire, head, scale, meat	Alcoholism, ear pain, inflammations, cholesterol, sore throat, umbilical cord inflammation, contusions, inflamed ear, hearing problems, ocular inflammation, urinary infection, deafness, asthma, muscle strain, erysipelas, wounds, hemorrhages, snakebite, conjunctivitis, edema, rheumatism, leukoma, stroke, asthma, diarrhea, vision problems	10	AC, BA, RN, PA, PB, MA, PE, AL, TO	2.000	[1, 2, 8, 9, 11, 16, 20, 22, 24, 27, 28, 30, 31, 33, 36, 38]
Siluriformes							
Cetopsidae							
Cetopsis candiru Spix and Agassiz, 1829 (Candiru)	NE	Meat	Whooping cough	1	TO	0.138	[37]
Aspredinidae							
Aspredinichthys tibicen (Valenciennes, 1840) (Tenbarbed banjo/viola)	NE	Barbels	Asthma	1	MA	0.138	[7, 9]
Aspredo aspredo (Linnaeus, 1758) (Banjo/viola)	NE	Barbels	Asthma	1	MA	0.138	[7, 9]
Callichthyidae							
Callichthys callichthys (Linnaeus, 1758) (Cascudo/Caboje)	NE	Entire	Asthma, umbilical hernia, bronchitis, helping a child to walk earlier	3	BA, AL	0.454	[2, 20, 39]
Pimelodidae							
Brachyplatystoma filamentosum (Lichtenstein, 1819) (Kumakuma/Filhote)	NE	Fin	Cough, alcoholism	2	TO	0.277	[37]
Phractocephalus hemioliopterus (Bloch and Schneider, 1801) (Redtail catfish/Pirarara)	NE	Fat	Burns on the skin, rheumatism, cough, wounds, bronchitis, whooping cough, hoarseness, pneumonia, asthma, cold, umbilical hernia	3	AM, TO, Brazil	0.723	[11, 31, 34, 37]
Pseudoplatystoma corruscans (Spix and Agassiz, 1829) (Spotted sorubim/Surubim)	NE	Fat	Burns on the skin	1	BA	0.138	[36]
Pseudoplatystoma fasciatum (Linnaeus, 1766) (Barred sorubim/pintado)	NE	Fat, gall	Scarring, whooping cough, body pain, muscular pains, bone pain, bronchitis, stroke	5	TO	0.769	[37]
Sorubimichthys planiceps (Spix and Agassiz, 1829) (Firewood catfish/Surubim-chicote)	NE	Meat	Tuberculosis, leishmaniasis	2	TO	0.277	[31]
Zungaro zungaro (Humboldt, 1821) (Gilded catfish/Jaú)	NE	Fat, skin, meat	Bronchitis, asthma, burns on the skin, rheumatism, cold, ear pain, tooth pain, chilblains	6	TO	0.908	[31, 37]

Table 1: Continued.

Taxa/local name	IUCN	Part used	Therapeutic indication	Number of bodily systems	State	RI	Reference
Doradidae							
Lithodoras dorsalis (Valenciennes, 1840) (Rock-bacu/bacu)	NE	Fat	Swelling	1	PA	0.138	[9]
Oxydoras niger (Valenciennes, 1821) (Ripsaw catfish/Abotoado)	NE	Fat	Asthma, bronchitis, grippe, scarring, dry skin	3	TO	0.492	[37]
Auchenipteridae							
Trachelyopterus galeatus (Linnaeus, 1766) (Driftwood catfishes/Cumbá)	NE	Entire, spur	Impotence, umbilical hernia, asthma	3	BA, AL	0.415	[20, 35, 40, 41]
Megalodoras uranoscopus (Eigenmann and Eigenmann, 1888) (cuiú-cuiú)	NE	Fat	Rheumatism	1	TO	0.138	[31]
Pterodoras granulosus (Valenciennes, 1821) (Granulated catfish/cuiú-cuiú)	NE	Fat	Rheumatism	1	TO	0.138	[31]
Gymnotiformes							
Gymnotidae							
Electrophorus electricus (Linnaeus 1756) (Electric eel/Peixe Elétrico, Poraquê)	LC	Entire, fat, spin, and bone	Acne, alcoholism, asthma, itching, contusions, headache, back pain, muscular pains, wounds, swelling, spots on the skin, osteoporosis, snake bite, insect bite, pneumonia, cold, rheumatism, deafness, muscle strain, thrombosis, tuberculosis	8	RN, PE, DF, AC, PA, MA, PI, PB, TO, BA	1.608	[1, 7–9, 12, 17, 27, 28, 31, 37]
Synbranchiformes							
Synbranchidae							
Synbranchus marmoratus Bloch, 1795 (Marbled swamp eel/muçum)	NE	Entire	Making the child walk sooner, bronchitis, asthma, bronchitis, umbilical hernia	3	BA	0.454	[2, 39]
Perciformes							
Sciaenidae							
Pachyurus francisci (Cuvier, 1830) (San Francisco croaker/Cruvina, curvina-de-bico)	NE	Otoliths	Asthma, back pain, diuretic effect, renal insufficiency	3	BA	0.454	[36]
Plagioscion squamosissimus (Heckel, 1840) (South American silver croaker/Corvina)	NE	Otoliths	Kidney stones, renal insufficiency, urinary infection, hemorrhages, snake bite	3	TO	0.492	[31, 37]
Plagioscion surinamensis (Bleeker, 1873) (Pacora/Corvina)	NE	Otoliths	Urinary infection, hemorrhages, snakebite	3	TO	0.41538	[31]

because the similarities are interpreted as indicative of a potential benefit [35]. Moura and Marques [35] recorded the use of the common wood catfish (*Trachelyopterus galeatus*) in the treatment of impotence, due to the species' large, fringed testicles.

Zootherapy has been the focus of increasing attention from the pharmaceutical industry [7]. These industries have used the biologically active components present in traditional medicines as sources for the production of many drugs [53]. Compounds extracted from fish are already used in official medicine, such as Tetrodotoxin, which originates from pufferfish and possesses a powerful anesthetic effect [54–56]. Other widely distributed compounds from fish, omega-3 fatty acids, are associated with the prevention and treatment of cardiovascular diseases, arthritis, kidney disease, and inflammation [57].

The exploitation of medicinal fauna resources by local populations and the pharmaceutical industry has had a negative impact on several species, with their survival threatened by overexploitation [10, 58]. Among the fish used therapeutically in Brazil, three species can be singled out as having an elevated danger of extinction and are included in the "vulnerable" category by the IUCN [59]: *Atlantoraja cyclophora*, *Balistes vetula,* and *Hippocampus erectus*. *Sphyrna lewini* is in the "in danger" category, with a very high risk of extinction, and *Pristis perotetti* and *Pristis pectinata* are "in critical danger." Among these species are four cartilaginous fishes that have low levels of fecundity, such as the ray, the hammerhead shark, and the swordfish. Seahorses (*Hippocampus* spp.) are considered susceptible to exploitation and are threatened worldwide due to excessive use and destruction of habitat due to their high monetary value and potential for commercialization [51] (Figure 5). The species *H. reidi*, currently listed in the "insufficient data" category, is widely commercialized for medicinal purposes throughout Brazil and exhibits low reproduction and high mortality rates in initial phases [60].

However, the great majority of fish identified in this survey have not yet been evaluated by the IUCN, or there is insufficient data for analysis (Figure 6). This fact highlights the scarcity of knowledge regarding the true situation of these fish, demonstrating the need for studies directed toward those species that are used medicinally to preserve these resources and all aspects linked to them. Also, there is no significant differences in the relative importance (RI) between IUCN categories according to the Kruskall-Wallis test ($P > 0.05$).

In addition, the extinction of some species could compromise both traditional knowledge and the discovery of new drugs [61] because these species could disappear before science becomes aware of their potential. The growing demand for the biotic resources used in traditional medicine is due to the increasing quantity of studies that demonstrate the efficacy of their use, drawing the attention of the pharmaceutical industry [62].

Extractivism is generally the only method for obtaining zootherapeutic resources, highlighting the need to add these species to conservation efforts by including creatures involved in zootherapeutic practices in planning for the management of fauna. Both the local population and the pharmaceutical industries can contribute in different ways to the maintenance of these resources. In addition, it is also necessary to understand the ecology and biology of the species used in medicine to propose effective strategies for managing these resources.

Final Considerations

We highlight the importance of fish in zootherapeutic practices in Brazil, emphasizing the knowledge gap that must be explored in ethnobiological and pharmacological research in the country. The Northeast region represents the major center for research on this subject, both in terms of the large number of publications and the number of local researchers.

We recommend greater investment in exploration projects for fish, especially in inland water resources, associating ecological parameters that drive population dynamics to better understand the relationships of humans with these resources. This will enable more efficient management proposals for the conservation of these species and their associated ecosystems and will allow for the perpetuation of traditional medical practices.

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Research Article

Plant Stem Bark Extractivism in the Northeast Semiarid Region of Brazil: A New Aport to Utilitarian Redundancy Model

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We use the model of utilitarian redundancy as a basis for research. This model provides predictions that have not been tested by other research. In this sense, we sought to investigate the stem bark extraction between preferred and less-preferred species by a rural community in Caatinga environment. In addition, we sought to explain local preferences to observe if preferred plants have a higher content of tannins than less-preferred species. For this, we selected seven preferred species and seven less-preferred species from information obtained from semistructured interviews applied to 49 informants. Three areas of vegetation around the community were also selected, in which individuals were tagged, and were measured the diameter at ground level (DGL) diameter at breast height (DBH), and measurements of available and extracted bark areas. Samples of bark of the species were also collected for the evaluation of tannin content, obtained by the method of radial diffusion. From the results, the preferred species showed a greater area of bark removed. However, the tannin content showed no significant differences between preferred and less-preferred plants. These results show there is a relationship between preference and use, but this preference is not related to the total tannins content.

1. Introduction

Several ethnobotanical studies have observed a great familiarity in the use of plants by local populations [1–3], indicating that this knowledge can provide information for the management and conservation of plant species. In the Brazilian semiarid region, a broad knowledge and use of medicinal plants by local people in the Caatinga ecosystem has been documented [4–6], including studies investigating the use of medicinal plants and its implications for conservation [7, 8].

One application of ethnobotany to the conservation and management of useful species of the Caatinga is the utilitarian redundancy model proposed by de Albuquerque and Oliveira [9]. Aiming to investigate the use pressure from local populations on plant species, the model presents two situations. The first indicates that in a redundant utilitarian category, that is, with a large number of species that serve the same function or use category, there is a decrease in the use pressure on a given species, as this pressure is spread out among a greater number of species. A second situation occurs in a redundant category: in the presence of preferred species, use pressure is shifted to these species. However, this model was proposed for a theoretical situation and lacks specific tests of its predictions.

The present study seeks to test this model's predictions by investigating whether there is indeed a shift of use pressure toward preferred species. We investigated the preferences of local communities for specific native plants for the treatment of inflammations because evidence shows that plants native to the Caatinga are preferred for medicinal use and that inflammation is one of the most important ailments for many local communities [6]. For example, several ethnobotanical studies have indicated native Caatinga species as priorities for future conservation programs considering the high use pressure that may be associated [7, 9, 10]. In addition, several studies have reported that many species of the Caatinga are used as anti-inflammatory, given the importance of this use category for various local communities [4, 6]. In this case, it is interesting to study the relationship between preference and use pressure on species used as anti-inflammatory, which provides theoretical implications for a better understanding of the utilitarian redundancy model, and also conservation implications for future management programs. Accordingly, we tested the hypothesis that preferred plants as anti-inflammatory by a local population of Caatinga suffer a greater use pressure than less-preferred plants.

Additionally, this study seeks to understand these preferences by analyzing the chemical compounds present in the bark of the species. There are several compounds tested in the literature which have an anti-inflammatory activity [11]. However, other researchers have observed that Caatinga species mentioned as anti-inflammatory by local populations have tannins in the bark [6, 12], indicating that this is an important class of compounds in the medicinal use of Caatinga species [7, 13–15]. Based on these observations, this research also seeks to test the hypothesis that tannin content represents a selection factor in the choice of species preferred by local people, while preferred plants will present a higher tannin content than less-preferred plants.

2. Materials and Methods

2.1. Study Area. This research was conducted in the municipality of Altinho in a semiarid region of Pernambuco (northeastern Brazil), located 163.8 km from the state capital. The population of the municipality of Altinho is approximately 22,363 people, with a territory of 454 km^2 [16]; the urban population is made up of approximately 13,000 people and the rural population approximately 9,500 people [16]. The municipality is situated in a Caatinga environment, with vegetation characteristic of semiarid northeastern Brazil, including deciduous and semideciduous species [15].

The studied community, known as *Carão*, is located 16 km from the center of the municipality of Altinho and consists of 189 people living on 61 houses [17]. The center of the community resembles a village, with houses very close to each other, although most of the houses outside the center are very dispersed. The streets are unpaved, which hinders the access to the community, and the houses are made of brick [17]. Recently, a system was built to carry water from local rivers to homes, but many residents still use cisterns to capture rainwater or carry water from local rivers to their homes using barrels [17].

There are vegetated areas surrounding the community that provide timber and nontimber resources to residents. The community is located next to a mountain, known as "Serra do Letreiro", which includes some areas of vegetation that, according to residents, have suffered no human impact because of their inaccessibility or inadequacy for cultivation, although much of the mountain's vegetation has been disturbed. The areas at the top of the "Serra do Letreiro" are known as "Chã da Serra" and are used as corn- and bean-growing areas, the main income-generating activities of the community, as well as pasture areas [18]. Other important resource areas are the mountain base, known as "base of slope", and "pastures" and "plantations" areas located close to the residences [18].

2.2. Ethnobotanical Data. This research started from a database built by previous ethnobotanical studies conducted in the study area [12, 14, 15, 17, 19–21]. From this database, we selected the informants who participated in this study, provided that they cited at least one plant useful for the treatment of inflammation, resulting in the selection of 49 informants more than 18 years old and the use of 24 native plants indicated for the treatment of inflammation by at least one informant. Species collected by authors from previous studies were deposited at the Herbarium Professor Vasconcelos Sobrinho (PEUFR) of the Universidade Federal Rural de Pernambuco (UFRPE).

The first stage of this research was based on data from a previous survey conducted in the area [22], which was based in semistructured interviews conducted with the selected informants. In the interviews, the checklist-interview technique was used through the presentation of visual stimuli to the informants, using photographs of studied plants [23]. Informants were asked to rank the photographs (plants) according to their preference [24] for each type of inflammatory condition mentioned during the interview. Plants presented in the top positions in various rankings were considered to be preferred, while those listed as lesspreferred took the bottom positions in various rankings. For this, a salience analysis was used to observe the plants positions in the rankings and define the preferred and less-preferred plants. Preference is here defined as the conscious choice of informants of a particular plant species over others that are equally available [25].

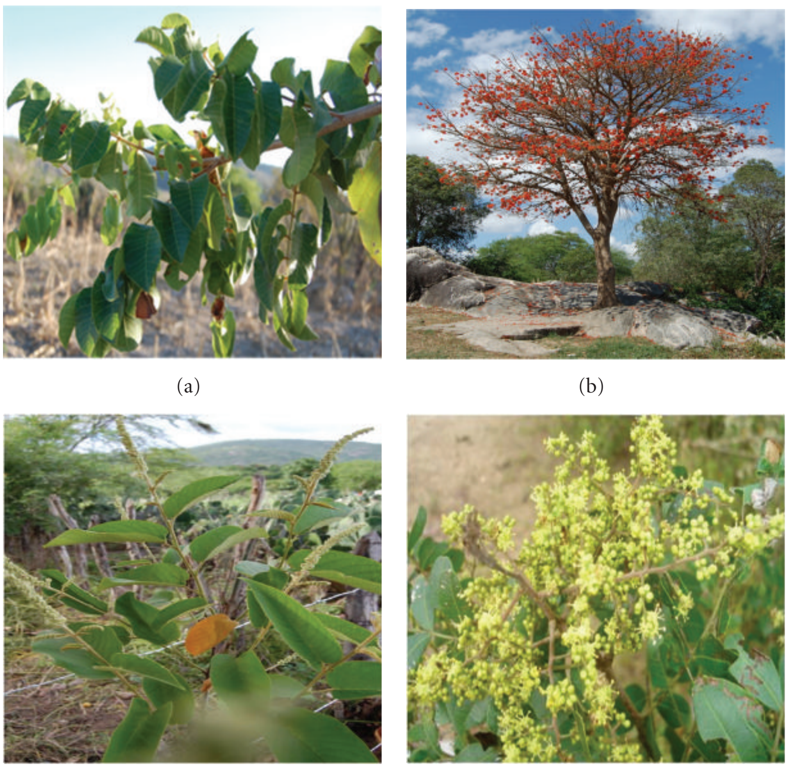
For the next steps, related to the extraction of stem bark and to measuring tannin content, we selected for study only those plants, both preferred and less-preferred, for which the bark was the primary source of reported anti-inflammatory properties. This selection was necessary because the hypothesis being tested depended on the use of stem bark as anti-inflammatory. In this case, measures of extraction of stem bark were made in species in which this plant part would be extracted mainly to treat inflammation, since the stem bark of several species in the community is used for various purposes. To select these plants, the database was checked for the number of cited uses for the bark of preferred and less-preferred species. Accordingly, 14 plants were selected (Table 1) that showed more than 50% of the number of uses cited indicating the use of its stem bark in inflammatory diseases. Figure 1 shows some of the studied species.

2.3. Evidence of Stem Bark Extraction from Preferred and Less-Preferred Plants. For this component of the study, vegetation areas close to the community were selected to test the first hypothesis. There were tours with two local experts, nominated by the community as knowledgeable about the vegetation areas' use history. Three areas were selected, from

Table 1: Plants suitable for the treatment of inflammation based on the preferences of the informants in the rural community of Carão, Altinho, northeastern Brazil. In parenthesis, the synonym by which the species is more widely known.

Family	Species	Popular name	Voucher
Preferred			
Anacardiaceae	*Myracrodruon urundeuva* Allemão	Aroeira	50872
Caesalpiniaceae	*Libidibia ferrea* (Mart. ex Tul.) L. P. Queiroz (*Caesalpinia ferrea* Mart.)	Jucá	48664
Celastraceae	*Maytenus rigida* Mart.	Bom-nome	46182
Fabaceae	*Amburana cearensis* (Allemão) A. C. Sm.	Imburana-açu	50486
	Erythrina velutina Willd.	Mulungu	46180
Mimosaceae	*Anadenanthera colubrina* (Vell.) Brenan	Angico	48663
	Mimosa tenuiflora (Willd) Poir.	Jurema-preta	50871
Less preferred			
Anacardiaceae	*Schinopsis brasiliensis* Engl.	Baraúna	49640
	Spondias tuberosa Arruda	Umbu	48652
Bignoniaceae	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos (*Tabebuia impetiginosa* (Mart. ex DC.) Standl.)	Pau-d'arco-roxo	50481
Burseraceae	*Commiphora leptophloeos* (Mart.) J. B. Gillett	Imburana-brava	48657
Cactaceae	*Cereus jamacaru* DC.	Mandacaru	*nc*
Caesalpiniaceae	*Hymenaea courbaril* L.	Jatobá	*nc*
Euphorbiaceae	*Croton blanchetianus* Baill.	Marmeleiro	48653

nc: not collected.



(a) (b) (c) (d)

Figure 1: Photos of some plants selected for this study, in the rural community of Carão, Altinho, northeastern Brazil. (a) *Myracrodruon urundeuva* Allemão "aroeira"; (b) *Erythrina velutina* Willd. "mulungu"; (c) *Croton blanchetianus* Baill. "marmeleiro"; (d) *Schinopsis brasiliensis* Engl. "baraúna". Photos: F. J. Vieira.

which, according to local experts, several people from the community use to remove the bark of local plants to treat diseases.

The first selected area (Area I)—S 8° 34′ 80′′, W 36° 05′ 28′′—has approximately 13,819 m^2 and is located in the "Pé da Serra", very close to the community, approximately 950 m from the center. The second selected area (Area II) —S 8° 34′ 50′′, W 36° 05′ 35′′—has approximately 2,195 m^2 and is located in the "Serra" region, approximately 1.4 km from the center of the community and about 550 m from Area I. The second area is located along the route that many locals take to their properties in the "Serra". The third selected area (Area III) is only 103 m from the center of Area II and is also located in the region of "Serra". Area III has an area of approximately 2,092 m^2, at S 8° 34′ 52′′, W 36° 05′ 29′′ (see Figure 2).

In the selected areas, it was not possible to find and include all 14 species selected for the study because some species did not occur or had few individuals. Therefore, the preferred species included in this stage were *Myracrodruon urundeuva, Anadenanthera colubrine*, and *Amburana cearensis*; those less-preferred were *Croton blanchetianus* and *Commiphora leptophloeos*. All individuals of these species were tagged with numbered plates and georeferenced with the inclusion criterion of being greater than 3 cm in diameter at ground level (DGL) [26]. For these species, measurements of the areas of available and removed bark were done using an adaptation of the method of Ando et al. [27]. The available bark area was calculated with the following equation: $A\ (cm^2) = 3.14 \times DBH \times h$, as the surface area of a cylinder. Accordingly, for all tagged individuals the diameter at breast height was measured (DBH at 130 cm above ground), with a height (h) value of up to 2 meters, believed to be the maximum height for extraction of stem bark for medicinal use (Figure 3).

Each instance of bark extraction (scarring) present on the stem of the individuals was considered as an extraction event, and these events were recognized in the field with the help of local experts. Once the scars were recognized, measurements of the area of extracted bark were taken by calculating the area of an ellipse (3.14 × major axis × minor axis) (Figure 3). The analysis considered all of the evidence of stem bark taken, regenerated or not, because it was not possible to discern whether the removal was recent, as each species responds differently to stem bark extraction. For example, Monteiro et al. [28] have demonstrated that the rate of regeneration can vary (months to years) in the same species, indicating the difficulty of specifying the behavior of a regenerative species without prior study.

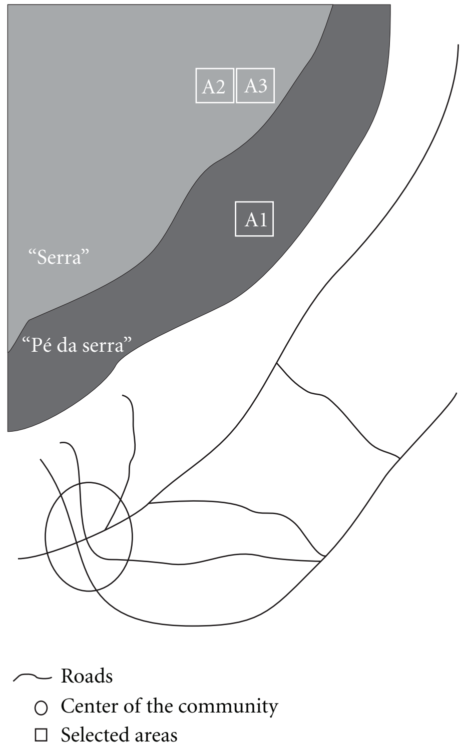


Figure 2: Representation of the study areas in the community of Carão, Altinho, northeastern Brazil. Area 1 (A1) is located in "Pé da Serra" and about 950 m away from the center of the community. Areas 2 and 3 (A2 and A3) are located in the region of "Serra", about 1.4 km from the center.

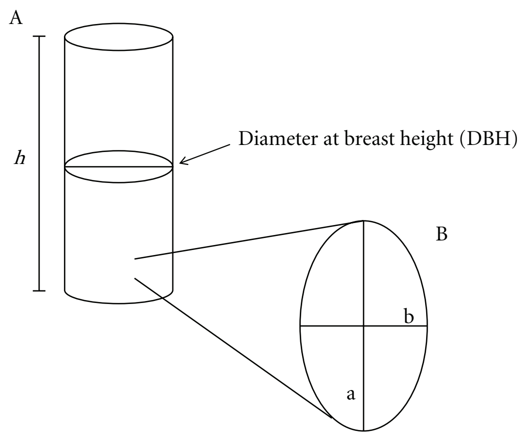


Figure 3: Measurements of the area of available and removed bark. (A) The cylinder represents the trunk of the plant, measured in height (h) and DBH. (B) The ellipse represents a scar of bark removed from the trunk, where the major axis (a) and minor axis (b) were measured.

2.4. Determination of Tannin Content. Of the 14 species selected for the study, the preferred species *Amburana cearensis, Anadenanthera colubrina*, *Erythrina velutina*, *Maytenus rigida*, *Mimosa tenuiflora*, *Myracrodruon urundeuva*, and *Libidibia ferrea* and the less-preferred *Schinopsis brasiliensis*, *Hymenaea courbaril*, *Handroanthus impetiginosus*, *Cereus jamacaru*, *Croton blanchetianus,* and *Spondias tuberosa* were selected for the estimation of tannins to test the second hypothesis of this research.

Of these selected species, 30 g of stem bark from three individuals of each preferred and less-preferred species were sent to the Laboratory of Natural Products of the Federal University of Pernambuco to determine the tannin content. The tannin content in the bark of each species was obtained by the radial diffusion method of Hagerman [29] adapted by Cabral et al. [30], and the experiments performed in authentic triplicates. Once in the laboratory, the bark was crushed and then macerated with methanol 50% (v/v) as a solvent. Once prepared, the mixture was administered in a solid medium in a 9-cm Petri dish, containing agarose and bovine serum albumin (BSA) in a buffer solution adjusted to pH 5.0 and consisting of 50 mM acetic acid and 60 uM ascorbic acid.

On each plate, three wells of approximately 8 μL were made at a distance of 2 cm from one another and from the edges of the plates, using a punch 4 mm in diameter, where three 8 μL aliquots of each plant sample were inserted. To obtain the standard curve, we used a solution of tannic acid, 25 mg/mL, of which aliquots of 2, 4, 8, 12, 16, and 20 μL were inserted into wells in triplicate [30]. Subsequently, the plates were sealed with Parafilm and incubated at a temperature of 30°C in an oven for 72 hours. The halos formed in the solid medium, from the interaction of tannins with protein samples of the medium, served as indicators of tannin content. For the readings of the rings, the plates were scanned, and the program Corel Draw ×3 Version 13 was used to design two perpendicular diameters in order to obtain an average diameter for each ring [30]. The tannin concentration was then obtained from the square of the mean diameter of each ring, in μg/μL, from the standard curve, and, finally, the tannin content was calculated as a percentage.

2.5. Data Analysis. To verify the hypothesis that the area of bark collected from preferred plants is larger than that of less-preferred plants, *t*-test and the Kruskal-Wallis test were used for comparison of means, depending on data normality. The *t*-test was used to evaluate differences between the two means, a mean of the area of bark collected from the set of preferred species and another mean regarding the less-preferred species. By using the Kruskal-Wallis test, it was possible to compare the mean areas of bark collected from the species individually. In addition, we used the chi-square test to investigate differences between preferred and less-preferred plants in the proportion of individuals with evidence of extraction and without bark extraction.

The marked individuals of each species were divided into diameter classes in 3 cm intervals to record the area of bark collected and the number of individuals with evidence of extraction for each diameter class. For this purpose, subjects were grouped into classes from 1 (0–3 cm) to 27 (from 78.1 cm to 81 cm). These tests were performed in two stages: considering the individuals of each species separately and considering all marked individuals of all species.

To test the second hypothesis, according to which there is a higher content of tannin present in preferred plants compared to less-preferred plants, the plants were classified according to the amount of tannins in their bark, based on Araújo et al. [12]. According to these authors, plants with a tannin concentration greater than 10% are regarded as having high tannin content, and those with less than 10% a low tannin content. Since the radial diffusion method used in this study decreases to about half the tannin content obtained by standard methods [30], the categories used were adapted to high concentration (>5%) and low concentration (<5%). The *G* test was used to test differences between preferred and less-preferred species with regard to the proportion of plants with high and low tannin content. The species that had a tannin content not detected were considered to have low content (<5%) because null values do not mean the absence of these compounds in the bark, as the radial diffusion method has low sensitivity [30]. All tests were performed using BioEstat 5.0 [31].

3. Results

3.1. Evidence of Bark Extraction of Preferred and Less-Preferred Plants. In the three areas selected for this study, 26 individuals of the species *Myracrodruon urundeuva* were marked, of which nine individuals had evidence of bark extraction, totaling 31 extraction events; 16 individuals of *Amburana cearensis* were marked, with five individuals showing evidence of bark extraction and a total of 16 events of bark extraction. For the species *Commiphora leptophloeos*, 175 individuals were marked, with only two individuals with evidence of bark extraction for a total of two extraction events; for *Croton blanchetianus*, 99 individuals were marked, but there was no evidence of bark extraction for this species. Finally, for the species *Anadenanthera colubrina*, 121 individuals were marked, and 13 individuals presented evidence of bark extraction for a total of 25 extraction events.

Only individuals that showed evidence of extraction were included in the analysis. In this case, the species that had the largest collected bark surface were *Myracrodruon urundeuva* (aroeira) and *Amburana cearensis* (imburana-açu) with means ($\bar{x}$) and standard deviations (σ) of 2025.8 cm^2 ± 2181.6 cm^2 and 2036.4 cm^2 ± 1931.9 cm^{2}of bark collected, respectively. These were followed by *Anadenanthera colubrina* (angico) with 1497.4 cm^2 ± 1372.8 cm^2 of bark collected. However, *Commiphora leptophloeos* (imburana-brava) had a mean and standard deviation of 579.3 cm^2 ± 219.8 cm^2, with low values of collected bark area. No significant differences were found between the mean areas of bark collected between species ($H = 2.58$, $P > 0.05$).

From the marked individuals of preferred species, the total area of bark collected was 116,898.7 cm^2, with a mean ($\bar{x}$) and standard deviation (σ) of 1771.2 cm^2 ± 1636.9 cm^2. However, for less-preferred species, only two individuals of *Commiphora leptophloeos* showed evidence of extraction, with a total area of bark collected of 1,158.6 cm^2 and mean and standard deviation of 579.3 cm^2 ± 219.8 cm^2. In comparisons between these averages, there was very significant difference ($t = 4.68$, $P < 0.01$), indicating that preferred plants have a greater area of bark collected than less-preferred plants. This result supports the hypothesis of this research, showing that preferred plants listed by the informants of the Carão community suffer more use pressure.

We found a total area of bark available of 228.9 m^2, and the species *Amburana cearensis*, *Commiphora leptophloeos* and *Myracrodruon urundeuva* showed a larger area of bark available, with means ($\bar{x}$) and standard deviation (σ) of 8487.5 cm^2 ± 2651.4 cm^2, 6659.5 cm^2 ± 2467.8 cm^2, and 6118.4 cm^2 ± 2731.1 cm^2, respectively. These species were followed by *Anadenanthera colubrina* and *Croton blanchetianus*, with means and standard deviation of 4985.9 cm^2 ± 2878.6 cm^2 and 2343.9 cm^2 ± 1258.7 cm^2, respectively. Combining the information obtained from the areas of bark removed and available, we found that species with larger area of bark available does not always have a larger area of bark collected, indicating that the collection does not appear to be related to resource availability.

By analyzing the extraction of the bark of the species by diameter classes, we observed that the highest values for area of bark extracted are concentrated in diameter classes 4 (9.1 cm to 12 cm), 5 (12.1 cm to 15 cm), 6 (15.1 cm to 18 cm), 7 (18.1 cm to 21 cm), and 8 (21.1 cm to 24 cm) (Figure 4). These diameters can be considered small, given that the largest individual observed was 78 cm in diameter (in the case of *Anadenanthera colubrina* individuals). However, apart from this individual, the largest individuals reached a diameter of 50 cm. In this case, the major bark extraction areas occurred in diameter classes from small to intermediate.

Investigating each species separately, we observed that they followed the same general pattern; that is, they presented a greater area of bark extracted in individuals of small to intermediate diameters. For example, for *Anadenanthera colubrina*, individuals of classes 1, 6, and 8 presented the highest areas of bark extracted for the species (Figure 5(a)); a similar case was found for *Myracrodruon urundeuva*, with classes 4, 6, and 8 (Figure 5(b)) having the highest areas of bark extracted. The diameter classes with larger areas of bark extracted were 5, 7 and 13 for individuals of *Amburana cearensis* (Figure 5(c)), and 9 and 10 for *Commiphora leptophloeos* (Figure 5(d)).

Figure 6 shows the number of individuals with evidence of extraction for each diameter class, considering all marked individuals of the species studied. There are more individuals with extracted bark in diameter classes 5, 6, 7, 8, and 10, which for most species are considered small and intermediate diameters.

Considering only the preferred species, a total of 27 individuals presented bark extraction, as opposed to 136 individuals that had no evidence of extraction. However, in less-preferred species, only two individuals presented bark extraction, as opposed to 272 with no evidence of extraction. The results of chi-square analysis showed that the proportion of individuals with and without bark extraction depends on the preference of the species ($X^2 = 41.35$, $P < 0.0001$) in the sense that preferred plants have a greater number of individuals with evidence of bark extraction in relation to the less-preferred species.

3.2. Comparison of Tannin Content between Preferred and Less-Preferred Species. The species showing the highest levels of tannins were the preferred species, such as *Mimosa tenuiflora* and *Anadenanthera colubrina*, with 12.58% and 8.24% of tannin content, respectively, and the species *Myracrodruon urundeuva* and *Libidibia ferrea*, with 6.88%, and 6.24% respectively. The preferred species *Amburana cearensis, Erythrina velutina*, and *Maytenus rigida* did not present quantifiable values, as the method could not detect their tannin levels. In turn, the less-preferred species showed lower tannin levels, such as *Schinopsis brasiliensis* with 5.53%, *Hymenaea courbaril* with 2.35%, *Croton blanchetianus* with 2.47%, and *Spondias tuberosa* with 1.51%, unlike the species *Handroanthus impetiginosus* and *Cereus jamacaru* that did not present quantifiable values (Table 2).

By analyzing the species in which the tannin content was quantified, it is possible to observe that the preferred species had higher tannin content than the less-preferred species. However, no significant differences were found between preferred and less-preferred species in the proportion of plants with high (>5%) and low (<5%) tannin content ($G = 2.09$, $P > 0.05$). This result rejects one of the hypotheses of this research, indicating that the preference of a plant for the treatment of inflammation does not appear to be linked to its tannin content.

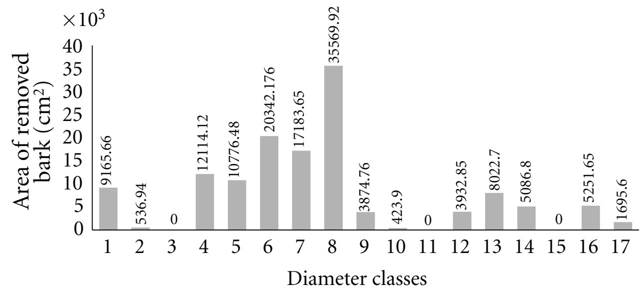


Figure 4: Values of the area of removed bark, divided into diameter classes, of the individuals in the community from the Carão, Altinho, northeastern Brazil. The classes, at intervals of 3 cm, correspond from 1 (0–3 cm) to 17 (48.1–51 cm). The numbers above the bars correspond to areas of bark extracted for each diameter class indicated in cm^2.

Table 2: Tannin content, expressed as a percentage, of the preferred and less-preferred species studied in the community of Carão, Altinho, northeastern Brazil.

Species	Tannin content (%)
Preferred	
Amburana cearensis (Allemão) A. C. Sm.	*nd*
Anadenanthera colubrina (Vell.) Brenan	8.24
Erythrina velutina Willd.	*nd*
Maytenus rigida Mart.	*nd*
Mimosa tenuiflora (Willd) Poir.	12.58
Myracrodruon urundeuva Allemão	6.88
Libidibia ferrea (Mart. ex Tul.) L. P. Queiroz	6.24
Less preferred	
Schinopsis brasiliensis Engl.	5.53
Hymenaea courbaril L.	2.35
Handroanthus impetiginosus (Mart. ex DC.) Mattos	*nd*
Cereus jamacaru DC.	*nd*
Croton blanchetianus Baill.	2.47
Spondias tuberosa Arruda	1.51

nd: not detected.

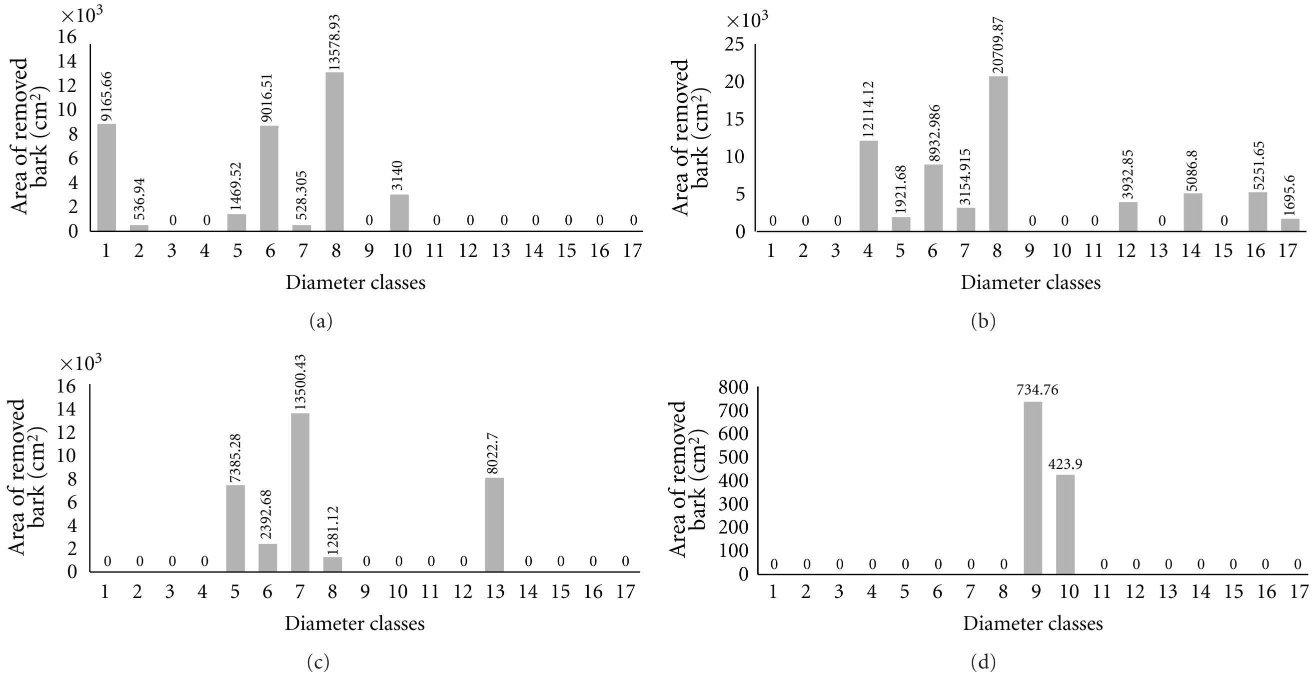


Figure 5: Area of bark extracted, distributed by diameter classes, of individuals of each species separately in the community of Carão, Altinho, northeastern Brazil. (a) *Anadenanthera colubrina* (Vell.) Brenan, (b) *Myracrodruon urundeuva* Allemão, (c) *Amburana cearensis* (Allemão) AC Sm, (d) *Commiphora leptophloeos* (Mart.) JB Gillett. The classes, at intervals of 3 cm, correspond from 1 (0–3 cm) to 17 (48.1–51 cm). The numbers above the bars correspond to areas of bark extracted for each diameter class indicated in cm^2.

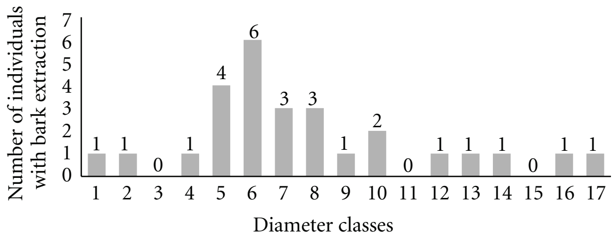


Figure 6: Distribution of studied individuals, with evidence of bark extraction, in diameter classes, in the community of Carão, Altinho, northeastern Brazil. The classes, at intervals of 3 cm, correspond from 1 (0–3 cm) to 17 (48.1–51 cm). The numbers above the bars correspond to areas of bark extracted for each diameter class indicated in cm^2.

4. Discussion

4.1. Evidence of Bark Extraction in Preferred and Less-Preferred Plants. According to the results, preferred plants showed a larger area of bark extraction and a larger number of individuals with evidence of extraction than less-preferred plants. This pattern has been found in other ethnobotanical studies in the Caatinga, including that of Ramos et al. [32], who found a high correlation between the preference for one species as fuel and its usage frequency in timber use, indicating that preference is used as a criterion for the effective use of the resource. Other studies have found similar results, such as that of Chettri and Sharma [33], who made a list of preferred species for use as fuel according to informants from communities in the Khangchendzonga Biosphere Reserve, India. By comparing that list with the extraction results for those species obtained by Chettri et al. [34] in the same area of study, it was found that a species with the highest preference among responders also showed the highest extraction, indicating that greater use pressure may be related to the preference for a given resource. It can also be found in the literature that for a given species, the preference of a population for individuals of certain diameter classes can also lead to a greater use pressure on those classes [35]. According to these authors, who conducted a study on collection patterns for *Anadenanthera colubrina*, an absence of individuals was observed in diameter classes considered by informants as preferred for use as stakes and as firewood.

Some works have referred to a greater potential use of preferred species, but they did not investigate the extraction of individuals as proposed by this paper. Examples of such investigations include de Albuquerque and Andrade [10], who conducted an ethnobotanical study in a Caatinga community and observed that preference is restricted to a small number of species and that these, in turn, may experience concentrated use pressure. Prance et al. [36] argued that preferred plants are used more than less-preferred plants for the same use but did not conduct an investigation assessing the levels of extraction of individuals. In this respect, with the information in this research, it is confirmed that for the study area, the preference of a species leads to greater use pressure of this resource. This information raises important implications for the utilitarian redundancy model.

With the investigation of the use pressure on plant species, the utilitarian redundancy model proposes two situations involving redundant and less redundant categories [9]. The results of this research validate the status of the second situation of the model, which states that for a category highly redundant in the presence of preferred species, the use pressure will be shifted to those species, increasing the pressure of use for this utilitarian category by increasing the number of preferred species. These results do not indicate that the first situation of the model is not valid. For example, one can find situations in which a redundant utilitarian category does not present species preference by the informants. In this case, a greater number of species in that category may lead to a mutual reinforcement and thus a lower pressure of use among individual species [9].

The preferred species *Myracrodruon urundeuva* and *Amburana cearensis*, followed by *Anadenanthera colubrina*, presented the largest areas of bark extraction. These preferred species have been reported in several studies as being important for local communities in various Caatinga environments [9, 37, 38]. de Albuquerque et al. [8] and Monteiro et al. [35] showed that the species *Myracrodruon urundeuva* and *Anadenanthera colubrina* have a high versatility among native plants, demonstrating that these plants typically have multiple uses [39] and are extensively used for various therapeutic treatments [6]. Although de Albuquerque et al. [8] claimed that a high versatility did not necessarily indicate a greater harvest pressure, a potential use pressure on these species can be expected.

The classes of small and intermediate diameter had the largest areas of bark extracted and the largest number of individuals with evidence of extraction. Monteiro et al. [35] found similar results when observing a decrease in individuals of the intermediate class of *Anadenanthera colubrina*, which are considered as favorites for use as stakes and fuel. Similarly, Lins Neto et al. [40] found a higher percentage of bark extraction in *Myracrodruon urundeuva* individuals with small diameters when investigating the use of this species by residents of two local populations of the Caatinga. This discussion should be seen in perspective, as the studies discussed above were conducted with uses other than medicinal. To decrease the use pressure concentrated in these classes, it is suggested that the extraction of bark is directed to individuals of greater size, which can better withstand the extraction, as there do not seem any differences in the therapeutic efficiency of bark, as measured by tannin content, when collected from individuals of different diameter classes [30, 41]. These authors found no differences in the amount of tannins among diameter classes for the species of *Myracrodruon urundeuva* and *Syderoxilon obtusifolium*.

4.2. Comparison of Tannin Content between Preferred and Less-Preferred Species. Tannins are phenolic compounds, products of secondary metabolism in plants, which protect them from external agents, such as attacks from herbivores [42]. According to Monteiro et al. [43], so far there are only a few studies investigating the activity of these compounds for the treatment of diseases from medicinal plants. For the treatment of inflammation, tannins form complexes with proteins and polysaccharides [44] which may, for example, form protective layers on injured epithelial tissues [45] that present antimicrobial and antifungal activity [46]. Therefore, tannins may exert anti-inflammatory activity in epithelial tissues.

When investigating the tannin content in the preferred species, it was observed that although the species *Myracrodruon urundeuva* and *Libidibia ferrea* have the highest tannin concentrations, along with *Mimosa tenuiflora* and *Anadenanthera colubrina*, there are still few studies on the biological activity of these species *in vitro* or *in vivo* for the treatment of inflammation. For example, in the few studies that investigate the anti-inflammatory properties of *Myracrodruon urundeuva*, anti-inflammatory activity was observed in the treatment of periodontitis [47], colitis [48], ulcers [49], and inflammation of the genital tract [50] in animal models.

It has been shown that the anti-inflammatory activity of *Myracrodruon urundeuva* and *Anadenanthera colubrina* is attributed to the large amount of tannins present in their bark [7, 12]. These species are also important because they are widely used by various local communities of the Caatinga for the treatment of inflammation [7, 10, 35]. Considering the importance of these species and the few pharmacological studies associated with them, it is important for future pharmacological studies to investigate the anti-inflammatory properties of these plants because they may indicate new medicinal potential.

According to the results obtained, it was expected that the tannin content present in preferred species would be significantly higher than that in less-preferred species because the tannin compound may account for the anti-inflammatory activity, but this was not the case. These results do not negate the importance of tannins in the selection of plants by populations of the Caatinga for the treatment of inflammation [7, 12], but indicate that the preference of a plant as anti-inflammatory does not seem to be linked to its total tannin content. It is also possible that other phenolic compounds are involved in the anti-inflammatory activity of these plants.

5. Conclusions

Few studies have investigated the relationship between preference and use, and these are focused on the timber and fuel use, for example. For medicinal use, properly anti-inflammatory use, this research showed that preferred plants actually had a higher pressure than less-preferred plants. From these results, the second situation of the utilitarian redundancy model is sustained in the sense that the preference for plants increases the use pressure in redundant utilitarian categories. However, this conclusion is limited to the community studied and the anti-inflammatory category. Other studies with a similar approach should be conducted in other regions and with different medical categories in order for more robust conclusions to be reached.

The results of this research, although focused on the anti-inflammatory category, showed that the species *Myracrodruon urundeuva*, *Amburana cearensis*, and *Anadenanthera* *colubrina* experienced higher rates of extraction. This fact, together with information from other studies conducted in local populations integrated in the Caatinga environment, shows that these species should be targeted in future management programs.

According to the data obtained, we cannot affirm that tannin content is a criterion for indicating preference, as there were no differences in tannin content between preferred and less-preferred species. However, future studies should be conducted because the present research examined only the total tannin content in the bark of the species studied, and differences can be obtained whether the content between tannins classes was studied.

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Research Article

Honey-Based Mixtures Used in Home Medicine by Nonindigenous Population of Misiones, Argentina

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Honey-based mixtures used in home medicine by nonindigenous population of Misiones, Argentina. Medicinal mixtures are an underinvestigated issue in ethnomedical literature concerning Misiones, one of the most bioculturally diverse province of Argentina. The new culturally sensitive politics of the Provincial Health System is a response to cultural practices based on the medicinal use of plant and animal products in the home medicine of the local population. Honey-based medicinal formulas were investigated through interviews with 39 farmers of mixed cultural (*Criollos*) and Polish origins in northern Misiones. Fifty plant species and 8 animal products are employed in honey-based medicines. Plants are the most dominant and variable elements of mixtures. Most of the mixtures are food medicines. The role of honey in more than 90% of formulas is perceived as therapeutic. The ecological distribution of taxa and the cultural aspects of mixtures are discussed, particularly the European and American influences that have shaped the character of multispecies medicinal recipes.

1. Introduction

The province of Misiones in Argentina displays a complex biocultural mosaic. The original inhabitants of this territory are Mby'a Guaraní indigenous people, who nowadays live in reserves and in rural areas in neighborhoods with nonindigenous farmers [1, 2]. In the 20th century Misiones received a massive wave of transnational migration from nearly all European countries, a few Asian countries, and neighboring Paraguay and Brazil, as well as internal migrants from other Argentinean regions [3, 4].

Misiones harbors one of the richest plant biodiversity in the whole Argentinean territory [5]. This is reflected in the number of plant species recognized as medicinal resources. Over 300 medicinal botanical taxa have been documented in ethnobotanical and ethnopharmacological works from this region [6–9]. The use of plants for health care is an important practice for Mby'a aboriginal people, as well as Mestizo and European migrants living there. They are employed in home medicine by lay persons and used by healing specialists (called *payé*, *curandero*, and *médico*) [10–12].

Medicinal plants not only are relevant resources as part of valuable traditional lore, but also play an essential role in the ethnomedical systems of people who have no health insurance. In Andresito municipality, located close to our study area, 77 percent of the population has no health insurance [9]. These people can only use hospitals and Primary Health Care Centers—sort of basic ambulatories—free of charge. On the other hand, easy access to Primary Health Care is one of the priorities for the local government in Misiones. In the period 2004–2007, according to the Federal Health Plan, 1000 new health promoters and 90 community doctors were incorporated into the Primary Health System [9]. In the same period, a few phytomedicines based on native plants (*Maytenus ilicifolia* Mart. ex Reissek, *Cecropia pachystachya* Trècul.) and well-appreciated exotic species (*Calendula officinalis* L.) were introduced into the market and distributed for free in Primary Health Care Centers [13, 14]. The aforementioned plants form part of popular pharmacopoeia [1, 7–9]. This fact illustrates the new culturally sensitive approach of the National/Provincial Health System, as well as an effort to make remedies more economically accessible. A new objective of the Provincial Ministry of Health is to provide training for health personnel and to inform farmers and the general population about rational and responsible attitudes towards the use of medicinal plants [9]. To achieve this goal, further investigation on knowledge and practices related to medicinal resource is needed. To date, complementary medicine, including phytotherapy, has been sparsely undertaken as a research subject by investigators in Misiones, in comparison to the biocultural diversity of the province. Moreover, some researchers, who studied the medicinal use of plants by aboriginal communities of Mby'a, have pointed out that these people have quite an individualistic approach towards plant selection and the choice of certain species [1, 11]. This fact makes local phytotherapy even more complex.

Honey is an important alimentary and medicinal resource in the region [15, 16]. A large number of wild species produce honey from the order Hymenoptera (bees, bumblebees, and wasps). The use of honey from stingless bees is a cultural marker of identity for the original inhabitants of Misiones—Guaraní communities, for whom these bees (Meliponini tribe) play an important role in the cosmology [17].

We still know very little about the diversity of uses of honey among the inhabitants of Misiones and South America, in general. Few studies have focused on honey-based remedies and they represent isolated pieces of information within the wide scope of ethnobotanical studies [18–22]. Therefore, only vague conclusions can be generated about the specificity of honey-based medicines and about the role of honey in multispecies formulas.

Our research among *Criollos* (people of mixed Amerindian and European origin) and Polish migrants had a pioneering and preliminary character [16]. It shows that *Criollos* and Polish migrants recognize and use the honey of 17 different ethnospecies, 7 of which have been employed in the treatment of a variety of ailments and illnesses. Honey is also applied as food medicine in health promotion and prophylactics. According to the local aesthetics, it is highly desirable to have a nest of stingless bees on the household premises. It is believed that the presence of bees brings prosperity to the household [16]. Therefore, honey and bees, specially stingless bee species, are very positively associated, which should favor their use and conservation. Both for *Criollos* and Polish settlers the most culturally important species are the native *yateí* (*Tetragonisca fiebrigi*) and the European honey bee—abeja—(*Apis mellifera*) [16].

The use of plants and animal products in home medicine forms a part of traditional ecological knowledge, which implies a close relationship between people and places [23]. Research among aboriginal and *Criollos* communities indicates the important relationship they have with forested areas as a source of natural medicines. Mby'a Guaraní maintain tight and strong bonds with the forest as the principal source of their existence and the frame of all their symbolic constructions [2]. Moreau [9] documented the use of 112 noncultivated medicinal plants among *Criollos* and migrants from Brazil in the north of Misiones. These people use plants from all habitats, however, primary and secondary forests provide the greatest number of medicinal species for them, followed by ruderal areas. Keller and Romero [8] in their study among *Criollos* farmers in the center of Misiones found that the majority of 176 botanical taxa employed in home medicine were noncultivated species. Forty-four percent of the species were cultivated in home gardens and fields, and only 3 percent were purchased in the market. There are no publications reporting on the importance of habitat for Polish or other European migrants in the context of medicinal resource use. According to Polish folk pharmacopoeia, Polish peasants have employed predominantly noncultivated herbaceous species, which grew in their home gardens, fields, and on pathway edges [24–26].

Plant and animal mixtures employed in the home medicine of local societies are understudied in ethnobiological and ethnopharmacological literature [27–29]. To date, just one piece of ethnobiological research has treated multispecies formulas used in the home medicine of the inhabitants of Misiones [16]. With this contribution, we would like to complement our previous publication. To do so we address and compare (1) the importance of plants and animal products employed in honey-based medicinal mixtures, (2) the role of honey in multispecies formulas, (3) ailments treated with these resources, and (4) source areas and forms of obtaining medicinal resources.

We hypothesize that different ethnospecies of honey bees and medicinal plants have different cultural and therapeutic importance for *Criollos* and Polish farmers. These groups explore different habitats for the procurement of medicinal species.

2. Material and Methods

2.1. Study Area. The research was conducted in the northern part of Misiones, which forms a part of the Atlantic Forest Ecoregion [30]. This is a semideciduous forest growing in a subtropical climate with hot summers (35–40°C), between December and March, and winters with frosts between June and August. Average annual rainfall is 1700–2200 mm, with no marked dry season [31].

The most important economic activities in the region are forestry and agriculture, supplemented by cattle breeding. The first is based on monoculture plantations of exotic species of pine (*Pinus* spp.) and eucalyptus (*Eucalyptus* spp.) for the paper and timber industry. The main crops are tobacco (*Nicotiana tabacum*), yerba mate (*Ilex paraguariensis*), té (*Thea sinensis*), and fruit plantations, mainly citrus. The provincial economy is based on raw material extraction with little industrial development [32, 33].

The research was conducted in two departments: Iguazú and General Manuel Belgrano. Both of them share a border with Brazil (in the north and northeast, resp.). The department of Iguazú is also bordered by Paraguay in the west. We worked in two areas: Wanda and Gobernador J. J. Lanusse settlements, in the department of Iguazú, and in hamlets

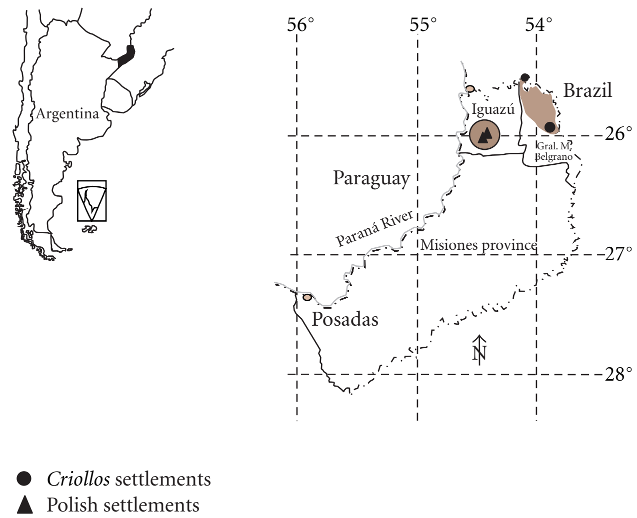

Figure 1: Study area.

in the Andresito Península and Maria Soledad municipality, Andresito Guaçurarí, and San Antonio (Figure 1).

Wanda and Lanusse were established as Polish rural settlements. Wanda, situated on the banks of the Parana River, developed into a town with semirural lots on its outskirts. The Lanusse locality, 36 km from Wanda, conserved its rural character with a poor infrastructure. Nowadays Wanda and Lanusse exhibit a multicultural character: in addition to the Polish pioneers and their children, Argentinean migrants from other provinces as well as Paraguayan and Brazilian immigrants live there.

The study sites of Peninsula Andresito and Maria Soledad (department of General Manuel Belgrano) are hamlets with minimal infrastructure (dusty unpaved roads, not completely electrified areas, satellite schools). They are inhabited by small farmers of mixed cultural backgrounds (hereafter called *Criollos*). Some people obtained their lots through a settlement scheme, which dates back to the 1980s and by spontaneous occupation that was subsequent to the foundation of the overseas immigrant colonies [32, 33]. Among the inhabitants of the study area are Argentineans and Brazilians, descendants of Germans and other European people who live neighboring the Paraguayan and Argentinean Mestizos. The distinction between Polish and *Criollos* communities rests on three criteria: self-identification, language and customs, and cultural institutions (see Zamudio et al. [16]).

2.2. Data Gathering. This field work took place in 2009. After obtaining prior informed consent, an open-ended questionnaire was applied in the Spanish language. It consisted of seven sections with questions that sought to understand the contexts of use of the honey of Hymenoptera. With regard to the medicinal uses assigned to honey and other products derived from it, we aimed to investigate (a) the illnesses treated, (b) the forms of preparation and administration of remedies that include honey, and (c) the role of honey in the preparation of home remedies when they included other elements (plants, animal products, pharmaceuticals). Additional questions were asked about the place and mode of obtaining the mentioned resources (honey and plants). Illnesses are reported according to local ethnomedical terminology and classification. Only the reports of self-experience were included in the analysis, thus reports of uses not tried by the study participants were discarded.

We worked with 16 Polish settlers and their descendants (hereafter called Poles or Polish migrants), mainly from the first and, occasionally, second generation born in Argentina, aged between 39 and 77 (9 men and 7 women), and with 23 *Criollos* farmers, aged between 20 and 70 (14 men and 9 women). In both cases, the proportion between men and women was similar. We worked with all the families that we found present at home at the time of our arrival, except if they were close relatives of one already visited. The inclusion criteria were: age—only adults were interviewed—and cultural background; we tried not to include descendants whose parents were mixed couples (Polish and *Criollos*). Only two participants from the Polish group have *Criollos* spouses. Almost all the interviewed farmers are small producers.

The plants were collected in the presence of the study participants. Then, voucher specimens were identified by the authors (Monika Kujawska) and deposited in the herbarium of the *Universidad Nacional del Noroeste* (UNNE). The herbarium references to the plant collection are provided in Zamudio et al. [16]. Some of the bees of the tribe Meliponini were identified by Claus Rasmussen (Department of Entomology, University of Illinois, USA) and Fernando Silveira (Department of Zoology, Federal University of Minas Gerais, Brazil), while the rest of the insects were identified by Fernando Zamudio. The insects were deposited in the entomological collection of the *Universidad Nacional de Misiones* (UNAM).

2.3. Data Analysis. In this analysis, we included bee species that were mentioned by at least three informants and referred only to the use of honey (not other products derived from bees). The relative importance (RI) was calculated for each plant and animal species based on the normalized number of pharmacological properties attributed to it and the number of body systems it treated [34]. Similarity between the Polish and *Criollos* population was evaluated for modes and places of obtaining the species by applying the Simpson Coefficient. This is a percentage index that uses presence-absence information and is interpreted as the proportion of shared taxa in relation to the site (the cultural group in our case) with fewer species. This particular index was chosen as it is appropriate for ethnobiological studies based on interviews, which yield variable data [35]. Parameters such as richness, shared and exclusive species are presented as well.

To evaluate the variability of the medicinal plants' use within each study group, the informants' consensus factor (ICF) was calculated [36]. To evaluate the variability of the medicinal resources' use between Polish and *Criollos*, the analysis of variance ANOVA was performed using consensus factor data transformed by the logarithm Log 10. The Infostat program was applied for these analyses [37]. Four categories were defined as sources of medicinal plants and animal products: home units, transformed habitats, forests, and markets. Home units comprise house premises including front- and backyard, fenced home gardens adjacent to the house, and orchards. Transformed habitats are environments where productive activities take place: cultivated fields, pasture (for cattle breeding) and also highly modified ruderal areas—roadsides and ecotone between farm and forest. Forest areas embrace disturbed primary and secondary forests, which retain the basic tree layer vegetation characteristic of the study area. This category includes also natural wetlands found in lower areas of the forest and in coastal environments adjacent to river courses.

3. Results

3.1. Medicinal Resources. We registered the use of 58 different taxa in the course of the field research. Fifty of them are botanical taxa (including 5 industrially processed plant products), belonging to 38 genera and 27 botanical families. Eight taxa are products of animal origin: honey of 5 bee species and fatty products extracted from three vertebrates (Table 1). *Criollos* mentioned 45, while Polish migrants 33 taxa. Twenty-seven taxa were mentioned exclusively by *Criollos* and 14 by Poles. The study groups share the knowledge and the use of 18 plant and animal taxa, which constitutes nearly one-third of all mentioned medicinal resources.

The study participants reported 109 medicinal uses, which included a single-species remedy—pure honey—and 214 uses in which honey was combined with other elements: with one plant species (39.3%), with two or more plant species (16.4%), with vegetable oil (5.6%), with milk (5.1%), with animal fat (4.2%), with two or more plants and a pharmaceutical (3.7%), with one plant and vegetable oil (2.8%), with one plant and a pharmaceutical (2.8%), with one plant and alcoholic beverage (2.3%), with alcoholic beverages (1.9%), with at least two plants and vegetable oil (0.9%), and with a pharmaceutical, and with one plan and fat (0.5%) each (Tables 1 and 2).

The single-species remedies refer to honey of 5 bee taxa: European honey bee—abeja—(*Apis mellifera*), yateí (*Tetragonisca fiebrigi*), mandasaia (cfr. *Melipona quadrifasciata*), mirí (*Plebeia* spp.), and carabozá (*Trigona spinipes*). Abeja and yateí have the highest relative importance value. Pure honey is used both internally and externally to treat, in the first place respiratory system disorders (Poles: 67.3%, *Criollos* 54%). However, the order of importance changes between groups for other body systems. Poles use pure honey to treat ailments of digestive system (10.9%), ophthalmic (9.1%), skin and humoral medicine syndromes (3.6%), circulatory, and psychological and general problems (3.6%). In contrast, *Criollos* use pure honey to treat skin (16%), digestive, ophthalmic, and musculoskeletal (8%), psychological problems (4%), and general (2%).

During the interviews, the participants were asked, which components in the mentioned mixtures had medicinal properties for them, and whether honey could be replaced by sugar. By this question, we aimed to determine the role of honey in multispecies formulas: as a medicine or as a sweetener. Over 90 percent of *Criollos* respondents considered all products as necessary components of mixtures,

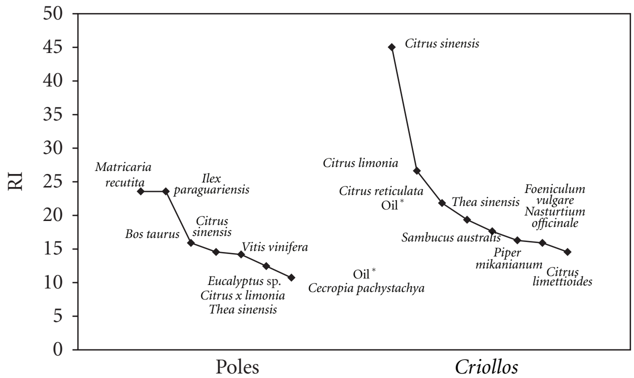

Figure 2: Rank-abundance curves (adapted) of species with the ten highest relative importance (RI) values by study group.

either containing abeja or yateí honey (as only these species were used in mixtures). Phrases like "both of them make a remedy" or "if you join them, then the medicine becomes more powerful" were common responses. Only in one case was honey employed as sweetener, in a mixture with vegetable oil for pediatric use. In another five cases *Criollos* informants stated that if they did not have honey, they used burned sugar, but honey was better than sugar. Respondents also remarked that if they did not have a plant or animal product, which they used normally, they replaced it with another element or prepared a remedy without it. For example, on one occasion an informant said that a mixture of ajo (*A. sativum*) and oil was also effective against flu, if there was no honey to be added, but they conceived this mixture to be less powerful. Seventy-two percent of Polish participants stated that all the components in mixtures had medicinal properties. The lower percentage provided by Poles in comparison with *Criollos* may be due to the fact that Polish migrants mentioned more mixtures with tea and milk than *Criollos*, and these products were not always considered as medicinal resources but rather as conveyance mediums for proper medicine (honey or a plant). Both Poles and *Criollos* stressed that it was important to drink something hot when one was ill to make the body sweat, especially in the case of respiratory illnesses. In four cases Poles mentioned that honey could be replaced by sugar and its role was to make the following mixtures more palatable: (1) mixture with capybara fat; (2) three cases of multispecies formulas containing bitter plants, which were prepared for children.

The relative importance (RI) analysis showed that different species are important for each of the study groups (Figure 2). The two most important species (excluding honey) for Poles are manzanilla (*M. recutita* L.) and yerba mate (*I. paraguariensis* A. St.-Hil.). None of these plants were mentioned by *Criollos*. The third most versatile product for Polish migrants, cow's milk (*Bos taurus*), was reported by *Criollos* only once. Among the ten most important medicinal resources used by *Criollos*, 6 were not mentioned even once by Poles. The exclusive species are native (*Sambucus australis* Cham & Schltdl. and *Piper mikanianum* (Kunth) Steud.) and adventitious plants (*Citrus sinensis* (L.) Osbeck, *C. reticulata*

Table 1: Relative importance (RI) value of species used in honey-based mixtures by Criollos and Poles in north of Misiones, Argentina. P/C: Poles/Criollos, RIP: relative importance Poles, and RIC: relative importance *Criollos*.

Scientific name, botanical family (common name)	(#reports) P/C	RIP	RIC	Mode of preparation and administration	Ailment
Achyrocline flaccida (Weinm.) DC., Asteraceae (marcela)	2/0	9.00	—	Oral, infusion, with lemon, and abeja's honey, a pharmaceutical* (optatively)	Cough, influenza
Allium cepa L., Alliaceae (cebolla)	1/2	7.28	7.28	Oral, syrup, with abeja's honey	Catarrh
Allium sativum L., Alliaceae (ajo)	0/4	—	12.45	Oral, decoction, with eucalyptus, *guabirá*, oil, and abeja's honey	Bronchitis, pneumonia
				Oral, frying o mixed without cooking, with oil, and yateí's honey	Cough
Aloe sp., Xanthorrhoeaceae (aloe)	1/0	7.28	—	Oral, mixture, with abeja's honey	Tonsillitis
Aloysia citriodora Palau, Verbenaceae (cedrón)	0/2	—	9	Oral, Infusion, with orange, yateí's honey or burned sugar, and a pharmaceutical	Catarrh, cough
Ananas comosus (L.) Merr., Bromeliaceae (ananá)	0/11	—	12.45	Oral, syrup, abeja's honey	Influenza, respiratory tract, bronchitis, pneumonia, colds, cough
Apis mellifera, (abeja)	47/124	68.2	66.48	Oral, pure	Dyspepsia, constipation; nervous commotion; blood pressure imbalance, blood cleansing (humoral syndrome) preventive, influenza, colds, cough, sore throat, tonsillitis, bronchitis, pneumonia, catarrh
				Topic, pure	Injury, bruises, abscess; muscular pain
Artemisia vulgaris L., Asteraceae (sertal)	1/0	7.28	—	Oral, Infusion, with abeja's honey	Dyspepsia
Bos taurus, (leche)	12/1	14	7.28	Oral, mixture, with abeja or yateí's honey	Bronchitis, catarrh, influenza
(manteca)	1/0	9	—	Oral, mixture, with abeja's honey	Cough, sore throat
Brassica oleracea L., Brassicaceae (repollo)	0/2	—	7.28	Topic, Compress with yateí's honey	Bruises, abscess
Bromelia balansae Mez, Bromeliaceae (caraguatá)	0/1	—	7.28	Oral, syrup with abeja or yateí's honey	Influenza
Brugmansia suaveolens (Humb. & Bonpl. Ex Willd.) Bercht. & J. Presl, Solanaceae (floripón)	2/0	9.00	—	Topic, with yateí or mirí's honey	Injury
Campomanesia xanthocarpa O. Berg, Myrtaceae (guabirá)	0/1	—	7.28	Oral, decoction, with eucalyptus, garlic, oil, and abeja's honey	Bronchitis, pneumonia
Carica papaya L., Caricaceae (mamón)	0/18	—	14.18	Oral, decoction, with lemon, *ambay*, *berro*, *sauco*, *talera*, *salvia* with abeja or yateí's honey	Tonsillitis, catarrh, influenza
				Oral, syrup, *talera*, lemon, *pariparoba* with yateí's honey	Sore throat
Cecropia pachystachya Trécul, Cecropiaceae (ambay)	3/22	10.73	10.73	Oral, decoction, eucalyptus, citrus, and abeja's honey	Catarrh, sore throat, cough
				Oral, decoction, with lemon, *mamón*, *berro*, *sauco*, *talera*, *salvia* with abeja or yateí's honey	Tonsillitis, catarrh, influenza
				Oral, syrup with abeja or yateí's honey	Cough, bronchitis, pneumonia

Table 1: Continued.

Scientific name, botanical family (common name)	(#reports) P/C	RIP	RIC	Mode of preparation and administration	Ailment
Celtis iguanaea (Jacq.) Sarg., Celtidaceae (talera)	0/16	—	12.45	Oral, decoction, with lemon, *mamón*, *berro*, *sauco*, *talera*, salvia with abeja or yateí's honey	Tonsillitis, catarrh, influenza
				Oral, syrup, with *talera*, lemon, *pariparoba* with yateí's honey	Sore throat
Cfr. Melipona quadrifasciata, (mandasaia)	0/1	—	7.28	Oral, pure	Influenza
Chaptalia nutans (L.) Pol., Asteraceae (lengua de vaca)	1/0	7.28	—	Topic, compress, with carabozá, mirí o yateí's honey	Injury
Citrus reshni Hort ex Tan., Rutaceae (mandarina)	0/4	—	21.84	Oral, infusion, with abeja's honey	Preventive
Citrus x limonia (L.) Osbeck, Rutaceae (limón)	14/46	12.45	26.63	Oral, decoction, tea, abeja or yateí's honey. With red wine, a pharmaceutical (optatively)	Influenza, colds, sore throat, cough
				Oral, syrup, with orange and abeja's honey	Cough
				Oral, syrup, with yateí's honey	Respiratory tract
Citrus aurantium L., Rutaceae (apepú)	4/2	9	14.18	Oral, decoction, with tea, abeja or yateí' honey, a pharmaceutical (optatively)	Influenza, cough
				Oral, syrup, with abeja or yateí's honey	Influenza
Citrus limettioides Tanaka, Rutaceae (lima)	0/2	—	14.56	Oral, infusion, with abeja's honey	Cough, preventive
Citrus limón (L.) Osbeck, Rutaceae (limón)				ídem *Citrus x limonia*	
Citrus paradisi Macfad., Rutaceae (pomelo)	2/0	9.00	7.28	Oral, mixture, with abeja's honey	Influenza, cough
Citrus reticulata Blanco, Rutaceae (mandarina)	0/4	—	21.84	Oral, infusion, with abeja's honey	Preventive
Citrus sinensis (L.) Osbeck, Rutaceae (naranja)	2/20	14.56	45.02	Oral, syrup, with abeja or yateí's honey; or with lemon and abeja's honey; with *cedrón*, yateí's honey or burned sugar, a pharmaceutical (optatively)	Colds, cough, catarrh, respiratory tract, nervous commotion
				Topic, poultice, with abeja or yateí's honey	Bruises, abscess
Citrus spp., Rutaceae (cítrico)	3/0	10.73	—	Oral, decoction, with eucalyptus, *ambay*, abeja or yateí's honey	Sore throat, catarrh, cough, influenza
Coffea arabica L., Rubiaceae (café)	3/0	10.73	—	Oral, infusion, with lemon and abeja's honey; with abeja's honey	Influenza, colds; cough
Cymbopogon citratus (D.C.) Stapf, Poaceae (cedrón)	2/4	9	12.45	Oral, mixture o infusion, with oil and abeja's honey; infusion with orange, yateí's honey or burned sugar and a pharmaceutical	Cough, catarrh, bronchitis, pneumonia, influenza
Cynodon dactylon (L.) Pers., Poaceae (gramilla)	3	—	10.73	Oral, infusion, with yateí's honey	Fever
Eucalyptus sp., Myrtaceae (eucalipto)	4/6	12.45	9.00	Oral, decoction, with *ambay*, citrus, abeja, and yateí's honey	Sore throat, cough, catarrh
				Oral, syrup, with citrus and yateí's honey; decoction with *guabirá*, garlic, oil, and abeja's honey	Influenza

Table 1: Continued.

Scientific name, botanical family (common name)	(#reports) P/C	RIP	RIC	Mode of preparation and administration	Ailment
Foeniculum vulgare Mill., Apiaceae (aipo)	0/4	—	15.9	Oral, syrup, with *sabuguero* and abeja's honey	Respiratory tract
				Oral, infusion, with yateí's honey or burned sugar	Tonsillitis, sore throat
Glycine max (L.) Merr., Fabaceae (aceite vegetal)	3/13	10.73	21.46	Oral, decoction, with abeja's honey and a pharmaceutical	Colds
				Oral, mixture, with abeja or yateí's honey; decoction, with eucalyptus, *guabirá*, garlic, and abeja's honey	Sore throat, bronchitis, pneumonia, influenza
				Oral, mixture or infusion, with *cedrón* and abeja or yateí's honey; frying or mixture, with garlic and yateí's honey	Cough, catarrh
				Oral, mixture, with yateí's honey	Constipation
Helianthus annuus L., Asteraceae (aceite vegetal)				ídem *Glycine max*	
Heteropterys glabra Hook. Malpighiaceae (tilo)	1/0	7.28	—	Oral, infusion, with abeja's honey	Nervous commotion
Hydrochoerus hydrochaeris, (grasa de carpincho)	5/3	10.73	10.73	Oral, mixture, with abeja or yateí's honey; with tea and abeja's honey	Catarrh, respiratory tract
Hydrocotyle leucocephala Cham. & Schltdl., Apiaceae (oreja de gato)	0/2	—	9.00	Topic, poultice, with abeja or yateí's honey	Bruises, absecess
Ilex paraguariensis A. St.-Hill., Aquifoliaceae (yerba mate)	4/0	23.56	—	Oral, infusion, with abeja or yateí's honey	Blood pressure imbalance, nervous commotion, blood cleansing (humoral syndrome), to fortify the body
Linum usitatissimum L., Linaceae (lino)	0/1	—	7.28	Oral, infusion, with abeja or yateí's honey	Cough
Lippia alba (Mill.). N. E. Br., Verbenaceae (salvia)	0/11	—	14.18	Oral, decoction, with lemon, *ambay*, *berro*, *sauco*, *talera*, *mamón*, abeja or yateí's honey; with abeja's honey and a pharmaceuticals	Tonsillitis, catarrh, cough, influenza
Matricaria recutita L., Asteraceae (manzanilla)	4/0	23.56	—	Oral, infusion, with lemon and abeja or yateí's honey, a pharmaceutical (optatively)	Cough, sore throat, influenza, catarrh, colds, dyspepsia
Mentha spp., Lamiaceae (menta casera)	0/4	—	9.00	Oral, infusion, with abeja or yateí's honey	Colds, cough
Nasturtium officinale R. Br., Brassicaceae (agrión, berro)	0/13	—	15.90	Oral, decoction, with lemon, *ambay*, *salvia*, *sauco*, *talera*, *mamón*, with abeja or yateí's honey	Tonsillitis, catarrh, influenza
				Oral, syrup, with abeja's honey; with *guaco* and abeja's honey	Cough, influenza, bronchitis, pneumonia, asthma, tuberculosis; respiratory tract
Cfr. *Mikania* sp., Asteraceae (guaco)	0/5	—	12.45	Oral, syrup, with *guaco* and abeja's honey	Cough, influenza, bronchitis, pneumonia, asthma, tuberculosis
Picrasma crenata (Vell.) Engl., Simaroubaceae (palo amargo)	2/0	9.00	—	Oral, infusion, with abeja's honey	Dyspepsia
Piper mikanianum (Kunth) Steud., Piperaceae (pariparoba)	0/5	—	16.28	Oral, syrup, *talera*, lemon, *mamón*, yateí's honey	Sore throat
				Topic, compress, with abeja or yateí's honey	Injury

Table 1: Continued.

Scientific name, botanical family (common name)	(#reports) P/C	RIP	RIC	Mode of preparation and administration	Ailment
Piper sp., Piperaceae (matico)	1/0	7.28	—	Oral, infusion, with abeja's honey	Dyspepsia
Plebeia spp. (mirí)	9/0	23.18	16.28	Oral, pure	Influenza, tonsillitis, colds, asthma; bronchitis, pneumonia, cough, muscular pain
Saccharum officinarum L., Poaceae (azúcar quemada, burnt sugar)	0/6	—	7.28	Oral, infusion, with orange, *cedrón* and pharmaceutical; with *aipo*	Catarrh, cough catarrh, sore throat, cough
				Oral, decoction, eucalyptus, citrus, and *ambay*	Tonsillitis, sore throat
(aguardiente)				Oral, macerated with *sabuguero*	Asthma
Sambucus australis Cham. & Schltdl., Adoxaceae (sabuguero, sauco)	0/12	—	17.62	Oral, syrup, with *aipo* and abeja's honey	Respiratory tract
				Oral, macerated with aguardiente and abeja's honey	Asthma
Sida cordifolia L., Malvaceae (malva)	0/1	—	7.28	Oral, infusion, with bee or yateí's honey	Cough
Sus scrofa domestica, (grasa de chancho, pork fat)	0/4		12.45	Oral, mixture, with abeja or yateí's honey	Colds, bronchitis, pneumonia
Tetragonisca fiebrigi, (yateí)	37/68	59.20	58.81	Oral, pure	Cough, respiratory tract, catarrh, asthma, influenza, sore throat, bronchitis, pneumonia, asthma, thrush; nervous commotion, preventive, parasites; dyspepsia
				Topic, pure	Ocular illness; insect's bite; bruises, abscess, injury; bronchitis, pneumonia
Thea sinensis L., Theaceae (té común, té negro)	14/14	12.45	19.35	Oral, decoction, with lemon or *apepú* and abeja or yateí's honey, a pharmaceutical (optatively)	Influenza, colds, catarrh, cough
Trigona spinipes, (carabozá)	0/8	25.29	14.56	Oral, pure	Stomach fever (*fiebre de estómago*), influenza, tonsillitis, asthma
				Topic, pure	Rheumatic illness
Triticum aestivum L., Poaceae (trigo, harina)	0/3	—	7.28	Topic, poultice, with abeja or yateí's honey	Bruises, absecess
Viola odorata L., Violaceae (violeta)	0/2	—	7.28	Topic, poultice, with abeja or yateí's honey	Bruises, absecess
Vitis vinifera L., Vitaceae (vino tinto)	7/0	14.18	—	Oral, decoction, with lemon and abeja's honey; mixture, with abeja's honey	Colds, catarrh, cough, influenza
Zea mays L., Poaceae (aceite vegetal)				ídem *Glycine max*	

* Pharmaceuticals composed of acetylsalicylic acid, paracetamol, or ibuprofen.

Blanco, *Foeniculum vulgare* Mill., *Nasturtium officinale* R. Br.). Medicinal resources used by *Criollos* achieved in general a higher RI value that those used by Poles. This indicates that medicinal plants, especially citrus, have more versatile applications in this community, hence they are used to treat a larger number of body systems, and a greater number of pharmacological properties is attributed to them.

3.2. The Conception of Environment in Relation to Medicinal Resources. The taxa used by Polish migrants and *Criollos* come from the home unit in the first place (43.8 and 45.7%, resp.) and from local markets in the second place (31.3 and 26.1%, resp.) (Table 3). The species originating from transformed habitats, which include fields, pastures, and pathways, present the lowest similarity between Poles and

Table 2: Numbers of affections according to body systems and forms of preparations.

Body system	no. affections	Forms of preparation
Respiratory	11	A (37; 27), B (18; 27), C (23; 23), D (7; 2), E (5; 6), F (10; 2), G (2; 0), H (0; 1), BD (0; 1), BE (4; 2), BG (5; 0), BH (2; 3); CE (0; 2); CH (1; 7)
Skin	5	A (1; 8), B (9; 12)
Humoral medicine	5	A (1; 0), B (4; 0), G (1; 0), BH (0; 1)
Digestive	4	A (6; 4), B (5; 0), E (0; 1)
Ophthalmic	1	A (5; 4)
Musculoskeletal	1	A (0; 4)
Psychological	1	A (1; 2), B (2; 1)
Circulatory	1	A (1; 0), B (1; 0)
General	1	A (1; 1), B (2; 1)

In parentheses no. reports (Poles; *Criollos*).
A (pure honey), B (honey, one plant species), C (honey, at least two plant species), D (honey, animal fat), E (honey, vegetable oil), F (honey, milk), G (honey, alcoholic beverage), H (honey, a pharmaceutical), BD (honey, a plant species, animal fat), BE (honey, a plant species, vegetable oil), BG (honey, a plant species, alcoholic beverage), BH (honey, a plant species, a pharmaceutical), CE (honey, at least two plant species, vegetable oil), and CH (honey, at least two plant species, a pharmaceutical).

Criollos, with two shared species (Table 3 and Figure 3). By contrast, species obtained from the forest have achieved the greatest similarity (Table 3). This means that species from the forest are better defined for both groups, while there is great variability in selection of resources from places like gardens, pathways, cultivated fields, and pastures.

More than 50 percent of the taxa are cultivated or bred in both groups, but the similarity of cultivated and bred taxa between *Criollos* and Poles is the lowest (Table 3). On the other hand, the purchased and collected medicinal resources show the highest similarity between these two groups, although in no case did the similarity exceed 60 percent. Generally, these are species with low RI value, with the exception of bee and citrus species reported by both groups. Bee species (*T. fiebrigi* and *A. mellifera*), ajo (*A. sativum*), milk (*Bos taurus*), and the fat of capybara (*Hydrochaerus hydrochaeris*) are shared by both groups but are obtained from different places and through different modes, which leads to exclusivity. For example, Poles obtain yateí's honey (*T. fiebrigi*) from hives kept in transformed habitats (farms) or purchase it in the market, and *Criollos* breed this species on the house premises or obtain the yateí's honey from the forest. Even within the same group, resources are obtained from two or three different places, which is the case of capybara's fat (*Hydrochaerus hydrochaeris*). *Criollos* hunt this animal in the forest or purchase it from informal posts or local markets.

3.3. Variability in the Ailments' Treatment and Local Pharmacopoeia. The registered medicinal resources are employed in the treatment of diverse ailments, which were lumped into 9 body system disorders. There is a total consensus among both groups and within each community in the treatment of ophthalmologic problems, and a high consensus in the respiratory symptoms and illnesses (0.86, 0.88 Polish and *Criollos,* resp.). Additionally, *Criollos* agree on how to treat skin problems (077). Within the Polish migrant community, there is a medium consensus with respect to treatment of skin, gastrointestinal, and general problems (Table 4). Statistical test did not show any significant differences in the consensus about the species used in the treatment of the different corporal system between the study groups ($F = 0.33$, $P = 0.726$; $\alpha = 0.05$).

4. Discussion and Conclusions

Working with an ethnobiological questionnaire on the use of honey in nonindigenous communities of northern Misiones led us to discuss medicinal plants. The presented results illustrate the rich complexity of home medicine among *Criollos* and Polish migrants [8, 9, 12]. A low diversity in the medicinal use of animal products in home therapies contrasts with the high number of plant resources employed in multispecies formulas. The prevalence of botanical resources in comparison with animal products documented in our research reflects a general trend in the local pharmacopoeias of other ethnic groups in Argentina [38–42]. The relative absence of honey in local pharmacopoeias may be explained by the narrow perspectives taken by researchers, who aim to address a given problem deeply, which inevitably leads to the partition of cultural domains into unnatural categories. Thus, honey is poorly reported as a medicinal resource in both ethnozoological and ethnobotanical studies.

The botanical species mentioned by study participants include groups of plants of different cultural origins, as a result of the cultural blending that took place in Misiones in the 20th century. A relatively high number of mentioned taxa are used exclusively by each of the study groups, although they live in the same area (60 km apart), which indicates a great local heterogeneity in choices of medicinal resources. This can be explained by the continuity/discontinuity of medical traditions and the cultural influences of the neighboring countries, which affect Polish migrants and *Criollos* differently, according to their geographical proximity.

The rich tradition of using medicinal plants and the honey of stingless bees by *Criollos* is explained by their longer presence in the region and the influence of both indigenous knowledge and European ethnomedical heritage [16]. Polish migrants, culturally more homogeneus than *Criollos*, could not continue their phytotherapy undisturbed in the subtropics of Argentina, due to the difference in local flora. However, they partly maintained their traditional herbal pharmacopoeia thanks to medicinal plant species, which they brought and found in Misiones (e.g., *M. recutita* L., *Arthemisia absinthium* L.), and globalized food plant species, mainly vegetables, which they found in Misiones and continued to use in their home therapies [12]. We presume that Polish migrants are mostly influenced by Paraguayan Mestizo culture in their use of natural medicinal resources. Some of the species used by Poles, for example, lengua de vaca (*Chaptalia nutans* (L.) Pol.), which is applied topically together with honey to treat injuries, has not been registered

Table 3: Species richness and similarity (Simpson Coefficient) between Poles and Criollos according to source and mode of obtaining resources used in honey-based mixtures.

	Source								Mode of obtaining					
	Home unit		Transformed habitats		Forest		Market		Collected		Purchased		Cultivated/bred	
Total species richness	27		16		10		16		18		17		34	
	Poles	*Criollos*	Poles	*Criollos*	Poles	*Criollos*	Poles	*Criollos*	Poles	*Criollos*	Poles	*Criollos*	Pole	*Criollos*
Richness	14	21	9	9	6	9	10	12	10	14	10	13	17	25
Relative %	43.8	45.7	28.1	19.6	18.8	19.6	31.3	26.1	31.3	30.4	31.3	28.3	53.1	54.3
Exclusive species	6	13	7	7	1	4	4	6	4	8	4	7	9	17
Shared species	8		2		5		6		6		6		8	
Simpson Coefficient	57.1		22.2		83.3		60		60		60		47.1	

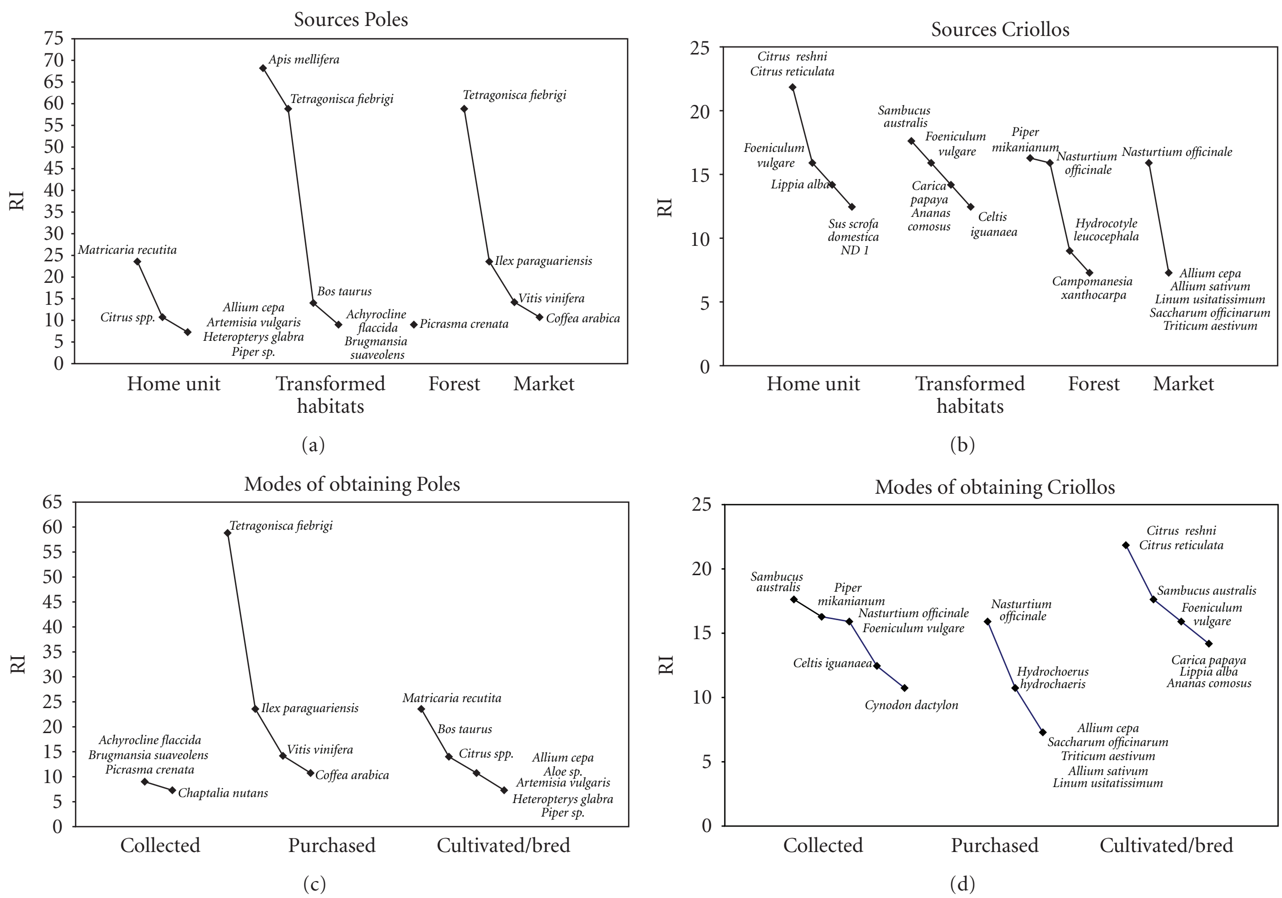

Figure 3: Rank-abundance curves (adapted) of exclusive species with higher relative importance (RI) value according to source and mode of obtaining resources by Poles and *Criollos* in honey-based mixtures.

in any of the research among *Criollos* in Misiones, but has been documented in Paraguayan ethnobotanical literature [43]. On the other hand, *Criollos* from our research are more influenced by Brazilian culture, which is reflected in plant and animal nomenclature [44].

The most important plant species—with the highest RI value for *Criollos*—are citrus species, nonnative to the area, coinciding with the *Criollos* populations of Yungas [40]. Citrus was introduced by Jesuit monks in colonial times and are now cultivated as cash crops in Misiones [45–47].

Table 4: Informants' consensus factor, comparison between Poles and *Criollos* concerning medicinal plant use according to the body systems.

	Poles	*Criollos*
Respiratory	0.86	0.88
Skin	0.5	0.77
Humoral medicine	0.38	0
Digestive	0.64	0.43
Ophthalmic	1	1
Musculoskeletal	—	0.33
Psychological	0.33	0.33
Circulatory	0	—
General	0.5	0.14

* $\text{Factor}_{\text{informants' consensus}} = (n_{\text{use-reports}} - n_{\text{taxa}})/(n_{\text{use-reports}} - 1)$.
(A higher value indicates a high rate of agreement between the informants, a low one a low degree of agreement).

The botanical species with the highest RI values used by Polish migrants reflect a blend of Polish and local traditions: manzanilla (*M. recutita*), which is the most important medicinal plant in Polish traditional pharmacopoeia [24] on the one hand, and on the other hand, yerba mate (*I. paraguariensis*), which is a native species, the base for the most popular social drink in this province [9]. It is a species that both *Criollos* and Polish migrants use daily, but according to our research, they use it differently. Poles employ it in a mixture with honey as food medicine to treat and prevent illnesses and *Criollos* use it as a social drink, which sometimes serves as a conveyance medium in order to ingest medicinal plants, which are added to it, but not with honey [9].

4.1. Multispecies Medicinal Formulas. The use of honey in medicinal mixtures has a long tradition in America [18]. In our research the employment of honey in mixtures prevails over the use of pure honey, in contrast to the study of Modro and colleagues in Brazil [22]. Plants are the most numerous resources in honey based multispecies formulas in both study groups. At the same time, plants and plant products are the most variable ingredients in these formulas. While *Criollos* employ more plants in mixtures than Polish migrants, the latter combine significantly more fatty products like milk, lard, and vegetable oil together with honey. Nevertheless, *Criollos'* multispecies medicines are significantly more complex: on average they mix 2.83 species, and Poles 1.63 species [16]. To the best of our knowledge, the analysis of single- versus multispecies medicines has not been undertaken as a research problem in Misiones. Therefore, it is difficult to claim that *Criollos* prefer mixtures over single-species medicines, although our research may indicate so in the addressed domain. Some suggestions also provide compilations on medicinal plants in other parts of Atlantic Forest, which include a great number of herbal mixtures [48]. In Polish folk pharmacopoeia, there is a strong prevalence of single-species remedies in comparison with medicinal mixtures. If applied, multispecies formulas have a low-component character [24, 26, 49]. Therefore, Polish migrants may have conserved this feature of their traditional phytotherapy, which was strengthened in Misiones, in the face of new experience with unknown flora.

Other studies on medicinal mixtures conducted in Latin America document their low-component character in home therapies. Lay people prepare mixtures predominantly made of 2-3 species at home, which is much fewer than those prepared by professional healers [27, 29, 40]. This fact is explained by the ingredients' availability, the time needed to prepare complex medicines [27] as well as the specialized knowledge of professional healers [40].

This research shows that the availability of products partly determines the composition of mixtures. If one component is not available, then the medicine is still prepared without it, or a missing ingredient is replaced by something else. Different species of citrus are especially subject to easy substitution. Therefore, there is a certain flexibility in the composition of medicinal formulas used by *Criollos* and Poles. The main purpose in combining different components is to make a medicine more effective, more "powerful."

In the research conducted among the Dominicans, Vandebroek and colleagues [29] suggested that the infectious character and/or perceived seriousness of a health problem played a role in the choice of mixture instead of single-ingredient remedies. The main purpose of combining different herbal and nonherbal ingredients was to provide a guarantee that there would be a substance that would be effective in the treatment of a particular illness. Ford [50] described this as following the flexibility of northern Mexicans concerning medicinal plant use: *if one item is not available, because it is out of season, or climatic conditions are inappropriate, another can be used. If one item does not cure, an alternative can be tried, if one cure helps somewhat, two or three might be even better*. This could be an explanation in our area too, but it may be more likely that the described practices reflect an ample knowledge of different alternative uses of plants and animals apt for medicinal mixtures.

