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KAMILA MARQUES PEDROSA

CARACTERÍSTICAS ECOLÓGICAS E O PARENTESCO DAS ESPÉCIES VEGETAIS UTILIZADAS POR POPULAÇÕES DO SEMIÁRIDO BRASILEIRO

Campina Grande, PB
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Tese apresentada ao Programa de Pós-graduação em Etnobiologia e Conservação da Natureza (UFRPE, UEPB, URCA e UFPE) como parte dos requisitos para obtenção do título de doutora em Etnobiologia, na linha de pesquisa bases ecológicas e evolutivas das relações entre pessoas e natureza.

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Dr. Sérgio de Faria Lopes
Dra. María de los Ángeles La Torre-Cuadros

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Para Maciano da Silva Pedrosa e Maria do Socorro Marques Pedrosa.

Dedico

Eita, Nordeste da peste,
Mesmo com toda sêca
Abandono e solidão,
Talvez pouca gente perceba
Que teu mapa aproximado
Tem forma de coração.
E se dizem que temos pobreza
E atribuem à natureza,
Contra isso,eu digo não.
Na verdade temos fartura
Do petróleo ao algodão.
Isso prova que temos riqueza
Embaixo e em cima do chão.
Procure por aí a fora
“Cabra” que acorda antes da aurora
E da enxada lança mão.
Procure mulher com dez filhos
Que quando a palma não alimenta
Bebem leite de jumenta
E nenhum dá pra ladrão
Procure por aí a fora
Quem melhor que a gente canta,
Quem melhor que a gente dança
Xote,xaxado e baião.
Procure no mundo uma cidade
Com a beleza e a claridade
Do luar do meu sertão
Exaltação ao Nordeste – Luiz Gonzaga de Moura

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A todos e todas, muito obrigada. Nada disso seria possível sem a colaboração de vocês.

Sumário

RESUMO

O uso da madeira das espécies vegetais é uma atividade histórica entre os povos da Caatinga. Nesse sentido, um aspecto de interesse científico é compreender como as pessoas através do conhecimento ecológico local usam recursos madeireiros. Partindo da ideia de que a remoção de madeira das plantas pode comprometer a diversidade vegetal da Caatinga, surge questões sobre como as pessoas mantêm suas atividades, em termos da utilização de plantas para construções, lenha e artefatos rurais, em ambientes perturbados. Além disso, esforços vêm sendo empreendidos para entender os traços funcionais de espécies de plantas que influenciam seu uso pelos humanos/comunidades locais. Nesta tese, buscamos compreender como características ecológicas e o parentesco de plantas podem influenciar na dinâmica do conhecimento ecológico local. Foram aplicadas entrevistas semiestruturadas a 120 especialistas locais (agricultores e agricultoras) com a utilização de formulários. Buscamos atingir esse objetivo a partir de duas abordagens. Inicialmente, buscamos investigar se o conhecimento ecológico local, em termos de redundância a nível individual, redundância do uso e número de espécies conhecidas, variavam nas diferentes localidades (áreas) estudadas, as quais foram classificadas de acordo com o nível de distúrbio antrópico crônico, que consiste em métricas de impactos humanos diretos e indiretos comunidades vegetais. A partir deste estudo nós encontramos que o conhecimento local apresentou menores informações sobre o número de espécies e redundância do uso na área de maior impacto antrópico crônico. Numa segunda abordagem, construímos a nossa hipótese filogenética de plantas citadas pelos entrevistados para investigar se as plantas indicadas para o mesmo fim estão mais intimamente relacionadas do que esperado ao acaso. Nós observamos que as plantas indicadas para combustível tinham uma maior representatividade ou aproximação das linhagens filogenéticas. Na nossa terceira abordagem, ainda através da análise filogenética, buscamos verificar se existia sinal filogenético para a densidade da madeira das espécies citadas e se as espécies citadas filogeneticamente mais relacionadas apresentam similaridade na redundância. Encontramos um grau moderado de agrupamento filogenético para a redundância de espécies e fraco para densidade da madeira das espécies úteis. Nosso conjunto de evidências contribuem para uma melhor compreensão da dinâmica do conhecimento ecológico local dos povos da Caatinga frente ao avanço dos impactos antrópicos crônicos; e deixa claro a importância de utilizar a história evolutiva das plantas úteis.

Palavras chave: Plantas úteis; redundância utilitária; Distúrbios antrópicos crônicos; filogenia.

ABSTRACT

The use of wood from plant species is a historical activity among the peoples of the Caatinga. In this sense, one aspect of scientific interest is to understand how people, through local ecological knowledge, use wood resources. Starting from the idea that the removal of wood from plants can compromise the plant diversity of the Caatinga, questions arise about how people maintain their activities, in terms of the use of plants for construction, firewood and rural artifacts, in disturbed environments. Furthermore, efforts have been undertaken to understand the functional traits of plant species that influence their use by humans/local communities. In this thesis, we sought to understand how ecological traits and plant relatedness may influence the dynamics of local ecological knowledge. Semi-structured interviews were applied to 120 local experts (mand and woman) using forms. We sought to achieve this goal from two approaches. Initially, we sought to investigate whether local ecological knowledge, in terms of redundancy at the individual level, redundancy of use, and number of known species, varied across the different localities (areas) studied, which were classified according to the level of chronic anthropic disturbance, which consists of metrics of direct and indirect human impacts plant communities. From this study we found that local knowledge presented less information about the number of species and redundancy of use in the area of greatest chronic anthropic impact. In a second approach, we constructed our phylogenetic hypothesis of plants cited by respondents to investigate whether plants indicated for the same purpose are more closely related than expected at random. We observed that the plants indicated for fuel had a higher representativeness or closeness of phylogenetic lineages. In our third approach, still through phylogenetic analysis, we sought to see if there was phylogenetic signal for the wood density of the cited species and whether the phylogenetically most closely related cited species show similarity in redundancy. We found a moderate degree of phylogenetic clustering for species redundancy and weak for wood density of useful species. Our body of evidence contributes to a better understanding of the dynamics of local ecological knowledge of Caatinga peoples in the face of advancing chronic anthropic impacts; and makes clear the importance of using the evolutionary history of useful plants.

Keyword: Useful Plants; Utility redundancy; Chronic Anthropogenic Disturbances; Phylogenetic.

1. INTRODUÇÃO GERAL

1.1 Objetivos e Questionamentos

Embora eu tenha raízes na etnobiologia tive a oportunidade de trabalhar em um Laboratório de Ecologia Neotropical (EcoTropics/UEPB). Nesse espaço, conheci e acompanhei pesquisas que me motivaram a tentar compreender como algumas questões de cunho ecológico e evolutivo podem estar relacionadas com o conhecimento local dos povos da Caatinga. Como acontece com a maioria dos grupos de pesquisa fomos orientados a investigar as nossas teses trabalhando em equipe durante as coletas de dados. Inicialmente, durante as coletas fitossociológicas, havia a proposta de analisar como variáveis antrópicas crônicas impactam as comunidades vegetais. Um tema pertinente para as florestas secas, uma vez que as populações humanas removem continuamente os recursos naturais, podendo afetar negativamente a biodiversidade local (PORTILLO-QUINTERO et al., 2010; RIBEIRO et al., 2015). E sob essas condições, surgiram questões sobre como esses fatores poderiam influenciar, também, na dinâmica das interações socioecológicas (BLANCO e CARRIÈRE et al., 2016; AXELSSON et al., 2021). Embora muitos etnobotânicos tenham se perguntando como os ambientes antrópicos da Caatinga podem influenciar no conhecimento e uso de plantas de seus povos (LUCENA et al., 2012; RIBEIRO et al., 2014, GUERRA et al., 2015), poucos haviam caracterizado o nível de distúrbio antrópico crônico nesses ambientes (GONÇALVES et al., 2021). E isso nos levou a questionar como o conhecimento local das pessoas pode variar em ambientes perturbados.

Existe uma preocupação de que as ameaças ambientais que resultam na perda da biodiversidade comprometam os meios de subsistência dos povos e o seu conhecimento ecológico local (CEL) (CÁMARA-LERET e BASCOMPT., 2020; KUNWAR et al. 2020). Mas, também, há evidências de que o CEL pode persistir diante de ameaças ambientais (ALVES et al., 2022), através da criação de estratégias para utilizar os recursos naturais (CÁMARA-LERET et al., 2017). A persistência do CEL á ameaças é o resultado da adaptação dos grupos humanos em responder as mudanças locais (WALKER et al., 2004; FOLKE 2006).

Embora seja complexo acessar como as pessoas respondem as mudanças do contexto ambiental (BIGGS et al., 2012), é possível estimar a dinâmica do CEL através do conhecimento sobre plantas e seus usos; e através do modelo de redundância utilitária que, por definição, consiste na sobreposição funcional de espécies indicadas pelas populações locais em um dado uso (ALBUQUERQUE e OLIVEIRA, 2007). O uso desse modelo em estudos que investigaram o uso de plantas medicinais admitem que as pessoas aumentam a redundância (com o tempo) nas categorias que são percebidas localmente como as mais importantes (SANTORO e ALBUQUERQUE, 2020). Sugerindo que, devido alguma demanda local, as pessoas tendem a conhecer um número maior de espécies. Dessa maneira, a redundância utilitária é um processo que favorece a resposta das pessoas diante de flutuações ambientais, uma vez que havendo o desaparecimento de uma espécie no ambiente, outras espécies cumprirá a mesma função (ALBUQUERQUE e OLIVEIRA, 2007; ALBUQUERQUE et al., 2019).

Sabendo que a redundância utilitária reune espécies que são funcionalmente utéis, diversos esforços científicos vem sendo empreendidos para entender porque determinadas espécies são selecionadas. A maioria dos estudos indicaram que as pessoas desenvolveram estratégias atribuindo a escolha das espécies através da semelhança morfológica ou por pistas organolépticas (MOLARES & LADIO, 2099). MEDEIROS et al., 2012). Assim, dado que as espécies são relacionadas evolutivamente, também, há de se observar que pode haver um critério de seleção baseado no uso de plantas que são mais próximas filogeneticamente (SASLIS-LAGOUDAKIS et al., 2015).

Dessa forma, o objetivo dessa tese foi compreender como características ecológicas e o parentesco evolutivo de plantas podem influenciar na dinâmica do conhecimento ecológico local. Para isso, optamos por utilizar o modelo de geração de redundância utilitária da Teoria Socioecológica da Maximização (ALBUQUERQUE et al., 2019) e a Hipótese de Seleção não aleatória (MOERMAN, 1979) para fundamentar os nossos resultados.

1.2 Estratégias de Pesquisa

Inicialmente para construção do desenho amostral da pesquisa as áreas de estudo foram selecionadas de acordo com diferentes níveis de cobertura vegetal. Para isso, utilizamos o índice de vegetação por diferença normalizada (NDVI), que tem como Proxy estimar a biomassa e produtividade da vegetação, através do cálculo: NDVI = (Infra Vermelho – Vermelho) / (Infra Vermelho +Vermelho) (ROUSE et al., 1973), dado pelo Software Argis. Os dados de NDVI foram obtidos a partir de imagens das bandas 4 e 5 do satélite Landsat 8, referentes a estação seca do ano de 2017 e obtidas no site eartherexplorer.usgs.gov. As bandas correspondem a proporção de luz refletidas pela vegetação detectadas por sensores, sendo designadas respectivamente como vermelho e infravermelho próximo. Com base nos valores obtidos, as áreas foram selecionadas de acordo com o nível de cobertura vegetal. As áreas faz parte de um recorte geográfico da Caatinga.

Posteriormente, com base nas áreas delimitadas foram incluídas as residências que estavam em um raio de até 5 km. Recorremos às associações rurais e agentes de saúde das comunidades rurais dos municipios de São João do Cariri, Cabaceiras, Barra de Santana, São José dos Cordeiros e Monteiro, no estado da Paraíba, Brasil, para fortalecer e garantir uma maior confiabilidade nas informações obtidas entre as populações locais e os pesquisadores. Os agentes de saúde e associações rurais foram acessados para nos apresentar a comunidade e para apontar as residências das populações locais.

Em relação à coleta de dados sobre o conhecimento ecológico local utilizamos técnicas complementares para enriquecer as listas de plantas através da nova leitura, turnê guiada e recurso visual (ALBUQUERQUE et al., 2014). A técnica de nova leitura consistiu em o pesquisador enunciar oralmente as plantas citadas pelo participante, de forma a propiciar a recordação de outras plantas (ALBUQUERQUE et al., 2014). Utilizamos um recurso visual de fotografias em dois momentos diferentes: primeiro, para aqueles participantes que afirmaram não conhecer as plantas; e segundo, para os participantes que mencionaram esquecer no momento das entrevistas (MEDEIROS et al. 2014). As fotografias tinham imagens de frutas, folhas, flores e caules de plantas com o hábito de árvores e arbustos que foram registradas durante o levantamento da vegetação nas comunidades. Também realizamos visitas guiadas para verificar a identidade botânica das espécies mencionadas pelos participantes e para coletar material taxonômico (ALBUQUERQUE et al. 2014).

Ainda em relação à coleta de informações sobre o conhecimento local, durante a pandemia da COVID-19, no início do ano 2020, todas as atividades foram interrompidas o que provocou uma redução do nosso número amostral a respeito da quantidade de áreas de estudo que deveriam ser visitadas.

Um dos questionamentos sobre o primeiro capítulo da tese, que abordou a dinâmica do conhecimento ecológico local em áreas perturbadas, foi analisado através de modelos lineares generalizados univariado de efeito misto. Consideramos utilizar cada comunidade rural (com o nível de distúrbios antrópicos crônicos) como variável preditora de efeito aleatório. Enquanto que, os dados sobre o número de espécies citadas e a redundância a nível individual de todas as pessoas como variável de efeito fixo. Essa análise permitiu utilizar o nível de distúrbio antrópico de cada área de estudo para subsidiar as discussões dos resultados sobre a dinâmica do conhecimento ecológico local das pessoas.

No segundo capítulo da tese utilizamos os primeiros resultados da coleta de dados para desenvolver um estudo piloto. Por meio de uma metodologia, na qual utiliza uma hipótese filogenética de plantas, construímos a nossa hipótese filogenética de plantas citadas para os usos. Realizamos uma análise de sinal filogenético no intuito de verificar se plantas úteis da Caatinga são mais semelhantes entre si do que esperado ao acaso.

No terceiro capítulo da tese construímos a nossa hipótese filogenética de plantas citadas através de uma unidade amostral maior. Registramos a densidade da madeira das espécies citadas (traço funcional) a partir da coleta de dados da literatura.

1.3 Estrutura da Tese

A tese é composta por cinco capítulos. De acordo com o modelo adotado pelo Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza, o primeiro deles denomina-se “Fundamentação Teórica” e subdivide-se em quatro tópicos, (i) Populações humanas na Caatinga: História dos processos de alteração das comunidades vegetais, (ii) A influência do ambiente no conhecimento ecológico local dos povos, (iii) A Redundância Utilitária é uma característica que indica estratégia no uso de plantas por povos da Caatinga e (iv) A compreensão do uso de plantas semelhantes a partir de hipóteses filogenéticas. Os demais capítulos são artigos científicos que respondem as perguntas da tese, com exceção do quinto capítulo, que é formado pelas “Considerações Finais”. Destes, o capítulo II foi publicado na revista “*Ethnobotany Research and Applications*”. O capítulo III foi publicado na revista “*Environmental Development and*

Sustainability". O capítulo IV foi submetido para a revista *"PloS One*" e está sob revisão. Abaixo estão detalhados estes trabalhos científicos:

Capítulo II: Referência Bibliográfica: Pedrosa, K.M., Ramos, M.B., Cunha, S.S., Maciel, M.G.R., Souza, S.M., Soares, H.K.L., Torre-Cuadros, M.A., Lopes, S.F. (2022). Local ecological knowledge dynamics of farmers in areas which have been chronically disturbed by human actions in the Brazilian Caatinga. Ethnobotany Research and Applications. 24, 1–21

O capítulo primeiro tem o **objetivo** de compreender a variação do conhecimento ecológico local de agricultores de uma região semiárida do Brasil utilizando o modelo de redundância utilitária e redundância a nível individual para as categorias combustível, construção e tecnologia. As **perguntas** que nortearam o nosso estudo foram: i) Existe diferença no número de plantas citadas pelos agricultores entre as áreas de estudo? ii) O número de espécies citadas pelos agricultores locais prevê uma maior redundância em nível individual? iii) Existe diferença na redundância em nível individual dos agricultores que vivem em áreas com diferentes cenários ambientais (estrutura da vegetação, clima e distúrbios antrópicos crônicos)? iv) Existe diferença na redundância utilitária entre as áreas de estudo? Nesse estudo, descobrimos que existem diferenças entre o número de espécies mencionadas e a redundância utilitária entre as áreas estudadas.

Capítulo III: Referência Bibliográfica: Pedrosa KM, Almeida HA, Ramos MB, Lopes SF. 2021. Plants with similar characteristics drive their use by local populations in the semi-arid region of Brazil. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-021-01355-7

O nosso estudo se baseia na premissa de que a similaridade das plantas influencia o uso etnobotânico comum, devido à relação taxonômica evolutiva. Por isso utilizamos a **hipótese** de seleção não aleatória de Moerman (1979) e tivemos como **objetivo** de que as plantas da Caatinga, indicadas para o mesmo fim, estão mais intimamente relacionadas do que esperado ao acaso. Os resultados que encontramos sugeriu que as plantas indicadas para combustível teriam uma maior representatividade ou aproximação das linhagens filogenéticas. Além de expandir nossa compreensão de como as pessoas locais utilizam a biodiversidade na Caatinga, nossa abordagem baseada em uma hipótese filogenética ajuda a compreender, de maneira explanatória, os critérios que podem orientar o uso de plantas pelas populações humanas locais.

Capítulo IV: Referência Bibliográfica: Pedrosa, K.M., Ramos, M.B., Torre-Cuadros, M.A., Lopes, S.F. Plant parentage influences the type of timber use by traditional peoples of the Brazilian Caatinga. PloS One. Submetido em novembro de 2022.

