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Medicinal fungi used by rural communities in Northeastern Brazil

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The use of fungi for diversified purposes is part of the history of mankind. We sought to report what is known about fungal species used for medicinal purposes by rural populations in Northeastern Brazil. To this end, semi-structured forms were applied to 176 informants from four rural communities located in the southern region of Piauí. The fungi were deposited in the Graziela Barroso Herbarium (TEPB) of the Federal University of Piauí. The use value (UV) and relative importance (RI) of each species were calculated and similarity was estimated with the Sorensen index. Medicinal use was identified for four basidiomycete species belonging to the families Agaricaceae [*Podaxis pistillaris* (L.) Fr.], Hymenochaetaceae (*Fomitiporia* sp.) and Polyporaceae [*Hexagonia hydnoides* (Sw.) M. Fidalgo and *Pycnoporus sanguineus* (L.) Murrill]. Indicated for intestinal colic in infants, *P. sanguineus* was the species that presented the greatest current and potential UV and greater cultural importance. Studies on the chemical and pharmacological composition of the mentioned species were found, indicating their antibacterial, antiparasitic, antiviral, antifungal and antioxidant potential. Knowledge about these fungi has been transmitted from generation to generation, with greater similarity among individuals of the female sex and adult age. The results showed that there is ethnomycological knowledge in rural communities still to be explored in the semi-arid region of Brazil and highlighted the importance of studies about the ethnological knowledge of medicinal fungi.

Keywords: Cultural conservation, Cultural importance of fungi, Ethnomycology, Folk medicine
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Fungi have been used since antiquity by mankind[1]. Traditional mycological knowledge involves biological and cultural aspects of their use, emphasizing the nutritive, hallucinogenic and medicinal properties explored by several ethnic groups[2,3].

Studies on the traditional knowledge and appreciation of mycological resources began in the 1950s, depicting cultural peculiarities of their use by different peoples[4]. Mycophilic populations gather ecological, gastronomic, economic and cultural knowledge about macrofungi[5-7], which have been used since prehistoric civilizations as alternative medicinal resources[8] and in mystical-religious rituals, with emphasis on hallucinogenic species[9].

Erosion of mycological knowledge is indicated by the decrease in the use of medicinal fungi among traditional communities of different continents resulting from facilitated access to industrialized medicines, loss of interest on the part of new generations[10] and recurring environmental impacts[11].

In Brazilian ecosystems, likewise in traditional populations in several regions of the globe, the diversity of macrofungi species constitutes a rich potential source of numerous bioactive substances that may be used as antibacterial, antifungal, antiviral, antiparasitic, antioxidant, anti-inflammatory, anticancer, antitumor, cytotoxic and anticoagulant agents[12-14]. Among the 376 genera of Basidiomycota reported to Brazil, some are widely known in other countries for their medicinal application, such as *Ganoderma* Karsten[15]. Representatives of this genus were already used in ancient China for health promotion[16] and some species have potential applications as chemotherapeutic agents, with confirmed bioactive properties[17].

Despite the rich diversity of mycobiota in the Brazilian territory, little is known about the use of wild fungi by the first inhabitants because the Europeans, the first settlers, did not incorporate the indigenous culture and thus the knowledge about the use of mycological resources by the natives was lost[18]. The current knowledge about the use of fungi

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in Brazil is almost exclusively related to indigenous groups in the Northern region of the country[19].

The use of regional flora and fauna in popular therapy is very rich in the Brazilian northeastern culture, but little is known about the use of the local mycobiota. The first ethnomycological studies in Northeastern communities were developed with indigenous peoples of Pernambuco backlands and rural communities in Southern Piauí and demonstrated notorious knowledge in the use of fungi to treat diseases affecting different body systems[20,21].

Although Northeastern rural communities are not markedly mycophilic, it is possible that they have ethnomycological knowledge and that this is particularly passed on among women, as it happens with medicinal plants. In this perspective, the objective of this study was to carry out a survey of the knowledge about medicinal fungi used in local therapy according to aspects such as sex and age group of rural populations in the South of the state of Piauí. A bibliographical survey was also conducted to know and systematize the bioactive properties of the macrofungal species cited as medicinal sources in the rural communities studied.