4.2. Honey-Based Mixtures as Food Medicines. Twenty-nine botanical species and 7 animal products (62 percent of the total) reported in our research are edible and are employed in the local diet [12, 51, 52]. Most of the registered mixtures are actually food medicines [53, 54]. The dominant character of mixtures as medicinal food is probably due to the dual function of honey as a medicinal and food resource among *Criollos* and Poles, who consume it on many occasions and in different contexts—as a tidbit and snack, as a component of the daily diet, and as a part of ceremonial food [16]. Additionally, food plants constitute an important part of local pharmacopoeias in the Atlantic Forest Ecoregion [55, 56].

The importance of food medicine has been well documented in Polish ethnomedicine [56]. Some of the formulas mentioned by migrants can be traced directly to Polish ethnomedical literature, for example, the blend of honey and milk used for coughs and sore throats [57]. *Criollos* use food plants originating from the Old World, like garlic—ajo—(*A. sativum* L.) and watercress—agrión—berro—(*Nasturtium officinale* R. Br.), which were not reported by Polish informants. In both groups edible herbal species are mainly nonnative vegetables and adventitious species. Also in other studies from Latin America there are many reports of the use of food plants in mixtures with honey, for example, different species of citrus, usually lemon [18, 19, 22, 27]. Cebolla (*A. cepa* L.) and ajo (*A. sativum*) are commonly used species in these preparations. The mixture of honey, onion, and oil was reported in Cuba [27], while honey and cebolla (*A. cepa*), and honey and ajo (*A. sativum*) are used medicinally in Brazil [19, 22]. Just as common is the use of vegetable oil, animal fat, and animal-derived products like milk and eggs. The mixture of fat (e.g., turtle or rhea fat) and honey is used to treat asthma, bronchitis, and flu in Brazil [21, 58, 59], Capybara oil (*Hydrochoerus hydrochaeris*), mentioned by both groups in our study, is one of the animals with medicinal properties most frequently cited by traders in the Federal District of Brazil [59]. Among the industrially processed plants, sugar (*Saccharum officinarum* L.) has been mentioned as a common ingredient especially in complex preparations such as bottles, syrups, and other mixtures [27, 29]. In contrast, in our research it is tea—té—(*T. sinensis* L.), which achieved the highest RI value and the highest frequency of mentions of all processed plants.

4.3. Ailments Treated with Honey-Based Medicines. Pure honey and honey-based mixtures are used primarily to treat respiratory symptoms and illnesses by both study groups. Additionally, there is a very high consensus within each group on the resources used in medicinal mixtures destined to treat respiratory system disorders. Among other body system disorders, skin problems are also commonly treated with honey-based medicines. However, *Criollos* use them more frequently than Poles do. Skin problems are treated predominantly with pure honey, or alternatively with a compress/poultice made from honey and a plant species. Honey is also considered a praised remedy for ophthalmic ailments. To treat eye problems, honey is applied exclusively in its pure form. Generally, the research shows that mixtures destined to treat internal problems are decisively more complex than those applied topically. Among other afflictions, digestive disorders and humoral symptoms gained some importance, especially among Poles. In the study region digestive disorders are treated predominantly with herbal medicines. Forty percent of all medicinal plants registered by Moreau [9] are used for digestive tract problems by the *Criollos* population. The results of our study are consistent with reports from other parts of Latin America. Honey, solely or in combination with other elements, is primarily employed in the treatment of respiratory system afflictions, followed by skin problems to a lesser extent, and with some variations in the order of importance, musculoskeletal, ophthalmic, circulatory, and digestive system disorders [19, 22, 27, 39]. Honey also has been reported as a tonic, an antidote to snake and dog bites, as an aphrodisiac, to treat culture-bound syndromes such as evil eye [19, 21, 39, 58, 60], and in mixtures to treat reproductive system disorders [39].

4.4. Medicinal Resources and Local Landscape. The selection of medicinal resources in home medicine is an ongoing process. In the study region, the pattern of plant and animal exploitation for medicinal purposes have been shaped by cultural and ecological aspects. As a consequence of the massive migration that Misiones witnessed, large portions of the Atlantic Forest of the Upper Parana have been converted into forest monocultures, cultivated fields and pastures. The nonindigenous population of the northern Misiones lives in modified and disturbed environments [61, 62].

Therefore, nearly all the species documented in this research come from modified habitats and home gardens. Very few of the species mentioned are collected from the primary forest, for example, *Picrasma crenata* (Vell.) Engl.; other plants, like *Bromelia balansae* Mez, *Campomanesia xanthocarpa* O.Berg, *Celtis iguanaea* (Jacq.) Sarg., *Hydrocotyle leucocephala* Cham. & Schltdl., and *Piper mikanianum* (Kunth) Steud. prosper both in primary and second growth forests. As for the honey of stingless bees, it is collected from the wild in the primary and secondary forest, but in the case of yateí and mirí, sometimes their nests are transported towards the household in logs, and honey is collected from there. The latter practice has been more often reported by Poles. Apart from ecological aspects, the dominant exploitation of home units by the study groups is due to the number of resources needed for complex remedies (see Cano and Volpato [27]). Keller and Romero [8] observed that *Criollos* from the central part of Misiones employed a similar number of cultivated and wild species in their home therapies, but the cultivated plants were used more frequently, due to easy access to them. The prevalence of plants and animal products originating from the home units is probably due to the same factor as in the case of *Criollos* from the center of Misiones—relatively small distance from medicinal resources. Strategies which aim to guarantee easy access to medicinal natural resources is a tendency observed in other parts of Atlantic Forest too, for example, among Caiçaras—farmers of mixed origin, and Afro-Brazilian communities living in the Atlantic Forest in the state of Santa Catarina, Brazil. These communities also explore managed and modified habitats in medicinal plant procurement [55, 62]. At the first sight, the practices of neighboring Mby'a communities, for whom the forest is the most important source of natural medicines, may contrast with the strategies of nonindigenous communities from the same region [2, 52]. Nevertheless, the Mby'a who camp or live in the forested areas also exploits the proximity of their households [1].

Over fifty percent of species and products used in honey-based mixtures are cultivated and nonnative to the area. The number of purchased and collected species is similar. The collected plants and animals are forest species and weeds, which prosper in ruderal and cultivated areas. There is a difference between Poles and *Criollos* in this respect. This is most probably due to the fact that *Criollos*, who have a longer presence in the area and are more influenced by indigenous communities, rely more on noncultivated species and explore more of the forest in search of plants and honey than Poles do. The relative importance of purchased products in medicinal formulas indicates that the knowledge of nonindigenous populations goes through a globalized process. The relevance of cultivated and purchased plant and animal products may be also due to the fact that honey-based mixtures are predominantly medicinal foods [16]. The low similarity, which we found between and within each of the study groups, considering the mode and place of obtaining medicinal resources is consistent with the diversity of approaches observed amongst Mby'a by Crivos and colleagues. Mby'a people as a cultural group share the same body of ecological knowledge, but individuals have different personal strategies for obtaining specific resources [1]. It is likely that the low similarity between Poles and *Criollos* is also due to cultural differences in their conceptions of the environment, and different approaches to management of environments.

This research has contributed to the documentation of local knowledge and practices concerning medicinal mixtures within the nonindigenous population of Misiones. On the one hand, we observe a great variability in honey-based mixtures, which reflects the inherited ethnomedical traditions of the study groups, a cultural legacy, which persisted throughout the migration process; then we observe the individualistic character of strategies and choices, as well as a heterogenic perception of resource availability between the cultural groups of Misiones. On the other hand, we observe a heterogeneity of practices within each cultural group. Heterogeneity in medicinal practices indicates variation in medicinal knowledge, which may positively influence knowledge exchange among individuals from the same community and between members of different cultural groups. It may also encourage people to experiment with plant and other medicinal resources.

On the whole, the new culturally sensitive politics of the Ministry of Health will make sense, if it shows a closer insight into this local dynamic and tries to understand what are the main social and environmental modelers involved in therapeutic choices. Therefore, new qualitative, in-depth approaches are needed to address the problem, such as stories of life, social networking, and knowledge exchange, so that future health actions are designed taking the appropriate local context into account [63–66].

Results like ours are also relevant to ethnopharmacological follow-up studies, because they inform how different elements are combined to create a desirable effect. Moreover, focusing solely on individual plants is not efficient in the treatment of those health afflictions that are preferentially treated with mixtures by local people (see Vandebroek et al. [29]).

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Research Article

The Trade in Medicinal Animals in Northeastern Brazil

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Over the centuries, a significant part of the Brazilian fauna is widely sold, more specifically in retail stores or street markets. The objective was to characterize the sale of medicinal animals in five large northeast cities. Information about the sale of zootherapeutic items was obtained in the cities of Aracaju-SE, Fortaleza-CE, Maceio-AL, Recife-PE, and Salvador-BA. A total of 68 animal species were sold for medicinal purposes in the cities studied; these are the first results on the use and sale of zootherapeutics in the markets of Aracaju, Fortaleza, and Salvador and first recorded on the medicinal use of the *Achatina fulica, Trachycardium muricatum, Philodryas olfersii, Desmodus rotundus,* and *Leptodactylus vastus*. Knowledge of the fauna utilized popular medicine is indispensable for conservation, demonstrating that research on this subject is necessary to determine appropriate practices for the management of the fauna.

1. Introduction

Brazil has a rich diversity of animal species, which, along with its extensive cultural diversity, is reflected in a complex knowledge of the uses of faunistic resources [1–3]. Over the centuries, a significant part of the fauna has been utilized for alternative therapeutic agents by different people of the country [1, 4], a practice that has been perpetuated since colonial times and currently is widely spread among rural and urban communities in various regions of Brazil [5, 6]. In the cities, zootherapeutic products are widely sold, more specifically in retail stores or street markets as noted by recent ethnozoological studies [1, 4, 7–12].

Studies carried out in stores and street markets for the purpose of evaluating the commerce of medicinal animals are scarce [13]. Albuquerque et al. [14] affirm that these outlets can, on a small scale, represent the biodiversity of a region, making it possible to identify areas of extensive exploitation, which can provide information to help monitor the regional biodiversity. From an ecological perspective, the sale of plants and animals at these locations makes them important, since the demand for these resources can have direct and indirect implications on the diversity exploited. Thus, as pointed out by Almeida and Albuquerque [7], the information obtained in these commercial centers can be utilized for the formulation of rational strategies in the commercialization and use of these resources.

Considering that various animal species sold for medicinal use are on lists of threatened species [15], the ecological implications associated with this modality of exploitation of fauna are evident. Whiting et al. [16] noted that biologists and ecologists have neglected information about traditional commerce in devising strategies for the conservation of the species utilized for the production of traditional remedies. Therefore, ethnozoological studies are important, because they provide information about the species utilized for traditional purposes (medicinal, religious, food, etc.), which can contribute to the development of actions that allow the maintenance of faunistic resources [7, 13, 17].

In Northeast Brazil, the commerce of zootherapeutic products is common. Recent studies conducted in 10 cities in the region [5, 12, 18–22] demonstrated the existence of intense use and commercialization routes of animals for medicinal purposes among these cities. However, there are still gaps concerning the richness of traded species, which makes it difficult to evaluate the magnitude and impact of this commerce on natural populations of the animals involved, as well as potential implications of such uses for the public health of local users.

Despite the existence of information on the sale of animals for medicinal purposes in some important cities of Northeast Brazil, such as Aracaju-SE, Fortaleza-CE, and Salvador-BA, there are no published data available. For the cities of Maceio-AL and Recife-PE, although the commerce of medicinal fauna has been previously investigated, the list of species presented does not include all taxonomic groups but shows few animals identified at the species level.

The objective of the present study was to characterize the sale of medicinal animals in five large northeast cities. More specifically, the work aimed to (i) list which animals are sold for medicinal purposes in the capitals of the states of Sergipe (Aracaju), Ceará (Fortaleza), Alagoas (Maceió), Pernambuco (Recife), and Bahia (Salvador); (ii) evaluate the versatility of the animal species by calculating the relative importance; (iii) test the idea of utilitarian redundancy; (iv) compare the degree of similarity between the localities sampled; (v) estimate the richness and diversity of species traded; and based on this information, discuss aspects related to conservation and public health associated with the medicinal fauna commerce in Brazil.

2. Materials and Methods

2.1. Area of Study. Information about the use and sale of zootherapeutic products was obtained in the cities of Aracaju-SE, Fortaleza-CE, Maceio-AL, Recife-PE, and Salvador-BA (Figure 1). In Maceio and Recife, prior studies on the sale of zootherapeutic products have been carried out [5, 22], where the first involved only one taxonomic group (reptiles) and both works did not show information on the number citations among the vendors, which prompted us to include these cities in our research.

2.2. Procedures. Field work was undertaken during the period from January to November of 2010, in public markets of Aracaju (Mercado Central), Fortaleza (Mercado Central, São Sebastião, and Praia do Futuro), Maceió (Mercado da Produção), Recife (Mercado São José, Afogados, Água Fria, Encruzilhada, and Casa Amarela), and Salvador (Feira de São Joaquim, Sete Portas, and Itapuã).

To obtain the information we interviewed 102 (65 men and 37 women) merchants about the use and commercialization of medicinal animals, being 12 in the Aracaju city (11 men and 1 woman), 29 in Fortaleza (17 men and 12 women), 17 in Maceió (7 men and 10 women), 21 in Recife (16 men and 5 women), and 23 in Salvador (14 men and 9 women).

Sampling was nonrandom intentional, in which the interviewees were predefined [23], composed only of people who actually sold zootherapeutic products. Semistructured questionnaires were used, complemented by free interviews and informal conversations. The questionnaires contained questions on the animal species used for medicinal purposes, their respective uses, preparations, and parts utilized.

To respect intellectual property rights, we adopted the following protocol in the field: before the survey, we introduced ourselves, explained the nature and objectives of our research, and asked the respondents for permission to record the information. The ethical approval for the study was obtained from the Ethics Committee of Universidade Federal da Paraíba (Protocol: CEP/HULW no. 065/10).

Vernacular names of species were recorded as quoted during the interviews. Zoological material was identified with the aid of specialists, through examination of voucher specimens donated by the interviewees or purchased at the surveyed markets, and through photographs taken during interviews of the animal species or their parts. Whenever necessary, these procedures were supplemented by checking vernacular names provided by traders against the scientific names, with the aid of taxonomists familiar with the study areas.

2.3. Data Analysis. The ailments treated by zootherapeutics were grouped into categories based on the model used by the "Centro Brasileiro de Classificação de Doenças" (Brazilian Center for the Classification of Diseases) [24].

To estimate the level of agreement between interviewees over which animals to use for each category, we calculated the informant consensus factor (ICF), adapted from Heinrich et al. [25] that looks at the variability of animals used for each treatment, and therefore the consensus between practitioners. This factor estimates the relationship between the "number of use reports in each category (*nar*) minus the number of taxa used (*na*)" and the "number of use reports in each category minus 1." ICF is thus calculated using the following formula:

$$\text{ICF} = \frac{nar - na}{nar - 1}. \quad (1)$$

The product of this factor ranges from 0 to 1. A high value (close to 1) indicates a high consensus, where relatively few taxa (usually species) are used by a large proportion of people, while a low value indicates that the informants disagree on the taxa to be used for treating a particular illness.

2.4. Relative Importance (RI). The relative importance (RI) of the species cited was calculated (adapted from Bennett and Prance [26]). Relative importance was calculated according to the following formula, with "2," being the highest possible value, indicating the most versatile species. The most versatile species are those that have the greatest number of medicinal properties: RI = NCS + NP, where NCS (number of body systems) is the number of body systems treated by a given species (NCSS) divided by the total number of body systems treated by the most versatile species (NCSSV). The number of properties (NP) is obtained by the relationship between the number of properties attributed to a species

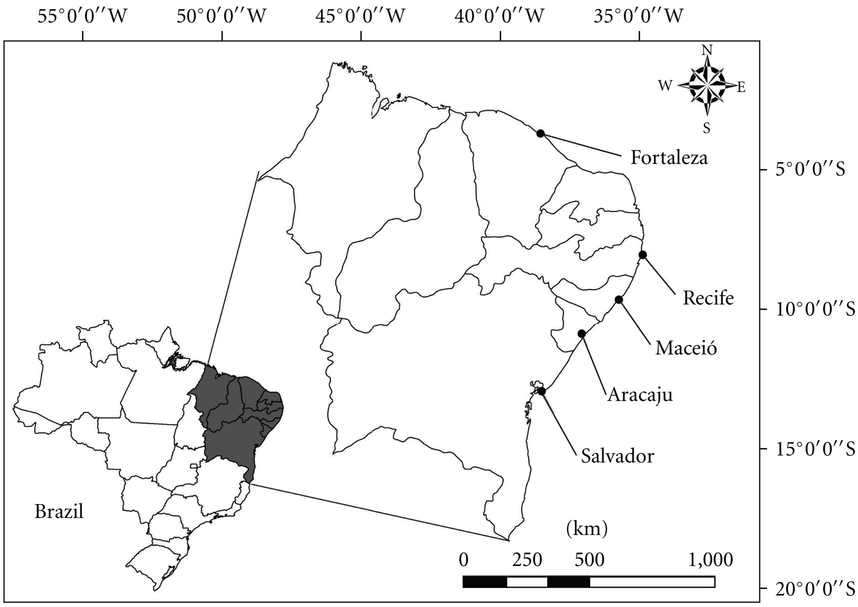

Figure 1: Map locating the cities studied in Northeastern Brazil.

(NPS) divided by the total number of properties attributed to the most versatile species (NPSV).

2.5. Utilitarian Redundancy of the Diseases and/or Symptoms. Utilitarian redundancy of zootherapeutic products was tested according to the model adapted from Albuquerque and Oliveira [27]. According to these authors, the idea of utilitarian redundancy is based on the theory of ecological redundancy (this theory indicates that all species present specific functions in the ecosystem, but some can show similar functions, minimizing damages in the ecosystem due the extinction) (see [28, 29]). Therefore, the notion of functional redundancy relies on the presumption that some species are utilized for the treatment of more than one disease and/or symptom, such that the inclusion of more than one species within a disease category can be a mechanism of reducing the impact on the animals sold for medicinal purposes.

To evaluate this hypothesis, each disease and/or symptom was categorized according to the level of redundancy of the species used: highly redundant (≥15% of the number of species utilized), redundant (15% < the number of species ≥5%), and not very redundant (<5% of the species). In order to evaluate the idea of utilitarian redundancy in a possibly better manner, the diseases and/or symptoms were not reclassified, and thus the names cited by the informants were kept.

2.6. Coefficient of Similarity. The composition of the species cited was compared between the cities studied by means of the similarity index based on data of multiple incidence. The similarity between the localities was estimated using the distance coefficient of Bray-Curtis [30]. The similarity matrix was constructed and grouping analysis performed in the past program [31].

2.7. Estimate of Species Richness. Initially, incidence data (presence or absence) of the species in the markets of Aracaju, Fortaleza, Maceio, Recife, and Salvador were used to estimate the richness of medicinal species sold in each city. The term richness of species refers to the number of species living in the determined area [32]. However, due to the difficulty to access the total number of species, indexes of estimated richness are important tools to identify the most probable number of species living on the ecosystem, community, or, as our work, on the public markets. Species richness was calculated utilizing the estimators CHAO 2, ICE, Jackknife 1, and Jackknife 2 (see [30]), with the program Estimate S 8.2.0 [33]. These indices have been utilized in ethnobotanical and ethnozoological studies [16, 34].

3. Results and Discussion

In the cities studied, the trade in animal-based medications was shown to be common practice. A total of 68 animal species, distributed in 47 families, were sold for medicinal purposes in the cities studied (Table 1). The most representative taxa were mammals (20), reptiles (17), and birds (12) (see Figure 2). These are the first results on the use and sale of animals for traditional medicine in the markets of Aracaju, Fortaleza, and Salvador, where the commercialization of respectively 19, 28, and 36 species was recorded. For the cities of Recife and Maceio, the number of species recorded was higher than that documented in previous works. In Recife, Silva et al. [5] recorded the commerce of 18 medicinal species, while in Maceió, Freire [22] reported the use of 17 species of reptiles sold for medicinal purposes. In the present study, we recorded 31 and 27 species in Recife and Maceió, respectively.

The increase in the number of species cited for medicinal purposes, sold in the markets of Recife and Maceio may be the result of the structure of the traditional medicine systems of the public markets, because these are open and dynamic systems, which are inclined to increase in species over the

Table 1: Animal species commercialized for medicinal purposes in the municipalities of Aracaju-SE, Fortaleza-CE, Maceió-AL, Recife-PE, and Salvador-BA.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Molluscs								
Achatinidae								
Achatina fulica (Ferussac, 1821), giant east African snail, caramujo gigante africano	Shell	Stroke	0.12	—	—	—	—	5/0.14
Cardiidae								
Trachycardium muricatum (Linnaeus, 1758), yellow pricklycockle, rala-côco	Shell	Stroke	0.12	—	—	—	—	2/0.14
Strombidae								
Strombus pugilis Linnaeus, 1758, west Indian fighting conch, estrombo-lutador-das-Índias-Ocidentais	Shell	Stroke and "simpatias"	0.23	2/0.56	—	—	—	1/0.14
Insects								
Apidae								
Apis mellifera (Linnaeus, 1758), honey bee, abelha italiana	Honey and wax	Bronchitis, cough, flu, nasal congestion, asthma, sore throat, stomach ache, diarrhea, and cracks in the feet	0.62	4/0.78	22/1.02	4/0.32	10/0.34	6/0.36
Melipona subnitida (Ducke, 1910), stingless bee, jandaíra	Honey and wax	Sore throat, cough, and diarrhea	0.18	—	4/0.55	—	—	—
Melipona scutellaris Latreille, 1811, stingless bee, uruçu	Honey and wax	Asthma, cough, flu, nasal congestion, earache, stomach ache, diarrhea, and gastritis	0.59	—	—	4/1.09	1/0.18	—
Partamona cupira (Smith, 1863), stingless bee, abelha cupira	Honey and wax	Sore throat, flu, cough, nasal congestion, and diarrhea	0.33	—	2/0.55	2/0.43	1/0.34	—
Blattidae								
Periplaneta americana (Linnaeus, 1758), cockroach, barata	Wings and whole animal	Asthma and earache	0.23	2/0.56	—	—	—	—
Termitidae								
Nasutitermes corniger (Motschulsky, 1855), térmite, cupim de aroeira	Whole animal	Asthma, cough, flu, and sore throat	0.21	—	4/0.45	—	—	—
Equinoderms								
Echinasteridae								
Echinaster echinophorus (Lamarck, 1816), starfish, estrela do mar	Whole animal	Asthma, flu, stroke, "simpatias," erysipelas, cancer, and thrombosis	0.64	7/0.83	—	3/0.44	—	6/0.60
Oreasteridae								
Oreaster reticulatus (Linnaeus 1758), starfish, estrela do mar	Whole animal	Asthma, stroke, erysipelas, cancer, "simpatias," and evil eyes	0.61	6/0.83	1/0.24	3/0.54	6/0.59	4/0.56

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Fishes								
Erythrinidae								
Hoplias malabaricus (Bloch, 1794), trhaira, traíra	Fat	Earache, healing, strain, sore throat, cough, asthma, swelling, urinary infection, and infections	0.79	2/1.39	4/1.17	—	—	—
Gymnotidae								
Electrophorus electricus, (Linnaeus, 1766), electric eel, peixe-elétrico, LR	Fat	Rheumatism, osteoporosis, crack in the feet, pains, inflammation, sore throat, asthma, cough, sinusitis, flu, swelling, itch, wound, earache, toothache, burns, muscular pain, bruises, strain, headache, joint pain, erysipelas, snake bites, skin diseases, healing, and boils	1.51	1/0.67	4/1.79	2/1.41	1/0.64	3/1.26
Syngnathidae								
Hippocampus reidi (Ginsburg, 1933), longsnout seahorse, cavalo-marinho, DD	Whole animal	Asthma, flu, stroke, erysipelas, toothache, circulatory problems, and thrombosis	0.64	4/0.39	4/0.24	4/0.54	7/0.28	9/0.78
Unidentified family								
Shark, tubarão	Cartilage	Rheumatism	0.12	—	1/0.24	—	—	—
Unidentified family								
Stingray, Raia	Fat	Sore throat, pains, rheumatism, burns, asthma, and infections	0.53	—	1/1.26	—	—	—
Amphibians								
Bufonidae								
Rhinella jimi (Stevaux, 2002), cururu toad, sapo cururu, LR	Skin and fat	Sore throat, asthma, flu, cough, rheumatism, inflammation, backache, osteoporosis, arthrosis, arthritis, strain, diarrhea, “simpatias,” toothache, cancer, infections, and earache	1.13	1/0.67	7/1.45	—	1/0.94	1/0.18
Leptodactylidae								
Leptodactylus labyrinthicus (Spix, 1824), South American pepper frog, rã-pimenta, LR	Fat	Sore throat, cough, and asthma	0.18	—	2/0.38	—	—	—
Leptodactylus vastus Lutz, 1930, South American pepper frog, rã-pimenta, LR	Fat	Sore throat, cough, asthma, arthritis, and backache	0.33	—	3/0.69	—	—	—

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Reptiles								
Chelidae								
Tortoise, cágado_Fortaleza	Fat	Rheumatism, cracks in the feet, arthrosis, backache, sore throat, and swelling	0.53	—	2/1.10	—	—	—
Tortoise, cágado_Recife	Carapace	Asthma, burns, and rheumatism	0.35	—	—	—	1/0.53	—
Cheloniidae								
Chelonia mydas (Linnaeus, 1758), green turtle, tartaruga verde, EM	Fat and carapace	Sore throat, rheumatism, swelling, inflammation, burns, healing, cough, asthma, arthritis, backache, cancer, backache, stroke, thrombosis, erysipelas, stomach ache, and infections	1.18	—	4/1.38	—	—	1/0.92
Testudinidae								
Chelonoidis sp, tortoise, jabuti	Fat	Sore throat, cough, asthma, earache, backache, and inflammations	0.53	—	1/1.17	—	—	—
Iguanidae								
Iguana iguana (Linnaeus, 1758), common green iguana, camaleão, DD	Fat and tail	Earache, deafness, sore throat, inflammations, swelling, wounds, burns, and acne	0.67	—	—	3/0.71	1/1.05	—
Teiidae								
Cnemidophorus ocellifer (Spix, 1825), spix's whiptail, calango	Whole animal	Stroke, thrombosis, cancer, and hemorrhoids	0.30	—	—	2/0.71	—	—
Tupinambis merianae (Duméril and Bibron, 1839), teju lizard, téju, LR	Fat, skin, and tail	Sore throat, pneumonia, sinusitis, flu, bronchitis, asthma, cough, rheumatism, swelling, strain, inflammations, earache, deafness, backache, arthrosis, arthritis, burns, osteoporosis, healing, muscular pain, cracks in the feet, toothache, headache, itch, lung problems, infections, pains, injuries, gastritis, snake bites, and skin diseases	1.67	1/2.00	12/1.83	3/1.79	8/1.82	5/1.66
Boidae								
Boa constrictor (Linnaeus, 1758), boa, jibóia, DD	Skin, fat, bone, and feces	Sore throat, cough, toothache, rheumatism, inflammations, asthma, flu, arthrosis, osteoporosis, cracks in the feet pains, arthritis, backache, healing, "simpatias," swelling, bruises, cancer, tuberculosis, pneumonia, edemas, and stomach ache	1.29	2/1.67	8/1.60	3/1.52	—	2/0.86

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Epicrates cenchria (Linnaeus, 1758), rainbow boa, salamanta, DD	Fat	Sore throat, rheumatism, swelling, backache, arthrosis, burns, and toothache	0.56	—	1/1.17	—	—	—
Colubridae								
Philodryas olfersii (Lichtenstein, 1823), Lichtenstein's green racer, cobra verde	Whole animal	Stroke	0.12	—	—	—	—	1/0.18
Spilotes pullatus (Linnaeus, 1758), yellow rat snake, caninana,	Bone and fat	Sore throat, cancer, and inflammations	0.35	—	—	—	—	1/0.42
Elapidae								
Micrurus ibiboboca (Merrem, 1820), caatinga coral snake, cobra-coral	Fat	Rheumatism, asthma, toothache, sore throat, cough, osteoporosis, swelling, inflammations, arthritis, and healing	0.57	—	—	3/0.97	—	—
Caudisona durissa (Linnaeus, 1758), rattlesnake, cascavel, LR	Fat, rattle, bone, and skin	Backache, rheumatism, cracks in the feet, osteoporosis, swelling, inflammation, arthritis, arthrosis, asthma, sore throat, earache, healing, burns, toothache, cough, bronchitis, snake bites, stroke, muscular pain, injuries, epilepsy, cancer, tuberculosis, "simpatias," "evil eyes," "attract partners," and "attract money"	1.70	2/1.67	3/1.38	2/2.00	4/1.88	3/0.96
Unidentified family								
Alligator, jacaré_Aracaju	Skin	Stroke, asthma, bronchitis, and rheumatism	0.38	3/0.94	—	—	—	—
Alligator, jacaré_Maceió	Skin	Stroke, bronchitis, backache, toothache, snake bite, and rheumatism	0.53	—	—	2/0.98	—	—
Alligator, jacaré_Recife	Fat and skin	Sinusitis, bronchitis, asthma, sore throat, toothache, burns, thrombosis, cancer, and diarrhea	0.71	—	—	—	4/1.35	—
Alligator, jacaré_Salvador	Skin	Asthma, stroke, tuberculosis, sexual impotence, snake bites, inflammations, menstrual cramps, headache, and stomach ache	1.07	—	—	—	—	6/1.24

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Birds								
Anatidae								
Anser anser (Linnaeus, 1758), greylag goose, ganso	Fat	Flu, cough and sore throat	0.18	—	—	—	1/0.28	—
Anas platyrhynchos Linnaeus, 1758, mallard, pato	Fat and eggs	Asthma, sore throat, sinusitis, and sexual impotence	0.30	—	—	—	—	2/0.54
Ciconiidae								
Coragyps atratus (Bechstein, 1793), black vulture, urubu, LR	Fat, liver, and e feather	"Simpatias," alcoholism, and asthma	0.35	—	1/0.24	4/0.44	2/0.18	—
Columbidae								
Columba livia Gmelin, 1789, common pigeon, Pombo	Fat	Sore throat, sinusitis, cough, and asthma	0.21	—	—	—	—	2/0.26
Phasianidae								
Gallus gallus, (Linnaeus, 1758), chicken, galinha	Fat and spur	Cough, sore throat, flu, sinusitis, sexual impotence, swelling, nasal congestion, fever, diarrhea, earache, skin diseases, strain, burns, menstrual cramps, inflammations, pains, bruise, and cracks in the feet	1.33	2/0.89	2/0.55	—	2/0.34	4/1.62
Numida meleagris (Linnaeus, 1758), helmeted guineafowl, galinha d'angola	Fat	Nasal congestion, flu, rheumatism, asthma, strain, burns, and healing	0.48	—	—	—	—	1/0.58
Pavo cristatus (Linnaeus, 1758), common peafowl, pavão	Fat and feather	Snake bite, asthma, and sore throat	0.26	—	—	1/0.44	—	1/0.28
Rheidae								
Rhea americana (Linnaeus, 1758), greater rhea, ema, NT	Fat	Acne, rheumatism, cracks in the feet, burns, and nasal congestion	0.49	—	—	—	1/0.76	—
Unidentified family								
Owl, coruja_Fortaleza	Fat	"Simpatias"	0.12	—	1/0.24	—	—	—
Owl, coruja_Salvador	Fat	Sore throat, rheumatism, toothache, sinusitis, pains, and infections	0.44	—	—	—	—	1/0.54
Unidentified family								
Pheasant, faisão	Fat	Sore throat, rheumatism, toothache, sinusitis, and pains	0.41	—	—	—	—	1/0.50
Unidentified family								
Hawk, gavião	Fat	Asthma, cough, sore throat, fever, diarrhea, and earache	0.53	—	—	—	—	1/0.64
Mammals								
Agoutidae								
Cuniculus paca (Linnaeus, 1766), spotted paca, paca, LR	Penis	Sexual impotence	0.12	—	—	—	—	1/0.14

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Bovidae								
Bos taurus (Linnaeus, 1758), cow, boi	Fat, tail, skin, horn, and fel (bile)	Asthma, sore throat, flu, stroke, bronchitis, thrombosis, swelling, diarrhea, sexual impotence, "evil eyes," and "simpatias"	0.77	—	4/0.24	4/0.60	2/0.53	5/0.82
Bubalus bubalis (Linnaeus, 1758), water buffalo, buffalo	Tail and horn	Asthma, stroke, and "evil eyes"	0.35	—	—	—	1/0.41	—
Capra hircus (Linnaeus, 1758), domestic goat, bode	Fat and brain	Cracks in the feet, burns, sore throat, asthma, sinusitis, pain, toothache, rheumatism, osteoporosis, infections, inflammations, bruise, erysipelas, strain, and sexual impotence	0.98	1/0.56	—	2/1.04	1/0.76	2/0.72
Ovis aries (Linnaeus, 1758), sheep, carneiro	Fat	Rheumatism, cracks in the feet, sore throat, osteoporosis, arthritis, arthrosis, healing, inflammations, cough, swelling, flu, asthma, burns, pains, muscular pain, acne, circulatory problems, joint pain, bruise, strain, and toothache	1.09	2/1.11	5/1.31	3/1.36	12/1.57	1/0.46
Bradypodidae								
Bradypus sp., sloth, preguiça	Fat, nail, and skin	Thrombosis, stroke, asthma, sore throat, "evil eyes," and circulatory problems	0,44	—	—	4/0.71	2/0.64	—
Canidae								
Canis lupus (Linnaeus, 1758), dog, cachorro	Fat	"Simpatias"	0.12	—	1/0.24	—	—	—
Cerdocyon thous (Linnaeus, 1766), fox, raposa, LR	Fat	Flu, asthma, pains, inflammations, snake bites, strain, rheumatism, and sore throat	0.59	—	—	4/1.09	1/0.18	—
Cervidae								
Mazama gouazoubira (G. Fischer, 1814), gray brocket, veado, VU	Tail, horne, and tíbia	"Simpatias," asthma, sore throat, cough, arthritis, and rheumatism	0.44	—	2/0.93	3/1.20	4/0.95	2/0.48
Dasypodidae								
Dasypus novemcinctus (Linnaeus, 1758), nine-banded armadillo, tatu galinha, LR	Fat and tail	Deafness, earache, asthma, burns, sinusitis, cough, pains, inflammations, urinary infection, strain, and rheumatism	0.85	—	—	1/0.71	1/1.15	—
Euphractus sexcinctus (Linnaeus, 1758), six-banded armadillo, tatu-peba, LR	Fat, tail, and legs	Deafness, earache, asthma, burns, sinusitis, cough, pains, inflammations, strain, rheumatism, "evil eyes," urinary infection, sexual impotence, injuries, tuberculosis, infections, and osteoporosis	1.22	—	—	1/0.71	1/1.20	3/1.22

Table 1: Continued.

Family/species/local name	Part used	Disease (or illness)	RI total	Number of citations per city/RI per city				
				Aracaju	Fortaleza	Maceió	Recife	Salvador
Delphinidae								
Sotalia guianensis (P.-J. van Bénéden, 1864), Guianan river dolphin, boto, DD	Fat, penis, eyes, and blood	"Simpatias," "attract partners," asthma, rheumatism, osteoporosis, burns, sexual impotence, swelling, inflammations, arthrosis, toothache, headache, stomach ache, earache, erysipelas, flu, cough, sore throat, muscular pain, menstrual cramps, cancer, tuberculosis, pneumonia, thrombosis, snake bites, skin diseases, healing, and backache	1.90	1/1.22	1/0.24	7/1.58	6/1.79	6/1.58
Erethizontidae								
Coendou prehensilis (Linnaeus, 1758), Brazilian porcupine, porco-espinho, coandú, LR	Spine	Asthma, bronchitis, cough, thrombosis, cancer, eczema, acne, toothache, stroke, "attract money," and earache	0.94	1/0.83	—	3/0.54	1/0.71	6/0.64
Felidae								
Leopardus pardalis (Linnaeus, 1758), ocelot, jaguatirica, gato maracajá, DD	Eyes	Asthma, "evil eyes," and sexual impotence	0.35	—	—	—	1/0.53	—
Myrmecophagidae								
Myrmecophaga tridactyla (Linnaeus, 1758), Anteater, tamanduá bandeira	Skin	Stroke	0.12	—	—	—	—	1/0.14
Phyllostomidae								
Desmodus rotundus (E. Geoffroy, 1810), vampire bat, morcego, DD	Whole animal	Asthma, stroke, and rheumatism	0.35	—	—	—	—	3/0.42
Suidae								
Sus scrofa (Linnaeus, 1758), pig, porco	Fat	Acne, boils, and bronchitis	0.26	—	—	—	1/0.41	—
Trichechidae								
Trichechus manatus (Linnaeus, 1758), manatee, peixe-boi, CR	Fat	Burns, earache, swelling, wounds, menstrual cramps, bruises, asthma, flu, toothache, inflammations, pains, rheumatism, arthrosis, arthritis, backache, osteoporosis, cancer, thrombosis, sore throat, sinusitis, erysipelas, snake bites, skin diseases, healing, headache, cracks in the feet, and sexual impotence	1.87	1/1.22	—	4/1.63	2/1.28	3/2.00
Unidentified family								
Whale, baleia_Recife	Fat	Sore throat and menstrual cramps	0.23	—	—	—	1/0.36	—
Whale, baleia_Salvador	Fat	Rheumatism and menstrual cramps	0.23	—	—	—	—	2/0.28

Legends: RI: relative importance; CR: critically endangered; EN: endangered; VU: vulnerable; NT: near threatened; LR: lower risk; DD: deficient data.

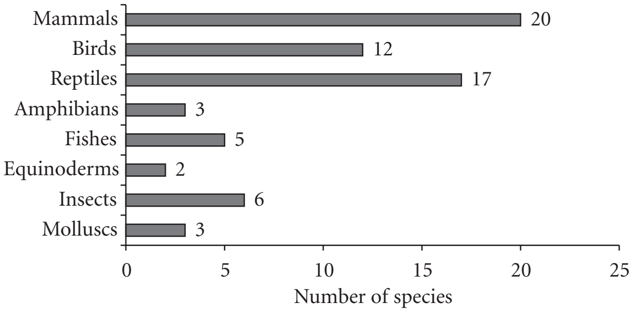

FIGURE 2: Number of animal species used as remedies per taxonomic category in Northeastern Brazil.

years, although with a tendency to maintain the species of greater importance [14]. These authors studied the sale of medicinal plants in the same market in different periods (1995 and 2002) and found an increase of 58 species in a period of seven years (1995 = 78 species and 2002 =136 species), but species of high relative importance continued to be present in the markets evaluated.

Similarly, the data obtained in the present study corroborated the results of Albuquerque et al. [14] for the commerce of medicinal plants. We found an increase in the composition of animal species in the markets of Recife and Maceio, where the sale of species of high relative importance was maintained, such as *Caudisona durissa* and *Tupinambis merianae*, which were recorded in the two periods in which the studies were performed.

In general, the diversity of medicinal species recorded in the present study confirms the importance of the fauna as a therapeutic resource in urban areas, corroborating previous studies that indicated the commercialization of zootherapeutic products as a common activity in various Brazilian cities (see [8, 12, 17–21]). Compared to other studies of markets in Northeast Brazil, the number of medicinal species traded in the cities studied is substantial. In Feira de Santana, BA, for example, a total of 16 animal species were reported being sold for medicinal purposes in the public markets of the city [18], in Santa Cruz do Capibaribe, PE, 37 species [19], in Caruaru, PE, 36 species [20], in the cities of Crato and Juazeiro do Norte 31 species [12], and in the metropolitan region of Natal, 23 species [21].

The majority of the medicinal species sold in the cities studied are the same as those sold and/or utilized in other cities in Northeast Brazil, with the exception of five medicinal species not previously recorded (Figure 3): *Achatina fulica*, *Trachycardium muricatum*, *Philodryas olfersii*, *Desmodus rotundus,* and *Leptodactylus vastus*. Of these species, four were cited only in the Salvador markets (*A. fulica* [cited by five informants], *T. muricatum* [cited by two informants], *P. olfersii* [cited by one informant], and *D. rotundus* [cited by three informants]) and only one in the Fortaleza markets (*L. vastus* [cited by three informants]).

The species of molluscs *A. fulica* and *T. muricatum* are utilized in the treatment of stroke. The fat of *L. vastus* is administered for the treatment of sore throat, cough, asthma, arthritis, and backache. The snake *P. olfersii* is utilized for the treatment of stroke and the bat *D. rotundus* is administered for the treatment of stroke, asthma, and rheumatism.

The species with the highest number of citations were *Apis mellifera* ($n = 46$), *Tupinambis merianae* ($n = 28$), *Hippocampus reidi* ($n = 27$), *Bos taurus* ($n = 23$), *Oreaster reticulatus* ($n = 20$). In other studies on the trade of zootherapeutic products in stores and street markets, these species are also often utilized in the production of traditional remedies [8, 12, 17–21].

Of the species recorded in the present work, the majority represent wild animals (82.4%). Only 12 species of domestic animals are sold as medicinal products, and they are *Anser anser*, *Anas platyrhynchos*, *Numida meleagris*, *Gallus domesticus*, *Pavo cristatus*, *Ovis aries*, *Capra hircus*, *Bos taurus*, *Bubalus bubalis*, *Canis lupus,* and *Sus scrofa*. These results corroborate the tendency observed in other studies, which have demonstrated that wild animals compose the greater part of the medicinal fauna utilized in popular medicine in Brazil [8, 12, 17–21] and in the world [35–40].

All animals cited occur in ecosystems close to the cities studied, with the exception of *Electrophorus electricus*. This species occurs in the Northeast Brazil region, only in the state of Maranhão [41]. Thus, the results indicate a tendency of the commercialization of animals that occurs in the proximity of the localities sampled. This demonstrates the importance of the local fauna in supplying the products utilized in the preparation of traditional remedies, which would reduce the costs for the acquisition and commercialization of zootherapeutic products, but this hypothesis needs to be adequately tested. These data corroborate other works conducted in markets in Northeast Brazil [7–9, 12, 17, 42], which also recorded a predominance of the use of animals of the local fauna for trade, showing the importance of the biodiversity of each region as a resource for zootherapy.

Various parts and metabolic secretions of the animals are utilized in the preparation of medications (Figure 4), and they are skin, fat, honey, wax, shell, wings, spines, rattle, blood, feces, horn, feathers, hoof, tibia, cartilage, eye, tail, liver, claw, foot, eggs, bile, and bone. Animals such as *A. fulica, T. muricatum*, *P. olfersii*, *D. rotundus*, *O. reticulates,* and *H. reidi* can be used whole.

Among the products cited by the informants, fat was cited most often, which can be extracted from the following animals: *H. malabaricus*, *E. electricus*, *R. jimi*, *C. mydas*, *T. Merianae,* and *B. constrictor*. The frequent utilization of fat can be attributed to the fact that the main animals utilized are vertebrates, which have a large quantity of fat in their body [19]. Another possible explanation for the marked use of body fat for medicinal purposes can be due its chemical composition. Body fat consists mainly of fatty acids, which have an extensive proven medicinal applicability [43–45], such that this intense use and/or medicinal trade can be the result of the empirical observation of the efficacy of fat by human users of this zootherapeutic product.

The medicinal animals listed in the present study are applied for the treatment of 58 diseases and/or symptoms (Table 2). The categories with the higher values of ICF were diseases of the respiratory tract (0.91), diseases of the musculoskeletal system and connective tissue (0.89), and undefined

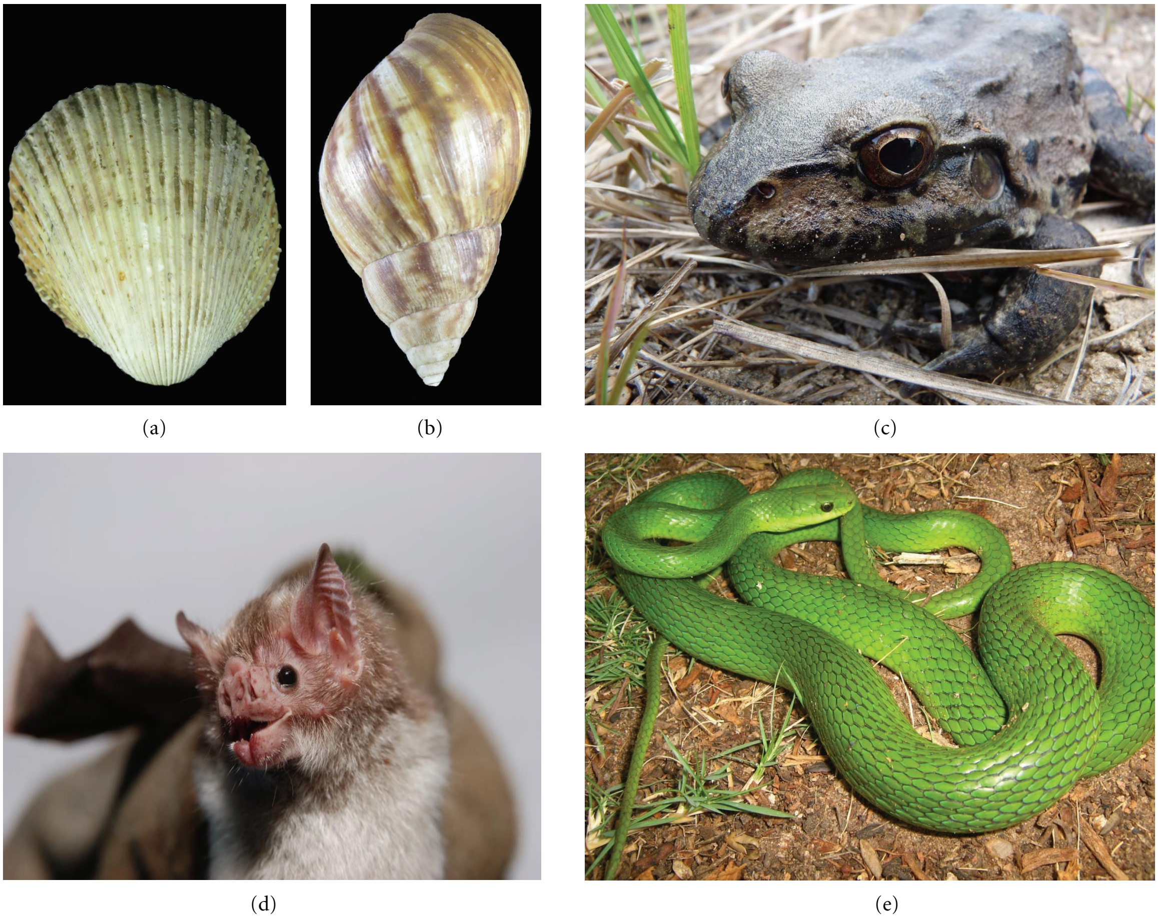

Figure 3: New records of species used in traditional medicine. (a) *Trachycardium muricatum*, (b) *Achatina fulica*, (c) *Leptodactylus vastus*, (d) *Desmodus rotundus*, (e) *Philodryas olfersii* (Photos: (a), (b) Joafrâncio P. Araújo; (c) Hugo Fernandes-Ferreira; (d) Patrício A. da Rocha; (e) Samuel C. Ribeiro).

diseases (0.88). These high values of consensus for these categories were also found in other works carried out in the public markets of North and Northeast Brazil [8, 9, 12, 19, 20].

A total of 1575 citations of uses for medicinal animals were cataloged (Table 3). The categories with highest number of citations were diseases of the respiratory tract (613 citations; 56 species), diseases of the musculoskeletal system and connective tissue (269 citations; 29 species), and undefined diseases (259 citations; 38 species). The diseases with highest number of citations were asthma (226 citations; 14.3%), sore throat (158 citations; 10.1%), and cough (111 citations; 7.1%). Other works carried out in the Northeast also indicate that these diseases are widely treated with medicinal animals [7–9, 12, 19, 20, 40].

Even with the high number of citations to illnesses treated with animal products commercialized in Brazil, there are few laboratory studies testing its efficacy. Ferreira et al. [45] indicate that the body fat of *Boa constrictor* does not present a clinically relevant bacterial activity, but when combined with antibiotics, the fat demonstrated a significant synergistic activity. Similar results are reported to the decoction of the lizard *Tropidurus hispidus* and the termite *Nasutitermes corniger* (see [46–48]). But et al. [49] report the antifever activity of the preparations using the horn of *Bos taurus*. Murari et al. [50] and Ferreira et al. [44] report that extracts of *Pavo cristatus* and the body fat of *Tupinambis merianae* demonstrated anti-inflammatory activity. Tempone et al. [51] showed that steroids from the skin of *Rhinella jimi* are active against leishmaniasis and trypanosomiasis. Besides the high number of animal species commercialized with medicinal uses in Brazil, studies about the improved biological activity of theses products are still preliminary and insufficient. So, the development of more studies is necessary to understand, evaluate, and validate the traditional and medicinal knowledge associated with the use of animal products.

Zootherapeutic remedies can be prepared in the following ways: (a) whole animals or body parts are utilized by maceration, where the resultant powder is ingested in the form of teas or together with food, and (b) body secretions and fat are administered as an ointment or ingested.

According to the informants, 60 species (88.2%) are of multiple uses, that is, they are administered in the treatment of more than one disease and/or symptom. The most versatile species, that is, with the highest RI values are *Sotalia guianensis* (1.90), *Trichechus manatus* (1.87), *Caudisona durissa* (1.70), and *Tupinambis merianae* (1.67). Alves et al.

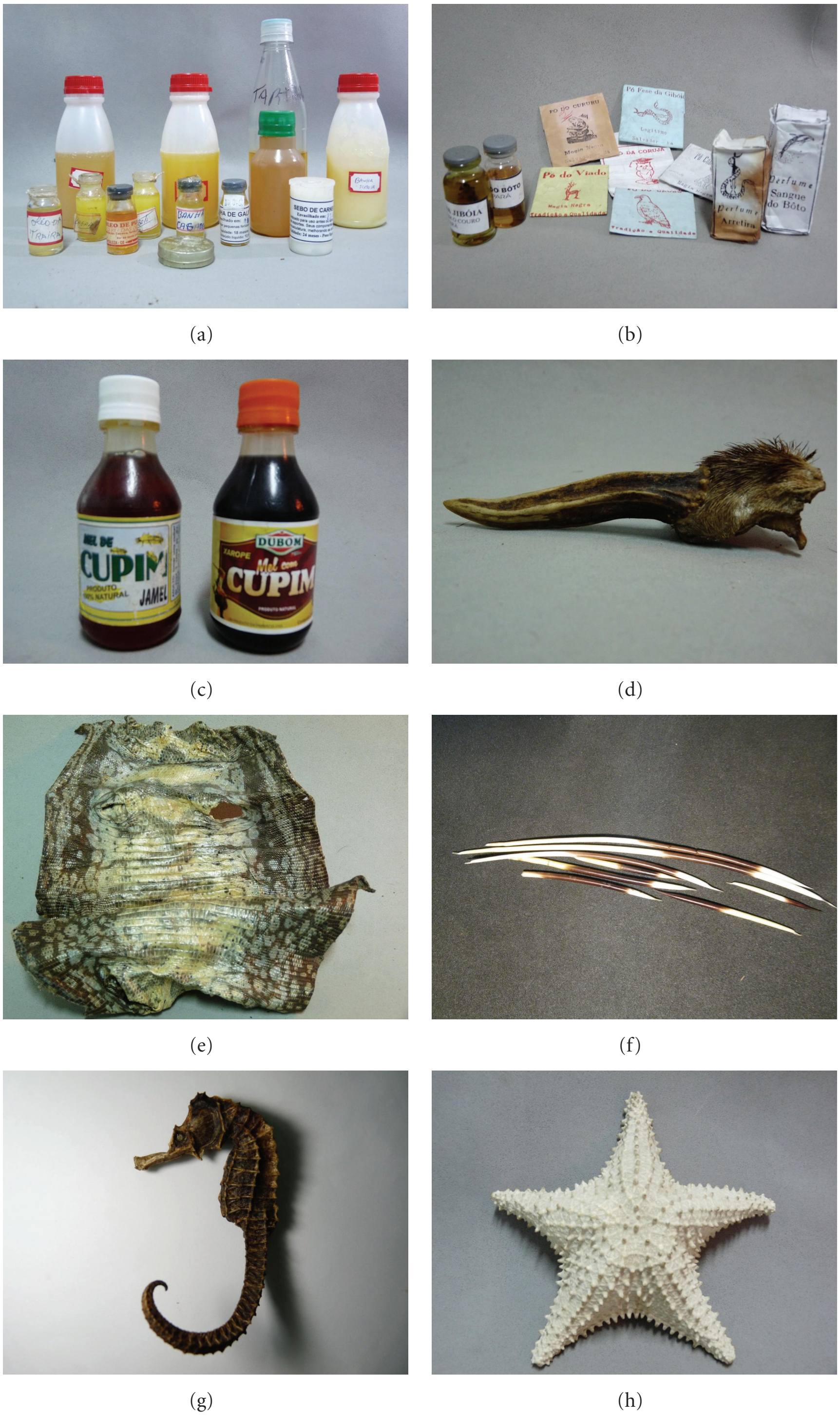

Figure 4: Examples of animal products used as remedies sold in Aracaju-SE, Fortaleza-CE, Maceió-AL, Recife-PE, and Salvador-BA public markets. (a) Body fat; (b) metabolism secretion such as blood, feces, and urine; (c) honey of *Nasutitermes corniger*; (d) horn of *Mazama gouazoubira*; (e) skin of *Tupinambis merianae*; (f) spine of *Coendou prehensilis*; (g) dried Seahorses (*Hippocampus reidi*); (h) dried starfish (*Oreaster reticulatus*). (Photos: Hugo Fernandes-Ferreira).

[20] and Almeida and Albuquerque [7] also cite *C. durissa* and *T. merianae* as versatile medicinal species in other studies carried out on the commerce of zootherapeutic products.

In contrast, the results obtained in this study show that the same disease and/or symptom can be treated with more than one animal species, demonstrating utilitarian redundancy as proposed by Albuquerque and Oliveira [27]. Among the diseases treated with zootherapeutic products in the cities sampled in the present work, 19 are "highly redundant," 23 are "redundant," and 15 are "not very redundant."

Table 2: Categories of diseases treated with animal-based medicines that are sold in public markets in Aracaju-SE, Fortaleza-CE, Maceió-AL, Recife-PE, and Salvador-BA, according to the "Centro Brasileiro de Classificação de Doenças" (1993).

Categories	Diseases cited "by the vendors"	Total
A	"Attract money," "attract partner," "simpatias," "evil eyes," itch, bruise, pain, skin disease, edema, weakness, swelling, inflammations, infections, circulation problems, and lung problems	15
B	Asthma, bronchitis, nasal congestion, sore throat, flu, pneumonia, sinusitis, and cough	8
C	Arthritis, arthrosis, healing, backache, toothache, joint pain, osteoporosis, and rheumatism	8
D	Earache and deafness	2
E	Alcoholism, injuries, muscular pain, strain, snake bites, and burns	6
F	Stomach ache and gastritis	2
G	Acne, boils, eczema, and cracks in the feet	4
H	Sexual impotence	1
I	Stroke, thrombosis, and hemorrhoids	3
J	Urinary infection and menstrual cramps	2
K	Headache and epilepsy	2
L	Diarrhea, erysipelas, and tuberculosis	3
M	Cancer	1
N	Fever	1
Total		58

A: undefined illnesses; B: diseases of the respiratory system; C: diseases of the osteomuscular system and conjunctive tissue; D: diseases of the ear; E: lesions caused by poisoning and other external causes; F: diseases of the digestive system; G: diseases of the skin and the subcutaneous tissue; H: mental and behavioural perturbations; I: diseases of the circulatory system; J: diseases of the urogenital system; K: diseases of the nervous system; L: diseases caused by parasites; M: neoplasias (tumours); N: symptoms not categorized in other part or section.

Diseases such as asthma, sore throat, rheumatism, and cough are examples of categories "highly redundant."

As shown in Figure 5, many species are included in the categories "highly redundant" and "redundant" (67 and 50, resp.), while few species are included in the category "not very redundant" (17 species). Based on the model of utilitarian redundancy, the pressure probably caused in the commercialized species in the markets evaluated is small, because the majority of the species are listed in the categories "highly redundant" and "redundant," where they also have various alternative therapeutic uses. In general, 23 species are on the red list of the IUCN [52], where six are in the category data deficient, 12 in the category low risk, and one in each of the following categories: near threatened, vulnerable, endangered, and critically endangered. In addition, the proportion of species considered threatened did not differ between the redundancy categories analyzed (chi squared = 0.435; $P > 0.05$).

According to Albuquerque and Oliveira [27], the model of utilitarian redundancy suggests that the inclusion of species in the same therapeutic category can lead to reducing the pressure on the medicinal use of animals, such that species included in redundant categories would have options of equivalent products in other species. In this context, the species included in the category "not very redundant" should be prioritized in the development of conservation strategies, because there would not be equivalent species for medicinal use. However, the species in the more concerning categories of the IUCN red list (*Rhea Americana*: near threatened; *Mazama gouazoubira*: vulnerable; *Chelonia mydas*: endangered; *Trichechus manatus*: critically endangered) were not reported as medicines to the treatment of the "not very redundant" diseases, reinforcing our point of view that the commercialization of animals to medicinal uses do not cause a great pressure over the wild livestocks of animals.

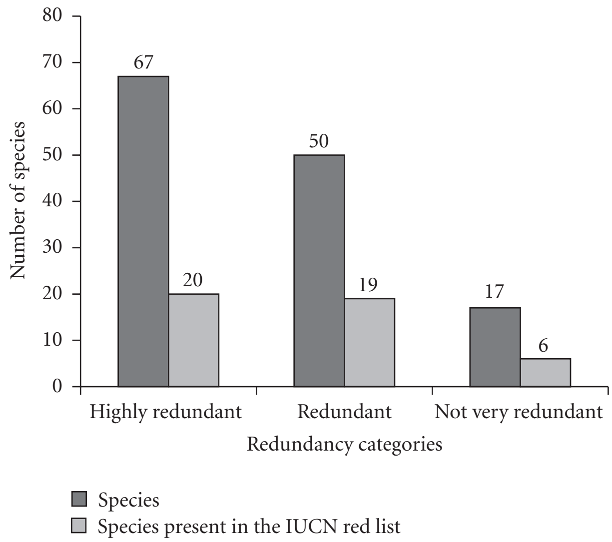

Figure 5: Distribution of the number of species cited per utilitarian redundancy category according to informants of the Aracaju-SE, Fortaleza-CE, Maceió-AL, Recife-PE, and Salvador-BA.

However, this interpretation, about prioritized in the development of conservation strategies, should be taken with caution, since Albuquerque and Oliveira [27] emphasized that even in a redundant category, if there are species that have a greater local preference, the pressure of use would certainly be shifted to them. In addition, the idea of redundancy

Table 3: Consensus factors of the informants for the categories described.

	Categories													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
All localities combined														
Species used	38	56	29	20	22	11	19	9	22	8	6	17	11	2
Percentage of species used (%)	55.8	82.3	42.6	29.4	32.3	16.2	27.9	13.2	32.3	11.7	8.8	25	16.2	2.9
Use citations	259	613	269	51	107	25	42	22	98	17	20	30	20	2
Percentage of use citations (%)	16.4	38.9	17.1	3.2	6.8	1.6	2.6	1.4	6.2	1.1	1.3	1.9	1.3	0.12
ICF	0.88	0.91	0.89	0.62	0.8	0.58	0.56	0.61	0.78	0.56	0.73	0.44	0.47	—
Aracaju-SE														
Species used	10	12	9	4	3	3	2	1	5	—	—	—	—	—
Percentage of species used (%)	52.6	63.1	47.3	21	15.8	15.8	10.5	5.3	26.3	—	—	—	—	—
Use citations	27	45	28	5	8	4	3	1	13	—	—	—	—	—
Percentage of use citations (%)	20.1	33.6	20.9	3.7	5.9	3	2.2	0.7	9.7	—	—	—	—	—
ICF	0.65	0.75	0.7	0.25	0.71	0.33	0.5	—	0.66	—	—	—	—	—
Fortaleza-CE														
Species used	19	23	12	4	4	3	6	1	—	1	—	—	—	—
Percentage of species used (%)	67.8	82.1	42.8	14.3	14.3	10.8	21.4	3.6	—	3.6	—	—	—	—
Use citations	69	155	79	7	4	9	10	1	—	1	—	—	—	—
Percentage of use citations (%)	20.6	46.3	23.6	2	1.2	2.7	3	0.3	—	0.3	—	—	—	—
ICF	0.74	0.85	0.85	0.5	—	0.75	0.44	—	—	—	—	—	—	—
Maceió-AL														
Species used	14	26	12	7	6	2	6	1	8	3	1	4	1	—
Percentage of species used (%)	51.8	96.3	44.4	25.9	22.2	7.4	22.2	3.7	29.6	11.1	3.7	14.8	3.7	—
Use citations	59	150	98	17	20	4	11	4	24	5	6	5	2	—
Percentage of use citations (%)	14.5	37	24.1	4.2	5	0.9	2.7	0.9	5.9	1.2	1.5	1.2	0.4	—
ICF	0.78	0.83	0.88	0.62	0.73	0.66	0.5	1	0.69	0.5	1	0.25	1	—
Recife-PE														
Species used	17	24	12	9	9	2	7	3	8	3	—	1	2	—
Percentage of species used (%)	54.8	77.4	38.7	29	29	6.4	22.5	9.8	25.8	9.8	—	3.2	6.4	—
Use citations	59	136	30	14	47	3	14	4	13	4	—	5	3	—
Percentage of use citations (%)	17.7	40.9	9	4.2	14.1	0.9	4.2	1.2	3.9	1.2	—	1.5	0.9	—
ICF	0.72	0.83	0.62	0.39	0.82	0.5	0.54	0.33	0.41	0.33	—	0.75	0.5	—
Salvador-BA														
Species used	15	26	13	4	10	3	6	6	15	4	6	14	7	2
Percentage of species used (%)	41.6	72.2	36.1	11.1	27.7	8.3	16.6	16.6	41.6	11.1	16.6	38.8	19.4	5.5
Use citations	46	127	34	4	28	4	7	12	48	8	14	20	15	2
Percentage of use citations (%)	12.4	34.4	9.2	1.1	7.6	1.1	1.9	3.2	13	2.7	3.8	0.5	4.1	0.5
ICF	0.69	0.8	0.63	0.57	0.66	0.5	0.17	0.64	0.7	0.57	0.61	0.32	0.5	—

A: undefined illnesses; B: diseases of the respiratory system; C: diseases of the osteomuscular system and conjunctive tissue; D: diseases of the ear; E: lesions caused by poisoning and other external causes; F: diseases of the digestive system; G: diseases of the skin and the subcutaneous tissue; H: mental and behavioural perturbations; I: diseases of the circulatory system; J: diseases of the urogenital system; K: diseases of the nervous system; L: diseases caused by parasites; M: neoplasias (tumours); N: symptoms not categorized in other part or section.

can be applied to the resilience of the local medical system, that is, highly redundant categories would be, in principle, more resilient than those not very redundant.

In relation to the similarity of the cities sampled (Aracaju, Fortaleza, Maceio, Recife, and Salvador), grouping analysis showed that the greater degree of similarity observed was between Maceio and Recife (Figure 6). In the grouping analysis, we can see that the cities close to each other showed greater similarity with regard to the animal species commercialized. Based on these results, these groupings can likely be a reflection of the presence of similar ecosystems in the cities sampled or the presence of more intense commercial routes of zootherapeutic products between closer cities.

Data on the commerce of medicinal animals are difficult to obtain, because many of the venders do not admit that they utilize or sell products originating from the fauna knowing that it can be illegal [17]. Therefore, the use of estimators of species richness represents an important tool.

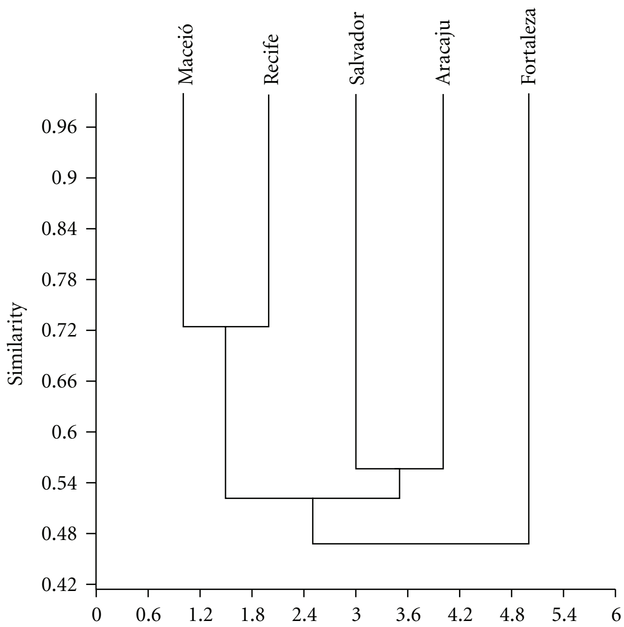

Figure 6: Cluster analysis of the species cited in the surveyed cities. (Correlation coefficient: $R = 0.93$).

Table 4: Comparison of observed species richness in Aracaju-SE, Fortaleza-CE, Maceió-AL, Recife-PE, and Salvador-BA public markets and the estimated species richness predicted by the estimators.

	Cities				
	Aracaju	Fortaleza	Maceió	Recife	Salvador
Sobs	19	28	27	31	36
Estimators					
ICE	25	34	28	49	48
Chao2	21	33	28	43	45
Jack1	25	36	29	44	49
Jack2	25	40	29	51	55

Sobs: observed species.

Our analyses demonstrate this, pointing out that the number of species commercialized tends to be greater than that recorded (Table 4 and Figure 7).

It was observed that for Aracaju, Fortaleza, Recife, and Salvador the estimators indicated the existence of more traded species than that recorded in the present work. In accordance with the study by Whiting et al. [16], in the market in Faraday, South Africa, the richness estimator Jack 2 was better for use in studies on zootherapeutic products. According to these authors, Jack 2 yielded values closer to the number of species observed. However, based on our results obtained with the estimators ICE and CHAO 2 for the data on the sale of animals in Maceio (see Table 4), we can infer that these two estimators are also reliable, because we obtained values close to those obtained through informants in the markets of Maceió.

The values obtained with richness estimators show that the richness of species sold for traditional medicines in Northeast Brazil is high. However, the scarcity of studies on zootherapy in the country, as all over the world, has led to the importance of the zootherapeutic resources being underestimated in the country.

Estimates of species richness were utilized in ethnobiological studies conducted by Begossi [34]. In the case of research on the use and/or commerce of animals or plants, this tool has been little exploited. According to Williams et al. [53], the use of indices of species richness and diversity in ethnobiological research can serve to (i) evaluate the amount of biodiversity human populations exploit; (ii) make it possible to compare communities (or markets) using quantitative data; (iii) infer the minimal number of species necessary for the maintenance of the uses by traditional communities. In summary, the use of these indices open new perspectives for ethnozoological studies, since they can provide estimates on the richness and diversity of animal species utilized, especially considering the difficulty in obtaining information about the trade of wild animals, which are generally carried out in a clandestine manner.

In the present work, we recorded at least 68 species sold in the cities studied. Of these species, 23 (33.8%) are on the red list of threatened species [52]. The categories in which these species are included are from data deficient up to endangered. Even for some species not considered in high risk categories, the medicinal use and trade are cited as one of the causes of threat and/or population decline for only one species (*H. reidi*). For the majority of commercialized species, however, medicinal trade is not considered a form of threat, although it represents an additional pressure, which should be monitored, especially for species that are extensively exploited.

It is important to point out that the medicinal use of animals cannot be considered the only threat to the conservation of the species utilized for these purposes. Some authors [54] point out that the remedies based on animals are mainly formed of subproducts that do not serve other purposes other than medicinal, and therefore, the true reason for hunting them may not be for medicinal use, such in the case of food.

Understanding the aspects that involved the commerce of medicinal animals is important for the formulation of management plans for sustainable use of medicinal animal species [3]. Some works on the sale of medicinal animals indicate a concern with respect to the maintenance of these faunistic resources, taking into consideration that in Brazil the sale of medicinal animals in stores and street markets is not monitored [13].

In other countries, some published works indicate that the trade of fauna for various purposes, including medicinal, is one of the main causes of threats to wild populations. Servheen [55] pointed out that 14 species of bears, on the IUCN red list, are traded in and outside of China for medicinal use without the monitoring of the number of individuals sold. According to Lee [56], the use of rhinoceros horn in traditional medicine has been indicated as one of the main causes for the population decline of these animals. Alves et al. [3], providing an overview of the global use of primates in traditional folk medicines, noted that >100 species were traded for this purpose, and as noted by Ahmed

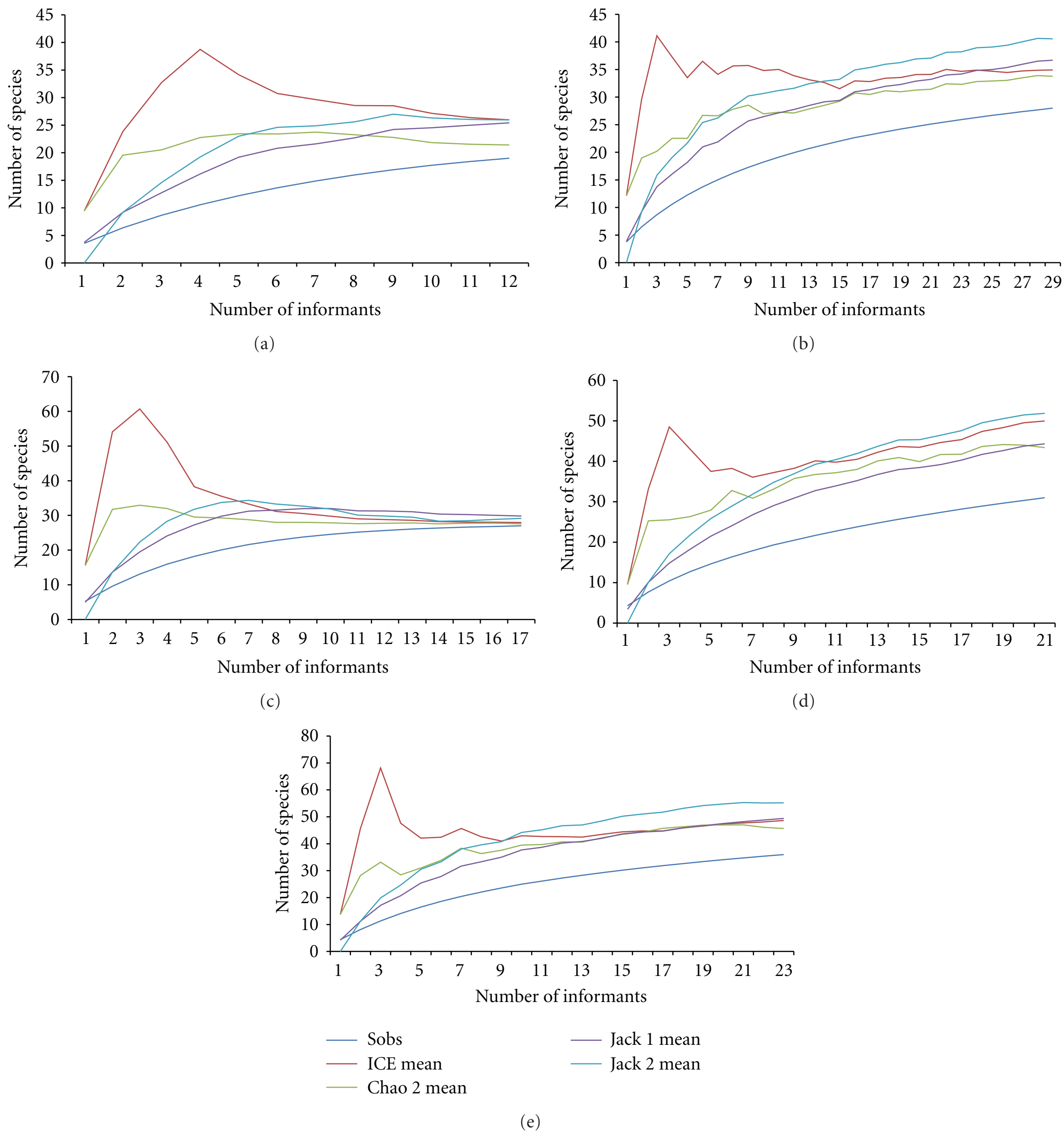

Figure 7: Graphs showing the values obtained with the richness estimators species assessed for each market. (a) Aracaju; (b) Fortaleza; (c) Maceió; (d) Recife; (e) Salvador.

[57] unchecked exploitation is leading to decreasing populations of primates utilized in traditional medicine in India. In Indonesia, Lee et al. [58] pointed out that the sale of mammals for various purposes, including medicinal, is one of the causes for declines in mammal populations. Athiyaman [59] reported that species of tigers are among the animals most endangered due to its trade for medicinal purposes without monitoring. Zhang et al. [60] stated that in China one of the major causes for the decline in species is illegal trade for food, craftwork, and medicinal purposes.

In Brazil, there is still no information that indicates the decline of species due to traditional medicine trade, although this activity has been indicated as one of the causes of a population decline of *H. reidi* [61, 62]. Although the intense commercialization of animals for medicinal purposes does not represent a significant impact for most of the species, such uses should be considered in strategies of management and conservation, particularly for those medicinal animals that are exploited more and on the list of threatened species [15].

Considering that animals represent an important source of remedies used in traditional medicines, zootherapy has become extremely relevant from a conservationist viewpoint [3]. In all the world, populations of various species have been utilized and the demand created by traditional medicine is probably one the causes of overexploitation found for some species of large mammals [1, 55, 57, 63].

According to Alves and Rosa [1], the ecological aspects associated with zootherapy represent one of the main reasons for studying the use of animals for medicinal purposes. However, it has not been possible to evaluate the magnitude of the impact of the medicinal use of the fauna, since the ways in which animals are used vary greatly [41], and the zootherapeutic products can be obtained indirectly from hunting for other purposes [11, 64]. Therefore, medicinal demand should be considered within a greater context of use of the fauna. The frequent commercialization of zootherapeutic products derived from particular species and their respective conservation status demonstrate that some animals deserve special attention.

In general, the use and commercialization of medicinal animals in Northeast Brazil is a reality consisting of an alternative for the treatment of various diseases, as well as representing an important source of income for various people. Knowledge of the fauna utilized popular medicine is indispensable for conservation, demonstrating that research on this subject is necessary to determine appropriate practices for the management of the fauna, thereby allowing the maintenance of the medicinal resources utilized and of the medicinal knowledge associated with these resources.

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Research Article

The Usefulness of Edible and Medicinal Fabaceae in Argentine and Chilean Patagonia: Environmental Availability and Other Sources of Supply

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Fabaceae is of great ethnobotanical importance in indigenous and urban communities throughout the world. This work presents a revision of the use of Fabaceae as a food and/or medicinal resource in Argentine-Chilean Patagonia. It is based on a bibliographical analysis of 27 ethnobotanical sources and catalogues of regional flora. Approximately 234 wild species grow in Patagonia, mainly (60%) in arid environments, whilst the remainder belong to Sub-Antarctic forest. It was found that 12.8% (30 species), mainly woody, conspicuous plants, are collected for food or medicines. Most of the species used grow in arid environments. Cultivation and purchase/barter enrich the Fabaceae offer, bringing it up to a total of 63 species. The richness of native and exotic species, and the existence of multiple strategies for obtaining these plants, indicates hybridization of knowledge and practices. Only 22% of the total species used are mentioned in bothcontexts of food and medicine, reflecting low-use complementation. This study suggests a significant ecological appearance and a high level of availability in shops and exchange networks in Patagonia, highlighting the need to consider the full set of environmental and socioeconomic factors in research related to the use and cultural importance of plants in regional contexts.

1. Introduction

Fabaceae is a family of cosmopolitan distribution, with approximately 730 genera and 19.400 species, lying in third place after Asteraceae and Orchidaceae with respect to species richness at a global level [1]. This high species richness is reflected in great morphological and chemical diversity, from which multiple uses are derived [2]. In socioeconomic terms, their importance for health and human alimentation is highlighted, although they also provide wood resources and dyes, resins, insecticides, fibres, fodder, and so forth [3, 4].

The nutritional value of Fabaceae is to a great extent due to their ability to fix atmospheric nitrogen for protein synthesis. This advantage has led to protein concentrations in leaves and seeds which vary between 20% and 40% dry weight, depending on the species [5]. Human societies have learned to select and incorporate mainly the seeds and fruit into their diet, taking advantage of the variety of essential amino acids they contain. In various cultures around the world they have become the principal providers of nonanimal protein, accompanying the carbohydrates provided by cereals [4].

Proof of their importance in human nourishment is the fact that they are, along with cereals, amongst the first plants to have been domesticated [5]. In America the cultivation of Fabaceae dates from prehistoric times [6, 7]. For example, at least five species of the genus *Phaseolus* (beans) were found in a wide range of geographic zones, from the meridional Andes to Mesoamerica and the Caribbean [8], very often along with *Zea mays* ("maize" and "corn") [4].

In Argentine Patagonia, Fabaceae seems to be one of the main gathered wild food resources, both in multiethnic populations situated in the Sub-Antarctic forest [9] and in indigenous communities of the arid steppe and Patagonian monte environments [10]. It is suggested by Pardo and Pizarro [11] that during the first stages of the Spanish colonization, the introduction of "chickpeas" (*Cicer arietinum),* "peas" (*Pisum sativum*), and "broad beans" (*Vicia faba*) from Europe to this part of the continent must have been extremely successful. The current importance of these exotic legumes is well known, since in many Patagonian vegetable gardens "broad beans"and "peas"are still cultivated as the main dietary resource [12].

With regard to medicinal uses, it has been pointed out that they are found amongst the five botanical families richest in therapeutic properties in the pharmacopeia of indigenous and rural populations in Holarctic [13], Neotropical [14], and Sub-Antarctic [15] regions. In particular, Barboza et al. [16] found that in Argentina Fabaceae is second in importance to Asteraceae in terms of richness of medicinal taxa. Their medicinal value lies partly in their effectiveness in the treatment of a wide variety of human ailments [17]. The variety of chemically active constituents, such as tannins, flavonoids, alkaloids, and terpenes often found in members of this family, are substances with a high level of biological activity, and the fact that they are used extensively would suggest a pattern of global ethnomedical knowledge [13, 18]. However, other ecological, morphological, and sociocultural factors in addition to these chemical-nutritional ones may explain more fully the vast use made of this botanical family [15, 19]. For example, the presence of coloured and/or conspicuous aerial organs, notable organoleptic features, and their diversity in local flora are characteristics which would probably have attracted the attention of human populations, leading to experimentation and use [14, 20, 21].

Ethnobotanical theory has widely indicated the importance of the environment as a determining factor in the selection of useful resources by human populations [22–25]. The work of Phillips and Gentry [26] was the first to make the connection in tropical and subtropical populations between higher density and abundance of plant species with greater cultural importance to the people. Later, the ideas of the ecological appearance theory [27, 28], applied to ethnobotanical studies, have been very useful in determining whether plant-human interaction is influenced by the ecological and chemical characteristics of the plants [29]. Following this idea, humans would prefer to forage for plants which are most visible (the most abundant species, large in size and/or perennial) for their food, also taking advantage of the benefits of their antiherbivore defences for medicinal resources [29, 30]. This approach assumes a direct relationship between species availability in any given environment and its cultural importance. From this perspective, people will have more opportunities to see and learn about the species growing closest to their dwellings and most available in time and space, than those which are less common, short lasting, or inaccessible [29, 31, 32].

Having said this, however, in current human populations (even the most isolated) people do not only select and depend on the resources available in their immediate ecological surroundings. The appearance or availability of plants may also be enriched and strongly influenced by cultural exchange processes, barter, and/or socioeconomic practices that enable a culture to use a distant resource, or one not belonging to their environment [33–35]. In addition, the socioeconomic relevance of certain resources of global importance [36] and their diffusion by the communications media have, since ancient times, moulded dietary habits and practices associated with health [37, 38]. Other supply sources, therefore, must be considered in the evaluation of the cultural importance of plant species.

Another point which has been linked to the cultural relevance of plants is their varied use in multiple contexts of alimentation and the healing of ailments, indicating a remarkable level of exploration and use intensification due to their singular, specific qualities [39–41]. The use of species considered to be functional foods or nutraceuticals follows a diffuse gradient which includes medicinal function, alimentary, or mixed, depending on the consumer's circumstances. Their complementary, multiple uses seem to be a characteristic of traditional and/or rural societies that maintain strong bonds with their environment [39, 40, 42]. However, in modern communities, which have more contact with market societies, the importance of these resources may vary or change, taking on new significance or value [43, 44].

The object of this study, then, is to ascertain the cultural importance and use of the Fabaceae family as a food and/or medical resource in Argentine-Chilean Patagonia. Using an approach which is based on the importance of the "ecological and nonecological appearance", of plants to humans, and bibliographical analysis, we will try to understand the current use of this plant group, considering this to be an indicator of its ethnobotanical relevance at a regional level. The preliminary questions we posed were as follows. (1) What does the environment have to offer in terms of Fabaceae species richness in the different ecological environments of Patagonia, and what is the cultural importance of these wild species as medicines and/or food to the local population? (2) Are the wild Fabaceae selected as food and/or medicine the most visible species (mostly shrubs or trees)? (3) Given their historical socioeconomic importance, are there other cultural ways of obtaining Fabaceae used by the current population? (4) Are the Fabaceae chosen for nutritional and therapeutic purposes used in a complementary way? (5) What is the current regional pattern of Fabaceae use by Patagonian dwellers?

2. Methods

2.1. Study Area. The geographical area studied lies between 37° S and 46° S and includes ecological communities established in different phytogeographical provinces: Patagonian, Monte, and Sub-Antarctic (Figure 1). The Patagonian and Monte provinces (Argentina) extend over plateaus and low mountains in cold, dry climates with annual precipitation varying between 100 and 270 mm. The dominant Patagonian vegetation is grass-steppe or shrub-steppe with scrub and/or cushion species. The Monte vegetation is xerophytic, psammophytic, or halophytic scrub. The Sub-Antarctic province (Argentina and Chile) extends across mountains and glacial valleys, where the climate is temperate and humid, and annual precipitations can reach 2000 mm. The environment

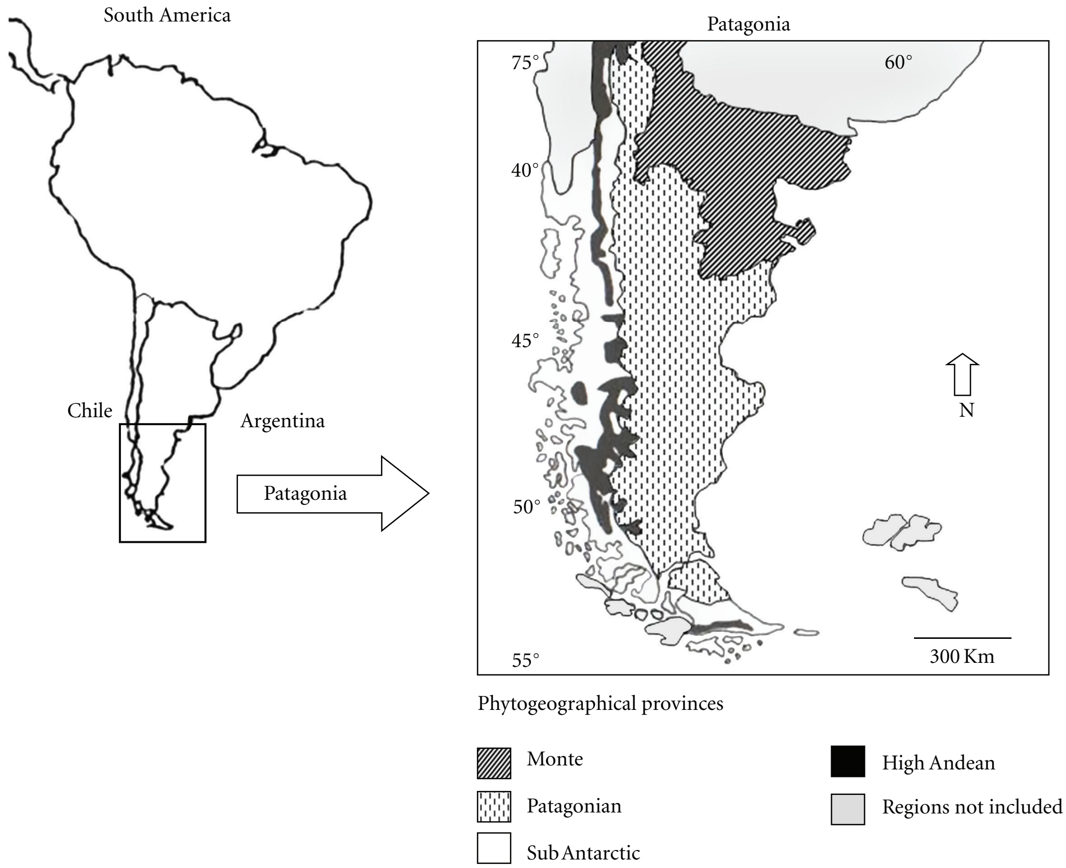

Figure 1: Study map of the Patagonian region and their phytogeographic provinces.

varies; there may be deciduous or evergreen forest with patches of grassland and peat bogs, amongst other possible vegetation types [45]. This phytogeographical heterogeneity leads to a high level of diversity in environments, microhabitats, life forms, biological associations, and plant species used by local populations [21].

The ethnobotanical articles analysed are from studies carried out in Chilean and Argentine Patagonia, mainly in small rural communities, of varying cultural origins (Mapuche, Creole, and/or Selk'nam). One urban community was also studied (San Carlos de Bariloche). In general, the rural communities of the indigenous peoples and Creoles studied were found on marginal lands, often in arid regions. Their economy is based on the breeding of domestic livestock. With the various political processes that brought about a restructuring of their lifestyle [46], they began a process of assimilation of the dominant societies, leading to migration of the younger generations to the urban centres, and an associated impoverishment of their living conditions. Despite all this, their culture of a strong connection with the earth and its natural resources is still alive, as are their practices of plant, animal, and mineral gathering. The urban population of Bariloche, in contrast, is highly heterogeneous and multiethnic in character [47].

2.2. Bibliographical Analysis. The environmental availability of Fabaceae in terms of species richness present in the flora of Argentine and Chilean Patagonia was analysed using Correa [48] and the Catalogue of Vascular Plants of Southern South America [49] as sources. A value for total richness of the area was obtained, as well as the relative richness of the Sub-Antarctic, Patagonian, and Monte phytogeographical provinces. The richness of Fabaceae used for food and medicinal purposes in the region was estimated from the establishment of a database compiled from ethnobotanical studies. Of approximately 50 studies reviewed, 27 sources were selected which mentioned at least one Fabaceae species in connection with the uses of interest to us. These sources included Biology graduates' degree theses, reviews, and scientific articles. The majority of these refer to the gathering and use of wild plants in rural areas on the part of Mapuche or Creole populations [10, 20, 25, 35, 50–64]. Five studies are review works [9, 65–68]. Few works make reference to the urban ethnobotany of Patagonian cities [69, 70] or deal with the cultural practices of other indigenous Patagonian populations such as the Selk'nam [71], revealing an imbalance in the topics studied in this region.

It should be mentioned that the principal variable studied in this work was Fabaceae species richness, not considering the frequency of cites per species, since this variable was not analysed in most of the works reviewed. This approach assumes that the accumulated richness of all the studies is a reflection of the level of cultural importance of the family under consideration. The heterogeneity of the studies due to the different environments dealt with and/or differences in sociocultural backgrounds was not analysed in this work, since our aim was to explore the role of Fabaceae on a purely utilitarian scale, in a wide sense.

2.3. Data Analysis. As an indicator of the cultural importance of the use of Fabaceae, we used the accumulated number of medicinal, edible, or mixed-use species in all 27 publications analysed. All species were categorised according to (1) biogeographical origin: native or exotic plants growing in Patagonia, and (2) methods of obtaining the plants: gathering, cultivation, and purchase-barter cited in each work. In addition, from the information obtained from the Catalogues of Patagonian Flora [48], of Vascular Plants from Southern South America [49], and from our own registers, the wild species obtained through gathering were categorised according to (3) ecological environment of origin: forest (Sub-Antarctic forests), steppe (Patagonian province), and/or monte, and (4) life form: herbs, shrubs, and trees.

The ecological availability of wild Fabaceae and species richness for medicinal and/or edible purposes corresponding to the three phytogeographical Patagonian environments (Sub-Antarctic, Patagonian, and Monte), their life forms (herbs, shrubs, and trees), and their supply strategies were compared with the χ^2 test ($P < .05$). Biogeographical origin, native or exotic, of the wild medicinal and/or edible species for each environment was compared using the binomial test ($P < .05$). The similarity of wild Fabaceae in these different environments was analysed with the Jaccard index (JI: $c/(a + b + c) \times 100$), where c is the number of plants that two environments have in common, a is the number of species unique to one environment, and b is the number of species unique to the other one [72]. With the objective of describing the current use pattern of Fabaceae by means of an integrated view of the relationships between all the variables analysed (biogeographic origin, use, life form, supply strategy), MDS (Multidimensional scale analysis) was used. MDS provides a spatial representation of the data that shows the positions of all the variables relative to each other [73]. The proportion of variation explained by this representation was measured with the value of R^2 (which varies between 0 and 1) and the stress, which is a measure of fit of the distances created, whose values for a good fit should be less than 0.1 [73].

3. Results and Discussion

3.1. The Ecological Environments of Patagonia: The Environmental Availability and Cultural Importance of Fabaceae. Argentine-Chilean Patagonia offers a diverse selection of wild Fabaceae, estimated at some 24 genera with 234 species and varieties. The Andean-Patagonian forests of Argentina and Chile present higher species richness than the arid provinces of the Argentine steppe and monte (forest: 130 species (40.6%), monte: 106 species (33.12%), and steppe: 84 species (26.25%); $\chi^2 = 9{,}9$; df = 2; $P < .05$, Figure 2). However, taken together (steppe plus monte), almost 60% of the species come from the arid Patagonian regions of Argentina, showing the significant preponderance of this group in these phytogeographic environments. The low similarity indices indicate that each of the ecological environments offers a set of unique species, especially the most humid forest region and the arid zones (JI = 9%), although the monte and steppe environments have a higher species coincidence (JI = 36%), when compared (Figure 2).

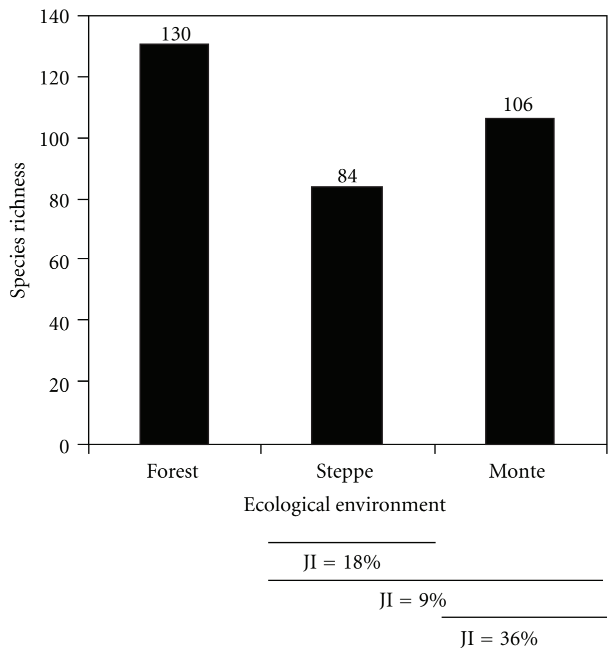

Figure 2: Wild Fabaceae richness in Argentine and Chilean Patagonia according to Correa [48] and Zuloaga et al. [49]. The JI values represent the percentage of common species among environments.

According to the bibliographical survey, local populations have identified and learned about the use of Fabaceae, including them in their daily lives as food and/or medicine. Of the 234 species that grow in Patagonia, some 30 species are used (12.8% of the total). Nineteen of these species are medicinal and 17 are edible (8% and 7% of the total flora, resp.) (Table 1). In relation to this, Rapoport and Drausal [38], in a study comparing flora from different regions of the planet, have suggested that for any environment or biota, a minimum of 10% of species can be expected to be edible. Our results, therefore, may mean that the listing obtained in this study is not exhaustive and does not reflect the complete richness of useful resources for humans, something which can be surveyed in future ethnobotanical studies.

The bibliographical sources studied indicate that the proportion of medicinal and/or edible species used do not

Table 1: Edible and medicinal Fabaceae plants cited by 27 ethnobotanical sources of Patagonia. Fa: farming; P-B: purchase-barter; G: gathering; M: monte; S: steppe; F: forest; E: edible; Me: medicinal.

Species	Vernacular names	Origin	Strategies (ecological environments)	Uses	Growth habits
Acacia aroma Gillies ex Hook. & Arn.	tusca	Exotic	Fa; P-B	E, Me	Shrub
Acacia caven (Mol.) Mol.	huayun, cawén, caven, espino	Native	G (M); P-B	E, Me	Tree
Adesmia boronioides Hook. f.	paramela, té silvestre, yerba carmelita, éter, yagneu, lonkotrevo	Native	G (F, S, M)	Me	Shrub
Adesmia emarginata Clos	paramela	Native	G (F, S)	Me	Shrub
Adesmia lotoides Hook. f.	kiárksh	Native	G (F, S, M)	E	Herb
Adesmia volckmannii Phil.	mamül choike	Native	G (F, S, M)	Me	Shrub
Anarthrophyllum sp.	neneo macho, rülinlawen	Native	G (S, M)	Me	Shrub
Arachis hypogaea L.	maní	Exotic	P-B	E	Herb
Astragalus garbancillo Cav.	garbanzo, garbancillo	Exotic	P-B	Me	Herb
Bahuinia forficata Link	lawén-huiguln, pezuña de vaca, pata de vaca, pezuña de buey	Exotic	P-B	Me	Tree
Caesalpinia paraguariensis (D. Parodi) Burkart	guayacán	Exotic	P-B	Me	Tree
Caesalpinia spinosa (Molina) Kuntze	tara	Exotic	P-B	Me	Tree
Cercidium praecox (Ruiz & Pav. ex Hook.) Harms	brea, chañar	Native	G (M)	Me	Shrub
Cicer arietinum L.	garbanzo	Exotic	P-B	E, Me	Herb
Cytisus scoparius (L.) Link	retama, retama negra	Exotic	G (F); Fa	E, Me	Shrub
Erythrina crista-galli L.	ceibo	Exotic	P-B	Me	Tree
Geoffraea decorticans (Gillies ex Hook. & Arn.) Burkart	chañar, chical, chucal	Native	G (M)	E, Me	Tree
Glycine max (L.) Merr.	soja	Exotic	P-B	E, Me	Herb
Glycyrrhiza astragalina Gillies ex Hook. & Arn.	regaliz	Native	G (S)	Me	Shrub
Hoffmannseggia erecta Phil.		Native	G (M)	E	Herb
Inga sp.	pacay, guaba	Exotic	P-B	E	Tree
Lathyrus magellanicus Lam.	alvergilla	Native	G (F)	E, Me	Herb
Lens culinaris Medik. c1	lenteja turca	Exotic	P-B	E	Herb
Lens culinaris Medik. c2	lentejón	Exotic	P-B	E	Herb
Lens culinaris Medik. c3	lenteja	Exotic	P-B	E	Herb
Lupinus albus L.	lupino	Exotic	P-B	E, Me	Herb
Lupinus sp.	lupino, chocho	Exotic	G (F); Fa	E	Herb
Medicago lupulina L.	lupulina	Exotic	G (F, S, M)	E	Herb
Medicago sativa L.	alfalfa, alfa	Exotic	G (F, S, M); Fa	E, Me	Herb
Melilotus albus Desr.	meliloto, trébol de bokhara	Exotic	G (F, S, M)	E	Herb
Melilotus indicus (L.) All.	trébol de olor, trebillo, trévül	Exotic	G (F, S, M)	Me	Herb
Melilotus officinalis (L.) Lam.	meliloto	Exotic	G (F, S, M)	Me	Herb
Otholobium glandulosum (L.) J. W. Grimes	Külen, trafilawen	Native	G (F); P-B	E, Me	Tree
Phaseolus coccineus L.	poroto chileno, poroto colorado	Exotic	Fa; P-B	E	Herb
Phaseolus lunatus L. c1	poroto pallar, ayayo, ailladito	Exotic	Fa; P-B	E	Herb
Phaseolus lunatus L. c2	poroto manteca	Exotic	P-B	E	Herb
Phaseolus vulgaris L. c1	frijol, poroto, purutu, dengüll, cüllhui	Exotic	Fa; P-B	E	Herb
Phaseolus vulgaris L. c2	poroto negro	Exotic	P-B	E	Herb
Phaseolus vulgaris L. c3	poroto colorado	Exotic	P-B	E	Herb
Phaseolus vulgaris L. c4	chaucha	Exotic	P-B	E	Herb

Table 1: Continued.