O capítulo terceiro foi pensando nos resultados anteriores. Novamente exploramos as informações coletadas nas entrevistas semiestruturadas. Por essa razão, nós associamos que as plantas, talvez, apresentassem características que as tornavam mais semelhante e empregada no mesmo uso. Dado que as espécies de plantas estão relacionadas evolutivamente buscamos responder, dentro dos usos madeireiros, (i) se existe sinal filogenético para a densidade da madeira das espécies citadas, (ii) e se as espécies citadas filogeneticamente mais relacionadas apresentam similaridade na redundância. Diferentemente do segundo capítulo, aumentamos o número amostral de pessoas e procuramos compreender usos mais específicos, como subcategorias. Observamos um agrupamento filogenético moderado no qual as plantas citadas relacionadas exibem redundância semelhante e um agrupamento fraco no qual as plantas citadas apresentam valores de densidade de madeira semelhantes.

2. CAPÍTULO I: FUNDAMENTAÇÃO TEÓRICA

2.1 Populações humanas na Caatinga: história dos processos de alteração das comunidades vegetais

A região semiárida do Brasil está inserida no domínio das Florestas Tropicais Sazonalmente Secas (SDTF), chamada Caatinga. A Caatinga é o maior núcleo (912.529 km^2) de distribuição das Florestas Tropicais Sazonalmente Secas da América do Sul (MORO et al., 2016; SILVA et al., 2017; SILVA e SOUZA, 2022). Considerada também como uma das regiões mais populosas do mundo, com aproximadamente 28 milhões de pessoas, com parte dessas pessoas localizadas em zona rurais (SILVA et al., 2017). A vegetação é composta de um mosaico de fisionomias, com 3.347 espécies de plantas floríferas (FERNANDES et al., 2019), dotadas de um conjunto de adaptações morfofisiológicas às condições climáticas (presença de espinhos, declive das folhas) (QUEIROZ et al., 2017) que tem a capacidade de limitar o desenvolvimento e distribuição das espécies vegetais (FERNANDES et al. 2020).

A região da Caatinga teve historicamente uma extração desenfreada de seus recursos naturais. Conforme houve o avanço da usurpação Europeia sobre os recursos naturais da Caatinga brasileira, os impactos sobre o meio ambiente têm crescido progressivamente (SOUZA e SOUZA 2016). Atualmente, é possível observar a história dos impactos antrópicos sobre a vegetação da Caatinga no estado da Paraíba, Brasil, através de cartas sesmaria, que constituíam doações de terras, datada no período de 1665 (Catalog of manuscripts of the Captaincy of Paraíba, 2015). Os primeiros lotes de terra eram localizados próximo aos rios, Paraíba, Taperoá e Sucuru, pois permitia a implementação de pastagens para criação de bovinos, equinos e caprinos (Catalog of manuscripts of the Captaincy of Paraíba, 2015).

Ao longo dos últimos 400 anos, os pequenos agricultores que ocupam a Caatinga costumam utilizar recursos vegetais para atender as práticas domésticas e para a agropecuária, através da extração de madeira para a construção de cercas (MEDEIROS et al., 2011; LIMA et al., 2015), preparo de lenha (RAMOS e ALBUQUERQUE et al., 2012; LIMA et al., 2016; HORA et al., 2021) e alimentação para os animais domésticos (NUNES et al., 2015). No entanto, a remoção de madeira por populações locais e o pastejo de seus animais domésticos são importantes motores de distúrbios antrópicos crônicos (DAC), definido pela remoção contínua e gradual de pequenos fragmentos na Caatinga (MELO et al., 2017; GONÇALVES et al., 2021).

Nas Florestas Secas, os distúrbios antrópicos vêm se intensificando nas últimas décadas se tornando uma das formas mais difundidas de mudanças ambientais em todo o mundo (SINGH, 1998; RIBEIRO et al., 2015). Estudos recentes têm demostrado que o DAC e mudanças nos níveis de precipitação em florestas secas acarretam negativamente os padrões de diversidade (ZORGER et al., 2019; RITO et al., 2017; COELHO et al., 2020) e aumenta a probabilidade de homogeneização biótica (RIBEIRO et al., 2015). Os efeitos das perturbações crônicas sobre a vegetação podem ser ainda mais agressivos a depender dos efeitos do clima (MORO et al., 2015). Uma vez que os gradientes de precipitação atuam como filtros ambientais que tem a capacidade de limitar a distribuição das espécies vegetais (NEVES et al., 2020), há uma maior preocupação com o aumento da temperatura e diminuição da pluviosidade nas florestas secas nos próximos anos (GOSLIN e ARNELL 2016).

As ações sobre a vegetação podem colocar os grupos humanos sob novas adaptações do conhecimento ecológico local (CEL) como resposta as modificações ambientais (HUYNH et al., 2020; MAGALHÃES et al., 2021). E sob essas condições, surgem questões sobre como esses fatores podem influenciar na dinâmica das interações socioecológicas (BLANCO e CARRIÈRE et al., 2016; AXELSSON et al., 2021).

2.2 A influência do ambiente no conhecimento ecológico local

Existe uma relação mútua entre o sistema ecológico (que se refere aos organismos que vivem do ambiente) e o sistema cultural (conjunto de práticas e conhecimentos que estruturam grupos humanos no ambiente), de tal modo que os dois sistemas interagem fortemente (FERREIRA-JÚNIOR et al., 2013), sendo representada pela expressão sistema socioecológico (BERKES e FOLKE, 1998). O sistema socioecológico é influenciado por características do ambiente e, portanto, chamados de sistemas abertos, uma vez que criam estratégias para adequação ao contexto ambiental que estão inseridos (TRZESNIAK et al., 2012). Por apresentar ajustamento ao ambiente, o sistema socioecológico possui múltiplas possibilidades de adaptação e renovação, fornecendo ao sistema resiliência e capacidade em responder as mudanças ambientais e culturais (MACLEAN et al., 2014).

Uma das características do sistema socioecológico é o conhecimento ecológico local (CEL), definido pelo acúmulo de uma tríade de conhecimentos, crenças e práticas, que evoluiu por processos adaptativos, transmitidos através de gerações por transmissão cultural (BERKES et al., 2000). De maneira geral, as populações locais que vivem em comunidades rurais construíram relações intrínsecas para conviver e utilizar a natureza através do conhecimento ecológico local.

O contexto ambiental é uma das variáveis preditoras mais usada para entender a dinâmica do conhecimento ecológico local. E dentre os aspectos relacionados ao ambiente, a disponibilidade de plantas permaneceu como uma das principais hipóteses que norteiam as pesquisas sobre o uso diferencial de plantas. Na etnobotânica, as primeiras evidências sobre a influência do ambiente no conhecimento surgiram com a pesquisa seminal de PHILLIPS e GENTRY (1993a). PHILLIPS e GENTRY (1993a) foram influenciados por ideias ecológicas, as quais explicavam como a aparência das plantas influenciava na herbivoria (FEENY, 1976). A ideia formulada em 1993 foi de que as plantas mais utilizadas por populações humanas seriam aquelas mais aparentes no ambiente. A hipótese de aparência, sugerida por estes autores confirmou observações indutivas de que as plantas mais abundantes eram mais úteis (JOHNS et al., 1990). Essa hipótese explicitou o uso de técnicas quantitativas para testar se a utilização de plantas por populações locais tinha relação com a disponibilidade.

As pesquisas que testam a hipótese de aparência tendem a explicar que as espécies mais aparentes no ambiente são as mais utilizadas, devido a maior probabilidade de experimentação (PHILLIPS e GENTRY, 1993a ; LUCENA et al., 2012). Muitos pesquisadores usam a hipótese de aparência ecológica para inferir as plantas que são importantes para os grupos humanos em virtude da maior frequência de uso das plantas (LUCENA et al., 2012; RIBEIRO et al., 2014; GUERRA et al., 2015). E com resultado veem que os parâmetros ecológicos, dominância e abundância, tendem a explicar, os usos de origem madeireira como construções, lenha e artefatos tecnológicos, enquanto para outros usos não há relação (GONÇALVES et al., 2016 a). Além disso, muitos trabalham utilizam a dominância e abundância de espécies nas comunidades vegetais para acessar áreas distintas, caracterizando-as como áreas conservadas (que não há coleta das plantas) e antrópicas (área de coleta de planta) (LUCENA et al., 2012; RIBEIRO et al., 2014). Entretanto, mensurar ambientes conservados é uma tarefa difícil, visto que a maioria dos ambientes apresenta algum nível de distúrbio antrópico. Além disso, até onde sabemos, os estudos que relataram o uso dessas amostragens não declararam os tipos de impacto humano nos ambientes classificados como antrópicos.

É crescente o uso de ferramentas espaciais que podem melhorar a validação dos níveis de perturbação antrópica nas comunidades vegetais. E as modificações na cobertura vegetal têm sido utilizadas como modelo para avaliar os impactos antrópicos sobre o uso de plantas por comunidades rurais. Por exemplo, CUNHA et al., (2022) utilizaram índice de vegetação de diferença normalizada (NDVI) para identificar áreas com diferentes níveis de cobertura vegetal e observaram que os agropastoris da Caatinga inseridos em ambientes de maior cobertura vegetal citam mais plantas. Em outro estudo realizado por ALVES et al., (2022), os autores também, utilizaram imagens de satélite para mapear o desmatamento e incêndios florestais próximos de comunidades rurais da Amazônia brasileira e verificaram a influência de ambos no conhecimento ecológico local. Em um estudo com populações de áreas sagradas no Nepal, KUNWAR et al., (2020) utilizaram imagens de sensoriamento remoto para analisar como a cobertura vegetal perdida, no decorrer de anos, influenciou no uso das plantas medicinais. Os autores perceberam que as práticas sagradas estavam mudando, especialmente, quando notavam que as áreas com declínio de cobertura vegetal incapacitaram a coleta de plantas medicinais (KUNWAR et al. 2020). Por outro lado, alguns autores apontaram para o fato de que em florestas secas, do nordeste brasileiro, as espécies utilizadas para construção de cerca estão ameaçadas (GONÇALVES et al., 2021).

É preciso considerar, também, que diante das ameaças ambientais, o conhecimento ecológico local tem a capacidade de utilizar mecanismos que asseguram o uso dos recursos vegetais. Por exemplo, devido à sazonalidade climática da região semiárida brasileira, as pessoas utilizam mais as cascas das plantas para o preparo de remédios devido a disponibilidade anual (ALBUQUERQUE, 2006). Há também evidências de que as pessoas selecionam plantas com características similares para uma mesma demanda utilitária (BROWN et al., 2011).

2.3 A Redundância Utilitária é uma característica que indica estratégia no uso de plantas por povos da Caatinga

O modelo de redundância utilitária foi proposto pela primeira vez em 2007 por Albuquerque e Oliveira, como analogia as ideias sobre redundância ecológica (WALKER 1992). Em ecologia, a redundância é explicada pela diversidade de funções que as espécies desempenham nas comunidades vegetais (DIAZ et al. 2004). Enquanto que, em etnobiologia, compartilha a ideia de que as populações locais utilizam um conjunto de plantas para um mesmo uso específico (ALBUQUERQUE e OLIVEIRA 2007).

Nos últimos 15 anos, diversos estudos utilizaram o modelo de redundância utilitária para investigar diferentes facetas do uso de plantas por grupos humanos. A previsão central da redundância utilitária prevê duas abordagens distintas: i) busca compreender as espécies que desempenham a mesma função e ii) avalia o grau de redundância, através do número de espécies indicadas para um uso específico (ALBUQUERQUE e OLIVEIRA, 2007). Para ambos os pressupostos há uma tendência em estudar os mecanismos que envolvem a pressão de uso das espécies úteis, a prioridade para conservação, o uso diferencial das plantas e a resiliência dos sistemas socioecológicos.

Os pressupostos da redundância utilitária tendem a explicar a resiliência do conhecimento ecológico local. Na etnobiologia, a resiliência é definida como a capacidade do sistema em absorver as modificações do meio, mas mantendo suas funções (WALKER et al., 2006). Essa definição é de difícil explicação, tendo em vista o leque de variáveis (ex.: idade, gênero, tempo de moradia, disponibilidade de espécies nas comunidades vegetais) que influenciam o conhecimento ecológico local. As variáveis ambientais podem ser fatores interessantes para compreender como a resiliência se comporta frente aos usos locais. Com o intuito de aprofundar o conceito de resiliência na etnobiologia, pesquisadores argumentam sobre o processo envolvido na capacidade e manutenção de um determinado uso (FERREIRA JÚNIOR et al. 2013). Por essa razão, partindo da premissa da teoria socioecológica da Maximização, que traz um novo olhar para a redundância utilitária, reforça a ideia de que as populações locais buscam reduzir os custos e maximizar seus benefícios ao utilizar plantas (ALBUQUERQUE et al., 2019). Por exemplo, Chaves et al., (2022) ao estudarem padrões de caça em uma região do semiárido verificaram que a preferência do sabor aumentou as chances de caçar animais, mas que os caçadores preferem caçar espécies que demandam de menor esforço.

Há maneiras distintas para medir a redundância utilitária, em termos de análise das informações do conhecimento das populações. Na prática, a maioria das pesquisas que testaram a redundância utilitária utilizaram os sistemas médicos como modelo (ALBUQUERQUE e OLIVEIRA, 2007; SANTORO et al., 2015; NASCIMENTO et al., 2016; REINALDO et al., 2021; FERREIRA-JÚNIOR et al., 2012). Através de um recorte histórico, até onde sabemos a proposta inicial de ALBUQUERQUE e OLIVEIRA (2007) permitiu a identificação de categorias terapêuticas classificadas de acordo com o nível de redundância de espécies, sendo elas, altamente redundante (>15% das espécies usadas para tratar uma doença dentro de uma categoria), redundante (<15% das espécies) e não redundante (<5% das espécies). Embora o índice de redundância utilitária, com base no percentual das espécies medicinais citadas, tenha sido utilizado por diversos estudos (SANTORO et al., 2015), foi observado que as espécies inseridas no índice possuem o mesmo peso e, portanto, pode influenciar no grau da redundância utilitária (MEDEIROS et al., 2020). Dessa forma, na tentativa de considerar o compartilhamento das espécies citadas pelas pessoas e a preferência da espécie (em termos de compartilhamento do conhecimento local), MEDEIROS et al., (2020) propuseram o índice de redundância utilitária para a indicação terapêutica (uredit) que permite considerar a preferência e compartilhamento das espécies pelas pessoas. Em relação à preferência, mesmo que ocorra a existência de algumas espécies igualmente disponíveis para um determinado tratamento, muitos indivíduos podem priorizar a utilização de alguma espécie em detrimento de outras (MEDEIROS et al., 2020).

Embora a redundância utilitária não leve em consideração a espécie, COE e GAOUE, 2021) levantaram a hipótese sobre a redundância da espécie em etnobiologia, mostrando que a história evolutiva entre as plantas citadas podem atuar na difusão da pressão de uso de plantas medicinais. Em relação à história evolutiva, muitas espécies vegetais são mais propensas a serem utilizadas devido ao compartilhamento de traços funcionais (defino como uma característica morfológica, fisiológica ou fenológica que é mensurável em nível de individuo e que afeta indiretamente a eficácia biológica) com outras espécies de um mesmo ancestral comum (VIOLLE, et al., 2007; TEIXIDOR-TONEU et al., 2018). Dessa forma, COE e GAOUE (2021) evidenciaram que ao analisar a história evolutiva de plantas medicinais, a preferência por uma espécie, por si só, não leva a pressão de uso e que as espécies redundantes lidam mais com a pressão de uso quando comparadas as espécies menos redundantes.

2.4 A compreensão do uso de plantas semelhantes a partir de hipóteses filogenéticas

A frequência de uso das plantas entre as famílias botânicas é desproporcional (MOERMAN, 1991), pois algumas famílias mostram mais representatividade do que outras (em termos de uso), o que é evidenciado pela hipótese não aleatória para os usos das plantas (MOERMAN, 1979, 1999). A seleção não aleatória de plantas é uma das idéias mais testadas em etnobotânica (MOERMAN, 1979, 1991; MEDEIROS et al., 2013; MULEBA et al., 2020), e tem contribuído com respostas pertinentes sobre o padrão de uso das plantas. A literatura tem mostrado que o componente químico é um atributo que pode ajudar a justificar a seleção de plantas medicinais, e talvez seja devido às características bioativas compartilhadas entre eles (ALBUQUERQUE et al., 2020). Isto pode se referir às explicações de Moerman onde ele explica que espécies da mesma família compartilham características devido a seu parentesco evolutivo, o que por sua vez pode influenciar sua fisiologia (MOERMAN, 1991).

A especificidade na seleção de plantas úteis vêm chamando a atenção de alguns pesquisadores para o fato de que as características compartilhadas entre as espécies podem ser inferidas pela história evolutiva (GARNATJE et al. 2017a). Por essa razão, métodos filogenéticos permitem explorar padrões globais sobre o uso de plantas que apresentam similaridade entre si (LEI et al. 2020).

Apesar do avanço, até o momento, o uso de filogenias é relativamente novo em etnobiologia (LUKHOBA et al. 2006). Mas, recentemente, tem ganhado impulso (SASLIS-LAGOUDAKIS et al., 2011, 2012, 2013, 2014; SAVO et al., 2015; HALSE-GRAMKOW et al., 2016; ERNEST et al., 2016; CÁMARA-LERET et al., 2017; DAI et al., 2017; LESO et al., 2017; GUZMAN e MOLINA, 2018; DÍAZ-FORESTIER et al., 2019; MOLINA-VENEGAS et al., 2020; PEDROSA et al., 2021). Esses estudos concordam com a natureza não aleatória na seleção de plantas através da distribuição filogenética de plantas úteis. Assim, as previsões cunhadas em filogenia estão emergindo como uma ferramenta relevante para explorar as relações entre o conhecimento ecológico local e seleção de atributos de plantas (GRACE et al., 2015).

Os padrões de uso de plantas parecem depender do compartilhamento de traços funcionais semelhantes (CÁMARA-LERET et al., 2017). Por exemplo, geralmente em uma árvore filogenética, os clados ricos em espécies tem maior probabilidade de uso medicinal do que clados com menos espécies (YESSOUFOU et al. 2015), sugerindo que as plantas que evoluem na mesma linhagem têm mais usos do que plantas evolutivamente isolada (GARNATJE et al. 2017b).