Methodology

The research was developed in the communities Cajazeiras and Saco from Canto do Buriti municipality and the communities Capim and Tamboril from Guaribas municipality. These municipalities are located 405 km and 610 km, respectively, from the capital Teresina, in the Southern region of the state of Piauí, Northeastern Brazil. The two communities of Canto do Buriti are situated approximately 260 km away from those of Guaribas (Fig. 1).

The two municipalities are within the ecological corridor that links the Serra da Capivara and Serra das Confusões National Parks, inserted in the phytophysiognomy of Caatinga, and have populations with relevant socio-environmental vulnerabilities for future projections of local environmental preservation. The climate is of the hot tropical semi-arid type, with a dry period of 7 to 8 months[22].

The study took place from December 2016 to February 2018 and was approved by the Research Ethics Committee (REC) of the Federal University of Piauí (UFPI) (register number 1,890,970) and was registered in the National System of Genetic Resource

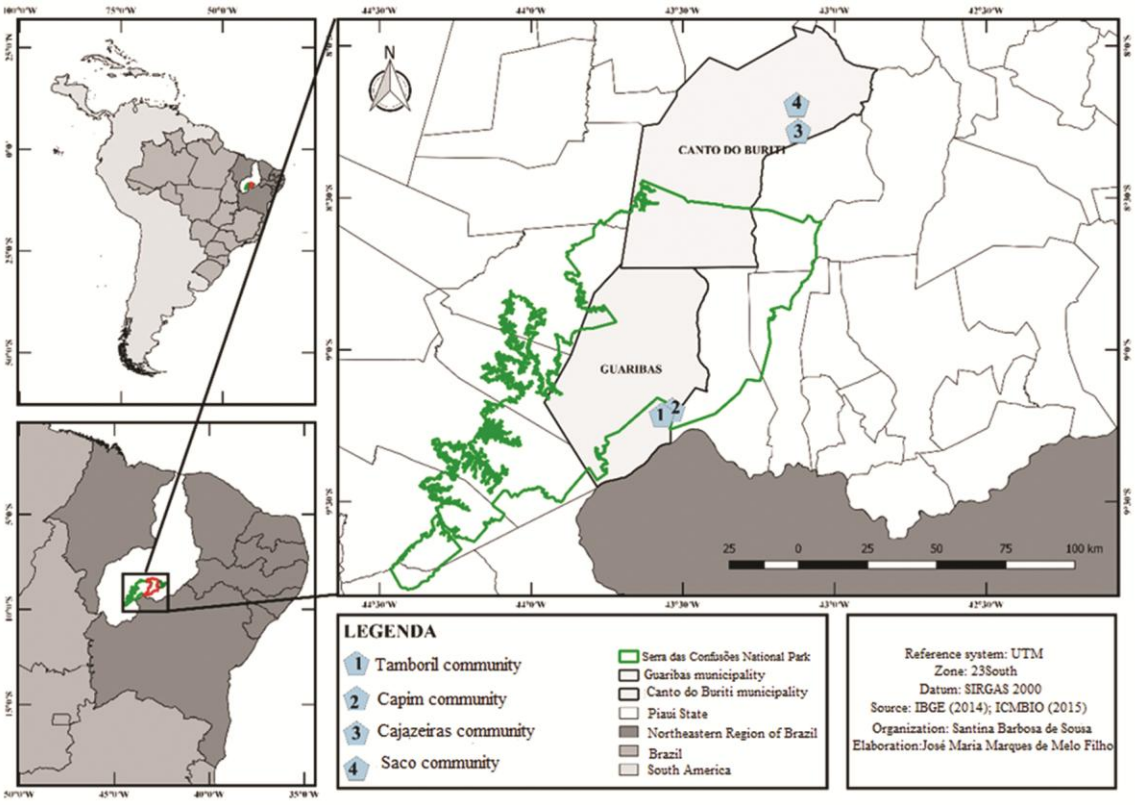

Fig. 1 — Location of the rural communities Tamboril and Capim (Guaribas municipality) and Cajazeiras and Saco (Canto do Buriti municipality), Piauí/Brazil. Source: José Maria Marques de Melo Filho (2018).