Species	Vernacular names	Origin	Strategies (ecological environments)	Uses	Growth habits
Phaseolus vulgaris L. c5	poroto alubia	Exotic	P-B	E	Herb
Pisum sativum L.	arveja, alverja	Exotic	Fa; P-B	E, Me	Herb
Prosopis alba Griseb.	tacu, huilca, huancu, algarrobo	Exotic	P-B	E	Tree
Prosopis alpataco Phil.	alpataco, soil mamül	Native	G (M)	E	Shrub
Prosopis chilensis (Molina) Stuntz emend. Burkart	algarrobo blanco	Exotic	P-B	E	Tree
Prosopis denudans Benth.	algarrobo	Native	G (M)	E	Shrub
Prosopis flexuosa DC.	algarrobo dulce, yoiwitru	Native	G (M)	E	Shrub
Prosopis rubiflora Hassl.	vinal	Exotic	P-B	Me	Shrub
Prosopis strombulifera (Lam.) Benth.	retortuño, pata de loro, chowel	Native	G (M)	Me	Shrub
Pterocarpus santalinoides L'Hér. ex DC.	sándalo	Exotic	P-B	Me	Tree
Robinia pseudoacacia L.	acacia blanca	Exotic	G (F); Fa	E	Tree
Senna alexandrina Mill.	sen	Exotic	P-B	Me	Shrub
Senna stipulacea (Aiton) H.S. Irwin & Barneby	quebracho, mayu, traftrafén	Native	G (F)	Me	Shrub
Sophora cassioides (Phil.) Sparre	pëlú	Native	G (F)	Me	Tree
Sophora macrocarpa Sm.	mayu, pëlúpëlú	Native	G (F)	Me	Tree
Sophora microphylla Aiton	pëlú	Native	G (F)	Me	Tree
Tamarindus indica L.	tamarindo	Exotic	Fa; P-B	E, Me	Tree
Trifolium pratense L.	trébol rojo	Exotic	G (F, S, M)	E	Herb
Trifolium repens L.	trébol blanco	Exotic	G (F, S, M); Fa	E	Herb
Trigonella foenum-graecum L.	fenogreco	Exotic	P-B	E, Me	Herb
Vicia faba L.	haba	Exotic	Fa; P-B	E, Me	Herb
Vigna angularis (Willd.) Ohwi & H.Ohashi	aduki	Exotic	P-B	E	Herb
Vigna radiata (L.) R. Wilczek	poroto mung	Exotic	P-B	E	Herb

show any preference towards species from the forest (20 species: 66%), from the monte (19 species: 63%), or the steppe (13 species: 43%) (χ^2 = 1,6; df = 2; $P > .05$. Figure 3). However, the arid zones (monte and steppe) contribute significantly more medicinal and/or edible species when taken together (Binomial test, $P < .05$). These results may reflect the high proportion of Fabaceae used which come from arid zones, and also the cultural importance of the forests, reflecting their greater structural complexity and plant richness in comparison with the other environments.

The notable advantage taken of arid zones for obtaining Fabaceae should also be analysed within the historical and political context of Patagonian communities. These populations, particularly those of indigenous ancestry, were originally from the subantarctic forests of Argentina and Chile [51]. Due to various sociopolitical processes [46] at the end of the 19th and beginning of the 20th century, these communities were forced to settle in areas on the edges of forests, that is, in the driest zones of Argentina, where they still live today [15]. The forests were either sold or became national and provincial biological reserves, inaccessible in terms of plant and animal resources [15]. This drastic change has very probably influenced socioenvironmental perception of Patagonian environments, affecting behaviour and the differential evaluation of alimentary and medicinal resources [74], and favoring the incorporation of the most available species in the new area settled [74]. De Lucena et al. [75] suggest that in populations which are constantly on the move, where access to resources within protected areas is impeded in some way, and in which the younger generations show little interest in learning about natural resources, the used value of the species would be the result of the people's capacity to adapt to the specific environmental conditions, including learning about the use of the species which are most available at that particular time.

Fabaceae is a botanical family of great importance amongst the flora of the world; many studies have revealed its abundance and ecological and cultural importance in arid regions of the planet, such as Brazil [75, 76], México [77], Africa [74, 78, 79]. Our preliminary results, with communities from arid environments well represented in our investigation, appear to show the same tendencies.

The Fabaceae species used as medicine or food in the region show much more similarity between environments (JI = 35%–JI = 55%. Figure 3) than the species registered in the published floras (Figure 2). In other words, many

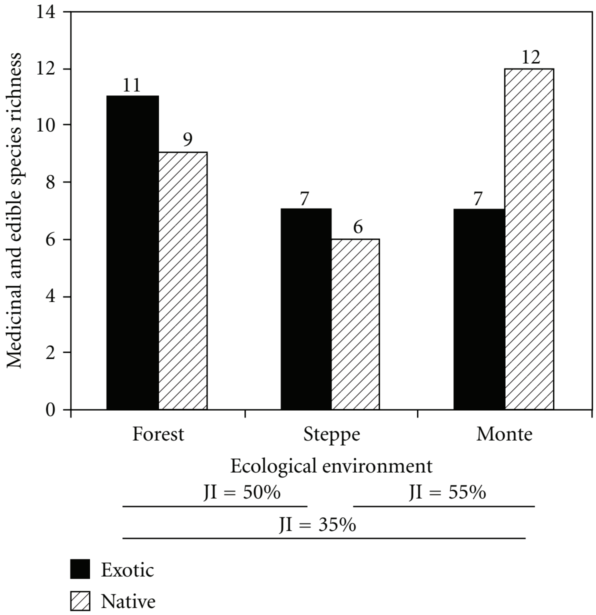

Figure 3: Edible and medicinal species richness of Fabaceae cited by 27 ethnobotanical sources and their ecological environments in Patagonia. JI: Jaccard similarity index.

useful species are shared between environments, which is directly connected to the high proportion of exotic Fabaceae, principally used for medicinal purposes, which are repeated along the environmental gradient and are not documented in the regional flora. These findings are indicative of the importance of ethnobotanical studies as points of reference and for the updating of regional flora and also point out the need for continuous feedback.

Parallel to this, it was found that the proportion of species of native and exotic origin used by locals in each environment was similar (binomial test$_{\text{forest,steppe,monte}}$, $P > .05$), indicating a high degree of incorporation of exotic resources. In general, exotic species have been widely spread and have adapted to all Patagonian Cultural landscapes [15, 21]. The high level of richness of these species seems to be associated with the growing abundance of anthropic environments in the region [58, 80]. Many exotic species growing in Patagonia have been pioneers in degraded environments and have rapidly become invasive [80]. At the same time these species, which tend to be "r" strategists in ecological succession [81, 82], have a repertory of phytochemicals for antiherbivore defence that are useful for medicinal purposes [24, 82]. In addition, some of them have been introduced from Europe, where for centuries they have enjoyed great prestige as therapeutic and/or edible resources (e.g., [83–85]). Publicity relating to their medicinal qualities is also regularly transmitted throughout the region, by means of media such as books, television, and radio [70]. All of the above suggests that the effective use of representatives of this botanical family is markedly influenced by its prominence both in cultural and in ecological terms.

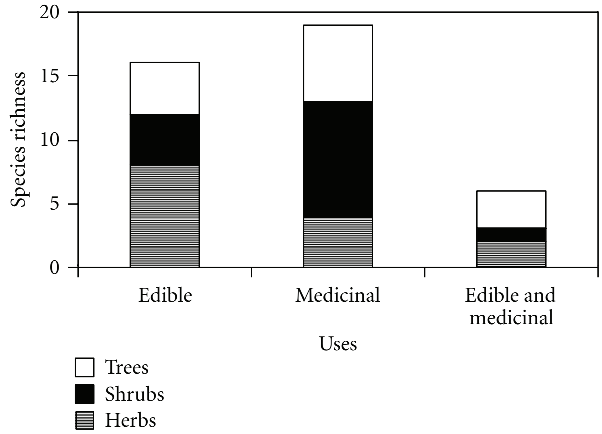

Figure 4: Richness of herbs, shrubs, and trees between wild edible and/or medicinal Fabaceae plants of Patagonia.

3.2. Life Forms of Medicinal and/or Edible Wild Fabaceae in Patagonia. Amongst the medicinal, edible, or mixed-use Fabaceae are found herbs, shrubs, and trees ($P > .05$) (Figure 4). However, a high proportion of woody Fabaceae (trees and shrubs) is observed in the three used categories analysed ($P < .05$). The high level of use of wild trees and shrubs for various purposes, including food, has also been highlighted in tropical areas and semiarid regions of the world by Felker [86]. Even though the proportion of herbs is lower in all areas, it is important to mention that in the case of edible use, plant richness with this life form is twice as high as for medicinal plants.

These results are in accordance with the theory of ecological appearance, favouring the greater use of the most conspicuous species in the environments. Similar results were found by Almeida et al. [82] and Albuquerque et al. [29] in studies of medicinal plants carried out in the semiarid region in the Northwest of Brazil, highlighting the high richness of native woody plant species. Our results, however, go against the tendencies found in tropical and subtropical zones, where herbs seem to fulfil an essential role in pharmacopoeias and diets (e.g., [24, 87, 88]). Nevertheless, even though low dominance values have been found for medicinal species of tropical and subtropical regions, these have often been registered as highly abundant in local flora. Abundance is also an expression of ecological appearance, which would increase their accessibility and use [75].

Our work shows that the contribution of Fabaceae to the set of medicinal and/or edible resources in the region is basically woody plants, visible, and conspicuous. Worthy of mention as examples are the shrubs *Adesmia boronioides* and *Cercidium praecox*, both widely recognised as medicinal on both sides of the Cordillera, the genus *Prosopis*, with trees and shrubs of great edible and medicinal value, and *Sophora* spp. with medicinal trees used since ancient times amongst the native peoples of Chilean Patagonia.

3.3. Other Methods of Obtaining Fabaceae Species Used by Local Populations. The medicinal and/or edible species of Fabaceae, as well as being gathered, are also incorporated

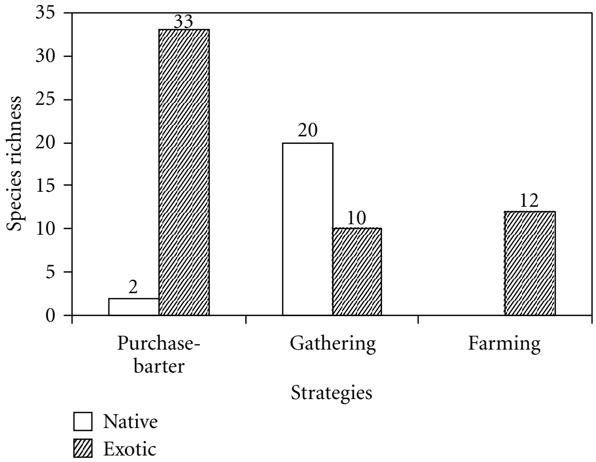

Figure 5: Richness of native and exotic Fabaceae plants obtained by gathering, purchase-barter, and farming in Argentine and Chilean Patagonia.

into the diet and natural and domestic medicine through cultivation, purchase and barter (Figure 5). In this way the richness value rises to a total of 63 species and varieties (more than twice as many), most being of exotic biogeographical origin (43 species) and the remainder native in origin (20) (Table 1).

The environmental supply, then, is increased by the provision of Fabaceae from other biogeographical regions, due to the nutritional, medicinal, and nutraceutical value of these species to Patagonian populations. The highest richness level is reached through the purchase and/or barter of species which are mainly exotic (35 species), followed by the gathering of native and exotic species (30), and finally through the cultivation of exotic species (12) ($\chi^2 = 24$, df = 2, $P < .05$).

Bartering (e.g., *Caesalpinia paraguarienses, Prosopis rubiflora, Tamarindus indica*) is carried out mainly in rural areas where species from different geographical zones are exchanged by small producers or local livestock breeders, who often travel around as temporary workers at sheep shearing time, a job which allows them to spend time in environments different to their own [89]. The cultivation of Fabaceae species in small vegetable gardens or greenhouses is directly linked with exchange networks between neighbours or through external horticulture or welfare agents, such as the agriculture and fisheries social plan, PSA *(Plan Social Agropecuario)* and Inta (*Instituto Nacional de Tecnología Agropecuaria*) [50]. The purchase of edible Fabaceae in a fresh state (e.g., *Vicia faba, Lens culinaris*), dry or tinned (e.g., *Phaseolus lunatus, P. vulgaris, Cicer arietinum*), takes place in greengrocers, grocers, supermarkets, and whole food stores, whilst those used for medicinal purposes are obtained from herbalists and health food stores (e.g., *Senna alexandrina, S. Stipulacea,* and *Bahuinia forficata*), and this cannot be underestimated. It is worthy of note that *Pisum sativum* and *Vicia faba* are amongst the most sold in the Northwest of Argentine Patagonia, production for both species being estimated at 1625 kg/year just in the area around the city of Bariloche in the province of Río Negro [69].

The resources that form part of the social exchange and barter networks, in general, are considered highly significant in cultural and socioeconomic terms [12]. In this case, purchase and barter reveal that these Fabaceae are resources obtained both internally and externally and are highly valued.

The variety of ways Fabaceae can be obtained might also be a response to the unpredictability of the socioenvironmental contexts of rural Patagonian populations which have been greatly affected by overgrazing and desertification [10]. In these conditions, the appearance and availability of wild resources become highly unstable in time. The diversified strategy could function as a mechanism in subsistence living to maximise the investment of time, energy, and monetary resources in the acquisition of these plants [74].

3.4. Complementary Use of Patagonian Fabaceae. Considering all methods of obtaining the plants (gathering, cultivation, purchase, and barter), it was found, although not statistically significant (binomial test, $P > .05$), that this botanical family seems to be more important in Patagonia as a food source (42 species) than as a medicinal resource (35). In agreement with this, Mösbach [62] has pointed out that since ancient times Fabaceae have constituted the basic accompaniment to many traditional recipes in the region, such as stews, jams, and farinaceous preparations.

Only 22% (JI) of the total number of species are used for both food and medicinal purposes (Table 1), reflecting low-use complementation. It has been amply shown that when herbolaria are analysed together, higher complementation is found in the use of medicinal and edible resources in traditional societies, which are distinguished by opposition to the dissociated use generally prevalent in industrialised societies (e.g., [39]). In this region in particular, Ladio [42] found that 63% of the species used in a Mapuche population in the Argentine steppe are used in a complementary way for medicinal and edible purposes. Our results indicate that the Fabaceae family, mainly due to their particular intrinsic characteristics, is used in a more segmented or compartmentalised way.

The great phytochemical and organoleptic diversity that characterises this family of vascular plants is well known [14]. It has been found that the organoleptic perception of many of the secondary metabolites present in the chemical package of this and other groups of plants may be one of the main intercultural clues for the medicinal and/or edible distinction and evaluation of the plants (e.g., [20, 89–91]). Compounds such as alkaloids, isoflavones, coumarins, saponins, and tannins are some of the antinutrients perceived as bitter-tasting which are present in many Fabaceae genera, such as *Astragalus*, *Lupinus, and Melilotus,* and these may orient their consumption towards medicinal use [92].

In response to this detection, and at the same considering the need to take advantage of their high protein content, humans have developed specific cooking and/or detoxification practices, so that species with some level of toxicity can be included in the diet [93–95]. In relation to this, several studies on the alimentation of Patagonian Pre-Columbian populations have documented different techniques of flavour improvement and detoxification using sun-drying followed by the grinding of seeds and edible roots [11]. A deeper study of the phytochemicals and organoleptics of Patagonian Fabaceae could provide the necessary clues to the understanding of this result of low complementation. In addition, it is possible that the higher popularity as a food source of *Phaseolus* spp. and other species in the South American region and in the World in general [79, 84, 86] has contributed to the increase in their use as food in detriment to their use as a medical resource in Patagonia.

3.5. An Approach to the Integrated Analysis of the Use of Fabaceae in Patagonia. Multidimensional analysis of the data shows a spatial and global representation of the different aspects of Fabaceae use in the region (Stress = 0.07; R^2 = 0.98. Figure 6). The species are divided into five groups which reveal the complex integration between uses, different supply strategies, biogeographical origins, and gathering environments. The medicinal and edible species are found to be clearly separated, showing the absence of use complementation. One group is made up of medicinal species, spatially separated from cultivated species. Another group consists of edible species, close to the group of exotic plants which are obtained mainly through purchase and/or barter. Finally, the group of native species can be seen, which are obtained mainly by gathering in forest, steppe, and Patagonian monte environments. It is evident, then, that there is compartmentalisation not only of medicinal-edible use but also of the different strategies that increase the diversity of species and uses, which at the same time reflects the importance of this family to local populations.

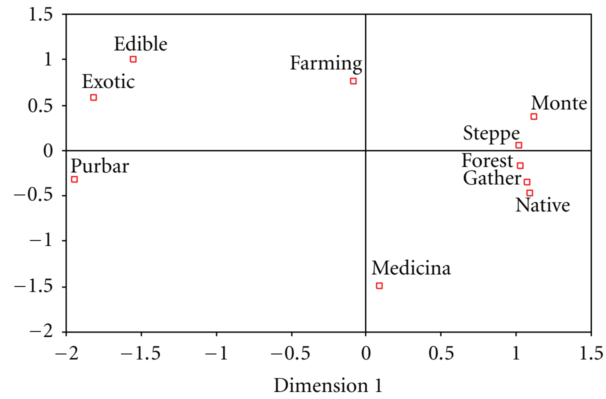

Figure 6: MDS of the data about uses (edible and medicinal), biogeographic origin (native, exotic), strategies (purchase-barter, gathering, farming), and ecological environments (monte, steppe, forest) of the Fabaceae used in Argentine and Chilean Patagonia.

4. Conclusions

This preliminary study reveals the current high level of usefulness of Fabaceae species in Argentine and Chilean Patagonia and the significant role they play as a food and/or medicinal resource. The bibliographical analysis has shown that the cultural practices associated with their use in the region, their recipes, and their symbolic value have been little studied, a subject which should be explored in more depth in the future.

At the present time, the different cultural enclaves in Patagonia use both native and exotic Fabaceae, indicating the hybridisation of knowledge and practices, a process which started with European colonisation of the region and continues due to the influence of the communications media. This process also reflects the great link that exists between the environmental changes in the surroundings, which, although we do not know whether they represent the cause or effect, demonstrates a direct connection between local populations and plants. The usefulness of this family is made more evident if the great richness of exotic species obtained through purchase, barter, or cultivation is considered. Different supply strategies are added to gathering practices, doubling the availability of Fabaceae in the region, and clearly showing its cultural value. This wealth of elements and practices indicates that due to their outstanding characteristics, the prominence of plants belonging to the Fabaceae family goes beyond ecology, since they also have an impact on socioeconomic and global society terms, which makes them abundant resources in shops and exchange networks. They also receive considerable publicity from various actors in society.

According to our bibliographical revision, there is little complementary medicinal-edible use of these plants. The question we must ask is whether this could be due to cultural patterns of knowledge loss regarding the varied uses of the species [4, 77, 86], to greater emphasis on their edible significance, to a singular, but also heterogeneous battery of phytochemicals in the group, or to limitations in the ethnobotanical study itself. Nevertheless, this work highlights the importance of considering the complete set of sociocultural and ecological factors that affect the use of any botanical group, thus establishing the different circuits involved in its use.

Finally, despite the contribution of bibliographical analyses to a general panoramic view of resource use, it should be noted that they are limited in that they offer "snapshots" of specific moments and depend on the varied visions of their respective authors. As proposed by Campbell and Luckert [74], resources are used in ways that fluctuate with time, in response to socioenvironmental changes experienced by human populations. For this reason, we emphasize the importance of employing a variety of research techniques in modern populations which will allow us to determine more accurately the cultural importance of the species used, and how this relates to the availability of plants in the environment. At the same time, we must be aware of other supply paths, with resources obtained from today's global society which play a significant role in the customs and habits of the people.

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Research Article

Bioactivity Evaluation of Plant Extracts Used in Indigenous Medicine against the Snail, *Biomphalaria glabrata*, and the Larvae of *Aedes aegypti*

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This investigation examined the molluscicidal and larvicidal activity of eight plants that are used in the traditional medicine of the Pankararé indigenous people in the Raso da Catarina region, Bahia state, Brazil. The tested plants were chosen based on the results of previous studies. Only those plants that were used either as insect repellents or to treat intestinal parasitic infections were included in the study. Crude extracts (CEs) of these plants were tested for their larvicidal activity (against *Aedes aegypti* larvae in the fourth instar) and molluscicidal activity (against the snail *Biomphalaria glabrata*). The plant species *Scoparia dulcis* and *Helicteres velutina* exhibited the best larvicidal activities (LC_{50} 83.426 mg/L and LC_{50} 138.896 mg/L, resp.), and *Poincianella pyramidalis*, *Chenopodium ambrosoides*, and *Mimosa tenuiflora* presented the best molluscicidal activities (LC_{50} 0.94 mg/L, LC_{50} 13.51 mg/L, and LC_{50} 20.22 mg/L, resp.). As we used crude extracts as the tested materials, further study is warranted to isolate and purify the most active compounds.

1. Introduction

The Brazilian northeast is the poorest region of Brazil and has the worst Human Development Indices [1]. Most of this population is subjected to neglected tropical diseases that predominantly affect the poorest and most vulnerable groups, contributing to the perpetuation of poverty, inequality, and social exclusion [2].

Schistosomiasis and dengue fever cause major public health concerns in Brazil and other tropical developing countries. Schistosomiasis is caused by the parasite, *Schistosoma mansoni*, which uses the *Biomphalaria glabrata* snail as an essential intermediate host in its life cycle. Dengue fever is caused by an arbovirus of the Flaviviridae family and is transmitted by the mosquito, *Aedes aegypti*.

The number of cases of dengue has grown in Brazil, with epidemics in the most densely populated urban areas. However, natural products with different biocidal activities can help to fight parasite vectors at the adult or larval stages and can act as alternatives to synthetic products due to their rapid biodegradation and lower cost [3].

Molluscicides have been used as a general strategy to eliminate the snail that transmits schistosomiasis [4]. According to the World Health Organization (WHO), the use of drug therapy in conjunction with the use of molluscicides is the use the most valuable method to control schistosomiasis in areas with intermediary hosts. The synthetic substance, niclosamide (Bayluscide), has been used as the standard molluscicide since the 1960s, as it is efficient in controlling snails; however, the high cost of niclosamide and the fact that it decomposes rapidly in the presence of sunlight have limited the use of this drug [5].

Popular knowledge has been an important source of information for scientific research in several areas of study. Ethnopharmacological and ethnobotanical investigations have been used as the main strategy for selecting medicinal plants, thereby shortening the time for the discovery of new drugs, whereas ethnodirected research consists of selecting species based on information from population groups [6].

Evidence for the efficacy and safety and the immediate availability of plant-derived products for the control or eradication of such diseases would be of great value because part of the population living in the affected areas use plants and animals as one of the few options for disease treatment [7–9].

Studies have found evidence that standard methods control the dengue-related mosquito larvae with low efficacy, a situation that demonstrates the need for other means to fight the proliferation of dengue [10] given the fact that results in epidemiology are context-dependent [11]. Similarly, despite the fact that a national schistosomiasis control program was implemented in 1975, the disease still occurs in 19 states and is endemic to eight states.

Ethnobiological studies have been carried out on the indigenous Pankararé people since 1993 [12]. In 2006 [13], the use of 64 plants was reported, 20 of which were used for medicinal purposes. Indeed, there is evidence that the Pankararé—in the Estação Ecologica Raso da Catarina (a conservation area), Bahia state—have a profound knowledge regarding the benefits of plants.

This study examines the molluscicidal and larvicidal effects of eight plants used by the Pankararé indigenous people for medicinal purposes. The aim of the study is to look for evidence of alternative methods to fight vectors of schistosomiasis and dengue, taking into account local potentialities.

2. Materials and Methods

2.1. Study Area and Population. The indigenous lands of the Pankararé are located in one of the driest of the Brazilian regions, with an average annual rainfall of between 450 and 600 mm [14] and an average annual temperature of 25°C; the climate is arid and semiarid. The natural vegetation is tropical dry forest of the type hyperxerophylous steppic savanna.

The Pankararé have a long history of interaction with their regional neighbors and are a peasant social group that sees itself as a distinct ethnic group among the regional populations (from the social organization standpoint, this is termed Indigenous Peasantry). In Brazilian indigenous communities, the central political figure is the *Cacique* [15]. The Pankararé comprise a very poor group that has a long history of territorial disputes. They practice subsistence agriculture, farm livestock on a small scale, and engage in other activities, such as hunting, the collection of honey and wild fruits, and handicrafts [16].

2.2. Ethnobotanical Survey and Plant Collection. Ethnobiologic studies have been carried out on the Pankararé indigenous people since 1993. However, the present study was based mainly on recent information [17], specifically, on studies that were conducted in 2008 and 2009. The ethnobotanical research was carried out after the community members were fully informed of its purpose and they had granted their permission to record information. Authorization was also obtained from the community *Cacique* and the National Foundation of Support to the Indians (FUNAI). The data were collected using some of the methods presented and discussed in a previous report [18], including the use of informal conversations and semistructured interviews with 35 residents of the indigenous community (9 men and 26 women, aged 23 to 64 years). The interviewees were identified using the snowball technique based on the information initially provided by the traditional specialists, that is, people that are knowledgeable about medicinal plants.

For the taxonomic identification of the species, we collected reproductive plants that were donated to and identified in the Herbarium of the University of Bahia State UNEB (HUNEB-Coleção, Paulo Afonso).

2.3. Obtaining the Extracts. Eight plants were tested in bioassays to evaluate their larvicidal and molluscicidal activities. Plants that are used as insect repellents or anthelmintics were included in the study. To obtain the extracts, botanical material was gathered between March 2008 and February 2009. Material of the collected species (roots, stems, stem bark, and leaves) was dried at room temperature and then ground to powder. From this powder, we obtained the crude extract (CE) of each material by extracting three consecutive times with 90% ethanol for 72 h in a stainless steel extractor at 27 ± 1°C followed by the remotion of the solvent in a rotary evaporator at 60°C. The concentrated and weighed crude extracts were bioassayed to evaluate their larvicidal and molluscicidal activities at the Institute of Chemistry and Biotechnology (IQB) at the Federal University of Alagoas, UFAL.

2.4. Evaluation of the Molluscicidal Activity. Individual snails of the species *Biomphalaria glabrata* (of diameter 13–18 mm and obtained from the Institute René Rachou in Belo Horizonte city) were housed in aquaria equipped with continuously circulating dechlorinated water, at the temperature of 28°C, in the bioassay laboratory of the IQB of UFAL, based on the protocol of Santos and Sant'ana [19]. The ethanolic extracts of the stems, stem bark, roots, and leaves of the plants were dissolved in an aqueous solution of Dimethyl Sulfoxide (DMSO 0.1%) to obtain various concentrations (0.10–100 μg/mL). The assay consisted of immersing five snails in 125 mL of the dissolved test extract for 24 hours. After this period, the snails were washed, placed in dechlorinated water, and fed. The snails remained under observation for a further 24 hours, and the dead snails were recorded and removed. The extracts that exhibited molluscicidal activity at

Table 1: Chemical composition and pharmacological activities of the plants used by the Pankararés, Bahia, northeast Brazil, as repellents or anthelmintics.

Popular name	Family/Species	Part used	Biological activity	Isolated substances	References
Pinhão branco[B]	euphorbiaceae/ *Jatropha mollissima* (Pohl) Baill.	Leaves, stem bark, and roots	Antioxidant	*	[20]
Jurema preta[B]	fabaceae/ *Mimosa tenuiflora* (Willd.) Poir.	Leaves, stem bark, and roots	*	Kukulkanins A and B	[21]
Velame	euphorbiaceae/ *Croton moritibensis* Baill.	Leaves and aerial parts	*	12-hydroxy-13-methyl-1,8,11,13-podocarpatetraen-3-one, 2-ethoxycarbonyltetrahydroharman and hydroxy-2-methyltetrahydroharman	[22]
Vassourinha[B]	plantaginaceae/ *Scoparia dulcis* L.	Aerial parts	Antidiabetic, antioxidant, cytotoxic, antiulcer, antileishmania, and anti-hyperlipidemic	Scoparic acid D	[23–32]
Pitó[A]	sterculiaceae/ *Helicteres velutina* K. Schum.	Aerial parts	Cytotoxic against various cancer lineages**	Cucurbitacins D and J**	[33]
Mastruz[B]	chenopodiaceae/ *Chenopodium ambrosioides* L.	Aerial parts	Inhibitor of the mitochondrial electron transport chain (toxicity), antiparasitic, antihyperperistalsis, anti-inflammatory, analgesic, antischistosomiasis, antituberculosis, larvicidal, antitumor, and antifungal	Caryophyllene oxide	[34–44].
Catingueira[A,B]	fabaceae/ *Poincianella pyramidalis* (Tul.) L.P. Queiroz	Leaves, stem bark and roots	Antimicrobial, antioxidant and antifungal	4,4′-dihydroxy-2′-methoxy-chalcone	[45–48].
Sambacaitá[B]	lamiacae/ *Hyptis pectinata* L.	Aerial parts	Antimicrobial, antinociceptive, anti-inflammatory, hepatoprotective, antibacterial, and antifungal	Calamusenone-antimicrobial	[49–54].

*No studies were found in the literature; **activity has been described for another species of the same genus; [A]larvicidal activity; [B]molluscicidal activity.

concentrations lower than 100 μg/mL in the duplicate bioassays were considered active and subjected to further tests. A total of 10 snails was used in these tests (maintaining the ratio of 25 mL of test solution per snail), and each concentration was tested in triplicate. In parallel, we carried out control tests using an aqueous solution of 0.1% DMSO with the molluscicide, niclosamide, at 3 μg/mL. We used the program Probit, version 1.5 [55] to calculate the LC_{50}.

The World Health Organization (WHO) has indicated that the crude extracts of plants presenting LC_{50} values of <40 ppm (0.04% and 0.4 μg/mL) have potential as larvicidal and molluscicidal compounds [56].

2.5. Evaluation of the Larvicidal Activity. The larvicidal activity was tested on the larvae of the mosquito *Aedes aegypti* in the bioassay laboratory of the IQB/UFAL, based on methodology described by the WHO [57]. The crude extracts were diluted in aqueous solutions of 1% DMSO to 500 μg/mL. Then, 10 larvae of *A. aegypti* in the fourth instar stage were prepared for immersion in the crude extract (20 mL). The larvae were counted 24 hours and 48 hours from the beginning of the experiment, and the tests were performed in quadruplicate. For the control, we used an aqueous solution of 1% DMSO containing 3 μg/mL of the synthetic larvicide, Temephos. The activity of the tested extracts was established based on the average percentage of mortality of the larvae after 48 hours (>75% [promising result], 50–75% [partially promising], 25–50% [weakly promising], and <25% [inactive]).

Table 2: In vitro larvicidal activity of ethanolic extracts from *Scoparia dulcis* and *Helicteres velutina*. LC: Lethal concentration reported as LC_{10}, LC_{50}, and LC_{90} (in mg/L).

Tested species	Popular name	Part used	LC_{10}	LC_{50}	LC_{90}
Scoparia dulcis	Vassourinha	Leaf	43.820	83.426	158.829
Helicteresvelutina	Pitó	Root	73. 029	171.683	403.607
Helicteresvelutina	Pitó	Stem	60.406	138.896	319.372

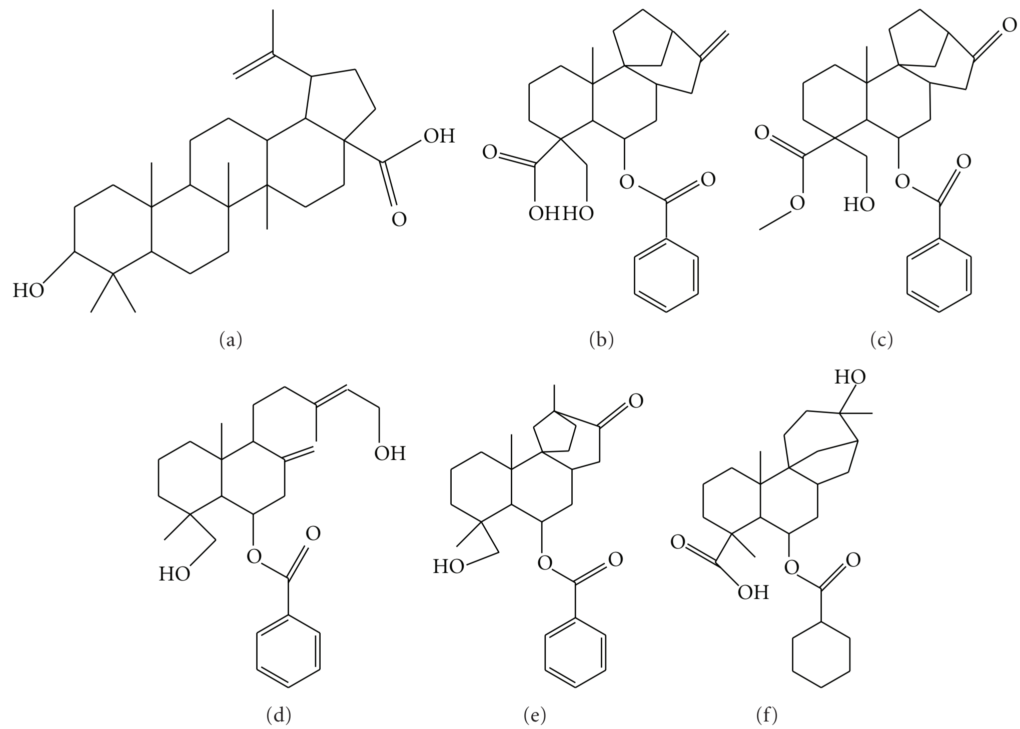

Figure 1: Chemical structures of selected compounds isolated from *S. dulcis*: (a) betulinic acid, (b) scopadulcic acid A, (c) scopadulcic acid B, (d) scopadiol, (e) scopadulciol, and (f) scopadulin.

2.6. Data Analysis. The results are reported as the average of three repetitions ($n = 3$) ± the standard deviation of the mean. The values found were subjected to ANOVA and Tukey's test ($P \leq 0.05$). All of the analyses were performed using the Microcal Origin, version 8.0, and GraphPad Prism, version 5.0, programs.

3. Results and Discussion

The eight plant species examined belong to six families and eight genera, and a biological activity has previously been described in the literature for these species (Table 1). These species were cited by the Pankararé as insect repellents (5 species) and/or anthelmintics (4 species). The analyses of the extracts and the root, stem, and leaf fractions demonstrated that seven (87.5%) of the eight tested species presented activity. Five species (62.5%) were active against the mollusk, *Biomphalaria glabrata*, and two species (25%) were active against larvae of the *Aedes aegypti* mosquito.

Two of the seven species with activity (*Chenopodium ambrosioides* L. and *Hyptis pectinata* Poit.) are cultivated in home gardens. The remaining five species (*Helicteres velutina* K. Schum., *Jatropha mollissima* (Pohl) Baill., *Poincianella pyramidalis* (Tul.) L.P. Queiroz, *Mimosa tenuiflora* (Willd.) Poir., and *Scoparia dulcis* L.) are native or ruderal species.

The species with the strongest activity against the larvae of *A. aegypti* was *S. dulcis*, whose ethanolic leaf extract presented an LC_{50} 83.426 mg/L. The next strongest activity was presented by *Helicteres velutina* K. Schum., with an LC_{50} of 138.89 mg/mL and 171.68 mg/L, respectively, for the extracts obtained from the stems (215 g) and roots (208 g) (Table 2).

Previous studies report that the extracts from the roots and stems of *S. dulcis* present a high activity against the bacterium *Klebsiella pneumoniae* and gram-negative bacteria [45]. Such results may be associated with the presence of steroids, saponins, polyphenols, and glutinol [58]. Flavonoids were also described as occurring in the aerial parts of *S. dulcis* [59], which suggests the presence of antioxidant activity. *S. dulcis* is a good source of betulinic acid (Figure 1), a compound with proven anticarcinogenic, antimelanoma, antiviral, and cytotoxic properties. Many biological activities that were found in *S. dulcis* have been attributed to various compounds, including scopadulcic acids A and B, scopadiol, scopadulciol, and scopadulin [60] (Figure 1).

Table 3: Molluscicidal activity against *B. glabrata* of plant extracts used by the Pankararé indigenous people (Bahia State, Brazil). LC: Lethal concentration reported as LC_{10}, LC_{50}, and LC_{90} (in mg/L).

Crude extract	Common name	Used part	LC_{10}	LC_{50}	LC_{90}
Jatropha mollissima	Pinhão-branco	Stem	20.00	33.55	56.26
Hyptis pectinata	Sambacaetá	Leaf	8.48	25.34	75.66
Poincianella pyramidalis	Catingueira	Leaf	0.04	0.94	20.03
Chenopodium ambrosoides	Mastruz	Leaf	1.99	13.51	91.57
Mimosa tenuiflora	Jurema preta	Stem	6.59	20.22	62.05

No data were found in the literature that could be used in a comparative analysis of *Helicteres velutina*, a species whose roots and stems exhibited activity in the present study; such previously reported data were found only for *Helicteres angustifolia* L. [33]. The other species tested did not present activity against the larvae of *A. aegypti* using the applied method.

P. pyramidalis (Tul.) L.P. (LC_{50} 0.94 mg/L), *C. ambrosoides* (LC_{50} 13.51 mg/L), *M. tenuiflora* (LC_{50} 20.22 mg/L), *H. pectinata* (LC_{50} 25.55 mg/L), and *J. molissima* (LC_{50} 33.55 mg/L) demonstrated the strongest molluscicidal activities (Table 3). The extracts of *C. moritibensis* (the stems, roots, leaves, stem bark, and root bark) did not exhibit any significant activity, as based on the recommendations of the WHO [56]. These recommendations propose that only the aqueous and alcoholic extracts of plants that promote the death of 90% of the animals when tested at concentrations equal to or lower than 20 mg/L (over a 24-hour exposure) should be tested in the field and deserve attention in studies on the purification and isolation of the most active compounds.

The ethanolic extract of *P. pyramidalis* has been used successfully against resistant strains of *Escherichia coli* (strain ATCC25922) and *Staphylococcus aureus* (ATCC25923) [48]. A phytochemical study of this species revealed the presence of phenolic compounds, such as glucosyl-phenylpropanoid acid, 4-Obd-glucopyranosyloxi-Z-7-hydroxycinnamic acid and 4-O-b-glucopyranosyloxi-Z-8-hydroxycinnamic acid, and flavonoids agathisflavone, apigenin, and kaempferol [53] (Figure 2).

The excellent efficacy of this species is important, and the crude extract deserves further studies with regard to the purification and isolation of the most active compounds. Importantly, *P. pyramidalis* occurs frequently and this species grows densely in semiarid dry forest in northeastern Brazil, locally known as caatinga [61], presenting the strong potential for large-scale exploitation without incurring a major risk to its population and the possibility of generating income for local communities and creating major public health benefits.

Mastruz (*C. ambrosoides*), which was the second most efficacious species, provides an essential oil containing the active ingredient monoterpene ascaridol [62]. The essential oil of this species has been used as an anthelmintic in humans but, due to its high toxicity, it has been replaced with safer drugs [63].

In a review on the phytochemistry of jurema-preta, Souza et al. [64] report the presence of several metabolites, such as alkaloids, chalcones, steroids, terpenoids, and phenoxychromones. Choi et al. [65] has suggested that many biological plant activities are due to the presence of total phenols, such as flavonoids and tannins.

Sambacaitá (*H. pectinata*), which is also bioactive, has proven anti-inflammatory, hepatoprotective, antibacterial, antifungal, and antinociceptive action [49–54].

The bark extract from *J. mollissima* was more toxic to the *A. aegypti* larvae than the leaf or root extracts. These results are similar to those found by Heal et al. [66].

The diterpenoids, jatrophone, and jatropholones A and B (Figure 3), are classified as cytotoxic substances, and the isolation of tumor growth inhibitors from this plant has been cited by Goulart et al. [67] and Kupchan et al. [68, 69]. These substances have been the subject of several scientific studies and have been reported to inhibit the effects of insulin [70].

Although previous researchers have studied the bioactive substances of seven of the eight species examined here, no reference was found concerning its molluscicidal or larvicidal potential.

Although there is a need for further investigation to isolate and identify the constituents of the crude plant extracts studied, the results of this study provide evidence that some of the plants tested contain natural insecticides and have the potential for larvicidal activity and may provide substitutes for synthetic products in the future. Developments in this direction may lead to important positive impacts on public health programs, particularly with regard to socially excluded populations.

4. Conclusion

During the molluscicidal tests, we verified that the leaf extracts of *Poincianella pyramidalis* and *Chenopodium ambrosoides* were very effective and had a high level of activity. However, other extracts were more promising for larvicidal activity; of particular note were the leaf extracts from *Scoparia dulcis* and the stem and root extracts of *Helicteres velutina*. Based on these results, the plants of the studied region have proven to be a rich source of substances with larvicidal activity (based on *Aedes aegypti* larvae in the fourth instar) and molluscicidal activity (based on the snail *Biomphalaria glabrata*). Further attention is warranted for the purification and isolation of the most active compounds

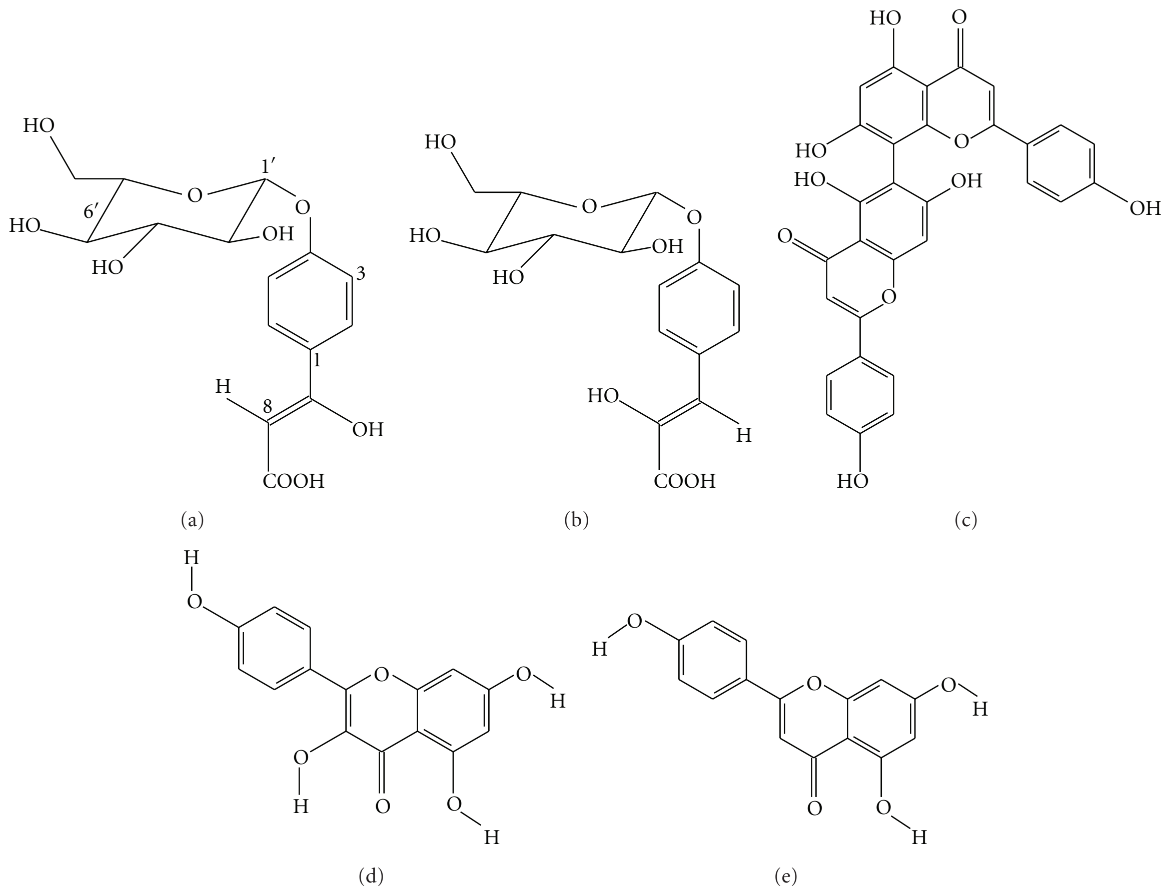

Figure 2: Chemical structures of some compounds isolated from *P. pyramidalis*: (a) apigenin, kaempferol and (b) agathisflavone.

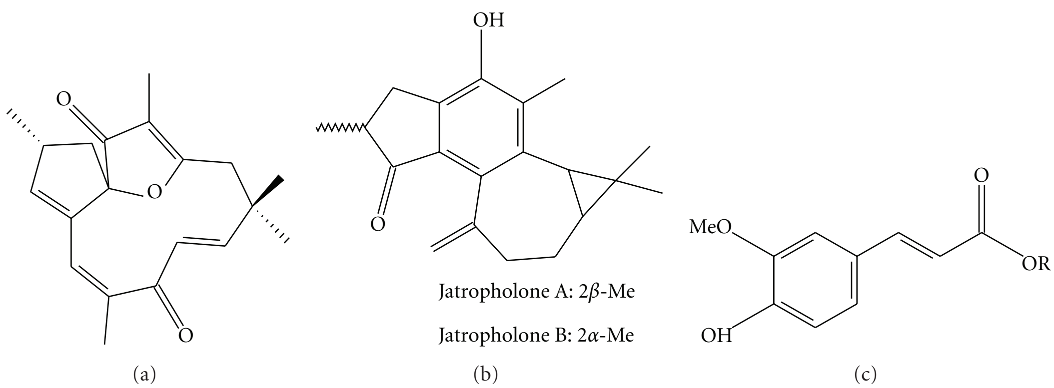

Figure 3: Chemical structures of some compounds isolated from plants of the genus *Jatropha*: (a) jatrophone, (b) jatropholone A and B, (c) ferulates.

from these extracts, and field tests are needed. From the information presented here, the need for an interdisciplinary research program in the northeastern semiarid region is evident, especially in the village of the Pankararé people. Such a program would be aimed at developing the sustainable use of natural resources and promoting community development.

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Research Article

Functional Foods and Nutraceuticals in a Market of Bolivian Immigrants in Buenos Aires (Argentina)

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This paper presents the results of a research in urban ethnobotany, conducted in a market of Bolivian immigrants in the neighborhood of Liniers, Ciudad Autónoma de Buenos Aires (Argentina). Functional foods and nutraceuticals belonging to 50 species of 18 families, its products, and uses were recorded. Some products are exclusive from the Bolivian community; others are frequent within the community, but they are also available in the general commercial circuit; they are introduced into it, generally, through shops called *dietéticas* ("health-food stores"), where products associated with the maintenance of health are sold. On this basis, the traditional and nontraditional components of the urban botanical knowledge were evaluated as well as its dynamics in relation to the diffusion of the products. Both the framework and methodological design are innovative for the studies of the urban botanical knowledge and the traditional markets in metropolitan areas.

1. Introduction

This paper presents preliminary results obtained from a research line about Urban Ethnobotany developed in the Laboratorio de Etnobotánica y Botánica Aplicada (LEBA), Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. The object of study is the botanical knowledge (BK) in the main metropolitan area of Argentina, the contiguous urban agglomerations surrounding Buenos Aires, the capital city of the country, and La Plata, the capital city of the province of Buenos Aires. The composition and the dynamics of the BK are evaluated. This knowledge guides the selection and use of plants, their parts and products deriving from them found in the context of the conurbation.

This survey has been developed in a Bolivian immigrant market located in the city of Buenos Aires, which provides the specific products for this community and it is also representative of the pluricultural context of the metropolitan area [1, 2].

Researches on traditional markets have usually been addressed from the anthropology and the economic geography points of view as systems in which their components (actors and social networks, exchange and distribution, the products with their origin and destination) have to be explored [3]. It is important to note that in Latin America, markets represent valuable places for ethnobotanical researches as they condense in a reduced area the local knowledge and values on biological products. "Markets are public spaces devoted to sell several products, as well as they are spaces of exchange and acquisition of cultural information. Those spaces are walking traces of a determined culture or society by reproducing in a small scale, the biological and cultural diversity of a region" ([4], authors' translation). Consequently, they have been object of study, especially those in rural areas [5, 6] but there are only some previous investigations about markets placed in urban areas as the one described here [7]. It is considered a priority subject, because markets are true germplasm banks that help to preserve plant diversity through the use of different species [8]. The aim of this paper is to contribute to the ethnobotanical studies of markets in Argentina from the perspective of urban ethnobotany and to promote ideas for other aspects related to the value of the markets in connection with the understanding of the BK of the urban areas.

2. Materials and Methods

2.1. Framework. Ethnobotany is a complex science due to both the diversity of issues and the variety of approaches that it includes. This plurality is framed in a broad concept of the discipline: the study of the relations between humans and their vegetal environment [9–11]. An aspect related to those relationships has acquired a central development: researches about *botanical knowledge* (BK), a set of knowledge and beliefs about the relationships between people and vegetal elements of their environment: plants, parts of plants, or products deriving from them.

Most of the surveys about BK have been oriented to societies called *traditional*. Even if this term is not exempt from discussion [12], it is considered that the *traditional botanical knowledge* (TBK), related to the concept of *traditional ecological knowledge* (TEK), is characteristic of culturally homogeneous contexts, with a long experience of human group in its environment; knowledge is transmitted from generation to generation orally and in the shared practices, and there is a direct link between production and consumption: those who consume produce [13–15]. Besides, the TBK is *adaptive,* because it allows adjustments of the group to the environmental changes; this is why it is not static or conservative but dynamic and innovative [16, 17]. There has been a rise in the number of studies about BTK, because they are usually endangered and their rescue is urgent.

On the other hand, the BK of the inhabitants of the urban agglomerations has been considered *nontraditional*; by contrast with the TBK, it corresponds to pluricultural contexts, with human groups without a large experience in the environment; knowledge is transmitted through social means of communication, and there is an indirect link between production and consumption: those who consume do not produce. The majority of the urban population knows little about the properties of the vegetal elements and less about their components or their origin, and the ways of obtaining and processing them are even less known [18]. However, this type of BK is also *adaptive,* because it guides the choice of what to consume [19]. Therefore, not long ago, several researches on urban ethnobotany came out based on studies about the BK of some part of the population of the conurbations. While some contributions on this field deal with plants product used by the average consumer in urban areas [1, 19, 20], up to now, most of the papers on urban ethnobotany are devoted to groups of immigrants that preserve a BK linked to their native traditions, which are readapted to their new context. In this way, there are several contributions from different parts of the world [21–33] and Argentina [2, 34–39].

The characterization of the BK of urban agglomerations is deficient if only the nontraditional BK is considered; together with it (including the scientific knowledge), different kinds of BK within the pluricultural context related to different traditions coexist: those of immigrants from various origin and those that belong to a part of the population that keeps their "family traditions". The BK of these segments is linked to traditions, but it does not constitute a TBK in the sense defined above. Thus, what we call *urban botanical knowledge* (UBK) is a complex and adaptive corpus formed with a set of knowledge and beliefs about vegetal elements that coexist and interact within the same pluricultural scope [1, 2, 37].

On this basis, urban ethnobotany gives an answer of how is the *composition* of the UBK, that is, which are its components: linked to traditions and nontraditional and what is its *dynamics*: how the transmission of knowledge about the vegetal elements and their uses take place in the studied area. Several plants, their parts, and products deriving from them are *visible* for all the urban population and belong to the general commercial circuit, and their uses are widespread by the media; other plants remain restricted to immigrant groups or to the sphere of familiar tradition, and they are *invisible* for the majority. Nevertheless, some of these vegetal elements become visible when they enter the general circuit. In terms of the UBK dynamics, a component of the restricted BK (linked to traditions) spreads, and it gets generalized.

2.2. Functional Foods and Nutraceuticals. In this paper, the survey data focused on species that are used, at the same time, for food and therapeutic purposes. In fact, the line between these categories of use is not always clear [40–42], and many plants "used for food" also "serve to heal". This idea is in tune with the broad concept of *health* as a state of complete physical, mental, and social well-being and not merely the absence of disease [43]. In urban agglomerations, shops called *dietéticas* ("health-food stores") [44] are the focus of attention about the concept of *healthy food*, which was widespread by the media, and they are the places chosen to buy dietary supplements, functional foods, and nutraceuticals.

The concept of functional foods is susceptible of different interpretations that referred to their characteristics, their active components, or their regulatory framework [45–48]. Overall, apart from their conventional value as a source of nutrients, functional foods provide benefits for certain body functions, important for the maintaining of health or to reduce disease risk [49, 50]. According to Kalra [51], functional foods are consumed for those purposes, but people are not aware of their specific components; however, they are recognized because they "are good for health". The concept of *nutraceuticals* is also debatable. However, from the point of view of the consumer, nutraceuticals are functional foods that help to prevent a disease or collaborate in its treatment; therefore, their particular effects are recognized. In this context it is noteworthy that what for a consumer is a functional food, for another one can act as a nutraceutical [51]. The categories presented in Table 1 derive from the consensus of informants.

Among immigrants, the integrative idea of "edible and healing plants" (functional foods and nutraceuticals included) is linked to their traditions, and it is invisible for the rest of the urban population. However, some functional foods and nutraceuticals prevalent within the immigrant community go on sale in the *dietéticas* (shops that are related to the nontraditional component of the UBK), and according to their diffusion level, spread by the media, they enter the general commercial circuit, and they become visible. The evaluation of this situation is an important methodological tool to understand the UBK dynamics: these health-food stores become *visualization* agents.

2.3. Study Area and Involved Actors. The Ciudad Autónoma de Buenos Aires or Capital Federal is placed over the West margin of the Río de la Plata in South latitude 34°36′ and West longitude 58°26′ [52]; it has an area of 202 km^2 and a population of 2,891,082 inhabitants [53]. Together with 24 departments of the Buenos Aires province, it forms the Great Buenos Aires [54, 55], with a total area of 3,833 km^2. These departments have a total population of 9,910,282 inhabitants [53]. In population terms, the Great Buenos Aires is the biggest conurbation of Argentina and the second in South America (after São Paulo metropolitan area and Mexico DF), the fifth of America, and the seventeenth in the world [56]. This large metropolitan area comprises strictly urban areas, some not urbanized areas with spontaneous vegetation, and transition areas between urban and rural sectors, named *periurban*, with mobile boundaries according to the urbanization rhythm and characterized by horticultural production that supplies the urban agglomeration [57–59].

The Bolivian immigration, caused especially for work reasons, settled first in the Northeast of the country, in the provinces of Jujuy, Salta, and Tucumán, working in the harvest. In the second half of the 20th century, their destinations diversified, and then, they settle again but this time in the metropolitan area of Buenos Aires, working with the horticulture in the periurban areas and the manufacturing industry, commerce, and the construction business in the urban areas [60, 61]. In 2001, 22% of the Bolivian population in Argentina (2,233,464 inhabitants according to that year census) was living in Jujuy and Salta, a low percentage compared to the 60% settled in Capital Federal (22%) and in the province of Buenos Aires (38%) that same year.

The preference of recent immigrants to settle in metropolitan areas is also seen in the age structure of population: in Capital Federal and Buenos Aires province, the Bolivian immigrants over 54 years old are about 15% of the total population, and in Jujuy, they are over 43%. In Buenos Aires city, the immigrants coming from Bolivia, Peru, and Paraguay are the 5% of its total population, and in the whole country, they represent a little less than the 2% [62].

The called *horticultural belt* of Buenos Aires (Berazategui, Florencio Varela, and La Plata departments) supplies fresh vegetables to the inhabitants of the conurbation Buenos Aires-La Plata and other provinces. In 2001, 39.2% of the producers were Bolivian: of that total 75% are tenants, 25% owners that work almost exclusively with work force coming from their own country [63]. If it is considered that the first Bolivian immigrants, who arrived in the area about two or three decades ago [59, 63], worked as agricultural laborers, the social mobility of the group is marked [64].

2.4. Liniers Bolivian Market. The market of Bolivian immigrants that is the object of study of this research is placed in the neighborhood of Liniers, in Buenos Aires, and it is known as *Liniers market* (or *Bolivian market* for the population that does not belong to the segment). Liniers is one of the 48 neighborhoods or districts in which the Capital Federal is divided. It is located in the west of the city, its area is of 5.4 km^2, and its population is of 44,234 inhabitants. With regards to public urban and intercity transportation, the neighborhood is one of the main points of the city, with a lot of buses short- and long-distance routes that communicate the Capital Federal with departments of the Great Buenos Aires. Its central bus station is the second most important of the city, after Retiro. Likewise, there is a train station of Ferrocarril Sarmiento that links Buenos Aires city with the provinces of Buenos Aires, La Pampa, Córdoba, San Luis, and Mendoza, west to the country [52]. Surrounding this train station and Rivadavia Avenue (that goes through the city from East to West and it continues to the province of Buenos Aires), there is a commercial area with different shops, an important shopping mall, and the *Bolivian market.*

This market is a set of premises and street stalls that is specially concentrated in the street José León Suárez, one block away (a hundred meters) from the train station which is in the intersection of José León Suárez and Rivadavia Avenue. In the premises and street stalls, located in the sidewalk, food and medicinal vegetables and several products deriving from them are sold; there are also bars and restaurants of typical food and other shops of the sort in the cross and side streets. This receives the name of *market* or, sometimes, *fair*. In a broad sense, it is a market, because it is a site designed to sell products, either permanently or on specific days. However, it is different from other markets in the city, because the premises and stalls are not inside a building. On the other hand, it can be considered a fair, but local fairs are usually placed outdoors (streets and parks) and are held on specific days.

The activity is more intense in the Liniers market during the weekend (in fact the vehicular traffic is stopped), when a lot of people from all over the city and nearby cities of the province of Buenos Aires go there to purchase products as well as a tour and meeting place. The market is visited by the members of the Bolivian community that ask for specific products to preserve their own traditional recipes (dietary and therapeutic), members of the Peruvian immigrant community, for similar reasons, neighbors who are not part of these immigrants segments who find it a cheap place with a wide and diverse selection and purchase of food and therapeutic, and, finally, some people from other neighborhoods of the city and different social sectors that have started to use this market as a place to buy functional foods and nutraceuticals.

Table 1: Exclusive and frequent functional food and nutraceuticals in the market of Bolivian immigrants in Liniers, Ciudad de Buenos Aires, Argentina.

Families/species	Local name	Parts/products	Uses	Situation	Samples
Apiaceae					
Coriandrum sativum L.	Cilantro	Fresh leaves	Food and condiment, as a substitute of parsley. Nutraceutical: diuretic, aperitive, digestive, and antispasmodic	Frequent	FB 430 (LEBA)
Asteraceae					
Baccharis articulata (Lam) Pers.	Carqueja	Fresh aerial parts (in bunches)	Beverage flavouring. Nutraceutical: tonic, digestive, hepatic, diuretic, febrifuge, and cordial; in external application, vulnerary	Exclusive	FB 416 (LP)
Baccharis trimera (Less.) DC.	Carquejilla/ Carqueja	Fresh aerial parts (in bunches)	Same as above	Exclusive	FB 424 (LEBA)
Cynara cardunculus L. (= *C. scolymus* L.)	Alcachofa	Leaves in bags and pills	For infusions. Nutraceutical: hepatic, cholagogue, choleretic, and depurative	Exclusive	JH H093, H094 (LEBA)
Matricaria recutita L.	Manzanilla	Fresh aerial parts (in bunches)	Beverage flavouring. Nutraceutical: sedative, slimming, digestive, antispasmodic, emmenagogue, pectoral, emollient, and vermifuge	Exclusive	FB 427 (LP)
Porophyllum ruderale (Jacq.) Cass.	Quirquiña	Fresh aerial parts (in bunches)	Food and condiment, for soups, stews and sauces. Nutraceutical: diaphoretic, antispasmodic; in external application, vulnerary	Exclusive	FB 413 (LP)
Smallanthus sonchifolius (Poepp. & Endl.) H.Rob.	Yacón	Fresh roots and jams	Food, as fruit or in salads (raw), for juices, syrups, jams, and teas. Functional food or Nutraceutical: antidiabetic	Exclusive	JH 6891 (LP), L006 (LEBA)
Stevia rebaudiana L.	Yerba dulce	Fresh aerial parts or whole plant	Sweetener, for infusions and confectionary. Nutraceutical: antidiabetic and "antiageing" (antioxidant)	Exclusive	FB 415 (LP)
Tagetes minuta L.	Huacatay	Fresh aerial parts (in bunches)	Condiment for soups, stews and sauces. Nutraceutical: diuretic, digestive, and antispasmodic. Insecticide	Exclusive	FB 403 (LEBA)
Basellaceae					
Ullucus tuberosus Caldas	Papa lisa/ Ulluco	Fresh tubers (sold loose or packed)	Food, for soups, stews, locro, and purees. Functional food: "healthy" food (antioxidant)	Frequent	FB 439 (LEBA)
Boraginaceae					
Borago officinalis L.	Borraja	Fresh aerial parts	Food, eaten as a vegetable or in patty fillings; condiment in sauces, soups, and stews. Functional food or nutraceutical: expectorant, cordial	Frequent	FB 414 (LP)
Brassicaceae					
Lepidium meyenii Walp. (= *L peruvianum* G. Chacón)	Maca	Roots in powder or as flour (sold loose or packed)	Nutraceutical: tonic of the nervous system, to stimulate memory, to improve sexuality and fertility, against fatigue and stress, "antiageing" (antioxidant). It is added to food and drinks	Frequent	JH H091, H160 (LEBA)
Families/species	Local name	Parts/products	Uses	Situation	Samples
Cactaceae					
Opuntia ficus-indica (L.) Mill.	Tuna	Arrope (syrup) (in bottles)	Food. Functional food o nutraceutical: diuretic, antispasmodic, emollient, and vermifuge	Exclusive	JH L002 (LEBA)

Table 1: Continued.

Families/species	Local name	Parts/products	Uses	Situation	Samples
Chenopodiaceae					
Dysphania ambrosioides (L.) Mosyakin & Clemants (= *Chenopodium ambrosioides* L.)	Paico	Fresh aerial parts (in bunches)	Condiment in soups, stews, and other foods. Beverage flavouring. Nutraceutical: tonic, aperitive, febrifuge, digestive, antispasmodic, carminative, hypotensive, emmenagogue, and vermifuge; in external application, antihemorroidal	Exclusive	FB 419 (LP)
Cucurbitaceae					
Cyclanthera pedata (L.) Schrader	Caiwa/ Achojcha	Fresh fruits.	Food, used as pumpkin, in stews and soups. Functional food or nutraceutical: antidiabetic, analgesic, and hypotensive	Exclusive	FB 417 (LEBA)
Cucurbita ficifolia Bouché	Cayote/ Alcayote	Fresh fruits	Food, as a fruit; also in soups and stews. Functional food or nutraceutical: antidiabetic	Exclusive	JH 565 (LP)
Sechium edule (Jacq.) Sw.	Chayote/ Papa del aire	Fresh fruits	Food, in stews, soups, fried, pies, and jams. Functional food or nutraceutical: diuretic, antidiabetic, and hypotensive	Exclusive	FB 418 (LEBA)
Euphorbiaceae					
Plukenetia volubilis L.	Sacha inchi	Seeds in snacks, liquid, ointment and in powder	Food. Nutraceutical: depurative, hypocholesterolemic, antioxidant; in ointment, for bone pain, and inflammation	Frequent	JH L029 (LEBA)
Lamiaceae					
Melissa officinalis L.	Toronjil/ Melisa	Fresh aerial parts	Condiment for sauces and various dishes. Nutraceutical: digestive, carminative, antispasmodic, cordial, and emmenagogue	Exclusive	FB 422 (LEBA)
Mentha x *piperita* L.	Menta	Fresh aerial parts	Condiment for various dishes. Beverage flavouring. Nutraceutical: aperitive, stimulant, digestive, antidiarrheal, carminative, and vermifuge	Exclusive	FB 428 (LEBA)
Mentha spicata L.	Yerba buena	Fresh aerial parts	Condiment for various dishes. Beverage flavouring. Nutraceutical: stimulant, digestive, hepatic, cholagogue, and pectoral	Exclusive	FB 423 (LEBA)
Rosmarinus officinalis L.	Romero	Fresh aerial parts	Condiment for various dishes. Nutraceutical: antispasmodic, digestive, hepatic, depurative, and emmenagogue	Exclusive	FB 457 (LEBA)
Leguminosae					
Arachis hypogaea L.	Maní boliviano	Dry seeds (sold loose)	Food, for soups and stews. Functional food or nutraceutical: laxative, emollient, and pectoral	Exclusive	JH L007 (LEBA)
Cicer arietinum L.	Garbanzo	Dry seeds and flour (sold loose)	Food, for soups, stews, and side dishes. Functional food or nutraceutical: diuretic, hypocholesterolemic	Frequent	JH L027 (LEBA)
Geoffroea decorticans (Gillies *ex* Hook. & Arn.) Burkart	Chañar	Arrope (syrup) (in bottles)	Food. Nutraceutical: antitussive, expectorant, anticatarrhal, balsamic, emollient, and antiasthmatic	Frequent	JH L005 (LEBA)
Glycyrrhiza glabra L.	Regaliz	Dry chopped roots	Sweetener. Nutraceutical: anti-inflammatory, digestive, antispasmodic, hepatic, diuretic, emollient, laxative, expectorant, and antiasthmatic	Frequent	JH H084 (LEBA)
Glycine max (L) Merr.	Soja	Dry seeds and flour (sold loose)	Food, for stews, soups, and salads. Functional food or nutraceutical: diuretic, hypocholesterolemic, digestive, and laxative	Frequent	JH L019 (LEBA)

Table 1: Continued.

Families/species	Local name	Parts/products	Uses	Situation	Samples
Lablab purpureus (L.) Sweet	Poroto japonés	Fresh beans	Food (cooked). Functional food or nutraceutical: astringent, antidiarrheal, digestive, and febrifuge	Exclusive	FB 404 (LEBA)
Lens culinaris Medik.	Lenteja común	Dry seeds (sold loose)	Food, for soups and stews. Functional food or nutraceutical: antianemic, digestive, and laxative	Frequent	JH L018 (LEBA)
	Lentejón		Same as above	Frequent	JH L017 (LEBA)
	Lenteja *turca*		Same as above	Frequent	FB H05 (LEBA)
	Lenteja *canadiense*		Same as above	Frequent	JH L013 (LEBA)
Lupinus albus L.	Lupín	Dry seeds (sold loose)	Food, for soups and stews. Functional food or nutraceutical: diuretic, vermifuge, emmenagogue	Frequent	JH L014 (LEBA)
Lupinus mutabilis Sweet	Tauri/Tarwi	Dry seeds (sold loose)	Food, for soups, stews, purees, tamales, humita, and tortillas. Functional food or nutraceutical: diuretic, emollient, and vermifuge	Exclusive	FB H14 (LEBA)
Pachyrhizus ahipa (Wedd.) Parodi	Ajipa	Fresh roots	Food, as fruit (raw) or vegetable (cooked). Functional food or nutraceutical: diuretic, expectorant, and antitussive	Exclusive	FB 374 (LEBA)
Phaseolus lunatus L.	Poroto pallar	Dry seeds (sold loose)	Food, for salads, soups, and stews. Functional food or nutraceutical: astringent, febrifuge, and emollient	Frequent	FB H13 (LEBA)
	Poroto de manteca		Same as above	Frequent	JH L024 (LEBA)
Phaseolus vulgaris L.	Poroto/ Chaucha	Dry seeds and fresh legumes (sold loose)	Food, for salads, soups, stews, and locro. Functional food or nutraceutical: diuretic, hypoglycemic, hypotensive, and resolutive	Frequent	JH L028 (LEBA)
	Poroto *alubia*		Same as above	Frequent	JH L023 (LEBA)
	Poroto *negro*		Same as above	Frequent	JH L021 (LEBA)
	Poroto *colorado*		Same as above	Frequent	JH L022 (LEBA)
	Poroto *regina*		Same as above	Frequent	JH L008 (LEBA)
	Poroto *cranberry*		Same as above	Frequent	JH L010 (LEBA)
	Poroto *San Francisco*		Same as above	Frequent	FB H11 (LEBA)
	Poroto *pitai*		Same as above	Frequent	FB H12 (LEBA)
	Poroto *paraguayo*		Same as above	Frequent	JH L020 (LEBA)
	Poroto *canario*		Same as above	Frequent	FB H10 (LEBA)
	Poroto *panamito*		Same as above	Exclusive	FB 443 (LEBA)
Pisum sativum L.	Arveja	Dry seeds and flour (sold loose)	Food, for salads, soups, and stews. Functional food or nutraceutical: digestive, febrifuge, against dermatosis, and contraceptive	Frequent	JH L026 (LEBA)

Table 1: Continued.

Prosopis alba Griseb.	Algarrobo blanco	Arrope (syrup) (in bottles) and flour (sold loose).	Food. Nutraceutical: stomachic, laxative, diuretic, pectoral, and antiasthmatic	Frequent	JH L004 (LEBA)
Tamarindus indica L.	Tamarindo	Fruit pulp.	Food and Condiment. Functional food or nutraceutical: digestive, refreshing, laxative, and purgative	Frequent	JH L001 (LEBA)
Vicia faba L.	Haba	Dry and toasted seeds (snacks) and fresh legumes (sold loose)	Food, for salads, soups and stews. Functional food or nutraceutical: diuretic, emollient, resolutive, and against colds	Frequent	JH L015, L016 (LEBA)
Vigna angularis (Willd.) Ohwi & H. Ohashi	Poroto adzuki	Dry seeds (sold loose)	Food, for soups and stews, with cereals and rice, and confectionary. Functional food or nutraceutical: digestive, laxative, and hypoglycemic	Frequent	JH H101 (LEBA)
Vigna radiata (L.) R. Wilczer	Poroto mung	Dry seeds (sold loose)	Food, for soups and stews. Functional food or nutraceutical: digestive, antidiarrheal, febrifuge, and tonic.	Frequent	JH L011 (LEBA)
Vigna unguiculata (L.) Walp.	Poroto tape/Caupí	Dry seeds (sold loose)	Food, for soups, stews and purees. Functional food or nutraceutical: diuretic, digestive, laxative, tonic, and galactogene	Frequent	JH L012 (LEBA)
Moraceae					
Ficus carica L.	Higo	Arrope (syrup) (in bottles)	Food. Functional food or nutraceutical: anti-inflammatory, emollient, vermifuge, and antioxidant	Exclusive	FB 453 (LEBA)
Myrtaceae					
Eucalyptus cinérea F. Muell. *ex* Benth.	Eucalipto	Branches with fresh leaves (in bunches)	Beverage flavouring. Nutraceutical: expectorant, against colds, anticatarrhal, antitussive, antiasthmatic, and antirheumatic	Exclusive	FB 425 (LEBA)
Oxalidaceae					
Oxalis tuberosa Molina	Oca	Fresh tubers (sold loose or packed)	Food, for soups, stews, purees (cooked). Functional food: "healthy" food (antioxidant)	Frequent	FB 438 (LEBA)
Poaceae					
Cymbopogon citratus (DC.) Stapf	Pasto limón/ Citronela	Fresh tillers (in bunches)	Condiment for food and beverage flavouring. Nutraceutical: sedative, stomachic, carminative, and antidiarrheal	Frequent	FB 407 (LEBA)
Zea mays L.	Maíz *morado* (*kulli*)	Whole dry spikes or in powder (sold loose)	To make *chicha morada* (refreshing drink). Nutraceutical: depurative, hypotensive, anti-inflammatory, and antioxidant	Exclusive	FB 431 (LEBA)
Families/species	Local name	Parts/products	Uses	Situation	Samples
	Maíz *chuspillo*	Dry grains (sold loose or packed)	For toasted corn. Functional food	Exclusive	FB 448 (LEBA)
	Maíz *huillcaparu*		To make *chicha* (alcoholic beverage). Functional food	Exclusive	FB 447 (LEBA)
	Maíz *colorado*		For soups, stews and other dishes. Functional food	Exclusive	FB 450 (LEBA)
	Maíz *blanco*		Same as above	Exclusive	FB 449 (LEBA)
	Maíz *mote* o *pelado*	Dry or cooked grains (sold packed)	For stews and other dishes, boiled in water. Functional food	Exclusive	FB 451 (LEBA)

Table 1: Continued.

	Barba de choclo	Dry styles (sold loose)	Diuretic, hepatic, and antinephritic.	Frequent	JH H163 (LEBA)
Rubiaceae					
Coffea arabica L.	Sultana	Seeds (seed coat) (sold loose or packed)	Beverage flavouring. Nutraceutical: antidiabetic, stimulant, antinephritic, and febrifuge	Exclusive	JH C095 (LEBA)
Morinda citrifolia L.	Noni	Pulp made flour or powder (loose or packed) and capsules	To make beverages or to add to infusions. Nutraceutical: stimulant of immune system, antidepressant, sleep regulator, "antiageing" (antioxidant), anti-inflammatory, and cordial	Frequent	JH H092, H161-H162 (LEBA)
Solanaceae					
Capsicum annuum L.	Ají *picante*	Fresh and dry fruits (sold loose or packed)	Food and condiment, for sauces, soups, stews, side dishes, and patty fillings. Functional food or nutraceutical: tonic, analgesic, and stimulant of the digestive system	Exclusive	JH C096 (LEBA)
	Ají *escabeche*			Exclusive	FB 433 (LEBA)
	Ají *amarillo*			Exclusive	FB 435 (LEBA)
	Ají *campanita*			Exclusive	FB 421 (LEBA)
Capsicum pubescens Ruiz & Pav.	Locoto/ Rocoto	Fresh fruits (sold loose) and in powder (packed)	Condiment for soups, sauces, stews, patty fillings, and various dishes. Functional food or nutraceutical: tonic, analgesic, and stimulant of the digestive system	Exclusive	JH C094 (LEBA)
Solanum tuberosum L.	Papa blanca, papa negra	Dried tubers (*chuño*) (sold loose or packed)	Food, for various dishes. Functional food and nutraceutical: cordial, hypotensive, and antispasmodic	Exclusive	FB 441-442 (LEBA)
	Papines	Fresh tubers (sold loose or packed)	Same as above	Frequent	FB 440 (LEBA)
Verbenaceae					
Aloysia citriodora Palau	Cedrón	Fresh aerial parts or whole plant	Food, condiment and beverage flavouring. Nutraceutical: against gastrointestinal disorders, sedative, and hypotensive	Exclusive	FB 455 (LEBA)
Aloysia polystachya (Griseb.) Moldenke	Burrito/ Burro	Fresh aerial parts or whole plant	Beverage flavouring, fresh leaves are added to mate or used for make medicinal teas. Nutraceutical: sedative, digestive, antispasmodic, hepatic, carminative, and antiemetic	Exclusive	FB 456 (LEBA)
Vitaceae					
Vitis vinífera L.	Uva	Arrope (syrup) (in bottles)	Food. Nutraceutical: refreshing, diuretic, astringent, and antidiarrheal	Exclusive	FB 454 (LEBA)

2.5. Methodological Design. Generally, for researches on traditional markets, the methodology proposed by Cunningham [3] has been followed. 30 outlets (street stalls and premises) have been surveyed, where samples of different vegetal elements were gathered. They have been placed, to document the work, in the collections of LEBA and the herbarium samples in the Herbario LP, División Plantas Vasculares, Museo de La Plata. For the species nomenclature, database of different institutions were followed for reference purposes [65, 66]. Ethnobotanical data were obtained according to usual qualitative methods [67–70], especially, using simultaneously participant observation (to record the plants actually marketed) and interviews (both open and semistructured ones), besides the literature review relevant to the observed plant elements. Questions were designed to obtain information concerning the name of species at the market, the parts of the plant commercialized, and the use(s) attributed to each of them. These procedures always performed with the consent of the informants. Data was registered following the parameters used in other studies about urban markets [7, 8, 71]. For some products, the information from labels and inserts was also assessed that for the general public, these directs the selection of products to consume.

Informants were interviewed on the basis of saturation of information, so 50 market sellers (from a total of 95 salesmen) of both sexes and different ages have been included. They are considered *qualified informants:* immigrants that expressed their knowledge about the characteristics and properties of different vegetal elements and the way they are used. They showed a positive attitude to provide the requested information.

The record of the gathered data for plants that are sold in the Bolivian market of Liniers pointed to three distinct categories.

(1) *Exclusive* items of the Bolivian immigrant segment are not found in the general commercial circuit, and they satisfy the characteristic needs of this group, which allows identifying the UBK linked to traditions.

(2) *Generalized* items which are also found in the general circuit (supermarkets, greengrocers, herbalist's shops, and *dietéticas*), and consequently, they are related to the nontraditional UBK.

(3) *Frequent* items in the immigrants setting that are also found in the general circuit but their presence is sporadic or, at least, they do not are very well known. However, they are sold in *dietéticas*, so these items are related to the UBK dynamics. The frequency within the market refers to the fact they are for sale in all the analyzed premises and street stalls.

For the purpose of this research, the generalized items were not considered, because they are visible for everyone. The focus is placed on the exclusive items (invisible) and the frequent ones (in process of visualization).

3. Results and Discussion

Until the moment, 160 edible species commercialized in Liniers Bolivian market have been surveyed (vegetables, legumes, fresh and dry fruit, condiments, and beverage flavorings). Of that total, products or part of plants considered functional foods or nutraceuticals, exclusive or frequent within the market, belonging to 54 species of 19 botanical families are sold. These are shown in Table 1, organized by families, in alphabetical order. The table also includes the local name, parts of the plant or products obtained from them, their uses, product situation: exclusive or frequent (under the terms defined above), and samples obtained and deposited in LEBA and LP under the leg. J. A. Hurrell et al. (JH) and F. Buet Costantino et al. (FB).

It is relevant to remember that the exclusive or frequent character concerns to the products and not to the species. In this way, the "arrope de higo" ("fig syrup"), *Ficus carica* L., is exclusive of the market but the edible fresh or dry fruits or the jams, which are also available in Liniers, are products with a wide diffusion in the general commercial circuit, so they are *generalized*, according to the categories of use. In the case of *Phaseolus vulgaris* L., the common bean and the ones called "alubia", "colorado" (red), "negro" (black) and "regina", among others [35], are frequent in the market (and consequently, they are available in the general circuit but generally they are sold packed); meanwhile, another beans called "canario" and "panamito" are exclusive of the Liniers market, where they are only sold loose.

3.1. Origin of Functional Foods and Nutraceuticals. The fresh vegetables commercialized in Liniers market are cultivated in homegardens of the conurbation periurban areas; most of them are situated in the Buenos Aires horticultural belt. This information was given by the interviewed informants, but it was also taken from researches about peri-urban homegardens developed in other research lines of the LEBA [63, 72–74]. In some cases, like *Porophyllum ruderale* (Jacq.) Cass., "quirquiña", and *Tagetes minuta* L., "huacatay", they were cultivated with seeds brought from Bolivia. Dry or manufactured products usually come from Bolivia as well, even if the origin of the product is different; for example, the leaves of *Cynara cardunculus* L., "alcachofa", of the tea bags and the pills that are sold in street stalls of Liniers are products originated in Peru but they have entered from Bolivia.

All the informats agree that the vegetal elements come from Bolivia and not from the Argentinean Northeast even if this region belongs to the same ecological and cultural Andean unit and the same edible and therapeutic plants are consumed; this is the case of, for example, the Andean edible roots *Smallanthus sonchifolius* (Poepp. and Endl.) H. Rob., "yacón", and *Pachyrhizus ahipa* (Wedd.) Parodi, "ajipa" [75–80].

3.2. Contexts of Circulation of Functional Foods and Nutraceutics. There are some fresh aerial parts of plants that are exclusive from Liniers market, like *Baccharis articulata* (Lam) Pers. "carqueja"; *B. trimera* (Less.) DC., "carquejilla"; *Matricaria recutita* L., "manzanilla"; *Borago officinalis* L., "borraja", *Dysphania ambrosioides* (L.) Mosyakin and Clemants, "paico", *Melissa officinalis* L., "toronjil"; *Mentha* x *piperita* L., "menta", *M. spicata* L., "yerba buena", *Rosmarinus officinalis* L., "romero", *Eucalyptus cinerea* F. Muell. *ex* Benth., "eucalipto", *Aloysia citriodora* Palau, "cedrón" and *A. polystachya* (Griseb.) Moldenke, "burrito". Nevertheless, they are also part of within-family product exchange, and they are also available from direct harvest in the conurbation periurban and nonurban areas. Of the species listed, the dry aerial parts are sold as an herbalist product in the general commercial circuit. In contrast, the aerial parts of *Porophyllum ruderale* and *Tagetes minuta* are not available in herbalist's shops and *dietéticas*. The fresh aerial parts of *Coriandrum sativum* L. are only commercialized in Liniers market (they are rarely found in the general circuit), and they are named "cilantro"; on the other hand, their mericarps, called "semillas" are named "coriandro", and they are widespread in supermarkets, *dietéticas* and spices' shops. In Liniers market, the whole plant of *Stevia rebaudiana* L., "yerba dulce", is sold, while in the *dietéticas*, there are only available packed products: in bags, liquid, or powder.

Fresh products which are exclusive of this Bolivian market are the edible fruits of the Cucurbitaceae: *Cyclanthera pedata* (L.) Schrader, "caiwa" or "achojcha", *Sechium edule* (Jacq.) Sw., "chayote" or "papa del aire", and the *Cucurbita ficifolia* Bouché, "cayote", or "alcayote". The last example is sporadically available in greengrocer, and the jam made from its pulp is sometimes sold in supermarkets, because it is from time to time cultivated in the homegardens of the periurban area [35, 36, 72, 78]. Among the Solanaceae, there are some varieties of *Capsicum annuum* L. that are exclusive of Liners market like (various fruits of different color that are offered fresh or dry, not powdered); and *C. pubescens* Ruiz and Pav., "locoto" or "rocoto" (fresh fruit and packed powder product). Other varieties of *C. annuum,* like peppers, fresh chilies, and condiment in powder (ground chili and paprika), are generalized vegetal elements. Of *Solanum tuberosum* L., "papa", are exclusive of Liners market the dry tubers called *chuño*, from both "blancas" (white) and "negras" (black) potatoes; while the fresh potatoes are available in the general commercial circuit [35], other small tubers of this species called "papines", are a frequent item in Liniers, but they are not exclusive: sometimes they are found in some greengrocer around the city.

Andean microthermal tubers, *Ullucus tuberosus* Caldas, "papa lisa" or "ulluco", and *Oxalis tuberosa* Molina, "oca", are valued nowadays due to their antioxidant properties [81], they are sold fresh, and they are frequent in Liniers market; sporadically, they can also be seen in some greengrocer of the general circuit. Occasionally, in the past, tubers of *Tropaeolum tuberosum* Ruiz and Pav., "isañu" or "añu" were sold in Liniers market, but they stopped selling them because there were no buyers; according to an informant, they have anaphrodisiac effects (apparently were used for this purpose by the soldiers of the Inca Empire), so people dismiss them [82, 83].

Among the Poaceae, *Cymbopogon citratus* (DC.) Stapf, "pasto limón" ("lemon grass"), the fresh tillers are sold in Liniers market and sporadically in the general circuit. Different varieties of "maíz", *Zea mays* L., are exclusive of the Bolivian market, like the "maíz morado" ("purple corn"), that are sold dry, whole, or in powder to make "chicha morada" (a refreshing beverage of Peru). The dry styles, called "barba de choclo", is frequent in the market and also in some herbalist's shops. Fresh corn is a generalized item.

Arrope (syrup) from fruits of *Ficus carica*, *Opuntia ficus-indica* L. and *Vitis vinífera* L. are exclusive products of Liniers market; however, the fresh and dry fruits of these species are available both in Liniers and in the general circuit. On the other hand, arrope of "algarrobo", *Prosopis alba* Griseb., and of "chañar", *Geoffroea decorticans* (Gillies *ex* Hook. and Arn.) Burkart are also sold in *dietéticas*. A flour from the fruits of *Prosopis alba* is available in Liniers and in *dietéticas*. The bark of "chañar" is sold as a therapeutic product in herbalist's shops, with similar effects as its syrup [2, 36]. The husk of the seed *Coffea arabica* L., "café", called "sultana" is only available in Liniers.

Lepidium meyenii Walp., "maca", *Plukenetia volubilis* L., "sacha inchi", and *Morinda citrifolia* L., "noni", in different products but mostly in powder are very frequent in Liniers, and lately, they are also available in *dietéticas*, quickly spreading in the general commercial circuit. "Maca" and "sacha inchi" come from Peru, where they have been known since Pre-Inca times [84, 85]. On the contrary, "noni" comes from Polynesia, from there it entered Peru, then it went to Bolivia and then to Argentina. It has had world diffusion because of the wide range of therapeutic effects are attributed to it [86].

The legumes that are sold in Liniers usually are found in the general circuit, but the dry seeds and flours obtained from some of them are less frequent; in Liniers market, they are frequent and they are sold loose. This is the case of the *Cicer arietinum* L., "garbanzo"; *Glycine max* (L) Merr., "soja"; *Lens culinaris* Medik., "lenteja", and its varieties, "lentejón", "lenteja turca" and "lenteja canadiense"; *Lupinus albus* L., "lupín"; *Phaseolus lunatus* L., "poroto de manteca" and "pallar"; *Pisum sativum* L., "arveja"; *Vicia faba* L., "haba"; *Vigna angularis* (Willd.) Ohwi and H. Ohashi, "poroto adzuki"; *Vigna unguiculata* (L.) Walp., "poroto tape" o "caupí" and *Vigna radiata* (L.) R. Wilczer, "poroto mung". The sprout of this last species is available in Buenos Aires as "brotes de soja" which are spread widely [35]. Enclusive of Liniers is the fresh legumes of *Lablab purpureus* (L.) Sweet, "poroto japonés", and the dry seeds of *Lupinus mutabilis* Sweet, "tauri" o "tarwi"; this one is an important Andean crop due to its high protein value [80, 83, 87] and the seeds of a variety of *Arachis hypogaea* L. called "maní boliviano" ("Bolivian peanut") [88]. The case of *Phaseolus vulgaris* has been mentioned before. *Glycyrrhiza glabra* L., "regaliz", is sold as therapeutic and as sweetener in Liniers and in some *dietéticas* and herbalist's shops.

The preserved pulp of *Tamarindus indica* L., "tamarindo", is available in Liniers market and, occasionally, in the general commercial circuit. It is interesting to notice that this same product is also commercialized in shops owned by Chinese immigrants, which are concentrated in another neighborhood of Buenos Aires, Belgrano, and the set of shops as a whole is called "barrio chino" ("Chinese neighborhood"). The same happens with the dry sees (sold loose) of the species of *Vigna*: "poroto adzuki", "poroto mung" and "poroto tape" [34–36]. The presence of these in two immigrant segments so different in origin and traditions within the same conurbation opens a future comparison, taking into account the UBK component linked to traditions.

Even though it has not been dealt in this paper, a project is being developed, within LEBA, which aims to the understanding of the setting of exchange networks. The informants describe clearly defined routes to obtain the products that enable obtaining them very quickly (48–72 hours from their origin place, in Bolivia, to their outlet place in the Liniers market), and they make the selling of perishable products feasible. However, it has to be highlighted the incorporation of the plants that provide these fresh products so they can be incorporated to the stock-in-trade of the periurban vegetable gardens, which results in an increase in the agrobiodiversity of the area.

4. Conclusions

The research developed in Liniers market, identified with the segment of Bolivian immigrants (a group with a long history in Argentina but with a recent presence in the metropolitan area of Buenos Aires), enables a characterization of the component of the UBK linked to traditions and its own dynamics. Besides, this market being placed in an urban area suggests that traditional markets are an important source of plant diversity, which adds variety and choices to the UBK, process that takes place in a short time and that is spread quickly to the rest of the population. In this way, elements previously invisible become visible. Considering *dietéticas* as visualization agents is a relevant methodological contribution for Urban Ethnobotany, because it helps to understand the BK dynamics in large metropolitan areas.

On one hand, typical elements of a community are incorporated through the market; in this particular case, well-known Andean crops, like "papines" (*Solanum tuberosum*), "oca" (*Oxalis tuberosa*), "ulluco" (*Ullucus tuberosus*), "yacón" (*Smallanthus sonchifolius*), "ajipa" (*Pachyrhizus ahipa*), "tauri" (*Lupinus mutabilis*), "caiwa", (*Cyclanthera pedata*), and "cayote" (*Cucurbita ficifolia*), and, likewise, the market imply a quick entrance of several exotic elements (both to the city and to the immigrant group), which becomes easier due to the informality of the products circulation; for example: the "noni" (*Morinda citrifolia*). Besides, sometimes several fresh product are incorporated to local horticulture to enhance their availability, thus promoting agrobiodiversity. On the other hand, a special mention about the use of vegetables and products deriving from them which are available in the Liniers market in terms of functional foods and nutraceuticals. The usage of food with therapeutic ends is not new, it has been part of human knowledge since ancient times, and it is present in several cultures, that is why it has been an object of study to professional of different areas of knowledge, including, especially in recent years, ethnobotany [40–42, 89, 90]. In the last three decades, this concept about "edible and healing plants" has been globalized and a renewed interest can be seen about the healing properties of food and the products that are known as *dietary supplements*, which are added to different substances so they are beneficial to the health. In this sense, traditional markets are relevant places to acquire functional foods and nutraceuticals, this is why they can satisfy the needs of regular consumers (members of the community) and, at the same time, respond to the demands of the pluricultural conglomerate in which they are immersed.

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Research Article

Distribution and Transmission of Medicinal Plant Knowledge in the Andean Highlands: A Case Study from Peru and Bolivia

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This paper presents a study of patterns in the distribution and transmission of medicinal plant knowledge in rural Andean communities in Peru and Bolivia. Interviews and freelisting exercises were conducted with 18 households at each study site. The amount of medicinal plant knowledge of households was compared in relation to their socioeconomic characteristics. Cluster analysis was applied to identify households that possessed similar knowledge. The different modes of knowledge transmission were also assessed. Our study shows that while the *amount* of plant knowledge is determined by individual motivation and experience, the *type* of knowledge is influenced by the community of residence, age, migratory activity, and market integration. Plant knowledge was equally transmitted vertically and horizontally, which indicates that it is first acquired within the family but then undergoes transformations as a result of subsequent contacts with other knowledge sources, including age peers.

1. Introduction

The social processes of acquisition and transmission of knowledge, which are unique to each culture, shape local (environmental) knowledge (hereafter LK) defined as "a cumulative body of knowledge, practices, and beliefs, evolving by adaptive processes and handed down through generations by cultural transmission" [1, page 1252] and [2, page 8]. While the transmission of LK was still considered a rather neglected field at the end of the 1990s [3], this is no longer the case today. An increased number of studies on the processes of transmission and acquisition of LK have been published in recent years, often linked to growing concerns over its loss [4–8]. Zent, for instance, states that the "persistence and resilience [of LK] over time is critically dependent upon (...) customary methods of knowledge transmission" [9, page 104]. Several authors use a model of cultural transmission that was first developed by Cavalli-Sforza and Feldman [10] and later refined by Hewlett and Cavalli-Sforza [11] (see also [4, 5, 8, 12]). This model describes four modes of cultural transmission, understood as "a process of social reproduction in which a culture's technological knowledge, behavior patterns, and cosmological beliefs are communicated and acquired" [11, page 922] together with their implications for cultural evolution: (1) vertical (parent-to-child, characterized as being highly conservative with slow cultural evolution and high intracultural variation, (2) horizontal (between unrelated individuals in which cultural evolution can be rapid and intracultural variation can be high), (3) one-to-many (as between a teacher and pupils, where communication is highly efficient, cultural evolution is most rapid, and intracultural variation is low), and (4) concerted or many-to-one (between the older and the younger members of social groups; this type of transmission is most conservative, and shows very slow cultural evolution and very low intracultural variation) [11]. Cultural transmission usually occurs through various mechanisms, depending on the context, whose relative weight must be evaluated to assess the stability of cultural traits over time and space [8].