Alternativamente, a literatura tem sugerido o termo etnobiologia convergente para explicar a presença de usos semelhantes para plantas incluídas no mesmo nó de uma filogenia (GARNATJE et al. 2017a). A revisão proposta por GARNATJE et al (2017a) faz referência a relevância de estudos moleculares para formulação de hipóteses filogenéticas com intuito de identificar plantas úteis que compartilham características similares. Embora, o uso de filogenia molecular traga maior confiabilidade sobre a história evolutiva das plantas, requer atenção no compartilhamento de termos evolutivos para etnobiologia. Por essa razão, o termo etnobiologia convergente foi aprimorado por HAWKINS e TEIXIDOR-TONEU (2017), os quais trouxeram uma nova contextualização e questionamentos a respeito do termo. Os pesquisadores contestaram que o termo etnobiologia convergente foi empregado de forma equivocada, pois não faz referência ao conceito evolutivo. Assim, indicam que para interpretar as características morfológicas compartilhadas entre as espécies deve ser utilizado o termo de homologia e não de convergência (HAWKINS e TEIXIDOR-TONEU 2017).

A hipótese de homologia é utilizada para estudar semelhanças, que ocorre na mesma estrutura, em diferentes espécies, sob todas as variedades de forma e função onde as espécies apresentam um mesmo ancestral em comum (PINA, 1991). Enquanto que a convergência evolutiva é aquisição de características similares em espécies de diferentes linhas evolutivas, ou seja, semelhanças morfológicas que evoluem independentemente nas plantas (PINA, 1991). No entanto, não se tem um consenso de qual termo deve ser utilizado. Todavia, é preciso entender que o uso de termos evolutivos específicos deve ser utilizado com cautela e deve ser utilizada de acordo com a hipótese filogenética proposta. Portanto, os autores sugerem que o termo de etnobiologia convergente deve ser limitado apenas nos casos em que há evidências que apoiem a hipótese de descobertas independentes de plantas dentre populações locais (HAWKINS e TEIXIDOR-TONEU, 2017).

O uso de hipóteses filogenéticas de plantas utéis tem sido empregados para entender como grupos humanos culturalmente distintos descobrem as plantas de forma independente. Por exemplo, SASLIS-LAGOUDAKIS et al. (2011) observaram que a descoberta independente de plantas ocorre quando uma mesma planta é usada da mesma forma por diferentes culturas. Isso indica que as populações humanas, que não interagem entre si, apreenderam ao longo do tempo e do espaço, independentemente, utilizar a mesma espécie (GARNATJE et al. 2017a). Os motivos, talvez, que levam diferentes povos a utilizar mesma planta para o mesmo uso é que algumas plantas têm a mesma característica morfológica. Dessa forma, podemos utilizar o termo etnobiologia convergente (que faz referência à hipótese de convergência evolutiva), uma vez que resulta na probabilidade de plantas parecidas possuírem mesma localização filogenética, pois compartilham um ancestral comum (GARNATJE et al. 2017b).

O grau de parentesco das espécies pode ser informativo na compreensão da descoberta independente de plantas por diferentes culturas (SASLIS-LAGOUDAKIS et al., 2012). Assim, as abordagens filogenéticas têm sido utilizadas em estudos de cunho transcultural em etnobiologia (TEIXIDOR-TONEU, 2018). Para compreender como populações distintas (Nepal, Nova Zelândia e Cabo da África do Sul) utilizam plantas medicinais, SASLIS-LAGOUDAKIS et al., (2012) utilizaram análises filogenéticas em uma abordagem transcultural, verificaram que plantas relacionadas são usadas para tratar problemas médicos nas mesmas funções terapêuticas. Os achados, também, indicam que as pessoas descobriram a eficiência das plantas de forma independente para mesma funcionalidade (SASLIS-LAGOUDAKIS et al., 2012).

Em um novo estudo, SASLIS-LAGOUDAKIS et al. (2014) observaram que grupos étnicos se assemelham no uso de plantas medicinais devido ao ambiente florístico semelhante. Recentemente, LEI et al., (2020) utilizaram uma abordagem similar, comparando floras através de métodos filogenéticos, para verificar se existe um padrão compartilhado dentre plantas medicinais. Nesse estudo, foram encontradas evidências de agrupamento filogenético entre plantas medicinais usadas entre culturas, sugerindo que o uso medicinal feito por populações localizadas em Omã, região da península Arábica, enfatiza mesmas linhagens de plantas usadas por outras populações participantes do estudo (Nepal, Nova Zelândia e o Cabo da África do Sul) (LEI et al., 2020). Essas informações podem sugerir que o ambiente florístico tende a influenciar no uso de plantas com algum grau de familiaridade e também devido sua bioatividade

(SASLIS-LAGOUDAKIS et al., 2012). Embora o crescente número de estudos utilizem hipóteses filogenéticas para acessar o parentesco de plantas medicinais úteis (SASLIS-LAGOUDAKIS et al., 2012; 2014; YESSOUFOU et al., 2015; GRACE et al., 2015; TEIXIDOR-TONEU, 2018; SOUZA et al., 2018; LEI et al., 2018, 2020; COE e GAOUE, 2021) poucos estudos, até onde sabemos, tem investigado os usos gerais de plantas (MOLINA-VENEGAS et al., 2020; CÁMARA-LERET et al., 2017) ou, especificamente, usos madeireiro de plantas.

3. CAPÍTULO II: Local ecological knowledge dynamics of farmers in areas which have been chronically disturbed by human actions in the Brazilian Caatinga

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Local ecological knowledge dynamics of farmers in areas which have been chronically disturbed by human actions in the Brazilian Caatinga

Research

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Abstract

Background: The diversity of plants indicated for the same use, plays important strategies which can affect the resilience of local ecological knowledge. In this context, we investigated the variation of local ecological knowledge through the richness of cited species, redundancy on an individual level and utilitarian redundancy (fuel, construction and technology) by local populations inserted in a dry forest with different environmental characteristics in northeastern Brazil.

Methods: We conducted semi-structured interviews with 120 local experts and described metrics which indicate the intensity of chronic human disturbance, defined as ongoing activities to remove natural resources, as well as the average annual rainfall in forests close to populations.

Results: We verified that there are differences between the number of species mentioned and the utilitarian redundancy between the studied areas. The richness of known species is suggested to influence redundancy on an individual level. Furthermore, we observed that information sharing about the plants among local experts is different, as some species were shared more than others.

Conclusions: Our results suggest that people living in areas of greater chronic anthropic impact and less rainfall may be subject to a lower resilience of local knowledge.

Keywords: Caatinga; ethnobotany; redundancy; chronic anthropic disorders.

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Background

Local populations have accumulated local ecological knowledge (LEK), which consists in the set of knowledge, practices and beliefs about natural resources (Berkes et al. 2000), that provide important strategies for the adaptation and resilience of people in different spaces (Folke 2006). Resilience is the ability of knowledge to absorb the new information that arises in the face of disturbances which cause changes, without changing its processes and functions (Walker et al. 2004; Ladio 2011). In this context, the resilience of a group will depend on the existing knowledge, which in turn will lead to better adaptation by the population in their environment. However, knowing the complexity of understanding resilience, some authors have suggested factors that can guide resilience for human well-being (Biggs et al. 2012; Ferreira-Júnior et al. 2015). In practice, utilitarian redundancy, related to the functional overlap of different species, so that they are used for the same use, is an exercise thatindicates the adaptive capacity of local ecological knowledge (Albuquerque & Oliveira 2007). For example, the adaptive capacity of local human populations is flexible with loss of a plant species, in terms of decrease or extinction of a species in the natural environment; other species perform the same utilitarian function (Ferreira-Júnior et al., 2015).

Although most of the recent literature on resilience has focused on local medical systems (Santoro et al., 2015; Zank et al., 2022), little has been evaluated on the importance of individual knowledge for system resilience. From this perspective, Ferreira-Júnior et al. (2013) demonstrated that an individual who knows many species is less vulnerable than an individual who knows few species. Thus, individual-level redundancy also demonstrates the importance of people’s ability to respond to environmental disturbances. From a spatial point of view, there may be a positive relationship between the richness of known species and redundancy on an individual leveland utilitarian redundancy (Ferreira-Júnior et al. 2015; Díaz-Reviriego et al. 2016; Albuquerque et al. 2019), starting from the idea that local diversity and direct contact with resources can motivate greater richness of known and cited species (Naah & Guuroh 2017; Cardoso et al. 2017; Corroto et al., 2019; Bystriakova et al. 2021). However, environmental fluctuations, such as the changes in vegetation caused by human impacts (Kunwar et al. 2018; Ali et al. 2022) have the ability to influence the diversity of plants available in the natural environment and this in turn can lead to variation in the adaptive capacity of one community (Brown et al. 2011).

The landscapes of several regions close to rural communities in northeastern Brazil undergo constant changes. Forest damage represents a worrying scenario for plant diversity in Seasonally Dry Tropical Forests (SDTFs) (Portilla-Alonso et al. 2011; Ribeiro et al. 2015). If chronic anthropogenic disturbances (CADs), defined by the continuous and gradual removal of small fragments in the vegetation, influence the reduction of heterogeneity (Singh 1998; Ribeiro et al. 2015), the richness of known species becomes an interesting variable for understanding. Chronic anthropic disturbance to vegetation is responsible for reducing the provision of ecosystem services and generates high socio-environmental costs (Araújo et al., 2021). Thus, a functionalist interpretation (see Ferreira-Júnior et al. 2015) related to aspects of resilience is important, as it manages to access how people maintain their activities in contrasting environments, such as dry forests.

Local human populations in the semi-arid region of Brazil generally collect wood resources from the dry forest (Caatinga) for energy demands (firewood and charcoal) and construction (rural and domestic) in order to perform local subsistence activities (Specht et al. 2019; Hora et al. 2021). Small farmers who occupy the Caatinga usually carry out activities to raise small herds, since agricultural practices occur seasonally due to water deficit, which determines collections guided by availability patterns (Lucena et al. 2012; Gonçalves et al. 2016), given the irregularity and may shape the use of plants by these human populations. Thus, considering the strategies of populations in dry forests, the flexibility to increase or decrease the alternatives of resources for the same utilitarian function can be a response to environmental fluctuations.

Thus, given the history of plant use in dry forest environments and the exposure of people to local environmental changes, our objective was to understand the variation of local ecological knowledge (LEK) of farmers in a semi-arid region of Brazil. The LEK variation between areas with different usage and occupation histories (chronic anthropic disturbances) can drive different responses in the resilience of ecological knowledge of local populations. From this, some guiding questions emerged: i) is there a difference in the number of plants cited by the farmers between the study areas? ii) The number of species cited by local farmers predict greater redundancy on individual level? iii) Is there a difference in the redundancy on an individual level of farmers living in areas with different environmental scenarios (vegetation structure, climate and chronic anthropic disturbances)? And iv) Is there a difference in utilitarian redundancy among the study areas?

Material and Methods

Description of the study área

This study was conducted in of the Brazilian semi-arid region (Cariri region) in the state of Paraíba, Brazil. The study involved local human populations consisting of in five rural communities distributed in different parts of Cariri (Fig.1). The rural communities involved were Riacho Fundo (7°23'47.6"S, 36°27'04.5"W), located in the municipality of São João do Cariri; Caiçara (07°23′8.12″S, 36 °23′36.74″W), located in the municipality of Cabaceiras; Alto dos Cordeiros (7°30'53.6"S, °59'46.6"W), located in the municipality of Barra de Santana; Viveiro (7°25'33.5" S, 36°48'43.0"W), located in the municipality of São José dos Cordeiros, and Olho d'água (7°54'56.6"S, 37°17'09.2" W) located in the municipality of Monteiro (Fig.1); from this point forward they will be called: Area 1 (A1), Area 2 (A2), Area 2 (A3), Area 4 (A4), and Area 5 (A5), respectively.

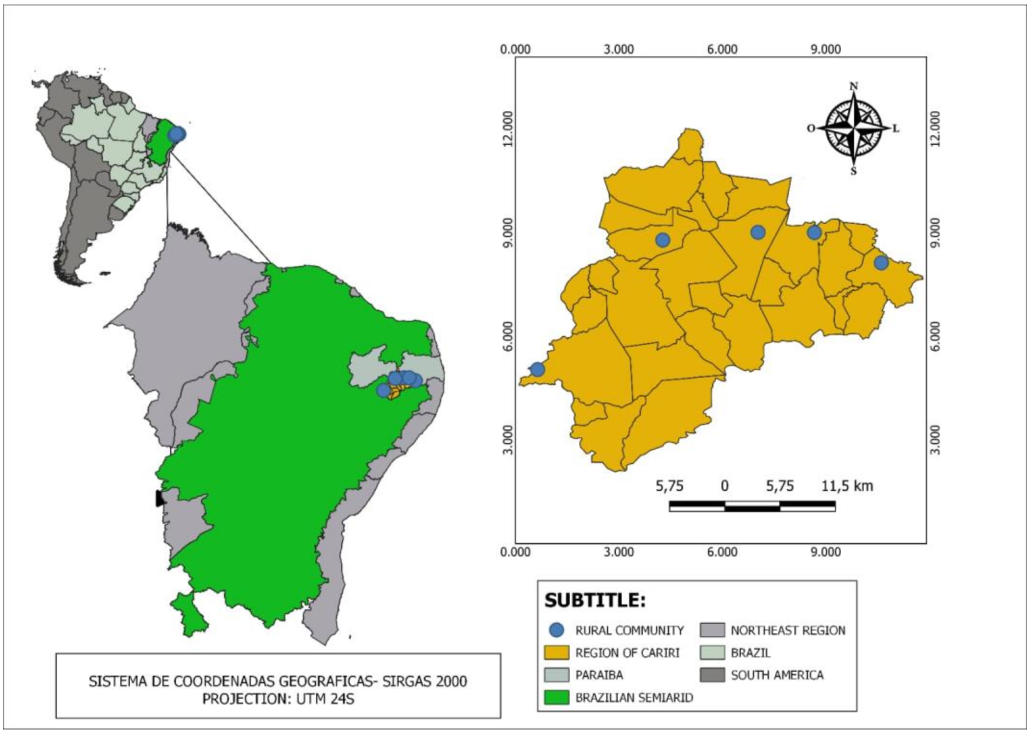

Fig. 1. Location of the communities studied, Paraíba state, northeast Brazil.

The climate of the Cariri region is (Bswh) hot to hot-semi-arid according to the Koppen classification, and it stands out for having the lowest rainfall regime in Brazil with 350 to 600 mm (Álvares et al.2013). The rains are concentrated in the months of February to April, but there is great interannual variation. The average annual temperature and humidity are 25°C and 65%, respectively. Environmental characteristics determine a Seasonally Dry Tropical Forest with vast endemic biodiversity, considered the largest SDTF in the world. The vegetation is composed of a mosaic of physiognomies, with 3,347 species of flowering plants, endowed with a set of morphophysiological adaptations to climatic conditions (presence of thorns, leaf deciduousness) (Fernandes et al. 2019; Queiroz et al. 2017).

The human populations included in the Caatinga environments of the present study are small farmers, descendants of older groups of indigenous peoples, quilombolasand European settlers as a result of the European colonization process that expanded throughout the 16thcentury (Catalog of manuscripts of the Captaincy of Paraiba, 2015). Small farmers practice agricultural activities (during the rainy season) and raise small herds of goats, sheep and cattle (all year round) to supplement their families' economic income.

Ethical and legal aspects

The study was conducted in accordance with the guidelines required by the National Health Council of Brazil through the Research Ethics Committee (resolution no. 466/12/CNS/MS; project approval protocol: 30657119.3.0000.5187). After explaining the purpose of the study to each ofparticipants, we invited them to sign the Free and Informed Consent Form (ICF). We requested authorization from the Chico Mendes Institute for Biodiversity Conservation (ICMBio/SISBIO), an agency linked to the Ministry of the Environment (MMA) (registration: 73540-1), to collect the botanical material. The species were identified through specialists according to the APG IV system (APG IV *et al.* 2016). All collected species cited by participantswere depositedinto the Manuel de Arruda Câmara Herbarium, State University of Paraíba, Campus I, Campina Grande, Paraíba, Brazil.

Collection of information on local ecological knowledge

The study areas were visited before conducting the interviews in order to establish a relationship of rapport and trust with the research participants (Triviños 1987). The first contact with the communities was organized by health agents and presidents of rural associations that work in the region. The professionals introduced us to some residents of the communities. The survey of local knowledge about the plants took place between August 2018 and February 2020 (on average twice a week). We chose to carry out a non-probabilistic selection of informants using the snowball technique (Bailey 1982) in order to select local experts. The Snowball method is when one participant recommends quotinganother participant of similar competence, repeating the process until saturation or until reaching the desired sample size. Men and women who practice subsistence activities in agriculture and raising domestic animals were invited, as they know and use plants on a daily basis. Participants under 18 years of age were not included. The local experts represent a sample of local human population who are located in the rural communities of present study. For this reason, the results and conclusions of research will be under perspective of local experts.

Plant use data were obtained through interviews and free lists (Albuquerque et al., 2014). From the free list, each participant was asked to list all species known. The free list method was complementary to interviews to elucidate the name and uses (fuel, construction and technology) of species cited by participants (Albuquerque et al., 2014). Semi-structured questionnaires were used for the interviews. The questions in the questionnaires sought to record people's knowledge of plants, for example: Which plants do you know? What plants are known for rural construction and home construction? What plants are known as firewood? What plants are known for coal? Which plants are known as technologies (more complex productions)? All uses recorded for the species from the semi-structured interviews and free list were classified into categories and subcategories of use in ethnobotany based on Lucena et al. (2007), namely: Fuel (firewood, coal), construction (wire fence, stick fence, hedge and roof) and technology (tool handles and household items). From this information, it was possible to analyze the number of plants cited among the study areas and to estimate the utilitarian redundancy. All information obtained was recorded in a field notebook. We used complementary techniques to enrich the plant lists, such as rereading, visual aids, and guidedtours (Albuquerque et al. 2014). The rereading technique consists of the researcher orally enunciating the plants mentioned by the participant in order to provide the recall of more plants (Albuquerque et al. 2014).