Management and Associated Traditional Knowledge (SISGEN) (register number AFAEC03). Authorization was granted for collections by the Biodiversity Authorization and Information System (SISBIO) (register n 65806-1).

In order to collect information on useful fungi, a semi-structured[23] form was applied to 94 families in the four communities. The form had questions addressing the knowledge about medicinal fungi, therapeutic indication, dosage, period when the fungi can be found, restriction of use and persons who passed on the information. The informants were invited to participate in the study and, after agreeing to participate, they received an informed consent form (ICF) for their reading and signing. Overall, 121 residences were visited and three people in each family were interviewed — the couple and a child over the age of majority when present at the moment of the interview — to verify the transmission of knowledge. Among the residences visited, 19 were closed and in 8 the families did not accept to participate in the research.

Collections of fungi samples were based on the morphological description provided by the interviewees and supported by guided tours[24] from March 2017 to February 2018, comprising all climatic seasons. We used Fidalgo and Bononi's[25] techniques for fungal collections and later identification and herborization. After collection, the species' identities were confirmed by the interviewees who cited them. After being identified by specialists linked to the laboratory of Basidiomycota (Lab B—UFPE) and the laboratory of fungal morpho-taxonomy (UFPB), the mycological material was incorporated into the *Micoteca* (room, department, or laboratory used to store fungal crops for research purpose) of the Graziela Barroso Herbarium (TEPB) of the UFPI.

The Use Value (UV) index was calculated according to the formula UV = Ui/n, where Ui = number of citations of use mentioned by each informant; n = total number of informants, with a distinction between citations of current (CUV) and potential (PUV) use value. The formula was proposed by Phillips and Gentry[26], adapted by Rossato, Leitão Filho, and Begossi[27].

The relative importance (RI) index of each species was calculated as proposed by Bennett and Prance according to the formula RI = NBS + NP, where NSC = number of body systems treated by a particular species (NBSS) divided by the total number of body systems treated by the most versatile species (NBSSV); NP = ratio between the number of properties assigned to a particular species (NPS) and the total number of properties assigned to the most versatile species (NPSV). The maximum RI obtained by a given species is 2.

A Q-mode (by variables) cluster analysis was performed with binary data (1 and 0) to check the similarity of knowledge of useful species among informants according to age group and sex using the NTSYS-pc 2.10 software[28]. The single linkage method (simple clusters) and the DICE (Sorensen) similarity coefficient were used in the analysis. The Mantel's test cophenetic correlation coefficient was employed for detection of goodness of fit, considering an adjustment of 70%. As a criterion for dividing groups by the age group of respondents, the delimitation used by the Brazilian Institute of Geography and Statistics29 was followed: young people (18-24 years), adults (25-59 years) and elderly (60 years and older).

Results and Discussion

A total of 176 informants living in the four rural communities, of whom 77 were males and 99 females, participated in the study. Of the sample universe, 30% (n=53) knew or used fungi for medicinal purposes. The lower representativeness of male interviewees was explained by the fact that they were mostly absent in the home at the time of the interviews due to work activities in the city of residence or in other cities in order to increase the income of the family.

The interviews were conducted with young, adult and elderly people whose age varied from 18 to 82 years. Most of them were native to the communities they lived. The main work of the families was agriculture (85%), followed by public service (11%) and household chores (4%). Most interviewees declared to be Catholic (83%) and the others were evangelicals (15%) or atheists (2%). The level of schooling was very low, and few participants had completed high school (2%) or college (2%); a good part of them were illiterate (19%) or had incomplete elementary school (30%) or only the initial grades (37%). The family income was also very low: 48% received less than one monthly minimum wage, 33% one minimum wage and only 19% received more than one minimum wage. Catholicism is very common among the Northeastern people, sustained in prayers, offerings, vows, and devotionalism[30] and the use of

items from local biodiversity to cure diseases is sometimes linked to the religious beliefs of local religious parties, including socio-cultural and economic aspects[31].

There were 57 citations (82% from informants of the female sex) of medicinal use of fungi and four macrofungi species belonging to the families Agaricaceae, Hymenochaetaceae and Polyporaceae (Fig. 2) were identified in the four communities.