Intracultural variation is another key contemporary field of inquiry related to LK and ethnobotanical research [13–27]. Intracultural variation is "patterned according to differences in individual experience and access to knowledge" [22, page 335]. These individual differences are determined by several factors such as age, gender, kinship relations, schooling, occupation, and contacts with other actors and sources of knowledge. Interest in discerning the patterns of intracultural variation is twofold. On the one hand, these patterns allow us to identify relationships with social factors of cultural change [28], thus providing information about processes of transformation of LK. On the other hand, they make it possible to infer how learning takes place [29] (cited by [15]), and hence to understand processes of knowledge transmission and acquisition. Nevertheless, studies on the distribution of LK have often produced unclear and sometimes differing results. For instance, most of the literature stresses the negative relationship between schooling and LK [9, 13, 15, 16, 18, 21, 30]. These authors generally highlight the influence of the role of acculturation through state-run education, which is considered an "intrusive knowledge form" [21] that competes with the acquisition of LK. However, the negative association between schooling and LK is low when school curricula are culturally contextualized [30]. Furthermore, a few cases are reported where some individuals with higher schooling had higher LK competence than their peers [3, 17, 19]. Zent, for example, states that the higher ethnobotanical scores of some children with higher schooling "may also be influenced by individual motivation and/or natural intelligence, since usually only motivated, smart people reach these upper educational levels" [31, page 11] (cited by [19]). Regarding the effect of migration on ethnobotanical knowledge, Pieroni and Vandebroek [32] describe two opposite explanatory concepts: (1) lower LK as a consequence of cultural adaptation and acculturation and (2) equal or higher LK due to resilience and strengthening of cultural identity. According to these authors, adaptation, as a result of cultural negotiations, is only one of the possible strategies migrants might adopt during their interaction with the host culture, whereas an opposite strategy might be one aimed at strengthening their cultural identities. While the first strategy would probably imply a loss of traditional knowledge and use of plants, the latter set of strategies might lead to a deliberate retention of ethnobotanical practices. In their study on knowledge of forest plants among a returnee community in Guatemala, Nesheim et al. [33] showed that migration can lead to changes in consumption patterns, and thus to the replacement of LK. However, they also demonstrated that some domains of LK, such as knowledge about medicinal plants, were maintained. The influence of the market economy on LK is another question that has interested ethnobiologists. Several researchers have stressed the danger that the global economy represents for LK, by leading to deep modifications of local management systems [34, 35]. According to these authors, the market economy threatens the social reciprocal exchanges by transforming nonmonetary values into monetary values. Another explanation is given by Reyes-García et al., who state that "the development of market economies tends to be correlated with greater socioeconomic heterogeneity, and therefore one might expect greater variance in plant knowledge as markets expand." [36, page 651]. Studies of the correlation between LK and market-related activities have, nevertheless, produced ambiguous or even contradictory results [16, 36].

In the Andes, LK has been described as being highly diverse and place specific, and transmitted from one generation to the next through cultural transmission [7]. In the last two decades, several development cooperation and research projects have been actively engaged in mitigating the loss of cultural diversity and LK in the Andean highlands, through activities such as the revalorization of Andean environmental knowledge and worldviews and implementation of bilingual and intercultural education programs [7, 37–40]. It is believed that the presumed erosion of Andean environmental knowledge is a consequence of the current deep transformations of Andean society resulting from an increasing process of "modernization", as represented by the state-run education system [7, 41, 42], the market economy [37, 41], migration to urban centers [37, 42], and the presence of primary health care services [41, 42]. Conversely, some researchers have highlighted the resilience of Andean knowledge, presented as being capable of reacting to change and conflict through mechanisms of "creative resistance" [43] or resilient adaptation and transformation [44].

As part of a larger research project on the processes of transformation in Andean medicinal knowledge, this paper deals with the patterns of distribution and transmission of medicinal plant knowledge in rural communities of the Peruvian and Bolivian Andes. Research questions to be answered include (1) what are the socioeconomic factors and personal variables that account for intracultural variation of medicinal plant knowledge in the Andean highlands? and (2) what are the dominant modes of knowledge transmission? Our first working hypothesis was that schooling, migratory activity, and market integration—all important factors of social change in the Andes-influence the distribution of medicinal plant knowledge among rural Andean communities. Our second hypothesis was that medicinal plant knowledge is mainly transmitted vertically from parents or grandparents to offspring—a transmission mode typical of conservative knowledge systems with high intracultural variation [11].

2. Materials and Methods

Research for the present paper was part of BioAndes, a regional program of the Swiss Agency for Development and Cooperation that aimed to conserve biocultural diversity in Andean areas of Peru, Bolivia, and Ecuador. BioAndes was executed by a consortium of local institutions and their network of local partners from November, 2005 to March, 2011 and included conservation projects and action-research activities (for a synthesis of BioAndes experiences see [40]). Agreements were signed between BioAndes and the municipal governments of the geographic areas in which this program was implemented, prior to the realization of the activities.

2.1. Study Sites. For the purpose of this study, two of the seven implementation areas of BioAndes were selected as case study sites owing to their similarity in terms of ecological and cultural settings: the district of Pitumarca in the Department of Cusco in Peru and the subcentral of Waca Playa in the Department of Cochabamba in Bolivia (Figure 1). Both have comparable biogeographic characteristics, the main difference being the dryer climate and lower altitude of the Bolivian site. In both areas, the natural vegetation has been seriously affected by human activity. The vegetation is mainly composed of shrubs, grasses, remnant patches of native *Polylepis* spp. forests, and exotic plantations (such as *Eucalyptus* spp. and *Pinus* spp.). Both areas are inhabited by Quechua-speaking indigenous farmers primarily engaged in small-scale subsistence farming and are characterized by high rates of temporal and permanent migration to urban centers and Amazonian lowlands. Agricultural activity is quite comparable and varies according to altitudinal belts: growing of grains and cereals (maize, wheat, barley, oats, and quinoa), vegetable and fruits, potatoes and other Andean tubers such as *Ullucus tuberosus* Caldas and *Oxalis* spp., and livestock herding (sheep, cows, and goats in Waca Playa and lamas and alpacas in the highlands of Pitumarca). At both sites the population is socially organized into peasant communities that were created after the agrarian reforms that took place in both countries (from 1968 to 1975 in Peru and in 1953 in Bolivia), when most *haciendas* (large land holdings of Spanish and other immigrant descendants) were dismantled, and land was distributed among the indigenous farmers. Andean medicine is prevalent in both study areas, with the existence of specialists such as healers (called *yachayniuq* or *p'aqo* in Pitumarca and *yatiri* in Waca Paya), midwives, and bone setters. Lay people also possess important knowledge about traditional remedies and self-medicate mostly by using plants collected locally and also animals and minerals [45–47].

Pitumarca District is located in Canchis Province, 87 km south-west of the city of Cusco, in the Southern Peruvian highlands. Altitude ranges from 3,400 meters above sea level in the valley to 6,372 meters above sea level at the Ausangate summit. The climate ranges from semihumid, temperate cold, to humid and frigid, with mean annual temperatures and precipitation varying according to altitude, from 12°C and 650 mm in Pitumarca (3,600 meters above sea level) to 8°C and 910 mm in Phinaya (situated at 4,500 meters above sea level) [45]. Precipitation is concentrated during the rainy season from November to February. The area belongs to the "Central Andean Wet Puna" ecoregion, characterized by montane grassland and shrubland biome [48]. The district is composed of a total of eleven peasant communities, which, in turn, are divided into "annexes" and "sectors". Research was carried out in two adjacent villages, which are, formally speaking, *anexos* (annexes) of peasant communities. The *anexo* Huasapampa (community of Pitumarca-Consachapi) is situated at 13°58′30″S and 71°22′41″W, at 3,700 meters above sea level, and is composed of 63 households. The *anexo* Huito (community of Pampachiri) is situated at 13°57′57″S and 71°23′29″W, at 3,680 meters above sea level, and is inhabited by 61 households. Both villages are located in the lower zone of Pitumarca's watershed, at 4 km from the district capital. At Pitumarca's weekly market on Saturdays, farmers sell their surplus production and merchants trade manufactured goods. Formal education is provided in the Spanish language in the *anexos* up to 6th grade and in Pitumarca up to the 12th grade. There is a health centre in the district capital with one medical doctor, two nurses, two obstetricians, and 6 auxiliary nurses. Each *anexo* is under the supervision of one auxiliary nurse, who visits the families once a month and trains community health workers in nutrition, hygiene, breastfeeding, and prevention of common afflictions such as parasitical illnesses, pneumonias, and diarrhea.

Waca Playa Subcentral belongs to Tunari National Park in Tapacari Province, 65 km east of the city of Cochabamba, in the Eastern cordillera of the Bolivian Andes. The altitude ranges from 2,760 to 4,100 meters above sea level. The climate is semiarid to semihumid and temperate cold, with a mean annual temperature of 11°C and mean average precipitation of approximately 500 mm that is distributed throughout the rainy season from November to March [47]. According to Olson et al. [48], the site corresponds to two global ecoregions and their corresponding biomes: the "Central Andean Puna" above 3,200 meters above sea level (montane grassland and shrubland) and the "Bolivian Montane Dry Forests" below 200 meters above sea level (tropical and subtropical dry broadleaf forests). Waca Playa is composed of five peasant communities, in two of which data were collected for the present study: the community of Tres Cruces (17°29′30″S and 66°28′34″W; 3,330 meters above sea level) inhabited by 49 households and the community of Lambramani (17°29′31″S and 66°30′44″W; 3,450 meters above sea level) with 40 households. The two communities are located 9 km (Tres Cruces) and 5 km (Lambramani) from Waca Playa respectively, where inhabitants from the communities and neighboring subcentrals meet at the weekly market to sell and exchange products. Schooling is offered in Spanish up to the 3rd and 6th grades in the communities (in Lambramani and Tres Cruces, resp.), and up to the 8th grade in Waca Playa. Since 1995, primary health care has been available at a health post in Waca Playa, where one auxiliary nurse operates. This health post provides limited healthcare to a total of 20 peasant communities from the three subcentrals of Waca Playa, Jatun Cienega, and Lapiani. Basic health care such as contraceptives, vaccination, painkillers, and antibiotics are provided. The auxiliary nurse also visits the communities, approximately once every two months. In case of serious illnesses or accidents people are sent to the hospital in the towns of Sipe Sipe, Vinto, or Quillacollo, approximately 40 to 50 km from Waca Playa.

2.2. Field Work and Selection of Participants. Field work was performed by the first author during numerous visits to the two case study sites between June, 2006 and April, 2010. Most data collection took place between March, 2007 and December, 2008. Logistic support was given by partners of BioAndes who already had a long working presence in these areas, namely, AGRUCO in Waca Playa and CEPROSI, IMAGEN, and IMAPI in Pitumarca. In each of the four communities, initial meetings were facilitated by these organizations in the local language to present the research aims and select the participating households. At these community meetings, it was also jointly decided that research results would be returned to the participants by means of the elaboration of medicinal

Figure 1: Map of the study sites. Research was conducted in two communities from Pitumarca District in the Department of Cusco, Peru, (a) and in two communities from Waca Playa Subcentral in the Province of Tapacari, Department of Cochabamba, Bolivia, (b).

plant booklets at each research site. Except in Huito, where there was no community consensus about authorizing the research because a few individuals expressed concern about the possible economic motivation of the study, community members from Huasapampa, Tres Cruces, and Lambramani all gave their collective verbal consent for carrying out the proposed research activities. In Huito, individual verbal consent was granted by the participants, who either voluntarily approached the first author to contribute to the research, or were approached by her and selected through snowball sampling.

The criteria for selection of participants were age and residence: each community assembly was asked to make a selection representing young (recently married and/or with small children), middle-aged (with grown-up children that participate in family tasks), and elderly households (couples or widows whose children had already left home). In Huito the same criteria were applied to selection of volunteers. Furthermore, in Waca Playa where the population is scattered over the territory, an additional criterion was to include an equal number of participants who lived in the communities' upper, middle, and lower zones.

2.3. Household Interviews. Semistructured interviews and freelisting exercises were conducted with 18 households from Pitumarca (9 households each from the Tres Cruces and Lambramani community, or 18% and 23% of all households, resp.) and 18 households from Waca Playa (10 households from Huasapampa and 8 households from the Huito community, or 16 and 13% of all households, resp.). The data were collected in three to six visits to each household, depending on the participants' availability, meaning that it was often impossible to complete the interview during one visit and that it continued during subsequent visits.

Interviews were conducted in Quechua, Spanish, or in both languages, according to the participants' preference and language ability, with the help of a native Quechua-speaking translator. The husband and/or the wife—and in some cases the children also—were asked questions about the household's characteristics, history, and livelihood strategies. In addition, the adult most knowledgeable about medicinal plants (husband or wife), according to the household members' own perceptions, was asked to list all the medicinal plants (s)he knew and/or used and explain how (s)he acquired his/her knowledge about natural remedies and Andean medicine in general. (S)he was also asked to include the medicinal plants that grew outside the research site, such as dry plants from the Amazon that they bought at the local markets or plants from the highlands that they exchanged with members of other communities. Interviews were conducted individually with the most knowledgeable member, but in about 50% of the cases, other members of the household unit (spouse and/or children) were present and allowed to intervene. This happened because interviews were usually conducted during the household's daily activities, during which other members were present; these activities included cooking and eating, washing clothes, resting during a day work in the fields, or grazing livestock. It was thus difficult to either systematically isolate only the most knowledgeable individual from the other household members, or to systematically ensure that all household members would be present.

Most interviews were recorded and translated into Spanish when they were conducted in Quechua and then transcribed. In the few cases when participants' authorization was not granted for recording or when it was technically not possible to do this, detailed notes were taken during the interviews in Spanish and eventually transcribed.

2.4. Plant Collection and Identification. Voucher specimens of most medicinal plants were collected and photographed at the two research sites during walks with participants. Information was recorded about the collection number, date, locality, informant, and the plants' local names. At the end of the day, specimens were pressed and dried according to standard botanical practices. In cases of contradictory information from different participants about a plant's name, additional specimens were collected in order to double-check the information. Cultivated and broadly distributed medicinal plants (such as *coca-Erythroxylum coca* Lam.) as well as rare or unavailable plants (plants at higher altitudes or in the Amazon lowlands, for instance) were not collected.

Voucher specimens were identified by specialists at the Herbarium Vargas from the *Universidad Nacional de San Antonio Abad del Cusco* in Cusco, Peru, and at the National Herbarium Martin Cardenas from the *Universidad Mayor de San Simón* in Cochabamba, Bolivia. When no voucher specimen was collected, the plants were indirectly identified on the basis of a comparison of their local names, biological and ecological characteristics, and medicinal uses with existing literature [44, 49, 50]. Plant scientific names and author names were verified for their correctness using the IPNI [51] and Tropicos.org [52] databases.

2.5. Data Analysis. Data were recorded at the household level, because preliminary field trips and observation showed that the household was the basic unit for health care practices at both research sites. When a household member is ill, the most knowledgeable parent usually diagnoses the ailment and decides on the treatment that will be administered—in some cases alone but frequently in consultation with the other parent. If this treatment includes the use of medicinal plants, which is frequently the case, then the children are often asked to collect these plants. As a consequence, knowledge about medicinal plants is widely shared and discussed at the household level, which also explains why the interviews were sometimes conducted with several household members.

The socioeconomic characteristics of participating households were compiled from interview transcriptions. The following variables were taken into account: community of residence, age, sex, kinship ties, level of education, migratory activity, degree of market integration, and health specialization. For the purpose of analysis, we distinguished the following three age categories according to the age of the main household member interviewed: (1) young households (20 to 34 years old), (2) middle-aged households (35 to 49 years old), and (3) old households (50 years old and above). We recorded the sex of the main household member interviewed. Where they existed, we recorded the first degree kinship ties between the main interviewee in each household (parents-child, grandparents-grandchild, aunt/uncle-niece/nephew, and between siblings, including in-laws). The level of education was measured as the level achieved by the main household member interviewed: (1) none (no formal education), (2) primary level (1 to 6 years of schooling), (3) secondary level (7 to 12 years of schooling), and (4) superior level (13 years of schooling and above). We distinguished three categories according to household migratory activity: (1) households with no migratory activity (who only made short trips to neighboring towns or communities to visit relatives, sell and buy products, or go to a health center), (2) seasonal migrants (who spend or in previous years had spent up to three months per year either in the lowlands as agricultural workers or merchants, or in neighboring urban centers to pursue off-farm activities); and (3) semipermanent migrants (who had lived for over one year outside the research area). We also classified participating households into three categories according to their market integration: (1) low (agricultural production mainly for own consumption, only surplus and, when necessary, one sheep or head of cattle sold at the local weekly market), (2) moderate (regular sale of agricultural products, sheep, own made wool, cheese or textiles on the local market and, in some cases, also at important commercial centers in the area), (3) and high (besides farm activities, these households traded cattle at important commercial centers in the area, made regular trading trips to the Amazon lowlands, and/or had a small store in the community). When households identified themselves and were identified by other community members as specialists (healers practicing Andean medicine or health workers collaborating with the health center) this information was also recorded.

On the basis of freelisting exercises, the number of medicinal plants mentioned by each household was recorded and taken as an indicator of plant knowledge. When several household members were interviewed, the plants that were cited by the various participants were summed. The number of medicinal plants mentioned thus corresponds to the household's total knowledge (at both study sites, the most knowledgeable household member contributed approximately 85% of this information as opposed to other household members). Furthermore, at each study site, an inventory of medicinal plants locally known and/or used by the 18 participating households was compiled. To identify the best-known medicinal plants, the number of households that mentioned each plant was tallied, and plants were ranked accordingly.

Comparison of the average or median medicinal plant knowledge among households was carried out in two ways. First, the amount of plant knowledge, calculated as the average or median number of plants mentioned per household, was compared at each research site according to the household's socioeconomic characteristics. The correlation between age and the total number of medicinal plants mentioned per household was statistically tested by means of the Spearman Rank Order Correlation in Pitumarca (because normality of data failed) and the Pearson Product Moment Correlation in Waca Playa (because the data were normally distributed). The categories of community of residence, sex of the main interviewee, level of education of main interviewee, migratory activity, and market integration were compared statistically by means of a t-test when data were normally distributed and equal variance testing passed, or alternatively with the Mann-Whitney Rank Sum test when one of these conditions was not met. Categories were only compared statistically when at least 5 households were involved, which was the case at both study sites for households according to their community of residence, households with seasonal versus semipermanent migration, and households with low versus moderate or high market integration. Households with no migratory activity (3 households in Pitumarca and 5 in Waca Playa) were thus pooled out of the analysis, and households with moderate and high market integration were merged into one category. Only in Pitumarca was it possible to compare households with primary education versus secondary education or higher, since in Waca Playa, there was only one household with secondary education or higher. At both sites, households' medicinal plant knowledge was not compared according to kinship ties or health specialization, because there were less than 5 households involved in each category.

Second, the type of medicinal plant knowledge was compared using cluster analysis (NTSYpc21 version 2.10 L) as used by [26], taking into account the plants mentioned by at least one third of all participants at each research site (6 of the 18 households from Pitumarca and 6 of the 18 households from Waca Playa). Cluster analysis is a useful tool for identifying pairs of participants with a high degree of agreement (on medicinal plants in our case) and kinship relations—which are, in turn, evidence of vertical and horizontal modes of cultural transmission [26]. Data were entered on an Excel spreadsheet with plant names as rows and households as columns, and cells contained the value "1" if the household mentioned the plant or "0" if it did not. The spreadsheet was imported into NTSYpc21 and the Dice coefficient was used to produce a matrix of (dis)similarity between pairs of households. A tree was then generated using the UPGMA-SAHN method. A correlation coefficient "r" (normalized Mantel statistic Z) was calculated to measure the correspondence between the tree matrix and the original data. The degree of fit of the cluster analysis was interpreted as follows: $0.9 \leq r$, very good fit; $0.8 \leq r < 0.9$, good fit; $0.7 \leq r < 0.8$, poor fit; $r < 0.7$, very poor fit. The clusters revealed by the trees were then interpreted in light of the household's socioeconomic characteristics, in order to identify patterns in the distribution of medicinal plant knowledge at each case study site.

The household interview transcriptions were analyzed qualitatively to assess the processes of knowledge transmission and acquisition. Answers about the source of acquisition of medicinal knowledge were summed according to the following categories, corresponding to the modes of cultural transmission described by Hewlett and Cavalli-Sforza [11]: (1) parents, grandparents (vertical transmission), (2) neighbors, extended family (horizontal transmission), (3) healers, specialists (horizontal transmission, "one-to-many" type), (4) elder (horizontal transmission, "many-to-one" type), and (5) supernatural origin, books, NGOs (nonpersonal modes of transmission). Likewise, the answers about the time of acquisition of plant knowledge were summed according to two categories: (1) childhood and (2) adulthood.

3. Results

3.1. Participating Households' Socioeconomic Characteristics and Medicinal Plant Knowledge. The socioeconomic characteristics and medicinal plant knowledge of the participating households are summarized in Tables 1 (data from Pitumarca) and 2 (data from Waca Playa). They include residence, age, age category, sex, kinship ties, education level, migratory activity, market integration, health specialization, and number of medicinal plants mentioned. The number of plants mentioned was elicited from the freelisting exercises. In both Pitumarca and Waca Playa, there were important variations in the amount of medicinal plant knowledge among participating households (range of 12–99 medicinal plants in Pitumarca, and 15–50 in Waca Playa).

No significant differences were found between the average or median number of medicinal plants mentioned by households according to the community of residence in either Pitumarca (Huasampa versus Huito communities; Mann-Whitney Rank Sum Test, $T = 74.5$) or Waca Playa (Tres Cruces versus Lambramani communities; t-test, $t = 1.082$). No correlation between age of the main interviewee and number of plants mentioned was found in Pitumarca (Spearman Rank Order Correlation) or in Waca Playa (Pearson Product Moment Correlation). Neither in Pitumarca nor in Waca Playa were there statistical differences between the median number of plants mentioned by households according to the sex of the main person interviewed (t-test; Pitumarca: $t = 1.819$, Waca Playa: $t = 0.552$). In Pitumarca

Table 1: Socioeconomic characteristics and medicinal plant knowledge of participating households from Pitumarca, Peru. Medicinal plants: total number of medicinal plants mentioned.

	Residence	Age (years)	Age category	Sex	First degree kinship ties	Education level	Migratory activity	Market integration	Health specialization	Medicinal plants
Household 1	Huasapampa	26	young	male	grandson of 8 and brother-in-law of 2	primary	seasonal	low	none	37
Household 2	Huasapampa	25	young	female	sister-in-law of 1	primary	seasonal	low	none	36
Household 3	Huasapampa	21	young	female	daughter of 5	superior	none	low	none	57
Household 4	Huasapampa	49	middle	male		primary	seasonal	high	none	22
Household 5	Huasapampa	52	middle	female	mother of 3	primary	seasonal	moderate	none	99
Household 6	Huasapampa	45	middle	female		primary	seasonal	high	none	50
Household 7	Huasapampa	44	middle	male		primary	seasonal	low	health worker	12
Household 8	Huasapampa	63	old	male	grandfather of 1 and brother of 9	primary	seasonal	low	Andean healer	82
Household 9	Huasapampa	76	old	male	brother of 8	primary	seasonal	low	Andean healer	44
Household 10	Huasapampa	62	old	male		primary	semipermanent	moderate	health worker	52
Household 11	Huito	32	young	male		secondary	semipermanent	low	none	28
Household 12	Huito	24	young	female		secondary	none	low	none	47
Household 13	Huito	38	middle	male		secondary	semipermanent	high	none	53
Household 14	Huito	43	middle	female		primary	seasonal	low	none	50
Household 15	Huito	42	young	male		primary	semipermanent	moderate	health worker	53
Household 16	Huito	47	middle	male		secondary	semipermanent	moderate	none	46
Household 17	Huito	68	old	male		none	seasonal	low	none	29
Household 18	Huito	65	old	female		none	none	low	none	47

there was no statistical difference (Mann-Whitney Rank Sum Test, $T = 44.500$) between the median number of plants mentioned by households that had only a primary education as compared to households that had a secondary education or higher. No differences in the amount of plant knowledge were found in either Pitumarca or Waca Playa when comparing households on the basis of seasonal versus semipermanent migration (Pitumarca: Mann-Whitney Rank Sum Test, $T = 47.00$; Waca Playa: t-test, $t = 0.0414$), or households with low market integration versus moderate or high integration (Pitumarca: t-test, $t = -1.138$; Waca Playa: t-test, $t = 0.918$). In summary, at both study sites, the amount of medicinal plant knowledge was not influenced by socioeconomic factors such as the community of residence, age, sex, level of education, migratory activity, or market integration.

In Pitumarca, participants mentioned a total of 249 medicinal plants that they knew and/or used in the free listing exercises. The 47 best-known plants (those that were mentioned by at least 6 of the 18 participating households) were used to compare households' medicinal plant knowledge with cluster analysis and are listed in Table 3. The tree resulting from the analysis (Figure 2) reveals four main clusters of households based on the similarity of their knowledge about medicinal plants. These clusters, when triangulated with the data from the households' socioeconomic characteristics presented above, can be interpreted as follows.

(1) Young households from the Huasapampa community, with seasonal or no migratory activity and low market integration; the cluster includes two siblings (in-laws).

(2) Old households from the Huasapampa community, with seasonal migratory activity and low market integration (apart from household 6, which is middle-aged and showed a high level of market integration); the two traditional healers, who are also siblings, are part of this cluster.

(3) Households from all age categories from the Huito community, with seasonal or no migratory activity and low market integration.

(4) Two middle-aged households, both from the Huito community, whose main interviewee was male, with semipermanent migratory activity and moderate market integration.

A fifth cluster of two households was identified even though the association between them is weak.

(5) One middle-aged and one old household, whose main interviewee was male, both with semipermanent migratory activity and moderate to high market integration.

Table 2: Socioeconomic characteristics and medicinal plant knowledge of participating households from Waca Playa, Bolivia. Medicinal plants: total number of medicinal plants mentioned.

	Residence	Age (years)	Age category	Sex	First degree kinship ties	Education level	Migratory activity	Market integration	Health specialization	Medicinal plants
Household 1	Tres Cruces	27	young	female	daughter of 9	primary	seasonal	low	none	27
Household 2	Tres Cruces	38	middle	female		primary	none	moderate	none	21
Household 3	Tres Cruces	51	old	male		primary	seasonal	low	none	23
Household 4	Tres Cruces	29	young	male		primary	seasonal	moderate	none	39
Household 5	Tres Cruces	39	middle	male	brother-in-law of 7, nephew of 6	primary	seasonal	moderate	none	17
Household 6	Tres Cruces	59	old	female	sister-in-law of 8, aunt of 5	primary	none	low	none	25
Household 7	Tres Cruces	38	middle	male	brother-in-law of 5	secondary	seasonal	low	none	15
Household 8	Tres Cruces	52	old	male	brother-in-law of 6	primary	semipermanent	moderate	none	16
Household 9	Tres Cruces	71	old	male	father of 1	primary	none	low	Andean healer	42
Household 10	Lambramani	43	middle	male		primary	semipermanent	low	none	27
Household 11	Lambramani	38	middle	female		none	semipermanent	moderate	none	32
Household 12	Lambramani	57	old	female		none	seasonal	high	none	24
Household 13	Lambramani	50	old	female		none	semipermanent	moderate	none	26
Household 14	Lambramani	50	old	female	niece of 15	none	seasonal	low	Andean healer	50
Household 15	Lambramani	63	old	female	aunt of 14	none	none	low	none	22
Household 16	Lambramani	38	middle	male		primary	none	high	none	23
Household 17	Lambramani	44	middle	male	brother-in-law of 18	primary	semipermanent	low	none	33
Household 18	Lambramani	54	old	female	sister-in-law of 17	none	semipermanent	moderate	none	47

Households were not grouped according to the sex of the main person interviewed (with the exception of two households from cluster 4 and the two households from cluster 5), nor were households that had a parents-offspring or grandparents-grandchild kinship relationship. Moreover, the household's levels of education showed great heterogeneity in the described clusters.

In summary, the analysis revealed the following patterns in the data: the factors that influence the distribution of medicinal plant knowledge in Pitumarca are community of residence, age category, intragenerational kinship ties, migratory activity, market integration, and health specialization in the case of Andean healers. The factors that did not have an influence on medicinal plant knowledge distribution were sex, intergenerational kinship ties, level of education, and health specialization in the case of health workers.

The participating households from Waca Playa cited a total of 150 medicinal plants. The 25 best known plants of this list (those mentioned by at least 6 of the 18 households) were used to run the cluster analysis (see Table 4). Figure 3 shows that the households from Waca Playa, on the basis of their knowledge about medicinal plants, were grouped into two main clusters, which in turn are divided into subclusters as follows:

(1) Households from the Tres Cruces community.

   (a) Young and middle-aged households, with seasonal or no migratory activity and low to moderate market integration.

   (b) Two old households with seasonal or no migratory activity and low market integration.

(2) Households from the Lambramani community (apart from households 8 and 9)

   (a) One middle-aged and one old household, whose main interviewee was male, both with semipermanent migratory activity and low to moderate market integration.

   (b) One middle-aged and one old household, with seasonal or no migratory activity, both with high market integration.

   (c) Two old households with seasonal or no migratory activity and low market integration; both are traditional healers.

   (d) Two old households, whose main interviewee was female, both with semipermanent migratory activity and moderate market integration.

Table 3: Medicinal plants from Pitumarca mentioned by 6 or more households ($N = 18$). Households: number of households who mentioned the plant. Voucher numbers: SM no. (P) = Sarah-Lan Mathez-Stiefel no. (Peru). Source: source of indirect scientific name identification: [a] = photograph taken by SM, [b] = [44], [c] = [50].

Local name(s)	Scientific name	Plant family	Households	Voucher numbers [or source]
ajinco	*Artemisia absinthium* L.	Asteraceae	7	SM73(P)
alqo kiska	*Acanthoxanthium ambrosioides (*Hook. and Arn.) D. Loeve	Asteraceae	10	SM10(P)
cáncer qhora	*Stachys* spp. (*S. arvensis* L., *S. herrerae* Epling)	Lamiaceae	8	SM123(P)-SM48(P)
cebada	*Hordeum vulgare* L.	Poaceae	6	SM122(P)
chiqchi	*Berberis carinata* Lechl.	Berberidaceae	6	SM35(P)
chirichiri	*Grindelia boliviana* Rusby	Asteraceae	15	SM91(P)
clavel, clavel rojo, clavel negro	*Dianthus* sp.	Caryophyllaceae	7	SM83(P)
coca	*Erythroxylum coca* Lam.	Erythroxylaceae	15	[b]
eucalipto	*Eucalyptus globulus* Labill.	Myrtaceae	16	SM78(P)
hierbabuena	*Mentha viridis* (L.) L.	Lamiaceae	9	SM5(P)
hinojo	*Foeniculum vulgare* Mill.	Apiaceae	6	SM51(P)
kanlli	*Margyricarpus pinnatus* (Lam.) Kuntze	Rosaceae	8	SM89(P)
kharo	*Colletia spinosissima* J. F. Gmel.	Rhamnaceae	12	SM21(P)
limón	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	6	[b]
llantén	*Plantago major* L.	Plantaginaceae	6	SM96(P)
llauli, china llauli	*Barnadesia horrida* Muschl.	Asteraceae	14	SM26(P)
malva	*Malvastrum* sp.	Malvaceae	11	SM18(P)
manka phaki	*Ageratina sternbergiana* (D.C.) R. M. King and H. Rob.	Asteraceae	10	SM27(P)-SM109 (P)
manzanilla	*Matricaria recutita* L.	Asteraceae	15	SM82(P)
matapalo	*Gaiadendron* spp. *(G. punctatum* G. Don, *G. Ellipticum* (Ruiz and Pav.) Baehni ex. J. F. Macbr.)	Loranthaceae	6	[c]
muña	*Minthostachys* spp. (*M. setosa* (Briq.) Epling, *M. spicata* (Benth.) Epling	Lamiaceae	13	SM33(P)-SM120(P)
muñak'a	*Muehlenbeckia volcanica* (Benth.) Endl.	Polygonaceae	8	SM31(P)
mutuy	*Senna birostris* (Vogel) H.S. Irwin and Barneby	Caesalpinaceae	13	SM20(P)
nabo, yuyo	*Brassica rapa* subsp. *campestris* (L.) A. R. Clapham	Brassicaceae	11	SM4(P)
oq'e thurpa	*Nototriches* sp.	Malvaceae	6	[c]
oqororo, alqo oqororo	*Mimulus glabratus* Kunth	Scrophulariaceae	10	SM19(P), SM38(P)
orqo llauli	*Dasyphyllum leiocephalum* (Wedd.) Cabrera	Asteraceae	7	SM77(P)
patakiska	*Austrocylindropuntia subulata* (Muehlenpf.) Backeb. subsp. *exaltata* (A. Berger) D. R. Hunt	Cactaceae	12	[a]
perejil	*Petroselinum sativum* Hoffm.	Apiaceae	9	SM9(P)
pilipili, diente de leõn	*Taraxacum officinale* F. H. Wigg.	Asteraceae	11	SM6(P)
pimpinilla	*Pimpinella anisum* L.	Rosaceae	7	SM79(P)
puka thurpa	*Nototriche* sp.	Malvaceae	8	[c]
puka t'ikaq kisa	*Cajophora cirsiifolia* C. Presl	Loasaceae	10	SM25(P)
p'uku p'uku	*Dichondra* sp.	Convolvulaceae	7	SM39(P)
pupusa	*Xenophyllum poposum* (Phil.) V. A. Funk	Asteraceae	9	SM93(P)
salvia	*Lepechinia meyenii* (Walp.) Epling	Lamiaceae	8	SM88(P), SM106(P)
sangre de grado	*Croton lechleri* Muell. Arg.	Euphorbiaceae	7	[b]
sasawi	*Leucheria daucifolia* (D. Don) Crisci	Asteraceae	16	SM94(P)

Table 3: Continued.

Local name(s)	Scientific name	Plant family	Households	Voucher numbers [or source]
thurpa	*Nototriche* spp. (*N.matthewsii* A. W. Hill, *N. turritella* A. W. Hill, *N. herrerae* Ulbr. ex A. W. Hill, *N. Flabellata* (Wedd.) A. W. Hill)	Malvaceae	9	[c]
toronjil	*Melissa officinalis* L.	Lamiaceae	8	[b,c]
uña de gato	Undet.		6	
wamanlipa	*Senecio tephrosioides* Turcz.	Asteraceae	16	SM95(P)
waraqo	*Opuntia floccosa* Salm-Dyck	Cactaceae	10	[a]
wichullu	Undet.		14	
yana kisa	*Urtica urens* L.	Urticaceae	6	SM50(P)
yawarch'unka	*Oenothera multicaulis* Ruiz and Pav.	Onagraceae	17	SM63(P)
zaptilla, pucucho pucucho	*Calceolaria* spp. (*C. sparsiflora* Kunze, *C. virgata* Ruiz and Pav., *C. aurea* Pennell)	Calceolariaceae	9	SM1(P)-SM111(P)-SM110(P)

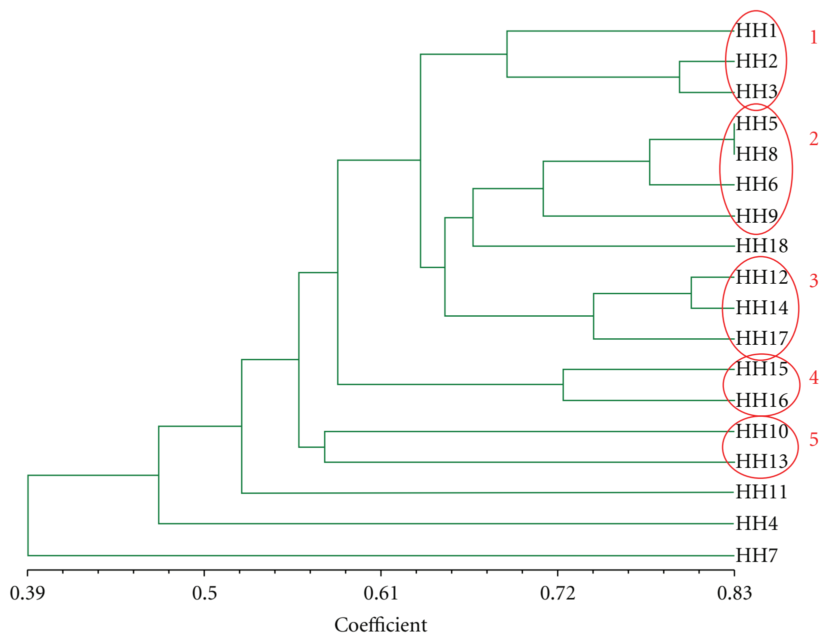

Figure 2: Tree resulting from cluster analysis of 18 households' knowledge about 47 medicinal plants in Pitumarca, Peru. HH no.: household number. Correlation coefficient $r = 0.81$ (good fit).

(e) Two middle-aged households with semipermanent migratory activity and low to moderate market integration.

According to this interpretation of the cluster analysis results, the factors that influence the distribution of medicinal plant knowledge in Waca Playa are the community of residence, age category, migratory activity, market integration, and health specialization. Sex, kinship ties (intra- and intergenerational) and education level do not influence medicinal plant knowledge distribution. Interestingly, these results confirm the patterns identified in Pitumarca.

3.2. Acquisition of Medicinal Plant Knowledge. Figure 4 shows how participating households in the two case study areas acquired their medicinal plant knowledge. As the figure il lustrates, households acquired their knowledge through a variety of sources. Vertical transmission (parents and grandparents) was mentioned by 67% and 94% of the households from Pitumarca and Waca Playa, respectively, (29 households in total), whereas horizontal transmission (neighbors, extended family, healers, specialists, and elders) was reported by 72% of the households from Pitumarca and by all the households from Waca Playa (31 households in total).

Six households from Pitumarca and five from Waca Playa learned about medicinal plants from a traditional healer or specialist (one-to-many mode of cultural transmission). But in the case of four of the households from Pitumarca, this specialist happened to be the parent or grandparent of the participant and was thus pooled out of the analysis, because it also accounts for a vertical mode of cultural transmission. Elders from the community were also reported as a source of knowledge (many-to-one transmission).

In addition to these interpersonal modes of cultural transmission, other types of knowledge sources were cited by

Table 4: Medicinal plants from Waca Playa, Bolivia, mentioned by 6 or more households ($N = 18$). Households: number of households who mentioned the plant. Voucher numbers: SM no. (B) = Sarah-Lan Mathez-Stiefel no. (Bolivia), RB no. = Regine Brandt no. Source: source of indirect scientific name identification: [a] = [44], [b]= [49].

Local name(s)	Scientific name	Plant family	Households	Voucher numbers [or source]
andres huaylla	*Cestrum parqui* L'Hér	Solanaceae	17	SM9(B), SM132(B), SM88(B)
chini muña, muña	*Clinopodium bolivianum* (Benth.) Kuntze	Lamiaceae	11	SM15(B), SM93(B)
coca	*Erythroxylum coca* Lam.	Erythroxylaceae	16	[a]
durazno	*Prunus persica* (L.) Batsch	Rosaceae	7	SM55(B)
kalisto, eucalipto	*Eucalyptus globulus* Labill.	Myrtaceae	16	SM6(B), SM14(B), SM87(B)
khara malva, malva	*Malva parviflora* L.	Malvaceae	8	SM32(B), SM33(B), SM73(B), SM83(B)
khara sapi, kharasa, leche leche	*Sonchus oleraceus* L.	Asteraceae	8	SM58(B), SM66(B), SM134(B)
k'oa muña, haya muña, muña	*Minthostachys ovata* (Briq.) Epling	Lamiaceae	11	SM10(B), SM76(B), SM57(B)
lanti lanti	*Plantago* spp. (*P. orbignyana* Steinh. ex Decne., *P. lanceolata* L.)	Plantaginaceae	6	SM61(B), SM103(B)-SM125(B), SM129(B)
llave	*Tripodanthus acutifolius* (Ruiz and Pav.) Tiegh	Asteraceae	9	[b]
manzanilla	*Matricaria chamomilla* L.	Asteraceae	10	SM62(B)
molle	*Schinus molle* L.	Anacardiaceae	15	SM16(B), SM89(B)
paiqo	*Chenopodium ambrosioides* L.	Amaranthaceae	7	SM29(B), SM60(B), SM67(B), SM91(B)
raqacho, raqa raqa	*Lepechinia graveolens* (Regel) Epling	Lamiaceae	9	SM18(B)
romansa, lanti lanti	*Rumex* sp.	Polygonaceae	10	SM22(B), SM70(B)
salvia	Undet.		8	—
sauco	*Sambucus nigra* L. subsp. *peruviana* (Kunth) Bolli	Adoxaceae	7	SM75(B)
sira ch'ilka	Undet.		6	—
sira paiqo, ch'ini paiqo	*Chenopodium ambrosioides* L.	Amaranthaceae	14	SM128(B)
t'ola	*Baccharis dracunculifolia* DC.	Asteraceae	7	SM13(B), SM100(B)
uri uri	*Pluchea fastigiata* Griseb.	Asteraceae	7	RB47.14
verbena	*Verbena hispida* Ruiz and Pav.	Verbenaceae	8	SM72(B)
wacanwayo	*Iresine* aff. *diffusa* Humb. and Bonpl. ex Willd.	Amaranthaceae	8	SM113(B)
wira wira	*Gnaphalium dombeyanum* DC.	Asteraceae	8	SM94(B), SM127(B)
zapatilla	*Calceolaria engleriana* Kraenzl.	Calceolariaceae	6	SM21(B), SM78(B)

the participants. The specialized knowledge of Andean healers, for instance, is usually believed to have a supernatural origin. Three (two from Pitumarca and one from Waca Playa) of the four specialists interviewed mentioned that their knowledge about traditional medicine could be explained by a *rayo* event (being struck by lightning), or by having been taught by the *apus* or *parajes* (sacred mountains that surround the communities). Four households (three from Pitumarca and one from Waca Playa) also mentioned that they became skilled in recent years through books or workshops about medicinal plants conducted by NGOs active in the area or through media such as local newspaper or radio broadcasts.

Regarding the time of acquisition of participants' medicinal plant knowledge, ten households from Pitumarca (56%) and fourteen from Waca Playa (78%) mentioned that they had learned as children, while twelve (67%) and eleven (61%) households from Pitumarca and Waca Playa, respectively, said that they acquired their skills as adults. Both times were sometimes mentioned by one household, which explains why the sum is greater than 18 at each study site. Here, also there seem to be equal portions of horizontally versus vertically acquired plant knowledge Knowledge about plant remedies is typically first acquired during childhood within the family (24 households in total), but an important part of this knowledge is also gained in adulthood, usually from people other than parents or grandparents (23 households).

As the quotations below demonstrate, there is a strong perception, widely shared among the participants, that medicinal plant knowledge is not "taught" as such, but it is the result of one's own personal active quest. In order to acquire medicinal knowledge, one needs to ask people in one's

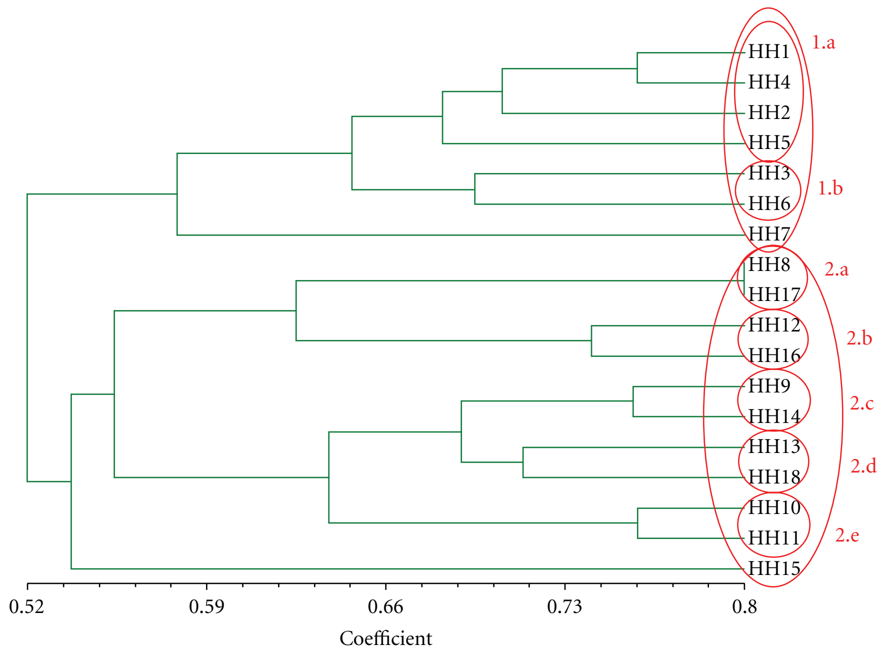

FIGURE 3: Tree resulting from cluster analysis of 18 households' knowledge about 25 medicinal plants in Waca Playa, Bolivia. HH no.: household number. Correlation coefficient $r = 0.64$ (poor fit).

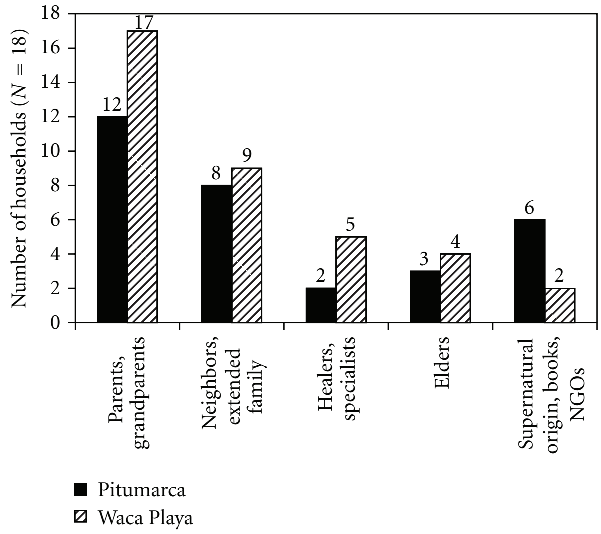

FIGURE 4: Sources of medicinal plant knowledge for 18 households from Pitumarca and 18 households from Waca Playa. Different sources were sometimes mentioned by one household, which explains why the sum is greater than 18 at each study site.

immediate environment, listen, look, try, and practice. And the capacity to learn will depend on interest, curiosity, intelligence, and in the end on personal ability.

> *"Nobody taught me [about medicinal plants]; I learned on my own, looking at what other people were doing. (. . .) I do not teach my children; they learn only by looking. [I do not teach them] because they do not understand; but if they see they get to understand better. They always see." (Waca Playa-Household 14, 29/04/2008)*

> *"From the elders, looking at the elders I learned [about healing]. I got more interested and with practice learned more and more. Thanks to my intelligence and ability I got to learn (..) My children are intelligent; they will learn by looking at what I am doing." (Pitumarca-Household 8, 29/07/2008)*

Medicinal plant knowledge is freely shared among community members out of solidarity and in a relationship of reciprocity, either through informal exchanges and comments during daily activities or when someone is ill and needs help from his/her neighbors or kin (see quotations below). In fact, the acquisition of medicinal plant knowledge is often the result of concrete illnesses that occur within the family, "as we walk through life", and that oblige one to look for a specific remedy within the communal body of therapeutic knowledge. According to the households interviewed, this also explains why women are usually more knowledgeable about plant remedies than men, since they need to care for the children when they are ill.

> *"When I went to the chacra [fields], I asked the elders [about medicinal plants] and they also asked me; this way we are sharing, this is our wisdom. (Pitumarca-Household 15, 01/10/2008)"*

> *"I learned [about medicinal plants] since I got ill; the neighbors bring me the plants. (. . .) I do not teach them [my children]; on their own they learn when someone from the family gets ill. For*

example, since I got badly ill (...) my husband and my daughter learned to heal. (...) My daughter knows how to gather thurpa (Nototriches spp.), oq'e thurpa (Nototriches sp.), puka thurpa (Nototriches sp.), chili chili (Geranium filipes Killip), from faraway places up in the mountains; she knows much more about this than me. Because I was ill, she asked the people that live in the communities; so from various sources of information [she learned]." *(Pitumarca-Household 5, 23/07/2008)*

The following narrative from a woman who grew up in town before coming back to the rural area where her parents lived illustrates that knowing how to use medicinal plants is considered to be among the skills needed to live in the community, skills which are not shared by people who live in urban centers.

"*When I was a child I did not know the medicinal plants. When I arrived here I saw my mother, she would heal my little sisters and my father when they would get ill. When I would get ill she also healed me, and by looking I learned.*" *(Waca Playa-Household 1, 01/12/2007)*

4. Discussion

4.1. Distribution of Medicinal Plant Knowledge. Our findings show that there is an important intracultural variation of medicinal plant knowledge in terms of the number of plants known at both study sites, but no clear patterns could be identified to explain this variation. Factors generally reported in the literature to account for differences in ethnobotanical knowledge and LK in general such as age [16, 21, 23, 53–56], sex [16, 18, 22, 23, 55, 57], schooling [9, 13, 15, 16, 18, 21, 30, 55], migration [42], or the market economy [34, 35, 41] did not influence the number of medicinal plants mentioned. A possible explanation for this result lies in important variations with respect to the level of specialization among participants. Indeed, the participants ranged from lay people with little knowledge to specialists. Arias Toledo et al. [17] encountered the same situation in the Cordoba region in Argentina. These findings imply that other factors, such as individual motivation, experience, and personality may play a more important role in influencing individual ethnobotanical knowledge than socioeconomic and other personal circumstances. This hypothesis is supported by our data which show that the acquisition of plant knowledge is the result of a personal quest and one's own interest and ability. These findings also suggest that Andean medicinal plant knowledge is not necessarily under threat of being lost due to factors of social change. This last hypothesis needs to be corroborated by complementary studies.

Contrary to our findings on the *amount* of plant knowledge, cluster analysis revealed clear patterns of variation in the *type* of medicinal plant knowledge at each study site and showed that the distribution of ethnobotanical knowledge was influenced by the community of residence, age, intragenerational kin relations, migratory activity, and market integration. Our study thus shows that knowledge about particular medicinal plants is highly patterned, even within one culturally homogeneous group living in the same biophysical territory. At each study site, households shared similar knowledge with their fellow community members, but demonstrated a type of knowledge distinct from households in neighboring communities. Other authors also describe Andean agricultural knowledge as "*art de la localité*" ("a local art") and conclude that it is intimately associated with a particular place [7, 58, page 209]. As a matter of fact, our study shows that medicinal plant knowledge is a skill needed to live in a particular community, as the example of a woman who had returned to the rural area after having lived in the city illustrated. Our interpretation of these results is that medicinal plant knowledge is a locally specialized resource that is part of the reciprocal exchanges that form the basis of Andean society [59] and that the extent to which this knowledge is shared within one community reflects the strength of its social organization. This was confirmed by the results showing the high importance of neighbors, elders, and the extended family in general in the transmission of knowledge about natural remedies, especially through their support during episodes of illness. Andean medicine is indeed one of the keystones of local society [60], and (community) specialization and reciprocity are among its structural features [59].

Another important finding from our study is that age peers, including siblings in the case of Pitumarca, have similar knowledge about medicinal plants, whereas this is not the case for kin from different generations, namely parents-children and grandparents-grandchildren. This result contradicts the hypothesis of a mainly vertical knowledge transmission. We suggest that life experience may be an important determinant of medicinal plant knowledge. People from the same generation are exposed to the same processes of change in the socioecological context throughout their lives (for instance, variable levels of migratory activity of the population, changes in the composition of vegetation or the status of natural resources, the presence of NGOs, etc.), and thus also to the same new sources of medicinal plant knowledge. (for instance, actors and contexts encountered during the migratory experience, new plants available locally, a workshop on medicinal plants conducted in the community, etc.). We believe that the prevalence of migration processes that affect all households at the study sites, but at different levels throughout the last decades, may account for the homogenization of plant knowledge among age peers. Another explanation is that age peers may face similar health problems and thus have the same need to know about natural remedies for treating them. Based on a survey conducted in Oaxaca, Mexico, Giovannini et al. [13] explain the positive correlation between age and knowledge and use of medicinal plants by the fact that people are more likely to become ill and be responsible for the health of others as they get older, and hence acquire more knowledge about medicinal plants. Our results also show that participants often acquired knowledge about specific plants when they faced a concrete illness, or were responsible for treating other household members, such as the case of women who care for young children.

The role of life experiences in individual medicinal plant knowledge can also explain our findings regarding the influence of migration and market integration. In Pitumarca and Waca Playa, households were often clustered according to their degree of migration and market activities. Both processes imply different degrees of mobility, since higher market integration meant traveling to the commercial centers of the region or to the Amazon lowlands. Consequently, both migration and market activities imply different degrees of interaction with noncommunity members, and thus access to new sources of medicinal plant knowledge. We postulate that the mobility of Andean households places them in situations of "encounters at multiple [social] interfaces" that stimulate the emergence of new knowledge as a product of the interaction between different actors [61]. Interestingly, our results show no difference in the amount of plant knowledge (number of plants reported) of households according to their migratory activity or degree of market integration. It thus remains to be elucidated whether the participating households have maintained their botanical knowledge or partially lost it and adopted new knowledge during their stay(s) outside the research sites. Nevertheless, the influence of mobility on medicinal plant knowledge is an indicator of the permeability of local medicinal systems by external influences. Ingold [62] describes knowledge about the world as a process of enskillment in the context of people's practical engagement with the environment. We believe that this is also true for migratory processes and that the attitude of a personal quest for medicinal plant knowledge described by the participants (by observing, questioning, and trying) is maintained and perhaps even enhanced during the migratory experience, giving continuity to the learning process in the host environment. In their study on medicinal plant use among Bolivian and Peruvian migrants in London, Ceuterick et al. [44] demonstrated how the resilience of Andean migrant communities includes processes of transformation, learning, reorganization, and renewal.

The fact that Andean healers at the study site share similar medicinal plant knowledge with their professional peers could be expected, since the distinction between specialist and lay knowledge is widely recognized in ethnomedicinal research around the world. In their paper on healers' knowledge in Bolivia, Vandebroek et al. [60] revised the literature about the specific modes of acquisition and transmission of specialist knowledge in several African and Latin-American countries. The three main sources of specialist knowledge include the family sphere, other experienced healers outside the family, and a supernatural origin (dreaming or communication with spirits). This was also observed in our study, where Andean healers reported that the source of their specialist knowledge was supernatural. We wish to draw attention to two additional aspects in our results. First, healers are not necessarily the most knowledgeable participants in their communities in terms of the total number of plants reported. At both study sites, some lay people actually possess a higher level of plant knowledge than the Andean specialists. Second, the clusters that include the healers in Pitumarca also include lay persons, and at both study sites, the clusters that contain halers are not isolated from the other clusters. These observations indicate that what differentiates Andean healers from lay people is not necessarily their high level of or exceptional idiosyncratic type of medicinal plant knowledge, but other personal attributes such as the supernatural origin of their knowledge.

Level of education had no influence on the distribution of the amount or type of medicinal plant knowledge among participating households, which contradicts previous findings about the negative correlation between schooling and LK [9, 13, 15, 16, 18, 21, 27, 30]. In line with Robinson [19], we believe that individual motivation has more influence on ethnobtanical knowledge than state-run education or other socioeconomic indicators of modernization. In the Argentinean Cordoba mountains, Arias Toledo et al. [17] reported on a group of persons with superior education, usually migrants from urban centers, who knew about a greater number of medicinal plants than their peers with less education. The former acquired their knowledge about plants through specialized books and training, or by asking local specialists. Similarly, participating households with the highest levels of education at both our research sites (secondary level or higher) exhibited a high personal interest in medicinal plants and expressed the desire to increase their knowledge by observing a healers, reading specialized books, or participating in workshops. Our findings imply that formal education does not compete with local forms of knowledge at our research sites. Not only do both systems coexist, but schooling may even indirectly strengthen medicinal plant knowledge.

4.2. Transmission of Medicinal Plant Knowledge. Our findings about the sources of acquisition of medicinal plant knowledge indicate that there are equal proportions of vertical versus horizontal modes of transmission at both study sites, which is a rejection of our working hypothesis and contradicts the results from other studies that state that LK is mainly transmitted by parents to offspring [3, 5, 11]. McElreath and Strimling [63] suggest that some ethnographic studies may have overestimated the importance of vertical transmission by focusing mainly on learning in children [63] (cited by [12]). Our own results support their position, since a comparable number of participants recalled that their teachers had been their parents or grandparents during childhood (vertical acquisition) as compared to those who had learned from other sources of knowledge during adulthood (horizontal acquisition). This may indicate that medicinal plant knowledge is first acquired within the family circle during childhood but that it then undergoes transformations as a result of subsequent contacts with other knowledge sources, including age peers. As Barsh argues, "every individual is necessarily engaged in a lifelong personal search for ecological understanding" [64, page 74]. Similar results about the increase of the importance of nonvertical transmission with age have also been reported in the literature [11, 12, 63].

Local healers represent another source of medicinal plant knowledge at our study sites (reported by almost one third of all participating households). Furthermore, the results from the cluster analysis indicate that Andean healers have a certain amount of medicinal plant knowledge in common with lay people from their communities. This observation suggests that healers are important actors in the cultural transmission of generalist knowledge, which represents a one-to-many mode of cultural transmission and thus of a highly dynamic knowledge system [11]. Lozada et al. [5] reported that experienced Mapuche healers used to play an important role in the transmission and conservation of plant knowledge in Northwestern Patagonia but that this was no longer the case and that knowledge transmission now occurred mainly vertically within the family. We might thus predict that the possible disappearance of these specialized healers, all elder people, in the next decades, could lead to transformations in the patterns of medicinal plant transmission. If the role of healers as knowledge transmitters is taken over by the older generation (either the parents or the community elders), then the change will be in the direction of a greater proportion of conservative transmission modes. Conversely, if the role of specialist is taken over by highly motivated and skilled individuals (that can be peers or neighbors from the young generation), this transformation would lead to a prevalence of dynamic transmission modes. As a matter of fact, our results also showed that other nonpersonal sources, linked to individual motivation and experience played a role in the acquisition of plant knowledge, and that these individual characteristics might indeed be the dominant factor of the amount of ethnobotanical knowledge.

4.3. Methodological Limitations of the Study. The methodological tool chosen for this research was freelisting. The aadvantage of freelisting and other types of open-ended questions frequently used in the social sciences is that responses from participants are not directed in any way by the researcher, thus allowing in our case for an unbiased inventory of the most significant plants known to and/or used by each participant. Freelists are useful for assessing who in a community knows more (or less) about medicinal plants [65]. The disadvantage of this tool is that a plant might not be mentioned, because it was simply "forgotten" during the exercise, as opposed to lack of knowledge about it. This can limit the subsequent use of statistical cluster analysis for comparison of knowledge between participants. The alternative would have been to undertake systematic data collection by means of a specimen identification task with each household, based on a selected list of medicinal plant vouchers (what Medeiros et al. [66] call a "check-list interview"). We have taken three measures to minimize methodological bias as a result of freelisting. First, interviews were carried out during several visits to each household, and in some cases, several household members were interviewed in order to obtain a complete list of known medicinal plants. Second, we used only the most frequently reported plants, assuming that these would be more widely known at the research sites. In fact, according to Martin [67], people tend to list the most culturally important plants first when asked to freelist. A limitation of this measure is that it disregards the lesser known plants, which can be interesting indicators of intracultural variation and knowledge transmission. However, these and other plants were taken into account for the comparison of the amounts of ethnobotanical knowledge (number of plants reported). Third, for the cluster analysis, we used the Dice coefficient to produce the (dis)similarity matrix between pairs of households. This coefficient puts a comparatively strong emphasis on the number of presence matches (number of plants known to each pair of households). This is not the case with other coefficients, such as, for instance, the simple matching coefficient that was used by other researchers to make similar cluster analyses [14].

A second methodological constraint of the present study was the limited sample size. A considerable amount of time was required to obtain qualitative data that provided in-depth overall knowledge about the research context and made it possible to establish relationships of trust with participants and conduct long open-ended interviews and informal exchanges. As a consequence, we collaborated with a total of 36 households at the two study sites over a total of 22 months. The same number of households was interviewed at each study site (18), in order to allow for comparison of the medicinal plant inventories from both sites. A larger sample size would be recommendable for a stronger statistical comparison of plant knowledge according to a set of differing socioeconomic variables.

Another aspect worth noting is the poor fit of the cluster analysis results from the Waca Playa case study. The correlation coefficient from the cluster analysis tree from Waca Playa was low ($r = 0.64$; poor fit), which means that the degree of correspondence of the analysis with the original data was weak, whereas the one from the Pitumarca tree was high ($r = 0.81$; good fit). Despite this, we included the results from Waca Playa in the present paper in order to verify whether the trends identified in the data from Pitumarca were confirmed. The data used in Waca Playa might be considered too limited to distinguish groups of clusters. The same analysis was thus run with a higher number of plants using the data sets from the two research sites (those mentioned by 17 and those mentioned by all 18 participating households), but the resulting correlation coefficients were even lower. One possible explanation for the weak results in Waca Playa could be the low agreement on medicinal plants among households, not allowing for strong patterns to be discovered. Defining culture as consensus, in line with Romney et al. [68], could offer an explanation for these results. According to these authors, participants who agree more with others are more knowledgeable. This was confirmed by our results, when comparing overall knowledge from Pitumarca with that in Waca Playa. In Pitumarca, where there was more agreement among households about commonly known medicinal plants, the total amount of medicinal plant knowledge was also greater (total of 249 plants known versus 150 in Waca Playa). A positive correlation between consensus and medicinal plant knowledge at the group level was also demonstrated by Vandebroek [26] although this correlation was negative at the individual level, namely, in the case of specialists who showed a low level of agreement with their peers but a high level of idiosyncratic knowledge.

A final constraint of this study is that voucher specimens of some plants could not be collected because of the study's time limitations, either because they grew far from the research site and were not easily available during the field work season, or because the specimens collected were deteriorated due to adverse climatic conditions. In these cases, the corresponding plants could only be determined indirectly through literature, which does not ensure the accuracy of this information and thus limits its use for future comparative studies with the same plants.

5. Conclusions

This study shows that LK in culturally homogeneous groups presents certain patterns of variation and distribution that result from differences at the socioeconomic and personal levels, including individual life experiences. Our findings demonstrate the usefulness of triangulating the results from several methods to assess intracultural variation, namely, by comparison of both the *amount* and *type* of ethnobotanical knowledge. On the one hand, comparison of the average or median number of plants mentioned per households did not allow us to identify clear patterns in the distribution of medicinal knowledge, but it provided clues about its resilience by demonstrating that factors of social change such as schooling, migration, or the market economy did not influence it. On the other hand, cluster analysis permitted a demonstration of the socioeconomic factors that explain more detailed differences and similarities between the types of knowledge in different households. In addition, assessment of the modes of transmission of medicinal plant knowledge was a valuable tool for better understanding of the dynamics of Andean LK. Future studies should investigate the transformations of the patterns of Andean environmental knowledge distribution and transmission over time. Processes of social change might indeed lead to a redefinition of the weight of the different factors that influence LK and modes of knowledge transmission. This kind of approach could provide valuable insights into the degree of resilience of Andean LK in a rapidly changing socioecological context.

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Research Article

Exploring the Links between Ethnobotany, Local Therapeutic Practices, and Protected Areas in Santa Catarina Coastline, Brazil

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We investigated the knowledge of medicinal plants in two areas proposed for the creation of protected areas for sustainable use in the city of Imbituba (SC). In this study, we analyzed the influence of gender, form of learning, and modern medicine on medicinal plant knowledge while also reflecting on the relationship of this knowledge *to in situ* conservation. Data collection was conducted through structured interviews, free listings, guided tours, and collection of botanical material. 197 species of medicinal plants belonging to 70 botanical families were recorded. Gender and the form of learning were factors that significantly influenced the similarity of the knowledge of medicinal plants among the informants. We also observed the existence of a therapeutic pluralism among key informants. Local medicinal plant knowledge emphasizes the importance of strategies to create protected areas of sustainable use as a way to ensure the maintenance of traditional lifestyles and associated local knowledge.

1. Introduction

Among the known natural resources managed by human populations, medicinal plants stand out as important links between people and the natural environment, a knowledge that is present in many local communities and with a large abundance of known and used species [1–6]. The knowledge of medicinal plants in traditional communities is closely linked to the practical aspect (doing), having been built over the years by social interactions of people among themselves and with the surrounding environment, this knowledge assumes an important role in the identity formation and self-recognition of these populations.

The use of medicinal plant in therapies is a widespread practice in folk medicine [4, 7, 8]. Access to modern medicine by the local population does not eliminate the use of local medicinal practices, which is often included in therapeutic pluralism of the communities. While not eliminating the practice of folk medicine, the introduction of modern medicine may lead to the disappearance or modification of some traditional practices [7, 9]. Other factors may also influence the knowledge of medicinal plants, such as gender, form of learning, religion, and age among others. In relation to gender, for example, several studies show that different occupations between men and women end up influencing their knowledge of plants [10–13].

Local knowledge can also be influenced by changes in traditional practices. The loss of natural areas, due to urbanization or large-scale agriculture, could influence significantly traditional practices. Natural areas are a source of therapeutic resource for many communities, and also a space for social organization and cultural reproduction. In the coastal region of Brazil, uncontrolled urban expansion and property speculation have led to extensive loss of natural areas, culture, and traditions of communities living in these areas [5, 8]. The access to territory is of primary importance to maintain the local and traditional way of life, because the environment of each given local community has the conditions for their cultural reproduction and identity [14].

As a form of resistance to the urbanization pressure, some traditional communities have been organizing and seeking recognition of their rights of access to land and natural resources. A strategy for recognition of their rights is the establishment of protected areas for sustainable use, allowing the maintenance of traditional livelihoods, sustainable use, and conservation of plant resources [15]. The latter reality

Figure 1: Map of study area showing the researched communities and the proposed boundaries of the protected areas in the municipalities of Imbituba, Santa Catarina (Brazil).

can be seen in the south-central coast of Santa Catarina, where local communities have requested the creation of two protected areas (PAs) for sustainable use, an Extractive Reserve (RESEX) for the Artisanal Fisheries of Imbituba and Garopaba and the Areais da Ribanceira Sustainable Development Reserve (RDS). The establishment of these PAs is a form of withstanding pressures and ensuring access to territory and natural resources for local communities.

Studies of how local knowledge is organized and influenced are important for understanding the processes and maintenance of local knowledge generation. The preservation of cultural identity requires that local knowledge is passed from generation to generation [16], and that the processes of knowledge generation are maintained. Moreover, these studies collaborated to incorporate the difference in knowledge of native plant into strategies for conservation.

In this context, this study aimed to investigate the knowledge about medicinal plants in two regions proposed for protected areas for sustainable use in the municipality of Imbituba (SC). As well as seeking to analyze the influence of gender, form of learning, and modern medicine on medicinal plant knowledge. In this study, reflections are made on the relationship of medicinal plant knowledge with the maintenance of traditional livelihoods and biodiversity conservation.

2. Area of Study

The municipality of Imbituba is located on the south-central coast of the state of Santa Catarina (Brazil), about 90 km south of the capital Florianópolis (Figure 1). Imbituba is a port city, with a population of about 40,000 inhabitants. All municipality is considered urban, and this means that people who are farmers have easy access to market, hospital, and other modern facilities.

The coastal landscapes present in Imbituba are heterogeneous and complex spatial structures [17, 18]. Imbituba is located in the Atlantic Forest biome, where a mosaic of different ecosystems are present, ranging from *restinga* to dense ombrophyllous forest. Other features of this landscape include lagoons, swamps, wooded *restingas*, grassy *restingas*, shrub *restingas*, *butiazais* (areas with high densities of an endemic small palm, *Butia catarinensis* Noblick & Lorenzi), and dense submontane ombrophyllous forest [17, 18].

The *restinga* vegetation is present in sand dune ranges composed mostly of endemic vegetation, which includes "originally herbaceous formations, undergrowth, shrub, or tree, which can occur in mosaics and also have areas that are naturally devoid of vegetation; such formations may have been kept as primary or transformed into secondary, as a result of natural processes or human intervention" [19].

The occupation of the region is long standing, formed in 1715 as the core of Azorean colonization and pioneers. Until the 1960s, families ensured their livelihoods with a combination of agriculture, fishing, and hunting [20]. The agricultural management made use of slash-and-burn farming, consisting of the accumulation of branches that were incinerated at the same time to clear and fertilize croplands [18].

The production system connected to family farming and artisanal fishing remained until the late 1970s, when the increase of tourist activities, with the implementation of the BR-101 and the intense property speculation, strongly contributed to a distortion of the traditional populations [17, 20]. At this time the Imbituba Industrial Complex was implemented in the Areais da Ribanceira region with the promise of creating new jobs that did not materialize. Thus, many farming families were displaced, but continued to occupy the area and practice agriculture [17].

Farmers and traditional fisherman in Imbituba have been going through an intense process of progressive land loss in order to carry out their way of life, such as access to the sea, lakes, agricultural fields, and the resources from these areas [20]. As a way to resist these pressures, farmers and fishermen in Imbituba proposed the creation of two PAs, an RESEX and an RDS. The purpose of this PA is to protect natural environments and to ensure the maintenance of the farmers and fishermen's livelihoods [17, 18]. Besides these two PAs in the making, the region is covered by the Environmental Protection Area (APA) of the southern right whale, founded in 2000, in order to protect the southern right whale (*Eubalaena australis,* Desmoulins, 1822) and ensure the sustainable use of natural resources in the region.

The initiative for the creation of the PAs comes from local community organizations and was supported by different groups. The process of creating the RESEX began in 2005, on request of the Forum Agenda 21 of Ibiraquera and the Association of Fishermen of Ibiraquera (ASPECI). This PA includes the municipalities of Imbituba and Garopaba, with an area of approximately 19.930 hectares, covering the lagoons of Ibiraquera, Doce, Encantada and Garopaba, and the adjacent coastline. The most significant portions are covered by water sheets (sea and lakes) and the area of the extractive reserve falls partly within the limits of the of the southern right whale protected area [17].

The request for the creation of RDS Areais da Ribanceira was presented by the Rural Community Association of Imbituba (ACORDI) in August 2005. The area proposed for RDS covers and encompasses agricultural areas, *restinga* ecosystems, and dense ombrophyllous forest. These environments are also used for the extraction of plant resources such as medicinal plants and *B. catarinensis*. The total area proposed for the RDS is approximately 2.100 hectares, and part of the area is included in the southern right whale protected area [18].

The procedures for the creation of RESEX are in an advanced stage of negotiations, only requiring the final approval by the Brazilian Ministry of Environment. However, there are still several steps to be accomplished in the procedures for the RDS creation.

3. Methods

3.1. Data Collection. The ethnobotanical information on medicinal plants was collected during the period between August 2009 and June 2010, through structured interviews with key informants, free lists, field notes, and guided tours [21]. The participation of informants was dependent on the acceptance of the term of prior informed consent (TAP).

Data was collected in 11 localities of Imbituba: Aguada, Areais da Ribanceira, Arroio, Alto Arroio, Barranceira, Campo D'Una, Imbituba Center, Divinéia, Ibiraquera, Morro do Mirim, and Ribanceira. These localities, or neighborhoods, are close to each other and with easy access, so people who live in a certain locality have relationships with people of other localities.

Sampling of study subjects was intentional; interviews were conducted with key informants, also called local experts, were recognized as having a specific knowledge. The selection of informants was based on the "snowball" method [22], in which each informant indicates other informants to cover the largest number of people who have the specific knowledge being investigated. The following were criteria for informant inclusion: adults, residents for over 20 years in the region and had knowledge of medicinal plants. Sampling was initiated through the indication of community leaders and researchers who developed studies in the communities and ended when there were no more new indications. Some informants were included randomly by accident, while looking up information on the homes of other key informants. The interviews were structured [21] and based on a preset of questions regarding the socioeconomic status of the informants, the way of learning about medicinal plants, differences in present and past knowledge and use of medicinal plants, traditional therapies, modern medicine, and a free list of known medicinal plant species.

A pilot study was conducted with three people to verify the need to adjust the methodology [21]. The interviews in the pilot study were included in the data, since the questionnaire underwent only minor modifications.

The free-list method, in which participants are asked to list the plants they know [21], was conducted with all informants and was intended to raise the species richness of known medicinal plants and specific information about these plants (the use/purpose, how it was obtained, and collection sites). The plants mentioned were collected in guided tours. The tour was held after the interview, taking place in the backyard of the respondent's home. Tours were also held in areas of native vegetation with informants who cited wild plants and those that were available for such an activity.

The collection of cited plant samples was conducted following the standard procedure for ethnobotanical species collection [21]. Plant materials were identified by specific bibliographies and consultations with experts. Plant material was deposited in the herbarium FLOR (UFSC/SC) and in the collection of the Human Ecology and Ethnobotany Laboratory/UFSC. Identification followed the classification system of APG II and scientific names were checked by consulting the website of the Missouri Botanical Garden [23].

Some mentioned plants were not collected due to their absence in the vicinity of homes, low abundance of some native species in the natural ecosystems, and walks with elderly informants that could not be carried out. The plants that were not collected were identified according to the collected specimens that had the same common name, or if there were no collected specimens, plants were identified by the description and by the common names. The specimens with common names that include more than one scientific species (e.g., *espinheira-santa*, *anador*, *quina*) or that there is no reference in the literature were classified as unidentified and were excluded from the analysis.

In some situations, informants were visited more than once, in order to collect plant specimens. Any additional plants that arose during these visits were not included in the comparative analysis between the informants, so that the difference in sampling did not influence the results.

The return of the results from the study occurred during the research, according to the demands presented by the community. Technical reports were prepared to assist in the legal process of access to land, lectures were held at community events and a workshop to return study results. An illustrative brochure publicizing the local ecological knowledge was also developed.

3.2. Data Analysis. Interviews and free lists were analyzed using descriptive statistics. The classification of indicated therapies was done according to World Health Organization (WHO) [24], yet other categories were added because the community recognize some local diseases that were not classified by WHO. To analyze known medicinal species a list of mentioned plants was prepared, with the plants common name/ethnospecies (in this study, ethnospecies was considered a synonym of common name, i.e., the identification of plants is done from the knowledge of the interviewees), botanical classification and frequency of citation. Randomized species-accumulation curve was used, seeking to assess the expected richness of used and known plants by the number of plant species [25]. This analysis was performed using the program EstimateS version 8.0 [26] with the Chao 2 richness estimator.

To analyze the influence of gender (male and female) and forms of learning (by elderly and courses/books) on knowledge of medicinal plants, the species richness for each group was compared using a t-test for gender and Mann-Whitney U, for form of learning—because the data did not show normality and homogeneity. The composition of the species mentioned by each group was compared using the ANOSIM analysis, using a matrix of presence and absence of cited species, where the informants were the sampling units and species mentioned were the variables. In this matrix, species mentioned by only one informant were excluded. From the absence/presence matrix, the Sorensen similarity matrix was calculated using the clustering method UPGMA. This analysis was performed using the program Primer 6.0 Beta [27]. The influence of form of learning was also analyzed through frequency of information about the question of how the person have learned about medicinal plants.

The influence of modern medicine was analyzed through the frequency of the medicinal plants and manufactured drugs that have been used by the family in the last month. Frequency analysis also was done for the use of doctors/agent of popular medicine and the perception of change on medicinal plants knowledge.

4. Results and Discussion

4.1. Interviews. Twenty-three key informants, 9 men and 14 women, were interviewed. It is noteworthy that in three interviews with male informants their wives were also present. Nine participants are members of ACORDI (Rural Community Association of Imbituba) and are involved in the process of creating the RDS. Five informants, or people of their households, are involved in the movement to create the RESEX.

The informants were between the ages of 40 and 86 years, the average being 68.5 years (SD 9.5). Fourteen are married, seven widowed, and two single. The families of the respondents have an average of 4 children (ranging from 0 to 9), living an average of 4 persons per household (ranging from 1 to 7). In regards to income, 65% are retired, 9% receive a pension, and 8% have income from fishing and agriculture, and 8% have their income from other services (health sector and school). Some retired people have been employed on past, but they maintain farm practices during all live, getting more expressive during retiring time.

4.2. Knowledge of Medicinal Plants. Through interviews and guided tours 218 ethnospecies of medicinal plants were recorded, of which 197 were identified taxonomically, belonging to 70 botanical families (Table 1). The families Asteraceae (16%) and Lamiaceae (8.5%) amounted to the highest number of species of cited medicinal plants. Asteraceae and Lamiaceae are among the families with the largest number of medicinal species cited in areas of *restinga* [2, 7, 21, 23].

This study showed a higher species richness compared with other ethnobotanical medicinal plant surveys conducted in the coastal regions of Brazil [8, 13, 28, 29]. During a study in Sertão do Peri (Florianópolis, SC), 114 species of medicinal plants were found, through 13 interviews, where all households of the site were visited, with refusal of participation by some informants [29]. For the region of Itapoá (SC), 109 species were recorded, resulting in 90 interviews in which informants were selected through random sampling [13]. In a study conducted with 14 key

Table 1: Medicinal plants (botanical classification, common name, and frequency of citation) cited by 23 key informants living in two areas proposed for protected areas of sustainable use in the municipality of Imbituba. No. is the number and collection: *F*: Herbarium FLOR (UFSC); *L*: Human Ecology and Ethnobotany (UFSC) lab collection; IC: identified in the field; and NI: not identified[1].

Botanical classification	Local name	Frequency of citation	No. collection
Adoxaceae			
Sambucus australis Cham. & Schltdl.	Sabugueiro	6	L1222
Alismataceae			
Echinodorus grandiflorus (Cham. & Schltdl.) Micheli	Chapéu-de-couro	4	L1139
Amaranthaceae			
Alternanthera brasiliana (L.) Kuntze	Meracilina, pinicilina	7	L1199
Alternanthera cf. *sessilis* (L.) R. Br. ex DC.	Anador	1	F38677
Alternanthera dentata (Moench) Stuchlik ex R.E. Fr.	Anador	1	L1114
Alternanthera sp1.	Gaiana	1	L1163
Alternanthera sp.	Anador	1	NI
Beta vulgaris L.	Beterraba	1	IC
Chenopodium ambrosioides L.	Erva-de-santa-luzia, erva-de-bicho	3	L1235
Amaryllidaceae			
Allium sativum L.	Alho	2	IC
Anacardiaceae			
Mangifera indica L.	Manga	1	L1188
Schinus terebinthifolius Raddi	Aroeira	1	IC
Apiaceae			
Centella asiatica (L.) Urb.	Pata-de-mula	1	L1205
Foeniculum vulgare Mill.	Funcho, endro	11	L1162
Apocynaceae			
Asclepias curassavica Griseb.	Erva-borboleta	3	L1149
Catharanthus roseus (L.) G. Don	Bambacá, figueira-inferno	1	F38679
Hoya sp.	Flor-de-cera	1	L1160
Tabernaemontana catharinensis A. DC.	Mata-olho	1	L1195
Araceae			
Zantedeschia aethiopica (L.) Spreng.	Copo-de-leite	1	IC
Arecaceae			
Bactris lindmaniana Drude	Tucum	1	NI
Aristolochiaceae			
Aristolochia triangularis Cham.	Cipó-mil-homens	12	L1143
Asparagaceae			
Sansevieria trifasciata Prain	Espada-de-são-jorge	1	IC
Asteraceae			
Acanthospermum australe (Loefl.) Kuntze	Féu-de-índio	1	L1158
Achillea millefolium L.	Mil-em-rama	2	IC
Achyrocline satureioides (Lam.) DC.	Marcela	7	L1192
Arctium minus Schkuhr	Bardana	1	L1120
Artemisia absinthium (Mill.) Y.R. Ling	Losna	4	L1183
Artemisia alba Turra	Cânfora, cânfora-da-horta	3	L1128
Baccharis milleflora DC.	Carqueja	1	L1130
Baccharis sp.	Carqueja	4	NI
Baccharis trimera (Less.) DC.	Carqueja	1	L1154
Bidens pilosa L.	Picão	11	L1209
Calea serrata Less.	Quebra-tudo	1	L1217
Calea uniflora Less.	Arnica	11	L1236
Centratherum punctatum Cass.	Saudade	1	L1225

Table 1: Continued.

Botanical classification	Local name	Frequency of citation	No. collection
Chamomilla recutita (L.) Rauschert	Maçanilha, camomila	13	L1184
Cnicus benedictus L.	Arataanga, caldo-santo, cardo-santo	8	L1131
Cotula australis (Sieber ex Spreng.) Hook. f.	Marcela-galega	8	L1193
Cynara scolymus L.	Alcachofra	3	NI
Eupatorium inulifolium Kunth	Erva-de-bicho, cambará-do-roxo	2	L1150
Mikania cordifolia (L. f.) Willd.	Guaco	1	L1168
Mikania glomerata Spreng.	Guaco	1	L1167
Mikania laevigata Sch. Bip. ex Baker	Guaco	5	L1237
Mikania sp1.	Guaco	1	L1238
Mikania sp.	Guaco	3	NI
Pluchea sagittalis (Lam.) Cabrera	Quitoco	1	L1218
Polygonum acuminatum Kunth	Erva-de-saracupa, Pimenta-d'água	1	F38676
Solidago chilensis Meyen		1	L1227
Spilanthes acmella Hutch. & Dalziel	Dormentina	1	F38681
Tanacetum parthenium (L.) Sch. Bip.	Rainha-das-ervas	5	L1219
Tanacetum vulgare L.	Catinga-de-mulata, Erva-mulata	5	L1135
Taraxacum officinale F.H. Wigg.	Dente-de-leão	1	L1146
Vernonia condensata Baker	Figatil, figatil-índio, Boldo-chileno	4	L1159
Vernonia scorpioides (Lam.) Pers.	Mata-pasto, São-simão	4	L1194
Vernonia polyanthes Less.	Assa-peixe	2	L1116
Basellaceae			
Anredera cordifolia (Tem.) Steenis	Macarrão	2	L1185
Bignoniaceae			
Jacaranda micrantha Cham.	Caroba, baratimã	1	L1132
Jacaranda puberula Cham.	Caroba-roxa	1	NI
Macfadyena unguis-cati (L.) A.H. Gentry	Unha-de-gato	1	NI
Tabebuia pulcherrima Sandwith	Ipê-roxo	2	L1175
Boraginaceae			
Cordia verbenacea DC.	Baleeira	5	L1119
Symphytum officinale L.	Confrei	7	L1144
Brassicaceae			
Brassica oleracea L.	Couve	1	
Coronopus didymus (L.) Sm.	Menstruz, manstrucho, menstruz-sementinha, menstruzo	14	L1198
Lepidium aletes J. F. Macbr.	Menstruzo-vassorinha, pinheiro-santo	1	L1126
Nasturtium officinale R. Br.	Agrião	5	IC
Bromeliaceae			
Tillandsia sp.	Gravatá-laranjeira	1	L1166
Cactaceae			
Opuntia sp.	Arumbeva, palma	1	NI
Pereskia aculeata Mill.	Amém	1	L1112
Rhipsalis baccifera (J. S. Muell.) Stearn	Erva-de-passarinho	1	L1220
Caricaceae			
Carica papaya L.	Mamão, mamão-macho	2	IC
Celastraceae			
Maytenus aquifolium Chodat	Espinheira-santa	2	L1155
Convolvulaceae			
Ipomoea batatas (L.) Lam.	Batata-doce	1	IC

Table 1: Continued.

Botanical classification	Local name	Frequency of citation	No. collection
Clusiaceae			
Garcinia gardneriana (Planch. & Triana) Zappi	bacupari	3	L1118
Commelinaceae			
Commelina cf. *benghalensis* L.	Capoerage, trapoeiraba, mato-que-o-grilo-dorme	1	L1230
Dichorisandra thyrsiflora J. C. Mikan	Cana-do-brejo-da-roxa	3	L1127
Tradescantia zebrina Heynh.	Trapoeiraba, ondas-do-mar	2	L1230
Costaceae			
Costus sp.	Cana-do-brejo	5	
Costus spicatus (Jacq.) Sw.	Cana-do-brejo	1	L1226
Crassulaceae			
Bryophyllum pinnatum (Lam.) Oken	Fortuna	4	L1161
Cucurbitaceae			
Sechium edule (Jacq.) Sw.	Chuchu, chuchu-amarelo	8	L1140
Cucurbita sp.	Abóbora	2	IC
Cyperaceae			
Bulbostylis capillaris (L.) Kunth ex C. B. Clarke	Cabelo-de-porco	1	F38673
Scirpus sp.	Piri	1	NI
Dioscoreaceae			
Dioscorea altissima Lam.	Salsa-parrilha	9	L1223
Dioscorea laxiflora Mart. ex Griseb.	Taiua	1	L1228
Equisetaceae			
Equisetum giganteum L.	Cavalinha, rabo-de-lagarto, Cana-cavalinha	8	L1136
Euphorbiaceae			
Aleurites fordii Hemsl.	Anozeiro, anoz	1	L1115
Jatropha multifida L.	Mercúrio-da-horta, Cura-corte, Metiolate	3	L1200
Manihot esculenta Crantz	Aipim, mandioca	2	IC
Ricinus communis L.	Mamoneira, carrapateira	2	L1190
Fabaceae			
Bauhinia forficata Link	Pata-de-vaca	1	IC
Bauhinia microstachya (Raddi) J. F. Macbr.	Pata-de-vaca	5	L1206
Bauhinia sp.	Pata-de-vaca	3	NI
Cajanus cajan (L.) Huth	Feijão-andu, feijão-guandu	4	L1157
Indigofera suffruticosa Mill.	Erva-de-anil	2	L1147
Mucuna urens (L.) Medik.	Olho-de-boi, corronha, curriancho	1	L1214
Senna corymbosa (Lam.) H. S. Irwin & Barneby	Fidigoso-bravo	1	F38675
Zollernia ilicifolia (Brongn.) Vogel	Espinheira-santa	2	L1156
Geraniaceae			
Pelargonium sp.	Malva-cheirosa, malva-simples	2	L1186
Labiaceae			
Leonotis nepetifolia (L.) R. Br.	Cordão-de-são-francisco, cordão santo	3	L1145
Lamiaceae			
Hyptis sp.	Mata-vilida, pau-de-negro	1	L1196
Hyptis suaveolens (L.) Poit.	Erva-cidreira	11	L1151
Lavandula angustifolia Mill.	Alfazema	5	L1110
Mentha pulegium L.	Poejo	5	L1211
Mentha sp1. L.	Hortelã, hortelã branca, hortelã-roxa	23	L1172

Table 1: Continued.

Botanical classification	Local name	Frequency of citation	No. collection
Mentha sp2.L.	Menta, vic	2	L1233
Mentha sp3. L.	Alevante, elevante, levante	3	L1180
	Manjericão-de-folha-mais-escura	1	L1189
Ocimum campechianum Mill.	Erva-doce, anis, alfavaca, são simão	10	L1148
Origanum vulgare L.	Orégano	1	L1215
Plectranthus barbatus Andrews	Boldo, boldo-de-chile, boldo-do-brasil	9	L1122
Plectranthus neochilus Schltr.	Boldo-miúdo	1	L1124
Rosmarinus officinalis L.	Alecrim	11	L1108
Salvia splendens Sellow ex Wied-Neuw.	Chá-do-reino	1	L1138
Tetradenia riparia (Hochst.) Codd	Incenso	3	L1173
Vitex megapotamica (Spreng.) Moldenke	tarumã, cinco-folha, nó-de-cachorro	2	L1212
Lauraceae			
Cinnamomum zeylanicum Blume	Canela, quina-do-mato	1	L1234
Laurus nobilis L.	Loro	8	L1182
Ocotea odorifera Rohwer	Canela-sassafraz	5	NI
Persea americana Mill.	Abacate	7	IC
Lythraceae			
Cuphea carthagenensis (Jacq.) J. F. Macbr.	Sete-sangria, TACO-de-índio, BOA-noite	6	F38678
Lythraceae			
Punica granatum L.	Romã	6	L1221
Malvaceae			
Gossypium hirsutum L.	Algodão	2	
Luehea divaricata Mart.	Açoita-cavalo	2	L1107
Malva parviflora L.	Malva-de-dente	4	L1187
Malva sp.	Malva	9	
Malvastrum coromandelianum (L.) Garcke	Guaxuma	1	L1169
Bombacopsis glabra (Pasq.) A. Robyns	Castanha	1	L1134
Triumfetta sp.	Carrapicho	2	L1133
Meliaceae			
Melia azedarach L.	Cinamomo	1	NI
Myristicaceae			
Myristica fragrans Houtt.	Noz-noscada	1	NI
Moraceae			
Ficus sp.	Figueira-branca	1	NI
Ficus pumila L.	Folha-de-hera	1	L1171
Morus nigra L.	Amora	3	L1113
Musaceae			
Musa sp.	Banana	2	
Myrtaceae			
Eucalyptus citriodora Hook.	Eucalipto-lima	3	IC
Eugenia uniflora L.	Pitanga	7	L1210
Psidium cattleyanum (Mart. ex O. Berg) Kiaersk.	Araçá	6	IC
Psidium guajava L.	Goiaba	6	IC
Syzygium cumini (L.) Skeels	Gibolão, cerejeira, Jambolão	2	L1165
Nyctaginaceae			
Boerhavia diffusa L.	Erva-tostão, erva-tristão, erva-tustão	3	F38671

Table 1: Continued.

Botanical classification	Local name	Frequency of citation	No. collection
Onagraceae			
Oenothera mollissima L.	Miliã	1	L1201
Oxalidaceae			
Averrhoa carambola L.	Carambola	1	NI
Oxalis spp. L.	Trevo	1	NI
Passifloraceae			
Passiflora edulis Sims	Maracujá	7	L1191
Phyllanthaceae			
Phyllanthus tenellus Roxb.	Quebra-pedra	10	L1216
Phytolacaceae			
Petiveria alliacea L.	Guiné	4	IC
Piperaceae			
Ottonia martiana Miq.	Jaborandin	1	L1176
Piper sp.	Pariparoba	1	L1204
Piper cf. *umbellatum* L.	Pariri	4	L1203
Plantaginaceae			
Plantago australis Lam.	Tansagem, tansagem-nativa, carssá	3	F38672
Plantago major L.	Tansagem	2	L1229
Plantago sp.	Tansagem	11	NI
Poaceae			
Coix lacryma-jobi L.	Lágrima-de-nossa-senhora	1	NI
Cymbopogon citratus (DC.) Stapf	Cana-cidreira, capim-cidrão, capim-santo	12	L1129
Cymbopogon winterianus Jowitt ex Bor	Citronela	1	NI
Eleusine tristachya (Lam.) Lam.	Capim-pé-de-galinha	1	F38680
Melinis repens (Willd.) Zizka	Capim-graxa	1	NI
Saccharum officinarum L.	Cana, cana-de-açucar	4	IC
Zea mays L.	Milho	2	IC
Polypodiaceae			
Microgramma vacciniifolia (Langsd. & Fisch.) Copel.	Cipó-cabeludo	1	L1142
Polygalaceae			
Polygala cyparissias A. St.-Hil. & Moq.	Gelol	3	IC
Proteaceae			
Roupala cf. *brasiliensis* Klotzsch	Carvalho	1	NI
Pteridaceae			
Adiantum cf. *raddianum* C. Presl	Avenca	3	L1117
Rosaceae			
Eriobotrya japonica (Thunb.) Lindl.	Ameixa	2	L1111
Rosa spp.l.	Rosa-branca, rosa-branca-verdadeira, rosa-vermelha, rosas	5	IC
Rubus sp.	Amora-do-mato	1	NI
Rubiaceae			
Coffea arabica L.	Café	2	L1125
Diodia radula (Willd. ex Roem. & Schult.) Cham. & Schltdl.	Erva-lagarto	3	L1152
Rutaceae			
Citrus limon (L.) Osbeck	Limão	3	L1181
Citrus reticulata Blanco	Laranja-crava	2	L1179
Citrus sinensis (L.) Osbeck	Laranja, laranja-azeda, laranja-bruta	14	L1178
Ruta graveolens L.	Arruda	5	IC

Table 1: Continued.

Botanical classification	Local name	Frequency of citation	No. collection
Salicaceae			
Casearia sylvestris Sw.	Chá-de-bugre	1	L1137
Sapindaceae			
Paullinia cupana Kunth	Guaraná	1	L1170
Simaroubaceae			
Picrasma crenata Engl. In Engl. & Prantl	Pau-amargo, pau-de-velha, pau-pra-tudo	4	L1207
Solanaceae			
Datura suaveolens Humb. & Bonpl. ex Willd.	Buzina	1	IC
Solanum lycopersicum L.	Tomate-miúdo	1	IC
Solanum cf. *paniculatum* L.	Jurubeba	4	L1177
Solanum tuberosum L.	Batata, batata-inglesa		IC
Theaceae			
Thea sinensis L.	Chá-preto	1	NI
Tropaeolaceae			
Tropaeolum majus L.	Chaga-de-cristo, capuchinha	1	IC
Urticaceae			
Cecropia sp.	Embaúva	1	NI
Parietaria sp.	Parietária	1	L1202
Urera baccifera (L.) Gaudich. ex Wedd.	Urtigão	1	L1232
Verbenaceae			
Aloysia gratissima (Gillies & Hook.) Tronc.	Erva-santa, erva-de-santa-maria, folha-santa, erva-das-dores	3	L1153
Aloysia triphylla Royle	Cidrão	8	L1141
Lantana camara L.	Bem-me-quer, calenda, mal-me-quer	5	L1121
Lippia alba (Mill.) N.E. Br. ex Britton & P. Wilson	Melissa, erva-melissa, salvia	13	L1197
Stachytarpheta cayennensis (Rich.) Vahl	Gervão, gervão-branco, gervão-roxo, zervão-roxo	6	L1164
Violaceae			
Viola odorata L.	Violeta-roxa	2	L1231
Vitaceae			
Cissus sicyoides L.	Insulina	3	L1174
Vitis vinifera L.	Uva	1	IC
Xanthorrhoeaceae			
Aloe sp1.	Babosa-de-folha-larga	1	NI
Aloe sp2.	Babosa	8	NI
Zingiberaceae			
Hedychium coronarium J. König	Noz-noscada-do-brejo	1	L1213

[1] In the not identified (NI) category the species collected in the field, but that were not possible to identify botanically, and species not collected were included, however, some of these were identified based on the common names.

informants in a *caiçara* community in Vila Velha (ES), 86 species were recorded [28]. In Pinto et al. [8] 98 species of medicinal plants were reported in Itacare (BA), by 26 informants, selected by nonrandom sampling. It is worth noting that these studies used different methods for ethnobotanical survey of medicinal plants, which can influence the values of richness, so the comparison between species richness should be done with caution.

The richness estimator Chao 2 estimated 286 species for the region studied (Figure 2); therefore, over 89 more medicinal plant species are expected to be found in the region than were sampled.

When the number of citations of each species was mea-sured, it was observed that 43% of the species were cited by only one informant (Figure 3), which demonstrates that there is a significant percentage of knowledge that is not shared between the local experts. In addition, the high number of rare species, cited by only one or two informants, influences the expected value of richness, which was calculated using the Chao 2 estimator, explaining 31% difference between the observed and expected richness (Figure 2).

The species most often cited was *menta (Mentha* sp1.), cited by all informants. *Laranja* (*Citrus sinensis* (L.) Osbeck) and *menstruz* (*Coronopus didymus* (L.) Sm) were mentioned by 61% of informants. *Camomila* (*Chamomilla recutita* (L.) Rauschert) and *melissa (Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson) were cited by 57% of the informants.

These species also appear as the most cited in other studies. In Giraldi and Hanazaki [29], *menta* (*Mentha* sp.), *camomila* (*Chamomilla recutita* (L.) Rauschert), and *laranja*

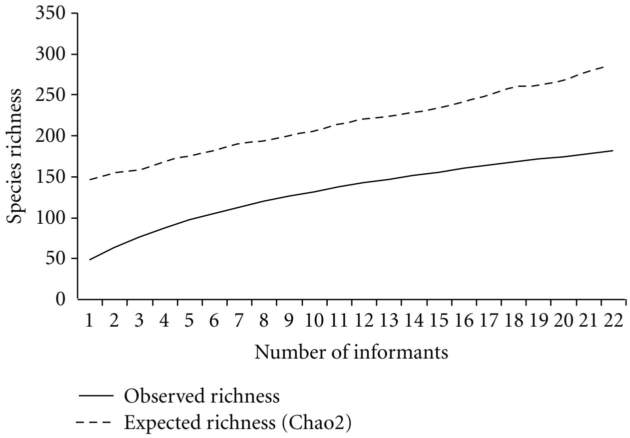

FIGURE 2: Accumulation curve and estimation of richness of known medicinal plants in the municipality of Imbituba, with a richness of 197 observed species cited by 23 key informants.