We used a visual resource of photographs in two different moments: first, for those participants who claimed not to know the plants; and second, for the participants who mentioned forgetting at the time of the interviews (Medeiros et al. 2014). The photographs had images of fruits, leaves, flowers and stems of plants with the habit of trees and shrubs that were recorded during the vegetation survey in the communities. We also carried out guided tours to verify the botanical identity of the species mentioned by the participants, and to collect taxonomic material (Albuquerque et al. 2014).

A total of 120 people participated in the study, represented by: Riacho Fundo community=30 (16 women and 14 men, with an average age of 58 years); Caiçara community=32 (20 men and 10 women, with an average age of 55 years; Alta dos Cordeiros community=24 (19 men and five women, with an average age of 45 years); Viveiro community=23 (15 men and eight women, with a mean age of 41 years); and Olho d'Água community=11 (seven men and four women, with a mean age of 48years).

Sampling of ecological data and botanical collection

We selected a phytosociological plot of 1000 m2 (20 x 50 m) for each rural community, totaling five plots. We sampled all tree/shrub species in each of these plots with height ≥ 1 meter and stem diameter at ground level (DGL) ≥ 3 cm, as they characterize plants in adult stages. Then, we identified the number of plant species in each study area from the vegetation survey. The average annual precipitation for each area was obtained through the WorldClim global climate data repository, updated in monthly and general average data in the total of the years 1970 to 2000, with a spatial resolution of about 30" (www.worldclim. org) using the rasterpackage (Hijmans, 2016) in R (R Core Team, 2019). Theaverage annual rainfall in the plots ranged from 379 to 690 mm.

Next, we used a disturbance index which comprises the integration of important disturbance metrics for Seasonally Dry Tropical Forests to estimate the intensity of chronic man-made disturbances (Martorell and Peters 2005; Arnan et al., 2018). We then identified two main types of disturbances based on the eight metrics recorded, namely livestock pressure and human activities. Cattle pressure is a direct metric measured in the field that refers to the estimate of total biomass per plot using feces from cattle, horses and goats. Human activities arean indirect metric and refers to the evidence of land use left by people. Then, we selected three 100 m² subplots within each 20×50 m plot to collect livestock pressure metrics, and counted the number of fecal pellets fromcattle, horses, donkeys, and goats/sheep. We subsequently collected, dried and weighed three pellet samples for each of these groups to calculate the average weight per plot and estimate the total biomass per plot from the feces of cattle, horses and goats/sheep (Supplementary data 1).

We used satellite images through Google Earth®(GE, 2016) to estimate human pressure indicators. We quantified the proximity to the urban center as the distance from the center of the plot to the nearest city (DC); proximity to the nearest rural property (PH); Trail density (TD). The density of households around the plot (DS) and land use (LUSE) were measured within a 2 km radius buffer from the center of the plot (Supplemental Table 1). All households were counted for DS, and the density of houses for the area was calculated. LUSE was visually estimated by the percentage of land with evidence of use, such as land cover dedicated to plantations, pastures and residences.

Data referring to the number of plants in the plant community, chronic anthropic disturbances and average annual precipitation enabled characterizing each plant community close to the local human populations.

Estimating Redundancy on an individual leveland utility redundancy

The data from all local experts was used to answer whether the number of species cited by local farmers affects theredundancy on an individual level. We chose to use the species richness cited by each participant for each use to obtain the utilitarian redundancy per participant (redundancy on individual level). Each participant cites a framework of species in general, but not necessarily all of them are suitable for a given use. For example, one participant cites 25 plants as fuel, but only 10 are indicated for coal use. Thus, we are assuming that the redundancy of each participant is the number of species cited for a given use, while the number of species cited in general will be treated as the individual richness of the participant.

We chose to calculate the utilitarian redundancy index (uredit “utilitarian redundancy for therapeutic indication”) (Medeiros et al. 2020) at the system level in terms of usage categoriesfor each use and for the community. We used the index for the categories and their localsubcategories: fuel (firewood and coal), construction (hedge fence, wire fence, stick fence and roof) and technology (tool handles and household items). We only used the uses that had more than one cited species for the calculation since the cited uses with only one species do not contribute to the generation of redundancy. Therefore, we removed the structuring, door and window uses in the construction subcategory. Next, we calculated the utility redundancy values using the following index: $Uredit = NSp + Cr$; in which: Nspis the total number of species cited for use, and Cris the contribution of the species to generate redundancy. The contribution of the species to generate redundancy (Cr) was calculated using the following formula: $\sum si/N$, in which: sirepresents the number of people who cited the species iin use, and Nrepresents the total number of people interviewed. The index considers information sharing about used plants. Therefore, by increasing the redundancy value, there is a greater number of species used for a particular use, and greater information sharing by people in a rural community (Medeiros et al. 2020). Thus, we calculated the Uredit for the uses in each study area. In a hypothetical scenario, Medeiros et al. (2020) exemplified the Uredit calculation through the knowledge of 100 people for the treatment of a disease. In this case four plants (a, b, c and d) are indicated, where plants a and b were mentioned by 50 people and plants c and d were mentioned by 40 and 10 people, respectively. The calculation would be: 4 + [(50 + 50 + 40 + 10)/100].

Statistical analysis

In order to verify if there was a difference in the number of known plants among the study areas the cited species richness was initially tested for normality using the Shapiro-Wilk test to answer our first question whether there are differencesin the species richness cited by farmers between the study areas. We subsequently used the Kruskal-Wallis test (data did not show a normal distribution, $p<0.05$). We then performed a post-hoc Dunn test to compare how much the group means differed. A Non-Metric Multidimensional Scaling (NMDS) analysis was performed to assess the composition of species cited between the areas using the Jaccard coefficient through the veganpackage (Oksanen et al. 2018). The ordering was carried out from a matrix withthe interviewees' code and respective location, and the presence and absence data of the mentioned species. We then used a Permutational Multivariate Analysis of Variance (PERMANOVA) with 9999 random permutations to test whether the groups segregated by the NMDS were significant.

Next, we fitted univariate mixed-effect generalized linear models (GLMM) with Binomial Negative distribution in the R package lme4 to test whether cited species affect the redundancy on an individual level in each usage category (redundancy on an individual level -response variables, count data) (Bates et al.,2015). We considered the community/village predictor as a random effect variable, while the cited species was considered as fixed effect. We compared the complete model with the null models for all GLMM models and selected the best model based on AIC. We also used the Kruskal-Wallis test to analyze whether there was a difference in redundancy at the individual farmer level between the study áreas.

We used Principal Component Analysis (PCA) to integrate anthropogenic disturbance measures (Arnan et al., 2018) using the vegan (Oksanen et al. 2018) and psych (Revelle, 2022) package in the R program to identify the level of impact of each study area. PCA was used to reduce the dimensionality of the data through a correlation matrix. All variables were standardized and therefore we used a correlation matrix. The variables used in PCA werebiomass of cattle dung; biomass of dung from horses; biomass of goats and sheep; distance from plot center to town); proximity to rural property; density of residences; density of trails; land use (Supplemental Table 1). All analyzes were performed in the R version 4.0.4 environment (R Core Team, 2019), and all the aforementioned packages were executed on this platform.

Results

A total of 61 plant species were recorded, belonging to 44 genera and 19 botanical families, destined for construction, fuel and technology uses by local populations (Supplementary Data 2). The construction category had the highest number of plant species cited, with 44 plants distributed in 15 families, followed by the technology category with 41 species distributed in 17 families. Finally, the fuel category presented 37 plants mentioned belonging to 13 families. *Astronium urundeuva* Allemão

(Aroeira), *Croton blanchetianus* Baill. (Marmeleiro), *Cenostigma pyramidale* (Tul.) Gagnon & G.P. Lewis (Catingueira), *Aspidosperma pyrifolium* Mart (Pereiro), *Mimosa ophthalmocentra* Benth (Jurema-branca), *Mimosa tenuiflora* (Willd.) Poir (Jurema-preta) and *Prosopis juliflora* (Sw.) DC. (Algaroba) were the most cited species by all local experts. In addition, the most used species among the usage categories were different; for example, *A. pyrifolium* for the construction category, *C. blanchetianus* for fuel and *Commiphora leptophloeos* (Mart.) JB Gillett for technology.

Significant differences between the species richness cited between the study areas were found (K= 47.678; p<0.05), Furthermore, we verified a separation of communities in the multidimensional space in analyzing the composition of cited species (F=0.24; p< 0.001) (Fig. 2), demonstrating similarity between the groups of cited species, with the exception of A5, which was different from the other areas. A5 has higher average annual precipitation, higher plant species richness and a lower CAD value (Table 1; Supplementary Data 1). On the other hand, A1 was the most impacted in terms of chronic anthropogenic disturbances (CADs) (Table 1; Supplementary Data 1), as well as having the lowest number of species cited by local experts (Table 1).

The richness of plants cited per person suggested influencing the redundancy on an individual level. When analyzing the richness of plants known for each area, we also verified the influence of the richness of the cited species on the redundancy on an individual level used as fuel, construction and technology (p < 0.05) (Fig.4; table 2). We also found that individual-level redundancy was different across study areas for fuel (K= 17.418; p = 0.0001), technology (K= 32.831; p < 0.05) and construction (K= 25.668; p < 0.05). Specifically, we found that individual-level redundancy differed significantly between the low (A3 and A4) and medium (A2 and A5) impact areas for fuel, technology and construction in the low (p < 0.05) and medium (p = 0.038; p=0.004; p=0.02), respectively (Fig. 3).

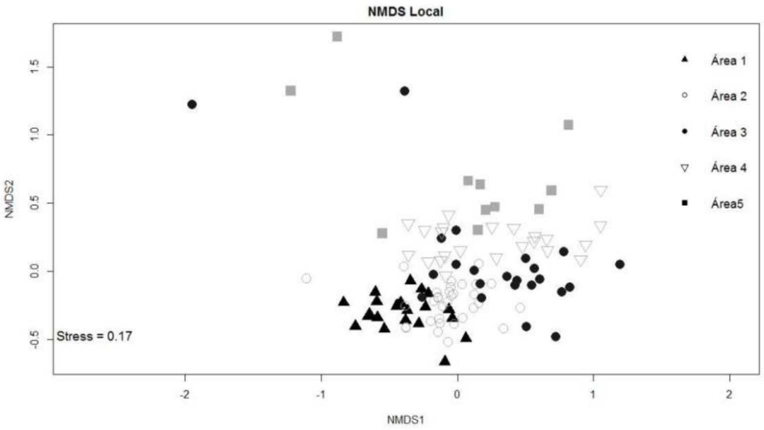

Fig. 2. Non-metric Scaling Method (Nmds) ordering, based on Jaccard's distance matrix, with the groupings for plant citation in the five study areas, northeastern Brazil, Paraíba state.

Table 1. Characterization of the environmental context of five rural communities studied in the Cariri region, northeastern Brazil, state of Paraíba. CAD (chronic anthropic disturbance); MAP (mean annual precipitation); plant species richness.

Parameters					
Communities	**A1**	**A2**	**A3**	**A4**	**A5**
CAD	2.0420	-0.6631	-0.3656	-0.3739	-0.6393
MAP (mm)	379	384	419	525	681
Plant Species Richness	8	13	20	9	33

A total of eight subcategories belonging to the fuel use, construction and technology categories were reported by the local experts (Table 3). We observed that the uses of firewood and wire fence had the greatest utilitarian redundancy (Table 4). In addition, we verified that the contribution of species to generate redundancy (in terms of knowledge sharing) was different, with greater representation of indication by people for a specific set of species (Table 3).

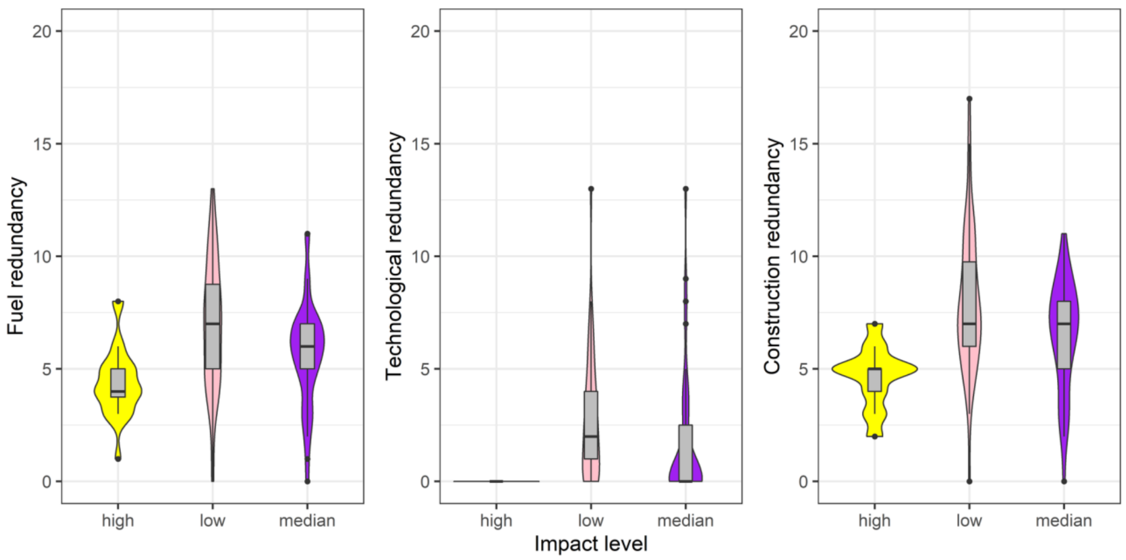

Fig. 3. Fiddle graphs showing individual farmers' redundancy as a function of level of chronic anthropic disturbance recorded in rural communities in the Cariri region, Paraíba state, northeastern Brazil. The high, low and medium predictor variables represent the level of disturbance recorded in each study area, where communities are represented: High (A1), low (A3 and A4) and medium (A2 and A5).

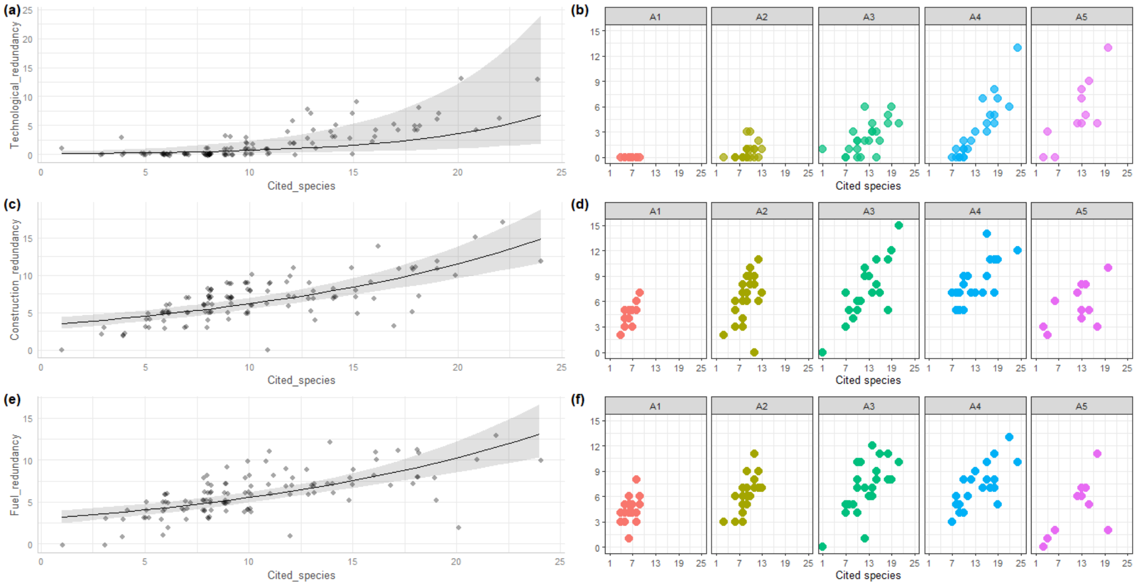

Fig. 4. Linear Generalized Mixed Models (GLMMs) to assess whether the number of species cited by local farmers affects individual-level redundancy across study areas in the Cariri region, Paraíba state, Brazil.

Table 2.Univariate mixed generalized linear model estimates.

Predictor variable	**Response Variable**	**Estimate**	**Std. Error**	**Z-value**	**Pr (>|z|)**	**AIC**
species richness cited	Technological redundancy at the individual leve	0.16102	0.01693	9.513	< 2e-16 ***	290.52
	Fuel redundancy at the individual level	0.061662	0.009282	6.644	3.06e-11 ***	532.51
	Constructionredundancy at the individual level	0.062331	0.008607	7.242	4.42e-13 ***	499.49

Table 3 Species with the highest number of sharing by survey participants for generating utility redundancy.

	Areas of study				
Use	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**
Firewood	**Use**	*C.pyramidale*	*C.pyramidale*	*C.pyramidale*	*C.pyramidale*
Coal	*A. urundeuva*	*C.pyramidale*	*C.pyramidale*	*M.tenuiflora*	*C.pyramidale*
Wire fence	*P. juliflora*	*A. urundeuva*	*M.tenuiflora*	*P. juliflora*	*A. colubrina*
stick fence	*C.blanchetianus*	*C.blanchetianus*	*C.blanchetianus*	*C.blanchetianus*	*C.blanchetianus*
Living fence	*C. leptophloeos*	*C. leptophloeos*	*C. leptophloeos*	*A. cearensis*	*C. leptophloeos*
Roof	*A. urundeuva*	*A. urundeuva*	*A. pyrifolium*	*C. leptophloeos*	*A. urundeuva*
Tool Handle	-	-	*A. pyrifolium*	*S. obtusifoliun*	*C. trichotoma*
Household Utensils	-	*C.leptophloeos*	*E. velutina*	*C. glaziovii*	*C. glaziovii*

Table 4**.** Uredit values (utility redundancy) for each use mentioned by local experts in each study area.