The knowledge and practices of use had been transmitted orally by family members (77%), older people in the community (12%), neighbors (6%) and folk healers (people who pray to cure illnesses, ward off evil, or predict the future) (2%). Mothers were the ones who most often played the role of transmitters of knowledge about medicinal fungi within the family, making 61% of the citations. This characteristic of horizontal oral transmission of knowledge is similar to that observed in studies with medicinal plants in the Northeast, where socialization of knowledge happens mostly among members of the family[32].

Among the medicinal uses identified, the species were indicated for the treatment of diseases of the reproductive, digestive, respiratory, cardiovascular, and urinary systems. The method of preparation and posology are described in Table 1, according to the references of the social actors surveyed.

Pycnoporus sanguineus (L.) Murril. is a saprophytic basidiomycete with slow growth that grows on wood and stands out in the environment by the orange-red coloration of the basidiocarps[33,34]. It occurs in all regions of Brazil, in different morphoclimatic domains[23]. This was the most cited species, with the most versatile indication of use in the four communities, reaching the maximum RI value (Table 1). It is also important to highlight that this species is the only one that has CUV, making evident that its UV is being transmitted through at least three generations.

The medicinal use of *P. sanguineus* seems to be related to indigenous knowledge because the informants who mentioned it were related to indigenous peoples who inhabited the microregion of São Raimundo Nonato/PI. Antihemorrhagic use of this species has also been reported in the traditional medicine of indigenous groups from the Northern region of Brazil[35]. The preference for this species is related to its availability in the environment, according to users, especially in rainy and dry periods. The antihemorrhagic indication may be related to the reddish color of the basidiocarp, as proposed in the theory of signatures in Paracelsian science, *similia similibus curantur*, or 'like cures like', which is widely present in the Brazilian traditional medicine[36].

Fig. 2 — Medicinal fungi known and used by populations from the rural communities Cajazeiras and Saco (Canto do Buriti) and Tamboril and Capim (Guaribas), Piauí/Brazil. Source: Direct search (2018), A: *Pycnoporus sanguineus*, B: *Hexonia hydnoides*, C: *Fomitiporia* sp., D: *Podaxis pistillaris*.

Table 1 — Species of medicinal fungi cited by informants from the rural communities Cajazeiras and Saco (Canto do Buriti) and Tamboril and Capim (Guaribas), Piauí/Brazil. Legends: BS (Body System), NC (Number of Citations), IU (Indication of Use), CUV (Current Use Value), PUV (Potential Use Value), RI (Relative Importance), MP/P (Method of preparation/posology).

Family Species (common name)	BS	NC	IU	CUV	PUV	RI	MP/P
Agaricaceae *Podaxis pistillaris* (L.) Fr. ("Capitão-do-campo")	Not identified	1	Antiparasitic anti-inflammatory	-	0.006	0.45	The fungus is opened and the spores allowed to land on the wound site.
Hymenochaetaceae *Fomitiporia* sp. ("Orelha-de-pau")	Cardiovascular	1	Anti-inflammatory	-	0.006	0.45	The fungus is cooked and compresses are prepared with warm water.
Polyporaceae *Pycnoporus sanguineus* (L.) Murrill ("Orelha-de-pau")	Reproductive	4	Anti-hemorrhagic (during the menstrual period)	-	0.026	2.0	Three small pieces of the fungus are infused in a glass of water. One tablespoon is taken twice a day for gastric antispasmodic effects, and one teaspoon thrice a day for antihemorrhagic, anti-inflammatory and renal antispasmodic effects.
	Digestive	42	Gastric antispasmodic	0.218	0.059		
		1	Gastric anti-inflammatory	-	0.006		
	Urinary	1	Renal antispasmodic	0.006	-		
	Respiratory	2	Anti-asthmatic	0.013	-		Three pieces of the fungus are infused in a glass of water, and eggs of a snail popularly called "aruá" (Gastropoda, *Pomacea canaliculata* Lam.) are added to the water. One tablespoon is taken twice a day.
Hexagonia hydnoides (Sw.) M. Fidalgo ("Orelha-de-pau")	Digestive	1	Antispasmodic	-	0.006	0.45	Three small pieces of the fungus are infused in a glass of water. One teaspoon thrice a day.