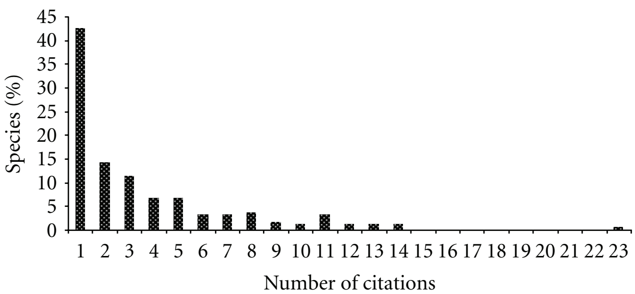

FIGURE 3: Percentage of medicinal plants species ($n = 197$) according to the number of times they were cited by 23 key informants in the municipality of Imbituba, SC.

(*Citrus sinensis* (L.) Osbeck) also appeared as the most cited. In Albertasse et al. [28] and Merétika et al. [13], *menta* (*Mentha* sp.) was also one of the most cited species. In Pinto et al. [8], the most cited plants were *menstruz* (*Chenopodium ambrosioides* L.) and *erva-cidreira* (*Lippia alba* (Mill) N.E. Br.). It should be noted that the two most cited species are common, generally cultivated in backyards and gardens, with the exception of *menstruz*, but this plant is spontaneous and easily accessible.

In relation to therapeutic uses, 18 categories were identified according to the body system they are used to treat (Figure 4). In addition to these categories, an "other" category was also included for diseases that do not fit any classification and the category "general," for plants that were cited to treat any condition. Some plants were included in ritualistic category due to its manner of use. Plants were considered as ritualistic if used to treat the "evil eye" in order to give a "shower of protection," to bless, among other uses. The main categories of use were digestive disorders (34%), undefined pain or conditions (19%), respiratory disorders (17%), and circulatory disorders (17%). Ethnobotanical studies conducted in other regions also found that digestive and respiratory system categories were cited as the main uses for medicinal plants [8, 12, 13, 28, 29].

When informants were asked about how they obtain each medicinal plant—cultivated, wild, or purchased—it was found that most plants are grown in backyards and gardens (60%), however, not necessarily by the informants. A significant percentage of the used medicinal plants (36.5%) are considered wild and extracted from the surrounding environments. The types of collection environments ranged from sand dunes, forest (*restinga* and hillside), secondary forests, swamps, fields, and plants that grow spontaneously in fields and near the houses. A small percentage (3.5%) of the plants is bought by informants (Figure 5). The use of a significant number of wild plants, which are extracted from the surrounding environment, demonstrates the connection of the population with the environment and emphasizes the importance of preserving this knowledge so these practices may continue. As pointed out by Cunha [30], the threat to local knowledge is not simply to the knowledge itself, but the conditions of production of knowledge.

4.3. Gender Influences on Knowledge. The analysis conducted to evaluate the influence of gender generated differentiated and complementary results. Women have cited more plants (average 31, SD 12.7) than men (average 26.8, SD 18.7). The comparison between the number of medicinal plant citations among the groups was not significant for gender ($P = 0.53$). On the other hand, when these groups were compared in terms of cited species composition, significant differences were found. In the analysis of similarity, ANOSIM, the differences between groups of men and women was significant ($P < 0.05$). The difference in knowledge between men and women was also addressed by Hanazaki et al. [12], Case et al. [11], Merétika et al. [13], and other studies. Hanazaki et al. [12] found differences in the number of medicinal plants citations among men and women in some *caiçara* communities on the coast of São Paulo, where men cited more plants than women. In Merétika et al. [13], it was observed that women knew more medicinal plants than men, but the difference was not significant. In a study conducted in the Manus Islands (New Guinea), Case et al. [11] found significant differences in the identification of names and uses of plants between men and women. They found that men knew more about plants, but in relation to medicinal plants no differences were found. The similarity analysis is a complement for the comparative analysis between groups. As this study shows the difference in knowledge does not necessarily arise in the number of plant species cited, but the quality of knowledge—people from different groups know different plant species.

4.4. The Influence of Form of Learning. When asked how they learned about medicinal plants, 65% said they learned through family members, 13% learned through other experienced people in the community (e.g., traditional healers), 43% attended medicinal plant courses (e.g., courses given by a religious health organization called *pastoral da saúde*), 9% learned through books, and 9% by personal experience with plants and nature. The high incidence of local experts who participated in medicinal plant courses is due to the fact that there is a unit of the *pastoral da saúde* (the *Pastoral da saúde*

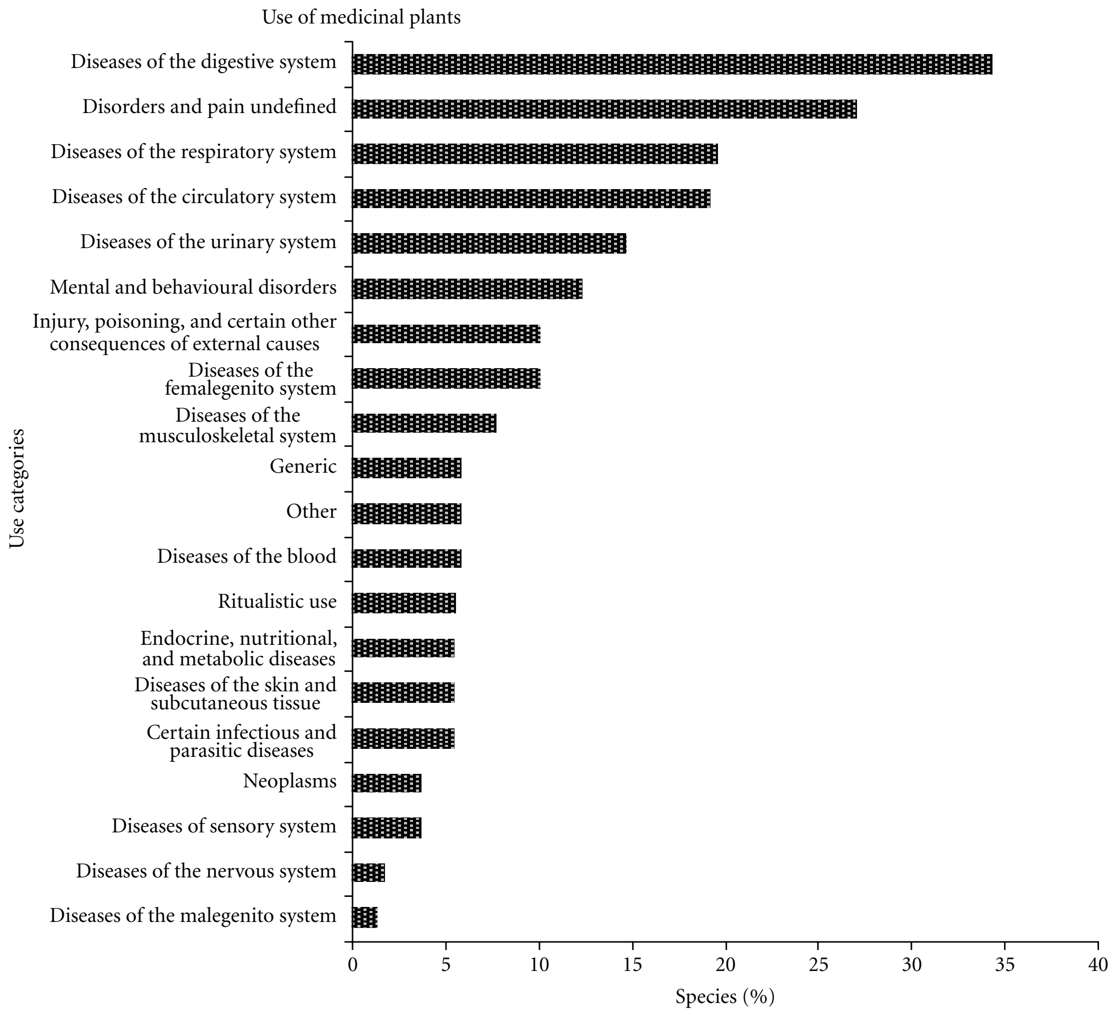

Figure 4: Percentage of medicinal plant species ($n = 197$) cited by 23 key informants in the municipality of Imbituba in relation to its therapeutic use category.

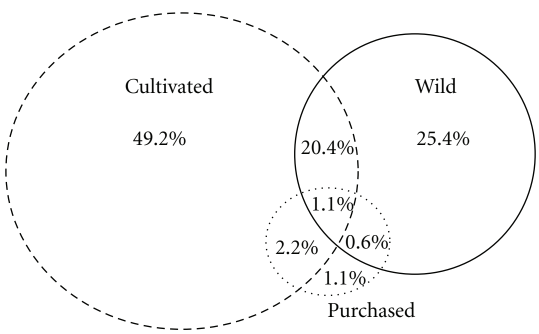

Figure 5: Percentage of medicinal plants species ($n = 197$) cited by 23 key informants from Imbituba, according to way of obtaining.

is a nonprofit, civic-religious society linked to he Catholic Church, officially established in 1986), in the center of the city, which administered some courses in the community.

To compare the difference of knowledge to do the form of transmission, we define two groups. People who learned through older people (transmission one to few) as opposed to courses/books (transmission one to many). People who learned through older people have cited more plants (average 30, SD 20.3) than people who learned through courses/books (average 28.3, SD 8.0). The comparison between the number of medicinal plant citations among the groups was not significant for form of learning ($P = 0.60$). On the other hand, when these groups were compared in terms of cited species composition, significant differences were found ($P < 0.01$).

The form of learning, or the way of transmission, can influence the knowledge of medicinal plants in Imbituba. Some studies have demonstrated that the transmission "one to many", as course and others forms of training, increases the homogeneity inside a population. This process maybe has happened in Imbituba with the course of *Pastoral da Saúde*. However, the transmission of knowledge in courses is seen as efficient, and the innovation can occur with facility and speed [31].

4.5. Therapeutic Pluralism and Traditional Knowledge of Medicinal Plants. Imbituba population has easy access to modern medicine. There is a hospital on the center of city, and health post and pharmacy in almost all localities. All informants have access to modern medicine and use it, but there is variation in the frequency in which they seek this resource. Regarding the use of medicinal plants, 91% of respondents reported using medicinal plants in the last month, but 13% of them had difficulty remembering which plants were used. In addition to medicinal plants, other traditional therapeutic practices are used by respondents, like the demand for *benzedeiras* (traditional healers). The *benzedeiras* were cited as a therapeutic resource for 70% of respondents; however, only 30% of the informants used this resource in the past. It is noteworthy that two of the informants are recognized as *benzedeiras* and are very popular with people in the community and other regions. Both were more than 80 years old when they were interviewed, and one of them passed away in September 2010.

Two other informants learned some *benzeduras* from older members of their families and use these therapies only with family. One of the informants was a herbal medicine man and had a shop in his home where he sold herbal potions to the community in the past. He currently no longer performs this role, due to legal and financial difficulties in maintaining the store.

The *pastoral da saúde* unit in Imbituba held courses in medicinal plants for the community and currently has study groups on medicinal plants. While this center may facilitate the maintenance of traditional therapies—as a process of use of medicinal plants—by the dissemination and appreciation of medicinal plants, the devaluation of some therapeutic practices may also occur, such as *benzedura*. This form of transmission can also homogenize the knowledge of medicinal plants, as we have seen on the influence of form of learning.

Taking into consideration the manufactured drugs and medicinal plants used by informants in a month, there are perceivable differences in the types of illnesses that are treated by each of the therapeutic practices, and that they are used in a complementary way (Figure 6). Informants often use medicinal plants to treat diseases related to digestive disorders, pains, and undefined conditions, respiratory problems, and mental and behavioral disorders. On the other hand, manufactured drugs are preferred for treating circulatory, endocrine, nutritional, and metabolic diseases.

Other studies that compared the use of medicinal plants and manufactured medicines also noted that medicinal plants are commonly used to treat diseases of the digestive and respiratory systems [7, 29], while manufactured drugs are used primarily to treat circulatory and endocrine systems [7, 29]. As discussed by Benítez et al. [32], medicinal plants are often used to treat simple ailments, that are not necessary to seek medical help, such as digestive problems and colds, especially, conditions that respond well to treatment with medicinal plants.

When asked about changes in the use and knowledge of medicinal plants, 70% of respondents commented that the use of medicinal plants is a practice that has declined in relation to the past. On the other hand, 30% of respondents believe that the use of medicinal plants is increasing again, due to concerns about the negative effects of allopathic drugs

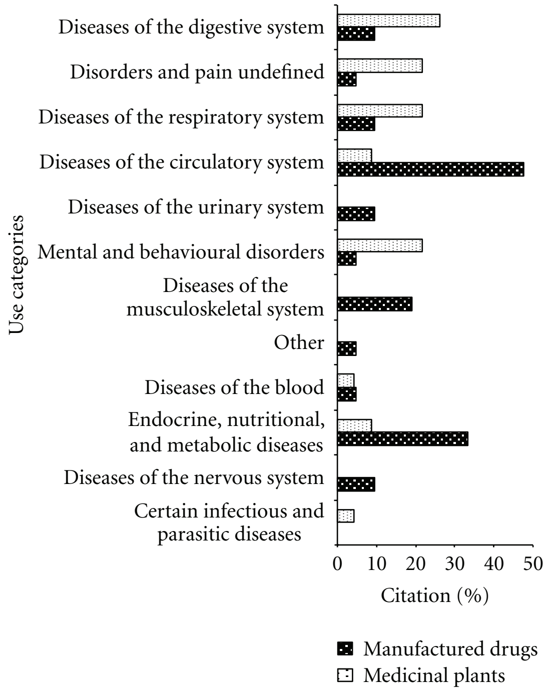

Figure 6: Percentage of types of diseases ($n = 12$) that are treated with manufactured drugs and medicinal plants by 23 key informants in the municipality of Imbituba.

and the influence of courses, such as the ones administered by the ministry of health.

> "There's a difference. At that time there were no doctors, hospitals. Today it's just doctors and pills, they do not want to make herbal teas anymore." (I7 ♀ Arroio).

> "Today nobody believes. They want the herbal teas to heal in an instant. Today there are doctors and medicines for whatever condition in the pharmacy." (I11 ♂ Imbituba center).

> "Before, they did not use because they did not know the properties. Before it was not valued because it was not understood." (I8 ♀ Arroio).

A therapeutic pluralism is perceived among local experts on medicinal plants, while people are using modern medicine and tradition practices in a complementary way (Figure 6). These data corroborate with Amorozo [7], who argues that folk medicine is influenced by modern medicine, it this does not destroy the existing systems, but adds to new possibilities. So illness can be seen as curable only by the doctor or by local experts, or people can treat the same disease through the two systems [33]. However, it is important to note that this survey was conducted only with local experts, who are known to have greater affinity to medicinal plants. Thus, it is important to also investigate how knowledge of medicinal plants and therapeutic pluralism are present in the community as a whole.

4.6. Traditional Knowledge and Sustainable Protected Areas. The data reflect the cultural importance of medicinal plants in Imbituba, even in the face of intense social, economic, and environmental changes that these local populations have been suffering. The maintenance of local knowledge encourages the conservation of natural ecosystems, in regards to the use of this resource, and strengthens the communities identity, helping to fight for their rights.

The large number of medicinal species, that are considered wild by the local population, reflects the importance of surrounding environments for the maintenance and the production of this knowledge. In this context, the creation of the RESEX and RDS, which seek to ensure land and maintenance of livelihoods for local populations, will support the strengthening of their traditional practices, including those related to health and knowledge and use of medicinal plants. It is important to note that the designation of these populations as traditional should refer to their cultural and historical rights over the area [14], and thus enabling maintenance their of autonomy and capacity for change. The traditional population of Imbituba has assumed an attitude in favor of conservation as a political strategy, a fact that is observed in several traditional communities in Brazil. The creation of a sustainable use protected area has become one of the most common alternatives to ensure both the conservation and use of natural resources and the access to the territory [14].

Moreover, if the PAs are created, traditional knowledge will be important for the development of the management plan of the area, as well as the development of an use plan compatible with the cultural aspects and the demands of the community, including the differences of knowledge among groups and different interests that coexist within the local population. As discussed by Hanazaki et al. [34], if the management and the decision making process are conducted in a participatory way, local communities can become empowered and thus play important roles in the *in situ* conservation, incorporating local knowledge into management strategies.

5. Conclusion

The communities living in the vicinity of the two proposals for protected areas in the region of Imbituba have a significantly important knowledge of medicinal plants. The high proportion of known medicinal plants in this region reflects the importance that this therapeutic approach has within the social structure of these communities, even with the strong influence of urbanization and easy access to modern medicine.

Gender and the form of learning are factors that significantly influence the similarity in knowledge of medicinal plants in the region of Imbituba. A therapeutic pluralism was identified in the region, where modern medicine and traditional practices are complementary to each other. There is a higher preference for one or the other depending on the type of the ailment. However, some informants perceive a devaluation of medicinal plants in relation to modern medicine by people in the community.

The richness of known medicinal plant species and the existence of traditional health practices demonstrate the resilience of traditional communities in the face of development pressures and urbanization that has been ongoing along the coast of Santa Catarina. This information is extremely important to the process of recognition and identification of these traditional populations and the fight for their rights through the creation of protected areas for sustainable use.

Acknowledgments

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Review Article

The Use of Medicinal Plants by Migrant People: Adaptation, Maintenance, and Replacement

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Given the importance of studying the knowledge, beliefs, and practices of migrant communities to understand the dynamics of plant resource use, we reviewed the scientific literature concerning the use of medicinal plants by migrant populations engaged in international or long-distance migrations. We considered the importance of two processes: (1) adaptation to the new flora of the host country (i.e., substitution and incorporation of plants in the pharmacopoeia) and (2) continued use and acquisition of the original flora from migrants' home countries (i.e., importation, cultivation, and/or continued use of plants that grow in both host and home environments). We suggest that, depending on the specific context and conditions of migration, different processes that determine the use and/or selection of plants as herbal medicines may become predominant.

1. Introduction

It is estimated that in 2010 approximately 214 million people lived in a location other than their country of origin [1], which corresponds to approximately 3% of the human population. This does not take into account internal migrations within a country, which are also important processes. The study of migrant people's health-seeking behavior can aid in understanding (1) the effects of cultural contacts in the dynamics of medicinal plant knowledge (2) the different ways in which therapeutic resources are perceived and used by the people, and (3) the biological and cultural contexts that determine the behavior of social groups [2–8].

There are numerous reasons why people leave their homeland. However, one of the central arguments in migration studies is that, upon reaching a new location, the newcomers face difficulties they did not previously experience (such as the lack of knowledge about the sociocultural and/or natural environment). Similarly, new opportunities absent in the homeland can also be experienced, such as an improved availability of certain health resources or land for agriculture [2, 9]. As stated by Lacuna-Richman [9] *"neither difficulties arise without relief, nor limitations without opportunities."*

One of the issues that arise from the study of plant use behavior in migrant groups is how this use change after migration and which changes occur in their therapeutic practices [10]. In this study, we consider the arguments of Volpato et al. [5], who proposed that two forces drive the traditional medical knowledge of migrant people: (1) the adaptation of their ethnomedical system to the new environment, in which the plant resources formerly used (in the home country) are being replaced with ones from the new environment and (2) the development of strategies to use and obtain the original plant medicines, either through cultivation or collection of species that occur in both environments, importation and marketing, or maintaining contact with relatives and friends from the place of origin. Regardless of the type of strategy followed by migrant groups, the present study assumes that cultures are not static [11]. Therefore, it is understood that they have the ability to define and actively influence the environment in which they exist.

Pieroni and Vandebroek [10] collected several chapters describing the ethnobiology of migrant groups and highlighted that there is little data available on this subject so far. These authors emphasized the migration of groups of people from the tropics to temperate countries, or intratropical and intratemperate migrations. In this paper, we continue to expand on this overview by examining the role of the processes triggered by migration that involve the use of medicinal plants in light of the available literature. We seek to categorize medicinal plant use strategies by migrant groups and discuss, with examples from the available literature, in which situations each of these strategies stands out. The referred strategies are divided into two groups: (1) adaptation of the ethnomedical system to the new flora of the host country and (2) acquisition of the original plants from the home country. Therefore, this paper was carried out to show evidence from the literature concerning our main hypothesis that the choice of the two type of strategy for a given migrant population will highly depend on factors such as (1) the degree of floristic and environmental similarity between home and host country, (2) variation in the prevalence of health conditions between home and host country, (3) degree of contact with local populations in the host country, (4) the involvement of social networks and the degree of contact between migrants and their homeland, (5) the ability and ease to acquire plants via importation (presence of commercial routes and plant entrance laws in the host country). Each of these factors will be further discussed in the present paper. It is also important to emphasize that our main focus is on international or long-distance migrations and we are not considering processes and patterns of internal migrations.

2. Adapting the Ethnomedical System to the New Flora of the Host Country

2.1. Replacement or Substitution of Species from the Home Environment with New Species from the Host Environment. When faced with a new environment that contains new plant species, migrants can, consciously or subconsciously, develop strategies to preserve the structure of their medical system by replacing plants from their place of origin with plants from the new environment [12]. This replacement process has been described in several studies of migrant populations [3, 8, 12–19]. In addition, we highlight some studies that specifically deal with African-Brazilian communities (i.e., people of African descent who went to Brazil during the period of slavery) [20–27].

When they arrived in Brazil, African slaves were forced to conform to the new environment. However, it seems that the biogeographic similarities of the continent of origin and the new environment made it easier for Africans to succeed in replacing plants with Brazilian species because both areas have dry forests and wetlands with similar physiognomies [22]. Some studies reinforced this hypothesis, observing that the African descendants maintained a local plant classification system very similar to the one from their places of origin [22, 25]. In many cases, the replacement of African plants with Brazilian was accompanied by transposing common names from the former to the latter. Such is the case with *niamba*, which refers to species of the genus *Cannabis* in Africa; in Brazil, the name was designated to the species *Vitex agnus-castus* L. Such substitution is supported by the morphological similarities between the leaves of these two taxa. Thus, Brazilian and African species may possess the same vernacular name, because these names were given to the Brazilian plants due to their similarities with African species [25, 26]. These observations led to the following question by Camargo [21]: what are the criteria that lead to the replacement of a plant from a place of origin with one from a new environment? Among the factors that can play a role in the process of replacement are taxonomic, morphological, chemical, and sensory characteristics of plants, as well as the influence of contact with local people [9].

Given the taxonomic similarity of the Brazilian and African floras, African species of the genera *Bauhinia, Kalanchoe, Vernonia*, and *Peperomia* were easily replaced by Brazilian plants of the same genera [22]. Species with phylogenetic proximity may contain similar compounds, guaranteeing their usefulness for the same purpose. However, given the importance of symbolism and ritual in African-Brazilian ethnomedicine, many species are likely to be replaced on the basis of their morphological similarity rather than because of their shared physiological or chemical effects. In the case of other replaced species, merely a sensory similarity, rather than a morphological correspondence, may be in order. Voeks [22], in comparing Yoruba practices with those of the Brazilian Candomblé, stated that because the bitter taste of plants plays a role in treating spiritual disorders, taxonomically distant bitter plants can be replaced by and even inherit the same names as the African originals. Thus, bitterness may be an inherent feature that facilitates and directs the replacement of plants in the host environment. In specialized herbal shops in the United States, called *botánicas*, Latino immigrants can purchase a herbal remedy called *salvia* or sage (*Pluchea carolinensis* (Jacq.) G. Don), which has a smell that reminds of European sage (*Salvia officinalis* L.) [28], even though there are distinctive features to the smell of both species. *P. carolinensis* is a shrub that grows naturally throughout the West Indies and from Mexico to northern South America and southern Florida. Interestingly, these species belong to very different plant families: *P. carolinensis* is an Asteraceae, whereas *S. officinalis* belongs to the Lamiaceae. However, their similarity in smell is probably close enough for these species to have acquired the same common name [28].

Finally, social and cultural pressures may require the replacement of species used as medicinal resources. Volpato et al. [6] investigated the preparation of a typical medical-religious beverage by Haitians living in Cuba and found that this drink is primarily prepared with *Artemisia absinthium* L, along with other macerated herbs, as an alcoholic drink. The authors state that some changes are occurring in the preparation of the drink and that the prejudice of the Cubans towards Haitian immigrants was the driving force behind these changes. Haitians were seen as less respected by Cuban society and as followers of Voodoo, a cultural practice that was frowned upon in the country. As a result, today that drink is used more often in culinary applications or as an aperitif rather than for magic and religious purposes, resulting in a change of species composition. Specifically, the trend has been to incorporate additional herbs and to reduce the amount of *A. absinthium* to make the drink less bitter.

It appears that plant replacement patterns in pharmacopoeia are strongly influenced by the characteristics of the host environment. Migrant populations can encounter three different scenarios: (a) the population migrates to a region far from the homeland that is virtually uninhabited [12, 19], (b) the population migrates to a region that is occupied by a traditional and usually native community [9], or (c) the migrant population moves to multicultural urban centers (e.g., Ceuterick et al. [3]). The involvement of each of these three scenarios may result in different strategies and degrees of substitution of plants.

When migrant populations settle in new places, they become intensively dependent on the new ecosystem. If there are no means to acquire plants from their original ecosystem, the population tends to replace unavailable medicinal plants with plants found in the surrounding flora. Inta et al. [12] compared the medicinal flora of two Akha populations (ethnic groups scattered in Southeast Asia) of which one migrated to China and the other to Thailand. The authors noted that the environment plays an important role in medicinal plant selection since the majority of the medicinal plants were not shared between the two communities; this is because most of the medicinal flora of the migrant population belongs to the settled ecosystem rather than the region of origin. Although all ecosystems are somehow different from one another, it is reasonable to hypothesize that significant differences between the host and home ecosystems can lead to important differences in plant use when it is difficult to acquire plants from the home country.

When migrants come in touch with local or indigenous communities, it is expected that the substitution of plants will be influenced to some degree by the prevalent practices of these peoples. Lacuna-Richman [9], in studying the use of nontimber forest products by Visayan people who migrated to Palawan (both in the Philippines), observed that most of the forest species of the new environment were initially unknown to the migrant people. Furthermore, they found that such species were presented to them by the native people or former migrants, usually in joint events of resin collection. Other studies have described the influence of indigenous peoples on African descendents in Brazil [23, 26].

2.2. Incorporation of New Plant Species or New Uses for Known Species in the Ethnopharmacopoeia. We consider the use of a plant species an incorporation when a new plant species is inserted in the pharmacopeia of migrant people without replacing a plant that was already known and used in the group's place of origin, thus occupying a niche in the pharmacopeia that was not previously considered. Although it is not easy to acknowledge whether a plant is being substituted or incorporated, in certain situations, a group selects a medicinal resource to treat a previously unknown therapeutic demand. This factor distinguishes replacement from incorporation for the purposes of our study. It can be either that a new plant species is incorporated into the pharmacopoeia, or that a new medicinal use for a formerly used species (in the home country) is incorporated in the new environment. For example, this is the case for plants used to treat high levels of cholesterol among immigrants from the Dominican Republic in New York City, as investigated by Vandebroek et al. [15]. In that study, the authors found that the use of plants for high cholesterol, such as *Avena sativa* L. (oats), *Ananas comosus* (L.) Merr. (pineapple), *Cucumis sativus* L. (cucumber), and *Apium graveolens* L. (celery), was not corroborated by the literature data on the use of these medicinal plants in the Dominican Republic. However, even though no literature data could be found that corroborated theses uses, the plant species belong to the contemporary pharmacopoeia in the Dominican Republic, and several of these same medicinal uses were confirmed during a comparative ethnobotanical study in the Dominican Republic in 2006, a year after recording the data in New York City. However, not all uses were corroborated in both host and home environments, and some of these uses probably represent true incorporations, such as the use of cucumber and celery to treat hypertension in New York City (unpublished data). In Brazil, the ritual use of *jurema* (*Mimosa tenuiflora* (Willd.) Poir) was probably incorporated into African traditions through contact with and influence of the indigenous Brazilians [27].

In the case of medicinal plants, an important factor that directs the incorporation of species into the medical systems of migrant people without replacement is the occurrence of new diseases that did not exist in the home environment. When faced with new diseases, migrant people can either develop strategies to treat those conditions with plants from their place of origin or from their new environment. Food plants that were incorporated by migrant groups can be taken as a reference. In a study of migrants from India in the United States, Palaniswamy [16] classified the diets of respondents as traditional, semitraditional, semiwesternized, or westernized, according to the consumption frequency of some items commonly consumed in the country of origin. The study found that dietary modification in the United States omitted foods with antihyperglycemic properties. This creates a concern regarding the incidence of diabetes, which is proportionally higher among US Indians in comparison with Caucasians.

New eating habits that are different from traditional ones can thus contribute to an increased incidence of diseases such as diabetes or even nutritional deficiencies, conditions for which migrant groups may not have ethnobotanical pharmacopoeias. Because migrant populations tend to abandon traditional diets that could prevent such conditions, the incorporation of a set of specific therapeutic practices for disease treatment is required. Such practices can be based on either conventional (biomedical) systems or the incorporation of certain plants from the new location that have already been identified as effective to treat these conditions by the host culture. In this case, trial and error and contact with local people may play important roles.

One central question in medical ethnobiology is how people diagnose recently appearing diseases, especially those that are difficult to identify, such as hypertension and diabetes. One possibility is that migrant people exchange information about those diseases with people from the host environment, which are used to deal with these diseases. But this needs to be further investigated. Outside the context of migration, some studies have described the use of herbal treatments for recently appearing diseases in local populations [29], but few studies have focused on how people treat previously unknown diseases with regard to the use of plants. For migrant populations, this theme is particularly relevant because they come into contact with a new environment that can host a range of new diseases hitherto unknown to them. In addition, it is important to consider that migrants often do not have easy access to health services, due to their immigrant status, lack or deficiency of such services, or other barriers, including those of language and culture [30, 31].

2.3. Abandonment of Plants or Practices from the Original Pharmacopoeia. Unlike replacement or incorporation, some plants or practices associated with them may simply be abandoned when a group migrates to a new environment. Abandonment of practices occurs when, for example, groups that originally inhabited areas with certain diseases migrate to areas where these diseases do not occur. van Andel and van't Klooster [18] reported that half the population of Surinam migrated to The Netherlands between 1972 and 1996; in this case, it became clear that the migratory population was no longer susceptible to malaria or other tropical infections. Ceuterick et al. [3] observed that plants previously used for the treatment of parasitic diseases in Colombia were no longer used for that purpose in London because the conditions that lead to people contracting such diseases were negligible in the inner city relative to the locations from which the Colombians migrated.

One reason for plant abandonment can be the impossibility of obtaining plants from the home country. This scenario can be due to the lack of social or commercial networks between the former and current countries, or even due to strict importation laws in the host country. Ceuterick et al. [3], for example, noticed that some Colombian migrants in London refrain from importing medicinal plants since it is common to associate Colombians with drugs and also because of the strict British importation laws. In New York City, some medicinal plants originating from the Caribbean, such as the Dominican endemic *Melocactus lemairei* (Monv. ex Lem.) Miq. ex Lem. are subject to CITES protection because of their ecological vulnerable status and are prohibited from importation.

When these difficulties to acquire certain plants lead to substitution, it can be argued that there is a loss in plant use but the practice previously associated with that species still remains. But, when hard-to-obtain plants are not substituted by other plants easily found in the host country, then not only the previously used plants are lost, but also the practices associated with them (e.g., plant use for treating disease X). As a consequence, these practices may become forgotten or even substituted by the use of allopathic alternatives.

3. Acquisition of Original Plants (from the Home Countries)

3.1. The Cultivation and Use of Wild Plants That Occur in Both the Host and the Home Environment. One method to bring plants closer from the original source is to cultivate these plants from the home country in the new environment or to use plants that spontaneously grow in both environments and that were already part of the group's pharmacopoeia prior to migration [5, 6, 22, 32]. For example, Indian migrants in Connecticut (USA) listed several culturally important plants they were growing in their home gardens, including mango, banana, curry leaf, holy basil, mint, jasmine, hibiscus, eucalyptus, oleander, gardenia, pomegranate, marigold, and *Bougainvillea*, despite difficulties of growing these plants in a temperate climate, bringing them from India, or obtaining them from specialty stores [16]. Given these difficulties, this strategy of acquiring plants is less often pursued as compared to other strategies, such as substitution and importation. According to Voeks [22], factors such as the coevolution of plant species with specific pollinators, coupled with frequent dioecy in many tropical species, reduce the possibility of acclimatization in new environments. In the case of African-Brazilian communities, seeds of African species such as *Garcinia kola* were brought to Brazil in several attempts at cultivation that failed due to the lack of fructification in the New World [22].

The *Tifey* example studied by Volpato et al. [6] also shows how the cultivation of plants in a new location was an important method for maintaining traditional practices. The authors found that some of the Haitian migrants they interviewed cultivated in their yards the primary species used in the production of *Tifey*. Therefore, despite some prejudice related to the use of this drink by the host culture, Haitian elders preserve its use by cultivating the main species that it consists of (*Artemisia absinthium*).

On the other hand, some species grow spontaneously in both the migrant people's place of origin and the new environment. Thus, there are no major obstacles in continuing the use of the same species. For example, Volpato et al. [5] have indicated that the high floristic similarity between Haiti and Cuba enabled Haitian immigrants to collect many of the medicinal plants from their homeland in Cuba. However, an in-depth analysis of the importance of native plants of the host country versus those that grow naturally in both the migrants group's country of origin and host country is often hampered by the lack of information in the literature regarding the geographic distribution of these species. When there exists a greater distance between the source environment and new environment, species with high dispersal potential (e.g., cosmopolitan species) can excel in the pharmacopoeias of migrant peoples. In fact, there is evidence that plants that are considered invasive or weeds are important both in terms of traditional pharmacopoeias and medical effectiveness [33, 34]. It has been noted in many studies that some of the more important medicinal plants for local communities are cosmopolitan plants that are characterized by a high probability of occurring in both the homeland and the new location. There exists evidence in the literature that more accessible or more ubiquitous species tend to be more useful to people [35–37].

The importance of invasive species can be quite high in the pharmacopoeias of migrant groups, particularly because the collection of these species may be the easiest way to acquire plants from the place of origin without the need to cultivate, purchase, or travel to the former environment. Such importance of this kind of plants can be observed in the literature from studies around the world. Voeks [22], for example, noted that 63% of the plants used by people of African descent in a region of Bahia (NE Brazil) are considered weeds, and many of these weeds are from the New World. Anthony [24] also noted that certain cosmopolitan or pantropical species, such as *Peperomia pellucida* (L.) Kunth and *Bidens pilosa* L., are used both in Africa and Brazil by people of African origin.

3.2. Importation of Plants from the Place of Origin. Certain plants of the migrant group's place of origin may not be readily available fresh in the new environment, due to the inability of natural occupation by these species, the inability of acclimation to the new location or simply because the new location is a major urban center, which reduces the possibility of cultivation or collection. However, when social ties are maintained between the migratory group and their home country, there is a continuous flow of people between the two locations, creating a possibility to acquire plants with relative ease. According to Balick et al. [38], the process of globalization that ensures the migration of people between countries and regions also allows for the importation or purchase of plant resources from their homeland. Thus, globalization creates transnational groups and also enables the exchange of genetic material through either purchase or exchange [38]. For example, van Andel and van't Klooster [18] have stated that roughly 2,000 kg of plant material enters The Netherlands from Suriname every week. However, this exchange of genetic material may face barriers due to the sanitary restrictions between different countries, as reported by Ceuterick et al. [3] in a study of plant use by Latino immigrants in London.

The role of markets, shops, apothecaries, or other places selling traditional medicines including dried or fresh plants, potions, tinctures, or religious objects, as distributors of species originating from source environments has been described in the literature [4, 14, 15, 18, 32, 39, 40]. Studying the role of these stores, Balick et al. [38] concluded that they are extremely important for Latin American immigrants living in New York, USA; these stores make hundreds of different plant species available to migrants, some of which are unique to the customers' countries of origin, enabling migrant groups to maintain their traditional medical systems.

In the case of migrant communities that move to large multicultural urban centers, the literature indicates that many retain their use of traditional medicine in centers that either contain markets selling traditional medicinal plants [3] or enable access to medicinal plants from their place of origin [6]. Such scenarios have been described in the cases of Surinamese migrants in Amsterdam [18] and migrants from the Dominican Republic [14] and Latin American countries [40] in New York City. In these cases, substitution may play a secondary role since people can easily get plants from their home country. Furthermore, ethnomedical systems based on the use of traditional herbal remedies can largely be replaced or complemented by biomedicine and allopathic remedies [17]. Similar phenomena occur in situations where groups who once lived in less-urbanized areas start to get better access to modern health services, regardless of whether or not they are migrant groups [41–43]. However, the coexistence of medicinal plant-based health seeking strategies with healing practices based on allopathic remedies is nowadays very paradigmatic of many health systems all over the world, not only in urban areas [44].

Another possibility to acquire these plants arises when people return to visit family and friends in their home countries, thus transporting local plants from the home country to their host country [4, 32]. Usually, the plants that are transported represent dried or processed material to prevent problems with agricultural inspection when entering the host country again.

Volpato et al. [19] studied the adaptation of traditional Sahrawi (nomadic tribes and shepherds traditionally from Western Sahara) in refugee camps in Algeria, located in desert environments and with scarcity of plant resources. Less than 2% of 57 plant species could be obtained locally, due to the extremely arid conditions. Thus, the Sahrawi depend on several social networks to obtain traditional remedies from their homeland. In this case, the continued use of traditional medicine represents an important element for maintaining the cultural identity of the group by maintaining a link with their places of origin [19].

In studying the use of medicinal plants by Colombians who had migrated to London, Ceuterick et al. [3] found that remedies that contained fresh produce as an essential ingredient were generally abandoned and replaced with fresh material that was available in London.

Depending on the type of contact that migrant people have with their place of origin, importation can be quite an important strategy. In New York City, 100 of the 112 most frequently mentioned medicinal plants (89%) by Dominican immigrants could be readily obtained either in *botánicas* (herbal stores that import plants transnationally) or in supermarkets (unpublished data). Turkish migrants in Cologne (Germany), for example, acquire half of their ingredients directly from Turkey through collection or purchase from markets in their country of origin [32]. Another significant portion of the materials is purchased in Cologne, through Turkish markets importing plants from Turkey [32]. Pieroni et al. [4] also observed that most medicinal plants used by Pakistani migrants in Bradford were sold in Pakistani markets in Northern England, while some species were also acquired during visits to relatives in Pakistan. The importance of markets can also be observed in the work performed by Waldstein [39]. She studied a group of Mexican immigrants living in Athens, USA, and concluded that none of the plants known and used in their ethnomedical systems were directly brought by the migrants from their country of origin, but rather were purchased from small Mexican grocery stores that, in turn, imported the materials from Mexico. Ceuterick et al. [8] also found that 34% of plant species used by Peruvian and Bolivian migrants in London were acquired in supermarkets, while another 16% were bought in Latino shops in London.

Another issue that may determine the importance of importation as a strategy for continued plant use is related to legal aspects of plant entrance in a given country. The degree of strictness in the regulation of importation can strengthen or weaken this plant use strategy. Surinamese migrants in Amsterdam, for example, rely heavily on importation because of the flexible entrance laws in The Netherlands, since no permit is needed for importing plants for personal use (except if it is a threatened species), and, although commercial importation requires a permit, all plants sold at a Surinamese medicinal plant market (which was the focus of the study performed by van Andel and van't Klooster [18]) were imported from Suriname.

On the other hand, strictness in plant importation in the United Kingdom makes it difficult for Latino communities to acquire some of their original plants [3, 8]. Peruvian migrants in London, for example, have difficulties in continuing the use of coca (*Erythroxylum coca* Lam.) products because of legal restrictions concerning the importation of this plant species. Although Colombian migrants can acquire their products in supermarkets and Latino shops, their own import from Colombia is less probable because of the British importation laws [3]. Most Northern hemisphere countries including the United States and Europe have strict laws concerning plant importation [45].

Another factor worthwhile mentioning is that it is not always possible to acquire each and any plant species used in the home country. Some species can be endemic or scarce, and international plant traders often consider only the most commonly used and valued plants. Therefore, pharmacopoeias based on endemic and noncommercial or less popular species may have difficulties to count on importation.

4. Replacement or Maintenance?

Next, we will try to make a comparison between strategies to acquire medicinal plants based on adaptation to the plants of the new environment and those based on obtaining the original plants. However, it is important to take into account that this was usually not the direct focus of the studies on the pharmacopoeias of migrant people and that we are indirectly analyzing this information based on nonuniform data obtained from the literature.

Some scholars [12, 22] have indicated that many plants used by migrant people are native to their new environments. A study that investigated African descendants in Brazil showed that approximately 49% of the plants used were from the New World, 35% from the Old World and 16% of uncertain origin [22], indicating that New World native plants have been incorporated or replaced in the ethnomedical systems of people of African origin.

A study of Dominican immigrants in New York City related their ethnobotanical data with information available in the literature on medicinal plants used in the Dominican Republic [13]. The authors found that only 29% of the plants used by the migrants were reported in Dominican literature on medicinal plants and attributed this to replacement of a portion of the medicinal plants used. On the other hand, Vandebroek et al. [15], also working with Dominican migrants in New York, found that major medicinal uses in New York, such as flu and common cold, were supported by the Dominican literature, while plants used for minor and "newly acquired or diagnosed" purposes, such as elevated levels of cholesterol, were not (yet) registered in the Dominican literature.

Additional evidence that supports the replacement hypothesis was provided by Inta et al. [12] in their investigation on the use of medicinal plants among the Akha people (from China) living in China and Thailand. Their study showed that only 16 of the 95 recorded plant species (17%) were used both in China and Thailand. This highlights the role of the environment versus the importance of cultural heritage in terms of the forces governing the continued use of traditional species.

However, replacement and incorporation are not always predominant factors in the dynamics of medicinal plant use by migrant people, particularly when migration is directed to a transnational major urban center. Some studies point out that strategies of acquisition of the original material from the home countries are more important factors in medicinal plant use by migrants [3, 32].

Regarding the use of medicinal plants by the Turkish community in Cologne (Germany), Pieroni et al. [32] noted that from the list of species mentioned two-thirds were plants that were used only in the Turkish pharmacopoeia, whereas the remaining third were used in both Turkish and German pharmacopoeias. Similarly, in their study of people of Colombian origin in London, Ceuterick et al. [3]

observed that 43% of medicinal plants were reported only in the ethnobotanical literature of Colombia, while 31% were reported in both Colombian and Western literature; thus, 74% of the species were present in the pharmacopoeia of the country of origin. The other species were found exclusively in Western herbal medicine (5%) or were not reported in any literature source (21%).

Pieroni and Gray [46] noted that the vast majority of medicinal plants that are used by Russlanddeutschen (ethnic descendants of Germans who migrated to Russia and returned to Germany) either occurred in both Russia and Germany or only in Russia. Given the complex nature of this migration, accentuated by the departure and return to Germany, this result may indicate (1) that Russlanddeutschen, when they migrated to Russia more than two centuries ago, replaced their remedies by incorporating Russian plants into their pharmacopeia or/and (2) that, after having migrated back to Germany in the last decade, they developed strategies to continue using plants from their Russian original pharmacopoeia without the need for replacement. Thus, two opposite strategies may have occurred.

Other studies [24, 27] only state that there was replacement of plants with those in the new environment, without mentioning or illustrating the importance of this phenomenon in comparison to other strategies for the selection and use of species, such as importation or cultivation.

Adaptation to the new flora is not always the most important strategy, though it seems to play an important role in the pharmacopoeias of migrant populations. Given the characteristics of the studies cited, we assume that the degree of urbanization and the contact of migrant people with people in the location of origin may influence the types of strategies adopted; specifically, the more urbanized the host location and the higher the degree of contact, the greater the tendency to purchase the original flora, due to either a lack of substitute species (in the case of urban centers) or the ease of obtaining the original plants (in case of continued contact with the people of origin).

5. Contact between Western and Traditional Medical Systems: Migration to Urban Centers

An important aspect to consider when analyzing the dynamics of medicinal plant use by migrants in urban centers is the intensity of contact of such groups with biomedicine. For analytical purposes, here we are generally referring to the dominant medical systems in urban centers, as well as the effects of their proximity. In its elemental form, these two medical systems, traditional medicine and biomedicine, present quite different ideologies, concepts, values, and belief systems. Traditional medicine typically considers the whole person and the person's cultural beliefs and values in the healing process. In contrast, biomedicine, synonym here of Western medicine, often operates with a Cartesian approach of separated body systems [47]. There are also contrasts in the way people understand and explain what sickness and health are, which are determined by cultural ideas and belief systems [2]. This contrast determines the choice of healing practices [41], and it can influence how medicinal plants are used by migrants, either distancing them or binding them more tightly to their traditional medical practices.

The coexistence of traditional and Western medical systems can occur, even though this can be conflicting at times. Several examples have been cited in the literature of such coexistence [2, 17, 41, 48] even if some traditional practices are sometimes lost. The stability of coexistence between these medical systems depends strongly on the access to elements of the flora of the migrant culture (e.g., access to markets, cultivation, or direct importation) and socioeconomic factors. According to Nesheim et al. [49], an improvement in the economic status of migrant populations undermines this coexistence because it reduces the dependency of the population on plant resources. On the other hand, retaining some traditional therapeutic practices from their places of origin may be a deliberate choice of migrant groups as a way of reaffirming their cultural identity [10].

If migrant populations do not have access to the plant species that are important to their traditional medical systems, then these systems may become at risk of extinction. Volpato et al. [6] found that Haitian people who migrated to Cuba had difficulties acquiring plants needed to produce *Tifey*. In some cases, other ingredients present in the Cuban flora had to be used as substitutions, which hampered the long-term continuity of the practice.

In general, difficulties in accessing biomedicine, because of its high cost, lack of transportation or available time, or the illegal status of some migrants, encourage the use of traditional medicinal resources. Waldstein [39] evaluated the traditional pharmacopoeia of Mexican immigrants in the USA and noted that, because of the strong influence of Western medicine, there was a coexistence between traditional and Western medical systems. In some cases, a combination of plants and drugs were used to treat disease. Belliard and Ramírez-Johnson [2] observed the same phenomenon when they analyzed the decision-making processes of Mexican women in California. Zapata and Shippee-Rice [7] studied a similar phenomenon in Latin American immigrants living in New England, USA. These authors cited the unawareness about the traditional medicine of these migrants, by medical professionals, difficulty in communication (different languages), and cultural prejudice as obstacles preventing access to biomedicine.

Zenk et al. [50] devised a theoretical model to discuss the events of choice in situations of cultural shock, called the "push and pull" model. According to these authors, external forces that are political, cultural, or economic either encourage or discourage the use of traditional medical systems (including medicinal plants) of specific cultural groups. The forces discussed in the "push and pull" model can be recognized as either positive or negative. As an example, the presence of biomedicine or difficulty in obtaining medicinal plants counteracts the use of traditional medical systems, whereas the absence of biomedicine because of geographical distance or socioeconomic barriers, as well as kinship, values and beliefs, is a driving force toward the use of traditional resources [51].

In some situations, contact with biomedicine results in a hybrid system in which traditional medicine and biomedicine are fused, or systems in which the two approaches are fairly intimately related. The Latin American immigrants in the study of Zapata and Shippee-Rice [7] traditionally consulted with experts of their own medical system, called traditional healers (*curandeiros*). However, since it was nearly impossible to consult with these healers in the New England town to which these people had migrated, immigrants sought cures in biomedicine, by consulting with doctors who most resembled traditional healers (i.e., physicians that were recognized as "naturalists" who prescribed traditional medicine drugs).

6. Problems and Challenges in Research with Migrants

One of the factors that should be considered in future studies focusing on migrants and that still lacks understanding is the dynamic nature of resource utilization when migrant groups are no longer subject to a specific disease. For example, a group might migrate to a new location where there are no vectors for a given disease that is endemic in their homeland (e.g., malaria). In this case, it is likely that the plants that were previously used by the group would be dismissed from their pharmacopeias in the new environment. Thus, absence of use of a resource does not reflect, in and of itself, an erosion of knowledge. Rather, it may simply indicate that the species is not longer being used because there is no longer is a demand for its use.

Some researchers believe that different cultural groups, in addition to developing their own cultural systems, are biologically adapted to their environments. Thus, they may develop an entire metabolic and physiological system that reflects local pressures. That is, different cultures exhibit unique sets of specific biological processes that depend on the environments in which they live and that determine which resources should be either used or avoided. This reasoning has not yet been thoroughly tested or studied though it may allow for a better understanding of the biological determinants of cultural practices.

Regarding the approach used to determine the influence of migration on ethnomedical systems, it is often difficult to figure out how much knowledge about medicinal plants has been lost by migrants in comparison with people from their place of origin because often no baseline data exist about these medical systems prior to migration. Some studies have developed strategies to perform comparisons, including (a) comparing the pharmacopeias of migrant people with the available literature of the place of origin [3, 5, 13, 15, 32, 46] and (b) comparing the pharmacopoeias of migrant people with the pharmacopoeias of the new environment's native people (e.g., Pieroni and Quave [52]). A third strategy would be to simultaneously compare the pharmacopoeias of a migrant group in the new host country with that in its place of origin.

Some limitations to these approaches are evident, as described below.

(a) Even in migrant groups' home countries there will be uses reported in the literature that are no longer active nowadays and are therefore not a part of the repertoire of species of the migrants [3, 13]. This means that there was no loss in cultural knowledge *after* migration.

(b) The fact that a species is used by migrants but is not present in the literature of the place of origin does not mean that this plant was included in the pharmacopeia after migration. It may only represent a gap in the ethnobotanical literature of the place of origin, which did not record representative or contemporary data on the local use of medicinal plants.

These reasons underscore the importance of identifying the origin and distribution of medicinal plants used by migrant populations because such information is an important indicator of the influences of local medicinal plants in these populations. For example, when a migrant group's pharmacopoeia is mostly composed of plants that are native to the host country rather than the home environment, it is likely that there was a process of change and people adapted to the flora of the host country. However, even if this proves to be the case, a comparison with the contemporary pharmacopoeia in the migrant group's home environment is still needed to analyze the proportion of global and cosmopolitan plant species versus native medicinal plants since globalization processes may have already had a profound impact on these pharmacopoeias prior to the process of migration.

7. Conclusions

Depending on the context and conditions of migration, different processes may play a role in the dynamics of medicinal plant use by migrant communities.

One of the main questions that emerges from this paper is under which circumstances does there exist a higher incidence of replacement and addition of plants to the original ethnopharmacopoeia and which factors are responsible for the opposite effect (acquisition of plants from the home country's pharmacopoeia)?

Several different hypotheses could answer this question. These include the following.

(a) In environments with similar floristic compositions (i.e., floristic similarity), replacement does not need to occur because migrant people have access to virtually the same diversity of plants as in the place of origin.

(b) When migration occurs but there is an easy link to the place of origin (i.e., two-way flow), the importation and cultivation of the plants from the place of origin are expected to be more important than practices of substituting medicinal plants.

(c) When migration is directed at large urban multicultural centers, the following phenomena can occur: (1) if it is easy to obtain plants from the local place of origin through either purchase or cultivation the use of these plants may be favored over replacing/substituting plants; (2) if access to these plants is difficult (e.g., due to availability, accessibility, or economic cost), it is expected that migrants would gradually lose their practice of using medicinal plants; (3) as migrants become more familiar with and better integrated in the host environment's biomedical system, they may prefer this system over their own ethnomedical practices. Research that compares preferences for both systems in first generation migrant groups versus the next generations may shed light on this assumption.

(d) Replacement will be more important when (1) the species of local origin are morphologically or taxonomically similar to the flora of the place of migration, enabling the use of substitutes with similar characteristics or (2) in the new environment there are communities that make use of (other) medicinal plants and they share this knowledge with the migrant groups.

In summary, we consider that the dynamics of medicinal plant use in migrant populations are intimately influenced by environmental, physical, economic, and sociocultural aspects and that further research is needed to elucidate which factors play a more important role in different situations.

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Research Article

Intracultural Variation in the Knowledge of Medicinal Plants in an Urban-Rural Community in the Atlantic Forest from Northeastern Brazil

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This study assessed the intracultural knowledge of the use of medicinal plants in an urban-rural community in an Atlantic forest fragment in northeastern Brazil. We examined the importance of native and exotic species and the effects of gender and age on that knowledge. We also compared data obtained from different groups of informants (local experts and general community). We conducted 194 interviews between June 2007 and January 2008, using the freelist technique and semistructured forms to collect ethnobotanical data. Information obtained from the community was compared with that from six local experts who participated in a survey in 2003. From a total of 209 ethnospecies, exotic and herbaceous plants presented higher richness. With respect to the number of citations, women and older informants were shown to know a higher number of medicinal plants. Comparing knowledge of local experts with that of the general community, we noted that experts know a similar wealth of plant families and therapeutic indications, but the community knows a greater species richness. These results indicate that local experts may provide useful information for studies that search for a quick diagnosis of the knowledge of a given community.

1. Introduction

In Brazil, the Atlantic Forest is one of the most biologically diverse ecosystems, responsible for harboring a large number of endemic species [1, 2]. It extends from Rio Grande do Norte to Rio Grande do Sul [3] and, given its location in the coastal area, is currently under strong pressure from real estate speculation. In addition, there are the pressures generated by timber extraction, the cycles of sugar cane, coffee, and gold, and, more recently, the expansion of farming and forestry with exotic species.

Human populations living in the surrounding areas of the Atlantic Forest play an important role in its exploitation as they often rely on forest resources for their subsistence and extract biological resources from it on a daily basis [4]. Understanding how these people use such resources is a task of great current interest, which may contribute to the discovery of products of economic interest and to the conservation of biological resources.

Thus, ethnobotanical studies can contribute to assessing how local knowledge is distributed among members of a community and the relationship between that knowledge and the increase of exotic species in the local repertoire of medicinal plants [5–7].

Common knowledge about plant resources, especially medicinal ones, is highly dynamic and subject to several influences, may vary according to gender, age, education level, income, roles that individuals play within the family, skills, and abilities [8–11], and may represent key elements of the knowledge of the diversity and richness of species [12].

Different social patterns have been reported to impact the knowledge of medicinal plants, emphasizing the need of studies that address such questions. For instance, Almeida et al. [13] did not observe any differences between the knowledge of men and women, whereas age and income were correlated with the number of citations for a given plant and its indication, suggesting that older people with a higher income had greater knowledge about such plant resources.

Thus, the goal of this study was to assess the intracultural knowledge of the use of medicinal plants in an urban-rural community in an Atlantic forest fragment in northeastern Brazil in order to document the importance of native and exotic species within the group of plants mentioned and the effects of gender and age on the knowledge of medicinal plants and to compare the quality of information gathered from different groups of informants (local experts versus general community).

2. Materials and Methods

2.1. Study Area. The study was conducted at Igarassu, located in the microregion of Itamaracá and the mesoregion of Recife, in Pernambuco state (7°50′20′′ S and 35°00′10′′ W; 20 m a.s.l.), 30 km from the state capital [14–16]. The climate is tropical, hot, and humid, with autumn/winter rains (according to the classification of Köeppen). The average annual temperature is 27°C, and the average annual rainfall is approximately 2,000 mm [14–16]. The municipality has a total area of 304.2 km^2, with a population of 72,990 people (219.9 inhabitants/km^2), 74.9% of which live in urban areas [14].

The predominant vegetation is composed of remnants of Atlantic forest, secondary forests, mangroves, palm trees, and areas of commercial and subsistence agriculture. There are ecological reserves in the city, such as the São José Plant Forest, with tall, dense vegetation, located on Transcanavieira Highway (PE-41) and with an area of 323.30 ha [17].

The community studied is known as "Três Ladeiras" and is located on the lands of the "São José Plant," a sugar refinery. The "São José Plant" is surrounded by Atlantic forest fragments belonging to an ecological reserve [18]. The forest is part of the conservation area of the Botafogo River basin, in accordance with state law no. 9860, which since August 12, 1986, has been aimed at protecting the landscape, soil, and river basin [19]. The fragments occupy a total area of 210 ha [18]. The community lies 30 km north of the county seat and is located at the back of a large hill, whose extension contains three elevations that give the community its name. The district has 1,794 inhabitants, of which 1,077 live in urban areas and 687 in rural ones [20].

Most men from the community work at the plant although the number of people employed by the refinery oscillates during the year, increasing and decreasing according to season and periods of land preparation, planting, and harvesting [15]. It is not unusual to find among the residents of the community families with small fields that provide nutritional and/or economic support during periods when there is no work at the plant [15]. There is no sanitation, medical care takes place in a health clinic for minor health problems, and disease control is provided by health workers through weekly home visits. Patients who require extra care are relocated to hospitals in the county seat of Igarassu.

2.2. Data Collection. Ethnobotanical data were obtained through the freelist technique, followed by semistructured interviews [21]. The interviews were conducted with the senior member of the family, over 18 years old, present on the visit of the interviewer. Initially, we obtained a Term of Informed Consent from those willing to participate in the study in accordance with the legal and ethical aspects of Resolution 196/96 from the Ethics and Research Committee [22].

Because the community had a large number of residents, we sampled 51% of all households and conducted 194 interviews (140 women and 54 men) between June 2007 and January 2008. The age of informants ranged from 18 to 93 years. For the interviews, one main question was asked: "What medicinal plants do you know?". In a second event, we gathered information on each species mentioned, the part of the plant used, the method of preparation, its indication and contraindication, as well as socioeconomic data from informants, such as gender, age, family income, and number of residents in the household. Ages were grouped into five different groups, ranging from 18 to over 68 years.

We used the data obtained in this study and in the work of Gazzaneo et al. [15] to compare the information obtained from the general community and local experts, respectively. The latter study was conducted in the same community in 2003 and was attended by six informants identified as "local experts," given their more detailed knowledge on the use of medicinal plants [23]. This group of informants was composed of three men and three women, with ages ranging from 51 to 102 years. The data sampling performed by Gazzaneo et al. [15] was intentionally nonrandom and assumed that local experts provide more specific, high-quality information about medicinal plants. To select this group of informants, the authors used the "snowball" method [24]. Data were collected using semistructured interviews that gathered information related to the knowledge of medicinal plants.

2.3. Species Categorization and Indications Mentioned by Informants. All plants mentioned during interviews were identified and classified as either native or exotic species according to their biogeographical origin. We considered native species those endemic to the study region and also native to South America. Exotic species were considered to be those of extracontinental origin, cultivated in the region, and widely distributed, such as tropical invasive and cosmopolitan species.

To calculate the relative importance of species, all indications mentioned by the informants were grouped into 18 disease categories, according to the classification from the World Health Organization [25]: digestive, respiratory, gynecological/urinary, circulatory, nervous, sensory, motor, puerperium, cutaneous, scarring, poisoning, neoplasia, hematopoietic, nutritional, infectious/parasitic, sexual inappetence and antiabortion, and postpartum. Diseases not categorized by the aforementioned system were grouped into the category "undefined ailments and pains" by virtue of their symptoms and signs of multiple origins [26].

All species mentioned by informants, excluding those commercialized, were collected, identified, and deposited in the herbaria of Professor Geraldo Mariz (UFP), at the Federal University of Pernambuco, Professor Dárdano de Andrade Lima (IPA), at the Agricultural Research Company, and Professor Sérgio Tavares (HST), at the Federal Rural University of Pernambuco.

2.4. Data Analysis. We calculated the value of relative importance (RI) for all species [27] with the following formula: RI = NBS + NP, where NBS is the number of body systems treated by a particular species (NBSS) divided by the total number of body systems treated by the most versatile species (NBSVS) and NP is the number of attributed properties of a particular species (NPS) divided by the total number of properties attributed to the most versatile species (NPVS).

The chi-squared adherence test was used to check for differences between the following factors: number of native versus exotic plants and number of plants observed in each life form (herb, shrub, and tree). We also compared the richness of exclusive species between different age groups, richness of families, total number of mentioned species, and number of exclusive species between local experts and the general community.

We used the Kruskal-Wallis nonparametric test to test for differences in the richness of ethnospecies and mentioned indications between men and women and between each age group and to check for differences between the relative importance of species mentioned by local experts and the general community.

We used Williams' *G*-test to compare the proportion of the number of native and exotic species (exclusive or not) mentioned by local experts and the general community.

The Spearman correlation test was applied to check for the relationship between the number of ethnospecies and the number of mentioned indications according to the age of the informants and to check for a relationship between relative importance (RI) of species mentioned by the general community and the RI calculated for local experts.

All statistical analyses were performed using the statistical package BioEstat 5.0 [28].

3. Results

3.1. Richness of Medicinal Plants Mentioned by Informants. In total, 209 ethno-species were mentioned during interviews; 151 were identified to the species level and 21 to the genus level only (Table 1). The plants were distributed in 74 families, and most families (66%) were represented by up to two species. The most represented families were Lamiaceae (10 spp.); Caesalpiniaceae and Curcubitaceae (8 spp.); Asteraceae, Euphorbiaceae, and Mimosaceae (5 spp.).

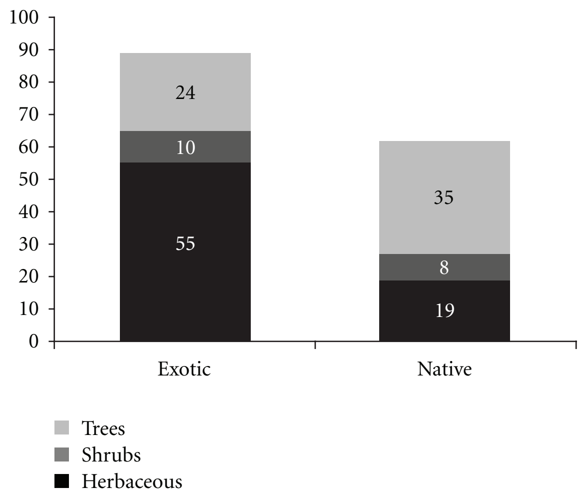

Figure 1: Origin and life form of the medicinal species mentioned in the community of Três Ladeiras, Igarassu, Pernambuco state, northeastern Brazil.

With respect to the origin of the identified species, we observed that 89 were exotic and 62 were native (Figure 1), and the difference was statistically significant ($\chi^2 = 4.8$; $P < 0.05$). That result indicates that informants knew more exotic plants that could be used for medicinal purposes. With respect to the life form of plants, there was a predominance of herbs (74), followed by trees (59) and shrubs (18) (Figure 1), but we only observed statistical differences when we compared the richness of shrubs with that of herbs ($\chi^2 = 34.01$; $P < 0.0001$) and trees ($\chi^2 = 21.83$; $P < 0.0001$). The number of herbs and trees was not significantly different ($\chi^2 = 1.7$; $P = 0.23$), indicating that the richness of herbs and trees was similar in the pool of plants mentioned by informants. However, when considering the distribution of species according to their origin, we observed a different pattern: for exotic plants, there was a higher number of herbaceous plants compared to the other two life forms (shrubs: $\chi^2 = 31.15$, $P < 0.0001$; trees: $\chi^2 = 12.16$, $P = 0.005$), whereas, for native plants, there was a higher number of trees (herbs: $\chi^2 = 4.7$, $P = 0.02$; shrubs: $\chi^2 = 16.95$, $P < 0.0001$).

The most mentioned species were *Schinus terebinthifolius* Raddi (aroeira-219 citations), *Alpinia zerumbet* (Pers.) B. L. Burtt & R. M. Sm. (colônia-190 citations), *Pithecellobium cochliocarpum* (Gomez) Macbr. (babatenon-183), *Plectranthus amboinicus* (Lour.) Spreng (hortelã graúda-155), *Mentha piperita* L. (hortelã miúda-141), and *Cymbopogon citratus* (DC.) Stapf (capim santo-133) (Table 1). Except for *S. terebinthifolius* and *P. cochliocarpum*, all these plants are exotic, emphasizing the importance of exotic plants to the knowledge of medicinal plants in the region.

3.2. Influence of Gender and Age on the Knowledge of Medicinal Plants. There were significant differences in the knowledge

TABLE 1: Medicinal plants mentioned in the community of Três Ladeiras, Igarassu, Pernambuco state, Brazil.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Acanthaceae						
Justicia pectoralis Jacq.	Chambá	Herbs	Native	21	0.33	0.37
Justicia sp.	Anador	—	—	25	—	1.00
Graptophyllum pictum (L.) Griff.	Melacilina	Herbs	Exotic	15	0.67	0.94
Amaranthaceae						
Alternanthera brasiliana (L.) Kuntze.	Novalgina	Herbs	Exotic	3	—	0.35
Pfaffia glomerata (Spreng.) Pederson	Acônico/Acônito	Herbs	Exotic	17	0.67	0.27
Anacardiaceae						
Anacardium occidentale L.	Cajueiro roxo	Tree	Native	113	0.33	1.24
Mangifera indica L.	Manga	Tree	Exotic	11	0.83	0.62
Schinus terebinthifolius Raddi	Aroeira	Tree	Native	219	1.17	1.60
Spondias purpurea L.	Siriguela	Tree	Native	3	—	0.27
Annonaceae						
Annona montana Macfad.	Aticum	Tree	Native	13	0.83	0.61
Annona muricata L.	Graviola	Tree	Exotic	4	—	0.30
Annona squamosa L.	Pinha	Tree	Exotic	1	—	0.12
Apiaceae						
Daucus carota L.	Cenoura	Herbs	Exotic	1	—	0.12
Foeniculum vulgare Mill.	Endro	Herbs	Exotic	12	—	0.74
Pimpinella anisum L.	Erva doce	Herbs	Exotic	45	0.33	1.09
Apocynaceae						
Catharanthus roseus L. G. Don.	Boa noite branca	Herbs	Exotic	3	—	0.27
Hancornia speciosa Gomes	Mangaba	Tree	Native	1	0.17	0.12
Arecaceae						
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	Macaiba	Tree	Native	30	0.17	0.76
Cocos nucifera L.	Coco amarelo	Tree	Exotic	7	0.17	0.39
Elaeis guineensis Jacq.	Dendezeiro	Tree	Exotic	2	0.17	0.24
Syagrus sp.	Coco catolé	Tree	Native	6	0.50	0.42
Asteraceae						
Acanthospermum hispidum DC.	Espinho de cigano	Herbs	Exotic	48	0.67	0.76
Conyza bonariensis (L.) Cronq.	Rabo de raposa	Herbs	Exotic	3	0.33	0.12
Helianthus annuus L.	Girassol	Herbs	Native	10	0.17	0.12
Matricaria chamomilla L.	Camomila	Herbs	Exotic	7	—	0.12
Pluchea sp.	Mar de cravo	Herbs	—	1	—	0.12
Gymnanthemum amygdalinum (Delile) Sch.Bip. ex Walp.	Alcachofra	Herbs	Exotic	50	0.33	0.83
Asteraceae 1	Carqueja	—	—	2	—	0.12
Begoniaceae						
Begonia reniformis Dryand.	Capeba	Shrub	Native	3	0.17	0.24
Bignoniaceae						
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Pau daico roxo	Tree	Native	8	0.67	0.54
Bombacaceae						
Chorisia sp.	Barriguda	Tree	Native	1	—	0.12
Boraginaceae						
Heliotropium angiospermum Murray	Crista de galo	Herbs	Exotic	1	—	0.12
Heliotropium indicum L.	Fedegoso	Herbs	Exotic	3	0.50	0.35

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Brassicaceae						
Nasturtium officinale R. Br.	Agrião	Herbs	Exotic	48	0.83	0.53
Bromeliaceae						
Ananas comosus (L.) Merr.	Abacaxi	Herbs	Native	14	—	0.39
Tillandsia usneoides (L.) L.	Salambaia	Herbs	Native	2	0.17	0.24
Burseraceae						
Protium heptaphyllum (Aubl.) Marchand	Amescla	Tree	Native	1	1.00	0.12
Cactaceae						
Cereus jamacaru DC.	Cardeiro	Tree	Native	5	—	0.12
Caesalpiniaceae						
Bauhinia forficata Link	Pata de vaca	Tree	Native	9	—	0.30
Caesalpinia echinata Lam.	Pau brasil	Tree	Native	1	—	0.12
Caesalpinia ferrea Mart. ex Tul.	Jucá	Tree	Native	11	0.50	0.27
Copaifera sp.	Pau dóleo	Tree	—	1	0.17	0.12
Hymenaea martiana Hayne	Jatobá	Tree	Native	27	1.33	1.20
Senna alata (L.) Roxb.	Café beirão	Shrub	Exotic	1	—	0.12
Senna occidentalis (L.) Link.	Manjirioba/Mata pasto	Herbs	Exotic	24	0.17	0.76
Poincianella pyramidalis (Tul.) L. P. Queiroz	Catingueira	Tree	Native	1	—	0.12
Capparaceae						
Cleome spinosa Jacq.	Mussambê	Shrub	Exotic	11	0.17	0.30
Caprifoliaceae						
Sambucus nigra L.	Flor de sabugo/Sabugueiro	Tree	Exotic	33	0.50	0.57
Caricaceae						
Carica papaya L.	Mamão	Tree	Native	7	0.33	0.46
Caryophyllaceae						
Dianthus caryophyllus L.	Cravo branco	Herbs	Exotic	4	—	0.27
Cecropiaceae						
Cecropia palmata Willd.	Embauba branca	Tree	Native	6	0.33	0.42
Chenopodiaceae						
Beta vulgaris L.	Beterraba	Herbs	Exotic	8	—	0.34
Chenopodium ambrosioides L.	Mastruz/Mentruz	Herbs	Exotic	85	0.67	0.68
Chrysobalanaceae						
Licania sp.	Oiti/Oiticica	—	—	2	—	0.24
Chrysobalanaceae 1	Oiticoró	—	—	1	—	0.12
Clusiaceae						
Vismia guianensis (Aubl.) Pers.	Lacre	Tree	Native	12	0.33	0.42
Combretaceae						
Buchenavia sp.	Imbiriba	—	—	4	0.33	0.15
Terminalia catappa L.	Coração de negro	Tree	Exotic	2	—	0.58
Convolvulaceae						
Ipomoea asarifolia (Ders.) R. et Sch	Salsa	Herbs	Exotic	1	0.17	0.15
Operculina alata (Ham.) Urb.	Batata de purga	Herbs	Native	1	0.50	0.12
Convolvulaceae 1	Acanfó/Acafú	—	—	10	0.33	0.34
Convolvulaceae 2	Sassá	—	—	1	—	0.12
Crassulaceae						
Kalanchoe laciniata (L.) DC.	Corona branca	Herbs	Exotic	17	—	0.81
Kalanchoe sp.	Corona roxa	—	—	6	—	0.51

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Cucurbitaceae						
Citrullus vulgaris Schard.	Melância	Herbs	Exotic	1	—	0.12
Cucumis anguria L.	Maxixe	Herbs	Exotic	1	—	0.12
Cucumis melo L.	Melão	Herbs	Exotic	1	—	0.12
Cucumis sativus L.	Pepino	Herbs	Exotic	2	—	0.24
Curcubita pepo L.	Jerimum	Herbs	Exotic	8	—	0.24
Luffa operculata L. Cong.	Cabacinha	Herbs	Native	1	0.17	0.12
Momordica charantia L.	Melão de são caetano	Herbs	Exotic	1	—	0.12
Sechium edule (Jacq.) Sw.	Chuchu	Herbs	Exotic	20	0.17	0.27
Equisetaceae						
Equisetum sp.	Cavalinha	Herbs	—	1	—	0.12
Euphorbiaceae						
Cnidosculus urens (L.) Arthur	Urtiga branca	Herbs	Native	25	0.50	0.68
Euphorbia tirucalli L.	Aveloz	Shrub	Exotic	1	—	0.12
Jatropha gossypiifolia L.	Pinhão roxo	Shrub	Exotic	5	—	0.35
Jatropha mollissima (Pohl.) Baill.	Pinhão branco	Shrub	Native	2	—	0.24
Manihot esculenta Crantz	Macacheira/Roça	Herbs	Native	1	—	0.12
Phyllanthus niruri L.	Quebra pedra	Herbs	Exotic	13	0.17	0.46
Ricinus communis L.	Carrapateira/Mamona	Shrub	Exotic	5	—	0.27
Fabaceae						
Bowdichia virgilioides Kunth	Sucupira	Tree	Native	5	0.50	0.39
Vicia faba L.	Fava	Herbs	Exotic	1	—	0.12
Zornia diphylla (L.) Pers.	Urinana	Herbs	Native	3	0.17	0.15
Flacourtiaceae						
Flacourtiaceae 1	Imbira branca	—	—	2	—	0.12
Heliconiaceae						
Heliconia psittacorum L. f.	Paquivira	Herbs	Native	1	—	0.12
Illiaceae						
Illicium verum Hook. f.	Anil estrelado	Tree	Exotic	9	—	0.73
Iridaceae						
Crocus sp.	Açafrão	Herbs	—	1	0.33	0.12
Eleutherine bulbosa (Mill.) Urb.	Alho do mato	Herbs	Native	3	0.67	0.15
Lamiaceae						
Aeollanthus suaveolens Mart. ex Spreng.	Macassá	Herbs	Exotic	32	1.33	1.13
Mentha piperita L.	Hortelã miúda	Herbs	Exotic	141	0.83	2.00
Mentha pulegium L.	Hortelã pastilha/H. vick	Herbs	Exotic	34	0.17	1.07
Ocimum basilicum L.	Manjericão/Manjericão são josé	Herbs	Exotic	50	0.50	1.16
Ocimum basilicum var. *minimum* (Willd.) Benth.	Manjericão miúdo	Herbs	Exotic	5	0.17	0.35
Ocimum campechianum Mill.	Alfavaca de caboclo	Herbs	Native	14	—	0.69
Ocimum gratissimum L.	Louro falso/L. caseiro/ Hortelã fernando/H. são severino	Herbs	Exotic	4	0.17	0.24
Plectranthus amboinicus (Lour.) Spreng.	Hortelã graúda/H. gorda/H. bahia	Herbs	Exotic	155	0.83	1.22
Plectranthus barbatus Andrews	Boldo caseiro/Boldo falso/Hortelã caboclo	Herbs	Exotic	17	0.50	0.84
Rosmarinus officinalis L.	Alecrim	Herbs	Exotic	11	0.17	0.96
Lamiaceae 1	Alfazema	Herbs	—	1	—	0.12
Lamiaceae 2	Alfazema de caboclo	Herbs	—	1	—	0.12
Lamiaceae 3	Veiga morta	Herbs	—	53	0.50	0.84

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Lauraceae						
Nectandra cuspidata Ness & Mart.	Canela	Tree	Native	71	—	0.95
Persea americana Mill.	Abacate	Tree	Exotic	15	0.83	0.62
Liliaceae						
Allium cepa L.	Cebola	Herbs	Exotic	12	0.67	0.34
Allium sativum L.	Alho	Herbs	Exotic	19	0.33	0.56
Aloe vera (L.) Berm.f.	Baborsa/Erva babosa	Herbs	Exotic	32	0.83	1.13
Loranthaceae						
Loranthaceae 1	Cipó estanca sangue	—	—	1	0.33	0.12
Malpighiaceae						
Byrsonima sericea DC.	Murici	Tree	Native	1	—	0.12
Malpighia glabra L.	Acerola	Tree	Exotic	10	—	0.51
Malvaceae						
Gossypium barbadense L.	Algodão	Shrub	Exotic	2	0.50	0.20
Uerna lobata L.	Malva rosa	Herbs	Native	11	0.33	0.51
Meliaceae						
Cedrela odorata L.	Cedro	Tree	Native	1	—	0.12
Mimosaceae						
Acacia sp.	Espinheiro	Tree	—	3	—	0.12
Anadenanthera colubrina (Vell.) Brenan.	Angico	Tree	Native	3	—	0.24
Inga bahiensis Benth.	Inga porco	Tree	Native	1	—	0.12
Mimosa tenuiflora (Willd.) Poir.	Jurema preta	Tree	Native	2	—	0.12
Piptadenia stipulacea (Benth.) Ducke.	Jurema branca	Tree	Native	1	—	0.12
Pithecellobium cochliocarpum (Gomez) Macbr.	Babatenom	Tree	Native	183	1.83	1.14
Pithecellobium saman var. *acutifolium* Benth.	Budão de velho	Tree	Native	2	—	0.24
Monimiaceae						
Peumus boldus Mol.	Boldo do chile	Herbs	Exotic	44	—	0.73
Moraceae						
Artocarpus communis J.R. Forst. & G. Forst.	Fruta pão	Tree	Exotic	3	—	0.35
Artocarpus integrifolia L. f.	Jaca	Tree	Exotic	2	—	0.24
Dorstenia sp.	Conta erva	—	—	1	0.83	0.12
Musaceae						
Musa paradisiaca L.	Bananeira	Tree	Exotic	19	0.33	0.73
Myrtaceae						
Eucalyptus citriodora Hook.	Eucalipto	Tree	Exotic	7	0.17	0.24
Eugenia uniflora L.	Pitanga	Tree	Native	58	0.17	0.59
Psidium guajava L.	Goiaba	Tree	Native	51	0.17	0.24
Psidium guineense Sw.	Araça	Shrub	Native	5	0.17	0.12
Syzygium aromaticum (L.) Merr. & L.M. Perry	Cravo do reino	Tree	Exotic	5	—	0.59
Syrygium jambolanum (Lam.) DC.	Azeitona preta	Tree	Exotic	14	0.17	0.69
Nyctaginaceae						
Boerhavia diffusa L.	Pega pinto	Herbs	Exotic	22	1.17	0.83
Guapira sp.	João mole	Tree	—	3	—	0.24

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Olacaceae						
Ximenia americana L.	Ameixa	Tree	Native	1	0.17	0.12
Oxalidaceae						
Averrhoa carambola L.	Carambola	Tree	Exotic	17	0.83	0.30
Papaveraceae						
Argemone mexicana L.	Cardo santo	Herbs	Exotic	7	0.50	0.24
Passifloraceae						
Passiflora edulis Sims.	Maracujá	Shrub	Native	12	0.17	0.49
Pedaliaceae						
Sesamum orientale L.	Gergelim preto/Gigilim	Herbs	Exotic	4	0.17	0.24
Phytolacaceae						
Petiveria alliacea L.	Timpi	Herbs	Native	7	0.67	0.54
Piperaceae						
Peperomia pellucida H.B.K.	Lingua de sapo	Herbs	Native	5	—	0.39
Piper nigrum L.	Pimenta do reino	Shrub	Exotic	2	—	0.24
Poaceae						
Cymbopogon citratus (DC.) Stapf	Capim santo	Herbs	Exotic	133	0.50	1.47
Imperata brasiliensis Trin.	Sapé	Herbs	Native	5	—	0.15
Phalaris canariensis L.	Alpiste	Herbs	Exotic	4	0.17	0.24
Zea mays L.	Milho	Herbs	Exotic	2	—	0.12
Polygalaceae						
Polygala sp.	Esquentado	—	—	1	—	0.12
Punicaceae						
Punica granatum L.	Romã	Tree	Exotic	14	—	0.49
Rhamnaceae						
Zizyphus joazeiro Mart.	Juá	Tree	Native	22	0.83	0.76
Rosaceae						
Pyrus malus L.	Maçã	Tree	Exotic	1	—	0.12
Rosa sp.1	Rosa amélia	—	—	1	—	0.12
Rosa sp.2	Rosa branca	—	—	7	0.33	0.62
Rubiaceae						
Borreria verticillata L. G. Mey.	Vassoura de botão	Herbs	Exotic	47	1.17	1.51
Genipa americana L.	Jenipapo	Tree	Native	53	—	0.64
Uncaria tomentosa (Willd. ex Roem. & Schult.) DC.	Unha de gato	Tree	Native	1	—	0.12
Rutaceae						
Citrus limetta Risso	Lima	Tree	Exotic	1	—	0.12
Citrus limonia Osbeck	Limão	Tree	Exotic	14	—	0.57
Citrus sinensis (L.) Osbeck	Laranja	Tree	Exotic	44	0.83	0.93
Ruta graveolens L.	Arruda	Herbs	Exotic	75	0.83	1.08
Sapindaceae						
Cardiospermum halicacabum L.	Cipó de vaqueiro	Shrub	Native	10	0.33	0.24
Cupania sp.	Cabotam	—	—	1	0.33	0.12
Serjania sp.	Cipó cururu	—	—	2	—	0.12
Sapotaceae						
Achras zapota L.	Sapoti	Tree	Exotic	1	—	0.12
Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.	Quixaba	Tree	Native	27	—	1.14

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Smilacaceae						
Smilax rotundifolia L.	Cipó japecanga	Herbs	Native	6	0.17	0.12
Solanaceae						
Capsicum frutescens L.	Pimenta	Shrub	Native	3	—	0.24
Nicotiana tabacum L.	Fumo	Herbs	Native	1	—	0.12
Solanum americanum Mill.	Avamoura/Erva moura	Herbs	Exotic	5	0.17	0.30
Solanum paniculatum L.	Jurubeba	Shrub	Exotic	4	1.00	0.35
Sterculiaceae						
Guazuma ulmifolia L.	Mutamba	Tree	Native	7	—	0.24
Theacaea						
Camellia sinensis (L.) Kuntze	Chá preto	Shrub	Exotic	4	—	0.20
Turneracea						
Turnera ulmifolia L.	Xanana	Herbs	Exotic	1	0.17	0.12
Verbenaceae						
Lantana camara L.	Chumbinho	Shrub	Native	5	0.33	0.19
Lippia alba (Mill.) N.E.Br.	Cidreira/Erva cidreira	Herbs	Exotic	94	0.67	1.86
Stachytarpheta elatior Schrad. ex Schult	Mocotó	Herbs	Native	4	0.67	0.12
Vitex agnus-castus L.	Liamba	Tree	Exotic	2	0.17	0.24
Violaceae						
Hybanthus sp.	Pepaconha	—	—	7	—	0.51
Vitaceae						
Cissus verticillata (L.) Nicolson & C.E. Jarvis	Insulina	Shrub	Native	5	0.17	0.12
Leea sp.	Café	—	—	3	—	0.27
Vitis vinifera L.	Uva	Shrub	Exotic	1	—	0.12
Zingiberaceae						
Alpinia zerumbet (Pers.) Burt. ex R. M. Smith	Colônia/Colonha	Herbs	Exotic	190	1.67	0.91
Costus sp.	Cana de macaco	—	—	27	—	0.84
Zingiber officinalis Rosc.	Gengibre vermelho	Herbs	Exotic	1	—	0.12
Unidentified						
Unidentified 1	Abre caminho	—	—	2	—	0.12
Unidentified 2	Açafroa	—	—	1	—	
Unidentified 3	Boca torta	—	—	1	—	0.12
Unidentified 4	Bugre	—	—	2	—	0.12
Unidentified 5	Cafofa	—	—	1	—	0.12
Unidentified 6	Canela de viado	—	—	1	—	0.12
Unidentified 7	Chumbinho branco	—	—	1	—	0.12
Unidentified 8	Cipó de boi	—	—	2	—	0.24
Unidentified 9	Imbira vermelha	—	—	2	—	0.12
Unidentified 10	Malicia branca	—	—	2	—	0.24
Unidentified 11	Malicia boi/M. fina	—	—	4	—	0.15
Unidentified 12	Malva ferro	—	—	1	—	0.12
Unidentified 13	Moça	—	—	1	—	0.12
Unidentified 14	Pé de galinha/Papo de peru	—	—	1	—	0.12
Unidentified 15	Pega rapaz	—	—	1	—	0.12
Unidentified 16	Perpetua branca	—	—	1	—	0.12

Table 1: Continued.

Family/scientific name	Vernacular name	Habit	Origin	Citation number	RI 2005*	RI 2008
Unidentified 17	Piripiri	—	—	1	—	0.12
Unidentified 18	Piriquiti	—	—	1	—	0.12
Unidentified 19	Quebra faca	—	—	5	—	0.27
Unidentified 20	Quentão	—	—	1	—	0.12
Unidentified 21	Rasteira	—	—	1	—	0.12
Unidentified 22	Rasteirinho	—	—	1	—	0.12
Unidentified 23	Salsa caroba	—	—	1	—	0.12
Unidentified 24	Sete casco	—	—	1	—	0.12
Unidentified 25	Tatajuba	—	—	1	—	0.12

* (—) denotes the absence of the species on the list of Gazzaneo et al. [15].
RI 2005: relative importance calculated from information given by local experts; RI 2008: relative Importance calculated from information given by the general community.

of medicinal plants according to gender, with women knowing a higher richness of ethno-species ($H = 117.29$; $P = 0.0006$) and indications ($H = 134$; $P = 0.0003$). They mentioned a total of 166 ethno-species, with a mean number of 13.33 ± 7.84 citations per person, and a total of 146 indications, with a mean of 10.16 ± 5.73 citations per person, whereas men mentioned 136 ethno-species and 93 indications, with a mean of 9.95 ± 7.05 and 7.51 ± 4.9 citations per person, respectively.

The number of plants and indications mentioned by each informant correlated with their age (rs = 0.33, $P < 0.0001$; rs = 0.37, $P < 0.0001$, resp.). However, when we compared the average number of ethnospecies and indications in each age group, we observed different patterns (Table 2). The number of known plants only varied in informants from the 18–28-year-old age group, suggesting that the richness of known plants was smaller in younger participants, which may reflect the limited experience and contact of young informants with plant resources from the region. Although informants aged 49–58 years old had greater knowledge of medicinal plants in the region, they were only significantly different from younger informants (Table 2). With respect to the number of indications mentioned in each age group, we observed a similar pattern to the previous one, with younger informants (18–28 yrs.) knowing a smaller variety of indications. However, the knowledge of informants was significantly higher for the age groups 49–58 years old and older than in other age groups.

When we analyzed the influence of gender and age on the distribution of knowledge, we observed a few patterns that often differed from the data presented by the general community. Younger women (18–28 yrs.) also had less knowledge of the richness of medicinal species, while, in other age groups, knowledge was homogeneous. For women, we observed the formation of two groups regarding the number of indications: one group consisting of the three younger groups, with a lower number of indications, and the other consisting of older age groups, with a higher number of indications.

For men, knowledge of plant richness and indications showed a different pattern. The knowledge of informants in the 18–48-year-old age groups did not present any statistical differences. That difference only appeared in the age groups 49–58 years old and older, indicating an increase in the number of species known and the variety of indications occurring only in older age groups, whereas for women it was also observed in younger age groups.

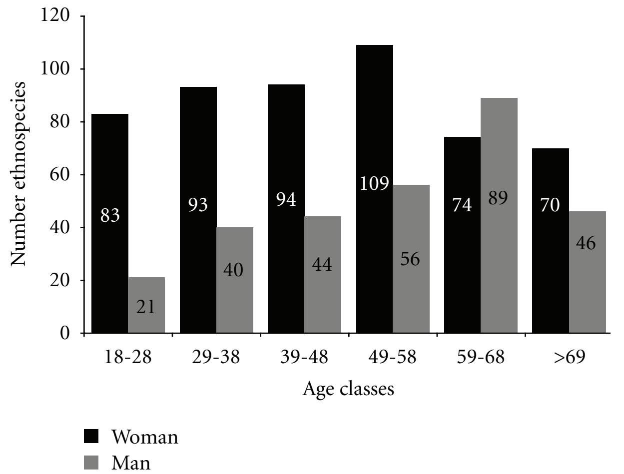

Figure 2: Distribution of the knowledge of medicinal plants between men and women in the community of Três Ladeiras, Igarassu, Pernambuco state, northeastern Brazil.

We observed a continuous increase in the number of ethno-species mentioned with an increase in age, for both men and women, when total plant richness was considered (Figure 2), up to the age group with the highest richness of plants mentioned. In subsequent age groups, plant richness started to decrease. Among women, the 49–58-year-old age group had the greatest knowledge of plants (109 ethno-species), whereas for men the greatest knowledge of plants was observed in an older class (59–68 yrs.). These results indicate that, in the community of Three Hills, the commitment of women to family care compels them to know, from an early age, a large number of plants with medicinal purposes.

Following the age groups with a higher number of plants, there was a decrease in plant richness in older groups,

Table 2: Distribution of the knowledge of medicinal plants by age group and gender in the community of Três Ladeiras, Igarassu, Pernambuco state, northeastern Brazil.

Age groups	NI	General average number of ethno-species $\chi \pm SD^*$	General average number of indications $\chi \pm SD^*$	NMI	NFI	Average number of cited ethno-species		Average number of cited indications		Total diversity of cited species	Number of exclusive species
						Male $\chi \pm SD^*$	Female $\chi \pm SD^*$	Male $\chi \pm SD^*$	Female $\chi \pm SD^*$		
18–28	43	8.8 ± 6^{a}	6.3 ± 3.6^{a}	8	35	5.37 ± 1.9^{a}	9.57 ± 6.4^{a}	4 ± 1.2^{a}	6.83 ± 3.8^{a}	85	10
29–38	44	11.66 ± 6.2^{b}	8.84 ± 4.6^{b}	8	36	7.6 ± 3.7^{ac}	12.55 ± 6.3^{b}	5.75 ± 2^{ac}	9.53 ± 4.8^{b}	103	11
39–48	41	11.98 ± 6.6^{b}	9 ± 4.9^{b}	12	29	8.83 ± 4.3^{ad}	13.28 ± 7^{b}	7.67 ± 4.5^{ac}	9.66 ± 5.1^{b}	99	12
49–58	28	16.39 ± 11^{b}	12.79 ± 7.7^{c}	7	21	11.71 ± 9.6^{bcd}	17.95 ± 11.3^{b}	9.14 ± 6.9^{bc}	14 ± 7.8^{c}	120	19
59–68	24	14.58 ± 8.8^{b}	10.7 ± 6.1^{c}	14	10	12.93 ± 9.4^{bcd}	16.9 ± 7.8^{b}	9.14 ± 6.3^{bc}	12.9 ± 5.2^{bcd}	112	19
>69	14	14.71 ± 6.7^{b}	11.5 ± 4.8^{c}	5	9	13.4 ± 7.4^{bcd}	15.44 ± 6.7^{b}	9 ± 4.5^{bc}	12.9 ± 4.6^{cd}	87	7

* Equal letters in the same column indicate a lack of statistical differences using the Kruskal-Wallis test ($P < 0.05$). NI: number of informants; NMI: number of male informants; NFI: number of female informants.

possibly related to memory loss, which is common among older people. We did not observe the same pattern when the mean number of plants mentioned by informants was analyzed, as previously noted (Table 2). In this case, people still mentioned a high number of citations, even in the oldest age group (>69 yrs.).

Exclusive species were mentioned in all age groups (Table 2), with a total richness of 78 exclusive species distributed in the six age groups. The 49–58- and 59–68-year-old age groups stand out for their higher richness, although there were no statistical differences in the number of exclusive species between age groups ($\chi^2 = 9.38$; $P = 0.09$), indicating that, in every age group, informants had a repertoire of exclusive plants that was not shared by people from other age groups.

3.3. Analysis of the Knowledge of Medicinal Plants between Local Experts and the General Community. Data obtained from the general community presented a higher richness of plant families and medicinal species when compared with data obtained from local experts. The difference was highly significant for total species richness ($\chi^2 = 11.921$, $P = 0.0006$) and exclusive species richness ($\chi^2 = 42.667$, $P = 0.0001$) but was not significantly different for the richness of plant families ($\chi^2 = 1.463$, $P = 0.2265$, Figure 3). The results indicate that the knowledge of local experts managed to represent the richness of useful plant families cited by the general community but not the total number of species (Table 3). However, the most species (84.2%) mentioned by at least 20 informants from the general community were also mentioned by local experts. This result indicates that expert informants mentioned medicinal plant species that are better known among other members of the community.

The numbers of exotic and native species mentioned by local experts and that by the general community were not significantly different according to Williams' *G*-test ($G = 0.9369$, $P = 0.3331$). Among exclusive species, we also did not observe any significant differences between native and exotic plants ($G = 0.153$, $P = 0.6957$), suggesting that local experts and the general community presented a similar citation repertoire of native and exotic species.

There was no significant difference between the relative importance (RI) of species mentioned by local experts and that by general community ($H = 0.7899$, $P = 0.3741$). We observed a significant correlation between local experts and the general community in the number of indications per species according to the Spearman correlation test (rs = 0.515, $P < 0.0001$). This result suggests that local experts and the general community provided similar information regarding the indication of medicinal plant species. Among the ten species with higher RI mentioned by local experts and the general community, the species *Borreria verticillata* L. G. Mey., *Hymenaea martiana* Hayne, *Mentha piperita* L., *Pithecellobium cochliocarpum* (Gomez) Macbr., and *Schinus terebinthifolius* Raddi occurred in both studies. These results show that using local experts to provide information on the indications of medicinal plants was useful in the given context. However, the same was not observed for data on species richness. Thus, we recommend engaging the whole community to gather such data. Such precaution may prevent a large number of known species from being neglected, as in our study.

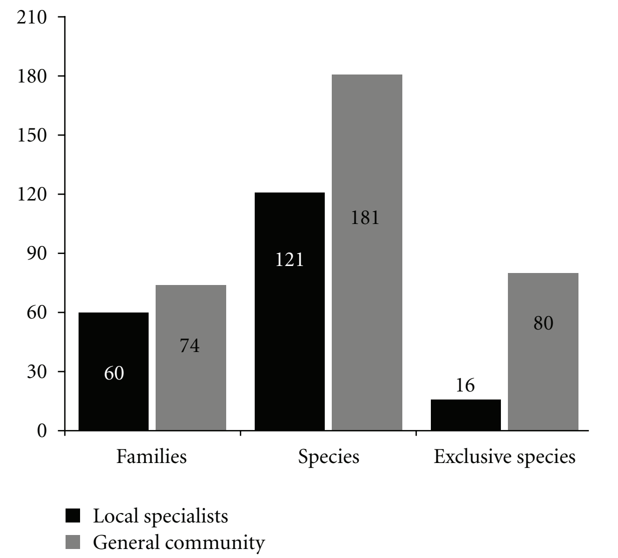

Figure 3: Comparison of the richness of families, species, and exclusive species between local experts and the general community.

4. Discussion

4.1. Richness of Medicinal Plants Mentioned by Informants. The study showed high diversity in the knowledge of medicinal plants, with significant results for species prescribed for basic health care. The acceptance of folk medicine and the limited access to public healthcare services in the community may be factors contributing to the knowledge of medicinal species in local medical practices.

A few plant families prominent in this study, such as Lamiaceae and Asteraceae, are reported as very diverse taxonomic groups in the literature. Their high diversity probably reflects a greater amount of bioactive compounds [29], which may explain their prominence in this study and in similar ones in other regions [30, 31].

Most medicinal plants used in the study area are exotic herbs that usually grow in anthropogenic areas, such as agricultural fields, gardens, and roads. Other studies performed in forest environments in different regions have shown that traditional communities select anthropogenic areas as important resource sources [32–36]. The frequent citation of herbs in the community of "Três Ladeiras" may be a consequence of the importance of this life form in anthropogenic areas, also due to the presence of strong bioactive compounds. In a study conducted in the same community, Gazzaneo et al. [15] also reported that more of the medicinal plants used by experts were herbs, collected mainly in the backyards of homes and small farms.