Uses	Uredit values of each use for each rural community				
	A1	**A2**	**A3**	**A4**	**A5**

Firewood	14.7	22.9	30.95	32.60	25.8
Coal	4.1	11.5	14.12	11.34	9.8
Wire fence	19.43	23.36	36.0	30.65	18.73
Stick fence	8.2	11.13	8.95	18.91	6.53
Living fence	5.36	9.79	2.08	2.0	2.0
Roof	2.06	6.4	8.33	3.20	8.91
Tool handles	-	-	10.95	19.43	12.66
Household items	-	2.22	4.66	2.23	2.23

Discussion

In this work we evaluated the local ecological knowledge dynamics of farmers located near forest fragments chronically disturbed by human activities. Our study confirms some trends observed in the literature, namely that local human populations inserted inenvironments of greater environmental heterogeneity have their possibilities of use increased, possibly motivated by the greater diversity of species in plant communities (Naah and Guuroh 2017; Barros et al., 2019; Bystriakova et al., 2021), while environments with a lower supply of plant species may restrict local use (Barros et al., 2019). In this context, considering the environmental characteristics, our data show that the general richness of the cited plants was lower in an area of greater anthropic impact and less rainfall, while the composition of cited species was different in the area of greater rainfall. The botanical knowledge of groups inserted in the Caatinga generally shows similarity in the number of known plants for both those living in moreconserved environments and for those living close to anthropogenic areas (Lucena et al. 2012; Gonçalves et al. 2021 b). The reasons that explain our results may be associated with the diversity of plant community in response to the average annual precipitation level, which can modulate the distribution of more drought-tolerant plants (Esquivel-Muelbert et al. 2017), because the vegetation can recover faster even in an impacted environment.

Our data suggest that there was a relationship between plant richness cited by the participants and redundancy on an individual level. This result indicates that the greater the number of plants known to a person, the greater the redundancy value on an individual level. Our objective in analyzing cited species richness and redundancy on an individual level was to clarify that the total number of known plants does not necessarily imply that all species are indicated in the same uses. In some cases, the richness of the cited species can generate a greater weight for specific uses, as was the case with the use of construction. Moreover, these inferences are important for understanding the role of individuals' local ecological knowledge in resilience, since according to previous studies (Thorsen and Pouliot, 2016), people are able to autonomously respond to their needs.

We found some evidence to support explaining our third question that is there a difference in the redundancy on an individual level of farmers living in areas with different environmental scenarios (vegetation structure, climate and chronic anthropic disturbances). We observed that local experts inserted in areas of more stressful environments (less rainfall and greater intensity of chronic anthropic disturbances) cite a low number of species and present a difference regarding redundancy on an individual level. The reduced number of species may mean that these local specialists do not adopt different plants for the same purpose. As discussed earlier, because of the lower plant diversity. If the low redundancy on an individual level and number of species cited is being driven by anthropogenic disturbances in vegetation observed during the survey, then local populations in areas with higher CAD (chronic anthropogenic disturbances) intensity may be reducing the number of useful species. As only one area (less rainfall and greater impact) showed a relationship of less redundancy on an individual level and number of species cited by people, this result should be interpreted as a suggestion of a relationship, not as strong evidence. Knowing that local residents are socially vulnerable and dependent on natural resources, one of implications of the previous results is that low redundancy on an individual level and number of species cited can become a challenge for the community if the environment continues to receive stimuli which direct the loss of species in the plant community (Ladio 2011).

Other dry forest environments have also experienced an increase in the degree of chronic anthropic disturbances (Sfair et al. 2018; Kaushik et al. 2021) and show that drier areas (in terms of water availability) are more sensitive to the effects of chronic disorders (Ribeiro et al. 2015). Anthropogenic disturbances in the researched region expanded throughout the process of European "colonization" in the 16thcentury (Catalog of manuscripts of the Captaincy of Paraíba, 2015). European territorial usurpation advanced in the semi-arid region of Brazil, land donations through sesmarialetters promoted expansion of agricultural production and the migration of cattle increased fires to remove arboreal vegetation (Catalogue of manuscripts of the Captaincy of Paraíba, 2015). Farmers practice their agricultural activities on privately owned land, but raising of domestic animals, especially goats, often takes place in common and open spaces in the Caatinga, such as in areas with greater native vegetation (Nunes et al. 2015; Marinho et al. 2016). These actions take place between generations and may be among those responsible for the anthropic impacts on the plant communities of the Caatinga (Gonçalves et al. 2021a). Moreover, in our understanding, verifying environmental changes in dry forest fragments can become thebasis for understanding the usage strategies of useful plants by local people.

In this study, the utilitarian redundancy values obtained for local uses in each study area were lower in the area of high chronic anthropic impact. This phenomenon can be explained through the following hypothesis: first, that the species cited for may have different weights (in terms of information sharing between people) due to the prioritization of certain species (Medeiros et al. 2020), favoring few species in a given use. Our results also highlight the importance of uses for firewood and wire fencing, a pattern also observed in forests in Madagascar (Brown et al.2011), Caatinga (Oliveira et al. 2019) and Chaco (Jiménez-Escobar et al. 2021), especially for firewood. The contribution of species to these uses is considered important due to the greater information sharing among local experts. The knowledge of these uses may be associated with the demand for greater amounts of native wood repair (as was the case with A. colubrina, C. pyramidaleand A. pyrifolium), mainly for the production of fences that are damaged by the domestic herd. This suggests that the local need for some uses tends to motivate people to select a greater number of species. For example, in a diachronic study, Santoro and Albuquerque, (2020) showed that people increase redundancy (over time) only in the categories which are locally perceived as most important. On the other hand, the other uses proved to be less redundant. The possible lower importance of some activities in some rural communities compared to others may be associated with the supply of other products for producing artifacts, such as roofs. These uses do not require constant repairs, with little need for replacement (Ramos et al., 2015), whichmay be responsible for lower redundancy.

However, one positive result was the information sharing between people. The contribution of the mentioned plants to generating redundancy was different, but there were exceptions. We observed that the most sharedplants among the areas were the same for firewood and fences. This becomes interesting from the point of view of utilitarian redundancy, as it can indicate that some species are prioritized over others. The high number of citations for the prioritized species perhaps tends to indicate the efficiency of the plant for use. The literature has revealed that there is a predominance of species from the Caatinga which are more likely to be used for logging purposes due to durability (Hora et al. 2021), wood ignition (Cruz et al. 2020) and in some cases due to similar morphological characteristics of the species (Pedrosa et al. 2021). However, although it is important for utilitarian redundancy, our data do not allow us to identify the usage intensity of each species generate redundancy. Thus, it is to be expected that future studies will insert local perception to understand why some species are more used than others. However, even with species prioritization, some uses are more salient in terms of redundant plants. Some reports during the interviews illustrate that the most shared species among the participants are recognized for presenting characteristics that refer to an advantage for use. For example, C. pyramidaleused as firewood was represented as follows:

> *It's a good wood, it's heavy, it has a core, it shines, it's warm and it doesn't smoke a lot"* (Female, 47 years old, Cabaceiras).

> *"It doesn't smoke, takes a long time to put out, hard and resistant coals"* (Female, 50 years old, São João do Cariri).

Ideas about sharing information for a given use are generally similar to the explanation proposed by the socioecological theory of maximization, in which local ecological knowledge contributes to the maximum performance of human groups in the environment (Albuquerque et al., 2019). Our results seem to be related to the utilitarian redundancy generation model which proposes that local knowledge is organized to be redundant, but the redundancy can vary in time and space (Albuquerque et al., 2019). This can be observed in our study when local specialists inserted in more stressful environments tend to reduce the number of species indicated in a given use. Thus, it would be interesting to investigate the intensity of sharing of each redundant species in a use in order to verify its impact on generating utilitarian redundancy. However, we would like to point out that our results correspond to a sample, and therefore our inferences about local knowledge are from the perspective of local experts.

Although our results do not intend to verify the use of species according to the collection intensity, local specialists seem to know a diverse number of plant species to maintain their daily activities from the functionalist point of view of redundancy onan individual level and number of species cited. This suggests that even in an environment with frequent chronic anthropic disturbances which can lead to the decline of a plant, other species will perform the same function. However, considering all the results, people inserted in more impacted areas are perhaps more likely to change their functional identity, while areas of greater plant richness (higher average annual precipitation and lower CAD) are more important for the resilience of local knowledge. At the same time, the idea that local ecological knowledge can adapt to these disturbances becomes interesting, as redundancy can increase resilience in these contexts of environmental change (Noble et al., 2015).

We hope that this look at local populations can alert us to the importance of employing their knowledge in global conservation challenges, as the use of species will tend to be increasingly motivated by changes in local and global scales over the next few decades, which can become a great challenge since small losses in species richness in plant communities can result in reductions in utilitarian diversity (Brown et al., 2011). Thus, one of the possible solutions is to protect the capacity of semi-arid lands to provide ecosystem services and to develop sustainable agricultural landscapes to enable the daily practice of human populations living in rural areas (Araújo et al., 2021).

Conclusion

In general, local experts in the studied areas indicate a greaternumber of plants for construction uses. We described chronic disturbance metrics in plant communities close to the study areas in order to support the environmental characterization. Thus, we observed that areas of greater chronic impact suggest less species richness cited. The richness of known species is suggested to influence the redundancy on an individual level. We found that firewood and wire fence had greater utilitarian redundancy among local experts. In contrast to the concerns associated with theeffects of wood harvesting by local populations, our inferences contribute to better understand the local ecological knowledge dynamics of Caatinga peoples in face of advancement of chronic anthropic impacts in these dry forest regions.

Declarations List of abbreviations: LEC = local ecological knowledge, SDTFs = Seasonally Dry Tropical Forests, CAD = Chronic Anthropogenic Disturbances, A1; A2; A3; A4 and A5 = Study areas, ICF = Informed Consent Form, ICMBio/SISBIO = Chico Mendes Institute for Biodiversity Conservation, MMA = Ministry of the Environment, APG = Angiosperm Phylogeny Group, EcoTrocpis = Neotropical Ecology Laboratory, DGL = Diameter at Ground Level, DC = Nearest city, PH = Proximity to the Nearest rural property, TD = Trail density, DS = The density of households around the plot, LUSE = land use, NMDS = Non-Metric Multidimensional Scaling, UREDIT = Utility redundancy values, PERMANOVA = Permutational Multivariate Analysis of Variance, PCA = Principal Component Analysis and GLMM = Mixed-Effect Generalized Linear Models.

Ethics approval and consent to participate: The study was conducted in accordance with the guidelines required by the National Health Council of Brazil through the Research Ethics Committee (resolution no. 466/12/CNS/MS; project approval protocol: 30657119.3.0000.5187).

Consent for publication: Not applicable in this section. Consent for publication: Not applicable in this section. Availability of data and materials: Plant materials were prepared and deposited in the herbarium the Manuel de Arruda Câmara Herbarium, State University of Paraíba, Campus I, Campina Grande, Paraíba, Brazil.

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Author contributions: KMP, MBR and SFL conceived the research idea. KMP, MBR, SSC, SMS and MGRM did the data collection. KMP analyzed and interpreted the data. HKLS Statistical analysis review. KMP, SFL and MALTC revised and improved the manuscript. All the authors read, reviewed, and approved the final version of the manuscript.

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Supplemental Table 1: Parameters related to species richness cited (sp_cited) and utility redundancy (red_fuel; red_tec; red_const) by local experts, within the five study areas, northeastern Brazil. This was followed by information regarding the environmental context, MAP (mean annual precipitation) and chronic anthropic disturbance metrics: CATTLE (Biomass of cattle dung); EQUINE (Biomass of dung from horses, horses and donkeys); GOAT (Biomass of goats and sheep); DC (distance from plot center to town); PH (proximity to rural property); DS (density of residences); TD (density of trails); LS (land use).

Site	People	sp_cited	red_fuel	red_tecn	red_const	MAP	CAD	impacto	goat	cattle	equine	DC	PH	DS	TD	LS
1	1	9	6	0	7	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	2	7	4	0	3	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	3	5	4	0	3	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	4	5	3	0	3	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	5	6	4	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	6	6	4	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	7	6	5	0	4	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	8	4	4	0	2	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	9	6	5	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	10	6	5	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	11	6	6	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	14	5	5	0	4	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	15	8	8	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	16	7	4	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	17	6	1	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	18	4	3	0	2	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	19	5	3	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	20	5	3	0	4	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	22	9	5	0	7	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	26	8	8	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	27	8	4	0	6	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	28	8	3	0	6	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	29	7	5	0	5	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
1	30	8	4	0	6	384	CAD1	high	2762	127	4873	8.79	5.89	493	2.56	7
2	31	12	7	2	11	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	32	9	7	1	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	33	9	6	0	9	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3

2	34	8	3	0	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	35	8	7	0	3	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	36	8	6	0	6	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	37	8	5	0	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	38	8	5	0	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	39	11	7	1	9	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	40	12	9	0	6	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	41	13	7	1	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	42	8	6	0	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	43	6	3	0	5	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	44	8	3	0	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	45	10	6	1	9	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	46	8	4	0	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	47	8	6	0	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	48	9	7	1	9	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	49	9	5	1	6	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	50	9	5	0	9	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	51	11	8	1	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	52	8	4	0	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	53	9	9	3	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	54	10	6	3	8	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	55	6	6	0	6	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	56	8	7	0	4	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	57	8	5	0	6	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	58	10	6	0	10	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	59	9	5	0	7	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	60	11	11	0	0	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
2	61	6	6	0	3	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3

2	62	3	3	0	2	379	CAD2	medium	0	22896	25	7.06	1.59	730	1.92	3
3	63	7	5	0	3	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	64	10	8	1	6	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	65	10	10	0	5	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	66	10	7	2	5	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	67	1	0	1	0	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	68	11	10	0	6	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	69	8	5	1	5	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	70	7	4	0	7	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	71	13	6	2	9	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	72	14	12	3	7	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	73	14	6	4	7	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	74	12	7	2	10	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	75	21	10	4	15	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	76	18	8	5	11	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	77	16	11	2	7	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	78	14	7	3	7	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	79	18	11	4	5	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	81	15	9	0	11	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	82	15	8	3	8	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	83	12	1	6	9	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	84	10	4	2	6	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	85	9	5	3	4	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
3	86	19	8	6	12	419	CAD3	low	0	4859	0	0.87	2.31	354	0	9
4	87	10	4	2	8	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	88	12	8	2	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	89	18	8	4	11	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	90	9	4	0	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5

4	91	19	5	7	11	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	92	17	7	5	11	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	93	15	7	7	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	94	10	4	0	9	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	95	18	7	8	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	96	16	10	3	14	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	97	8	6	0	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	98	16	8	4	9	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	99	10	4	1	9	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	100	9	5	0	5	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	101	10	8	1	5	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	102	11	6	1	9	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	103	10	4	0	8	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	104	8	5	1	5	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	105	18	11	5	11	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	106	7	3	0	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	107	24	10	13	12	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	108	13	9	3	7	525	CAD3	low	0	0	0	3.87	2.79	562	0.32	5
4	109	22	13	6	17	525	CAD4	low	0	0	0	3.87	2.79	562	0.32	5
5	110	13	6	8	4	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	111	13	7	4	8	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	112	13	7	7	5	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	113	12	6	4	7	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	114	20	2	13	10	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	115	3	0	0	3	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	116	14	7	5	8	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	117	17	11	4	3	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	118	4	1	3	2	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3

5	119	6	2	0	6	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3
5	120	15	5	9	5	681	CAD4	medium	0	0	0	18.4	2.23	451	0	3

Supplemental Table 2. Species recorded for different use categories in rural communities of Cariri, Paraíba, northeastern Brazil. Followed by vernacular name, Voucher and communities (referring to species cited in each study area) 1 (species cited) and 0 (species not cited) represented by ACAM (Herbarium Manuel de Arruda Câmara), NC (not collected).