Chemical and pharmacological studies indicate the presence of substances in the basidiocarp of *P. sanguineus* that have biological activity capable of treating bacterial infections, without toxicological risk for experimental animals[37].

The indication of the basidiocarp of *P. sanguineus* for the treatment of asthma, reported by residents of the Cajazeiras community, was associated with the eggs of *"*aruá*"*, whose egg masses are collected in this community. Egg masses of this gastropod can be found in emerging substrates in flooded areas[38]. People who need to take the medication are not to learn its composition, as reported: "*those who are going to drink the tea cannot know what it is made of"* (informant FRFL, 43 years old). Similar information was given in Pernambuco, another state of the Northeast, where *"*aruá*"* eggs are indicated for the treatment of dislocations of the foot, dysentery and respiratory diseases. In this later case, it is also recommended that the patient be unaware of what he is taking, otherwise the medication will not have effect[39].

The relationship between the known fungi and medicinal plants was common among the interviewees who preferred to make use of fungi growing on plant substrates of the local pharmacopeia. *Pycnoporus sanguineus* was preferably collected when growing on *Pityrocarpa moniliform* (Benth.) Luckow & R.W Jobson ("quipé", "angico-de-bezerro"), while *H. hydnoide* and *Fomitiporia* sp. were related to *Myracrodruon urundeuva* Allemão ("Aroeira"). The correlation of the plant with the basidiocarp seems to originate from the purpose of use, as it is the case of *P. moniliform*, cited by informants for the treatment of problems of the digestive system. This plant has been proven to produce bioactive substances that provide it with antimicrobial activity[40]. Similar findings are observed in European and Asian countries, where medicinal fungi are preferably collected from trunks of some *Betula* L. species, also popularly indicated as medicinal. Therapeutic properties attributed to fungi and plants are similar and many have scientific support, showing that basidiocarps present compounds similar to those produced by the phorophyte[41,42].

Only one informant from the Cajazeira community cited *H. hydnoides* as medicinal, indicated to treat colic in infants, a therapeutic indication similar to that of *P. sanguineus*; both were known by the common name "orelha-de-pau" (Table 1).

The spores of *P. pistillaris* were cited to be used for extraction of insect larvae from wounds. This use was indicated by a local healer who performed healing of illnesses through prayers, in the decade of 50. This species is widely distributed in arid and

semi-arid regions of Africa, Asia, Australia and the Americas[14] and is abundant in rainy days, being found on roadsides and in open fields in the municipalities where the interviewees lived. In a research conducted by Sousa *et al.*[21] within a rural community in the municipality of São Raimundo Nonato, in Southern Piauí, *P. pistillaris* was indicated for the treatment of diseases, similarly to traditional populations in Arabia studied by Al-Fatimi *et al*. (2006). In Colombia, spores of *P. pistillaris* are used as a cosmetic by indigenous women for protection from ultraviolet radiation and in religious rituals; however, there is a belief that their continuous use can cause misfortune due the black color of the spore mass[43]. The species is also considered useful in the food and popular pharmacopoeia of arid regions of Mexico[44].

Ethnospecies known as "orelha-de-pau" were mentioned by an informant of the Saco community as useful in former difficult times, when there were no health centers in the city and motorized transport was scarce. The whole basidiocarp was used as a buffer for accidental cuts in the field, attached to affected area with the aid of fibers of *Neoglasiovia variegata* (Arr. Cam.) Mez ("Caroá"), to stop the bleeding; the basidiocarp was macerated with water and served to treat the wound.

Saponins (*H. hydnoides*), epicorazine (*P. pistillaris*), polyporin and cinnabarin (*P. sanguineus*) are produced by the three species cited and have scientifically proven biological activity against viruses, bacteria, fungi and some parasites and may explain the allusion to some therapeutic properties reported by the informants (Table 2).

The ethnomycological knowledge of young men and women was similar to that recorded among male members of any age group (r=0.95, Mantel t=2.15, p=0.95); they expressed knowledge only about *P. sanguineus.* It was found similarity among the interviewed adults and female interviewees, who have knowledge about a greater number of species of medicinal macrofungi (Fig. 3). The results indicate that knowledge about useful species in popular therapy is being transmitted through generations, with greater dominance among adult women.