According to Voeks [37], weeds are often abundant in easily accessible places and rich in bioactive compounds, and as a result they are widely represented in tropical medicinal floras.

Table 3: Exclusive species list from the work of Gazzaneo et al. [15].

Family/scientific name	Vernacular name	Habit	Origin	RI
Asteraceae				
Egletes viscosa (L.) Less.	Macela	Herbs	Exotic	0.17
Tagetes sp.	Cravo de defunto	Herbs	—	0.17
Caesalpiniaceae				
Senna obtusifolia (L.) H.S. Irwin & Barnbey	Mata pasto	Herbs	Exotic	0.17
Tamarindus indica L.	Tamarindo	Tree	Exotic	0.17
Caprifoliaceae				
Sambucus australis Cham. & Schlecht	Flor de sabugo	Tree	Exotic	0.50
Clusiaceae				
Symphonia sp.	Bulandi	Herbs	—	0.17
Euphorbiaceae				
Croton sp.	Marmeleiro	Shrub	Native	0.17
*Euphorbia thymifolia*L.	Pé de pombo	Herbs	Native	0.67
Loranthaceae				
Phthirusa pyrifolia (H.B.K.) Eichl.	Esterco de passarinho	Herbs	Native	0.50
Malvaceae				
Malva sp.	Malva branca	Herbs	—	0.17
Poaceae				
Brachiaria mutica (Forsk.) Stapf	Capim de planta	Herbs	Exotic	0.33
Dendrocalamus giganteus Munro	Bambu	Tree	Exotic	0.17
Saccharum officinarum L.	Cana	Herbs	Exotic	0.17
Rhizophoraceae				
Rhizophora mangle L.	Mangue	Tree	Native	0.33
Rubiaceae				
Cephaelis ipecacuanha (Brot.) A. Rich.	Papeconha	Herbs	Native	0.50
Rutaceae				
Pilocarpus sp.	Jaborandi	—	—	0.33
Sapotaceae				
Pradosia sp.	Burinhê	—	—	0.33
Scrophulariaceae				
Scoparia dulcis L.	Vassourinha	Herbs	Exotic	0.17

RI: relative importance value.

4.2. Influence of Gender and Age on the Knowledge of Medicinal Plants. Women had greater knowledge of medicinal plants when compared to men in the community studied. That result was probably due to women being the caregivers for their families, a trend also observed in other studies [5, 38–40]. This scenario may also reflect the different activities performed by men and women in the community because the latter must dedicate themselves to their homes and families, which help them assimilate the knowledge they will need to keep their homes healthy at an earlier age. We should add that most species from the list of mentioned plants were exotic and herbaceous plants that are found in places women are more familiar with, such as backyards.

The study showed that young informants had less knowledge of medicinal plants when compared to older ones, which can be attributed to a lack of interest in learning and practicing such knowledge in younger generations, who are increasingly influenced by modernization. Several studies have reported similar results [38, 41–45]. It is also important to notice that older people are more experienced and have had greater contact with plant resources and time to exchange knowledge with other informants from the region. Moreover, older people are more often affected often by various illnesses, which may help to increase their repertoire of plants and indications. In addition, they are responsible for preparing home remedies for themselves and for younger people, favoring the retention of knowledge and prompting younger individuals to use the plant resource without necessarily having knowledge of the remedy or its preparation.

4.3. Analysis of the Knowledge of Medicinal Plants between Local Experts and the General Community. This research showed that studies focused on experts can generate useful information, with a satisfactory level of reliability. But these are eminently suitable for quick diagnosis about the knowledge and use of medicinal plants in a community. That approach has the advantage of minimizing costs and time when collecting ethnobotanical data in the community surveyed. However, studies aiming to gather such information in greater detail should ideally engage other members of the community. That may prevent a large number of known species from being neglected. Vandebroek [46] reports that the careful selection of informants is a key task of the ethnobiologist and cannot be a simple step. The author suggests that, for a scientifically rigorous research, should be involved as many participants as possible, but if time is really a limiting factor, it is necessary to select key informants who have a high degree of knowledge about plants in the region as well as a high level of consensus with others.

Within this scenario, the association between both groups of informants is also possible [45–47]. In fact, the information gathered from key informants (experts) in those studies helped prepare semistructured forms and consensus analyses among informants. In some cases, local experts are used as facilitators for data collection, accompanying the researcher during interviews with other members of the community. These studies serve as examples of the advantages and limitations of different informant profiles and emphasize the importance of clearly establishing the goals the researcher hopes to achieve to best engage the most appropriate informants.

It should be noted, additionally, that there was a five-year interval between the data obtained from local experts and the general community. The influence of such a gap could not be measured or controlled, given the sampling design of each study and the dynamic character of human knowledge, and this limitation restricts the possibility of extrapolating the considerations discussed here. Moreover, we could not completely rule out the possibility that the so-called local expert informants have been added to the sample of the present study.

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Research Article

Mapuche Herbal Medicine Inhibits Blood Platelet Aggregation

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12 plant species traditionally used by the Mapuche people in Chile to treat wounds and inflammations have been evaluated for their direct blood platelet inhibition. Seven of the 12 tested plant species showed platelet inhibitory effect in sheep blood, and four of these were also able to inhibit the ADP- (5.0 μM) and collagen- (2.0 μg/mL) induced aggregations in human blood. These four species in respective extracts (in brackets) were *Blechnum chilense* (MeOH), *Luma apiculata* (H_2O), *Amomyrtus luma* (DCM : MeOH 1 : 1) and *Cestrum parqui* (DCM : MeOH 1 : 1). The platelet aggregating inhibitory effects of *A. luma* (DCM : MeOH 1 : 1), and *L. apiculata* (H_2O) were substantial and confirmed by inhibition of platelet surface activation markers.

1. Introduction

Chile has an extraordinary variety of plants and animals, thanks to the latitudinal extent of the country and its great altitudinal range. The Chilean Winter Rainfall-Valdivian forest is one of the most exceptional and exposed biodiversity hotspots of the world. It encompasses approximately 40% of Chile's land area and harbours both endemic flora and fauna. About 50% of the 4000 vascular plant taxa found in this area are endemic. Through collaboration, we have access to the traditional medicinal plants from this area [1–3]. The plants examined are traditionally used by the Mapuche people in Chile to treat wounds and associated infections, as shown in Table 1. This paper evaluates the platelet inhibitory capacity of 12 selected plant species.

Platelet receptors on the surface of the platelets determine the reactivity of platelets and have a wide range of agonists and adhesive proteins [7]. Current antiplatelet therapies target key pathways of platelet activation, including surface receptors and signalling molecules. Aspirin has been the foundation of antiplatelet therapy for over 50 years, and it inhibits platelets by irreversibly acetylating Ser529 of cyclooxygenase 1 (COX1), thereby inhibiting thromboxane A_2 formation by the platelets. Aspirin has been shown to reduce vascular death in high-risk patients by 15% and nonfatal vascular events by 30%, as evidenced by meta-analysis of over 100 randomized trials [8–10]. Several medicinal plants have direct or indirect antiplatelet effects, many through inhibition of COX1 or 2. Likewise, a variety of fruit extracts have been tested *in vitro* for their antiplatelet property, and tomatoes have been found to have a very high activity [11]. It was showed that tomato extract inhibited both ADP- and collagen induced aggregation by up to 70% but not AA-induced platelet aggregation. Various fruit juices have also been tested, and some flavonoids have been established as inhibitors of collagen-induced platelet activity [12, 13]. The effect of flavonoids is well established, and for coffee, it was showed that the caffeine is not the inhibitor [14] but rather the phenolics that was also found inside the platelets. Many of the effects observed are often due to synergistic effects, which is also seen on tomato and grape juice, and the effect can be expected to be lower for the individual compounds [11–14].

Table 1: Overview of the plants examined for blood aggregation inhibition, including voucher number, Latin name, local name, and use. All the plants have been collected in region X in the Valdivian Coastal Range Forest. L: leaf, S: stem, R: root, W: whole plant, T: thorn, and F: flower.

Family	Voucher number	Latin plant name	Collected part	Common name	Local use
Araliaceae	PM01-44	*Pseudopanax laetevirens* (Gay.) Baill.	L, S	Sauco	Leaves, fruit and bark are used for wound healing, as anti-inflammatory, laxative and as diuretic [3]
Asteraceae	PM01-28	*Baccharis absinthioides* Hook. & Arn.	L		*Baccharis* leaves are used for wound healing, as anti pyretic and analgesic [4]
Blechnaceae	PM01-18	*Blechnum chilense* (Kaulf.) Mett.	L, S, R	Costilla de vaca	The whole plant is used towards gonorrhoea and wound and eye infections [3]
Gunneraceae	PM01-09	*Gunnera chilensis* Lam.	L, S	Nalca	Stem and root are used against uterus pains, as haemostatic and anti-inflammatorial [3]
Lamiaceae	PM06-38	*Satureja multiflora* Briq. in Engl & Prantl	L	Oreganillo	Leaves used for digestive problems [5]
Malvaceae	PM01-10	*Corynabutilon vitifolium* (Cav.) Kearney	L, S	Huella	Bark, stem and leaves are used for liver diseases and uterus contractions [3]
Myrtaceae	PM03-24	*Amomyrtus luma* (Molina) D. Legrand & Kausel	L, S	Luma	Leaves are used to decrease blood pressure and cholesterol levels, and to treat liver diseases [3]
Myrtaceae	PM01-40	*Luma apiculata* (DC.) Burret	L, S	Arrayán, Quetri	Leaves are used to treat diarrhea, dysentery, ingestion [6]
Myrtaceae	PM01-16	*Ugni molinae*	L, S	Murta	The fruit is stimulating and refreshing [3]
Onagraceae	PM+1-19	*Fuchsia magellanica* Lam.	L, S		Leaves are used as antipyretic, blood pressure regulator, diuretic and wound healing [3]
Poaceae	PM03-32	*Anthoxanthum utriculatum* (Ruiz & Pav.) Y. Schouten & Veldkamp	L	Ratonera	Roots are used traditionally [3]
Proteaceae	PM03-25	*Lomatia ferruginea* (Cav.) R.Br.	L, R		*Lomatia* leaves and bark are used as laxative, expectorant and as anti-inflammatory [3]
Solanaceae	PM05-35	*Cestrum parqui* L'Hér	L	Palqui	Leaves are used to relief fevers, and towards skin diseases [3]
Winteraceae	PM07-05	*Drimys winteri* J.R. & G. Forster	L, B		Leaves are used as antipyretic, in wound healing, as diurectic anti inflammatory agent, and against ulcers [3]

The plants collected for this study have been chosen based on their use in the treatment of wounds and inflammatory diseases [1, 2]. Many inflammatory mechanisms are involved in wound healing. Especially, platelets plays a crucial role in haemostasis and thrombosis, and they also play an important role in wound healing, inflammation, antimicrobial host defence, angiogenesis, and tumour growth and metastasis [15]. Therefore, plants used against these or related diseases have been collected. The plants examined in here are collected based on ethnopharmacological data from the Region de Los Lagos in southern Chile, part of the Chilean Winter Rainfall-Valdivian forest [3, 16, 17]. Deforestation threatens this area, and the evaluation of traditional medicine might help to preserve the area with its natural richness. Furthermore, the evaluation also contributes to the preservation of the Mapuche culture, and a sustainable production and/or collection of plants may create an economic foundation as an alternative to the felling of the rainforest.

The aim of the study was a screening of a variety of Mapuche herbal medicine for platelet inhibitory effects. Inhibition on platelet aggregation in sheep blood was chosen as an initial screening method due to the large volumes of blood needed. Plant extracts with activity in sheep blood were subsequently investigated for inhibitory effects on human blood platelets.

2. Material and Methods

2.1. Plant Material. The plant species in this study are traditionally used to treat wounds, wound infections, and/or inflammatory ailments by the Mapuche people. The collection have been conducted in February in the years 2001, 2003, 2005, 2006, and 2007 under the supervision of Alfonso

Guzman [18]. All plants have been collected in Region de Los Lagos located in Chile's region X. Available plant parts were collected without destroying the population, for example, leaves, stems, flowers, and roots though mainly leaves are used for teas, the preferred preparation in Mapuche traditional medicine (Table 1) [17]. After collection, the plant material was immediately dried at room temperature and transported to Denmark for further studies, where it was kept dry and in darkness until use. Voucher specimens are stored at the Botanical Garden and Museum, University of Copenhagen (C); see Table 1 for voucher specimen number.

2.2. Extraction and Sample Preparation. Dried material from 12 different species of Chilean plants was subjected to extraction. 5 mL DCM : MeOH 1 : 1 was added to 0.5 g dry plant material and exposed to ultrasonication for 30 minutes and filtration. This was repeated twice, and the combined extracts were evaporated to dryness. This procedure was repeated using MeOH and finally by H_2O. The dried extracts were stored at −20°C until used for the aggregation assays. The screening was conducted in each of these three plant extracts, DCM : MeOH 1 : 1, MeOH, and H_2O. Yield of extractions are given in Table 2.

2.3. Preparation of Samples for Aggregation and Flow Cytometry Assays. The dried extracts were dissolved in DMSO : EtOH 1 : 4 in order to reach a concentration of 20 mg/mL, only extracts that was fully redissolved where taken forward. Tested extracts are listed in Table 2. The DMSO : EtOH samples were diluted in sterile filtered HEPES-tyrode's buffer pH 7.4 (137 mM NaCl, 2.7 mM KCl, 1.0 mM $MgCl_2$, 12 mM $NaHCO_3$, 0.4 mM Na_2HPO_4, 5.5 mM glucose, 10 mM HEPES) for aggregation assays, and in HEPES-tyrode's buffer with 0.5% BSA for flow cytometry assays to a final concentration of 1 mg/mL. The DMSO : EtOH samples diluted in HEPES-tyrode's buffer was added to PRP as a 1 : 10 dilution. HEPES-tyrode's buffer containing 0.5% DMSO : EtOH 1 : 4 was used as vehicle control. Sample and vehicle control were incubated in PRP at 37°C for 30 min before aggregation experiments. Final concentration of plant extract and vehicle control in the aggregometer was 0.1 mg/mL. A pure MeOH aliquot was treated as an extract, and the effect of DMSO and MeOH was observed in all assays but did not show any significant effect.

2.4. Platelet Aggregation Assay. Platelet aggregation assays were performed in sheep and human blood in duplicates. Sheep blood was used for the bulk screenings, where a large volume of blood was needed. Human blood from the authors SSF (female, 32) and IT (female, 37) was used for selected extracts to verify an inhibitory effect seen in sheep blood at first screening. None of the human volunteers had been exposed to antiplatelet medication for at least 2 weeks prior to blood sampling. Venous blood was drawn with minimal stasis using a 21 G needle into Vacutainer tubes containing 3.2% (0.129 M) sodium citrate (1 : 9), after discarding the first 2 mL.

Platelet-rich plasma (PRP) was prepared by centrifugation of citrated blood at 150 ×g for 10 minutes (human blood) or 1200 ×g for 3 minutes (sheep blood) at 21°C. Autologous platelet-poor plasma (PPP) was prepared by centrifugation of the remaining blood at 3000 ×g for 10 min at 21°C. In each sample, the platelet count of the PRP was determined by an automated counter (Medonic CA 620Vet, Boule Medical AB, London, UK), and based on the count PRP was adjusted to the standard concentration (250,000 platelets/μL). Platelet aggregation was performed by standard procedures (Chronolog VS700, Chronolog Corp., Haverton, Pa, USA) with the following modifications: 225 μL PRP and 25 μL agonist were used in all experiments. Platelet poor plasma with DMSO : EtOH samples diluted 1 : 20 in HEPES-tyrode's buffer was used as reference to eliminate bias of the extract colouring in the test. Final concentrations of the agonists in sheep samples were 5 μg/mL collagen (Chronolog Corp, Haverton, Pa, USA) and 5 μM adenosine diphosphate (ADP—Bio/Data, Horsham, PA) and 2 μg/mL collagen and 5 μM ADP in human samples. Extract and vehicle control samples were analysed in parallel.

Aggregation response was recorded using the Aggrolink software (Chronolog Corp). Maximal aggregation (MA) was recorded in order to obtain a % inhibition of plant extract, comparing the vehicle control (HEPES-tyrode's buffer including BSA) with that of the plant extract %inhibition = (MA vehicle control − MA extract)/MA vehicle control ∗ 100%.

The experiments were approved by the Animal Experiments Inspectorate under the Danish Ministry of Justice. All human blood used was drawn from the authors themselves.

2.5. Initial Experiments in Aggregometer. Arachidonic acid (AA), ADP and collagen were tested in several concentrations in sheep blood in order to find the most suitable agonists and the appropriate concentrations of these.

Based on the results from the initial experiment it was decided to test AA in 500 μM, ADP in 5.0 μM, and collagen in 2.5 μg/mL in an initial experiment, and from that, it was decided to use ADP and collagen to all future experiments in the aggregometer. The tested ADP concentration at 5.0 μM was suitable, whereas the collagen concentration was increased from 2.5 μg/mL to 5.0 μg/mL. The aggregation percentage in the collagen-induced reaction with vehicle control was 61%, and by increasing the concentration of agonist, the aggregation percentage would hopefully also increase in order to get closer to the desired 70%. AA was not used in any further experiments.

ADP and collagen were used as agonists based on the initial experiments. For human blood, it was decided to lower the collagen concentration to 2.0 μg/mL due to the observed aggregation. The ADP concentration was the same (5.0 μM) as in the experiment with sheep blood.

To establish the plant extract testing concentration, the MeOH extract of the pharmacologically well described of *Drimys winteri* [6] was tested in three different concentrations, 10, 1, and 0.1 mg/mL. All three gave high inhibition

Table 2: Mapuche medicinal plant extracts tested in sheep blood. The agonists are ADP (5.0 μM) and collagen (5.0 μg/mL) and the obtained aggregations are shown in percentage. Extracts are tested in 0.1 mg/mL end concentrations. The aggregation is shown for both extract and vehicle control. If the extract aggregation is 20% lower than that of the vehicle control inhibition is observed.

Plant	Extract	Extract Yield (% dw)	Agonist	% Aggregation (extract)	% Aggregation (vehicle control)	% Inhibition	Inhibition
Amomyrtus luma (leaf)	DCM : MeOH 1 : 1	6.8	ADP	47	88	47	Yes
			Collagen	25	85	71	Yes
	MeOH	14.4	ADP	61	60	−2	No
			Collagen	30	83	64	Yes
	H_2O	6.7	ADP	45	68	34	Yes
			Collagen	23	86	73	Yes
Anthoxanthum utriculatum (leaf)	DCM : MeOH 1 : 1	5.2	ADP	38	49	22	Yes
			Collagen	106	124	15	*1
	MeOH	4.9	ADP	33	68	51	Yes
			Collagen	22	77	71	Yes
	H_2O	4.8	ADP	50	51	2	No
			Collagen	39	75	48	Yes
Blechnum chilense (leaf)	DCM : MeOH 1 : 1	2.8	ADP	52	62	16	No
			Collagen	26	44	41	Yes
	MeOH	1.8	ADP	38	52	27	Yes
			Collagen	1	18	94	Yes
Cestrum parqui (leaf)	DCM : MeOH 1 : 1	7.6	ADP	49	81	40	Yes
			Collagen	27	91	70	Yes
	MeOH	3.7	ADP	44	77	43	Yes
			Collagen	30	83	64	Yes
	H_2O	15.9	ADP	73	82	11	*1
			Collagen	52	82	37	Yes
Corynabutilon vitifolium (leaf)	DCM : MeOH 1 : 1	3.6	ADP	48	54	11	No
			Collagen	44	35	−26	No
	MeOH	3.7	ADP	39	59	34	*1
			Collagen	48	49	2	No
Fuchsia magellanica (leaf)	DCM : MeOH 1 : 1	12.2	ADP	45	45	0	No
			Collagen	10	12	17	No
	MeOH	6.2	ADP	30	52	42	Yes
			Collagen	32	38	16	No
Gunnera chilensis (leaf + stem)	DCM : MeOH 1 : 1	13.1	ADP	50	59	15	No
			Collagen	49	64	23	Yes
	MeOH	3.3	ADP	40	56	29	*1
			Collagen	35	65	46	Yes
	H_2O	6.5	ADP	50	71	30	*1
			Collagen	68	56	−21	*1
Lomatia ferruginea (leaf)	DCM : MeOH 1 : 1	2.7	ADP	24	55	56	Yes
			Collagen	9	33	73	Yes
	MeOH	1.1	ADP	43	50	14	No
			Collagen	6	55	89	*2
	H_2O	6.9	ADP	57	43	−33	No
			Collagen	30	50	40	*1

Table 2: Continued.

Plant	Extract	Extract Yield (% dw)	Agonist	% Aggregation (extract)	% Aggregation (vehicle control)	% Inhibition	Inhibition
Luma apiculata (leaf)	DCM : MeOH 1 : 1	4.5	ADP	51	65	22	*1
			Collagen	42	75	44	*1
	MeOH	4.9	ADP	18	52	65	Yes
			Collagen	20	64	69	Yes
	H_2O	9.1	ADP	19	56	66	Yes
			Collagen	21	74	72	Yes
Pluchea absinthioides (leaf)	DCM : MeOH 1 : 1	8.9	ADP	47	57	18	*1
			Collagen	17	39	56	Yes
	MeOH	2.9	ADP	48	50	4	No
			Collagen	10	36	72	Yes
	H_2O	4.4	ADP	43	51	16	No
			Collagen	9	51	82	*2
Pseudopanax laetevirens (leaf)	DCM : MeOH 1 : 1	7.3	ADP	45	59	24	Yes
			Collagen	23	61	62	Yes
	MeOH	6.2	ADP	43	57	25	*1
			Collagen	4	60	93	Yes
	H_2O	13.3	ADP	50	66	24	Yes
			Collagen	8	6	−33	No
Satureja multiflora (leaf + stem)	DCM : MeOH 1 : 1	7.2	ADP	44	74	41	Yes
			Collagen	31	81	62	*1
	MeOH	7.1	ADP	60	67	10	No
			Collagen	44	125	65	*1
	H_2O	14.3	ADP	61	64	5	No
			Collagen	11	43	74	*2

*1: Aggregation curve and output % does not correlate, and the result is doubtful.
*2: Aggregation curve is very flat, this is suspicious.

with 0.1 mg/mL yielding 38% (ADP agonist) and 90% (collagen agonist) inhibition of sheep blood aggregation. Taking into account that the 0.1 mg/mL was also significantly easier to dissolve in the testing buffers, it was decided to use this concentration throughout the screening. This would still give positive results for potent aggregation inhibitors.

2.6. Flow Cytometry. The DMSO : EtOH samples from *Amomyrtis luma* and *Luma apiculata* (1 mg/mL) diluted in HEPES-tyrode's buffer containing BSA pH 7.4 was used for flow cytometry experiments. 0.5% EtOH in HEPES-tyrode's buffer with BSA was used as vehicle control. Citrated human blood was incubated with DMSO : EtOH/HEPES-tyrode's samples (final concentration of 0.1 mg/mL) or vehicle control at 37°C in 30 minutes.

Samples were assayed within 15 minutes from venipuncture. Microcentrifuge tubes were prepared containing a mixture of either HEPES-Tyrode's buffer, phycoerythrin (PE) conjugated anti-CD62P (Santa Cruz Biotechnology, Santa Cruz, Calif, USA), fluorescein isothiocyanate (FITC) conjugated PAC-1 (Becton Dickinson, San Jose, Calif, USA), or HEPES-Tyrode's buffer, PE-Cy5-conjugated anti-CD42b (Becton Dickinson), fluorescein isothiocyanate (FITC) conjugated PAC-1 (Becton Dickinson, San Jose, Calif, USA) and eptifibatide. To both mixes platelet agonist was added for the detection of platelet surface P-selectin and activated GPIIb/IIIa. Pilot experiments using several different agonist concentrations were performed to identify agonist concentrations giving maximal and submaximal platelet activation. Final concentrations of agonists in the reaction mixture were 1 or 5 μM of thrombin receptor activating peptide (TRAP, Sigma-Aldrich, Brondby, Denmark), 0.5 or 20 μM of ADP (Bio/Data Co., Horsham, Pa, USA), or no agonist (HEPES-Tyrode's buffer). All ADP and TRAP dilutions were made as batches and stored at −20°C along with vehicle control for the controls to minimize dilution variation. Antibody mixtures were prepared as batches and kept at 4°C. After incubation, P-selectin and activated GPIIbIIIa samples were fixed by 1% formaldehyde in HEPES-saline. Samples were analyzed in an FACSCalibur (Becton Dickinson) flow cytometer. Platelets were identified by light scatter properties and expression of CD42b. All samples were tested in triplicates.

3. Results

3.1. Platelet Aggregation in Sheep Blood. After conducting the initial experiments, a total of 33 extracts, from 12 different plants were screened in ADP (5.0 μM) and collagen (5.0 μg/mL) induced aggregations in the aggregometer. Table 2 shows the average reading of duplicates and whether or not the plant extracts were able to inhibit ADP and collagen induced aggregation. All extract was compared towards the vehicle control and if the observed aggregation was 20% lower for extract test than for the vehicle is was concluded that the extract inhibited aggregation. Additionally, all extracts was tested with two different inducers, this further support the validity of the inhibition results.

Plant samples that in a convincing way were able to inhibit the aggregation in sheep blood were subsequently tested in a similar experiment with human blood. The below seven plants in the respective extracts were the ones chosen to be tested again.

The DCM : MeOH 1 : 1 extracts of *Amomyrtus luma, Blechnum chilense*, *Cestrum parqui, Lomatia ferruginea*, and *Pseudopanax laetevirens* were active as were the MeOH extracts of *A. luma*, *Anthoxanthum utriculatum B. chilense, C. parqui*, *Luma apiculata,* and *P. laetevirens*, and the water extracts of *A. luma*, *C. parqui,* and *L. apiculata*. These samples were all chosen to be tested in human blood.

3.2. Platelet Aggregation in Human Blood. Seven of the species tested in sheep blood was tested in human blood. The activity is listed in Table 3. The four plants *A. luma* (DCM : MeOH 1 : 1 extract), *B. chilense* (MeOH extract), *C. parqui* (DCM : MeOH 1 : 1 extract), and *L. apiculata* (H_2O extract) showed inhibitory effect in both sheep and human blood in both ADP- and collagen induced aggregations (see Tables 2 and 3). Furthermore, the H_2O extract from *A. luma* showed inhibition in the collagen induced aggregation.

3.3. Flow Cytometry. In order to confirm the obtained results from the aggregation experiments the *A. luma* DCM : MeOH 1 : 1 extract and the *L. apiculata* H_2O extract were tested for inhibition of platelet surface activation markers flow cytometry.

Table 4 shows the tested extracts and the percent inhibition of PAC1 MFI and CD62P (P-selectin) MFI by addition of ADP (0.5 μM and 20 μM) and the human specific inducer TRAP (1.0 μM and 5.0 μM). PAC1 and CD62P are both markers of platelet activation, and in order to be assigned an inhibitory effect the extracts should inhibit both activation markers using both agonists at all concentrations.

The extracts from *L. apiculata* and *A. luma* showed clearly inhibitory effect of both PAC1 MFI and CD62P MFI in the tested ADP concentrations as well as with the addition of 1.0 μM TRAP, whereas only a slight inhibitory effect is observed when 5.0 μM TRAP was added. TRAP was used in the flow cytometry assays since it is a human specific platelet inducer.

4. Discussion

The four plants *Amomyrtus luma*, *Blechnum chilense*, *Cestrum parqui*, and *Luma apiculata* showed inhibitory effect in both sheep and human blood in both ADP and collagen induced aggregations. Of these *L. apiculata* (H_2O extract) and *A. luma* (DCM : MeOH 1 : 1 extract) was the most prominent candidates for further examinations. The two extracts were examined using platelet specific markers PAC1 and CD62P and the human-specific inducer TRAP and ADP in a flow cytometry assay. PAC1 and CD62P (P-selectin) does not bind to resting platelets but only to activated platelets [19]. These studies showed clear platelet inhibitory effect on platelet surface activation markers by the two markers as shown in Table 4. The effect observed in the flow cytometry confirms the results seen in the aggregometer.

The ethanol extract of the leaves of *A. luma* has been shown to contain 1-phenylpentan-3-one (4.6/8.5%) and 1-phenylhexan-3-one (3.5/12.3%) as well as β-caryophyllene oxide (10.7/6.6%) and linalool (59.3/11.3%) [20], of these the β-caryophyllene oxide has been shown to spontaneously aggregate blood platelets [21] at 100 μg/mL concentrations. This effect contradicts the observed effect of the extract, where aggregations was inhibited and suggest a strong inhibition of the organic extracts of *A. luma* since β-caryophyllene oxide would have been extracted with both DCM : MeOH 1 : 1 and to some extend also MeOH. The presence of β-caryophyllene oxide could be part of the explanation on why no inhibition was observed for the MeOH extract using ADP as an inducer. Further studies are needed to determine the active constituents in *A. luma*.

The MeoH extracts of *B. chilensis* have previously been shown to have antimicrobial effects [3]. *L. apiculata* have previously been shown to have xanthine oxidase inhibitory activity (30% inhibition at 50 μg/mL EtOH : H_2O 7 : 3 extract) [22], and antiviral activity on herpes (IC_{50} = 100 μg/mL, EtOH extract) [23]. But none of these studies provides information to what could be active constituent, and no phytochemical data was found for these two species. COX inhibitory activity indirectly inhibiting P-selectin expression on human platelets [24]. It has been demonstrated that caffedymine from cocoa, have COX inhibitory activity, with 43% inhibition of COX-1 at 0.01 μM, and that caffedymine suppress P-selectin (CD62P) expression on platelets by 33% at a concentration of 0.05 μM [24]. The inhibition of COX enzymes may be a main contributing factor to suppressing P-selectin expression [24], which could be the effect observed with extracts of *L. apiculata* and *A. luma*. In order to confirm or invalidate this theory, COX inhibitory effect of *L. apiculata* and *A. luma* would have to be examined. Several plant extracts have already been tested for their COX activity [25] and this would need to evaluated along with determination of the active constituents.

It has previously been shown, that a MeOH : H_2O 1 : 1 extract from *C. parqui* was able to inhibit aggregation of human blood platelets induced by ADP [26]. This confirms that some extracts from *C. parqui* are able to inhibit ADP induced platelet aggregations. However, the same was not observed in an AA-induced platelet aggregation, which implies that, the extracts anti-inflammatory activity did not implicate the inhibition of the cyclooxygenase pathway, that has been seen in other studies [27]. A suggestion is that the extract inhibited a site upstream of AA metabolism, since the case might be that ADP has triggered the release of AA in the

Table 3: Seven plant species that showed inhibitory effect in sheep blood were subsequently tested in human blood. The agonists are ADP (5.0 μM) and collagen (2.0 μg/mL) and the obtained aggregations are shown in percent. Extracts are tested in 0.1 mg/mL end concentrations. The aggregation is shown for both extract and vehicle control. If the extract aggregation is 20% lower than that of the vehicle control inhibition is observed.

Plant	Extract	Agonist	% Aggregation (extract)	% Aggregation (vehicle control)	% Inhibition	Inhibition
Amomyrtus luma (leaf)	DCM : MeOH 1 : 1	ADP	57	73	22	Yes
		Collagen	62	87	29	Yes
	MeOH	ADP	66	70	6	No
		Collagen	68	70	3	No
	H_2O	ADP	66	69	4	No
		Collagen	60	76	21	Yes
Anthoxanthum utriculatum (leaf)	MeOH	ADP	63	64	2	No
		Collagen	63	68	7	No
Blechnum chilense (leaf)	DCM : MeOH 1 : 1	ADP	73	77	5	No
		Collagen	74	73	−1	No
	MeOH	ADP	60	83	28	Yes
		Collagen	61	86	29	Yes
Cestrum parqui (leaf)	DCM : MeOH 1 : 1	ADP	61	84	27	Yes
		Collagen	67	84	20	Yes
	MeOH	ADP	70	70	0	No
		Collagen	71	71	0	No
	H_2O	ADP	74	71	−4	No
		Collagen	64	68	6	No
Lomatia ferruginea (leaf)	DCM : MeOH 1 : 1	ADP	72	72	0	No
		Collagen	73	71	−3	No
Luma apiculata (leaf)	MeOH	ADP	70	67	−4	No
		Collagen	65	71	8	No
	H_2O	ADP	46	84	45	Yes
		Collagen	54	85	36	Yes
Pseudopanax laetevirens (leaf)	DCM : MeOH 1 : 1	ADP	69	72	4	No
		Collagen	66	72	8	No
	MeOH	ADP	69	72	4	No
		Collagen	69	76	9	No

Table 4: Flow cytometry results from *L. apiculata* H_2O extract, and *A. luma* DCM : MeOH 1 : 1 extract. Inhibitions of the platelet activation markers, PAC1 and CD62P are shown in percent compared with vehicle control. The agonist is ADP in 0.5 μM and 20.0 μM, and TRAP in 1.0 μM and 5.0 μM. Extracts are tested in 0.1 mg/mL end concentrations.

Plant extract	% Inhibition of PAC1 MFI				% inhibition of CD62P MFI			
	ADP 0.5 μM	ADP 20.0 μM	TRAP 1.0 μM	TRAP 5.0 μM	ADP 0.5 μM	ADP 20.0 μM	TRAP 1.0 μM	TRAP 5.0 μM
Luma apiculata (H_2O extract)	34.4	20.1	74.1	8.0	38.9	28.1	80.7	3.5
Amomyrtus luma (DCM : MeOH 1 : 1 extract)	30.1	17.8	78.1	12.4	37.7	27.4	83.2	6.4

pathway [26]. These data could explain the data observed and the two datasets suggest that *C. parqui* contains several active constituents. The plant itself have long been known to cause poisoning in cows, and it has been shown that the toxicity is in the organic phase that contained low molecular weight phenols [28], among these flavonoids that as mentioned have been shown to have antiplatelet activity. With more than 150 publication on *C. parqui* and its pharmacology and several toxic and pharmacologically active terpenoids isolated from the plant [29] further studies are not of high priority.

5. Conclusion

In the present work, four Chilean plant species were shown to inhibit platelet aggregating induced by ADP and collagen in both sheep and human blood. The four species were *Blechnum chilense* (MeOH extract), *Luma apiculata* (H_2O extract), *Amomyrtus luma* (DCM : MeOH 1 : 1 extract) and *Cestrum parqui* (DCM : MeOH 1 : 1 extract). The platelet aggregating inhibitory effects of *A. luma* (DCM : MeOH 1 : 1 extract) and *L. apiculata* (H_2O extract) were furthermore confirmed by inhibition of platelet surface activation markers.

At present, there is still a great need for preventative and therapeutic, anticoagulant medicine, and plants and their fruits seem to constitute possible alternatives to drugs currently used. It is of great interest to explore this inhibition further for the three species *B. chilense, L. apiculata, A. luma*.

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Research Article

Inhibitory Effect of *Helicteres gardneriana* Ethanol Extract on Acute Inflammation

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The anti-inflammatory effect of an ethanol extract of *Helicteres gardneriana* (Nees) Castiglioni was assayed in experimental models of pleurisy and microcirculation *in situ*. Treatment of animals with 500 mg/kg body weight reduced the exudate volume (35% reduction) induced by intrapleural injection of carrageenan and the migration of polymorphonuclear cells into the inflamed pleural cavity of rats (40%). Additionally, rolling and adhesion of leukocytes and the number of leukocytes that migrated toward the perivascular space in response to the carrageenan injection were decreased by the extract (500 mg/kg). These data demonstrate the anti-inflammatory effect of the ethanol extract of *Helicteres gardneriana* and imply that inhibition of leukocyte-endothelial interactions is important in the extract's mechanism of action.

1. Introduction

The genus *Helicteres* belongs to the family Sterculiaceae and includes several species such as *H. angustifolia, H. sacarolha*, and *H. isora* that are used in folk medicine for their analgesic and anti-inflammatory properties [1–3]. Studies performed with extracts obtained from *H. isora* have demonstrated its ability to inhibit abdominal writhing induced by administration of acetic acid in a mouse model of pain [4].

Plants of the genus *Helicteres* (*H. isora* and *H. angustifolia*) contain triterpenoids [5, 6], cucurbitacins [7, 8], flavonoids [9, 10], neolignans [11], rosmarinic acids [12], and essential oils [13] which may contribute to their pharmacological effects. *In vivo* and *in vitro* experimental assays have shown that some of these constituents have anti-inflammatory effects [14–19].

Recent experimental assays have shown that applying *Helicteres gardneriana* crude extract significantly reduced ear edema and inhibited the activity of the enzyme myeloperoxidase. Furthermore, photoacoustic data showed that the strong anti-inflammatory effects of the extract were associated with the deep penetration observed for the extract [20]. In spite of these findings, no studies have evaluated the systemic anti-inflammatory effects of *Helicteres gardneriana* extract.

The acute inflammation reaction is characterized by edema formation and recruitment of leukocytes into the injured tissue. At the beginning of the inflammatory process, chemical substances secreted at the site of injury mediate the endothelial cell contraction, causing a subsequent increase in vascular permeability and consequent edema formation. Simultaneously, a coordinated sequence of events occurs and initiates the migration of leukocytes from the vascular system to the site of the lesion. Tethering and rolling of leukocytes on the vessel wall is the initial and fundamental event, followed by firm adhesion to the endothelium [21, 22]. The inflammatory reaction is necessary for tissue recovery and provides the correct cytokine signals and cell machinery to clear up the site for tissue regeneration [23]. However, uncontrolled inflammation has unfavorable effects on the course of tissue healing because the inflammatory cells are also able to induce tissue damage.

The present study evaluated the effects of an ethanol extract of *Helicteres gardneriana* (EEHg) on the inflammatory response using models of carrageenan-induced pleurisy and microcirculation *in situ*. Here, we describe the anti-inflammatory effects of this extract on the edema, mobilisation of leukocytes, and leukocyte-endothelium interactions.

2. Materials and Methods

2.1. Animals. Male Wistar rats (220–260 g) were used. The animals were maintained in a controlled temperature of 22°C and a 12 h light/dark cycle with water and food available *ad libitum*. The experimental protocol was approved by the Ethics Committee for Animals of the State University of Maringá (no. 024/2006).

2.2. Plant Material. The aerial parts of the *Helicteres gardneriana* plant were collected in July 2004 in the floodplain of the Upper Paraná River, Municipality of Taquaraçú, Mato Grosso de Sul, Brazil. The material was appropriately preserved and deposited at the Nupélia Herbarium of the State University of Maringá, Paraná, Brazil (HNUP no. 2844). The material was dried in an air-circulating oven at 40°C and then ground in a cutting mill. The extract was obtained by extraction with absolute ethanol at room temperature. The solvent was then removed in a rotating evaporator to produce the ethanol extract [24]. Immediately prior to use, the EEHg was diluted in a 16% dimethylsulfoxide solution (DMSO : water, 1 : 6).

2.3. Rat Pleurisy. Pleurisy was induced by injection of 0.25 mL of a carrageenan suspension (200 μg) in the intrapleural cavity, according to the technique described by Vinegar et al. [25]. The carrageenan was diluted in saline buffered with phosphate (PBS, pH = 7.4). Four hours after induction of pleurisy, the animals were killed, and the inflammatory exudate was collected. The exudate volume was measured, and an aliquot of 50 μL was diluted in Turk solution (1 : 20) and used to determine the total number of leukocytes in a Neubauer chamber. For differential counting of leukocytes, the remaining fluid was centrifuged at 2500 rpm for 10 min, and the cells were resuspended. The slides were prepared, dried, fixed, and stained with May-Grunwald-Giemsa. The number of mononuclear and polymorphonuclear leukocytes in the exudate was determined with the aid of a light microscope. The EEHg (250 and 500 mg/kg), dexamethasone (0.5 mg/kg—standard anti-inflammatory), vehicle (16% DMSO—negative control), and saline (0.9%—negative control) were administered orally by gavage, in different groups of rats, which had fasted for 15 h, 30 min prior to the induction of pleurisy.

2.4. Determination of Total Nitric Oxide Concentration in Pleural Exudates. The concentration of total nitric oxide (NO_3^- + NO_2^-) was determined in the pleural exudates of control rats and rats treated with EEHg. The samples were deproteinized by centrifugation (5000 ×g for 120 min at 4°C) in Eppendorf tubes with 10 kDa filters. Total NO was determined by first incubating the samples and calculating the standard curve (aqueous solutions of KNO_3 at concentrations ranging from 0.2 to 200 μM) with 20 μL nicotinamide adenine dinucleotide phosphate (100 μM), flavin adenine dinucleotide (5 μM), and NO_3^- reductase (200 μm/mL) for 1 h at 37°C. Next, 20 μL lactate dehydrogenase (13.5 U/mL) and pyruvate (9 mM) were added, and the samples were further incubated for 30 min at 37°C. After this period, 50 μL of Griess reagent (a solution containing 0.1% sulfanilamide +0.01% naphthylethylenediamine in 5% phosphoric acid) was added, and the samples were allowed to rest for 10 min at ambient temperature. The concentrations of total NO were determined in the exudate by measuring absorbance at 540 nm [26].

2.5. Determination of Rolling, Adhesion, and Migration of Leukocytes in the Microcirculation of Spermatic Fascia in situ. Rolling behavior and adhesion of leukocytes to the endothelium were evaluated in the internal spermatic fascia of rats 2 h after injection of the carrageenan suspension (100 μg) in the wall of the scrotal chamber [27, 28]. Animals anesthetized with chloral hydrate (500 mg/kg, s.c.) were maintained on a special board thermostatically controlled at 37°C with a transparent platform for transillumination of the tissue on which the spermatic fascia was exposed and fixed for microscopic analysis *in situ*. The preparation was kept moist and warm with Ringer-Locke's solution (pH 7.2–7.4) containing 1% gelatin. The vessels selected for the study were postcapillary venules with a diameter of 15–25 μm. The numbers of rolling and adherent leukocytes were determined at 10 min intervals. The leukocytes were considered to adhere to the venular endothelium if they remained stationary for more than 30 s. In another series of experiments, the number of leukocytes that migrated to an area of 2500 μm^2 of connective tissue adjacent to the postcapillary venules 4 h after carrageenan injection was determined. This area was defined on the video screen, 80 × 32 μm in tissue corresponding to 9.2 × 3.7 cm on the screen. Five different fields were evaluated on a single animal to avoid variability based upon sampling. Data were then averaged for each animal. EEHg (500 mg/kg), dexamethasone (0.5 mg/kg), vehicle (16% DMSO), and saline (0.9%) were administered orally by gavage 30 min before the carrageenan injection to different groups of rats that were fasted for 15 h.

2.6. Statistical Analysis. Results are expressed as mean ± standard error of the mean (S.E.M.). Data were subjected to analysis of variance (one-way ANOVA) followed by Tukey's *post hoc* test. Values of $P < 0.05$ were considered statistically significant.

3. Results

3.1. Effect of EEHg on Pleurisy. Intrapleural injection of carrageenan in groups of animals pretreated orally with saline or DMSO induced an acute inflammatory response, characterized by an increase in pleural exudate volume and

Table 1: Exudate volume and total and differential leukocytes counts in inflammatory pleural Exudate of rats, 4 h after injection of carrageenan (Cg, 200 μg/cavity).

Groups of animals	Exudate volume (mL)	Leukocytes/mm^3		
		Total	mononuclear	Polymorphonuclear
Basal	0.10 ± 0.01	6700 ± 450	1800 ± 160	4900 ± 390
Cg + Sal	0.91 ± 0.07^{c}	59800 ± 4810^{c}	11770 ± 107^{c}	48030 ± 4176^{c}
Cg + DMSO	0.90 ± 0.07^{c}	60270 ± 3910^{c}	9850 ± 1333^{c}	50420 ± 2999^{c}
Cg + Dex$_{0.5}$	0.24 ± 0.01^{e}	28000 ± 1447^{a,e}	2309 ± 324^{b,e}	25691 ± 1355^{b,e}
Cg + EEHg$_{250}$	0.85 ± 0.10^{c}	58090 ± 3986^{c}	9040 ± 1361^{c}	49050 ± 3059^{c}
Cg + EEHg$_{500}$	0.63 ± 0.04^{c,d}	41860 ± 3434^{c,d}	13080 ± 1409^{c}	28780 ± 2573^{b,d}

Each value represents the mean ± S.E.M. of 6–8 animals. Dexamethasone (Dex) administered orally, 0.5 mg/Kg was used as a reference anti-inflammatory (positive control). Basal = animals that received injection of PBS in the cavity (PBS + Sal), Cg = carrageenan, Sal = 0.9% saline, DMSO = 16% dimethylsulfoxide, EEHg = ethanol extract of *Helicteres gardneriana*. $^{a}P < 0.05$, $^{b}P < 0.01$, and $^{c}P < 0.001$, compared to basal group, $^{d}P < 0.05$, $^{e}P < 0.001$ compared to groups Cg + Sal and Cg + DMSO (one-way ANOVA, Tukey's test).

Table 2: Number of rolling and adherent leukocytes during 10 min periods after 2 h and migrated leukocytes after 4 h of inflammatory stimulus.

Groups of animals	n	Leukocytes		
		Rolling	Adherent	Migrated
Basal	5-6	126.8 ± 10.2	7.8 ± 1.4	7.7 ± 0.3
Cg + Sal	5–9	205.1 ± 14.0^{a}	23.0 ± 1.9^{a}	17.4 ± 0.8^{a}
Cg + DMSO	5–7	201.3 ± 14.8^{a}	22.0 ± 0.9^{a}	17.0 ± 0.4^{a}
Cg + Dex	5-6	110.8 ± 11.2^{b}	6.3 ± 0.7^{b}	7.9 ± 0.2^{b}
Cg + EEHg$_{500}$	6-7	138.7 ± 11.2^{b}	9.2 ± 1.3^{b}	8.6 ± 0.5^{b}

Each value represents the mean ± S.E.M. of 6–8 animals. Dexamethasone (Dex) administered orally, 0.5 mg/Kg was used as a reference anti-inflammatory (positive control). Basal = animals that received injection of saline in the scrotal pouch (Sal + Sal), Cg = carrageenan, Sal = 0.9% saline, DMSO = 16% dimethylsulfoxide, EEHg = ethanol extract of *Helicteres gardneriana*. $^{a}P < 0.05$, compared to basal group. $^{b}P < 0.001$, compared to the groups Cg + Sal and Cg + DMSO (one-way ANOVA, Tukey's test).

number of leukocytes migrated to the cavity, compared to basal parameters (obtained from normal animals that received an injection of PBS in the cavity) (Vol. exudate: basal = 0.1 mL; Cg + Saline = 0.91 ± 0.07 mL; Cg + DMSO = 0.9 ± 0.07 mL; number of leukocytes/mm^3: basal = 6700 ± 450; Cg + Saline = 59800 ± 4810; Cg + DMSO = 60270 ± 3910). Treatment of animals with EEHg (500 mg/kg, p.o., administered 30 min prior to carrageenan injection) significantly reduced the volume of the inflammatory pleural exudate (31% $P < 0.001$) and the number of migrated polymorphonuclear leukocytes (30% $P < 0.001$). Treatment of the animals with dexamethasone caused a pronounced reduction in the volume of the exudate (73% $P < 0.001$) and in the number of migrated leukocytes (53% $P < 0.001$). The results are presented in Table 1.

3.2. Effect of EEHg on the Total Concentration of Nitric Oxide Present in Pleural Exudates. As expected, NO levels increased in the inflammatory pleural exudate of control rats pretreated with 0.9% saline or 16% dimethylsulfoxide, p.o., 30 min before intrapleural carrageenan injection (Basal, 10.1 ± 1.2 μM; Cg + Sal, 32.5 ± 2.3 μM; Cg + DMSO, 31.6 ± 1.8 μM). Treatment of animals with the EEHg did not significantly change NO concentrations in inflammatory pleural exudates (Cg + Hg$_{500}$, 28.1 ± 1.1 μM).

3.3. Effect of EEHg on Rolling, Adhesion, and Migration of Leukocytes in the Microcirculation of Spermatic Fascia In Situ. Intradermal injection of carrageenan into the wall of the scrotal chamber of animals pretreated orally with 0.9% saline (Cg + Sal) or 16% dimethylsulfoxide (Cg + DMSO) induced an acute inflammatory response characterized by an increase in rolling leukocytes, adherence of leukocytes to vascular endothelial, and migration of leukocytes to the perivascular space 2 and 4 h after induction of a local inflammatory reaction compared with the baseline (obtained from normal animals that received saline injection in the scrotal chamber). Treatment of animals with EEHg (500 mg/kg) reduced the number of rolling leukocytes (84.0%) and the number of adherent leukocytes (90.7%) 2 h after stimulation with carrageenan. The same treatment reduced the number of leukocytes that migrated to the tissue adjacent to postcapillary venules (90.5%) 4 h after stimulation with carrageenan. Dexamethasone caused total inhibition of the number of rolling and adherent leukocytes and almost complete inhibition of the number of migrated leukocytes (97%; Table 2).

4. Discussion

The search for new drugs that effectively interfere with the inflammatory process continues to be important. In the present study, the anti-inflammatory activity of orally administered EEHg was evaluated in models of carrageenan-induced pleurisy and microcirculation *in situ* by injecting carrageenan into the scrotal chamber of rats.

The model of pleurisy has been extensively used to investigate the mechanisms involved in acute inflammation and to evaluate the effectiveness of drugs with anti-inflammatory properties [25, 29]. As expected, in our experiments, intrapleural carrageenan injection caused an accumulation of pleural exudate, accompanied by intensive migration of inflammatory cells into the pleural cavity. Oral administration of the EEHg significantly reduced the volume of pleural exudate that accumulated in response to carrageenan injection. Furthermore, treatment with the extract also inhibited the migration of polymorphonuclear cells but was not effective at reducing the number of mononuclear cells in the pleural cavity. Similarly, in previous studies, we found that the EEHg was also able to strongly reduce the migration of neutrophils in a mouse model of ear edema induced by croton oil, demonstrated by a reduction in myeloperoxidase activity [20].

The pronounced effect of the EEHg in experimental models of inflammation encouraged us to investigate its effect on the process of leukocyte migration to the inflammatory site. To our knowledge, few studies have demonstrated the inhibitory actions of plant extracts on leukocyte-endothelial interactions in microcirculation [30]. This process is complex and involves a sequence of molecular-mechanical events on leukocyte and endothelial cells, including rolling, arrest, adhesion, and transendothelial diapedesis. These events require reciprocal interactions between molecules in neutrophils and endothelial cells, in addition to the production of inflammatory and chemotactic mediators that modulate the recruitment of neutrophils [31].

In the present study, the data obtained show that the EEHg markedly inhibits the rolling behavior of leukocytes, their subsequent firm adherence to the vessel wall, and the cell migration after application of an inflammatory stimulus. Therefore, the inhibitory effect of EEHg on the process of exudation (edema) and cell migration suggests that it might exert effects on the chemical mediators involved in the vascular response and the chemotaxis process. Additionally, neutrophils adhering to the vessel wall secrete a number of enzymes and chemical mediators that contribute to edema formation [32, 33], which is consistent with subsequent studies that have demonstrated impairment of the acute increase in vascular leakage in animals depleted of neutrophils [34, 35].

Therefore, we hypothesized that the impairment of neutrophil interactions with the vessel wall contributes to reduced edema in animals treated with EEHg, indicating that the interaction of leukocytes with the vessel wall is an important mechanism underlying its anti-inflammatory effects. Importantly, the anti-inflammatory effect of EEHg extract was observed in different tissues, possibly involving an inhibitory effect on different chemical mediators, and thereby suggesting systemic activity. However, we could not precisely determine which mediator or proinflammatory agent is inhibited by the extract. In the pleurisy model, the possibility of an effect on NO generation may be discarded because EEHg did not alter total NO concentration in the pleural exudate. Experiments are underway to assess the mechanism by which the active components of the *Helicteres gardneriana* extract exert their anti-inflammatory effects.

Conflict of Interests

The authors declare that they have no conflict of interests.

Authors' Contribution

J. O. de Melo carried out the main experiment and participated in the drafting of the paper. S. Baroni, L. L. M. de Arruda, M. C. T. Truiti assisted materially in obtaining the extracts, and S. M. Caparroz-Assef contributed in the experimental assays, R. K. N. Cuman provided important comments in the paper, and C. A. Bersani-Amado conceived of the study and participated in its design, coordination, and elaboration of the final paper. All the authors read and approved the final paper.

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Review Article

Natural Products from Ethnodirected Studies: Revisiting the Ethnobiology of the Zombie Poison

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Wade Davis's study of Haitian "zombification" in the 1980s was a landmark in ethnobiological research. His research was an attempt to trace the origins of reports of "undead" Haitians, focusing on the preparation of the zombification poison. Starting with this influential ethnopharmacological research, this study examines advances in the pharmacology of natural products, focusing especially on those of animal-derived products. Ethnopharmacological, pharmacological, and chemical aspects are considered. We also update information on the animal species that reportedly constitute the zombie poison. Several components of the zombie powder are not unique to Haiti and are used as remedies in traditional medicine worldwide. This paper emphasizes the medicinal potential of products from zootherapy. These biological products are promising sources for the development of new drugs.

1. Introduction

Ethnopharmacological studies have been extensively discussed as a promising strategy for development and discovery of new medical and pharmaceutical products [1]. Ethnopharmacology relies on accumulated cultural experiences with nature to aid in identifying bioactive molecules. There is evidence that ethnographically directed studies may be more efficient than other bioprospecting strategies; however, most of these studies have focused on the use of plants [1]. Gertsch [2] has argued that many of the pharmacological activities attributed to natural products are merely artifacts from data extrapolations, particularly in *in vitro* studies [3], and unreliable assays. This suggests a basic question: why have pharmacological investigations of thousands of plants and animals yielded so few products? One of the main reasons is a disconnection between investment and research; the large investments made for screening these compounds are not matched by those for research.

These findings emphasize the diversity of molecules and commercial drugs that result from ethnographically directed investigations. Such research, despite its potential for developing new drugs, has not attracted significant amounts of investment. Coordinated efforts to advance this mode of drug discovery are in their initial stages. Significantly, increasing numbers of leads are derived from animal products [4], although ethnodirected efforts related to the fauna are still scarce.

Like plants, animals have been a source of medicinal treatments since antiquity. Their presence in the pharmacopoeia of traditional populations [5] is considered universal by many researchers. The hypothesis of universal zootherapy, for example, postulates that every human culture that has developed a medical system utilizes animals as a source of medicine [6].

The ubiquity of animals in folk medicine is illustrated by studies of ethnobiology worldwide [7–11]. These studies, which have attracted increasing academic interest in recent years, have found a great deal of diversity in the animals used for therapeutic purposes, including insects [12, 13], vertebrates [7, 14, 15], and marine invertebrates [16, 17]. Studies of medicinal animals can assist in pharmacological screening and may serve both as a source of medicine and as a measure of economic value for these species [18].

In a review of new drugs from natural products, Harvey [19] reported 24 drugs based on animals and 108 based on plants, which suggests that animals are still poorly studied. Moreover, many pharmacological studies of animals did not report use of ethnographic information [20, 21].

This work examines the state of ethnodirected pharmacology in two ways. First, based on anthropologist Wade Davis's 1986 description, the components of the traditional Haitian "zombie powder" poison were studied. For the animal species involved in the poison preparation, we examine nomenclatural changes, geographic distributions, origins, ecological data, and conservation status. For the plants involved, we briefly review their current ethnobotanical uses, phytochemistry, and pharmacology as measures of the progress made since the Davis' report. We also discuss how ethnographic information about animal-derived medicines is used in present-day pharmacology and the relative scarcity of animal-derived products in natural product libraries. This paper suggests that traditional knowledge about animals can assist in locating potential therapeutic agents and is expected to fill gaps in knowledge about the traditional use of this resource.

Published ethnopharmacological reports regarding medicinal animals and plants were analyzed. For animals, reports and secondary documents describing medicinal animal use and pharmacological reports describing the use of traditional zoological products were used. Documents were obtained from Science Direct (http://www.sciencedirect.com/), Scirus (http://www.scirus.com/), Google Scholar, Scopus (http://www.scopus.com/), Web of Science (http://www.isiknowledge.com/), and Biological Abstracts (http://www.science.thomsonreuters.com/) using the following search terms: "Zootherapy + Biochemistry," "Ethnozoology + Bioactive compounds," "Ethnozoology + Biochemistry," "Medicinal animals," "Ethnozoology + Pharmacology," and "Ethnopharmacology + Animals." Review papers were excluded. A database characterizing the general profile of the studies and aspects related to the animal's popular and pharmacological uses was assembled. In some cases, the studies dealt with pharmacological analyses of more than one animal species, but only provided information regarding the popular use of one. In these cases, only species with both pharmacological and popular use data were incorporated into the database.

Ethnobotanical, phytochemical, and pharmacological information describing each of the plant species described by Davis [22] was assembled. First, the Scirus database (http://www.scirus.com/), which includes Science Direct, MedLine, and PubMed and Google Scholar were searched using the search terms "[*scientific species name*] AND ethnobotanicals," "[*scientific species name*] AND pharmacology," "[*scientific species name*] AND chemical composition", and "[*scientific species name*] AND molecules;" review articles were also considered. Patent records were searched using the Scirus database with the search terms "[*scientific species name*] AND medicine" and "[*scientific species name*] AND drugs." For species with few related scientific studies, we also performed a supplementary search at the Natural Products Alert database (NAPRALERT). It is not our intention to present an exhaustive review of the secondary literature, but rather to give an overview of the literature pertaining to these species.

2. Ethnobiology of the Zombie Poison

2.1. Landmark: Wade Davis—The Serpent and the Rainbow. Travel narratives are a longstanding source of information about America's peoples and environment. Foreign visitors undertook the process of developing a nomenclature for the newly discovered regions. In the 1980s, writing in this mode, Davis contributed a landmark piece of ethnopharmacological research.

Davis was born in BC, Canada, in 1953. He studied at Harvard the University, where he graduated with a doctorate in ethnobotany. He studied various Indian tribes, providing him with wide-ranging experience and making him a renowned ethnobotanist and photographer [23]. He has written and continues to publish books and scholarly articles. One of his major contributions involves his ethnopharmacological study of "zombie poison."

This research began after Davis had completed his studies at Harvard and returned there as an assistant to Richard Evans Schultes. Schultes, a professor at the Botanical Museum of Harvard, studied the ethnobotany of the Indians of Northwest Amazon. He was particularly interested in medicinal plants, particularly hallucinogens, seeing such study a possible source of new medicines.

In 1982, Schultes asked Davis to travel to Haiti to "initiate the search for the Haitian zombie poison" [22] and to develop research suggested by Nathan Kline, a psychiatrist studying psychopharmacology, and Heinz Lehman, the director of the Department of Psychiatry and Pharmacology at the McGill University. Kline told Davis, "if we could find a new drug that the patient became deeply insensitive to pain and paralyze him, and another to return him harmlessly to normal consciousness, this would revolutionize modern surgery" [22]. Lehman added, "That's why we meet to investigate all reports of potential anesthetic agents. We must look more closely at this supposed zombie poison, if it exists"

[22]. Kline affirmed that the "undead" [22], or "zombies," were victims of Vodou practitioners.

Davis hypothesized the existence of an anesthetic, which, administered in adequate dosage, would reduce the metabolism of the victim to the point that he or she would be considered dead. However, the victim would remain alive and could be revived with the administration of an antidote. Such a drug would have broad medical and pharmacological potential. At the time, this process even attracted the interest of NASA as a model of artificial hibernation [22].

Davis aimed to discover "the frontier of death" [22], as Lehman put it. He traveled to Haiti to find Voodoo practitioners and obtain samples of the zombie poison and antidote, observing Voodoo preparation and recording their use. Davis stood out among ethnobotanists for his work on the "zombification" process, in which he strove to be systematic and objective. His work described and contextualized the process, its mystique, and the animal and plant species involved. This research forms the foundations of our knowledge of the anesthetic contained in the zombie poison.

Davis' travel chronicle, *The Serpent and the Rainbow* [22], provided important insights and observations about this phenomenon. He described it as "an elusive phenomenon that [he] had difficulties to believe" [22]. His investigations of the zombie phenomenon were of great technical, scientific, and marketing relevance. Davis describes zombification in long passages of his narrative, leaving a rich commentary on what he saw.

2.2. Zombification: Theory and Practice. Since 1915, when Haiti was occupied by the United States of America, zombification has attracted interest in western culture [22, 24]. From the standpoint of western psychiatry, a "zombie" is defined as a female or male individual that has been poisoned, buried alive, and resurrected. These individuals manifest symptoms that would be classified as a catatonic schizophrenic, characterized by inconsistency and catalepsy, alternating between moments of stupor and activity [22]. As described by Davis, the word "zombie" had meaning rooted in the culture and beliefs of the Haitian peasant society. "*Precisely the Haitian definition of zombie [is of] a body without character, without will*" [22]; a zombie is "undead" [25] and in a state of lethargic coma. A zombie, in this sense of the word, is identified through its lifeless expression, nasal intonation, and repeated and limited actions and speech.

"Zombification" is a religious practice related to Voodoo. From the perspective of Voodoo, zombies are created by witchcraft, an essentially magical phenomenon. These beliefs regarding the natural and supernatural worlds developed over Haiti's history of colonization and intermarriage and are a synthesis of the religious beliefs of Haiti's original inhabitants with those of African origin and European Christianity [26, 27]. The zombie poison powder was controlled by Haitian secret societies with roots in West Africa. The poison was and still is used as a form of sanction for those who "violated the codes of society". In Haiti, zombies are not themselves considered objects of fear; rather, popular fear focuses on becoming a victim of zombification [22, 28].

In Haiti, the estimated number of new zombifications exceeds one thousand cases per year [28]. Despite its apparent prevalence, Haiti classifies this practice as criminal activity tantamount to murder (Article 246 of the Criminal Code of Haiti).

In his publications, Davis suggested that zombies in Haiti were "produced, made," in contrast to the image of folkloric zombies [29]. He showed the existence of zombies using the rational methods of western science, revolutionizing the ethnographic narrative when placed in the first person [29]. Reflecting on his research on the zombie poison, Davis said: "*[...] it is implied that its main chemical components had to be topically active. For descriptions of wandering zombies, it seemed likely that the drug induces a prolonged psychotic state, whereas the initial dose had to be capable of causing a stupor similar to death. Since, in all probability, the poison was an organic derivative, its source had to be a plant or an animal commonly found in Haiti. Finally, whatever was the substance, it should be of an extraordinary power.*"

Davis was especially interested in the plant and animal species used to prepare the poison: "*[carried] a kaleidoscopic Haitian bag built of empty cans of soda. The specimens that I filled included lizards, a polychaete worm, two marine fish and numerous tarantulas—all preserved in alcohol—as well as several bags of dried plant material. Two bottles of rum contained the antidote, while the poison itself was in a glass jar [...]*" [22]. He later added: "*If the mystery of the zombie phenomenon had to be resolved, these specimens were the most important clues. Without them, there was nothing concrete.*"

Davis' descriptions of zombification continue to have great relevance as records of the process of bringing a person apparently dead to life and have come to play an important role in the pharmaceutical industry's understanding of ethnography as a source of new drugs. Within this context, Davis' publications provoked a great deal of controversy in the foreign press. Most reports suggested that his writing combined folklore, culture, ethnobotany, and pharmacology [29, 32]. Similarly, many reported, often with a tone of censure, that Davis caricatured Voodoo as a closed cultural system, ignoring changes since its formation in the eighteenth century [29, 33].

There are many descriptions of zombies and the practices surrounding zombification, ranging from scientific reports and doctoral dissertations to popular movies, computer games, magazines, websites, and numerous other forms of cultural expression [26, 34, 35]. References to zombies can even be found in computing, biotechnology, and artificial intelligence [29].

2.3. Composition of the Zombie Poison. As noted throughout the text, many interesting issues surround zombification. We have highlighted several of these issues in Davis' report. Davis' interdisciplinary approach included documenting the formulations of the zombie poison and antidote [24]. He helped to develop the field of ethnobiology by answering questions as an interdisciplinary ethnobiologist that could not be answered with other modes of inquiry.

During his field research in Haiti between 1982 and 1984, Davis learned of eight distinct zombie poison formulations and assisted in their preparation *in loco*. At the time, he had two main informants: Marcel Pierre, "*an old and faithful follower of Francois Duvalier*" [22], and Herard Simon.

From Pierre, Davis learned of a poison preparation that contained plant and animal material from five distinct species. The preparation related by Simon contained 15 species encompassed in 13 genera, and his account included the administration of a preparation based on *Datura stramonium* L. (Solanaceae) after zombification. Only Pierre revealed the composition of an antidote, which contained plant material from five species, including a plant only identified by its genus (see Table 1).

Here, we do not present a complete account of the scientific research surrounding zombification, nor do we address the controversy surrounding the "truth" of this practice. This paper instead aims to recover the composition of the zombie poison, as reported by Davis, and survey our knowledge of each of its components (with emphasis on animal-derived products) and its implications for the development of new drugs. Davis' narrative serves as a platform to discuss the utility of ethnobiological study.

3. Survey of the Current Components of the Zombie Poison and Antidote

3.1. Plants. Plant species are the most widely used sources in folk medicine, with thousands of species used around the world. (In some cases, the specific plant parts used in the poison have not been investigated in chemical and pharmacological studies. The specific plant parts used to prepare the zombie poison are not known for all species.)

3.1.1. Albizia lebbeck (L.) Benth. Davis' informants cited *A. lebbeck* as a major component of the zombie poison. Pierre's preparation employed the fruit, while Simon's included the seeds [22]. In various populations in India, the juice of the roots of *A. lebbeck* combined with those of the leaves and bark of *Diospyros peregrine* is used to treat snake bites [36], asthma [37], diseases related to vision, night blindness, pyorrhea, toothache, insect and scorpion bites [38], disorders related to male fertility [39], wounds, leprosy injuries [40], and various inflammatory conditions [41].

Extracts of *A. lebbeck* stem bark contain tannins, flavonoids, anthraquinones, saponins, steroids, terpenoids, and coumarins [41, 42]. Ethanolic extracts and petroleum ether were tested against four models of inflammation in rats (carrageenan, dextran, Freund's adjuvant, and cotton pellet) and administered at a dose of 400 mg/kg. The substances gave inhibitions ranging from 34.46% to 68.57% [41]. The aqueous extract of *A. lebbeck* showed antimicrobial activity against nine different microorganisms [43]. The methanol extract of the bark administered to rats affected levels of testicular androgens by altering spermatogenesis [44], and the saponins present in the bark interfered with fertility in rats [45]. Antispermatogenic and antiandrogen activities are related [44, 46]. A protein called lebbeckalysin, isolated from the seeds, has antitumor, antibacterial, and antifungal activities [47]. There are dozens of patents involving this species and its chemical components (such as a set of herbs with antiallergenic properties, international publication number WO 2006067802 A1).

3.1.2. Aloe vera (L.) Burm. f. The antidote described by Pierre included the leaves of the *Aloe vera* plant [22]. These leaves are used to treat leukorrhea [48], hypertension, heartburn, cancer, dandruff, stomach problems, hair loss, bruises, rheumatism, intestinal helminthes, and inflammation and are also used as an emollient [49]. This species is also used to aid in the healing process [50].

This plant contains diverse chemical compounds, including anthraquinones, carbohydrates, enzymes, proteins, vitamins, and hormones, of which several exhibit pharmacological activity [51, 52]. Extracts and chemical components of *A. vera* have shown immunostimulant, antimicrobial, antidiabetic, anti-inflammatory, wound healing, antioxidant, anticancer, hepatoprotective, and skin moisturizing effects, as well as utility in treating skin diseases [51, 52]. This species is used in pharmaceutical, hygienic, and cosmetic products [51]. Out of all the species discussed here, *A. vera* is represented in most patents. For instance, patent WO 2006055711(A1) describes a preparation containing *A. vera* for treatment of neurological syndromes, chronic pain, inflammatory bowel disease, and viral infections.

3.1.3. Anacardium occidentale L. Simon cited *A. occidentale* as a component of the zombie poison [22]. This species is widely used in human food and is available commercially in processed food products. Davis [24] reported that this species was traditionally used as a purgative, diuretic, febrifuge, and cough treatment. The leaves and stem bark are used to treat diarrhea, kidney infection, heartburn, inflammation of the female organs, tuberculosis, general inflammation, and diabetes and was also used as an antiseptic [49].

A. occidentale's leaves contain tannins, flavonoids, and saponins [65]. The hydroalcoholic extract of the leaves did not produce toxic symptoms in rats at doses up to 2000 mg/kg [65] and showed antiulcer activity [66]. Anacardic acid, a phenolic compound, has not produced biochemical or hematological changes in rats at doses below 300 mg/kg [67] and has shown antioxidant activity [68] and cytotoxic activity against leukemic cells by inducing apoptosis [69]. Anacardic acid derivatives have been patented as antimicrobial agents (WO2008062436A2).

3.1.4. Mucuna pruriens (L.) DC. The fruit of *M. pruriens* was employed in the poison described by Pierre [22]. In India, its seeds are ground with almonds and ingested to treat sexual debility and rheumatism and are also used as a tonic [38]. Haitians use these plants to treat parasitic infections; a teaspoon of the hair of the *M. pruriens* fruit (which contains formic acid and mucunaina) mixed with *Psidium guajava* L. is taken before breakfast for three days, causing severe diarrhea that eliminates worms from the intestine and stomach [70].

The seeds of *M. pruriens* contain alkaloids [71], phenolic compounds, tannins, L-dopa, lectins, protease inhibitors,

Table 1: Components of the poisons and antidotes used for zombification, as related to Davis by informants Marcel Pierre (MP) and Herard Simon (HS).

Local name	Species	Family
Poison—MP		
Plants		
Pois-Gratter/Mucuna	*Mucuna pruriens* (L.) DC.	Fabaceae
Tcha-tcha	*Albizia lebbeck* (L.) Benth.	Fabaceae
Amphibian		
Cane toad	*Rhinella marina* (Linnaeus, 1758)	Bufonidae
Fishes		
Crapaud de mer	*Sphoeroides testudineus* (Linnaeus, 1758)	Tetraodontidae
Fou-fou	*Diodon hystrix* (Linnaeus, 1758)	Diodontidae
Antidote—MP		
Plants		
Aloe	*Aloe vera* (L.) Burm. f.	Xanthorrhoeaceae
Bois ca-ca	*Capparis cynophallophora* L.	Capparaceae
Bois chandelle	*Amyris maritima* Jacq.	Rutaceae
Cadavre gâte	*Capparis* sp.	Capparaceae
Cedar	*Cedrela odorata* L.	Meliaceae
Roughbark Lignum-vitae	*Guaiacum officinale* L.	Zygophyllaceae
Poison—HS		
Plants		
Ave	*Petiveria alliacea* L.	Phytolaccaceae
Bayahonda	*Prosopis juliflora* (Sw.) DC.	Fabaceae
Bresillet	*Comocladia glabra* Spreng.	Anacardiaceae
Bwa piné	*Zanthoxylum martinicense* (Lam.) DC.	Rutaceae
Cana muda	*Dieffenbachia seguine* (Jacq.) Schott	Araceae
Consigne	*Trichilia hirta* L.	Meliaceae
Maman guêpes	*Urera baccifera* (L.) Gaudich. ex Wedd.	Urticaceae
Mashasha	*Dalechampia scandens* L.	Euphorbiaceae
Pomme cajou	*Anacardium occidentale* L.	Anacardiaceae
Tcha-tcha	*Albizia lebbeck* (L.) Benth.	Fabaceae
Amphibian		
Hispaniolan common treefrog	*Osteopilus dominicensis* (Tschudi, 1838)	Hylidae
Cane toad	*Rhinella marina* L.	Bufonidae
Fishes		
Fugu	*Sphoeroides testudineus* (Linnaeus, 1758)	Tetraodontidae
Fugu	*Sphoeroides spengleri* (Bloch, 1785)	Tetraodontidae
Fugu	*Diodon hystrix* (Linnaeus, 1758)	Diodontidae
Fugu	*Diodon holocanthus* (Linnaeus, 1758)	Diodontidae
"Postzombification paste"—HS		
Plants		
Zombie cucumber/stramonium	*Datura stramonium* L.	Solanaceae

and saponins [72]. This species has shown antioxidant and chelating activities [73]. The ethanolic extract of these seeds showed aphrodisiac activity in male rats with no adverse effects or ulceration at a dose of 200 mg/kg [74]. Clinical studies have shown that *M. pruriens* regulates steroidogenesis and improves semen quality in men with infertility [75]. Studies have shown this species to be an effective treatment for Parkinson's disease *in vivo*; this activity could be related to the presence of L-dopa, an important drug for the treatment of Parkinson's disease [76–78]. The aqueous extract of its seeds has shown hypoglycemic effects [79]. The seeds have also been shown to be beneficial treatments for venomous snake bites [80, 81]. *M. pruriens* extract has been patented for the treatment of Parkinson's (WO 2005092359 A1).

3.1.5. Prosopis julifiora (Sw.) DC. P. julifiora was a component of the poison described by Simon [21]. Brazilian sources record the use of this species' leaves for the treatment of skin diseases [49], asthma, bronchitis, conjunctivitis [82] fever, warts, gonorrhea, eye problems, parasites, diarrhea, and ulcers [83–88].

This species contains steroids, alkaloids, coumarins, flavonoids, sesquiterpenes, and stearic acid [89]. The hydroalcoholic extract of its pollen had antioxidant activity both *in vivo* and *in vitro* [89]. The alkaloid fraction from its leaves has been observed to have significant effects on glial cells, inducing cytotoxicity, reactivity, and nitric oxide production [90]. Moreover, it has shown antipyretic, diuretic, antimalarial, antibacterial, hemolytic, and antifungal activities [85, 91–95]. No drug patents involving this species or its constituents were found.

3.1.6. Capparis cynophallophora L. The leaves of *C. cynophallophora* were part of Pierre's antidote preparation [22]. It has been used to treat cough, pneumonia, flu, digestive problems, skin diseases, abdominal pain, rheumatism, snakebites, and digestive problems and has also been used as an emmenagogue [49, 96]. Two common flavonoids, kaempferol and quercetin, have been isolated from this species [97]. Oliveira et al. [9] reported that these flavonoids may exhibit antinociceptive activity [9]. This species was not found in any registered patents.

3.1.7. Zanthoxylum martinicense (Lam.) DC. Simon's poison preparation included *Z. martinicense* [22]. Davis [24] reported that, in Cuba, the leaves and bark of this plant were used as a tonic and to treat syphilis, rheumatism, and alcoholism. It has also been reported to act as an antispasmodic, rheumatism treatment, diuretic, and narcotic [98, 99]. A phytochemical screening revealed the presence of isoquinoline alkaloids, triterpenes/steroids, lignans, quinones, lactones/coumarins, tannins/phenols, and saponins [100, 101]. The plant showed antifungal activity against two microorganisms, *Microsporum canis* and *Trichophyton mentagrophytes* [102]. There were no registered patents for this species.

3.1.8. Guaiacum officinale L. G. officinale was used in the antidote described by Pierre [22]. Records of Caribbean natives using this species as a treatment for reproductive problems date back to the 16th century [103]. It has also been used to treat inflammation of the stomach, inflammatory diseases of respiratory organs, rheumatism, amenorrhea, and gonorrhea and has been used as a laxative, anticonvulsant, cardiac depressant, diuretic, diaphoretic, chronic, expectorant, abortifacient, diuretic, purifying treatment, and antidote for accidental poisoning [95, 104–110]. Its chemical composition includes triterpenes, alkaloids, and various guaianins [111, 112]. Its extracts have shown *in vitro* and/or *in vivo* stimulant activities for smooth muscle, as well as abortifacient, diuretic, antimicrobial, anti-inflammatory, and spasmolytic activities [113–117]. This species is included in several patents; in one example, its prepared extract was patented to treat skin inflammation and psoriasis (EP1832294A1).

3.1.9. Trichilia hirta L. In Simon's account, *T. hirta* was used to prepare the poison [22]. Davis [24] reported the use of its leaves to treat anemia, asthma, bronchitis, and pneumonia and as a tonic in Cuba. It contains steroids and triterpenes [118–120]. Its methanolic extract showed no antibacterial activity against the organisms *Escherichia coli* and *Staphylococcus* [121], but antimalarial and larvicidal activities were reported [122]. This species was not found in any patents.

3.1.10. Petiveria alliacea L. P. alliacea was cited by Simon as a component of the zombie poison [22]. A substance found in this species, dibenzyl trisulphide, exhibits antitumor and immunomodulatory activities [123]. The extract displayed several mechanisms of action that may explain its antitumor activity, such as cell cycle arrest in G2 phase, induction of cytoskeletal reorganization and DNA fragmentation [124]. The benzyl trisulfide and benzyldisulfide fractions of the plant's crude extract showed acaricidal activity in *Rhipicephalus* (*Boophilus*) *microplus* [125]. Several compounds isolated from this species have antibacterial and antifungal activities [126, 127]. The extract of *P. alliacea* showed promise as a wound treatment [128]. Fractions of the extract of this species also showed depressant activity in mice [129], and anti-inflammatory and analgesic effects have also been reported [130]. A product that includes the patented dibenzyl trisulphide compound was indicated for the treatment of cancer (20080070839 A1).

3.1.11. Urera baccifera (L.) Gaudich. U. baccifera was cited by Simon as a component of the zombie poison [22]. It is used as an emmenagogue and to treat persistent fever, skin infections, snakebites, aches and pains, rheumatism, inflammation, arthritis, gastrointestinal disorders, and gonorrhea [85, 131–135]. It has anti-inflammatory and analgesic activities *in vivo* [136]. Its extract did not show pronounced leishmanicidal activity [135]. No patents relating to this species were found.

3.1.12. Cedrela odorata L. C. odorata was a component of the zombie poison antiotde described by Pierre [22]. This astringent plant is used to treat pain, malaria, fever, aches, atonic seizures, anemia, gangrene, diarrhea, abdominal pain, chills, edema, vertigo, coughs, malaise, gastrointestinal pain, leishmaniasis, stroke, tooth pain, numbness after an insect bite, and erysipelas and is used as an abortifacient and vermifuge [63, 122, 137–141]. Several compounds have been isolated from this species, including sesquiterpenes, triterpenes, flavonoids, steroids, and limonoids [142–145]. No patents related to this species were found.

3.1.13. Dieffenbachia seguine (Jacq.) Schott. D. seguine was among the components of Simon's zombie poison preparation [22]. This plant is considered toxic in many parts of the world. However, it is used as a choleretic, female aphrodisiac and contraceptive and to treat dropsy, gout, dysmenorrhea, sexual impotence, and sterility [98, 146–149].

Tannins, alkaloids, terpenoids, steroids [150], triterpenes, and a great variety of lipid compounds [151] have been reported in the extracts of *D. seguine's* leaves. These extracts showed weak antiproliferative activity on a human colon cancer cell line with IC_{50} >50 μg/mL [150]. The sap of this species contains toxic metalloproteins that cause necrosis at the site of contact. A patent describing the use of plant substances, including a substance from species *D. seguine*, as spermicidal and anti-infective agents and as prophylactics against sexually transmitted diseases and the human immunodeficiency virus has been filed (WO 2007074478 A1). Other studies have reported vasodilator, hypotensive, antifertility, contraceptive and/or interceptive, and spasmogenic activities [152–155].

3.1.14. Datura stramonium L. In Simon's account, he indicated that *D. stramonium*, among other ingredients, was administered after removal of a zombie from the grave [22]. This species is commonly used to treat asthma and as a hallucinogen. Sixty-seven unique tropane alkaloids have been detected in its extract. At certain concentrations, this plant is known to induce delusions and altered mental states [156]. Agglutinin, a lectin isolated from *D. stramonium*, inhibited proliferation and induced differentiation in glioma cells [157]. There are thousands of patents related to scopolamine (a commercialized pharmaceutical product) directly or indirectly. One example of these is a European patent application for the treatment of depression and anxiety (WO 2006127418 A1).

3.1.15. Dalechampia scandens L. D. scandens was a component of Simon's zombie poison preparation [22]. It is used to treat cough and flu [122], and cytotoxic activity has been reported [158]. No patents related to this species were found.

Comments. Plants have been the main source of molecules for the development of new drugs. Cragg et al. [159] reported that "more than 60% of anticancer agents used are derived from natural products." Significant plant-derived medicinal substances include elliptinium, etoposide, irinotecan, taxol, vincristine, and teniposide, among others [159].

Generally, the components of the poison by Pierre and Simon [22] would be expected to have toxic effects, while those of the antidote might have beneficial effects (detoxifying, hepatoprotective, or immunomodulatory activities, e.g.).

M. pruriens, P. alliacea, U. baccifera, D. seguine, and *D. stramonium* were all cited as poison components. The seeds of *M. pruriens* have been shown to be effective in *in vivo* studies and clinical trials for the treatment of Parkinson's disease and contain a compound that is commercially exploited for this purpose [160]. The extract of *M. pruriens* and specifically L-dopa has proven effective in the treatment of many symptoms, such as tremor, difficulty in movement, difficulty walking, and depression, in the pathology of Parkinsons. *P. alliacea* and *U. baccifera* show analgesic activity [22]. *D. seguine* may facilitate the absorption of the bioactive substances of the poison, because this species causes irritation in the epidermis. The studies also indicate that *D. stramonium* is a potent hallucinogen; this activity may be due to anticholinergic activity triggered by its tropane alkaloids, such as hyoscyamine and scopolamine, which may be metabolized into atropine.

A. vera used as an antidote may be due to any number of its observed beneficial properties, including immunostimulant, antioxidant, and hepatoprotective activities.

A sizeable obstacle in understanding the pharmacological mechanisms and effects of the zombie poison is the disparate chemical and pharmacological components in its preparation. This diversity makes it difficult to disentangle each species' specific role. Such preparations combining traditional components often act on not only physiological but psychological and spiritual levels. Study of the role of each compound could provide clues about their roles in the poison.

Although the majority of plant species considered here have been the subject of at least one *in vitro* or *in vivo* pharmacological study, and they contain dozens of known bioactive molecules, research on the pharmacological basis of the process of zombification is not conclusive; the role of each of the molecules involved in this process is not yet known. Almost 30 years after Davis' research, there are still many unanswered questions.

3.2. Amphibians. Vertebrate species are among the least-used in folk medicine; approximately 29 species are known to be employed [161, 162].

3.2.1. Rhinella marina (Linnaeus, 1758) (Buga Toad). Rhinella marina (Linnaeus, 1758), also known as the common toad, large buga toad, or cane toad, has undergone several modifications in the genus and epithet (*Bufo marinus* Schneider, 1799; *Bufo marinus* Gravenhorst, 1829; *Bufo angustipes* Taylor & Smith, 1945; *Bufo pythecodactylus* Rivero, 1961; *Bufo marinus* Cei, Erspamer & Roseghini, 1968) but has always been classified within the family Bufonidae [163–166]. This species is native to Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, and Trinidad and Tobago) and South America (Bolivia, Colombia, Ecuador, Guyana, French Guiana, Peru, Suriname, Venezuela, and the southern portion of Brazil) [166–170].

The buga toad was likely introduced into Haiti from explorers' ships or as a biological form of pest control [171, 172]. Because it is aggressive and highly dispersive, this toad is found in both natural and urban environments and is abundant everywhere it is found [173]. It is nocturnal in several ecosystems, including the Amazon rainforest, savanna, humid woodlands, equatorial dry forests, agroecosystems, and urban areas, with population peaks in open and altered areas [173]. It can be found in many microhabitats, such as leaf litter, holes in buildings, falling trees, branches, and leaves [174]. *R. marina's* rising population requires urgent conservation measures to prevent local extinction of native species, and it represents a major threat to frog fauna [164, 175, 176].

Species in the family Bufonidae derive toxic and pharmacological properties from granular glands in their backs [177], which biosynthesize several chemical compounds for protection from predators and microorganisms [178].

These properties make this family valuable as a source of bufotoxins, a class of bioactive molecules [179]. It is also a significant cause of injury for domestic and wild animals, mainly resulting from predation attacks [180]. Substances isolated from the skin of these toads, referred to as "dendrobatid alkaloids," are used as antimicrobial agents, a chemical defense against predators, irritants, hallucinogens, convulsants, nerve poisons, and vasoconstrictors. The alkaloid epibatidine, a painkiller 200 times more potent than morphine, was also derived from this family, being found in some species of poison dart frogs. Other such alkaloids include batrachotoxins (sodium channel activators), histrionicotoxins (noncompetitive blockers of nicotinic channels), decahydroquinolines, various izidines, epibatidine (a potent nicotinic agonist), tricyclic coccinellines, pseudophrynamines, and spiropyrrolizidines (potent noncompetitive blockers of nicotinic channels) [181] and the pumiliotoxin, allopumiliotoxin, and homopumiliotoxin group.

3.2.2. Bufo bufo (Linnaeus, 1758). *Bufo bufo* (Linnaeus, 1758), popularly known as the common toad, is a complex of Bufonidae species. A review of the literature concerning these species is urgently needed, as *Bufo bufo* was synonymized with *Bufo vulgaris* (Laurenti, 1768), which became a null clade in conventional taxonomy [164, 166, 182, 183]. This species was observed first across almost all of Europe (except Ireland), most islands in the Mediterranean, the Middle East (Lebanon, Syria and Turkey), and North Africa (northern coast of Morocco, Algeria, and Tunisia) [182]. Although reported by Davis [22], it is not a native species of Haiti and was likely introduced during the colonization of the Hispaniola during the frequent contact with large vessels originating from the Iberian Peninsula, especially Spain. However, to the best of our knowledge, there are no taxonomic occurrences of this species in Haiti. *Bufo bufo* is a habitat generalist and is found in urban areas, coniferous forests, seasonal forests, woodlands, meadows, and arid environments [184]. It is remarkable for its stable populations in areas where it is endemic. It has therefore attracted little concern from the International Union for Conservation of Nature—IUCN, although it is classified as near-threatened in Spain due to a sharp decrease in its population from constant trampling and climate change [185–187].

3.2.3. Osteopilus dominicensis (Tschudi, 1838). *Osteopilus dominicensis* Tschudi, 1838, a member of the family Hylidae [164, 166, 188, 189], is endemic to Haiti and the Dominican Republic [188, 190, 191] and is found at altitudes from sea level to 2000 m [171, 172, 188, 192]. It is found in lentic water bodies in open environments, forests, and agroecosystems, especially on the edges of permanent or temporary ponds [189, 190]. Like all hylids, its arboreal habits are facilitated by its adhesive discs [177], and it commonly uses bushes as vocalization sites [189, 190]. It is remarkable for its stable populations in areas where it is endemic. It has therefore attracted little concern from the International Union for Conservation of Nature—IUCN, although some studies have detected reductions in some isolated populations [188, 189, 193] and have recommended protection of their reproductive sites as a primary conservation measure [189, 193, 194]. We found no reports of the chemical composition of its skin or pharmacological activity related to this species or species of phylogenetically related genera such as *Osteocephalus* and *Phyllodytes* [164].

Comments. For centuries, the skin of amphibians, especially those of the genus *Bufo*, has been used in traditional Chinese and Japanese medicine [129]. Gomes and Colleagues [129] reported that these skins provide a wide range of bioactive compounds with different therapeutic potentials, including antiprotozoal, antiviral, antineoplasic, cardiotonic, antiarrhythmic, antidiabetic, immunomodulatory, antibacterial, antifungal, sleep-inducing, analgesic, contraceptive, behavior-changing, wound healing, and endocrine activities (other than insulinotropic). The molecules identified include bufogenins, bufadienolides, or bufotoxins, which, interestingly, have chemical structures that interact with the cyanogenic glycosides present, for example, in the plant *Digitalis purpurea* [195]. These authors reported vasoconstrictor activity from the skin secretions of *Rhinella marina* in an experimental model of umbilical artery rings and placental vessels.

The quality and quantity of bufadienolides from this species, for example, vary significantly during ontogenetic development, especially in eggs [196]. Gao et al. [197] found at least 43 compounds in methanol extracts from the genus *Bufo*, including commercial samples. These authors reported, from various sources, that at least 100 compounds have been identified, including bufadienolides and indole alkaloids. Despite reports of potential oncological applications of these substances, their adverse effects, such as cardiotonic action [129], are a source of concern. This cardiotoxicity is widely known, having been recorded for many species, including *Bufo viridis* [198]. Although we have reservations about the records of *Bufo bufo* in Haiti, this species is widely used in traditional oriental medicine. Gao et al. [197] observed, through an analysis of geographical variations, that in many cases the chemical composition of *Bufo* venom did not meet the requirements of Chinese pharmacopoeia.

Davis' informants provided information about the amphibians used to prepare the zombie poison [22]. The two formulations are quite different, both in their components (Table 1) and modes of preparation. Davis reported that both poisons employed both the common toad and the marine toad. He was likely referring to *Bufo bufo* (because in his work, he refers to this species similarly in other contexts) and *Rhinella marina*. One of the poisons also included the skin of the frog *Osteopilus dominicensis*. The ingredients of this poison were highly diverse and caught Davis' attention [22]. From an ethnopharmacologic perspective, the desired activity may be obtained through such additions due to interactions among the drugs present. However, it is also possible that such additions were used only to give importance and status to the manufacturer of the poison, and do not impact its pharmacologic activity.

3.3. Fish. Fish are among the animals most frequently used in traditional folk medicine. At least 110 species of fish in Latin America are used in traditional medical systems [161].

3.3.1. Sphoeroides testudineus (Linnaeus, 1758). Known as the puffer fish, painted puffer fish, or pining puffer fish, *S. testudineus* is found in the western Atlantic from New Jersey to Santa Catarina and is the most abundant species on the Brazilian coast [199–201]. It lives in bays and estuaries, reaching and entering freshwater, and reaches 25 cm in total length [199]. It is reef-associated and may spend its entire life cycle in estuarine waters. It is very abundant in fish assemblages in estuaries and bays [202–204]. This species, like others from the family Tetraodontidae, can as, a defense mechanism, inflate its body through ingestion of water or air. It feeds mainly on crustaceans, mollusks, plants, and invertebrates [205]. It reproduces by external fertilization in open waters by placing eggs on substrates and has a mean total length of 13 cm at sexual maturity [206]. It contains tetrodotoxin, a potent ichthyotoxin found in its skin, liver, and gonads, where it acts as pheromone [207]. This potent neurotoxin, also known as "tetrodox," blocks potential actions in nerves by blocking voltage-gated, fast sodium channels in nerve cell membranes, preventing affected nerve cells from firing. The biological actions of the tetrodox include paresthesias [208] of the lips and tongue, followed by sialorrhea, sweating, headache, weakness, lethargy, ataxia, tremors, paralysis, cyanosis, aphonia, dysphagia, seizures, dyspnea, bronchorrhea, bronchospasm, respiratory failure, coma, and hypotension. In affected organisms, cardiac arrhythmias may precede a complete respiratory failure and cardiovascular collapse [209].

3.3.2. Sphoeroides spengleri (Bloch, 1785). Like *S. testudineus, Sphoeroides spengleri* is also commonly known as the puffer fish or pining puffer fish. *S. spengleri* is distributed in the western Atlantic from Mass, USA to Sao Paulo, Brazil [199, 200]. It is found in shallow waters near the coast that are not exposed to freshwater and is common on reefs. This species has high levels of tetrodotoxin in its muscles, skin, and viscera that constitute a risk to its predators, while the levels in puffer fishes of the genus *Lagocephalus* are smaller, suggesting a lower risk. However, there are no concrete data on this type of poisoning [210, 211]. *S. spengleri* feeds on mollusks, crustaceans, and echinoderms and reaches 15 cm [199]. It is often consumed by fishermen along with species of *Lagocephalus laevigatus* [210, 212], although most are captured for fishkeeping.

3.3.3. Diodon holocanthus (Linnaeus, 1758). Known as spiny puffer fish, *D. holocanthus* is a widely distributed species found in almost all tropical areas of the western Atlantic, from Florida to southern Brazil. This marine species is associated with living reefs and reaches 30 cm [199]. In Brazil, it has been recorded in both shallow and deep coral reefs and always within the substrate, although not in abundance [213]. Spiny puffer fishes are nocturnal and are benthopelagic adults and pelagic juveniles. This species lives alone and feeds on mollusks, sea urchins, and crabs [214]. Members of the family Diodontidae can inflate their bodies by ingesting water or air as a complementary defense mechanism to their spikes. *D. holocanthus* is used in fisheries and is of great importance in fishkeeping [215].

3.3.4. Diodon hystrix (Linnaeus, 1758). D. hystrix, like the species above, is also known as spiny puffer fish. It is found in tropical and temperate regions worldwide. In the western Atlantic, it can be found from Massachusetts to southern Brazil [199]. This fish reaches 60 cm, has a relatively long pelagic stage, and feeds at night, with a diet mainly consisting of clams, crabs, and sea urchins [199]. It inhabits marine environments and lives in coral reefs up to 50 m deep. It lives alone and has nocturnal habits. They feed on invertebrates like sea urchins, gastropods, and hermit crabs [214]. It is not normally used as food, is rarely fished, and is instead used mostly as a commercial fishkeeping species [215].

Comments. Saxitoxin (STX) and tetrodotoxin (TTX), obtained from the above species [216], are considered key components in inducing catalepsy or motor paralysis, fundamental actions of the zombie poison [28].

However, there is evidence that other neurotoxic and cytotoxic substances are involved in zombie poison [216]. Landsberg et al. [217], compiling information from prior reports, reported that while TTXs and STXs are chemically different, they produce similar biological responses in mammals, including tingling and numbness of the mouth, lips, tongue, face, and fingers, paralysis of the extremities, nausea, vomiting, ataxia, drowsiness, difficulty in speaking, and progressively decreasing ventilation efficiency. A comparison of these symptoms with the descriptions of zombification reinforces the hypothesis that these neurotoxins are responsible for the phenomenon.

In a recent review, Zimmer [31] described the mechanisms and actions of TTX on the cardiovascular system of mammals. These actions include, depending on the dose, bradycardia, hypotension, a rapid drop in blood pressure, cessation of breathing, and dissociation/cessation of ventricular contractions. There is a set of clinical criteria for diagnosing TTX exposure; Table 2 compares these symptoms to those symptoms reported by Davis [22] for cases of zombie poisoning. This comparison also reinforces the hypothesis that TTX poisoning plays an important role in zombification.

We do not intend to evaluate the claims on the zombification here, given the complexity and controversy surrounding the issue. As Littlewood and Douyon [28] suggested, there is no single explanation for zombies, but mental disorders and equivocal identification may be plausible explanations. These authors studied three cases of possible zombification occurring between 1996 and 1997 in Haiti. At least two of those cases were equivocal identifications in which families claimed to recognize a deceased relation. Genetic analysis in these two cases showed that the zombies had no kinship with the people who recognized them. On this topic, Littlewood and Douyon [28] wrote, "What is more difficult to understand is the apparent acquiescence of the "returned relative" not only to being a zombie but to being a "relative."" Zombification is therefore a phenomenon that

Table 2: Clinical grading system for TTX poisoning as described by Fukuda and Tani [30] and modified by Zimmer [31].