			Comunidades					
Família	**Espécie**	**Nomes populares**	**A1**	**A2**	**A3**	**A4**	**A5**	**Voucher**
			Species citation by local experts in the study areas					
Anacardiaceae	*Astronium urundeuva* (M.Allemão) Engl.	Aroeira	1	1	1	1	1	ACAM 1991
	Schinopsis brasiliensis Engl	Baraúna	1	1	1	1	1	ACAM 2009
	Spondias tuberosa Arruda	Umbuzeiro	0	0	1	1	1	ACAM 1579
Annonaceae	*Annona leptopetala* (R.E.Fr.) H.Rainer	Pinha-Brava	0	0	0	1	1	
Apocynaceae	*Aspidosperma pyrifolium* Mart. & Zucc.	Pereiro	1	1	1	1	1	ACAM 1995
Bignoniaceae	*Handroanthus albus* (Cham.) Mattos	Pau-d'arco-Amarelo	0	0	1	1	1	To define
	Handroanthus impetiginosus (Mart. ex DC.) Mattos	Pau-d'arco-Rocho	0	0	0	1	1	To define
	Tabebuia aurea (Silva Manso) Benth.& Hook.f. ex S.Moore	Craibeira	1	1	1	1	1	To define
Boraginaceae	*Cordia trichotoma* (Vell.) Arráb. ex Steud.	Frei-Jorge	0	0	1	0	1	To define
Burseraceae	*Commiphora leptophloeos* (Mart.) J.B. Gillett	Umburana	1	1	1	1	1	To define

Cactaceae	*Cereus jamacaru DC. subsp. jamacaru*	Mandacarú	0	1	1	1	1	To define
	Pilosocereus pachycladus F. Ritter	Facheiro	1	1	1	1	0	To define
Capparaceae	*Cynophalla flexuosa* (L.) J.Presl	Feijão-Bravo	0	1	1	0	0	ACAM 2014
	Crateva tapia L.	Trapiá	0	0	1	0	0	Para definir
Combretaceae	*Combretum leprosum* Mart.	Mufumbo	0	0	0	1	0	ACAM 1990
Euphorbiaceae	*Cnidoscolus quercifolius* Pohl	Favela	0	0	0	1	0	ACAM 1996
	Croton blanchetianus Baill.	Marmeleiro	1	1	1	1	1	To define
	Croton heliotropiifolius Kunth	Marmeleiro-branco	1	0	1	1	1	ACAM 1983
	Euphorbia tirucalli L.	Aveloz	1	1	1	1	0	To define
	Hymenaea courbaril L	Jatoba	0	0	0	1	1	To define
	Jatropha mollissima (Pohl) Baill.	Pinhão-Bravo	1	1	1	1	0	ACAM 1984
	Manihot glaziovii Müll.Arg.	Maniçoba	0	1	1	1	0	To define
	Sapium glandulosum (L.) Morong	Burra-Leiteira	0	1	0	0	0	ACAM 2010
Fabaceae	*Amburana cearensis* (Allemão) A.C.Sm.	Cumarú	0	0	0	1	1	ACAM 1981
	Anadenanthera colubrina (Vell.) Brenan	Angico	1	1	1	1	1	ACAM 1982
	Bauhinia cheilantha (Bong.) Steud.	Mororó	0	1	1	1	1	ACAM 1986
	Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz var. *ferrea*	Jucá	1	0	1	1	1	ACAM 1996
	Cenostigma pyramidale (Tul.) Gagnon & G.P. Lewis	Catingueira	1	1	1	1	1	ACAM 1988

	Chloroleucon foliolosum (Benth.) G.P.Lewis	Jurema-de-coronha	0	1	1	0	0	ACAM 2011
	Dahlstedtia araripensis (Benth.) M.J. Silva & A.M.G. Azevedo	Sucupira	0	0	0	0	1	ACAM 2007
	Desmanthus virgatus (L.) Willd.	Jureminha	0	0	0	0	1	ACAM 2006
	Enterolobium contortisiliquum (Vell.) Morong	Tambor	0	0	0	1	1	ACAM 2000
	Erythrina velutina Willd.	Mulungu	0	1	1	1	1	To define
	luetzelburgia auriculata (Allemão) Ducke	Pau-de-Serrote	0	0	0	1	0	ACAM 1997
	Mimosa arenosa (Willd.) Poir.	Unha-de-gato	0	1	1	1	0	To define
	Mimosa caesalpiniifolia Benth	Sabiá	0	0	1	0	0	To define
	Mimosa lewisii Barneby	Jurema-amorosa	0	1	0	1	1	To define
	Mimosa ophthalmocentra Mart. ex Benth.	Jurema-de-embira	1	1	1	1	1	ACAM 1992
	Mimosa tenuiflora (Willd.) Poir.	Jurema-Preta	1	1	1	1	1	ACAM 1989
	Piptadenia retusa (Jacq.) P.G.Ribeiro, Seigler & Ebinger	Jurema branca	1	1	1	1	1	ACAM 1978
	Prosopis juliflora (Sw.) DC.	Algaroba	1	1	1	1	1	To define
	Senna spectabilis (DC.) H.S.Irwin & Barneby	Canafístula	0	0	1	1	1	ACAM 2005
Malvaceae	*Ceiba glaziovii* (Kuntze) K.Schum.	Barriguda	0	0	1	1	1	ACAM 1993
Meliaceae	*Cedrela odorata* L.	Cedro	0	0	0	1	0	To define
Nyctaginaceae	*Guapira hirsuta* (Choisy) Lundell	João-Mole	0	0	1	0	0	To define

	Guapira laxa (Netto) Furlan	Pau-Piranha	0	0	0	1	1	To define
Olacaceae	*Ximenia americana L.*	Ameixa	0	0	1	1	1	To define
Rhamnaceae	*Sarcomphalus joazeiro* (Mart.) Hauenshild	Juazeiro	1	0	1	1	1	ACAM 1933
Rubiaceae	*Coutarea hexandra* (Jacq.) K. Schum	Quina-Quina	0	0	0	1	1	To define
Rutaceae	*Zanthoxylum rhoifolium* Lam.	Limãzinho	0	0	0	1	1	To define
Sapotaceae	*Sideroxylon obtusifolium* (Roem. & Schult.) TDPenn.	Quixabeira	1	1	1	1	1	ACAM 1994
Sem identificação	Morfo1	Bálssamo	0	0	0	1	1	NC
	Morfo10	Quebra-Faca	0	0	0	1	1	NC
	Morfo11	Rabo-de-Cavalo	0	0	1	1	1	NC
	Morfo2	Cipaúba	0	0	1	0	0	NC
	Morfo3	Guachumba	0	0	0	1	1	NC
	Morfo5	Jurema-Brava	0	1	1	0	0	NC
	Morfo6	Jurema-Mulatinha	0	1	0	0	0	NC
	Morfo8	Louro	0	0	0	1	0	NC
	Morfo9	Pau-Cachão	0	0	0	0	1	NC
	Morof4	Jurema-de-Caboblo	0	1	1	0	0	NC

4. CAPÍTULO III: Plants with similar characteristics drive their use by local populations in the semi-arid region of Brazil

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Plants with similar characteristics drive their use by local populations in the semi-arid region of Brazil

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Abstract

Similarity among plants is explained by evolutionary history and can mediate the selection that human populations make of such resources. Ethnobotanical data were collected through semi-structured interviews with a total of 25 key informants. Locally important plants were evaluated by calculating their Use Value (UV). A phylogenetic tree of the entire set of species cited by the participants was generated to analyze the phylogenetic signal of useful plants. A total of 41 species were cited and classified into nine uses. Our data set indicated that the cited plants are not randomly distributed among botanical families. The use of plants may be driven by the similarity of attributes between species. The phylogenetic signal test indicated that there is high representation of phylogenetic lineages among ethnobotanical uses. We suggest that similar plants tend to have similar utilitarian functions, and perhaps this is the criterion which directs plant selection by local populations.

Keywords: Selection; Population Locations; Ethnobotany; Phylogenetic signal.

Introduction

Understanding strategies related to the dynamics of plant selection and use by local human populations has been a central issue in ethnobiology (Cámara-Leret et al. 2017; Cardoso et al. 2015; Parihaar et al., 2014; Savo et al. 2015). The relationships between the availability of plants and their use have been investigated for a long time, with much evidence indicating that human populations predominantly use plants which have greater availability in the landscape (Gonçalves et al. 2016). In addition, the number of plants used is generally influenced by species richness (Cunha et al. 2020). Some researchers have included models to better understand the factors that govern the use of plants in ethnobotany (Albuquerque et al. 2019; Cámara-Leret et al. 2017; Gaoue et al. 2017; Medeiros et al. 2013). However, the mechanisms which dictate the selection criteria used by humans are not yet fully understood.

The plant use frequency among botanical families is disproportionate (Moerman, 1991), with some families showing greater representativeness than others in terms of use, which is evidenced by the non-random hypothesis for the uses of plants (Moerman, 1979,1999). For example, the family Fabaceae is used for various purposes in some regions, while in others it has few uses (Medeiros et al. 2015). This hypothesis is one of the most tested in ethnobotany (Medeiros et al. 2015; Díaz-Forestier et al. 2019; Di et al. 2020), however, there is no standard pattern for similar use of taxonomic groups worldwide.

The idea of utilitarian equivalence has been used to clarify the common use of taxonomically similar medicinal plants (Reinaldo et al. 2020). Evidence on utilitarian equivalence suggests that local populations select medicinal plants which have similarities (Reinaldo et al. 2020). The equivalence model can provide relevant information for identifying species that share similar characteristics, especially due to the set of chemical compounds which may be present in taxonomically related species (Albuquerque et al. 2020). Another factor may be independent learning through the use of related plants due to their morphological similarity (Garnatje et al. 2017).

Despite studies showing a concentration of taxonomic groups for uses, there is still no consensus on the reasons which lead to the selection of certain species with similar characteristics in relation to others. One possibility for investigating this question is through an evolutionary approach. Plants within the same family with close evolutionary relationships probably share similar secondary compounds (Juddy et al.

2007). This information can strengthen ideas about the selection of plants which derive from a common ancestor (Savo et al. 2015).

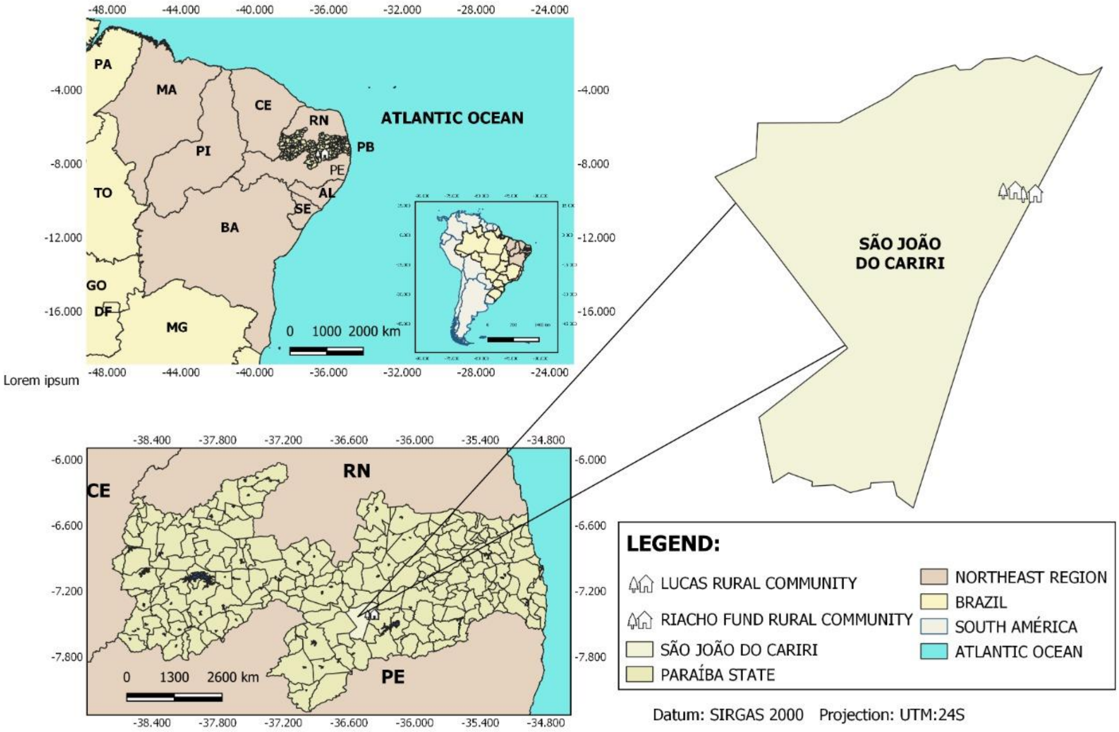
The use of phylogenies is relatively new for ethnobiology (Lukhoba et al. 2006). However, such an approach has recently gained momentum (Saslis-Lagoudakis et al. 2011, 2014; Yessoufou et al. 2015; Ernst et al., 2016; Halse-Gramkow et al. 2016; Cámara-Leret et al. 2017; Leso et al. 2018; Lei et al. 2018, 2020; Sousa et al. 2018; Guzman and Molina 2018; Díaz-Forestier et al. 2019). The common hypothesis tested among these studies is that plant selection criteria are based on phylogenetic similarity. Thus, studies have shown that plants that evolve in the same lineage have more common uses when compared to others that are evolutionary isolated (Yessoufou et al. 2015; Garnatje et al. 2017).

The use of phylogenetic hypotheses and methods is emerging as useful tools to describe the usage patterns of plants by human populations (Saslis-Lagoudakis et al., 2011, 2012). Research using this tool is generally focused on revealing plants with pharmacological potential, with a large gap for other uses (Saslis-Lagoudakis et al. 2015). However, in addition to phylogenetic trees, the phylogenetic signal test has been recommended for testing whether useful plants are more closely related than expected at random (Webb et al. 2008). Thus, herein we have used the diversity of useful species and phylogenetic signal to investigate plants with a specific ethnobotanical potential used by local populations in the semi-arid region of Brazil.

Methods

Study area

This study involves local populations from rural communities of Lucas and Riacho Fundo in the municipality of João do Cariri, in the Cariri microregion, state of Paraíba, Northeast Brazil (Fig. 1). The communities are located around Serra da Arara (07º23’8.12”S, 36º23’36.74”W), approximately 15 km from the urban center. The municipality of São João do Cariri occupies an area of 13,845 km^2 and has a population of 4,344, with 2,347 in the urban zone and 1,997 in the rural zone (IBGE 2017). Annual rainfall for the Cariri region ranges from 350 to 600 mm (Xavier et al. 2016; Souza et al. 2020). The altitude varies between 400m on/in plane surfaces and 1100 m in the highlands (Xavier et al. 2016). The region’s climate is Bsh (hot semi-arid) according to the Koppen classification (Álvares et al. 2013). The vegetation is classified as seasonally dry tropical forest (SDTF) with physiognomic variety and endemic biodiversity (Silva et al. 2017). It contains plant species with physiological and morphological characteristics adapted to the weather conditions, such as trees and shrubs with small leaves; the presence of waxes, trichomes, and leaves modified as thorns; twisted spiny trunks; and succulence (Queiroz et al. 2017).



Ethnobotanical Inventory

Ethnobotanical data were obtained through interviews using semi-structured questionnaires (Albuquerque et al., 2014). We interviewed people who are locally recognized as plant specialists. Thus, we chose to use a non-probabilistic sampling recruitment using the snowball technique in order to select the plant specialists (Albuquerque et al., 2014). The Snowball method (Bailey, 1994) is when one participant recommends to quote another participant of similar competence, repeating the process until saturation or until reaching the desired sample size. This technique was adapted based on the following inclusion criteria: the key informants were those who were over 18 years of age and were recognized by the community as maintainers of traditional knowledge about plants. Data were collected from May to October 2015. A total of 25 key informants (13 women and 12 men) between the ages of 48 and 82 years of age participated in the study.

Socioeconomic description of the studied communities

The socioeconomic information from this study was recorded and published by Pedrosa et al. (2019). Agriculture and livestock occur throughout the year among the activities which generate economic income for local populations (Pedrosa et al., 2019). The cultivation of corn and beans supplies family consumption for agriculture, while the populations have small herds of sheep, goats and cattle for livestock (Pedrosa et al., 2019). Another important economic activity is producing and processing leather in tanneries to prepare utensils. In addition, communities are assisted by federal government programs, and people over the age of 55 are retired (Pedrosa et al., 2019). The vast majority of participants have incomplete elementary education, while younger people have high school or higher education (Pedrosa et al., 2019).

Collection of botanical material and taxonomic identification

Guided visits were performed for taxonomic identification of cited species (Albuquerque et al. 2014). The species were identified in the literature and compared with herbarium specimens, and the names were confirmed by experts, and subsequently deposited in the Herbário Manuel de Arruda Câmara, Universidade Estadual da Paraíba, Campus I, Campina Grande, Paraíba, Brazil. The species were classified into families and genera according to the Angiosperm Phylogeny Group IV system (Chase et al. 2016).

Legal and ethical aspects

To collect ecological knowledge, the present study was submitted to the *Comitê de Ética em Pesquisa com Seres Humanos* (*CEP*; committee for ethics in research with human beings) of the Universidade Estadual da Paraíba through the opinion no. 45049415.5.0000.5187, as required by Resolution no. 466/12/CNS/MS of the *Conselho Nacional de Saúde do Brasil* (National Health Council of Brazil). According to this resolution, informants who agree to participate in the study are asked to sign an Informed Consent Form (ICF), allowing publication of ethnobotanical information.

Data Analysis

Usage citations were organized into functional domains according to ethnobotanical literature, namely: food, fuel, construction, fodder, medicinal, technology, poison and veterinary (Lucena et al. 2012). The use value (UV) index was calculated with the sum of uses of each species mentioned by each informant divided by the total number of informants (VU = ∑U/total n of informants) in order to investigate the species most relevant to people (Rossato et al. 1999).

A phylogenetic tree of the whole species pool was generated using Phylomatic in the Phylocom version 4.2 program (Webb et al. 2008). This tool provides a phylogenetic hypothesis for the relationships among taxa by matching the list of species with up-to-date family and genus names, and tip labels of a provided megatree (Webb et al. 2008). In this case, the topology of R20120829.new provided at (http://phylodiversity.net/phylomatic/) was used. An ultrametric phylogeny including branch length in millions of years (Ma) was obtained using bladj in Phylocom. This command fixes the root node (angiosperms, 179 Ma) and other nodes to specified ages based on Magallon et al. (2015). We used the Phylocom phylogeny, which includes all species in our dataset, to estimate the phylogenetic signal in functional domains by using Blomberg's K (Blomberg et al. 2003), which quantifies the amount of variance in an observed trait in relation to the expected variance under a Brownian motion model of evolution. The results of $K = 0$ means that there is no phylogenetic signal; $K < 1$ indicates that there are less than expected similarities in the Brownian motion model; and $K > 1$ implies that close relatives are more similar to that expected in the evolution of Brownian motion. We assessed the significance of both metrics by recalculating K a thousand times on phylogenies with randomly permuted tips. We conducted the phylogenetic signal analyses using the phytools (Revell 2012) package in R.

RESULTS

A total of 41 species belonging to 19 botanical families were cited (Table 1). The species are used for 1408 ethnobotanical uses, classified into nine functional domains such as fuel, construction, technology, food, forage, medicinal, veterinary, poison/abortion and others. The five most culturally important species by use value were: *Myracrodruon urundeuva, Tabebuia aurea, Sideroxylon obtusifolium, Spondias tuberosa* and *Commiphora leptophloeos* (Table 1).