Despite the evidence of the transmission of knowledge across generations, the adult and elderly population stated that younger people have little interest in learning about natural resources for the treatment of diseases. They also affirmed that modern access to pharmaceutical medications is greater than in the past, as observed in the following oral discourses: "*when the children were little, there was no medicine available from drugstores, then we would use homemade medicine*" (informant AMT, 53 years old),. "*at the time I had the kids there was no boutique medicine"* (informant MFPT, 57 years old). These discourses show that the use of local natural products occurred, not only due to the low availability of medicines in conventional pharmacies, but also because of the precarious access of rural communities

Table 2 — Bioactive compounds present in macrofungi used in folk medicine of the rural communities Cajazeiras and Saco (Canto do Buriti) and Tamboril and Capim (Guaribas), Piauí/Brazil.

Species	Activity	Bioactive agent	References
Hexagonia hydnoides (Sw.) M. Fidalgo	Antibacterial	Saponin	[29]
Pycnoporus sanguineus (L.) Murrill	Antibacterial Antiparasitic Antiviral Antifungal Antioxidant	Polyporin Cinnabarin Sterols	[27- 29, 36]
Podaxis pistillaris (L.) Fr.	Antibacterial	Epicorazine	[14, 45]

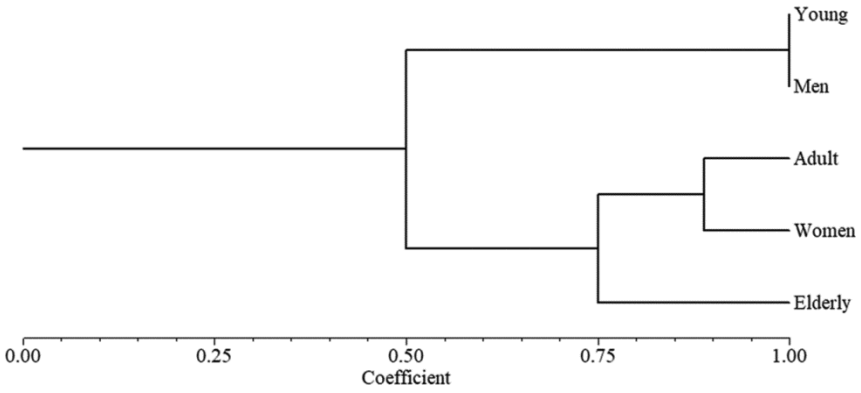

Fig. 3 — Dendogram with binary data of the medicinal fungi species known by age group and sex of interviewees in the rural communities of Cajazeiras and Saco (Canto do Buriti) and Capim and Tamboril (Guaribas), Piauí/Brazil.

to more developed urban centers, not to mention the absence of motorized transport. Loss of interest in the medicinal use of fungi has also been reported for rural populations of Mexico in which communities tend to lose traditional knowledge among new generations because they have no interest in such practices[10].

Although the discourse emphasized a decrease in the medicinal use of fungi, a member of the Tamboril community reported that "*there are some relatives in São Paulo who ask for the fungi to use as medicine"* (informant MRT, 56 years old). This request for basidiocarps of *P. sanguineus* by relatives residing in one of the largest cities in Brazil, and even who are not currently interacting with the family in the community, provides evidence of the maintenance of family tradition regarding the use of macrofungi.

Conclusions

This research demonstrated the knowledge about fungi used for medicinal purposes in the rural populations studied, indicating the existence of ethnomycological knowledge, particularly among female, adult and elderly individuals in communities that inhabit the Caatinga, which has not been explored until present date.

Considering the cultural diversity of the Northeast regarding the use of natural resources for therapeutic purposes, it is believed that it is possible to broaden the knowledge about the use of medicinal fungi through the development of studies in other rural communities in order to understand the relationship between rural people and fungi, rescue the ethnomycological knowledge, and associate it with research of bioactive metabolites with pharmacological potential.

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Conflict of Interest

Authors' declare there is no conflict of interest.

Authors' Contributions

SBS performed fieldwork and edited the manuscript. JBL performed the statistical analysis. RFMB edited the manuscript. LHCA edited the manuscript and identified the species.

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