Clinical grading system	Description of zombification [22]
First, "oral numbness and paraesthesia, sometimes accompanied by gastrointestinal symptoms (nausea)"	Digestive disorders with vomiting.
Second, "numbness of face and other areas, advanced paraesthesia, motor paralysis of extremities, incoordination, slurred speech, but still normal reflexes."	—
Third, "gross muscular incoordination, aphonia, dysphagia, dyspnoea, cyanosis, drop in blood pressure, fixed/dilated pupils, precordial pain, but victims are still conscious."	—
Fourth, "severe respiratory failure and hypoxia, severe hypotension, bradycardia, cardiac arrhythmia, heart continuing to pulsate for a short period."	Pronounced breathing difficulties, pulmonary edema, hypertension, hypothermia, renal failure, and rapid weight loss.

transcends psychopharmacologically and reminds us of the need for understanding social and cultural context. To varying degrees, traditional medicines worldwide interact with a web of relationships beyond medicine and physiology.

4. Medical and Pharmaceutical Implications

TTX has received more attention than other natural marine products due to its potent inhibition of sodium channels. Although biotoxins have been the subject of research for about 70 years, only in the past 10 has significant progress been made [218], as illustrated by the growing number of publications. Until 2007, formulations containing TTX had not been approved for use in the United States [218]. Several patents have been deposited, such as one owned by Wex Pharmaceutical Inc. for the use of TTX and STX in pain management.

Among amphibians, the most studied species is most likely *Rhinella marina* (Linnaeus, 1758), presumably due to its wide distribution and abundance. Until 2000, despite its continued use in traditional Chinese medicine, few studies had been conducted on its pharmacological properties, therapeutic potential, or toxicity [219]. However, interest in TTX and STX has considerably raised this species' profile. Bufadienolides have been reported as excellent cardiotonics and as a possible alternative to drugs available on the market [220]. Nevertheless, to the best of our knowledge, there is only one registered patent in the United States (936 063) for an antifungal and antimicrobial peptide derived from *Bufo bufo gargarizans* (now known as *Bufo gargarizans*) (Cantor, 1842).

The scenario sketched here shows the pharmacological potential of animal toxins. This potential invites scientific investment, especially in the cases above, which are widely distributed and abundant and also display promising and relevant pharmacological activities. Even considering the status that these animals gained from Davis' ethnobiological reports [22] and all the following controversy, progress is slow, despite the obvious potential for the development of new drugs. One issue is that many organisms are studied for their chemistry and biological activity from an ecological and evolutionary perspective. In the next section, we discuss how ethnographical knowledge of folk medicine can be employed, with specific reference to zombie poison.

5. Pharmacological Studies of Animals Used in Folk Medicine

Although research on animal use in folk medicine is still in its initial stages, it has intensified in recent years, especially in Latin America (mainly Brazil and Mexico), Africa, and Asia. These surveys have found an impressive number of animals used in folk medicine. At least 1,500 animal species are known to be used in traditional Chinese medicine [221], and at least 587 are used in Latin America [161]; these numbers are likely to increase dramatically with additional research.

Most medicinal animals used in traditional folk medicine are vertebrates, although significant quantities of invertebrates (mainly insects) are also used. In general, the groups with the largest numbers of medicinal species were mammals, birds, fishes, and reptiles. Amphibians comprise the least common group among medicinal vertebrates. Worldwide reviews report at least 165 species of reptiles [222], 101 species of primates [223], 55 species of bovidae [224], and 46 carnivorous mammals [14, 223] used in traditional folk medicine.

Pharmacological approaches that test the activity of animal products based on traditional knowledge are relatively rare (Table 3). Few studies in the literature use this approach; most ethnopharmacological research is instead focused on plants [19]. However, it is possible that some studies have made use of ethnographic information but did not explicitly state this.

These studies are largely related to animals used in developing countries, with Brazil and China being the targets of four investigations and the medicinal animals of India and Saudi Arabia the focuses of three and one study, respectively. Studies with this approach are more common in developing countries because such countries depend on natural products to satisfy their medical needs [225]. China and Brazil have been reported to have high rates of plant and animal use for medicinal purposes [225], as can be seen in our survey of natural products.

Interestingly, nine of the studies tested the therapeutic activities of products derived from vertebrates (Table 3),

Table 3: Survey of nine pharmacological studies based on folk knowledge of medicinal animals. *While the listed activity was detected, there is no indication that the compound is popularly used for this purpose.

Order	Family	Species	Popular name	Detected activities	Reference
Artiodactyla	Camelidae	*Camelus dromedarius*	Dromedary	Cytotoxicity	[53]
Carnivora	Ursidae	*Ursus thibetanus*	Bear	Anti-inflammatory, anticonvulsant, analgesic	[54]
Carnivora	Ursidae	*Ursus arctos*	Bear	Anti-hepatitis C	[55]
Galliformes	Phasianidae	*Pavo cristatus*	Peacock	Anti-snake venom	[56]
Haplotaxida	Megascolecidae and	*Lampito mauritii*	Earthworm	Anti-inflammatory, antipyretic	[57]
Isoptera	Termitidae	*Odontotermes formosanus*	Termite	Antimicrobial	[58]
Isoptera	Termitidae	*Nasutitermes corniger*	Termite	Antimicrobial	[59, 60]
Perissodactyla	Rhinocerotidae	*Diceros bicornis*	Rhino	Antipyretic	[61, 62]
Squamata	Teiidae	*Tupinambis merianae*	Tegu	Anti-inflammatory, antimicrobial	[63, 64]

while only three works employed invertebrates. This discrepancy is surprising because the regulations regarding vertebrates, even for research purposes, are generally much more restrictive than those for invertebrates. Moreover, vertebrate conservation is a more pressing issue than that for invertebrates [226].

Animal-derived products were assayed most often for antimicrobial activity (4 studies) and inflammatory and antipyretic activities (3 studies each). These three indications are also among the most common tests of efficiency for plant-based therapeutic natural products [227–230]. These tests are common because they are relatively simple, easy to conduct, and inexpensive and because of the high frequency of natural products indicated to treat them; they are well-studied and, therefore, have led to a vast number of natural product treatments.

Despite the prevalence of antimicrobial activity in pharmacological studies, such activity was found only once in vertebrate studies; it was found commonly, however, in studies of invertebrates. The prevalence of antimicrobial activity in invertebrates may be due to syntheses of toxins and other substances that can damage bacterial membranes or decrease their ability to multiply [19]. Some herbivorous invertebrates (such as insects) can concentrate secondary plant compounds, which may contribute to their anti-microbial activity [19].

Moreover, plant substances with antipyretic and anti-inflammatory activities are used more commonly than those of vertebrate origin. In fact, studies have found compounds from plants, such as saponins and terpenoids, in the chemical composition of various animal venoms [231]. However, vertebrates can also concentrate those substances, although in many cases they are derived from insects or are present in their biological composition [15]. For example, tribes in South America apply poison from the skin of poison dart frogs (of the family Dendrobatidae) to arrow tips used for hunting. However, most of the alkaloids that are known to give these frogs their toxic properties are derived directly from arthropods in their diets, which are mostly made up of insects [232, 233].

It is noteworthy that, in studies of the venom of Anura, there has been little investigation of the correlation between diet and bioactive biosynthesis because most research related to frog diets is limited to identification of their prey [234–236]. Frog diets generally exceed their energy requirements, as they are also used to produce toxins. This behavior is evidenced by research conducted with the family Dendrobatidae clade, which is found predominantly in tropical region, that found significant production of toxins among anurofauna [177, 237].

Some of the most commonly used pharmacological assays include measurement of the rectal temperatures of mice (three studies), analysis of minimum inhibitory concentrations (MICs) (three studies), and tests of mouse paw and ear edemas (two studies each). These tests reflect the most studied therapeutic indications.

This survey emphasizes the great potential of medicinal products obtained from zootherapy. In a more critical analysis, although interesting biological activities have been found, in our view, none was sufficiently potent to suggest potential for drug development. Additionally, such research carries implications for conservation because the amount of biomass required for such studies is substantial, and some species are endangered or vulnerable. All these aspects should be taken into consideration when designing studies, ethnographically inspired or otherwise, of medicinal animals.

6. Final Considerations

In this paper, we emphasize the great potential for study of medicinal animals from traditional knowledge, given the large number of species used worldwide. There is strong evidence of significant and relevant biological activities in vertebrate and invertebrate animals. The ethnobiology of the zombie poison, which contains ingredients used in many folk medical traditions that have led to the development of medically and pharmacologically important drugs, is an objective illustration of the role of traditional knowledge in modern drug discovery.

Although we found few pharmacological studies directly derived from zootherapy or ethnozoological studies, such studies are promising sources of potential new drugs. Thus, we recommend additional effort to develop pharmacological discovery studies using traditional medicinal animals. However, to balance the scientific and social impacts of this research, knowledge of each species natural history is required. This information will allow sustainable use of each species, allowing natural recovery and recruitment. Species of the family Bufonidae, especially the genera *Bufo* and *Rhinella* (Amphibia), and fish of the families Tetraodontidae and Diodontidae are promising candidates for investigation, both for their toxicological potential and as models of biosynthesis. Their favorable properties include significant toxin production, efficient metabolic pathways, potent biological activity, and their relative abundance. Surprisingly, there are still few studies on these species, despite the two extensively studied toxins, TTX and STX. Dozens of substances, some with neurotoxic and cytotoxic activity, can be recovered from these species. The few patent applications found underline the need for change in research methodologies and the wealth of biochemistry that has yet to be discovered.

These natural products are used in traditional medical systems by peoples around the world. They are present in their practices and strongly embedded in their culture. Understanding these phenomena may also prove useful for understanding how these medical systems have developed, especially in situations with limited access to the resources of modern medicine.

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Review Article

Ethnobiology and Ethnopharmacology of *Lepidium meyenii* (Maca), a Plant from the Peruvian Highlands

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Lepidium meyenii (maca) is a Peruvian plant of the Brassicaceae family cultivated for more than 2000 years, which grows exclusively in the central Andes between 4000 and 4500 m altitude. Maca is used as a food supplement and also for its medicinal properties described traditionally. Since the 90s of the XX century, an increasing interest in products from maca has been observed in many parts of the world. In the last decade, exportation of maca from Peru has increased from 1,415,000 USD in 2001 to USD 6,170,000 USD in 2010. Experimental scientific evidence showed that maca has nutritional, energizer, and fertility-enhancer properties, and it acts on sexual dysfunctions, osteoporosis, benign prostatic hyperplasia, memory and learning, and protects skin against ultraviolet radiation. Clinical trials showed efficacy of maca on sexual dysfunctions as well as increasing sperm count and motility. Maca is a plant with great potential as an adaptogen and appears to be promising as a nutraceutical in the prevention of several diseases.

1. Introduction

Lepidium meyenii Walpers (maca) is a Peruvian plant growing over 4000 m with high potential for bioprospecting [1]. Maca has been used for centuries in the Andes for nutrition and to enhance fertility in humans and animals [1, 2]. The demand for food particularly with benefits for health is high, but it will increase over the future years. Then, the search of plants with these potentials is of interest.

This plant belongs to the brassica (mustard) family and Lepidium genus [1]. The most relevant plants related to *Lepidium meyenii* are rapeseed, mustard, turnip, black mustard, cabbage, garden cress, and water cress. Lepidium constitutes one of the largest genera in the Brassicaceae family. The species from North America and Europe has been extensively studied, and the *Lepidium meyenii* from the Andean region has recently been studied profusely because of the great health benefits [3–5]. Maca grows at a habitat of intense cold, extremely intense sunlight, and strong winds. Maca is used as a food supplement and for its presumed medicinal properties [3].

The Peruvian native population in the central Andes use the hypocotyls after it has been naturally dried and in amounts >20 g/d. There are no reports of adverse reactions after consuming *Lepidium meyenii* in food [4]. However, natives from the highlands of Peru recommend that maca be boiled before its consumption because fresh maca may have adverse effects on health [5]. The effects of fresh maca on health have not been scientifically assessed yet. Preparations from the maca hypocotyls were reported to be of benefit for health [3–5].

The hypothesis that maca may be effective in improving health status, particularly reproductive function, is supported by several lines of evidence. Historical aspects and biological properties of maca, gathered from experimental and clinical studies on this species, reveal the importance of this plant as nutraceutical food, and that maca was adapted to conditions as harsh as observed at high altitude [2, 3, 5–7]. The aims of this review are to summarize and assess the evidence from experimental and clinical studies for or against the effectiveness of maca in the improvement of different functions.

2. History and Tradition

Maca has been cultivated in the Peruvian central Andes, in the former Chinchaycocha (Plateau of Bombón); present-day: Carhuamayo, Junin, and Óndores in the Junin Plateau close to Cerro de Pasco [2]. Maca was probably domesticated in San Blas, Junin (present day: Ondores) some 1,300–2,000 years ago.

The first written description about maca (as a root without identification of the botanical or popular name) was published in 1553, in which Cieza de Leon, a chronicler of the Spaniard conquest of Peru noted that in the Peruvian highlands, particularly in the province of Bombón (Chinchaycocha; present day: Junin) the natives used certain roots for maintenance [6]. The roots, he was referring to were maca.

Father Cobo [2] was the first to describe the name of maca and its properties in 1653. He stated that this plant grows in the harshest and coldest areas of the province of Chinchaycocha where no other plant for man's sustenance could be grown. Cobo also referred to the use of maca for fertility. In the 18th century, Ruiz referred to the fertility-enhancing properties of maca and also its stimulant effect [7]. I believe stimulant effect could be related to energizer effect or an effect on mood or well-being.

Traditionally, after being harvested maca is dried naturally and can thus be stored for many years [5]. The dried hypocotyls are hard as stone (Figure 1). After being naturally dried maca hypocotyls can be eating. Before eaten, the hypocotyls need to be boiled in water to obtain a soft product which can be consumed as juice, the most frequent form of use [4].

The boiling process seems to increase active metabolites. In fact, increased temperature affects the availability of several secondary metabolites in plants sometimes increasing some metabolites and in others a reduction in metabolites is observed. In maca, one of the important constituents is glucosinolates. These compounds are sensitive to heating [8]. Other metabolites, however, are increased after heating. For instance, heating decreases the activity of epithiospecifier protein and increases formation of sulforaphane, a derivative of isothiocyanates and glucosinolates, in broccoli [9].

After 2, 15, and 30 min of heating at 88°C, the vitamin C content of raw tomato drops significantly. Yet, the content of translycopene per gram of tomato increases [10]. Moreover, antioxidant activity also increases after heating tomatoes [10].

3. Ethnobiology

Maca is characterized by an overground and an underground part. The overground part is small and flat in appearance. This seems to be the result of an adaptation process to prevent the impact of strong winds. The underground part is the hypocotyl-root axis.

The principal and the edible part of the plant is a radish-like tuber that constitutes the hypocotyl and the root of the plant. This hypocotyl-root axis is 10–14 cm long and 3–5 cm wide and constitutes the storage organ storing a high content of water. After natural drying, the hypocotyls are dramatically reduced in size to about 2–8 cm in diameter (Figure 1). The average weight of the dried hypocotyls may

Figure 1: Dried hypocotyls of naturally dried black (upper), yellow (middle), and red (bottom) maca.

vary considerably. For instance, in our experience, we found a range of weight between 7.64 and 23.88 g in the Peruvian central Andes.

There are many types of maca that can be characterized by the color of their hypocotyls. In Carhuamayo, Junin, in the Peruvian highlands, 13 colors of maca have been described, ranging from white to black [11]. Recently, it has been demonstrated that different types of maca (according to its color) have different biological properties [16, 20, 35].

4. Chemistry

Primary metabolites correspond to the nutritional component of the hypocotyls, and the secondary metabolites to compound with biological and medicinal properties.

4.1. Primary Metabolites. The dried hypocotyls of maca are approximately 13–16% protein, and are rich in essential amino acids. Fresh hypocotyls contain 80% water and have high amounts of iron and calcium (see [5]). A more complete description of the composition of dry maca shows [12] 10.2% proteins, 59% carbohydrates, 2.2% lipids, and 8.5% of fibre. Free fatty acids are also present in maca, the most abundant being linoleic, palmitic, and oleic acids. Saturated fatty acids represent 40.1% whereas unsaturated fatty acids are present at 52.7%.

Maca contains amino acids (mg/g protein) like leucine (91.0 mg), arginine (99.4 mg), phenylalanine (55.3 mg), lysine (54.3 mg), glycin (68.30 mg), alanine (63.1 mg), valine (79.3 mg), isoleucine (47.4 mg), glutamic acid (156.5 mg), serine (50.4 mg), and aspartic acid (91.7 mg). Other amino acids present but in less proportion are histidine (21.9 mg), threonine (33.1 mg), tyrosine (30.6 mg), methionine (28.0 mg), hydroxyproline (26 mg), proline (0.5 mg), and sarcosine (0.70 mg). Minerals reportedly found in maca were iron (16.6 mg/100 g dry matter), calcium (150 mg/100 g dry matter), copper (5.9 mg/100 g dry matter), zinc (3.8 mg/100 g dry matter), and potassium (2050 mg/100 g dry matter) among others (see [5]).

4.2. Secondary Metabolites. Maca contains several secondary metabolites [5]. The secondary metabolites macaridine, macaene, macamides, and maca alkaloids are only found in this plant [13]. Macaenes are unsaturated fatty acids [13]. Other compounds include sterols as beta-sitosterol, campesterol, and stigmasterol.

Different glucosinolates as the aromatic glucosinolate glucotropaeolin have been described within maca. Benzyl glucosinolate has been suggested as chemical marker for maca biological activity. However, this has been discarded since glucosinolates may easily metabolize to isothiocyanates and these in other smaller metabolites [14].

Benzyl glucosinolate is also present in another Peruvian plant named mashua (*Tropaeolum tuberosum*). This plant, however, has opposed effects to maca since administration to male rats reduced sperm count [15] in contrast with the known effect of maca increasing sperm count [16].

It has been observed that maca batches from different producers significantly vary in the amount of macaene, macamides, sterols, and glucosinolates [17–19]. In 2005 appeared the first publication indicating that different maca color types have different properties [20]. More recently, it has been found that maca colors associate with variations in concentrations of distinct bioactive metabolites [19, 21]. These compounds individually or acting in synergy may be acting favoring the reported biological properties from maca.

The differences in proportion of secondary metabolites between maca colors may explain different biological properties described for maca.

5. Ethnopharmacology of Maca

5.1. Experimental Studies. Since 2000 to this date, several studies have been reported on biological or pharmacological effect of maca on experimental animals. The results have been consolidated in Table 1.

The process of preparation of maca is important to obtain adequate biological effects. Traditionally maca is boiled or extracted in alcohol before it is consumed [4]. In experimental studies, aqueous extract of maca is only effective after boiling pulverized maca hypocotyls in water.

The greatest effect on spermatogenesis was observed with the ethyl acetate fraction of the hydroalcoholic extract of black maca [42]. Extract after boiling (Aqueous extract) has similar effect of hydroalcoholic extract of maca [14]. In fact, the effect of maca on benign prostatic hyperplasia (BPH) seems to be related with the content of benzyl glucosinolate. Both, aqueous and hydroalcoholic extract of red maca, to a similar extent, reduced the prostate weight in rats with prostatic hyperplasia induced by testosterone enanthate (TE) [14].

Table 1: Properties for maca after *in vivo* administration in experimental animals.

Species	Property	Source
Rats	Increase sperm count and sperm motility	[16]
	Increase male sexual behavior	[13, 22, 23]
	Small effect on rat male sexual behavior	[24]
	Nutritional	[25]
	Antistress	[26, 27]
	Prevent testosterone-induced prostatic hyperplasia	[20]
	Reversed osteoporosis	[28, 29]
	Neuroprotective effects	[30]
	Protects against UV radiation	[31]
	antioxidant status, lipid, and glucose metabolism	[32]
Mice	Increase male sexual behavior	[13]
	Increase embryo survival	[33]
	Prevent testosterone-induced prostatic hyperplasia	[34]
	Increase number of offsprings	[33]
	Improve memory and learning	[35–37]
Guinea pigs	Increase number of offsprings	[38]
Fish	Nutritional	[39, 40]
	Increase embryo survival	[39]
Bulls	Improve sperm quantity and quality	[41]
	Unaffected mating behavior	

6. Experimental Studies on Reproduction

6.1. Male Reproduction

6.1.1. Sexual Function. Treatments of experimental animals with pulverized maca hypocotyls in doses of 15, 25, 75, and 100 mg/kg and the assessment of sexual behavior at 1, 7, 15, and 21 days of treatment yielded different results [22, 24]. The first study found increased sexual behavior of males at treatment days 1 and 15 [22] whereas the second study did not find changes in male sexual behavior at treatment days 1 or 21 [24]. Macaenes and macamides have been reported as novel compounds in maca [13] and probably responsible to improve sexual behavior [13], although this needs to be further demonstrated.

6.1.2. Sperm Function. Maca has been found to increase sperm count in normal rats and in pathological conditions produced by exposure to high altitude [42], lead acetate injections [43], and malathion [44]. Maca also increases sperm motility [16]. Black maca and in minor proportion yellow maca are the varieties responsible to increase sperm count and sperm motility whereas red maca had no effect [16].

6.1.3. Prostate Function. Testosterone enanthate (TE) administered to mice [34] and rats [14, 20, 45] induced prostatic hyperplasia. Red maca administered with TE for 21 and 42 days to male rats or mice prevented the prostatic hyperplasia. Yellow maca had intermediate effects and black had not effect on prostate size. In fact, red maca reduced prostate weight in a dose-response manner without any changes in testosterone levels and seminal vesicle weight [14, 45]. Regarding the secondary metabolites involved in the effect of red maca on prostate size, when different doses of benzylglucosinolates in red maca extracts were assessed, a dose-dependent reduction in prostate weight was observed, suggesting that these compounds may be responsible for the biological effect of red maca [14]. However, other secondary metabolites presented in red maca could be also responsible for the effect on prostate size. In fact, other authors found that polyphenols could inhibit prostate size [46, 47]. Recently, it was suggested that polyphenols in red maca may be related to the reduction in prostate size [34].

Prostate zinc levels were increased by TE administration, an experimental model to induce prostatic hyperplasia. Red maca was able to reduce zinc levels in TE-treated rats. Although red maca was able to reverse the effect of TE administration in prostate weight and zinc levels, no effect was observed in seminal vesicle weight, another androgen-dependent organ [20]. Finasteride, the standard pharmacological treatment for prostatic benign hyperplasia, which inhibits the activity of the enzyme 5 alpha reductase which in turn blocks the conversion of testosterone to dihydrotestosterone, was able to reduce both prostate and seminal vesicle weights but did not completely reduce zinc levels in prostate (unpublished data). Our results may possibly suggest that red maca and finasteride could have different mechanisms of action. In fact, previous studies showed that red maca specifically affects prostate size without altering testosterone or estradiol levels either in mice or in rats with prostatic hyperplasia induced by TE [14, 20, 45]. Also, it has been published that maca has no effect on androgen receptor [48, 49]. The latter supports the hypothesis that red maca effect is at a postandrogen receptor action level [14] or that RM exerts an inhibitory effect at a level postdihydrotestosterone conversion [45].

The finding that maca reduces benign prostatic hyperplasia (BPH) is a contribution of science since no traditional description refer to this effect. This is comprehensible since BPH occurs since 50 years of age, and before century XX, expectancy of life was below 50 years.

6.1.4. Serum Hormone. Testosterone controls sexual desire and spermatogenesis. However, the effect of maca on these physiological processes does not seem to be regulated by changes in serum testosterone or intratesticular testosterone levels. However, the mechanism is not yet known [48]. Thus, further chemical and molecular research is required to identify which of the many components of maca accounts for the effects observed.

6.2. Female Reproduction. Serum estradiol levels were not affected in different studies which used mice [50], rats [16, 45], or humans [51]. Moreover, with an *in vitro* assay in our laboratory, we could not show that maca has a proliferative effect on MCF-7 cells [Vaisberg and Gonzales, unpublished observations].

Maca extract has been demonstrated to improve the number of offsprings in mice [33]. This effect seems to be due to an effect favoring survival of embryos. This has also been suggested in rainbow trouts [39, 40]. Recently, in our laboratory it has been demonstrated that extract of red maca is more effective to improve quality of embryos in mice (unpublished data).

Extracts of red and black maca have protective effects on bone architecture in ovariectomized rats without showing estrogenic effects on uterine weight [28]. This finding may suggest the possibility to study effect of extracts of maca for treatment of women with osteoporosis.

7. Memory and Learning

Although no traditional descriptions have been found about effect of maca on learning and memory, actually natives in the central Peruvian Andes ascribe to the use of maca in children improves school performance. They do not exactly know which variety of maca has better effect on memory and learning. Experimental studies have shown that black variety of maca has beneficial effects on learning and memory in experimental animal models. Black maca improved learning and memory in ovariectomized mice [35, 37] and in scopolamine-induced memory impairment in mice [36].

Three varieties have been studied (black, red, and yellow maca) and black maca was the only on showing significant biological effects [35]. Studies have been performed using hydroalcoholic extracts of maca or boiled aqueous extract of maca. Both were similarly effective in improving memory and learning [35–37]. Black maca (0.5 and 2.0 g/kg) decreased brain malondialdehyde (MDA) levels marker of oxidative stress and acetylcholinesterase (Ache) levels in ovariectomized mice whereas no differences were observed in monoamine oxidase (MAO) levels [37]. Black maca seems to improve experimental memory impairment induced by ovariectomy, orchidectomy, scopolamine, and alcohol due in part to by its antioxidant and Ache inhibitory activities.

In summary, different evidences suggest that maca, particularly black maca, improves learning and memory.

8. Studies in Humans

Interest in maca has in increased worldwide during the last 10 years. This increased interest in maca has also been accompanied by some concern about safety. Piacente et al. (2002) [52] described the presence of (1R,3S)-1-methyl-1,2,3,4-tetrahydro-β-carboline-3-carboxylic acid (MTCA) in maca hypocotyls. On this finding, the authors made some generalizations about the action of MTCA suggesting that it can be toxic. These affirmations have motivated the French Agency for Sanitary Security (AFFSA) issued an opinion about the risk for the health of the consumer using the pulverized roots of maca [53]. However, MTCA also occurs on fruits like oranges and grapefruit and fruit juices [54], which are frequently used because of their favorable properties on health. MTCA has been described on the fermented garlic extract [55, 56], and its concentration increases with time, in turn increasing its antioxidant activity. Moreover, MTCA is detected in several foods, and in some, in concentrations relatively high (greater than the ones found by Piacente in maca) suggesting that claims are overestimated.

In a recent paper, several arguments indicate that MTCA in maca is safe [57]. In addition, maca is not mutagenic but it contains several beneficial compounds, some of which have anticarcinogenic properties [5, 58]. The consumption of maca must not generate concern, taking in account that, as mentioned in the French alert [53], it has not been reported any toxicity in the case of maca traditional consumption that requires a boiling process. MTCA is a natural constituent of several plants and on consumption of such plants there is no toxicity found. This suggests that as a multicomponent it may lose its adversity as drug action.

Furthermore, a recent study was designed to investigate health status in a population from the Peruvian central Andes (Carhuamayo, 4100 m) which traditionally consumes maca and compared it with a population from the same place which does not consume maca. The study, based on a survey, assessed maca consumption, sociodemographic aspects, health status, and fractures in men and women aged 35–75 years old. In a subsample were assessed the hepatic and kidney functions and hemoglobin values. From the sample studied, 80% of the population consumed maca. 85% of them consume maca for a nutritional purpose.

Maca is used since childhood and mainly after hypocotyls it is naturally dried. The consumption is mainly as juices, and the variety that they consume is a mixture of different colors of the hypocotyls. Maca consumption is associated with higher score in health status (Figure 2), lower rate of fractures, and lower scores of signs and symptoms of chronic mountain sickness. In addition, maca consumption is associated with low body mass index and low systolic blood pressure.

Hepatic and kidney function, lipidic profile, and glycemia were normal in the population consuming maca. In summary, this study demonstrated in a population traditionally using maca that consumption of this food is safe [4].

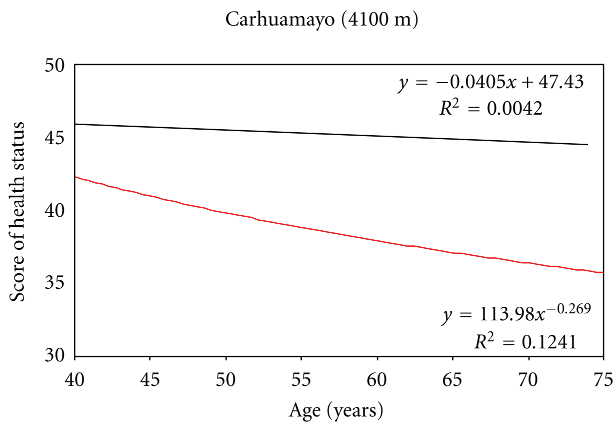

Figure 2: Score of health status from men and women residents of Carhuamayo, Junin at 4100 m in the Peruvian Central Andes. Upper line: population consuming extracts of maca. Bottom line: population not consuming maca; Source: [4].

9. Maca and Sexual Function

Sexual dysfunctions are highly prevalent in our society worldwide, and the occurrence of sexual dysfunctions increases directly with age for both men and women [59]. They occur in 20–30% of men and 40–45% of women according to 18 descriptive epidemiological studies from around the world [60].

Most sexual problems relate to sexual desire (interest in sex) in both females and males and male erectile dysfunction (ED) [60]. Interest in medicinal plants to treat sexual dysfunctions has increased in the last 20 years [61].

Maca has been described to improve sexual behavior in experimental animals [13, 22, 23], although conflictive results may be observed [24]. Traditionally maca has been referred to as a plant to improve fertility [2] and as an energizer [3]. In a randomized study we were unable to demonstrate effect of maca on penile erection in apparently healthy adult men after 12 weeks of treatment with gelatinized maca compared with results using placebo [Gonzales, unpublished data].

Recently, a systematic review has been performed on effect of maca on sexual function in humans [62]. In this review, according to the authors only four randomized clinical trials (RCT) met all the inclusion criteria [49, 63–65].

According to the review, two RCTs suggested a significant positive effect of maca on sexual dysfunction or sexual desire in healthy menopausal women [49] or healthy adult men [63], respectively, while the other RCT according to the reviewers failed to show any effects in healthy cyclists. However, analyzing results from such study, authors showed that maca extract significantly improved the self-rated sexual desire score compared to the baseline test ($P = 0.01$), and compared to the placebo trial after supplementation ($P = 0.03$) [64]. The effect in this study was as early as 14 days of treatment which is significantly shorter that that showed with gelatinized maca in which effects were observed after 8 weeks of treatment.

A further RCT assessed the effects of maca in patients with mild erectile dysfunction using the International Index of Erectile Dysfunction-5 and showed significant effects on subjective perception of general and sexual well-being [65].

A study was not included in the systematic review because no placebo effect was assessed [66]. In such study, maca was administered in two doses (1.5 g/day and 3–0 g/day) to patients with selective-serotonin reuptake inhibitor-(SSRI-)induced sexual dysfunction. The Arizona Sexual Experience Scale (ASEX) and the Massachusetts General Hospital Sexual Function Questionnaire (MGH-SFQ) were used to measure sexual dysfunction.

Subjects on 3.0 g/day maca had a significant improvement in ASEX (from 22.8 ± 3.8 to 16.9 ± 6.2; $z = -2.20$,

$P = 0.028$) and in MGH-SFQ scores (from 24.1 ± 1.9 to 17.0 ± 5.7; $z = -2.39$, $P = 0.017$), but subjects on 1.5 g/day maca did not. Libido improved significantly ($P < 0.05$) based on ASEX item number 1, but not by dosing groups. Maca was well tolerated [66].

Although evidence suggests an effect of maca on sexual desire and mild erectile dysfunction data also revealed that maca extract seems to have better effect [64] than gelatinized maca [63] and that of maca flour. The difference seems to be due to the fact that extract allow the concentration the secondary metabolites.

In summary, there is evidence that maca may improve sexual desire but is inconclusive an effect on erectile function.

10. Maca and Sperm Function

In a study in 9 apparently healthy men who had received maca for 4 months showed an increase in seminal volume, sperm count, and sperm motility [67] (Table 2). Serum hormone levels (LH, FSH, prolactin, estradiol, and testosterone) in men were not affected by treatment with maca [51, 67].

Maca powder and maca extract were unable to activate androgen receptor-mediated transcription in prostate cancer cell lines [48] or in a yeast-based hormone-dependent reporter assay [49].

In summary, experimental and one clinical studies suggest that consumption of maca is associated with an increase in sperm count.

11. Maca as an Energizer

Maca has been shown to reduce scores in depression and anxiety inventories [49, 66]. A self-perception survey showed that maca acted as energizer compared with placebo in apparently healthy men [3].

Maca extract administration for 14 days significantly improved 40 km cycling time performance compared to the baseline test ($P = 0.01$), but not compared to the placebo trial after supplementation ($P = 0.05$).

In summary, scientific evidences suggest that maca may be an energizer.

12. Maca and Metabolic Syndrome

One study has been reported on effects of maca alone or combined with another supplements in patients with metabolic syndrome. The randomized placebo-controlled 90-day study assessed the effects of maca and yacon in combination with silymarin on plasma and lipoprotein lipids, serum glucose, and safety parameters in patients suffering from the metabolic syndrome.

No adverse effects were found in volunteers using silymarin (0.8 g/day), silymarin + yacon (0.8+2.4 g/day), and silymarin + maca (0.6 + 0.2 g/day). A moderate AST level and diastolic blood pressure increase was found in volunteers using maca (0.6 g/day) [68].

However, a randomized clinical trial in healthy men showed that gelatinized maca reduced systolic and diastolic blood pressure after 12 weeks of treatment [3]. Moreover, maca significantly inhibited the hypertension relevant angiotensin I-converting enzyme (ACE) *in vitro* [69].

In a population traditionally consuming maca, systolic blood pressure was lower than in those not consuming maca [4]. Similarly, AST levels were similar in those consuming and those not consuming maca [4].

Maca contains high amounts of potassium [5]. Potassium is an important nutrient to reduce risk of hypertension [70] and as a primary metabolite may be useful in patients with hypertension. In addition other secondary metabolites may be also be active to reduce blood pressure [69].

13. Maca and Osteoarthritis

In a randomized double-blind study on 95 patients with osteoarthritis, a combination of *Uncaria guianensis* (cat's claw; 300 mg) and maca (1,500 mg) was administered twice a day for 8 weeks and compared with a treatment with glucosamine sulfate. Both treatments substantially improved pain, stiffness, and functioning in the patients [71]. However, as the study did not include a placebo control group, glucosamine effects remain unclear.

14. Toxicity

Maca has been used for centuries in the Central Andes of Peru, and no toxic effects have been reported if it was consumed after boiling [5]. Previous review data on *in vivo* and *in vitro* studies with maca indicate that its use is safe [5]. Further evidence shows that aqueous and methanolic extracts of maca do not display *in vitro* hepatotoxicity [72]. Moreover, freeze-dried aqueous extract of maca (1 g/kg BW) in mice did not reveal any toxic effect on the normal development of preimplanted mouse embryos [73].

Results in rats show that different types of maca (black, red, and yellow) have no acute toxicity at ≤17 g of dried hypocotyls/kg BW. Rats treated chronically for 84 days with 1 g/Kg BW showed no side effects and a histological picture of liver similar to that observed in controls [74]. As usual doses in rats are 1-2 g/Kg BW, it is suggested that maca is safe. Human consumption of ≤1 g/kg per day is considered safe, as well. However, as referred above in a study in patients with metabolic syndrome the administration of maca at a dose of 0.6 g/day for 90 days resulted in a moderate elevation of AST and diastolic arterial pressure [68]. This has not been confirmed in other studies [3, 4]. Data on population of 600 subjects in the Peruvian central Andes showed that maca consumption was safety and that health status was improved [4].

15. Final Comments

Consumption of Maca worldwide has significantly increased during the last 10 years. This is depicted in Figure 3 which presents data on maca export from Peru, the only country producing maca. During 2010, Peru exported maca for

Table 2: Semen variables before and 4 month after maca treatment.

Semen variable	Before maca $N = 9$	After maca $N = 9$	P value
Volume (mL)	2.23 ± 0.28	2.91 ± 0.28	<0.05
pH	7.47 ± 0.09	7.44 ± 0.07	NS
Sperm count (10^6/mL)	67.06 ± 18.61	90.33 ± 20.46	NS
Total sperm count (10^6/mL)	140.95 ± 31.05	259.29 ± 68.17	<0.05
Motile sperm count (10^6/mL)	87.72 ± 19.87	183.16 ± 47.84	<0.05
Sperm motility grade a (%)	29.00 ± 5.44	33.65 ± 3.05	NS
Sperm motility grade a + b (%)	62.11 ± 3.64	71.02 ± 2.86	<0.05
Normal sperm morphology (%)	75.50 ± 2.02	76.90 ± 1.23	NS

Data are mean ± standard error of the mean. N = number of subjects, NS: not significant, source: [67].

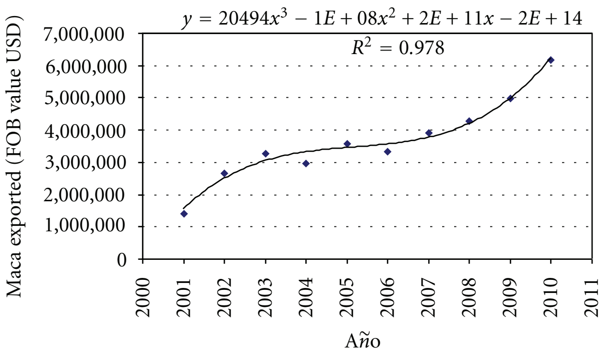

Figure 3: Maca exported from Peru in the last 10 years. Data are in FOB values (USD).

a value of 6,179,011.8 USD, 4.36-times higher than value exported during 2001.

Clearly, further research is required to address the mechanisms of actions and the active principles of this plant. However, available data suggest that maca has several important biological properties, and scientific evidence of these properties could be important for farmers, dealers, and consumers. Furthermore, it is necessary to demonstrate the biological effects of specific secondary metabolites of maca and their actions when added as a mixture.

Maca is a plant with great potential as an adaptogen and appears to be promising as a nutraceutical in the prevention of several diseases. Scientific evidence showed effects on sexual behavior, fertility, mood, memory, osteoporosis, metabolism, and the treatment of some tumor entities. However, the active principles behind each effect are still unknown. Macamides have been described as novel compounds of maca that have not been found in any other plant species so far [13]. It is suggested that this lipid fraction of maca may be responsible for the increase in sexual behavior [13, 23]. Studies on testicular function, spermatogenesis, fertility, mood, memory, and prostatic hyperplasia [16, 35, 42, 75] were performed with aqueous extracts that contain only trace amounts of macamides [17]. This suggests that compounds other than macamides are responsible for these activities.

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Research Article

The First Report on the Medicinal Use of Fossils in Latin America

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There have been very few ethnopharmacological studies performed on the traditional use of fossil species, although a few records have been conducted in Asia, Africa, and Europe. This study is the first ever to be performed on the use of Testudine (turtle) fossils for folk medicine in Latin America. An investigation was conducted in the Araripe Basin, which is one of the most important fossil-bearing reserves in the world due to the diversity, endemism, and quality of preservation of its fossils. We propose the formalization of a new discipline called ethnopaleontology, which will involve the study of the dynamic relationship between humans and fossils, from human perception to direct use.

1. Introduction

While most ethnopharmacological reports address the use of plants and animals in traditional medicinal practices [1–6], studies on the medicinal use of minerals are less common. The use of fossils for traditional remedies is an underexplored aspect of ethnopharmacology. Fossils are found in the myths and narratives of many different cultures and are used for traditional medicinal practices around the world [7, 8]. In a recent review of the worldwide use of fossils, Geer and Dermitzakis [7] reported on the use of belemnites, ammonites, and trilobite fossils, as well as echinoid, brachiopod, oyster shells, shark teeth, and mammal fossils, primarily in Africa, Asia, and Europe. Despite this report detailing evidence of fossil use, ethnoecological studies focusing on the relationship between human cultures and fossils are scarce. This relationship is complex and involves not only cultural and social aspects but also scientific and economic aspects because many scientific discoveries are a result of mining activity around the world. According to Mayor [9, 10], the relationship between humans and fossils is very ancient, and evidence of it can be found in the folk traditions of diverse people groups. Mayor reports that ancient Greeks and Romans "collected, measured, displayed, and pondered the extinct bones of beasts, and they recorded their discoveries and imaginative Interpretations of the fossil remains in numerous writings that survive today" [10].

This study focuses on the use of Testudine fossils for medicinal purposes in Latin America and is based on a casual record made during paleoherpetological investigations in the city of Nova Olinda, Ceará State, which is located in northeastern Brazil. Living reptiles stand out among vertebrates used for zootherapeutic purposes and are commonly used for traditional medicine on every continent [5, 6, 11–17]. They are also used for many other purposes: as pets, for food, for magicoreligious purposes, and for crafts [5, 6, 11, 16–24], which explains their significant presence in the animal trade [25] and the perceived need for conservation initiatives [26, 27].

Unlike living natural resources, fossil populations do not require management for their sustainability, but it is worth considering the importance of regulating their use by human societies [28]. They fit into the category of "World Heritage", as they represent a door to the past and provide scientists with the opportunity to investigate the history of the planet and of life [28, 29].

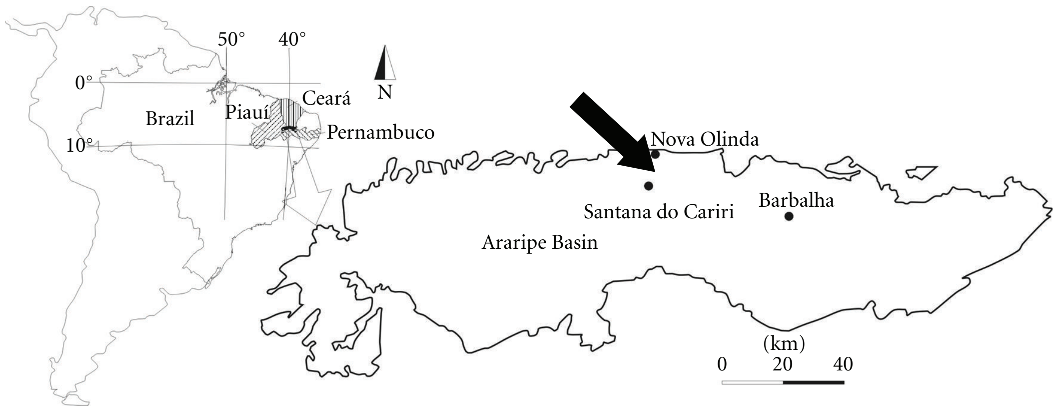

Figure 1: Location of the Caldas Quarry in the municipality of Nova Olinda, Ceará, northeastern Brazil.

The study discussed in this paper was done in the Araripe Basin, known for being from the Cretaceous period, which is abundant, biologically diverse; and preserved well [30]. The Crato, Ipubi, and Romualdo Formations are important areas in the Araripe Basin [31], not only because of their fossil reserves of unparalleled scientific interest but also because they exist as a result of the ornamental rock trade, with over 372 mining companies exploiting the Cretaceous limestone from the region [32]. Mining activity has been responsible for the discovery of several fossil species that have contributed to our understanding of the evolution of paleobiodiversity; however, it has also resulted in increasing numbers of fossils being destroyed before the scientific community has gotten a chance to analyze them [33].

2. Material and Methods

The Araripe Basin (Figure 1) is a sedimentary unit located in the states of Pernambuco, Ceará, and Piauí, which are located inland in northeastern Brazil, between 38°30′ and 40°50′ W longitude and 7°05′ and 7°50′ S latitude. It covers a land area of 8,000 km^2 [30].

The findings presented in this paper were casually recorded during field sampling performed in 2005 by G. J. B. Moura [30, 33–36] in the quarries of the Crato Formation. The study consisted of informal conversations with three workers from the Portland Cement Company working in the Caldas Quarry, which is in the municipality of Nova Olinda, Ceará, between the cities of Santana do Cariri and Nova Olinda, on the right side (from Nova Olinda to Santana do Cariri) of state Highway CE-255, which connects both cities. The Caldas Quarry is known for its significant mining activity in the region [32, 33] and as the discovery site of several new fossil species, including Anura [30, 33–35], Testudines [37], pterosaurs [38], and crocodilians [39]. The perceptions of quarry workers regarding the significance of fossil findings in this area were important considerations for this study. Although there are still no study reports that include the perceptions of quarry workers, the authors of this study are currently conducting research aimed at the development of such reports.

Figure 2: *Araripemys barretoi* Price, 1973 (Sauropsida-Testudine) deposited at the Museum of Santana do Cariri, Santana do Cariri-CE, reference number MPSC-V-010.

3. Results and Discussion

We collected information regarding the use of turtle shell fossils (Figure 2) as reported by quarry workers in the city of Nova Olinda (Figure 3). The shell is scraped and administered orally as a sedative, especially for very energetic, vigorous children. The turtle fossils originated from the Cretaceous strata of the Arrive Basin, especially from the Crato (Lacustrine Paleoenvironment), Ipubi (Lacustrine Paleoenvironment), and Romualdo (Marine Paleoenvironment) Formations, which belong to the Santana Group [31, 33].

Among the different species of Testudine fossils observed in the Araripe Basin, at least five species should be emphasized: (1) *Araripemys arturi* Fielding, Martill and Naish, 2005, belonging to the Pleurodira clade, (2) *Araripemys barretoi* Price, 1973, also belonging to the Pleurodira clade, (3) *Brasilemys josai* Lapparent de Broin, 2000, (4) *Cearachelys placidoi* Gaffney Campos and Hirayama, 2001 (Pleurodira), and (5) *Santanachelys gaffneyi* Hirayama, 1998 (Cryptodira). These species are mainly marine turtles [35, 40].

(a)

(b)

Figure 3: Workers at the Caldas Quarry cutting laminated limestone (photographs by Michel Fernandes Teixeira, 2009).

We propose the creation of a new discipline, ethnopaleontology, to study the dynamic relationship between humans and fossils, including aspects such as the cultural perception of fossils, fossil trade, and fossil use (mythical and direct). Ethnopaleontology differs from Medical Geology, which involves the study of the relationship between the geological environment and health issues of plants, animals, and people [41], and from Ethnopedology, which, according to Alves et al. [42] "consists of a set of interdisciplinary studies devoted to understanding the interfaces between the soil, the human species and other ecosystem components". We argue that ethnopaleontology belongs within the scope of geomythology, which can be understood as "the science of recovering ancient folk traditions about complex natural process or extraordinary events [10]". According to Mayor [9]:

> "Native Americans observed, collected, and attempted to explain the remains of extinct invertebrate and vertebrate species long before contact with Europeans, and their cultural connection with fossils continues today. Their explanations, expressed in mythic language, were based on repeated, careful observations of geological evidence over generations".

In ethnopaleontology, human attention is centered, not on the mineral composition of the fossil, but on the fossil itself as a representation of an organism that once lived, which includes the symbolic significance associated with such a representation. However, the most likely reason for the pharmacological use of fossils originates from the mineral elements that constitute them; this is the link between ethnopaleontology and medical geology.

Among the therapeutic uses for fossils, only those involving mammal fossils have been previously reported; they have been used as sedatives and for the treatment of several ailments, including diphtheria, sore throat, high stress, heart and liver problems, insomnia, manic behavior, excessive perspiration, night sweats, and chronic diarrhea (e.g., [7]). Testudine species are currently used in traditional medicine in Latin America to treat arthritis (*Gopherus flavomarginatus*, Leglier 1959), catarrh, erysipelas, bronchitis, asthma (*Chelonoidis carbonaria* Spix, 1824), sore throat, rheumatism, hernias, wounds, leishmaniasis, varicocele, earaches, female issues, asthma and pain (*Chelonoidis denticulata* Linnaeus, 1766) (e.g., [2, 5, 6]). They are also used to control thirst.

In northeastern Brazil, species that move slowly, such as *Uranoscodon superciliosus*, are typically used as a sedative; however, there is no record of the use of Chelonidade or Testudinidae as sedatives in Latin America (e.g., [2]). This type of use by imitative or mimetic association is common in folk medicine practices. The principles of sympathetic medicine are applied to cure afflictions that have a resemblance to the affected organ (e.g., [7]); however, the relationship as perceived by a culture may also involve mythological elements, as in the Afro-Brazilian cults in northeastern Brazil, where plants or animals are used for certain purposes according to the deity that "owns" that particular resource [4, 43].

The potential pharmacological activity of fossils may be scientifically explained by their mineral composition. Minerals have been used in medicinal practices of different cultures for different purposes, from topical (e.g., to treat skin ailments) to internal use [44]. For instance, Park et al. [44] observed antibacterial activity in a mixture of minerals containing sericite, talc, and halloysite. The association between medical geology and ethnopaleontology approaches can undoubtedly help us advance our knowledge of the pharmacological properties of minerals and the traditional medical systems that use such resources for health care purposes. This paper highlights the research possibilities in a region of great scientific importance, the Araripe Basin, and expands our understanding of the use of such resources in traditional medical systems.

Because of the substitution of living components with minerals during the lithification process, fossils may concentrate minerals of scientific and commercial interest and, therefore, like flora and fauna, are considered to be national property and are legally protected by Article 20 of the Brazilian Federal Constitution of 1988. We would like to underscore Decree no. 98830 of 1990, regulating the collection of fossils by foreigners; Law no. 8176 of 1991, establishing the exploitation of fossils without authorization from DNPM as a crime against the Union; and Law no. 9605 of 1998, establishing sanctions/penalties for crimes against fossiliferous property in the country. Although the collection of fossils is regulated in Brazil, most fossiliferous reserves are subject to illegal practices. The Araripe Basin, for example, has been the target of a countless number of illegal actions regarding fossils [28, 45]. Thus, it is important to develop more efficient conservation programs to preserve these rare traces of past life accumulated over geological time, which, in addition to enabling the understanding of biological evolution, may also hold materials of great interest to the socioeconomic development of the country.

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Research Article

Levels of Tannins and Flavonoids in Medicinal Plants: Evaluating Bioprospecting Strategies

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There are several species of plants used by traditional communities in the Brazilian semiarid. An approach used in the search for natural substances that possess therapeutic value is ethnobotany or ethnopharmacology. Active substances that have phenolic groups in their structure have great pharmacological potential. To establish a quantitative relationship between the species popularly considered to be antimicrobial, antidiabetic, and antidiarrheal, the contents of tannins and flavonoids were determined. The plant selection was based on an ethnobotanical survey conducted in a community located in the municipality of Altinho, northeastern Brazil. For determination of tannin content was utilized the technique of radial diffusion, and for flavonoids, an assay based on the complexation of aluminum chloride. The group of plants with antimicrobial indications showed a higher content of tannins compared to the control groups. The results evidence suggests a possible relationship between these compounds and the observed activity.

1. Introduction

For centuries, extracts from plants have been used as folk remedies against various health problems [1], with many natural products leading to the development of clinically beneficial drugs [2]. According to Cox [3], the discovery of the medicinal benefits of these plants can be accomplished in two ways: by random selection or by selecting a target identified through phylogenetic (close relatives of plants known to contain useful compounds are included in the sample), ecological (plants in particular habitats with determinate life forms), or ethnopharmacological surveys (ethnodirected) (identifying plants traditionally used for specific diseases) [4].

The probability of finding useful compounds in plants by random selection is low (only 1 in 10,000 exhibits promising activities of interest to researchers), particularly in areas of high biodiversity such as the Caatinga, a typical semiarid ecosystem of northeastern of Brazil [5]. Already ethnobotanical surveys, according to Farnsworth quoted in [6], have contributed 74% of all medicines derived from plants. For example, in a study by Kaileh et al. [1] in a traditional Palestinian community, the selection of twenty-four folklore medicinal plants mentioned or described in the literature resulted in four potent cytotoxic species. In another study conducted in Mexico, the result was even more satisfying; antimicrobial activity was demonstrated in 75% of the plants that were tested, mainly for diseases of bacterial origin in the studied area [7].

Consequently, the ethnodirected approach has received significant attention in recent years [1]; several studies have been aimed at contributing to the development of this tool in the search for natural substances with therapeutic action in the northeast region of Brazil [8–11]. In that region, traditional knowledge about medicinal plants has long been an integral part of popular medical practice, being used by 90% of the economically disadvantaged population to treat their health problems [12].

The Caatinga is crucial to human life because it offers a wide variety of plant and animal resources for the survival of those who live there [8, 9, 13–16]. Among its benefits are the medicinal plants found within that are the basis of Brazilian popular medicine [10].

Many of the plant species used in Caatinga as folk medicines include phenolic compounds in their compositions, leading to the popular belief that the attributed therapeutic activities are associated with the presence of these compounds [8, 17–19]. Compounds with phenolic group in its structure have a pharmacological potential [20], which is represented by activities such as antimicrobial [21–23], hypoglycemic and/or antidiabetic [24–29], and antidiarrhoeal [30–33].

Previous studies have found phenols in 100% of a group of medicinal plants in the Caatinga [17, 19]. Moreover, in some species that have high value for local communities, the compounds of interest appear in high concentrations, often supporting therapeutic indications that are locally assigned [8].

Thus, our current research is focused on the following question: Is the content of phenolic compounds (tannins and flavonoids) in the groups of plants popularly indicated for diseases related to the activity of these compounds? We hypothesized that there would be a strong relationship between high levels of these compounds and the native species from Caatinga selected by an ethnobotanical survey. If this tendency was confirmed, it would then be possible to predict or direct studies of bioprospecting for medicinal plants of the region.

2. Material and Methods

2.1. Data Collection. Our study is based on an ethnobotanical survey conducted by the Laboratory of Applied Ethnobotany (LEA) from UFRPE that resulted in the creation of a database with information about the plant species used by the community. Their study was conducted in the rural area around Altinho, which is located in the central Agreste at 163.1 km from Recife (capital of Pernambuco State). The region has a total area 454.486 km^2 and a semiarid, hot climate [34]. In this study, after legal procedures such as collecting signatures of a Free and Informed Term of Consent from all persons over eighteen years of age in the community (see [35]), the ethnobotanical information was collected and divided into three stages: first, a general survey regarding the use and knowledge of medicinal plants with the community; second, local experts were selected based on the quality and quantity of information they provided in the first stage; third, the specialists were subjected to the technique of a free list, which consists of gathering information from a specific domain of knowledge [8, 19, 36–39].

2.2. Selection of Plants for the Study. To select plants for the study, a literature search was performed on the pharmacological activities that are common to the categories of secondary metabolites we had chosen to focus on: tannins and flavonoids. Various activities of phenolic compounds were identified: antimicrobial [21–23], antioxidant, anti-inflammatory, antidiarrhoeal [30–33], cardioprotective, and hypoglycemic and/or antidiabetic [24–29].

Subsequently, we identified which of these common activities were present as therapeutic agents in the medicinal plants surveyed in the Carão Community from the ethnobotanical survey mentioned above. The database from the overall ethnobotanical survey was filtered, with inclusion criteria that all species should be native (when they are native to South America) [9] in the Caatinga and that they possessed the selected therapeutic activities, to give a total of 25 plants (Table 1). In this community, 12 species were cited to have antimicrobial activity, but only nine were native. Similarly, 20 possessed antidiarrhoeic activity, but only 10 met the criteria. Finally, of the nine species that had antidiabetic and/or hypoglycemic action, only six were selected following the same reasoning (see Table 1).

After the random choice of species (30), four groups were established to analyze the content of phenolic compounds.

(i) *Group 1*: random selection of 10 cited plants, based on the general survey, which served as the control group.

(ii) *Group 2*: selection of nine plants with described antimicrobial indication based on the general survey.

(iii) *Group 3*: selection of 10 plants with described antidiarrheal indication based on the general survey.

(iv) *Group 4*: selection of six plants with described hypoglycemic and/or antidiabetic indication, based on the general survey.

2.3. Determination of Phenolic Compound Contents

2.3.1. Sample Preparation. Plant samples were collected according to the general ethnobotanical survey conducted by the LEA group from the specific parts of plants used by the community for each therapeutic indication. Each sample contained at least three individual plants of the same species that were mixed to compose a single sample. Samples were collected in June 2009. After drying at room temperature, the samples were crushed in an industrial crusher and standardized with an electromagnetic stirrer and sifters to obtain a granulometry of 60 Mesh.

2.3.2. Determination of Tannin Contents. The tannins were quantified by Hagerman's radial diffusion method [40] as adapted by Cabral et al. [41]. Thus, for the preparation of the gel was used a solution of 50 mM acetic acid and 60 mM ascorbic acid, adjusting the pH to 5 with the addition of sodium acetate, which was added in agarose (type I) (Sigma-Aldrich) 1%. Subsequently, the mixture was brought to the heating, stirring, until boiling point, so that there was a complete homogenization of agarose. After cooling

Table 1: Medicinal plants analyzed with their levels of tannins (T) and flavonoids (F) in dry samples in an ethnobotanical survey conducted in the Caatinga vegetation in Pernambuco state, Northeast Brazil.

Group: indication	Scientific name	Popular name	Part used	*F* (%)	*T* (%)
Group I:	*Schinopsis brasiliensis* Engl.	Baraúna	Bark	2.55	5.53
random selection	*Hymenaea courbaril* L.	Jatobá	Bark	0.46	2.35
	Handroanthus impetiginosus (Mart. ex DC.) Mattos (*Tabebuia impetiginosa* (Mart. ex DC.) Standl.)	Pau d'arco roxo	Bark	0.1	—
	Cereus jamacaru P. DC.	Mandacaru	Cladode	0.2	—
	Capparis jacobinae Moric. ex Eichlera.	Incó	Leaf	1.29	—
	Serjania lethalis A. St.-Hil.	Ariú	Root	0.05	1.21
	Manihot glaziovii Muell. Arg.	Maniçoba	Bark	0.3	1.89
	Nicotiana glauca Graham.	Pára-raio	Leaf	1.6	—
	Solanum aculeatissimum Jacq.	Gogóia	Root	1.91	—
	Crataeva tapia L.	Trapiá	Bark	0.03	—
Group II:	*Amburana cearensis* (Allemão) A.C. Sm.	Imburana açu	Bark	0.33	—
antimicrobial	*Ziziphus joazeiro* Mart.	Juazeiro	Bark	0.14	—
	Anadenanthera colubrina (Vell.) Brenan	Angico/preto	Bark	0.39	8.24
	Erythrina velutina Willd.	Mulungu	Bark	0.21	—
	Maytenus rigida Mart.	Bom nome	Bark	0.3	—
	Mimosa tenuiflora (Willd.) Poir.	Jurema lisa	Bark	0.2	12.58
	Caesalpinia pyramidalis Tul.	Catingueira rasteira	Bark	0.65	6.01
	Myracrodruon urundeuva Allemão.	Aroeira	Bark	2.95	6.88
	Guapira laxa (*Netto*) Furlan.	Piranha	Bark	0.04	—
Group III:	*Libidibia ferrea* (Mart. ex Tul.) L. P. Queiroz (*Caesalpinia ferrea* Mart.)	Jucá	Bark	0.49	6.24
antidiarrheal	*Caesalpinia pyramidalis* Tul.	Catingueira rasteira	Bark	0.65	6.01
	Lantana camara L.	Chumbinho	Leaf	3.72	—
	Croton blanchetianus Baill.	Marmeleiro	Bark	0.47	2.47
	Croton rhamnifolius Willd.	Velame	Leaf	2.71	—
	Eugenia uvalha Cambess.	Ubaia	Bark	0.72	1.68
	Spondias tuberosa Arruda.	Umbu	Bark	2.26	1.51
	Croton argyroglossum Baill.	Rama branca/ Velame branco	Bark	0.23	—
	Ziziphus joazeiro Mart.	Juazeiro	Leaf	1.75	—
	Cedrela odorata L.	Cedro	Bark	0.21	2.09
Group IV:	*Bauhinia cheilantha* (Bong.) Steud.	Mororó branco	Leaf	4.94	1.82
hypoglycemia and/or antidiabetic	*Croton argyroglossum* Baill.	Rama branca/ Velame branco	Bark	0.23	—
	Spondias tuberosa Arruda.	Umbu	Bark	2.26	1.51
	Tillandsia usneoides (L.) L.	Salambaia comprida/ Samambaia	Whole plant	0.3	—
	Erythrina velutina Willd.	Mulungu	Bark	0.21	—
	Maranta divaricata Roscoe.	Cana de macaco	Bark	0.02	—

—: not detected.

(±45°C) was added to bovine serum albumin (BSA) fraction V fatty acid free (Sigma-Aldrich) at a concentration of 0.1%. Aliquots of 10 mL were distributed in Petri dishes with 9 cm in diameter that were placed on a level surface to which they were formed uniform layers of the gel. After total solidification of the gel, wells were made with a capacity of about 8 μL, 2 cm distant from each other and the edges of the plates with a punch of 4 mm in diameter. The samples were analyzed in triplicate.

Samples (100 mg powdered) were extracted in 1 mL methanol: water 50% (v/v) for one hour at room temperature. Three successive aliquots of 8 μL were applied to extract formed with the aid of micropipettes, directly in the wells. After complete absorption by the gel of aliquots of the extracts, the plates were sealed with parafilm and incubated at 30°C for 120 h. The extract containing tannin after reaction with albumin produces an opaque precipitate in the form of disc, from which the diameter squared is proportional to the concentration of tannins in the extract [40]. To construct the standard curve were used five different aliquots of a solution of tannic acid 25 mg/mL. We used Corel Draw X3 Version 13 to measure the diameters of the rings formed.

2.3.3. Determination of Total Flavonoid Contents. Quantification of flavonoids was based on a procedure described by Amorim et al. [42] consisting of a spectrophotometric test at 420 nm, which was considered precise, reproducible, highly accessible, and highly practical.

Samples of 500 mg of each plant were transferred to a 50 mL Erlenmeyer flask. Next, 25 mL of methanol pure for analysis (P.A.) was added, and the mixture was then heated on a hot plate at 80°C ± 5°C for thirty minutes. Finally, the extract was filtered through filter paper and transferred to a 50 mL volumetric flask.

The precipitate was washed with 25 mL of methanol and filtered again into the same flask, completing the volume of methanol. From this solution, 0.5 mL were transferred to a 25 mL volumetric flask. Into these flasks were added 0.6 mL of glacial acetic acid, 10 mL of a pyridine-methanol solution (2 : 8) and 2.5 mL of a 5% methanolic solution of aluminum chloride. Distilled water was then added to fill the flask. After 30 minutes at rest at room temperature, absorbance readings were taken by spectrophotometry at 420 nm. The samples were analyzed in triplicate.

For the standard preparation, 6.0 mL of methanol were added to a 10 mL volumetric flask followed by 5.0 mg of Rutin, purchased from Sigma-Aldrich. To achieve complete dissolution of the standard, the solution was maintained for five minutes in an ultrasound bath. Additional methanol was then added to complete the final volume of the flask. From this solution, aliquots of 0.1, 0.25, 0.5, 1.0, 2.5, and 3.75 μg/mL were taken and transferred to 25 mL flasks.

To each flask were then added 0.6 mL of glacial acetic acid, 10.0 mL of pyridine 20%, and 2.5 mL of methanolic solution of aluminum chloride at 5%, followed by water to complete the volume. After resting for 30 minutes at room temperature, the absorbances were read at 420 nm in glass cuvettes.

A blank solution was prepared in a 25 mL volumetric flask, using all reagents described before (except the extract or standard), and its absorbance readings at 420 nm were taken as a white solution to zero the equipment.

2.4. Statistical Analysis of Data. The levels of tannins and flavonoids of each plant group were statistically compared to each other by the Kruskal-Wallis test. The relative proportions of these compounds between plants of the same group were determined using the *G* test from Williams based on Araújo et al. [8]. For the purposes of this test, tannin levels are typically considered high when >10% and low when <10%, and flavonoids high when >1% and low when <1%. However, we realized that for radial diffusion the percentage of tannins decreases by almost half [41]. Therefore, for our analysis, we considered that tannin levels were high when >5% and low when <5%. In all analyses, a power decision of $\alpha < 0.05$ was assumed. All tests were performed using Software BioEstat 4.0 [43].

3. Results and Discussion

The average comparison in the tannin content was not significant in either group of therapeutic indications when compared to the control group. The group of species popularly thought of as antimicrobial ($\overline{x} = 3.74 \pm 4.78$) and antidiarrheal ($\overline{x} = 2 \pm 2.37$) had higher average tannin contents than the group of plants that were chosen at random ($\overline{x} = 1.09 \pm 1.79$).

Studies have shown that tannins possess antidiarrhoeal [23, 32, 33, 44–49] and antimicrobial activities [50, 51], and, although the difference in tannin levels of these two groups was not significant in our study, compared to the random group of plants (Table 1), these compounds are more concentrated in plants with these activities [8, 17–19].

The group of antimicrobial plants exhibited proportionally greater occurrences of high levels of tannin compound when compared to the control group ($P < 0.0001$, $G = 29.77$), to the group of antidiarrheal plants ($P < 0.0004$, $G = 12.75$), or the group of antidiabetic plants ($P < 0.0001$; $G = 68.33$). Additionally, the antimicrobial group had the highest average tannin levels of the four analyzed, despite the fact that five of the nine species of this group did not register high levels. However, Alencar et al. [37] identified tannin in four of these five species: *Amburana cearensis* (Allemão) AC Smith, *Ziziphus joazeiro* Mart, *Erythrina velutina* Willd., and *Maytenus rigida* Mart. This discrepancy may have occurred because different methodologies were used.

Mimosa tenuiflora (Willd.) Poir., popularly known as jurema-preta, exhibited the highest tannin content (12.58) (Table 1). In the Caatinga community, it is used for its antimicrobial property that has been demonstrated pharmacologically [52–54]. The tannic compounds are believed to be responsible for most of this activity [54].

In a separate but related study based in the same region, Araújo et al. [8] identified *Anadenanthera colubrina* (Vell.) Brenan and *Myracrodruon urundeuva* Allemão, and not *Mimosa tenuiflora*, as the species possessing the highest levels of tannins. In their analysis, the quantification of tannins was performed by chemical precipitation of casein method to identify whether plants indicated as anti-inflammatory and/or healing were associated with the presence of these compounds. The discrepancy in determining which species exhibit higher levels of tannin may be rationalized based on the different chemical properties that were tested for using the two tannin-detection methods [41].

The plants listed popularly as antimicrobial, almost 50% of them, have a higher occurrence of tannins towards the group of random plants, elucidates the idea that groups of specific therapeutic indications can serve as a criterion to find Caatinga species with high levels of this compounds. This

Table 2: Comparison between the amounts (%) of tannins and flavonoids in a herbal ethnodirected strategy selected from the vegetation of the Caatinga in the state of Pernambuco, northeast Brazil.

Group: indication	Tannins (average ± standard error)	Flavonoids (average + standard error)	Proportions of species with high versus low tannin content	Proportions of species with high versus low flavonoid content
Random selection	1.09 ± 1.79[a]	0.849 ± 0.91[a]	10.00/90.00[a]	40.00/60.00[a]
Antimicrobial	3.74 ± 4.78[a]	0.28 ± 0.17[a]	44.44/55.56[b]	11.11/88.89[b]
Antidiarrheal	2.0 ± 2.37[a]	0.94 ± 0.94[a]	20.00/80.00[a]	40.00/60.00[a]
Hypoglycemia and/or antidiabetic	0.55 ± 0.86[a]	1.32 ±1.95[a]	0.00/100.00[c]	33.33/66.67[a]

Averages or proportions followed by the same letter in column do not differ at 5% probability of Kruskal-Wallis.

observation was verified by Araújo et al. [8] facing the species as inflammatory and/or wound healing in this region.

Regarding the presence of flavonoids, in all the species common to both our analysis and that of Alencar et al. [37], we observed a 100% agreement. However, just as in the case of the tannins, no significant differences between the averages of the groups with therapeutic indications were observed for the flavonoids (Table 2). The averages of antidiabetic plant groups ($\overline{x} = 1.32 \pm 1.22$) and antidiarrheal ($\overline{x} = 0.94 \pm 0.94$) were slightly higher than the control group ($\overline{x} = 0.849{+}0.91$).

None of the therapeutic indication groups displayed proportionally higher occurrences of flavonoids when compared to the randomized group. The group of antidiarrheal plants had the same proportion of species with high levels of flavonoids as the control group, and both showed a higher occurrence of these compounds compared with the antimicrobial plants ($P < 0.0001$; $G = 21.33$).

The diabetes group of plants also exhibited a higher occurrence of flavonoids when compared with antimicrobial plants ($P = 0.0002$; $G = 13.42$), indicating that in our study the flavonoids did not display a strong association with activity despite literature precedent showed the contrary [55–57]. Pharmacological evidence already exists of antidiabetic [56, 58] and antidiarrhoeal activities [58–60] derived from the presence of flavonoids in plant species.

Contrary to our expectations, due to the small sample size of the antidiabetic plant group, these species showed the highest average levels of flavonoids in relation to the other studied indications. Additionally, the species that had highest content of these compounds, *Bauhinia cheilantha* (Bong.) Steud (4.94) (Table 1), is popularly associated with this therapeutic indication. Da Silva et al. [61], in a study on the chemical compositions and pharmacological potentials of plants of the genus *Bauhinia*, mention that this activity has been scientifically proven in this species by the treatment of rats with diabetes induced by alloxan with its methanolic extract (600 mg/kg).

Thus, the fact that the group of antimicrobial plants possesses a higher proportion of plants with high tannin levels compared to the other therapeutic indications studied may serve as evidence for future analyses aimed at finding species with high levels of this compound that appear to be locally associated with this activity. However, we are aware that other compounds, not analyzed in this study, may exert a therapeutic action cited by the local community.

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Research Article

Comparison of Effects of the Ethanolic Extracts of Brazilian Propolis on Human Leukemic Cells As Assessed with the MTT Assay

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Propolis is a resinous product collected by honey bees. It was also reported that propolis has a wide variety of biological actions, including antimicrobial activity and antioxidant, anti-inflammatory, and suppressive effects of dioxin toxicity activities. The aim of this study was to compare the in vitro cytotoxic activities of green propolis (G12) and red propolis (G13) in human leukemia cells. These cells were incubated with different concentrations of propolis and 48 hours after the IC_{50} was calculated for each cell. The results showed that the red propolis has cytotoxic effect in vitro higher than green propolis. Red propolis was showed to be cytostatic in K562 cells and caused the same amount of apoptosis as its control Gleevec. In conclusion, these results showed that red propolis is more cytotoxic than the green propolis in a variety of human cell lines of leukemia. Red propolis may contain drugs capable of inhibiting cancer cell growth. Therefore, further isolation of respective chemical ingredients from the red propolis (G13) for identification of the activities is necessary.

1. Introduction

Propolis is a resinous product collected by honey bees (*Apis mellifera*) from tree exudates mainly resins of leaf bud mixed with beeswax to form a sealing material in their honeycombs, smooth out the internal walls, and protect the entrance against intruders [1]; it was also reported that propolis has a wide variety of biological actions, including antimicrobial activity [2], antiherpes [3], and suppressive effects of dioxin toxicity [4]. Because of the wide range of biological activities, recently propolis has also been extensively used in food and beverages to improve health and diseases [5].

The medical application of propolis preparation had led to increased interest in its chemical composition and its botanical origins, because so far mainly polyphenols being flavonoids aglycones, and its derivatives. The chemical composition of the main flavonoids in propolis has been found to be quantitatively variable, depending on the environmental plant ecology [6, 7]. Therefore, we have collected 600 samples of propolis obtained by Africanized *Apis mellifera* in Brazil and then analyzed all samples. We found that Brazilian propolis is classified into 13 groups based on physicochemical characteristics. Among all groups of propolis, group 12, which is known as green propolis, is widely used mainly for ingredients of functional food and pharmaceutical purposes and the botanical origin of propolis group 12 was the resin of *Baccharis dracunculifolia* in southeastern Brazil [7]. We evaluated the effect of ethanolic extracts of the propolis group 12 and bud resins of botanical origin of propolis group 12 on proliferation of metastasis and primary tumor-derived human prostate carcinoma and observed that both samples induced growth inhibition that was associated with S phase arrest [8].

Recently, we found reddish propolis in beehives located along the sea and river shores in northeastern Brazil. We observed that bees kept in that area were collecting the red exudates on the surface of *Dalbergia ecastaphyllum* (*L*) Taud., which is the botanical origin of propolis group 13, and both samples of the red plant exudates and the propolis were analyzed and it was found that both samples contained similar ingredients [9]. The objective of this paper was to investigate the effect of ethanolic extracts of propolis group 12 (G12) and propolis group 13 (G13) in human leukemia cells.

2. Materials and Methods

2.1. Preparation of Ethanolic Extracts of Propolis. Recently, Brazilian propolis has been classified into 13 groups. Among these 13 groups of propolis, groups 12 and 13 were used for this investigation. Propolis group 12 was collected in the southeastern region in Brazil such as the state of São Paulo and Minas Gerais, and we have observed that bees (Africanized *Apis mellifera*) were visiting mainly bud or unexpanded leaves of *Baccharis dracunculifolia* (Compositae). In case of propolis group 13, the propolis was collected from beehives located in woody perennial shrubs along the sea and river shores in northeastern Brazil. It was observed that the bees visited mainly *Dalbergia ecastaphyllum* (*L*) Taud. (Leguminosae) to collect the red resinous exudates on its surface and from holes in the branches. Consequently, the color of propolis group 13 is also red. Two ethanolic extracts of propolis groups 12 and 13 were prepared as follows. Each group of propolis sample (50 g) was extracted with 600 mL of 80% (v/v) ethanol at 60°C for 30 min. After, extraction, the mixture was centrifuged and the supernatants were individually evaporated to complete dryness at 40°C and the resulting powder was designated as ethanolic extracts of propolis. These ethanolic extracts of propolis were analyzed by reversed-phase high-performance liquid chromatography (RPHPLC) and the results are shown in Figure 1 and Table 1.

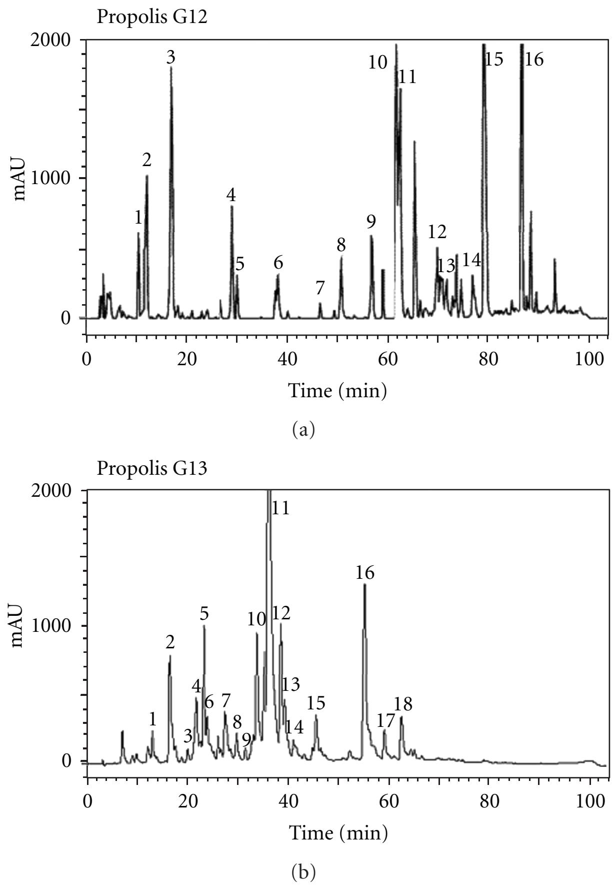

Figure 1: RPHPLC chromatograms of ethanolic extracts of propolis groups 12 and 13.

2.2. Cell Lines. The cell lines used in this study were, K562, chronic myelogenous human leukemia [10], HL60, acute promyelocytic leukemia [11], NB4, human acute promyelocytic leukemia [12], Ramos human Burkitt lymphoma [13], Raji human Burkitt lymphoma [14], Nalm16 [15] and Nalm6, human B cell precursor leukemia [16], RS4, human B cell precursor leukemia [17], B15, human B cell precursor leukemia [18], and REH, human B cell precursor leukemia [19]. The cells were grown in plastic bottles (25 cm^3) containing RPMI 1640 (Sigma R6504) medium supplemented with 10% fetal calf serum (Gibco 16000-044), 1% penicillin (10000 IU/mL), and streptomycin (10 mg/mL) (Gibco 15070) at 37°C in humidified air with 5% CO_2. The medium was changed every 48 h.

2.3. Cytotoxicity Assays. The cytotoxicity of each propolis in the cell lines indicated above was determined by the MTT (3-(4,5-dimethylthiazol-2-yl)-2-5 diphenyl tetrazolium bromide) assay. MTT is captured by cells and reduced intracellularly in a mitochondrion-dependent reaction to yield a formazan product. The ability of cells to reduce MTT provides an indication of their intactness and mitochondrial activity that serves as a measure of viability [20]. After a 48 h incubation with propolis (seven concentrations on a logarithmic scale from 1 to 1000 μg/mL), the plates were centrifuged to pellet the cells, the supernatant was removed, and 10 μL of MTT (Sigma, M5665) dissolved in 100 μL of phosphate-buffered saline (Sigma P4417) was added followed by incubation for 4 h at 37°C in a humid, 5% CO_2 atmosphere. After this period, the plates were centrifuged again, the supernatant was removed, and the insoluble formazan crystals were dissolved in 150 μL of Isopropyl alcohol. The absorbance was read in a Synergy ELISA plate reader (Bio Tek Instruments, Highland Park, Winooski, USA) at 570 nm. The results were expressed as percentage inhibition relative to control cells (considered as 100%).

2.4. Trypan Blue Exclusion Test. Aliquots of K562 and Nalm16 cells (3×10^6/mL, 1 mL/well) were plated in six-well culture plates (Corning, New York, NY, USA) containing RPMI 1640 medium supplemented with 10% heat inactivated fetal bovine serum (FBS) (Gibco 1600-044), 1% L-glutamine, 50 U/mL penicillin, and 50 mg/mL streptomycin, followed by the addition of group 12 or group 13 propolis and a cytotoxic reference drug. The cells were incubated in a final volume of 10 mL for 24, 48, and 72 h at 37°C in

Table 1: Flavonoids and other chemical constituents of propolis groups 12 and 13, determined by RPHPLC (mg/g^{-1}).

Peak no.	Propolis G12 compound	Quantity in mg/g^{-1} of propolis	Peak no.	Propolis G13 compound	Quantity in mg/g^{-1} of propolis
1	Coumaric acid	10.7	1	Rutin	1.3
2	Ferulic acid	2.4	2	Liquiritigenin	7.1
3	Λ 245 nm[a]	+	3	Daidzein	4.3
4	Cinnamic acid	2.6	4	Pinobanksin	6.0
5	Pinobanksin	1.7	5	Λ 251, 292 nm[a]	+
6	Kaempferol	1.3	6	Quercetin	1.9
7	Isosakuranetin	4.9	7	Luteolin	2.1
8	Chrysin	1.9	8	Λ 241, 272, 281 nm[a]	+
9	Acacetin	6.7	9	Dalbergin	0.9
10	Kaempferide	12.6	10	Isoliquiritigenin	12.1
11	Λ 244 nm[a]	+	11	Formononetin	19.5
12	Λ 230 nm[a]	+	12	Λ 235, 263 nm[a]	+
13	Λ 245 nm[a]	+	13	Pinocembrin	7.1
14	Λ 228, 246 nm[a]	+	14	Pinobanksin 3-acetato	2.6
15	Artepillin C	38.6	15	Biochanin A	1.5
16	Λ 223, 276 nm[a]	+	16	Λ 238, 260, 269 nm[a]	+
			17	Λ 233, 249, 329 nm[a]	+
			18	Λ 233, 256 nm[a]	+

[a] Unidentified constituents represent only UV spectral absorption maxim. + Present, but not quantified.

a humidified 5% CO_2 atmosphere. At each interval, 1 mL of cell suspension was withdrawn and mixed with a solution of 0.4% trypan blue (Sigma T6146) to counting the cells in a Newbauer hemacytometer [21].

2.5. Analysis of Apoptosis by Laser Scanning Cytometry. Flow cytometry was also used to assess the cytotoxicity of the propolis extracts and cytotoxic reference drugs in each cell type [22]. The mode of cell death was analyzed using TACS Annexin V-FITC kits (R&D Systems, Inc. Minneapolis, Minn, USA). The cells were resuspended (3×10^6 cells/mL) in RPMI 1640 with serum and plated in six-well polystyrene plates containing culture medium and the propolis or drug to be tested (final concentration: 100 μg/mL) prior to incubation at 37°C for 1, 3, 6, 12, 24, 48, and 72 h. At the end of each period, the cells were washed once with 1 mL of PBS, centrifuged, and incubated for 15 min in medium containing calcium and annexin-V. The cells were then washed again and resuspended in 0.4 mL of buffer containing propidium iodide (5 μg/mL). The samples were analyzed in a Becton Dickson FACSCanto flow cytometer in conjunction with FACSDiva software (Becton Dickson immunocytometry Systems, San Jose, Calif, USA). Control cells stained with annexin V-FITC or propidium iodide were used to adjust the cytometer compensation and gating.

2.6. Statistical Analysis. Each propolis extract was screened six times against all of the cell lines and the results were expressed as mean ± standard deviation (SD). Cytotoxicity was assessed by plotting cell survival versus propolis/drug concentration (on a log scale) followed by sigmoidal curve fitting and determination of the IC_{50} by the least squares method. Boxplots were used to analyze the distribution of IC_{50} data and compare the responses to the two propolis extracts. Differences between the IC_{50} for the two propolis extracts within a given cell line were determined by using Student's *t*-test whereas differences among the IC_{50} values for a given extract among cell line were assessed by analysis of variance (ANOVA) followed by Games-Howell pos hoc test, because there was not homogeneity of variances ($P < 0.001$ for Levene's test). A value of $P < 0.05$ indicated significance. All statistical comparisons were done using SPSS software version 7.5.

3. Results and Discussion

3.1. Cytotoxicity. Figure 2 (Boxplots) showed that the IC_{50} values for the two propolis extracts in the different leukemia cell lines were significantly different, with red propolis (group 13) being more potent cytotoxic in all cases. The greatest differences were observed with K562 and HL60 cells and the smallest difference with RS4 cells. Analysis of the boxplots in Figure 2 indicated that the responses to red propolis (G13) were less dispersed within each cell line and among cell lines (similar IC50 values) than those to green propolis (group 12), indicating less variation in the sensitivity of cells to the former extract. The IC_{50} values for a given extract among cell line were assessed by analysis of variance (ANOVA) followed by Games-Howell pos hoc test, because there was not homogeneity of variances ($P < 0.001$ in Levene's test for G12 and G13). ANOVA was positive for differences of IC_{50} among cell lines in both extracts ($P < 0.001$ for G12 and $P = 0.040$ for G13). These indicated that the responses to red propolis (group 13) were less dispersed

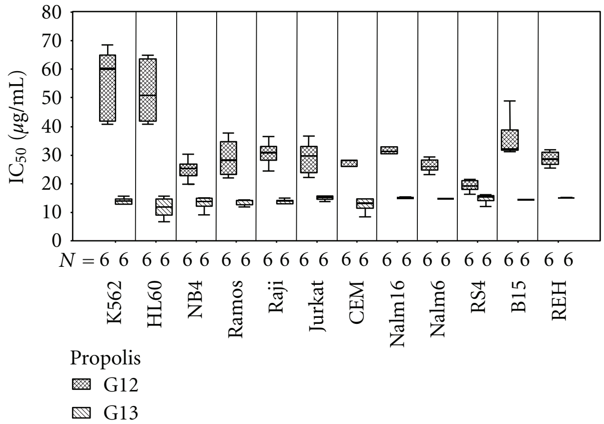

Figure 2: Boxplots of IC_{50} values for green propolis (G12) and red propolis (G13) in different leukemia cell lines by MTT assay.

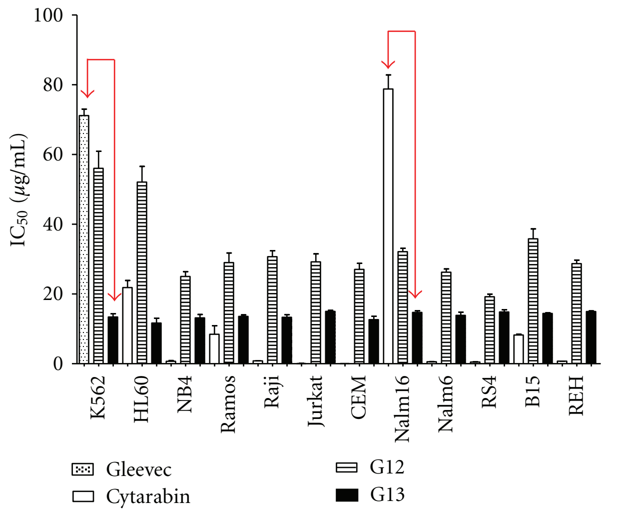

Figure 3: Results of MTT assay for propolis (G12) and (G13) using K562 and Nalm6.

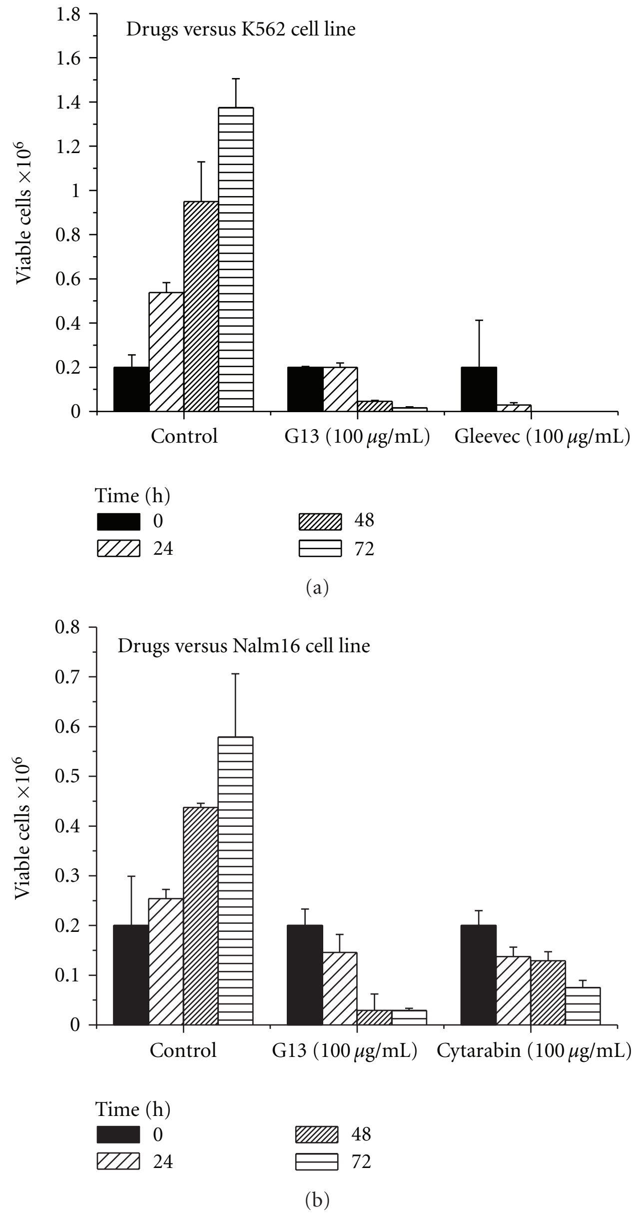

Figure 4: The kinetics of dye exclusion with Trypan blue.

within each cell line and among cell lines (similar IC_{50} values) than those to green propolis (group 12), indicating less variation in the sensitivity of cells to the former extract. The IC_{50} values for the two propolis groups were significantly different in all cases.

After analyzing the data obtained from MTT, when comparing the effect of propolis G13 with Gleevec and cytarabine, there was marked difference between K562 and Nalm16 cells. We selected the two cells for testing by trypan blue exclusion and apoptosis with Annexin V. Figure 3 demonstrated that K562 and Nalm16 the biggest difference between the IC50 of G13 and cytarabine (drug used in clinical oncology) for these two cell extract of propolis G13 when the compare Gleevec or cytarabine had great significance ($P < 0.0001$).

3.2. Trypan Blue Exclusion. Using trypan blue solution 0.4% (Sigma T8154), we quantified the viability of K562 cells and Nalm6 during periods of 24, 48, and 72 hours in front of G13 propolis and compared them to controls and cytarabine Gleevec. We concluded that a strong cytotoxicity reduced the number of viable K562 cells after 24 hours treating with Gleevec as shown in Figure 4(a). When we observed the effect caused by propolis G13 after 24 hours, there was a citostase because the number of viable cells is the same as the control. Observing Figure 4(b), we see a gradual reduction of cells for cytarabine Nalm16 and a great reduction in viable cells after 48 hours for G13 propolis.

3.3. Apoptosis. By Figure 5(a) it was noted that Gleevec reached the maximum apoptosis at 12 hours before the G13 propolis; this difference demonstrated the effectiveness of drug Gleevec which is the drug chosen for treatment of chronic myeloid leukemia (here represented by K562) given

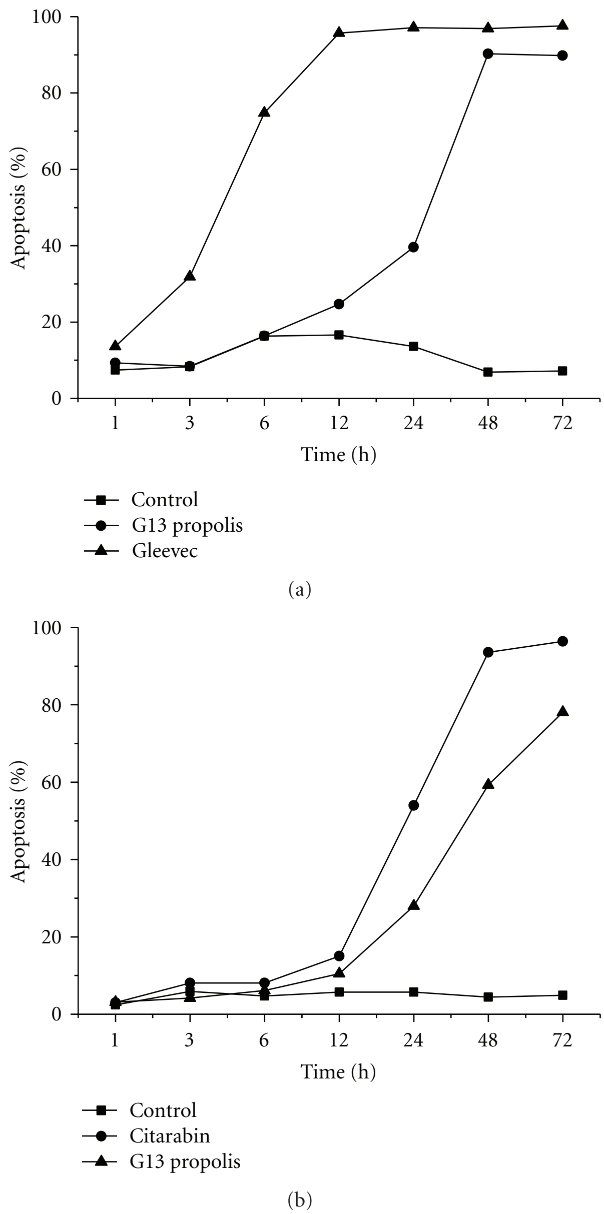

Figure 5: Analysis of apoptosis by laser scanning cytometry.

its efficiency; however, it was observed that the G13 could, after a period of 12 hours, reach a significant percentage of apoptosis which did not occur when comparing the cytotoxic cytarabine with propolis in Nam16 G13 cell line (Figure 5(b)). These results were obtained from a single experiment.

4. Conclusion

These results indicated that propolis G13 is more cytotoxic than the green propolis (G12) in a variety of human cell lines of leukemia. G13 propolis contains chemical ingredient for inhibiting cell growth of certain types of cancer. Nalm16 and K562 cell lines, represent leukemia with high mortality, and in these trials it was suggested that there is a useful chemical ingredient in these extracts. K562 chronic myeloid leukemia is the CML in blast crisis, and the cells carry the Philadelphia chromosome with a BCR-ABL b3-a2 fusion gene (Hehlman 2007). In the past, the treatment was done with antimetabolites (cytarabine, hydroxyurea), alkylating agents, interferon alpha 2b, and steroids, but these drugs have been replaced by Gleevec. NALM-16 cell line originated from peripheral blood of a patient with relapse of leukemia pro-B lymphocyte in a subacute LLC and bad prognosis and protocolarmente; in addition to other drugs, cytarabine is used for treating this leukemia. We provide data to search for drugs with cytostatic capacity possibly present in the extract of propolis G13 raising the specter of drugs with potential therapeutic use in oncology.

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Research Article

Ethnobotany in Intermedical Spaces: The Case of the Fulni-ô Indians (Northeastern Brazil)

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We analyzed the Fulni-ô medical system and introduced its intermedical character based on secondary data published in the literature. Then we focused on the medicinal plants known to the ethnic group, describing the most important species, their therapeutic uses and the body systems attributed to them. We based this analysis on the field experience of the authors in the project Studies for the Environmental and Cultural Sustainability of the Fulni-ô Medical System: Office of Medicinal Plant Care. This traditional botanical knowledge was used to corroborate the hybrid nature of local practices for access to health. We show that intermedicality is a result not only of the meeting of the Fulni-ô medical system with Biomedicine but also of its meeting with other traditional systems. Finally, we discuss how traditional botanical knowledge may be directly related to the ethnogenesis process led by the Fulni-ô Indians in northeastern Brazil.

1. Introduction

The present study consists of the authors' thoughts on their participation in the project Studies for the Environmental and Cultural Sustainability of the Fulni-ô Medical System: Office of Medicinal Plant Care. This project analyzed the medical practices of the Fulni-ô Indians (Águas Belas, Pernambuco, Brazil) and used local knowledge to improve access to health through the production of remedies based on plants. The present paper consists of an interdisciplinary proposal grounded between ethnobotany and anthropology—especially medical anthropology—and based on the interpretation of the authors as ethnobiologists. However, the positions defended here are entirely the authors' responsibility and do not represent the position of the team that participated in the project. The text is also based on a rereading of works previously published on this group [1–7].

First, we analyze local medical practices, above all the, therapeutic itinerary, which considers the different alternatives known and used by the Fulni-ô in their search for good health. Due to its multiple aspects, the Fulni-ô medical system will be analyzed using the concept of "intermedicality" that was originally used by Greene [8] to denote the hybrid and mutable nature of a shamanic system. In contrast to the widely accepted concept of static local medical practices, intermedicality results from the interaction between the local system and biomedicine. According to Greene [8], the specific practices show that the intimate relation between these two systems constructs a specific space that is contextualized and has values, symbols, practices, rites, and ethnological classifications to be incorporated, re-invented, and redesignated.

Fòller [9] uses the same concept to study therapeutic practices among the Shipibo-Conibo. However, this author emphasizes a sense of conflict and struggle between the biomedical ideology (which represents the "colonial project") and the local medical systems. Thus, these spaces of intermedicality not only create situations of interchange, as evidenced by Greene [8], but also political spaces of resistance against the hegemonic power and knowledge that biomedicine represents [9].