Table 1 Species recorded in different use categories in the rural communities of Curral do Meio and Lucas, São João do Cariri (Paraíba, northeast Brazil), followed by use value

Species	**Vernacular Name**	**Uses**	**VUgeral**
Anacardiaceae			
Spondias tuberosa L.	Umbuzeiro	Al,Ct,Cb,Fr,Ot	4
Myracrodruon urundeuva Allemão	Aroeira	Cb, Ct, Fr, Me, Ot, Tc, Vt	5,8
Schinopsis brasiliensis Engl.	Baraúna	Cb, Ct, Me, Fr, Ot, Tc	2,24
Apocynaceae			
Aspidosperma pyrifolium Mart.& Zucc.	Pereiro	Cb, Ct, Fr, Ot, Tc, Vn	3,2
Arecaceae			
Syagrus Oleracea (Mart.) Becc.	Coco Catolé	Al	0,08
Copernicia prunifera (Miller) HE. Moore.	Carnaúba	Tc, Fr, Ot	0,16
Bignoniaceae			
Tabebuia aurea (Silva Manso) Benth. & Hoock	Craibeira	Ct, Cb, Fr, Ot, Tc	4,8
Burseraceae			
Commiphora leptophloeos (Mart.) J. B. Gillet	Umburana	Cb,Ct,Ot,Me,Fr,Tc,Vt	3,36
Capparaceae			
Cynophalla flexuosa (L.) J.Presl	Feijão bravo	Cb, Ct, Fr, Me, Tc, Vt	0,6
Celastraceae			
Maytenus rigida Mart.	Bom nome	Cb, Ct, Fr, Me, Ot, Tc	1,12
Combretaceae			
Thiloa glaucocarpa (Mart.) Eichler	João Mole	Tc, Ct, Fr	0,12
Combretum leprosum Mart.	Mufumbo	Fr, Tc, CT, Ot	0,2
Euphorbiaceae			
Manihot glaziovii Muell Arg.	Maniçoba	Al, Cb,Fr, Ot, Tc, Va	0,88
Cnidoscolus quercifolius Pohl	Faveleira	Fr, Me, Ot	0,84
Croton blanchetianus Baill	Marmeleiro	Cb,Ct,Fr,Me, Ot	1,88
Croton heliotropiifolius Kunth.	Marmeleiro branco	Ot, Md,Fr	0,28

Jatropha mollissima (Pohl) Baill.	Pinhão bravo	Me, Vt, Cb, Tc	1,08
Sapium lanceolatum (Müll. Arg.) Huber	Pau Leite	Al, Ot, Fr,Va	0,12
Fabaceae			
Bauhinia cheilantha (Bong.) Steud.	Mororó	Al, Cb,Ct,Fr,Me	0,8
Poincianella pyramidalis (Tul.) L.P.Queiroz	Catingueira	Ct, Cb, Tc, Ot, Fr, Me, Vt	2,52
Libidibia ferrea L.P.Queiroz	Jucá	Cb, Ct, Fr, Me, Tc, Ot, Tc, Vt	0,88
Mimosa tenuiflora (Willd.) Poir.	Jurema preta	Cb,Ct,Fr,Me,Ot	2,36
Anadenanthera colubrina var. colubrina (Griselb.)	Angico	Cb,Ct,Fr, Me,Ot, Tc,Vt, Va	2.68
Senna martiana (Benth.) H.S.Irwin & Barneby	Canafístula	CB, Fr,Md, Ot, Tc	0,52
Amburana cearensis (Freire Allemão)	Cumarú	Tc, Cb, Md, Ot	0,24
Dahlstedtia araripensis (Benth.) M.J. Silva & A.M.G. Azevedo	Loro	Me, Cb, Fr	0,24
Erythrina velutina Willd.	Mulungu	Or,Tc, Me, Ot, Tc	1
Inga sp.	Ingazeira	Fr, Cb, Tc	0, 52
Piptadenia stipulacea (Benth.) Ducke	Jurema branca	Cb, Ct, Fr, Ot	0,64
Mimosa ophthalmocentra Mart. ex Benth.	Jurema vermelha	Cb, Ct, Fr	0,2
Albizia polycephala (Benth.) Killip ex Record	Espinheiro	Cb	0,8
Malvaceae			
Pseudobombax marginatum (A. St.Hil., Juss. & Cambess.) A. Robyns	Imbiratã	Me,Ot, Ot	0,44
Ceiba glaziovii (Kuntze) K. Schum	Barriguda	Me,Ot, Ot	0,44
Myrtaceae			
Eugenia uvalha Camb.	Ubaia	Al,Ct,Ot, Fr	0,44
Olaceae			
Ximenia americana L.	Ameixa	Al, Cb, Ct, Fr, Me, Vt	1,04
Rhamnaceae			
Ziziphus joazeiro Mart.	Juazeiro	Al,Cb, Ct,Fr,Me,Ot	2,84
Rubiaceae			
Tocoyena formosa (Cham. & Schltdl.) K. Schum.	Jenipapo	Ot	0,04
Sideroxylon obtusifolium (Roem & Schult.) T. D. Penn.	Quixabeira	Al,Ct,Fr,Cb,Me,Ot,Tc	4,32
Nocotiana glauca	Oliveira	Ct, Fr,Ot	0,2
Verbenaceae			
Vitex gardnerianum Schauer	Jaramataia	Al, Ct, Fr	0,2

The most diverse botanical family (in number of species) indicated for the functional domains was Fabaceae. This family highlighted medical use (~42.10% of total registered uses), construction (~42.10%) and technology (~21.05%), followed by Euphorbiaceae family for fuel (~10.52%) and forage (~10.52%) (Fig. 2).

An investigation into the phylogenetic structure of the species showed the presence of functional domains with plant species grouped by similar uses (Fig. 2). The mentioned uses for species indicate that there is less than expected similarity based on the Blomberg's model (K<1) for food (K=0.6105, P=0.307), medicinal (K=0.685, P=0.097), forage (K=0.540, P=0.673), fuel (K=0.797, P=0.014), construction (K=0.700, P=0.074), technology (K=0.622, P=0.242), poison/abortion (K=0.660, P=0.213), veterinary (K=0.573, P=0.499) and others (K=0.532, P=0.737). The results of the phylogenetic signal test were not significant, but indicate that there is a representativeness of phylogenetic strains in the various ethnobotanical uses (Figure 2).

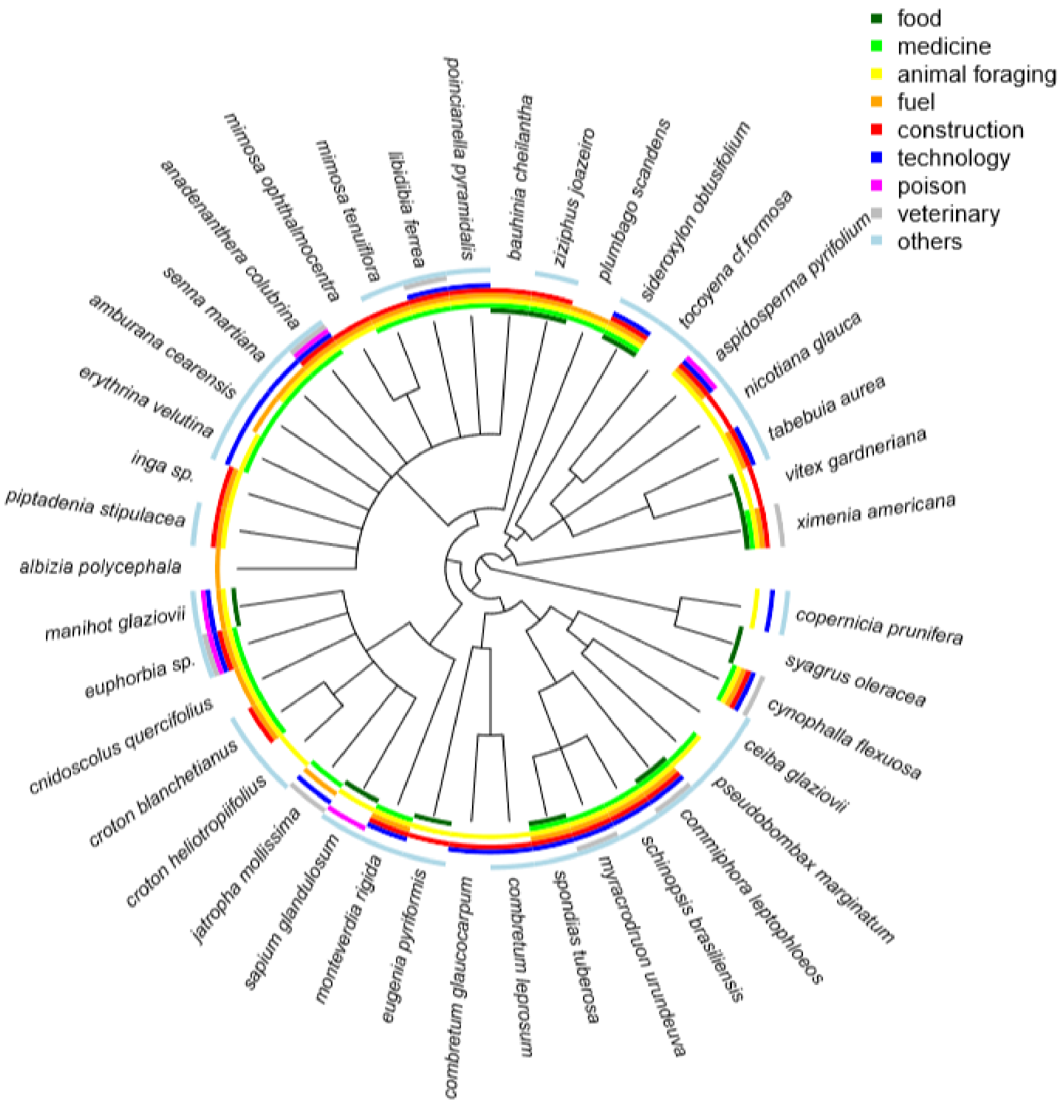


Fig. 2 Phylogenetic tree of all species cited by residents of rural communities Lucas and Riacho Fundo, São João do Cariri, Paraíba, Brazil. The color markings on the branches represent the functional domains and respective species cited by the populations.

DISCUSSION

In terms of ethnobotanical uses, the registered plant species were not randomly distributed among families. A greater utilitarian preference was observed for Fabaceae and Euphorbiaceae when compared to other families, corroborating what has been observed in other studies (Moerman 1979, 1999; Medeiros et al. 2013; Díaz-Forestier et al. 2019). Such a result may comprise an indication of taxonomic signal in ethnobotanical uses for arboreal plants of seasonally dry tropical forest.

Taxonomic preference can suggest two possible explanations. First, the taxonomic signal may reflect the distribution and abundance of species available in the environment. We observed that families like Fabaceae and Anacardiaceae have a greater number of species with high use value (UV). This result may indicate that they are plants that are easily found by people (Lucena et al. 2012; Gonçalves et al. 2016), which may explain why some species (such as *Myracrodruon urundeuva*) have a high UV, since evidence suggests that their individuals are widely distributed and close to rural communities in the study region (Pedrosa et al. 2019; Ramos et al. 2020)

Although some families that have higher taxonomic richness have higher UVs, we observed that Sapotaceae and Rhamnaceae, both with a single registered species, presented high UV. This finding demonstrates the insipience of generalizing that taxonomic richness among families is the only possibility of registering locally important plants. It is probable that species of these taxa have characteristics which make them useful, and thus they are employed for different local uses and not only due to their availability.

A second explanation for taxonomic preference may be related to phylogenetic conservatism. The phylogenetic signal demonstrated by K values based on Blomberg's model suggests that the measured attributes are phylogenetically labile (Blomberg et al. 2003). However, this lability is no different from chance (considering the P-value derived from the null model). These values in ecology indicate the tendency for related species to resemble each other more than they resemble species taken at random from phylogeny (Münkemüller et al. 2012). In ethnobiology, these data suggest that there is a representativeness of phylogenetic lineages in the varied uses of ethnobotanical data.

We observed that it is possible to analyze which plants among clades are indicated for uses. Even if below what was expected, the phylogenetic signal indicated that there are similarities between our data set. These data suggest that it is probable that people tend to use plants for the same purpose due to similarity in the morphological characteristics possessed by the species. This demonstrates that closely related plant taxa within a local flora are employed for uses in similar conditions, and that this is perhaps due to the evolutionary history of the plant species involved (Saslis-Lagoudakis et al. 2012; Rønsted et al. 2012; Cámara-Leret et al. 2017; Sousa et al. 2018. Lei et al. 2020).

Through the depositions of local populations, we believe that knowledge of certain plant characteristics influences common use. Plants which are resistant to the effects of biotic and abiotic variables, for example, are used in rural construction projects. Likewise, plants used as firewood to supply domestic stoves often have a potential for flammability (Hora et al. 2021). Other studies have found similar patterns (Cardoso et al. 2011; Nunes et al. 2015; Cámara-Leret et al. 2017). For example, Cámara-Leret et al. (2017) observed the association of functional characteristics of palm trees for different local uses. The results of this study suggest that the correlations between plant characteristics and uses are due to phylogenetic autocorrelation (Cámara-Leret et al. 2017). However, research has devoted more attention to medicinal plants with pharmacological potential, and has revealed the importance of phylogeny in identifying plants for bioprospecting that share secondary chemical compounds used in the same treatment (Rønsted et al. 2012; Ernst et al. 2016; Leso et al. 2017)

The tendency towards a pattern based on the use of similar plants is a mechanism which can help better understand human behavior regarding plant use (Brown et al. 2011; Cámara-Leret et al. 2017; Albuquerque et al. 2019). Our study contributes to this body of literature by showing that species diversity and the phylogenetic signal tend to explain the common use of plants. Although phylogenetic tools can reveal a pattern, the results presented herein do not enable defining human behavior. We believe that the behavior of people in selecting plants can differ depending on the use (Albuquerque et al. 2019). In addition, we reaffirm the importance of understanding the usefulness of related plants for local populations (Lei et al. 2020). Recently, studies have shown that forests will be increasingly influenced by changes at local and global scales (Coelho et al. 2020). Such influences can represent a great challenge since small losses in the functional diversity of plants close to rural communities can compromise utilitarian diversity (Cámara-Leret et al. 2017).

CONCLUSIONS

The plants mentioned among the ethnobotanical uses tends to be non-random. This suggests that local populations specifically choose plants based on a common characteristic. Although our results do not show a strong phylogenetic signal, there is a representativeness or approximation of phylogenetic lineages with the plant use data. The values for phylogenetic signal obtained herein are probably related to the our sample size. Perhaps ethnobotanical research using a larger regional set of angiosperm species would reveal stronger evidence. In addition, we believe that it is necessary for future investigations to use environmental and socio-cultural variables to interpret functional characters as a criterion for the use of plants in order to understand the mechanisms which govern plant selection.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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5. CAPÍTULO IV: Plant parentage influences the type of timber use by traditional peoples of the Brazilian Caatinga

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Plant parentage influences the type of timber use by traditional peoples of the Brazilian Caatinga

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Abstract

Local populations select different plants to meet their demands, so that morphologically similar species can be more used for a given use. Herein, we seek to understand whether plant species that are phylogenetically closer together are used in a more similar way than distant species in the phylogeny. Thus, we expect a strong phylogenetic signal in the characteristics of the species used for timber uses by local populations. Ethnobotanical data were collected in five rural communities in a semi-arid region of Brazil. A total of 120 local experts were selected and interviewed using semi-structured questionnaires. The people's knowledge of plants was organized into usage subcategories. We estimated the redundancy values for the mentioned species, and we compiled data from the literature on the wood density values of the cited species through a literature search. We constructed our phylogenetic hypothesis of useful plants and used comparative phylogenetic methods to estimate the phylogenetic signal. Our results showed a strong phylogenetic grouping for both tool handle and craft uses. We observed a moderate phylogenetic grouping in which related cited plants exhibit similar redundancy and a weak grouping in which cited plants present similar wood density values. Although plant parentage has been associated with some ethnobotanical uses, it is important to mention that culture also influences plant selection by human groups in terms of knowledge associated with botanical use.

Keywords: Knowledge; use; wood density; redundancy; phylogeny.

Background

Plants and human beings are involved in a dynamic process, as human beings developed ways to use them based on their knowledge, practices and beliefs (1). However, these practices are one of the most tangible proofs of the reality of ecosystem services (2), and the provision of wood from plants by local populations of the Brazilian Caatinga is one of the main resources used for producing rural artifacts, biofuel and construction (3,4). Thus, investigating the local knowledge of the people about the plants used by them is interesting and relevant, considering that the rural population that lives in the Caatinga use wood as a raw material to meet their daily demands.

Despite all the diversity of plants that occur in the Caatinga (a Seasonally Dry Tropical Forest) (5), human groups use a specific subset of species to meet their local demands (4). Overall, to the best of our knowledge, less than 70 species of timber plants have been described in the literature as useful by local human populations in the Caatinga (6,7). The selection of these useful species is generally influenced by their availability in the environment (8) or by the wood quality of the species (9,10). In the first case, local populations observe and select species according to their abundance and frequency in the natural environment, while in the second case, people follow criteria to select resources. For example, people look for attributes of plant species that give greater performance during their use (11,12,13).

Plant species tend to embody similar functional attributes due to evolutionary heritage (14). For this reason, ethnobotanical studies use phylogenetic hypotheses to answer whether useful plant species share similar uses (15–17), suggesting that species which are more closely related to each other would have similar morphological traits (18). This does not imply that phylogeny per se influences traditional use of plants, but that traits of useful species may be more similar than expected by chance, as related plants are similar in both morphophysiological traits and utility (19). Thus, it is to be expected that the use of plants by humans is influenced by the characteristics of related species, such as the size of the plant (20), but it is still not very well understood what the characteristics of Caatinga plants which support timber uses are, and whether these similarities are related to phylogeny.

Associating characteristics of certain species can serve as a strategy for plant selection by human groups. Among these strategies, utilitarian redundancy is an important phenomenon among groups in the Caatinga (21). Utilitarian redundancy predicts low pressure on the usage of species based on the idea that the greater the number of species indicated for the same use, the lower the usage pressure on them, except when there are preferred species (21,22) and phylogenetically related species (17). A recent study of evolutionarily-related medicinal plants found that the effect of preference on usage pressure depends on species redundancy (17). This result may concomitantly change the scenario regarding the understanding of species' usage pressure, as related plants may be more used by human groups (17). However, despite previous studies addressing this issue, it is still necessary to understand the similarity in the functions of certain redundant species that are selected for timber uses.

In this context, our objective is to understand whether related species are known for the same purpose by local populations in a region of the Caatinga. We start from the hypothesis that phylogenetically closer plant species share morphological characteristics and are used in a more similar way than distant species in the phylogeny. Assuming that the availability of plant species in the natural environment influences the collection of plants for firewood and construction (8), we expect a positive phylogenetic signal in the traits shared between the species used, except for firewood and fencing. Furthermore, given that plant species are evolutionarily related (23), we seek to answer: (i) whether there is a phylogenetic signal for the wood density of the cited species; (ii) and if the phylogenetically related species cited show similarity in redundancy.