The concept of intermedicality has already been used to help understand the indigenous groups in northeastern Brazil. After investigating practices of healthcare access among the Ramkokamekrá of the state of Maranhão, Oliveira, [10] highlighted the power struggle between biomedicine and local medical systems. She also showed how the latter overlaps local practices. Silva [11] observed the same scenario among the Atikum of the state of Pernambuco and emphasized that biomedicine and traditional medical system "stand in opposition in the contest for legitimacy and for a privileged sphere of action (...) in a symbolic struggle for recognition within the community."

We then investigate a specific part of this local medical system: the knowledge and use of medicinal plants. We describe therapeutic uses assigned to plant resources and bodily systems, and we describe the culturally most important plants based on the consensus on their use. We emphasize that this specific knowledge is also the result of different medical traditions and can be understood as "intermedical." However, in spite of the fact that intermedicality has been defined as a "contact zone" that reproduces neocolonial discourse and Western ideology [8], we argue that the hybrid nature of the Fulni-ô pharmacopoeia contributes to greater local "medical security."

In addition to guaranteeing greater access to health, local knowledge on medicinal plants can be understood as an element affirming Fulni-ô identity. Fulni-ô pharmacopoeia is a component of an intermedical system and is used to discuss how this knowledge fits into and strengthens the process of "ethnogenesis" that is experienced by the indigenous ethnic groups in northeastern Brazil. We show that the process of ethnogenesis that is experienced by the Indians of northeastern Brazil also takes place at the local medical system.

Our main goal is to use empirical and secondary data to analyze the Fulni-ô medical system as a space of "intermedicality" and "ethnogenesis." Using these concepts, we assume that local medical systems are neither static nor mere reservoirs of pre-Colombian culture. Instead, they are creative and changeable, and thus this ability to "*actively negotiate the construction of their knowledge and practices is not a corrosive effect, but precisely what is necessary in order to assure their 'cultural survival'* " [9]. The present text supports the concept that Indians are active subjects in the process of sustaining their culture in spite of the historical difficulties they have experienced; we duly recognize Indians as "resistant" and not "resurgent" or "emerging."

2. The Scene: Political, Historical, and Cultural Ethnicity of Fulni-ô Indians

The historical reality experienced by the indigenous ethnic groups of northeastern Brazil, which is strongly marked by an old and notable process of colonization, separates them from any attempt to apply existing generalizations about indigenous societies [12], such as the figure of the "Indian" that is widespread in the popular imagination. Similar to other indigenous societies of the same region, the Fulni-ô do not fit perfectly with the common imaginary view of the Indian [13]. The unity that exists between this ethnic groups is not shown through their social institutions or in their connection to the environment. Rather, the unity is shown because they have suffered and participated in the construction of northeastern Brazil as a political and historical "conglomerate" [14].

According to Oliveira [13], the specific reality experienced by the Indians of northeastern Brazil demands a different analytical basis originated from two specific aspects. The first aspect is associated with the existent pressure on the land as Northeast Indians seek to solve conflicts with landgrabbers, squatters, and large property holders regarding the use of the few arable lands in the region [14]. In contrast to indigenous groups in other parts of the country, such as the North, conflicts are tied to the demarcation of lands and the use of natural resources, such as ores and forest products. In addition to particularities linked to the land, the Indians of the Northeast do not have a strong cultural discontinuity and cultural visibility with respect to Brazilian society as a whole. The many years during which they were subjected to colonialist policies (persecution, discrimination, forced settlement, ethnocide, and subjugation) resulted in the absence of "diacritical" marks that would delineate different cultures.

When one thinks of the northeastern indigenous people, in addition to recognizing their historical context, one emphasizes a phase of identity reconstruction or of the constitution of new ethnic groups who represent the protagonists for these societies based on a social process with a specific dynamic. Thus, indigenous communities of the Northeast are different because they have constructed a unique phenomenon of social reconstruction known as "ethnogenesis" (Ethnogenesis has also been called "journey back," "emergence," and "resurgence" [15].) This process, led by the Fulni-ô in the mid-1940s, is characterized by the political, historical, contextual, and situational (re)construction of a self-consciousness and a collective identity (and not only of a differentiation of culture and traditions) that is configured as a social limit with the purpose of achieving collective goals [14, 16, 17]. According to Oliveira [13], two factors favored this unusual process of "recuperation" by the ethnic groups: (1) economic and political contexts that strengthened the demand for the land and (2) the appearance of a favorable scenario for the old indigenous group recognition by the Service of Protection for the Indian (SPI). The old indigenous groups had their settlements officially abolished in the eighteenth century [13]. The principal demands were a differentiated state policy and access to land was fundamental to the necessities of subsistence and cultural reproduction.

The first ethnogenesis events were unleashed by the networks of kinship existing among the indigenous groups that were not yet recognized by the state. Here, we strongly emphasize that the journeys of certain shamans and other Indians in these groups were a propulsive factor, which becomes a key aspect for the analyses proposed here. These journeys were crucial for the diffusion of politically constructed diacritical signs, such as the "tore." This religious and sacred dance spread among groups and became a "*unifying and common institution (...) a political ritual, used whenever it was necessary to mark the frontiers between 'Indians' and 'whites'*" [14]. Distinctions were made evident by the religious aspects being modified, adapted, reinvented, or imported from other cultures during these events of mobility. Again, with respect to the importance of journeys and religions as ethnic affirmation, the same author states

> "*... anthropologists know that pilgrimages can be important means for the construction of a sociocultural unity between persons with different interests and standards of behavior. (...) It is precisely this that is verified in the most recent studies on the ethnic groups of the Northeast. (...) We need to see that these journeys only took on this significance because the leader also acted in another dimension, making other journeys, which were pilgrimages in the religious sense, directed toward the reaffirmation of the moral values and fundamental beliefs that provide the bases for the possibility of a collective existence.*"

The Fulni-ô led the ethnogenesis events in northeastern Brazil, as they were the only group in the region that still expressed itself with its own language, Yatê (one finds different spellings in the literature when referring to the native tongue of the Fulni-ô, such as Ia-tê or Yaathê. We have chosen the form that appears in Rodrigues [18]), from the Macro-Gê trunk [18]. However, the Fulni-ô are further characterized by certain restrictions on marriage with non-Indians, by dancing the "toré" and by spending three months each year secluded in the village of "Ouricuri" to observe their sacred ritual by the same name.

According to oral tradition, the Fulni-ô, which means "those who live close to the river" (in this case the Ipanema River), is a fusion and settlement, on the part of the Portuguese crown, of five peoples who inhabited the region: Flowkassa, Tapuya, Brogadais, Carnijós, and Fulni-ô. At present, there are three villages in the Fulni-ô Indigenous Land: "Main Village," where the great majority of the Indians live, and "Xixiaklá" and "Ouricuri," where sacred rituals are observed (Figure 1). A total of 4336 Indians live in the Fulni-ô Indigenous Land (Terra Indígena Fulni-ô, TIF) [19], which is adjacent to the urban center of Águas Belas, separated only by a little creek. The main economic activities are agriculture, cattle raising, and handicrafts. Based on many visits to the village and many conversations with the Indians, including the shaman, we concluded that there is no basic sanitation and that trash is a recurring problem.

The Ouricuri ritual is an essential political and religious institution for the Fulni-ô and is important for a better understanding of the ethnic group and the analyses presented here. According to Souza [1], the Ouricuri "*is the principal ritual, and it plays an important role in social cohesion and in strengthening and giving value to the group identity and its religious perpetuation, thus becoming the thing most responsible for the symbolic configuration of the culture.*" The ritual is observed in the village of the same name, which is approximately seven kilometers from the main village. The Fulni-ô move there for three months of the year between September and November. The entire ritual, including its organization and prayers, is secret and is forbidden to non-Indians. However, some details are known. Communication is preferably in Yatê, which creates a space for passing on and perpetuating the language. During the Ouricuri ritual, the Fulni-ô intensely work on their spirituality not only because it is a time dedicated to prayers but also due to the proximity of the village to a native forest ("Ouricuri Forest"), which is considered to be the dwelling place of their ancestors (Figure 2). According to testimony, the months of Ouricuri are anxiously awaited because the ritual renews energies and creates spiritual peace. As good health is intimately associated with the Fulni-ô cosmology and religion, the ritual provides a special moment for healing (Laplantine and Rabeyron [20] hold that in these spaces for healing, there is a search for personal physical and spiritual well-being and for plenitude and wisdom. According to them, healing is situated "decidedly on the side of the sacred, and frequently of the secret (...), and we quickly cross the boundaries between that which in our culture is reserved for health, and that which is reserved for salvation").

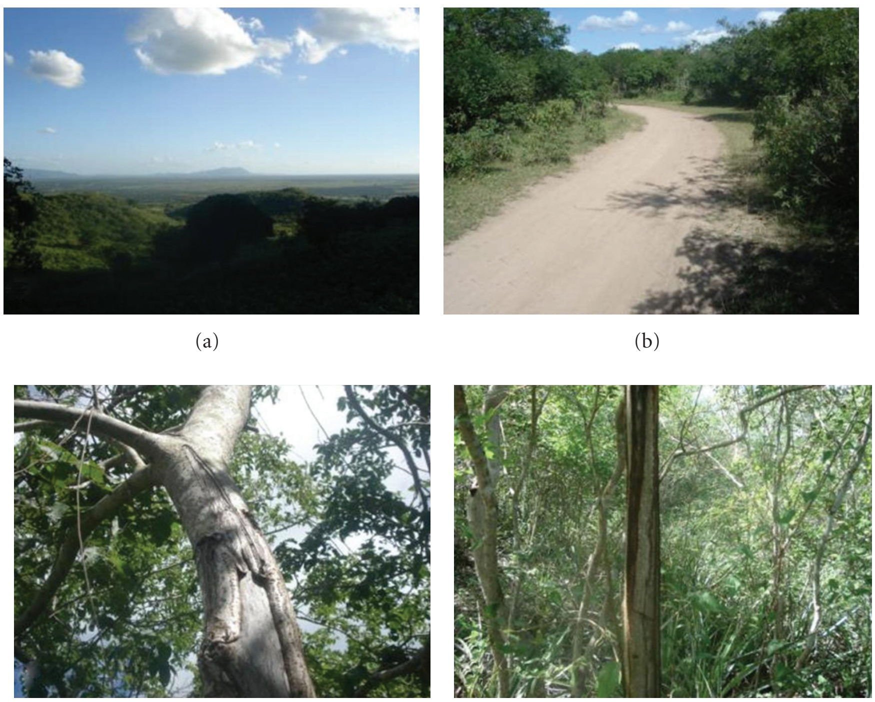
Further, in the ritual, there is a spatial separation between the sexes. The women and babies live in little colorful houses usually located at the village periphery, while men sleep in a large central shed next to a "juazeiro" tree that is considered to be sacred. The consumption of alcoholic beverages, the use of electronic devices, and sex are prohibited. In the village of Ouricuri, there is no electricity or basic sanitation and trash is collected sporadically.

3. Data Collection

Some of the empirical data were collected by 344 semi-structured interviews between November 2007 and March 2008 from a stratified-probability sample of the Fulni-ô population inhabiting the head village, including only men and women over the age of fifteen (the procedures for which are detailed in Albuquerque [5, 6]). The project arose as an initiative of the ethnic group and the researchers became partners in the undertaking. The general interviews began with the presentation of the team and its objectives. The interviews lasted between 30 minutes and two hours, depending on those interviewed. Access to local channels and representations was facilitated by the presence of a native researcher, who was an important part of the team considering that questions could be associated with protected group secrets and its representations. This researcher's involvement allowed us to avoid needing a non-Indian researcher, who would likely be inexperienced in the culture and neglectful of social signs, taboos, and codes. This behavior could generate embarrassing situations and could risk not only the results of the research but also the researcher acceptance in the community ("in order to achieve real communication with those with other cultures, we need to discover etiquettes for intercultural communication. If "speaking" is important to communication, "not speaking" can have various meanings,

(a) (b) (c) (d)

Figure 1: Fulni-ô Indigenous land, Águas Belas (NE Brazil). (a) "Main Village"; (b)–(d) "Ouricuri Village".



(a) (b) (c) (d)

Figure 2: Fulni-ô Indigenous land, Águas Belas (NE Brazil). (a) Overall view of Fulni-ô Indigenous land; (b) road through the "Ouricuri Forest"; (c)-(d) bark extraction of medicinal plants in the "Ouricuri Forest" and its vegetation structure.

from shyness and humility to disagreement or reprobation" [21]).

The team evaluation meetings were important for the identification of various problematic aspects, particularly regarding data recording. If a researcher is not completely acquainted with the nature of the questions for the instrument being used or is not trained regarding cultural questions, the researcher may record information in the wrong way and compromise the general interpretation of the results. This was the case for the immediate translation of some native categories. For example, informants cited plants for the treatment of "hemorrhoids." In the local system, some people use the term to designate a type of parasitic infection. An immediate translation can generate information that is not trustworthy. Another case is that of the local category, "gastro," which designates oral candidiasis in children ("sapinho"). The researcher, in an attempt to categorize, a priori, may translate the category as problems associated with the digestive apparatus.

Our theoretical premises can justify the choices we made in terms of our methodological procedures. We started from the idea of culture as a system of shared knowledge [22]. Thus, a medical tradition based on the use of plants is part of a system of cultural beliefs and practices, which are shared and receive consensus among members of a group.

To access local knowledge about medicinal resources, we opted for interviews with the use of questionnaires consisting of open-ended questions, which allowed room for a greater breadth of answers [23]. The application of questionnaires in a single-interview event was considered a limiting factor because some interviewees seemed not to recall plants used in their domestic practices at the moment of the intervention. However, when the sample of interviewees is representative, there is a good chance of recovering plants and information from the general consensus of the community, though at the expense of losing more specific information from the nuclear family. Thus, we did not assume that all interviews were individual because contributions from neighbors and family members were sometimes obtained, a process that could not be controlled by the interviewer. The presence of a fourth person at the interview may have motivated the interviewee to change his opinion or to furnish data that in principle did not belong to his domain. Depending on the context and the motivations, these interferences can affect the validity of the data collected [24].

Questions specific to the ethnobotanical investigation focused on knowledge about plants: how they are used and prepared and the places where these resources are collected. Thus, the questions sought to account for the following information: (1) vernacular names of plants; (2) diseases (natural or supernatural) for which the plants were mentioned; (3) parts of plants used in preparations; (4) complete methods of preparation; (5) forms of administration of the medication; (6) quantities used in the preparation of the medications.

For quantitative analysis, the citations from the interviews were examined and categorized at a later date. However, we tried as much as possible to respect the cultural specificities of the reality investigated. For example, in the case of "bálsamo," we considered the following citations for a single ethnospecies: "bálsamo," "baspo," "basso," "bássimo," and "bássamo." Similarly, therapeutic indications were later categorized, as was the case for "amidalite," which brought together the following indications: "tonsillitis," "tonsils," "tonsils inflammation," "inflamed tonsils," and "tonsil pain." To get an idea of the versatility of the Fulni-ô pharmacopoeia, its therapeutic indications (we refer to the native categories as "local therapeutic categories" or "local therapeutic indications," which are culturally recognized diseases whether they are biological (in the sense of the biomedical tradition) or spiritual in nature) were categorized in 18 bodily systems according to the World Health Organization [25]: undefined problems or pains (AND); categories without biomedical correlation (CSB); diseases of the endocrine glands, nutrition and metabolism (DGE); infectious and parasitic diseases (DIP); mental and behavioral disorders (DMC); diseases of the skin and subcutaneous cellular tissue (DPS); diseases of the blood and hematopoietic organs (DSH); diseases of the osteomuscular system and connective tissue (DSO); pregnancy, birth and puerperium (GPP); injuries, poisonings and other occurrences from external causes (LEO); neoplasias (NEO); disorders of the sensory system (TOL); disorders of the sensory system (TOU); disorders of the circulatory system (TSC); disorders of the digestive system (TSD); disorders of the genitourinary system (TSG); disorders of the nervous system (TSN); and disorders of the respiratory system (TSR).

To get an initial idea about the most important plants in Fulni-ô culture, we developed an index for calculating "relative importance." This index was constructed based on the study of various quantitative techniques used in ethnobotanical investigations [26] that aggregate different variables in a single instrument. In this sense, our index determines the "relative importance" of each plant based on (1) its versatility (wealth of uses reported); (2) total citations for the plant (an indirect measure of consensus about its use); (3) a correction factor (to avoid the overestimation of plants cited by few informants or the underestimation of well-known plants that are not very versatile). As shown above, this index reformulates existing techniques. We use it because we believe it is an adequate tool to analyze the reality investigated. However, as discussing the qualities of this new index is not the aim of this study, we will only do so in future paper.

The relative importance (RI) of each species was calculated by the following formula:

$$\text{Relative Importance}_{sp} = \text{Log}\left(\text{MU}_{sp} + \text{Cit}_{sp} * \left(\frac{\text{Ni}_{sp}}{\text{Ni}_{total}}\right)\right), \quad (1)$$

where MUsp: wealth of medicinal uses of the species; Citsp = total citations for the species; Nisp = total informants who cited the species; Nitotal = total informants.

In order to discuss the relationship between the Fulni-ô medical system and other traditional systems, all of the plants mentioned in the interviews were classified as native or exotic. Plants were considered native to the local medical system when their original geographic distribution could be traced to the South America. Conversely, plants were classified as exotic to the local medical system when their presence in the area was the result of human activity, whether intentional or unintentional. Thus, the plants considered exotic did not originally occur in the Brazilian semiarid, but were introduced by man. In this sense, it can be said that the exotic plants were introduced to the Fulni-ô through the contact with other cultures.

Finally, the team was also directed to collect the medicinal plants cited by the interviewees that were available in close proximity to the interview sites, such as in backyards, vacant lots, streets, or from neighbors, at the time of the interview. This procedure allowed for their scientific identification and avoided possible errors caused when extrapolations are made concerning the botanical identification (scientific name) of the ethnospecies cited. For example, *Ocimum gratissimum* L. is known locally as "alfavaca de caboclo" (caboclo basil), "alfavaca de vaqueiro" (cowboy basil), and "louro" (laurel). Another species, *Ocimum campechianum* Mill, is also known as "alfavaca de vaqueiro." The collection of material while accompanied by each interviewee avoids the overestimation of the local importance of a botanical species that might happen if the record was based only on the popular name. If botanical materials were not collected for verification and material testimony, then every time "alfavaca de caboclo" was cited, for example, the association with one of these scientific names could incorrectly support the role of the species for the Fulni-ô. Likewise, the native research assistant was instructed on procedures for collecting botanical material with an emphasis on obtaining samples for scientific studies. This brought important benefits to the research: (a) the collection of specimens in a high quality of condition, which allowed for more precise identification and (b) the immediate manipulation of the samples (drying, pressing, and mounting) [27].

In the present study, out of respect for the Fulni-ô traditions and acknowledging the importance of local knowledge for the structure and differentiation of the local medical system, we will not present the confidential data or the list of species that compose the pharmacopoeia of the ethnic group. Moreover, the researchers signed a confidentiality agreement, and the publication of specific information about the plants has not yet been authorized by the ethnic group. The discussions presented here stem from theoretical reflection on information already available in the literature [1–7] and from the personal experience of the authors during their work with the Fulni-ô Indians.

4. Results and Discussion

4.1. The Fulni-ô Medical System: Knowledge and Use of Medicinal Plants. Within their medical system, the Fulni-ô use the medicinal properties of 243 native or exotic ethnospecies (Figure 4). Because we respect the confidentiality of the data, these are not presented here. Local remedies are prepared with preference for the perennial parts of the plants, such as bark and root. According to Albuquerque [28], this aspect of the use of medicinal plants, which is widely found in the Caatinga vegetation, may reflect an adaptation to the particularities of this semiarid region. However, the Fulni-ô also use other plant parts, such as fruits, flowers, and seeds, in making their remedies. The principal locations cited in the interviews for collecting resources were the backyards of interviewees' residences, the backyards of their relatives, the streets in Aldeia Sede, a mountain known locally as Serra do Comunaty (Mountain of the Community), and the native forest surrounding the village of Ouricuri. A total of 183 ethnospecies notably exotic species, such as "mentruz," "hortelã da folha miúda," "erva cidreira," "samba caitá," "capim santo," "hortelã da folha grande," and "boldo"—were collected in anthropogenic areas. The forest of Ouricuri, which is especially important during the ritual, offers native and arboreal resources, such as "aroeira," "alecrim do mato," "quixabeira," "bom nome," "imburana de cambão," "imburana de cheiro," and "juazeiro". Thus, the resource zones play complementary functions in the local medical system by providing distinct resources.

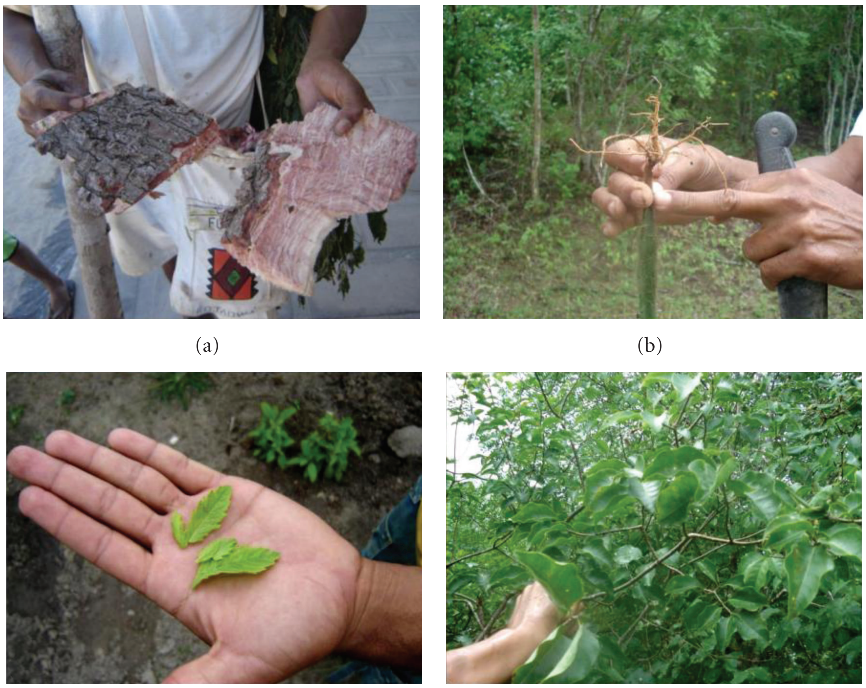
The Fulni-ô traditional medical system is quite broad and responds to a total of 18 bodily systems (Table 1). Including the *undefined problems or pains (AND),* the category that contains the greatest wealth of medicinal plants cited, there are 120 plants in total. This is followed by *disorders of the digestive system (TSD)* and *disorders of the respiratory system (TSR)*, with 98 and 91 plants, respectively. The therapeutic indications that had the greatest number of citations of use are colds, general inflammations, coughs, stomach pains, tranquilizers, fevers, wounds, strokes, wound healing, expectorants, and headaches.

Using the index proposed in this study, the ten most important plants were: "aroeira," "alecrim do mato," "mentruz," "sambacaitá," "erva cidreira," "quixabeira," "hortelã da folha miúda," "capim santo," "bom nome," and "imburana de cheiro"—of which five plants are native. In this list, "alecrim do mato," "mentruz," "sambacaitá," "erva cidreira," "hortelã da folha miúda," and "capim santo" are exotic species. These ten plants also stand out with respect to the variety of bodily systems on which they work. That is, they are quite versatile. The "aroeira," for example, is the most versatile plant with respect to bodily systems treated (14 in all), followed by "bom nome" and "quixabeira" (12 systems each). Other medicinal resources used are clays and fat from animals, such as tortoises, snakes and lizards, which are not plant-based but still deserve being reported.

4.2. The Fulni-ô Medical System: A Space of Articulation. The Fulni-ô medical system was characterized by Souza [3, 4] and mainly consists of two matrices that interact in the search for a cure: the traditional medical system and biomedicine—each represented by different institutions and agents. Specifically, according to Souza, the traditional Fulni-ô medical system is essentially shamanic, given that its conceptions about disease, health, and cures are intimately associated with religion and to the Ouricuri ritual. Knowledge and practices are transmitted orally and are

(a) (b)

Figure 3: Base pole in Fulni-ô Indigenous land, Águas Belas (NE Brazil). (a) Base pole; (b) store of medications in the Base pole.



(a) (b) (c) (d)

Figure 4: Use of medicinal plants in Fulni-ô Indigenous land, Águas Belas (NE Brazil). (a) A healer showing some medicinal plants collected in native forests; (b) a Fulni-ô indicating the part of the "urtiga" that is used in treatments; (c) "menstruz" leaves; (d) "pereiro", a medicinal plant collected in native forests.

concentrated in local specialists, called "rezadores" (prayers), "parteiras" (midwives), and "mais velhos" (elders).

Biomedicine is represented in the Fulni-ô reality by the Base Pole (Figure 3), where one schedules appointments, exams and medical travel, and by the Health Center, where consultations, exams and dental treatment take place [2]. The Base pole is also responsible for the distribution of medications purchased by the DSEI/PE (special Indigenous Health District; for more details concerning the differential policy for indigenous health, see Athias and Machado [29]). To carry out specific activities, such as health campaigns, house calls, the scheduling of appointments, and the distribution of medicines for those who have problems with mobility, there is a team of Indigenous Health Agents (*Agentes Indígenas de Saúde,* AIS). According to Souza, when more special care is needed, such as surgery, the Fulni-ô receive biomedical attention in the Maternity of Águas Belas or are sent to large centers, such as hospitals in Garanhuns, Caruaru, and Recife.

The Fulni-ô medical system shows clear evidence of its intermedical nature where a differential relation between power and capitalist ideology are present. The following are examples of intermedicality in the Fulni-ô medical system: the symbolic power and dependence of industrialized medications in the community; the high consumption of these same medications, with a turnover, in only one six-month period, of 120,000 Reais; the presence of a health center in the village of Ouricuri, the location of the sacred ritual, where

Table 1: Bodily systems addressed by the Fulni-ô medical system and the wealth of plants cited. Indigenous Land of the Fulni-ô, Águas Belas (PE).

Bodily system (WHO)	Wealth of ethnospecies
Undefined problems or pains (AND)	120
Categories without biomedical correlation (CSB)	23
Diseases of the endocrine glands, of nutrition and metabolism (DGE)	58
Infectious and parasitical diseases (DIP)	64
Mental and behavioral disorders (DMC)	37
Diseases of the skin and subcutaneous cellular tissue (DPS)	42
Diseases of the blood and hematopoietic organs (DSH)	11
Diseases of the osteomuscular system and connective tissue (DSO)	32
Pregnancy, birth, and puerperium (GPP)	23
Injuries, poisonings, and other occurrences from external causes (LEO)	60
Neoplasias (NEO)	13
Disorders of the sensory system (TOL)	5
Disorders of the sensory system (TOU)	14
Disorders of the circulatory system (TSC)	51
Disorders of the digestive system (TSD)	98
Disorders of the genitourinary system (TSG)	68
Disorders of nervous system (TSN)	22
Disorders of the respiratory system (TSR)	91
Not possible to report*	1
General Total**	843

*The information cannot be provided, especially due to cultural norms.
**Refers to the set of all of the citations and not the total species cited, as it considers plants that were indicated for more than one system.

there is the highest incidence of diseases and the greatest demand for traditional treatments, such as prayers and medicinal plants; the high demand for biomedical treatments even during the ritual of Ouricuri, in spite of the distance from the Base Pole; the appreciation of certain procedures and biomedical treatments, such as birth in the birth center, to the detriment of traditional practices, such as the role of "midwives"; symptoms and treatments for falling ill are linked to biomedicine, although explanatory models bring together different spheres of social and biological life, such as participation in the ritual of Ouricuri, the spiritual world, work, and emotional exhaustion; finally, poor service at large biomedical institutions, such as the birth center of Águas Belas.

In addition, biomedicine is present in the practice of some of the Indigenous Health Agents who, although they are Indians, adopt the agency's discourse. In informal conversations, certain indigenous agents favored and gave value to biomedical practices in their activities. Fóller [9] found a similar situation and believes that this partial position is a "survival strategy" and not "opportunism," as the local agents who were interviewed thought that the most appropriate technological package was the one that guaranteed their salary. However, in spite of the fact that Fulni-ô agents hold their positions by recommendation, the reason for their biomedical discourse still needs a better appraisal.

Another example of intermedicality is the appropriation of biomedical categories to refer to symptoms and treatments. Various biomedical therapeutic indications and treatments were cited in the interviews, including those by local specialists. These included "colic," "inflammation," "antiseptic," "depression," "purgative," "expectorant," and "hypertension". However, some biomedical terms were redefined, as was the case for the "hemorrhoids" category that was initially understood by researchers as being "dilations of the veins of the rectum with or without flow of blood." A better appraisal of the local meaning allowed us to observe that for the Fulni-ô, the local category "hemorrhoids" has to do with enterobiasis, a parasitic worm infection. Finally, we highlight names of certain plants used in traditional medicine that have associations with industrialized medications, such as "anador," "dipirona," "terramicina," "ampicilina," and "novalgina," although this traditional/industrial overlap is not exclusive to the Fulni-ô experience. Albuquerque et al. [24] compiled information from the scientific literature on the use of medicinal plants by traditional communities in the Caatinga, and they demonstrated that this phenomenon exists in various locales.

The examples cited above show clearly the intermedical field constructed in the Fulni-ô reality through contact between the traditional medical system and biomedicine, and some of these contacts show an asymmetrical power relationship. Capitalist ideology is explicitly marked by the creation and expansion of the local economy, showing, as Fòller [9] states, that the local acceptance of biomedicine cannot only be analyzed with respect to high technology and therapeutic efficacy. Local acceptance should consider economic and ideological factors as well. Contact between these two medical traditions influences the dynamics of the two systems but conceives points of conflict and clashes of interests that will make it difficult for traditional medicine to succeed.

Thus, the examples cited above reinforce the concepts of Greene [8] and Fòller [9]: the intermedical field is a "contact zone" where points of conflict and clashes of interests are evident. Biomedicine represents a colonial project of domination that no longer takes place through economic or territorial conquest but happens through the strong influence on local cultures and, especially, through scientific knowledge. Despite the fact that this notion exists, the construction of an intermedical field may contribute to ethnic affirmation and to safer health access. In fact, the intermedical field begins with a relation of forces that are, in principle, asymmetric but that create a counter-force of resistance to power and hegemonic ideology. The counterforce unleashes resistance and cultural reaffirmation, which is a process of ethnogenesis. Thus, just as the demand for land released the first manifestations of ethnogenesis, the ideological pressures present in the Fulni-ô intermedical system are configured as a new sphere of demands for a differentiated ethnic identity. Finally, intermedicality diversifies the possibilities of finding a cure and optimizes access to health.

4.3. The Traditional Medical System as a Space for Ethnogenesis. To understand how the points of conflict and confrontation in the zone between the traditional medical system and biomedicine unleashed new forces for self-affirmation by the Fulni-ô—characterized by the desire to recover knowledge and traditional uses of medicinal plants—we will analyze the process that culminated in the planning of the project Studies for the Environmental and Cultural Sustainability of the Fulni-ô Medical System: Office of Medicinal Plant Care. We will also analyze the traditional botanical knowledge of the Fulni-ô Indians. This project is interdisciplinary and participative in nature and is financed and directed by the Area of Traditional Indigenous Medicine/VIGISUS II/FUNASA and carried out by the Mixed Association Cacique Procópio Sarapó (AMCPS).

The recent journeys to the community, whether for cultural presentations or for the sale of handicrafts (especially in large urban centers), were fundamental for the process of construction of the Office Fulni-ô and for the first manifestations of ethnogenesis. Specifically, we highlight the role of José Francisco de Sá (Xycê, in the native language), the former president of the AMCPS, who traveled numerous times to Brasília (DF) looking for more profitable sales of Fulni-ô handicrafts. During one of his journeys, he was invited to participate in a course on medicinal plants, which strengthened his already existing interest in the therapeutic properties of plants. Considering the reality of the medical system, which is characterized by its precarious nature and excessive use of medications, among other conflicts, José Francisco learned about the existence of financial resources intended for research and promotion of traditional indigenous medicine. His initial project was approved by the National Health Foundation (Fundação Nacional da Saúde, FUNASA). His initial idea was to strengthen traditional practices—specifically the use of medicinal plants from the Fulni-ô pharmacopoeia—as an alternative to industrialized medications. According to Fòller [9], the awareness of traditions and identity is stimulated by direct contact with other realities.

The first advances were the construction of a bed and a nursery for the cultivation of medicinal plants at the TIF. Twelve Indians participated in a theoretical and practical course on management and associations, agricultural techniques, and the production of herbal remedies. A pharmacist offered training for the production of herbal remedies at a laboratory in Garanhuns, Pernambuco State. It was through these activities that José Francisco came into contact with plants that were still unknown to him, such as "poejo" and "transagem." Later, when more funding became available, a laboratory for the production of herbal remedies and the Fulni-ô Office of Medicinal Plant Care was constructed with the appropriate equipment (Figure 5). Currently, the workshop is still preparing for production, but it is characterized as a space for sharing knowledge. Many Indians take some plants from its beds and have the opportunity to learn with José Francisco.

One may conclude that concrete advances have been made in recovering and giving value to traditional knowledge. Even without the production of herbal remedies at the workshop, advances were made from the recognition of the importance of local practices of healing to the Fulni-ô identity and from recognition of the unfavorable situation of this medicine in confronting the domination of the discourse and practices of biomedicine. Like other activities, traditional medicine can be understood as resistance to an attempt to homogenize and subjugate an essentially heterogeneous and subjective system.

The training of José Francisco in Brasília and the training of the 12 Indians in Garanhuns will allow for the production of herbal remedies as characterized by their scientific framework. Even the alternative of allowing a reduction in the consumption of industrialized medications is external to the culture. The forms of preparation, the locations and the tools are different from so-called traditional practice. The physical structure of the Fulni-ô Workshop for the Manipulation of Plants, with all of its equipment, is an institutionalization of medical practices (Figure 5). However, we need to make a distinction, as Fòller proposes [9], between biomedical "medicine" and biomedical "power." In this sense, the presence of knowledge, practices, and technologies are recognized as ideological appropriations in which a process of "negotiation and renegotiation" in the construction and resistance of ethnic identity is "dynamic and transitory." A similar phenomenon was identified by Greene [8], who identified the prescription of injections, or the complementary use of industrialized medications, in shamanic sessions among the Aguaruna Indians of Peru. The injections enchanted the Aguaruna and exhibited a high symbolic power for therapy, especially because of the character of the treatment—that of introducing into the sick person something that restores his or her health—is very close to their traditional explanations for cures and diseases.

4.4. Intermedicality, Ethnogenesis, and the Use of Medicinal Plants. The new understanding of the process of ethnogenesis of the Fulni-ô Indians—a cultural reaffirmation based on the value of traditional medical practices—also interferes with the utilization of some resources from the local system, such as medicinal plants. The Fulni-ô pharmacopoeia, the bank of medicinal plants known and used by the ethnic group, was considerably influenced by contact with other traditional medical systems, especially beginning with the historical experience of the Indians of northeastern Brazil, and once more, with the journeys made by members of the community.

At least 102 (42%) of the 243 species that compose the Fulni-ô pharmacopoeia are exotic species. Assuming that an exotic plant was not originally part of the environment experienced by a given community, in our case, the region of the Fulni-ô Indigenous people, the incorporation of an exotic plant in the local pharmacopoeia occurs due to some

(a) (b)

(c) (d)

Figure 5: Fulni-ô office of Medicinal Plant Care in Fulni-ô Indigenous land, Águas Belas (NE Brazil). (a) Bark of "Aroeira," a medicinal plant; (b) equipment for the production of herbal remedies; (c) bed and a nursery for the cultivation of medicinal plants; (d) herbal remedies.

contact with a different reality. In addition to detecting the presence of exotic species in the local pharmacopoeia, we also applied the index proposed. This index considers different variables jointly in order to detect the relative importance of plant resources in cultural practices of healthcare access. Thus, results showed that among the ten most cited plants, five are exotic. This information leads us to believe that in addition to being part of local knowledge, the exotic species play an important role in traditional practices due to their versatility and consensus about their use.

This massive presence of exotic plants in the bank of plants used is viewed in different ways in the literature. Some authors state that their presence in the traditional pharmacopoeia is evidence of "cultural erosion" or "acculturation," which reflects a passive vision of culture or a vision that is incompatible with the notion of ethnogenesis. In contrast, Albuquerque's [28] understanding of the importance of exotic plants for different cultures suggests that the presence of exotic species results from a process of "diversification." The author understands that cultures are active in constructing their realities and that exotic species reflect a cultural "strategy" for diversifying the set of plants used, including new elements and making possible a greater range of useful resources. Albuquerque's [28] ideas agree with the Fulni-ô reality because the interviews showed that at least 14 therapeutic indications are treated only with exotic plants.

As stated earlier, the lived history of the Fulni-ô influenced the construction of the current pharmacopoeia. Like all northeastern ethnic groups, they suffered various processes linked to the land, such as their sedentarization in villages, which aimed to homogenize them through catechisms and interethnic marriages [14, 30]. In some cases, like those of the Artikum of the Serra do Umã, different indigenous ethnic groups and groups of blacks inhabited the same portion of land [17]. The settlements or isolated territories became a space where different groups were able to share their traditional knowledge about cures—a process similar to what took place with the Fulni-ô. Many studies have investigated the presence of exotic plants in local pharmacopeias [31, 32] and have located intercultural exchanges as one of the principle motives [33]. For example, Janni and Bastien [34] studied the Kallawaya Indians in Bolivia and observed that a large part of their knowledge of medicinal plants comes from journeys by members of the various tribes to communities in different ecological zones. These authors state that a large part of the wealth of knowledge is due to the incorporation of knowledge developed externally to the Indian culture.

Again, the role of travel in the enrichment of the local pharmacopoeia was fundamental, as in the case of Towê, the Fulni-ô Indian who has knowledge of many medicinal plants. Towê travels to different places, especially Brasília, to sell handicrafts and to publicize Fulni-ô culture through the Cafuia, a dance for artistic presentation. During these journeys, Towê has learned about different biomes and medicinal plants and has worked for a long time in a pharmacy with herbal remedies. As a result, of the 243 plants cited, 23 (9.4%) belong to his knowledge alone. Each trip brings something new to the Fulni-ô reality that can be incorporated into local practices if it passes through the local crucibles of the community. Journeys, thus, have the potential to enrich the local pharmacopoeia if the knowledge is shared with the community. Many studies have investigated the intracultural diffusion of knowledge [35–38] and note that many variables influence this process, including the social prestige of the individual who possesses the knowledge [39, 40]. That is, the knowledge learned and stored by Towé may potentially be absorbed by the entire ethnic group, but its diffusion depends on many variables, including Towé's political role and prestige within the Fulni-ô.

The current Fulni-ô pharmacopoeia is the result of the incorporation of other knowledge, and thus the Fulni-ô medical system is plural—not only in offering different forms of access to health but also in being the fruit of many other medical systems. In spite of very notable traits of biomedicine found in local practices, the intermedicality of the Fulni-ô medical system is also constructed through the appropriation of other traditional systems from other cultural matrices (a phenomenon that shapes the pharmacopoeia for all the human groups in the Caatinga.) The appropriation and redefinition of these systems constructs the Fulni-ô identity at the present time and guarantees them, in spite of points of conflict and clashes of interests, various possibilities of access to cures.

The intermedicality of the Fulni-ô system strengthens local "medical security" (an allusion to the concept of "nutritional security"). As documented by Souza [1, 4], many older people prefer to use traditional practices and seek services from biomedicine only when these are ineffective; in the same way, medicinal plants are an alternative cure for diseases that require expensive remedies, that are not available at the pharmacy of the Base Polo or that are difficult to access due to mobility problems.

The existence of different alternatives for curing the same disease reduces the use pressure that is placed on the plants used in treatment, which contributes to the conservation of biodiversity. Albuquerque and Oliveira [41] evaluated this premise for a rural community in Pernambuco and observed that the use of a wide variety of species (i.e., alternatives) for the same therapeutic indications (headache, inflammation, fever) reduces the use pressure on each of the species and allows them a greater possibility of remaining in the environment for future use. In these cases, we hope that intermedicality will guarantee what we call "resilience" of medical systems. However, this scenario requires that locally used medicinal plants have the same prestige, which does not occur in the Fulni-ô reality. Interviews suggest that just a few species are highly preferred; that is, only a few species receive most of the attention in terms of collection, as is the case for "aroeira," "imburana de cheiro," and "alecrim do mato."

As noted earlier, the most cited therapeutic indications by the Fulni-ô were colds, general inflammations, coughs, stomach pains, tranquilizers, fevers, wounds, strokes, wound healing, expectorants, and headaches. These indications are exactly the ones treated with a greater range of species. In other words, the most frequent infirmities are treated with a wider spectrum of resources. Thus, we expect that this relationship will allow greater security in the treatment of the more frequent diseases, as many possibilities of treatment exist, which reduces the used pressure per species. However, future studies should be done to better evaluate this question.

5. Conclusions

Analysis of the Fulni-ô medical system, from the point of view of intermedicality, allows us to recognize its multiplex nature and the fruit of the hybridization of the local medical system with other traditional systems and biomedicine. Although there are well-defined spaces of action in each one of the traditions, given their proper specificity, there is an interaction with the construction of the local medical system that results in different points of articulation depending on the correlation of existing forces and the interests that are involved. We recognize that biomedicine is floating in an ideology that does not encourage heterogeneity but seeks homogenization as a means to domination. Nevertheless, its presence in the Fulni-ô reality strengthens their search for an identity and ethnicity and, with the traditional medical system as the driving force, allows for an outlet for another event of cultural reelaboration. Once more we see that the Indians are active agents in constructing their reality. The ideological appropriations presented here are not evidence of a cultural de-structuring but evidence of the incorporation of a symbolic power to renew forces, which guarantees cultural perpetuation. Oppression makes it necessary to struggle even against expressions like "resurgent," "remaining," or "mixed" Indians. As they themselves recognize, they are "resistant" Indians—which is the appropriate name for those who with much health, whether hybrid or not, have struggled against more than 500 years of cultural, economic, or political persecution.

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Research Article

A New Application for the Optimal Foraging Theory: The Extraction of Medicinal Plants

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The Optimal Foraging Theory was used to identify possible patterns in bark extraction and the selective cutting of *Anadenanthera colubrina* (Angico), a medicinal plant. The hypotheses were built on two approaches: selection of collection place and bark exploitation occurrence in only one of these resource areas. The results suggest that the distance that must be traveled to reach each gathering site determines the extent of the extraction process, showing that people minimize the time and energy spent in *A. colubrina* collection. The availability of each site appears not to influence the operation. The resource amount was the optimized variable for bark extraction, which was analyzed in only one collection zone. In contrast to the phenomenon of collection place selection, the distance between angico individuals, the management period, and the tannin content did not affect bark extraction. This study also discusses how certain cultural aspects influence the extraction of angico.

1. Introduction

Ecological and evolutionary models are used in different studies on human populations and are important in trying to better understand the criteria for decisions concerning natural resource use and how human beings occupy living space because they allow for detecting patterns and predicting situations [1]. Despite being subject to some criticism [1–3], one of the most frequently used tools in human population studies is the Optimal Foraging Theory. The theory assumes that there is a cost/benefit ratio in obtaining any resource necessary to life and that natural selection favors foraging behavior, which optimizes species fitness [4, 5]. The energetic return (ratio of gained and spent energy in foraging events) is certainly the most studied variable in studies of optimal foraging, possibly due to the direct influence of researches in nonhuman animals. However, the Optimal Foraging Theory suggests that other variables are considered in the events of search and collection of resources [6], such as nutritional value.

There are different types of optimization within the theory that differ according to the biological process addressed, (see [5, 7–10]). MacArthur and Pianka [7] constructed a theoretical model in an attempt to determine which habitat (i.e., resource zone) species should visit during foraging activities because resources will vary with regard to their quality, abundance, and spatial distribution [7, 11].

This model predicts that more productive environments with higher resource biomass (resource availability) generally accumulate more consumers [6]. Thus, when the model of MacArthur and Pianka [7] is transposed to the reality of ethnobotanical research, it is expected that most productive areas with higher availability of plant environmental resources will have a larger amount of extraction events and will be more recognized locally, receiving, therefore, an increased amount of use citation.

According to MacArthur and Pianka [7], foragers spend energy and time in obtaining resources. Therefore, the distance to be traveled to obtain a resource determines the choice of the site to be visited. It is expected that closer resource areas receive greater attention in plant resource collection and are subject to a greater number of extraction events. Additionally, the model considers that resource acquisition is divided into two distinct moments: the search itself and its management. Specifically for management, resources that are difficult to handle demand more time and energy [11]. In the case of ethnobotany, this means that, due to certain characteristics such as the presence of thorns and the hardness of wood or bark, resources that are more difficult to extract potentially have a lower preference of use.

Based on the foregoing research, the present study aimed to evaluate whether the use of plant resources in a rural community of Pernambuco follows the cost/benefit predictions of the Optimal Foraging Theory, focusing on the knowledge and the use of *Anadenanthera colubrina*, an important species to local communities in the Caatinga. The study was performed on two levels. The first approach is regional and aims to understand the selection of sampling sites to be visited during species collection, with the hypothesis that extraction events of *A. colubrina* are dependent on its density and the distance of these areas from the community. Additionally, it was tested whether the areas with the highest number of use citations are those with the highest densities of *A. colubrina* determined. The second approach focused on the bark harvested in one of the site collections, since that plant part is locally the most important. For this second approach, it was hypothesized that bark collection (total extraction events) is dependent on the distance to be traveled, bark thickness, difficulty of collection, and, finally, tannin content (resource quality).

As previously pointed, the Optimal Foraging Theory considers other variables capable to optimization beyond energy. In this regard, transposing the optimal approaches to the use of medicinal plants, we hypothesized that the bark collection depends on the resource quality, in this case the amount of tannin provided by the resource. Therefore, both the bark thickness and its tannin concentration are important factors in this model.

Based on the results of this work, this study contributes to optimization theory in four ways. This was the first effort to empirically understand plant resource use under optimal foraging patterns within the Brazilian's semiarid context. Second, this study analyzed the extraction of a resource that is mainly used for medicinal purposes. Third, this study investigates both the harvested amount and the harvested resource quality of the species. Finally, the current research contributes to theory by discussing how biological nature and cultural systems interact to influence human behaviors.

2. Material and Methods

2.1. Study Area. The study was conducted in the municipality of Altinho (8° 29′ 32′′ S e 36° 03′ 03′′ W), which is located in the Agreste of Pernambuco, Northeast Brazil, characterized by a semi-arid warm climate (BSh) according to the Köppen classification, with average temperature around 23°C and annual rainfall between 300–1200 mm/year [12]. Altinho is located 160 kilometers (km) from the state capital and its population is approximately 22,000 people, evenly distributed between urban and rural areas [12]. The region is covered by a vegetal formation known as hipoxerophyte Caatinga, which is highly seasonal, deciduous, thorned and made up of different physiognomic and floristic compositions.

The research was performed in the Carão community (S 8° 35′ 225′′ and W 36° 05′ 576,′′ see Alencar et al. [13]), which is composed mainly of rural farmers who specialize in the production of maize, beans and palm. According to figures from the health center, 189 people live in the community, of which 112 are over age 18 (67 women and 45 men). The community is 16 km from the urban center of Altinho, with difficult access via non-paved roads [14].

The Carão community is located near a mountain known as the Serra do Letreiro, with a maximum altitude of 700 meters (m). It presents as a large mosaic of different seral stages in which shrubs and trees predominate. In relatively inaccessible areas, on the slope of the Serra do Letreiro, that, according to residents, have never suffered human intervention, there are plant communities in advanced succession stages. In other localities of the slope vegetal transformation has taken place in private areas for cultivation, especially of maize and beans. The mountain is an important source of plant resources, especially trees, for building or medical purposes. Other units that make up the local landscape and provide different resources include: the base of the slope that correspond to the mountain base, usually composed of several plant communities in initial succession stages triggered by the abandonment of pastures or crops, and the terrains, which is a particular and large area surrounding a residence, usually enclosed by fences. The terrains are composed of pastures, areas intended for grazing of animals where certain tree species with local importance, such as *Spondias tuberosa* Arruda and *A. colubrina*, are tolerated; manioc fields or planting, areas for cultivation of maize, beans and palm; and home gardens, areas immediately adjacent to the residences [15].

One of the most important plants used by Caatinga communities is the Angico *Anadenanthera colubrina* Vell. (Brenan) (Mimosaceae). This species plays important roles in different-use categories [16], although it is mainly used for traditional medicine [17]. In the community of Carão, the Angico is well known by the dwellers. The bark is mainly used for therapeutic purposes, and, because the medicinal category is considered the most important, the bark is the most exploited resource in the community. The bark is also exploited for its application to tanning (i.e., an artisanal processing of animal skins into leather); however, this activity is not common among the dwellers in Carão, and only two people are tanners within the community. Both the therapeutic and tanning properties result from the tannin within the species' bark. The use of Angico is strictly local, and only a few leather pieces are sold to the people of the region. There is no a regular commercial activity associated with Angico extraction.

2.2. Ethnobotanical Survey. This study is part of an ethnobotanical research program carried out since 2006 in the Carão community [13, 14, 18, 19]. Following the determinations in Resolution 196/96 of the National Council of Ethics, which governs research dealing with human beings, all informants who agreed to participate in the study signed a Term of Free and Informed Consent (FICT).

Information on the knowledge and use of *A. colubrina* necessary for testing the hypotheses was collected from semi-structured interviews [20] conducted between August 2006 and July 2007. A total of 36 men and 65 women aged 18 years or older, totaling 101 participants or 90.2% of the community's adult population, were interviewed. To access all known and used plants, a free listing technique was employed [20], in which the dwellers were asked to record the known plants and their used parts, attributed uses, collection places, and use forms. Only the information about Angico was used in this study. Information about the knowledge and use of the species will be discussed in a subsequent publication. The total number of citations in each action area was used to test whether the environmental availability (absolute density of *A. colubrina*) influenced the informants' consensus concerning the collection sites.

Subsequently, 15 residents were selected from among the participants who recognized *A. colubrina* as a resource in the initial interview to participate in a second stage of interviews. This phase aimed to explore more deeply the process of choosing and defining action areas to be visited for Angico extraction and the features observed in *A. colubrina* individuals making them suitable for bark collection. Among the 15 participants in this second phase of interviews were local experts (people recognized by their peers as holding considerable knowledge on the use of plants) on, in this case, *A. colubrina*. In this sense, the ethnobotanical information required for statistical tests and results discussion were collected from a triangulation of methods, using a quantitative and qualitative approach.

2.3. Availability and Extraction of Anadenanthera colubrina. To understand the selection of resource areas, it is considered the local classification of the landscape that was presented in detail by Almeida et al. [21]. For the present study, only three were considered, since they are the only areas recognized as a source of *A. colubrina:* slope, base of slope, and ground (Figure 1). Of these, only ground is not presented by Almeida et al. [21] and corresponds to regions adjacent to houses, for planting of fruit trees and small livestock. A more detailed map of the region is available in Alencar et al. [13].

Two different strategies were used for sampling vegetation; the choice depended on the characteristics of each area. In the slope, which has been little altered by humans according to the residents, the point-centered quarter method was used [22]. For this area, 180 quarters points were allocated at 20 m from each other. These points were equally divided into 9 parallel transects, which were also at 20 m distance from each other. This relatively inaccessible resource zone is located approximately 3 km from the core population. In the base of slope, a site with clear signs of bark extraction was chosen, with selective cutting where an *A. colubrina* population had grown. As this location was formerly a pasture and has well-defined boundaries, all of the Angico individuals present in a 2.7-hectare (ha) area were sampled. This population is located about 900 m from the community center. Finally, ten properties were selected for ground analysis and, as performed at the "base of slope," had their area recorded and all Angico individuals sampled.

Although distinct, it is believed that the sampling strategies used did not hamper or distort the data analysis. Firstly, these strategies estimate the same ecological parameter, the absolute density (AD), which was the variable used for tests in this study. Secondly, sampling at the base of slope and the grounds were the same, the only difference is that in this last collection area, the total area is subdivided among the properties visited. Finally, in addition to the sampling described for the slope, which considered an inclusion criterion, additional hikes were performed in the area to identify individuals of *A. colubrina*.

The CGL (circumference at ground level) was recorded for all *A. colubrina* individuals as well as the presence or absence of bark extraction or selective cutting events. The absolute density (number of individuals per hectare) was calculated according to the method of Araújo and Ferraz [22]. Such sampling information was used to test whether the Angico environmental availability in each gathering site determines the absolute and relative total number of exploitation events. To test whether the bark extraction is dependent on individuals' distance from the community, tannin content, bark thickness, and sampling difficulty, only the population sampled in the mountain range basis was considered (Figure 1). The choice of this area was based on the high density of Angico individuals, its presence in one of the locally recognized resource areas, its status as a common use area, the clear presence of sampling events and, finally, the fact that only one individual of *A. colubrina* had been sampled in the slope (which forbids the modeling proposed here). In this area, the individuals with diameter at breast height (DBH) larger than 6 cm had four bark samples obtained from different positions on the stem at a height of 2 m to determine the bark thickness, an indirect measure of the resource amount offered by each Angico individual and its tannin concentration. Bark thickness was estimated in the field using a caliper with 0.005-milimeter (mm) accuracy, and bark samples were then dried in an oven in the field. These dried bark samples were used for tannin concentration analysis. Finally, all individuals in the area were categorized into two types: few aculei (FA-type), when few and small aculei were present, and many aculei (MA-type), when they were large and densely distributed near the stem. In this sense, this classification aims to evaluate whether the difficulty of collection influences extraction events. Samples from different individuals of *A. colubrina* were collected and deposited into in the Professor Vasconcelos Sobrinho Herbarium (PEUFR), Federal Rural University of Pernambuco.

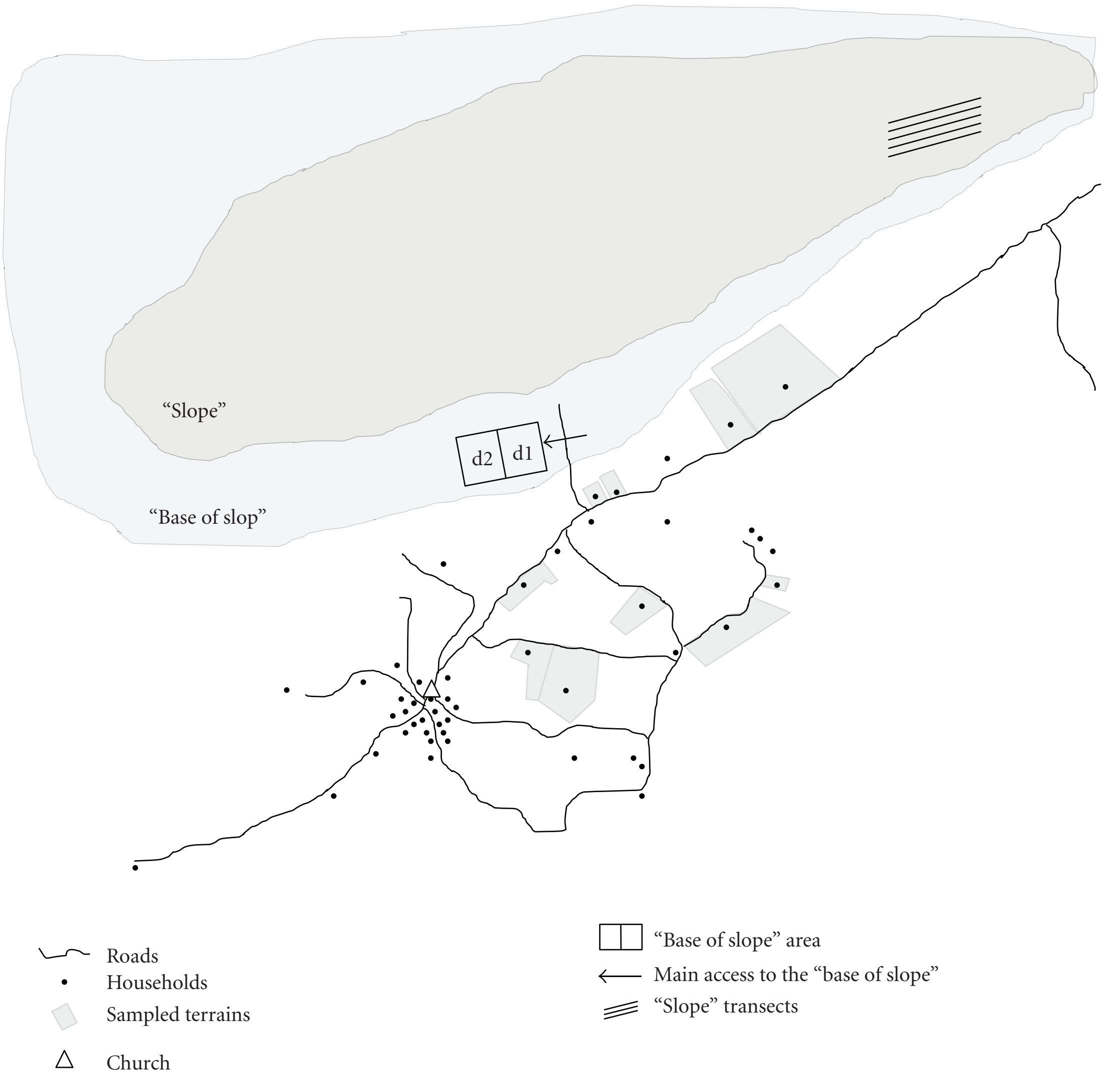

Figure 1: Sketch of the Carão community, Altinho municipality, PE, Brazil, showing the areas used to estimate the environmental availability of *Anadenanthera colubrina* (Vell.) Brenan. d1 and d2 represent the subdivision of base of slope into two blocks of distance used in the analysis of distance effect on the tannin concentration and Angico extraction.

2.4. Tannin Concentration. Assuming that *A. colubrina* is important for its medicinal uses and for tanning animal leather due to the presence of tannins in its bark, the tannin concentration (grams per micro liter—g/μL) was assessed as one of the variables to be optimized in the bark extraction process as an indirect measure of the resource quality. An adaptation of the Radial Diffusion Method [23] was used to determine the tannin concentration [24]. For sampling design, three factors were considered. First, the diameter classes were considered to investigate whether there is a relationship between concentration and individual diameter. The diameter at ground level (DGL) was measured for all individuals in the area, which is a standard methodology for Caatinga [25]. They were categorized into diameter classes with a 3-centimeter amplitude. These classes allow for analysis of the size and/or age phase of the population's individuals. The following classes were considered: 2 (3–5.99 centimeter-cm), 3 (6–8.99 cm), 4 (9–11.99 cm), 5 (12–14.99 cm), 6 (15–17.99 cm), 7 (18–20.99 cm), 8 (21–23.99 cm), 9 (24–26.99 cm), and 10 (27–29.99 cm). Second, aculeus density in the stem of each individual was considered according to the two types, FA-type and MA-type, which were previously described in Section 2.3. Finally, the last variable to be considered in the design was distance of the individuals with regard to ease of access. Thus, to determine whether the tannin concentration varied with distance, the area was subdivided into two blocks of 120 × 130 m, the first (d1) being nearer and the second (d2) more distant from the community (Figure 1). In this sense, the sample design to determine the tannin concentration was a 7 × 2 × 2 randomized block factorial design with three replications. Eighty-four individuals were randomly selected for tannin analysis.

2.5. Data Analysis. To assess whether there were differences in the amount of *A. colubrina* extraction between different resource areas, the absolute and relative total numbers of events of selective cutting and bark extraction were compared by chi-squared (contingency table). It is assumed a relationship between signal collection and use pressure in each area; that is, the use pressure in each area of collection is related to the frequency of use.

The slope was omitted from that analysis because it presented only one Angico individual, without evidence of exploitation. The distances between these areas and the community were estimated by GPS. The distance to be traveled to access each area was used as indirect measure of energy spent in collection events.

To assess whether there were differences between diameter classes in the bark extracted from the base of slope area, the total number of events in each class was compared using the *G* test. In addition to the chi-squared test, the *G* test was used to analyze data frequencies. A polynomial regression was performed to assess whether there is a link between diameter class and tannin concentration in the bark. This curve was used to analyze whether the diameter classes with higher frequencies of extraction events match the diameter classes with higher tannin concentrations. The total number of individuals with signs of bark extraction between the two types of Angico, the MA-type and the FA-type, was compared using the chi-squared contingency table analysis. Assuming that tannin concentration could vary between these two types of Angico, which, along with the gathering difficulties, could determine the intensity of bark extraction; the *t*-test was used to identify differences in tannins between these two types. Again, the use pressure is related to the total collection events.

A. colubrina individuals were categorized into six bark thickness classes with an interval of 1 cm, and the extraction events were compared by the *G*-test. As performed for tannin concentrations, a regression was performed to assess the relationship between diameter class and bark thickness. The resulting curve was used to examine whether the diameter classes with higher frequencies of collection correspond to those with greater bark thicknesses. Finally, to identify whether Angicos' distance in relation to the community influences the events of Angico collection, the categorization of the area into two blocks by distance, d1 and d2, was again considered. The extraction events between these two areas were also compared by the *G*-test. All tests were performed using statistical packages: Bioestat v 5.0 [26] and Startgraph v 5.1.

3. Results and Discussion

3.1. Resources Zone Selection. A total of 119 individuals of *A. colubrina* were sampled in the ground, 1040 in the base of slope and only one in the slope, corresponding to absolute densities of 4.33, 385.19, and 5.0 ind./ha, respectively, (Table 1). The greatest environmental availability of *A. colubrina* is, therefore, in the base of slope. Of the 119 Angicos existing in the ground area, 62 (52.1%) showed extraction signs, 18 (15.2%) of bark collection, and 48 (40.33%) of selective cutting. In the base of slope, 73 (7.01%) individuals were exploited, of which 34 (3.26%) showed signs of bark withdrawal and 42 (4.03%) of selective cutting. The single individual from the slope showed no evidence of exploitation. The total absolute ($X^2 = 5.813, P = 0.0159$) and relative (proportion of exploited to non-exploited individuals) ($X^2 = 293.97, P = 0.0001$) prevalence of bark extraction events and selective cutting were higher in the ground collection zone than those in the base of slope.

Table 1: Comparison among the three areas known as collection sites of *Anadenanthera colubrina* (Vell.) Brenan in the Carão community, Altinho, PE, Brazil, emphasizing the ecological parameters and species extraction, as well as the recognition of areas in the interviews.

	"Grounds"	"Base of slope"	"Slope"
Total of sampled individuals	119	1040	1
Absolute density (ind./hectare)	4,33	385,19	5
Total of exploited individuals (%)	62 (52.1)	73 (7.01)	0 (0)
Bark extraction (%)	18 (15.2)	42 (4.03)	0 (0)
Selective cutting (%)	48 (40.33)	34 (3.26)	0 (0)
Citations in the interviews (%)	42 (60.86)	1 (1.44)	26 (37.68)

These data suggest that the distance of resource areas from the community determines the choice of places to be visited in extraction events, with nearby zones visited most. In this sense, energy and time spent are minimized in collection events. Ladio and Lozada [27] studied the use of food plants by a community in Patagonia and tested different hypotheses related to the optimal use of these resources. Despite evaluating the full range of plants recognized as food, the authors found a similar situation, in which the community extracted a higher percentage of food resources in the vicinity of residences. The authors justify this pattern by the fact that two distant areas demanding a greater investment of time and energy and have a lower abundance of resources. Like the abundance of plants taken as food, studied by Ladio and Lozada [27], the environmental availability of *A. colubrina* does not define its extraction in the Carão community. Although the base of slope presents a significantly higher absolute density, this area does not have a higher density of bark extraction. Thus, it is possible to state that the distance from the resoursce area influences the selection of the site being visited; that is, the time and energy required to visit each area for the collection of *A. colubrina* are two variables to be optimized during extraction events.

Thus, the data suggest that the strategy used by the residents in the exploitation of *A. colubrina* is intended to reduce collection time. In other words, within the perspective of the Optimal Foraging Theory, residents optimize the return on events of Angico collection by reducing search time and, hence, the energy spent, rather than optimizing collection amount. This strategy may be a reflection of the main uses of *A. colubrina* in the production of medicinal infusions. For such use, only a relatively small volume of bark, about 200 g, is required.

The ground was cited 42 (60.86%) times in the interviews, the base of slope only once (1.44%), and the slope 26 (37.68%) times (Table 1). No differences were observed between the total citations of the two most cited sites (ground and slope), ($X^2 = 0.0523$, $P = 0.0689$). In this sense, the ground, areas closest to residences that suffer more use pressure, stands out in the number of citations received. The base of slope had a small number of citations attributed to it. However, in contrast to extraction data and despite being a more distant site with low abundance of *A. colubrina*, slope stood out in interviews in terms of the number of citations as much as ground. Unlike the collection events data, interview data suggest that the distance from the collection site and density of Angico do not determine residents' recognition of an area as a resource area.

The interviews with the experts also pointed out some issues that are taken into account in the selection process for a resource area to be visited. The initial issue is that collection of plant resources such as Angico is not always independent of other activities. The residents affirmed that *A. colubrina* is collected when performing other tasks, such as herding cattle and weeding clearings. In this sense, collecting Angico in the mountains, where many areas of cultivation and grazing are located, is not a local preference but a fact because the interviewees spend much of their time devoted to their daily living activities. The residents also stated that *A. colubrina* is a rapid growth species, even after selective cutting. The local recognition of this growth warrants, in addition to proximity, the strong use pressure on individuals located in the ground. Additionally, there is a local belief that influences the choice of action areas. Some informants say that plants used for medicinal purposes cannot be collected from borders of roads or very frequented places because they are quite seen. Finally, another important issue is the political organization. Many residents reported not collecting *A. colubrina* in certain areas, especially in base of slope, because these are private properties.

The previously shown extraction and interview data suggest that *A. colubrina* extraction by the Carão community follows some premises of the Optimal Foraging Theory. However, some findings did not support this theory. How does an area like base of slope, with a density of *A. colubrina* almost ten times higher than the other areas, have only 7.01% of its Angicos exploited and go unrecognized as a resource area in the resident interviews? In conjunction with the gardens at each home, why was the slope the most cited and recognized resource area, despite its lower Angico density?

According to Martin [28], the collected information should be relative, there are difficulties in establishing what is good for humans because, in addition to their biological characteristics, social groups also respond to a cultural system. Accordingly, Sih and Milton [29] argued that the Optimal Foraging Theory should not be used simply to understand human behavior without a critical position. Therefore, this study reports that Angico extraction is driven by the interaction of environmental aspects, such as spatial distribution and resource density, with cultural factors of the Carão community. These cultural factors include spatial work distribution, dwellers' knowledge of species location on the slope, and resource collection.

Species use dynamics can also influence the selection of resource zones to be visited. The preferable use of the species is for medicinal purposes, and the current amount used is relatively low as use depends on illness events. Accordingly, collection does not compromise the Angico individuals or the dwellers because community members are aware of the species' spatial distribution and do not need to search for new individuals.

Therefore, as Martin [28] stated, the optimal outcomes in human populations occur within their cultural features. Future studies should be conducted to better understand this relationship as well as how cultural characteristics inherent to human groups reflect or distort the cost/benefit relationships in obtaining resources, especially in a longer time interval.

3.2. Bark Extraction in Base of Slope

3.2.1. Collection Difficulty (Aculei). As stated previously, 34 (3.26%) of 1040 *A. colubrina* individuals sampled in the base of slope presented evidence of bark extraction. Of all "Angicos," 390 were classified as MA-type, with 14 (3.58%) being exploited, while 650 were categorized as FA-type, with 20 (3.08%) individuals presenting signs of collection. Despite interviews suggesting that the aculeus amount in the stem is a selection criterion, no differences in the proportions of exploited and nonexploited individuals for each type ($X^2 = 0.199, P = 0.655$) were observed. According to the informants, it is better to extract FA-type bark because it presents fewer aculei, its shaft is more rectilinear, it is easier to carry in large quantities, and its bark is more easily removed.

3.2.2. Diameter Class and Bark Thickness. When the total numbers of extraction events in each diameter class were compared, three classes stood out in terms of the number of exploited Angico: 8 (24–26,99 cm), 9 (27–29,99 cm), and 11 (33–35,99 cm) (Table 2). Thus, the bark extraction events are concentrated in the intermediate diameter classes. Figure 2(a) shows how thickness relates to diameter classes, showing a linear and positive relation ($Y = 0.307286 + 0.0159271 * X; P = 0.001; R^2 = 14.9575; R^2$ adjusted $= 0.1496; \text{SD} = 0.086; F = 58.04$). The higher the diameter class, the greater the bark thickness, and; consequently, more resources are available for *A. colubrina* individuals. In this sense, because the larger diameter classes are represented by only four individuals, the data suggest that the bark extraction in the base of slope focuses on the greatest return of resources, concentrating on those individuals that provide a greater quantity (thickness) of bark.

Additionally, when Angico individuals in the area were categorized in relation to bark thickness and the total extraction events in these categories were compared, it appears that the largest category (thickness between 6.00 and 6.99 mm) is most exploited ($P = 0.005$) (Figure 3). Therefore, individuals with greater bark thickness were more heavily

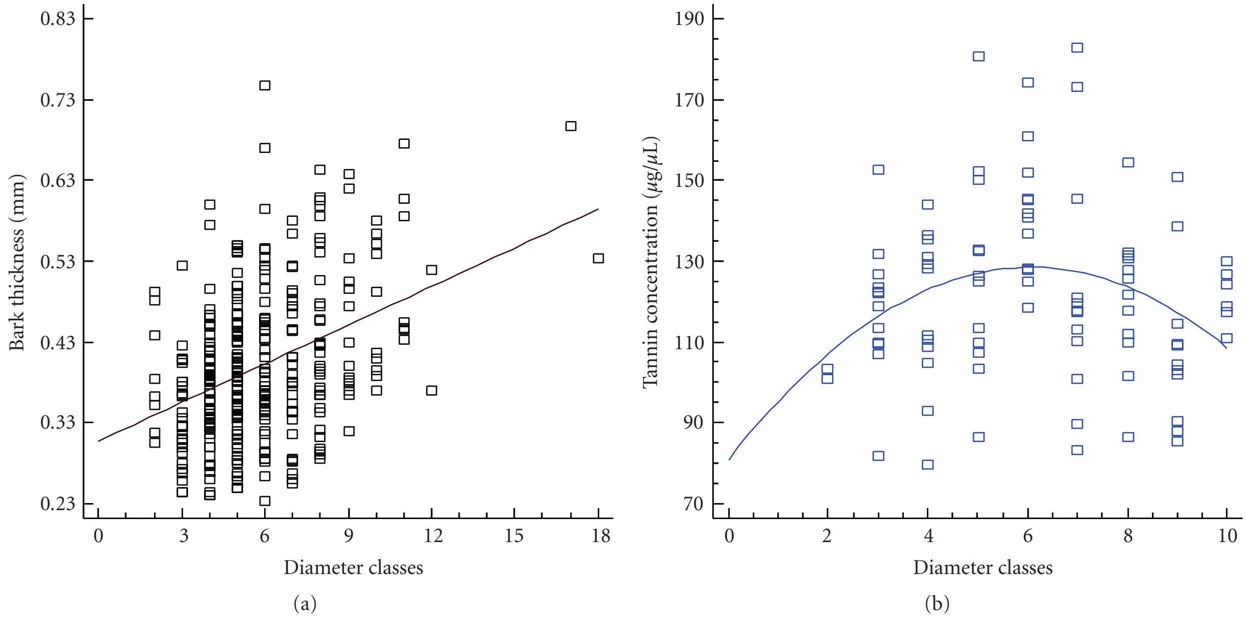

FIGURE 2: Tannin content and bark thickness in relation to the diameter classes in a population of *Anadenanthera colubrina* (Vell.) Brenan in the Carão community, Altinho, PE, Brazil. (a) Ratio between bark thickness and diameter classes from 2 (6–8,99 cm) to 18 (54–56,99 cm) ($Y = 0.307286 + 0.0159271 * X; P = 0.001$). (b) Distribution of tannin concentrations in relation to the diameter classes from 2 (6–8,99 cm) to 10 (30–32,99 cm) ($Y = 80.7965 + 15.7183 * X - 1.29551 * X2, P = 0.0001$).

TABLE 2: Bark extraction of *Anadenanthera colubrina* (Vell.) Brenan by diameter classes and the types of many aculei and few aculei in a population of base of slope, Carão community, Altinho, PE, Brazil. *Diameter classes that concentrate extraction events in proportion.

Type of	"Many aculei" (MA)			"Few aculei" (PA)			All individuals		
diameter classes (cm)	Without signs	With signs	Total	Without signs	With signs	Total	Without signs	With signs	Total
1 (0–2.99)	15	0	15	216	0	216	231	0	231
2 (3–5.99)	69	0	69	142	1	143	211	1	212
3 (6–8.99)	86	0	86	103	0	103	189	0	189
4 (9–11.99)	66	2	68	58	1	59	124	3	127
5 (12–14.99)	51	1	52	51	2	53	102	3	105
6 (15–17.99)	33	2	35	24	2	26	57	4	61
7 (18–20.99)	16	1	17	16	4	20	32	5	37
8 (21–23.99)*	18	2	20	13	6	19	31	8	39
9 (24–26.99)*	8	1	9	4	2	6	12	3	15
10 (27–29.99)	10	0	10	1	1	2	11	1	12
11 (30–32.99)*	3	2	5	2	1	3	5	3	8
12 (33–35.99)	1	1	2	0	0	0	1	1	2
13 (36–38.99)	0	0	0	0	0	0	0	0	0
14 (39–41.99)	0	0	0	0	0	0	0	0	0
15 (42–44.99)	0	0	0	0	0	0	0	0	0
16 (45–47.99)	0	0	0	0	0	0	0	0	0
17 (48–50-99)	0	1	1	0	0	0	0	1	1
18 (51–53.99)	0	1	1	0	0	0	0	1	1
Total	376	14	390	630	20	650	1006	34	1040

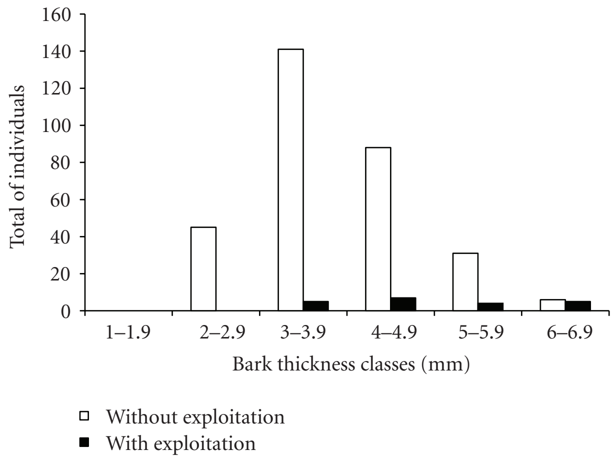

Figure 3: Bark extraction events of *Anadenanthera colubrina* (Vell.) Brenan divided into thickness classes in a population of base of slope, Carão community, Altinho, PE, Brazil.

used during bark collection. This parameter is a criterion used when selecting the individuals of *A. colubrina* to be extracted.

3.2.3. Tannin Concentration. The Angico individuals evaluated in the tannins test presented an average concentration of 121.46 g/μL (SD = 21.90), with minimum and maximum concentrations of 79.0 and 183.0 g/μL, respectively. Unlike the case of bark thickness, the diameter classes in which bark collection events are most frequent are not those with the highest tannin concentrations. Figure 2(b) shows the relationship between diameter classes and tannin concentrations ($Y = 80.7965 + 15.7183 * X - 1.29551 * X^2; P = 0.001; R^2 = 7.82496; R^2$ adjusted $= 0.0573; \text{SD} = 21.24; F = 3.72$). The calculated polynomial curve shows that the tannin content increases with the diameter up to a peak and then decreases, and the concentration peak is found in individuals from diametric class 6 (18 to 20.99 cm). Therefore, the diameter classes that showed significant differences in the number of individuals exploited do not match the classes with the highest tannin content (tannin peak); that is, the classes with the greatest number of extraction events (8, 9 and 11) are in the range where tannin content decreases. Thus, content of tannin, the chemical compound responsible for the main uses of *A. colubrina*, is not optimized during bark collection in the area evaluated.

Like the total number of individuals exploited in the two types, MA-type and FA-type, the tannin concentration did not differ between types ($P = 0.4931$). This information seems to be recognized by residents; despite the local preference to collect individuals of *A. colubrina* with few aculei, there is almost a consensus among them that the two types are equally strong.

3.2.4. Individuals Distance. It was expected that Angicos nearer to the main access point of the base of slope area would present a greater number of collection events since their collection would demand less time and energy. However, there were no differences in the total number of individuals exploited between the two blocks of distance ($X^2 = 0.436, P = 0.5093$). Accordingly, bark collection is equally distributed in the base of slope and, therefore, is not influenced by the time and energy spent during extraction.

Concerning bark collection specifically in the base of slope, the data suggest that there is no differential collection between the types few aculei (FA-type) and many aculei (MA-type). In this sense, as theoretical models suggest that easy management resources receive more attention, it was expected that the difficulty of collection would influence extraction. The models also predict that a difficult management resource will be exploited only if the return offsets the energy and time spent. As previously noted, unlike studies with food resources, which consider the return on energy as a measure of optimization, the tannin concentration was considered in the present study. However, as noted, tannin content also does not vary between the two morphological types of *A. colubrina.* The tannin content appears not to be a selection criterion for which Angico will have its bark exploited. The initial hypothesis was that, by conscious criteria or not, residents exploited barks of individuals with higher tannin levels. However, diameter classes with more extraction events did not correspond to those with the highest tannin levels. The classes with more exploitation did correspond, however, to those classes with the greatest bark thicknesses. Accordingly, the data indicate that, for bark collection, only the volume available for each Angico individual (bark thickness) is optimized because optimization based on tannin concentration does not occur. Such information may indicate that the resource quality for medicinal uses, measured by the tannin concentration, does not determine the collection and the optimization occuring by collecting larger bark volumes. The distance to be traveled between each individual and the main point of access to the area, an indirect measure of time and energy required, also did not influence the extraction. The area analyzed may be too small to assess the influence of distance or the existence of other access points.

4. Conclusion

This study shows that some aspects of *A. colubrina*, a primary medicinal resource; the extraction in the Carão community is influenced by environmental characteristics, as well as specific characteristics of individuals. At first, factors that determine the resource area selection to be visited during extraction events were analyzed. Subsequently, it was analyzed the factors that influence the specific house collection and medicinal resources more locally demanded at one of these collection areas. Both approaches are designed on the light of Optimal Foraging Theory, and the different variables analyzed in this study are summarized in Table 3.

Few investigations have evaluated the use of plants based on the Optimal Foraging Theory [27, 30, 31], especially for medicinal plants. In this sense, the biggest difficulty was to transpose the optimum premises for medicinal uses. In principle, it is difficult to conceive an optimization process

Table 3: Summarization of the two approaches built from the Optimal Foraging Theory: resource zone selection and bark extraction in the base of the slope and the respective variables analyzed for the understanding of *Anadenanthera colubrina* (Vell.) Brenan extraction patterns in the community of Carão, Altinho, PE, Brazil.

Approach		
Resource zones selection	Extraction	Use citations
Availability of *A. colubrina*	No optimization	No optimization
Distance	Optimized	No optimization
Bark extraction in the base of slope	Extraction	Interviews
Tannin contration	No optimization	Optimized
Individuals distance	No optimization	Optimized
Diameter classes	Optimized	Optimized
Collection difficult (aculei)	No optimization	Optimized

for collecting medicinal plants, since the foraging studies focus on food resources, traditionally having the energy as analytical factor. However, despite this theoretical basis be maintained when the distance of collection sites, accessibility, difficulty of collection, and amount collected were analyzed, given the specifics of the medical category, the collected energy was not considered as a variable to be optimized, but the tannin concentration.

From this study it was concluded that the optimization ecological relationships can be verified in other use categories other than food and that, in principle, there are no theoretical limitations to the TFO use in different contexts of use. One of the major contributions of this research is that the data analyzed do not support the analogy between energy-mediated return (food crops) and bioactive compounds-mediated return (medicinal plants), that is, for optimum medicinal use seems not to consider the optimal plant quality, but the amount capable to be exploited.

The data from this study suggest that natural resource use, such as the extraction of *A. colubrina*, depends on both cultural and environmental factors and that human behavior is influenced by these two types of factors. Additionally, ecological theories and tools are important instruments for analyzing human populations. However, they need to be carefully used and further contextualized, especially when analyzing cultural specificities.

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Research Article

Evaluation of the Antimicrobial Activity of the Decoction of *Tropidurus hispidus* (Spix, 1825) and *Tropidurus semitaeniatus* (Spix, 1825) Used by the Traditional Medicine

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Tropidurus hispidus and *Tropidurus semitaeniatus* are two lizard species utilized in traditional medicine in Northeast Brazil. Their medicinal use includes diseases related with bacterial infections such as tonsillitis and pharyngitis. They are used in the form of teas (decoctions) for the treatment of illnesses. In this work, we evaluated the antimicrobial activity of the decoctions of *T. hispidus* (DTH) and *T. semitaeniatus* (DTS) against bacterial strains, namely, standard and multiresistant *Escherichia coli*, *Staphylococus aureus*, and *Pseudomonas aureuginosa*, alone and in combination with aminoglycoside antibiotics. The decoctions were prepared using the whole body of the dried lizards, and the filtrate was frozen and lyophilized. When tested alone, the samples did not demonstrate any substantial inhibition of bacterial growth. However, in combination with antibiotics as aminoglycosides, decoctions reduced the minimal inhibitory concentration (MIC) of the assayed antibiotics against multiresistant strains of *S. aureus* and *P. aureuginosa*. Chemical prospecting tests revealed the presence of alkaloids in DTS. This is the first study evaluating the medicinal efficacy of *T. hispidus* and *T. semitaeniatus* and contributes to the list of new sources of medicines from natural products of animal origin.

1. Introduction

Natural substances from animals, plants, and minerals have provided a continuous source of medications [1]. In Brazil, as in other countries, animals and plants have been widely utilized since antiquity by the traditional medicine [2, 3], and according to Alves and Rosa [4], they have played a significant role in the healing arts up to nowadays.

Despite their prevalence in the practice of traditional medicine throughout the world, the medicinal use of animals have often been neglected in research, compared to medicinal plants [5]. According to Alves et al. [6], emphasis has been placed for the most part on plant-based medications more than on those from animal origin. Besides, plants are easier to collect, store, and sell. However, recent publications have demonstrated the importance of zootherapy in different sociocultural environments worldwide, and examples of the use of remedies derived from animals can currently be found in many urban and semiurban localities, particularly in developing countries [2, 3, 7, 8].

Reptiles are among the species most utilized in popular medicine, and their role in practices and beliefs related to the treatment and/or prevention of diseases has been reported by different traditional communities worldwide [4, 7–11].

Table 1: Species utilized in the antimicrobial analyses.

Species	University/Archive no.	
Tropidurus hispidus	Universidade Regional do Carri-URCA	LZ-847
Tropidurus semitaeniatus	Universidade Regional do Carri-URCA	LZ-926

Table 2: Fresh weight, dry weight, and yield of decoctions of *Tropidurus hispidus* and *Tropidurus semitaeniatus* (g).

Species	Fresh weight	Dry weight	Solvent	Yield of crude extract
Tropidurus hipidus				
Whole animal	193.5	52.00	Distilled water (DTH)	11.0539
Tropidurus semitaeniatus				
Whole animal	94.68	27.7067	Distilled water (DTS)	4.4885

DTH: decoction of *Tropidurus hispidus;* DTS: decoction of *Tropidurus semitaeniatus*.

Despite the extensive use of reptiles for medicinal purposes, there is a general lack of detailed information about the exploitation of these animals and their impact on the species involved [11].

Among the species utilized in traditional medicine in Brazil, we can cite *Tropidurus hispidus* and *T. semitaeniatus. Tropidurus semitaeniatus* (Spix, 1825) is endemic to the "Caatinga" biome. Popularly known as the "outcrop lizard," it is a small lizard with a diurnal habit. It is found on broad rocky surfaces (outcrops), and with a dorsoventral flattened body, specialized at getting into small cracks in the rocks, where it is protected and probably remains during the warmest hours of the day [12]. *T. semitaeniatus* is a carnivorous animal, with a sit-and-wait feed strategy, consuming a large variety of preys, mainly ants [13]. In popular medicine, *T. semitaeniatus* is indicated for the treatment of measles, asthma, alcoholism, dermatomycosis, and chickenpox [6].

Tropidurus hispidus (Spix, 1825), also known as the "lava lizard" or "catenga," inhabits the Brazilian Northeastern region [14, 15]. It is found in diverse habitats, mainly on tree trunks, rocks, and walls [14, 15] and lives mainly in open areas. This is a diurnal and territorial lizard with a sedentary-opportunistic feed strategy [13, 15–18]. It feeds mainly on arthropods, some plants, flowers, and small vertebrates [14, 19]. According to Barbosa [20], *T. hispidus* is used in the treatment of chickenpox in a community in Paraiba State. Alves and Rosa [3] noted in their studies the popular use of this species in the treatment of sore throat, tonsillitis, and pharyngitis.

According to Freire [21] and Marques [22], the utilization of these lizards in traditional medicine is also associated with the treatment of inflammation, dermatitis, venereal diseases, and snake bites, being consumed in the form of a decoction, and because of the small size of the specimens, it is used whole in the preparation of a tea. Alves et al. [6] also described other forms of use for these species in which a tea (decoction) is included, besides the ingestion of a broth of cooked meat and the application of the live animal on the affected area. Many of these diseases such as inflammation and dermatitis can be associated with pathogenic microorganisms, including bacteria and fungi, which suggest a possible antimicrobial potential for these species.

Traditional medicine, in general, represents a field in which there is still little research in terms of evaluation of therapeutic or clinical potential [23], and few studies have been done until now to demonstrate the clinical efficacy of animal products for medicinal purposes [24]. Therefore, the aim of this work was to determine the antimicrobial activity of decoctions prepared with the lizards *T. hispidus* and *T. semitaeniatus*, tested alone and in combination with antibiotics.

2. Material and Methods

2.1. Zoological Material. The animals were collected in the municipality of Crato (7°14′03′′S × 39°24′34′′W), Ceará, Brazil in April 2010. They were caught manually and with air pistols by rummaging through habitats where these animals can be found (Permission for collection: 154/2007 no. 23544-1 process no. 17842812). Once the lizards were collected and sacrificed, their skins were removed and dried in a drying oven to prepare extracts. Control specimens were fixed in 70% alcohol and deposited in the zoology collection of the Universidade Regional do Cariri/LAZ-URCA (Table 1).

2.2. Preparation of Decoctions of T. hispidus (DTH) and T. semitaeniatus (DTS). The decoctions of *T. hispidus* and *T. semitaeniatus* were prepared by submersing the whole lizards, already oven-dried, in boiling distilled water for 2 h. Afterward, the decoction was filtered, frozen, and later lyophilized. A concentrated form was used in the antimicrobial assays. The yields for the decoctions are shown in Table 2. The decoctions were then stored in a freezer for future analyses.

2.3. Strains. The experiments were carried out using the following bacteria: clinical isolates of *Escherichia coli* (EC27), *Staphylococcus aureus* 358 (SA358), and *Pseudomonas aureuginosa* PA RB1 and the standard strains *E. coli* ATCC 10536, *S. aureus* ATCC 25923, and *P. aeruginosa* ATCC

Table 3: Results of chemical prospecting of decoctions of *Tropidurus hispidus* and *Tropidurus semitaeniatus*.

Classes of secondary metabolite	DTH	DTS
Phenols	−	−
Pyrogallic tannins	−	−
flobatenic tannins	−	−
Anthocyanins	−	−
Anthocyanidines	−	−
Flavones	−	−
Flavonols	−	−
Xanthones	−	−
Chalcones	−	−
Aurones	−	−
Flavanonols	−	−
Leucoanthocyanidins	−	−
Catechins	−	−
Flavanones	−	−
Terpenes	−	−
Alkaloids	−	+

DTH: decoction of *Tropidurus hispidus;* DTS: decoction of *Tropidurus semitaeniatus*. (+) presence and (−) absence.

15692 [25]. All the strains were maintained on heart infusion agar slants (HIA, Difco), and, before the assays, the cells were grown overnight at 37°C in brain heart infusion broth (BHI, Difco).

2.4. Drugs. The antibiotics utilized, gentamicin, kanamycin, amikacin, and neomycin, were obtained from Sigma Chemical Corp, St. Louis, Mo, USA. All the drugswere dissolved in sterile water before use.

2.5. Drug Susceptibility Tests. The test solution of the decoctions of the two species was prepared by dissolving 10 mg of the samples in 1 mL of dimethylsulfoxide (DMSO-Merck, Darmstadt, Germany), obtaining an initial concentration of 10 mg/mL. This solution was then diluted to 1024 μg/mL using sterile water. The minimal inhibitory concentrations (MIC) of the extracts were determined using microdilution assays in BHI broth with bacterial suspensions of 10^5 CFU/mL and drug concentrations varying from 1024 to 1 μg/mL (in 2-fold serial dilutions) [26]. MIC was defined as the lowest concentration of drug at which no bacterial growth was observed. For the evaluation of extracts for antibiotic-modifying activity, MICs of the antibiotics were determined in the presence and absence of each decoction at subinhibitory concentrations (128 μg/mL), and the plates were incubated for 24 h at 37°C.

2.6. Chemical Prospecting. The chemical tests to determine the presence of heterosides, saponins, tannins, flavonoids, steroids, triterpenes, cumarins, quinones, organic acids, and alkaloids were performed according to the method described by Matos [27]. The tests are based on visual inspection for a color changes or formation of a precipitate after the addition of specific reagents. The results obtained are presented in Table 3.

3. Results

The decoctions of the lizards *T. hispidus* and *T. semitaeniatus* did not show a clinically relevant antibacterial activity, presenting a MIC ≥1024 μg/mL against all bacterial strains tested, suggesting that these lizards are ineffective in traditional medicine against bacterial infections. DTH and DTS were tested for possible antibacterial activity when combined with commonly used antibiotics. No effect of any decoction was observed against the multiresistant strain of *E. coli*-EC27. Against the strain SA358, DTS combinated with a kanamycin and amikacin significantly reduced the MIC of these antibiotics as observed in Table 4. DTH also enhanced the action of the kanamycin against the same bacterial strain. Against the multiresistant clinical isolate and *Pseudomonas aureuginosa* RB1, both DTH and DTS showed synergism with the aminoglycosides neomycin and gentamicin (Table 4). The chemical prospecting tests demonstrated the presence of alkaloids in the decoction of *T. semitaeniatus*, but not in the case of *T. hispidus,* as seen in Table 3.

4. Discussion

The present study demonstrated that decoctions of *T. hispidus* and *T. semitaeniatus* did not presents clinically relevant antibacterial activity, with MIC of ≥1024 μg/mL against all the strains used. Similar results were obtained in a study by Ferreira et al. [28], demonstrating the lack of *in vitro* antimicrobial activity of body fat from *Tupinambis merianae*, which is used in popular medicine against bacterial infections caused by *E. coli* and *S. aureus*, besides, several proteins and peptides from animals present antibacterial activity [29].

On the other hand, a synergistic effect was observed between the extracts with aminoglycosides, reducing the MIC of the antibiotics was also observed in other studies with natural products isolated from animals and plants [30–32]. Therefore, there is a need to understand how these substances act in order to increase the activity of conventional antibiotics, since a substantial decrease in the concentration of aminoglycosides would be a promising improvement in the chemotherapy of infections. According to Matias et al. [33], several components of the extracts can act as cell permeabilizers, increasing the cellular uptake of antibiotics [34]. Interference with bacterial enzyme systems can also be a potential mechanism of action [35]. These mechanisms of action can be involved in the combination of an antibiotic with a natural product at a subinhibitory concentration [36, 37].

The presence of alkaloids in the decoction of *T. semitaeniatus* used in these antimicrobial assays can be a strong indication that these substances present the antibiotic-modifying activity, since these extracts potentiated the antibiotic action (Table 4). Studies have demonstrated different pharmacological activities of alkaloids [38, 39]. In the case of DTH, which does not contain alkaloids but still showed synergism

Table 4: MIC values (μg/mL) of aminoglycosides in the absence and presence of 128 μg/mL of decoctions of *T. hispidus* or *T. semitaeniatus* against *Escherichia coli* 27, *Staphylococcus aureus* 358, and *Pseudomonas aeuruginosa* RB1.

	EC 27			SA 358			PA RB1		
	MIC	MIC combined		MIC	MIC combined		MIC	MIC combined	
		DTH	DTS		DTH	DTS		DTH	DTS
Antibiotic									
Kanamycin	78.1	78.1	78.1	156.2	39.1	39.1	625	625	625
Amikacin	78.1	78.1	78.1	156.2	156.2	19.5	312.5	312.5	312.5
Neomycin	78.1	78.1	78.1	78.1	78.1	78.1	625	78.1	156.2
Gentamicin	19.5	19.5	19.5	9.8	9.8	9.8	78.1	19.5	19.5

DTH: decoction of *Tropidurus hispidus;* DTS: decoction of *tropidurus semitaeniatus.*

with particular aminoglycosides, other possible bioactive substances not detected may be responsible for its synergistic effect, necessitating further studies to identify these natural products.

It is important to note that the use of natural products combined with conventional drugs has been previously described. Calvet-Mir et al. [40] reported the use of traditional medicine products in combination with Western medicine for the treatment of diarrhea, vomiting, and stomach ache. Vandebroek et al. [41] reported on the use of natural products and commercial medications together for the treatment of diseases of the respiratory and digestive tracts.

According to Ferreira et al. [42], studies of substances from reptiles must be stimulated to determine their pharmacological activities. Ciscotto et al. [43] described the antibacterial and antiparasitic activities of l-amino acid oxidase from the venom of this snake. Morais et al. [44] reported the anticoagulant activity of antithrombin factor from *Bothrops jararaca* (Wied, 1924) venom. Products from other species of reptiles were also studied in attempt to elucidate their pharmacological proprieties. Liu et al. [45] demonstrated the antitumor effect of extracts of the lizard *Gecko japonicas* (Schlegel, 1836), which is widely utilized in Chinese traditional medicine. The lysozymes of the turtles *Trionyx sinensis* (Wiegmann, 1835), *Amyda cartilaginea* (Boddaert, 1770), and *Chelonia mydas* (Linnaeus, 1758) demonstrated a strong antibacterial activity [46].

5. Conclusion

The decoctions of *T. hispidus* and *T. semitaeniatus*, alone, did not show antimicrobial activity, suggesting the ineffectiveness of products derived from these animals for the treatment of bacterial infectious diseases in traditional medicine. However, the decoctions were found to be effective when combined with aminoglycoside, demonstrating a pharmacological potential to enhance the antibiotic activity. Further studies with natural products of animal origin are needed since this field still remains few explored compared to phytotherapeutic substances, and the medicinal potential of products derived from animals can lead to notable advances in conventional medicine, as well as to the development of management techniques in the conservation of species with potential medicinal use.

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