Methods

Study area description

The present study was conducted in a portion of the Brazilian semi-arid region (Cariri region), in the state of Paraíba, Brazil. The study involved local human populations located in five rural communities distributed at different points (Fig.1).

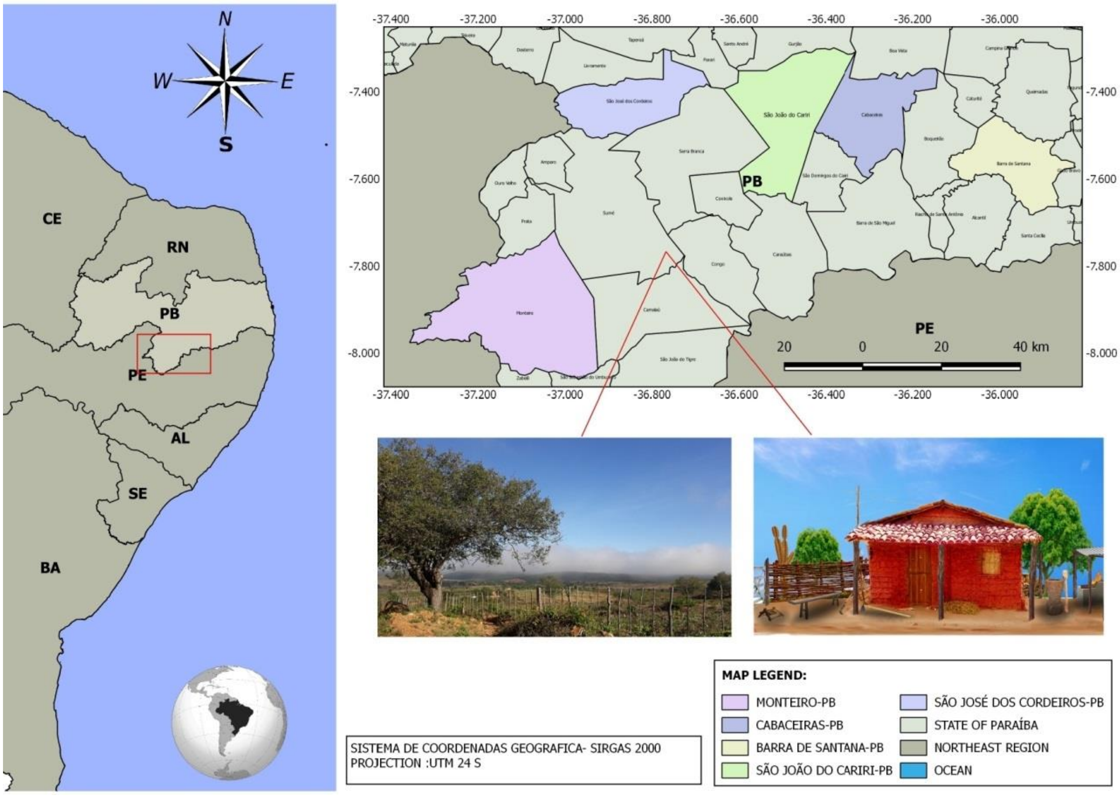


Fig.1 Location of the studied communities, Paraíba state, in northeast Brazil.

The people who live in rural areas of the Caatinga are small farmers, also known as *catingueiros* (24). The *catingueiros* are of mixed origin, descendants of older groups of indigenous peoples, *quilombolas* (a quilombola is an Afro-Brazilian resident of quilombo settlements first established by escaped slaves in Brazil) and European settlers, the result of the European colonization process that expanded throughout the 16th century (25). The *catingueiros* located in the Cariri region of the state of Paraíba, Brazil, are culturally similar. Given the climatic conditions with only two seasons (rainy and dry) it allows most local populations to raise small herds of cattle and goats and carry out agricultural practices such as planting grains, beans, corn, and vegetables in the rainy season.

The Caatinga climate is Bswh (hot to hot-semi-arid, according to the Koppen classification), and stands out for having one of the lowest rainfall regimes in Brazil, ranging from 350 to 600 mm per year (26). The average annual temperature varies between 25°C and 41°C. The Caatinga is considered a Seasonally Dry Tropical Forest (SDTF) and its vegetation is influenced by environmental filters which modulate the assembly of plant communities (27). The Caatinga is represented by an endemic flora, endowed with a set of morphophysiological adaptations to climatic conditions, and a strong phylogenetic niche conservatism (28), resulting in highly heterogeneous vegetation types.

Selection of informants and collection of local ecological knowledge

We selected research participants using the snowball technique (29). The Snowball method is when a participant recommends citing another participant of similar competence, repeating the process until saturation or until the desired sample size is reached. Thus, men and women who practice subsistence activities in agriculture and raising domestic animals were selected. Participants under 18 years of age were not included. Data collection took place between August 2018 and February 2020 (data collection took place twice a week on average). We conducted interviews with 120 local experts (men and women) residing in the five selected rural communities. The local experts represent a sample of the local human population that is located in the rural communities of the present study. Thus, the results and conclusions of the study will be from the perspective of the local knowledge of this sample.

We used semi-structured forms to collect information about local knowledge containing the following questions: Which plants do you use? How do you use plants? What plants are used for rural construction and home construction? What plants are used as firewood? What plants are used for coal? Which plants are used as technologies (production of artifacts through specific treatments). Usage citations were organized into categories and subcategories according to the ethnobotanical literature (30), namely: fuel (firewood), construction (wire fencing, hedge fencing, roof and door) and technology (tool handles, household items and crafts).

Ethical and legal aspects

This study was carried out in accordance with the guidelines required by the National Health Council of Brazil through the Research Ethics Committee (resolution no. 466/12/CNS/MS; project approval protocol: 30657119.3.0000.5187). In addition, we obtained the consent of the participants through their signing of an Informed Consent Form (ICF). We requested authorization from the Chico Mendes Institute for Biodiversity Conservation (ICMBio/SISBIO), an agency linked to the Ministry of the

Environment (MMA) (registration: 73540-1) to collect the botanical material. The species were identified through specialists according to the (31). All species were incorporated into the Manuel de Arruda Câmara Herbarium, State University of Paraíba, Campus I, Campina Grande, Paraíba, Brazil.

Estimating the redundancy value of the cited species

The species redundancy proposed by (17) was calculated for each species cited by local experts during the interviews. The index consists of $R = \sum si/n$, in which: ΣSi is the sum of the total number of plant species that can be used for a given use; n is the total number of species cited by the participants; and W is the total number of uses of a given species. However, the "W" component of the index tends to increase the weight of the versatility of the cited species, which consists of the number of usage categories indicated for a plant (32). Therefore, we chose not to use this component in our analysis and adapted it by removing it.

Wood density of the cited species

We collected a morphological measure of wood density (WD) which is related to wood quality for all plant species cited by the local experts in our study. The data referring to the wood density of the species were collected from a literature search. We consulted "Scielo" and "Google Scholar" using the keywords "Scientific name of the species + "wood density" to collect the information (Supporting information 1). In addition, we extracted data on some species from the Global Wood Density Bank (33). We assigned the value corresponding to the genus for the species that we did not find the values for wood density. Only the species and genera found in the Caatinga biome were recorded. Moreover, we did not collect data that mentioned common names without the scientific name of the species. We focused on tree plants because they are the most useful in terms of timber use for populations in the Caatinga.

Phylogenetic tree

We constructed a phylogeny of timber plants using the V. PhyloMaker package in R (34). This tool provides a phylogenetic hypothesis for vascular plant relationships

(34). The megatree includes all plant families, approximately 10,587 genera, 70,533 species and 479 families of vascular plants existing in the world (34). The phylogenetic hypothesis we used was constructed using molecular data from GenBank, phylogenetic data from the tree of life, and the fossil record (34). V. PhyloMaker provides three types of phylogenetic trees; we used S3, which uses the same approach implemented in Phylomatic and BLADJ.

Next, we standardized the nomenclature of plant names according to The Plant List (www.theplantlist.org) and flora Brasil (http://reflora.jbrj.gov.br/reflora/listaBrasil/) through the plantiminier repository (package gustavobio/flora) in order to build our phylogenetic hypothesis. We chose to use both platforms to obtain greater data fidelity. We built a phylogenetic tree considering the species that were cited by the local participants, excluding Cactaceae, Arecaceae and unidentified species (genus or family), and we considered 39 genera and 17 botanical families for the study.

Data analysis

Prior to the analyses, we coded plant uses as binary traits: 1, when a species is used for a timber use from the seven categories, and 0 when no timber use was assigned to the species (Table S1, Supporting Information).

We used Pagel’s lambda (henceforth λ) (35) to test our first hypothesis that the characteristics of species used by local populations are suitable for similar uses, in which we assume that the evolution of traits follows the Brownian motion model (23), where: values of λ close to 0 are found for data without phylogenetic dependence, while values close to 1 indicate strong phylogenetic clustering.

We also used Pegel’s lambda for our questions that phylogenetically close species tend to have species redundancy and similar wood density. Furthermore, considering that each wood use has different quality requirements (36), we used Pegel’s lambda to verify whether phylogenetically close species tend to have similar wood density for each use subcategory. We also evaluated the correlations between species redundancy and wood density of the cited species through a phylogenetic autocorrelation using a generalized phylogenetic least squares (PGLS) analysis (37). All analyzes were conducted in R (38) using the phylolm (39), phytools (40), geiger (41) and caper packages (42).

Results

We recorded 44 plants belonging to 17 families and 39 genera (Table 1) from a total of 120 people interviewed. Most families had only one or two species registered for some use, with the exception of Euphorbiaceae and Fabaceae, with six and 20 species, respectively. Wood was the main plant part indicated for uses, except for the hedge fencing category, in which the entire tree is used. The highest number of species was indicated for wire fencing (32 spp.), followed by firewood (28 spp.) and tool handles (21 spp.).

The uses with the lowest number of species mentioned were roofs (11 spp.), doors (10 spp.), hedges (eight spp.) and household items (five spp.). Among the species, *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. ex S.Moore had the highest value for wood density, while *Cenostigma pyramidale* (Tul.) Gagnon & G.P. Lewis L. had the lowest value (Table 1). *Astronium urundeuva* (M.Allemão) Engl. has a higher redundancy value, while *Ceiba glaziovii* (Kuntze) K. Schum. has less redundancy (Table 1).

Table 1. Species cited for different usage categories by local populations in the state of Paraíba, Northeastern Brazil. Followed by the vernacular name, Voucher represented by ACAM (Herbarium Manuel de Arruda Câmara), NC (not collected) and the values referring to the attribute (wood density) and index (species redundancy).

Familia	**Espécies**	**Nome Vernacular**	**Voucher**	**Atributo**	**Índice**
Anacardiaceae	*Astronium urundeuva* Allemão	Aroeira	ACAM 1991	0.55	2.89
	Schinopsis brasiliensis Engl	Baraúna	ACAM 2009	0.47	2.67
	Spondias tuberosa Arruda	Umbuzeiro	ACAM 1579	0.49	0.60
Annonaceae	*Annona leptopetala* (R.E.Fr.) H. Rainer	Pinha-Brava	NC	0.75	0.44
Apocynaceae	*Aspidosperma pyrifolium* Mart. & Zucc.	Pereiro	ACAM 1995	0.61	2.51
Bignoniaceae	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos	Pau-d'arco-Rocho	NC	0.83	1.09
	Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	Craibeira	NC	1.03	2.04
Boraginaceae	*Cordia trichotoma* (Vell.) Arráb. ex Steud.	Frei-Jorge	NC	0.74	1.49
Burseraceae	*Commiphora leptophloeos* (Mart.) J.B. Gillett	Umburana	NC	0.43	1.71
Capparaceae	*Cynophalla flexuosa* (L.) J. Presl	Feijão-Bravo	ACAM 2014	0.34	0.69
Combretaceae	*Combretum leprosum* Mart.	Mufumbo	ACAM 1990	0.97	1.89
Euphorbiaceae	*Cnidoscolus quercifolius* Pohl	Favela	ACAM 1996	0.44	0.20
	Croton blanchetianus Baill.	Marmeleiro	NC	0.67	2.29
	Croton heliotropiifolius Kunth	Marmeleiro-branco	ACAM 1983	0.26	1.64

	Euphorbia tirucalli L.	Aveloz	NC	0.54	0.87
	Hymenaea courbaril L.	Jatobá	NC	0.95	0.42
	Jatropha mollissima (Pohl) Baill.	Pinhão-Bravo	ACAM 1984	0.36	1.24
	Manihot glaziovii Müll. Arg.	Maniçoba	NC	0.35	0.38
	Sapium glandulosum (L.) Morong	Burra-Leiteira	ACAM 2010	0.34	0.18
Fabaceae	*Amburana cearensis* (Allemão) A.C.Sm.	Cumarú	ACAM 1981	0.6	0.11
	Anadenanthera colubrina (Vell.) Brenan	Angico	ACAM 1982	0.88	1.87
	Bauhinia cheilantha (Bong.) Steud	Mororó	ACAM 1986	0.91	2.27
	Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz var. *ferrea*	Jucá	ACAM 1996	0.97	2.22
	Cenostigma pyramidale (Tul.) Gagnon & G.P. Lewis	Catingueira	ACAM 1988	0.11	2.09
	Chloroleucon foliolosum (Benth.) G.P.Lewis	Jurema-de-coronha	ACAM 2011	0.83	1.71
	Dahlstedtia araripensis (Benth.) M.J. Silva & A.M.G. Azevedo	Sucupira	ACAM 2007	0.62	0.73
	Enterolobium contortisiliquum (Vell.) Morong	Tambor	ACAM 2006	0.52	0.80
	*Erythrina velutina*Willd.	Mulungu	ACAM 2000	0.2	1.29
	luetzelburgia auriculata Allemão) Ducke	Pau-de-Serrote	ACAM 1997	0.36	0.62
	Mimosa arenosa (Willd.) Poir.	Unha-de-gato	NC	0.83	1.27
	Mimosa caesalpiniifolia Benth	Sabiá	NC	0.78	0.67
	Mimosa lewisii Barneby	Jurema-amorosa	NC	0.80	0.67
	Mimosa ophthalmocentra Mart. ex Benth.	Jurema-de-embira	ACAM 1992	0.48	1.67

	Mimosa tenuiflora (Willd.) Poir.	Jurema-Preta	ACAM 1989	0.60	2.07
	Piptadenia retusa (Jacq.) P.G.Ribeiro, Seigler & Ebinger	Jurema-branca	ACAM 1978	0.61	1.67
	Senna spectabilis (DC.) H.S.Irwin & Barneby	Canafístula	ACAM 2005	0.87	1.69
Malvaceae	*Ceiba glaziovii* (Kuntze) K.Schum.	Barriguda	ACAM 1993	0.59	0.11
Nyctaginaceae	*Guapira hirsuta* (Choisy) Lundell	João-Mole	NC	0.48	0.67
	Guapira laxa (Netto) Furlan	Pau-Piranha	NC	0.48	0.60
Olacaceae	*Ximenia americana* L.	Ameixa	NC	0.83	1.38
Rhamnaceae	*Sarcomphalus joazeiro* (Mart.) Hauenshild	Juazeiro	ACAM 1933	0.71	1.27
Rubiaceae	*Coutarea hexandra* (Jacq.) K. Schum	Quina-Quina	NC	0.6	1.02
Rutaceae	*Zanthoxylum rhoifolium* Lam.	Limãzinho	NC	0.25	0.67
Sapotaceae	*Sideroxylon obtusifolium* (Roem. & Schult.) TDPenn.	Quixabeira	ACAM 1994	0.72	2.29

Phylogenetic clustering was strong for the species used for tool handles (λ=0.75) and crafts (λ =1.01) (Figure 2). All other usage categories showed weak phylogenetic clustering for firewood (λ = 0.11), household items, roof, hedge fencing, wire fencing and door (λ = 6.67x10^{-5}), respectively.

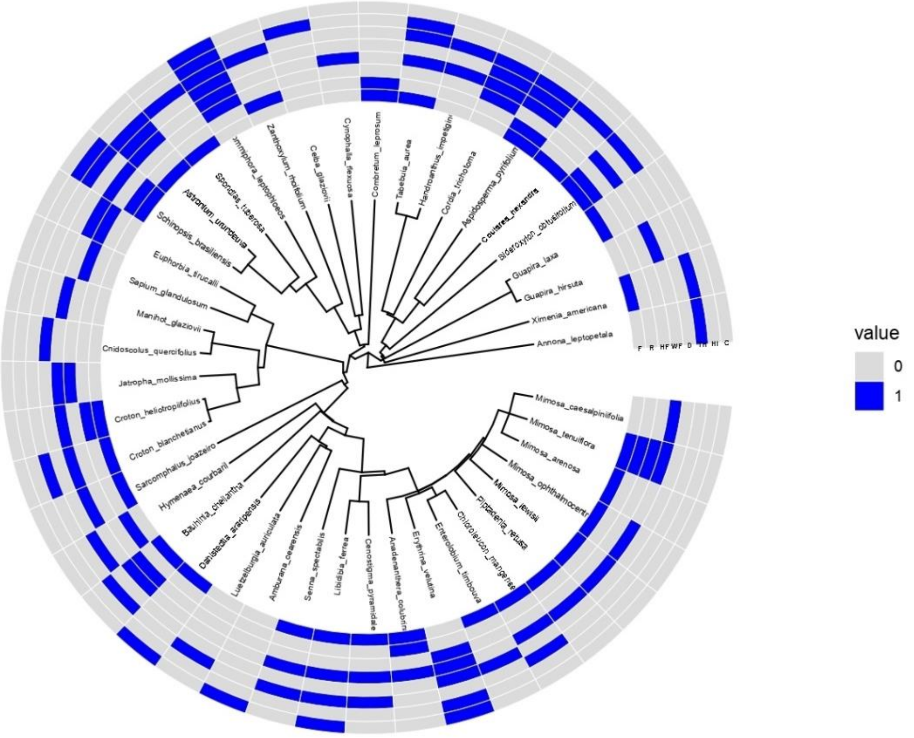
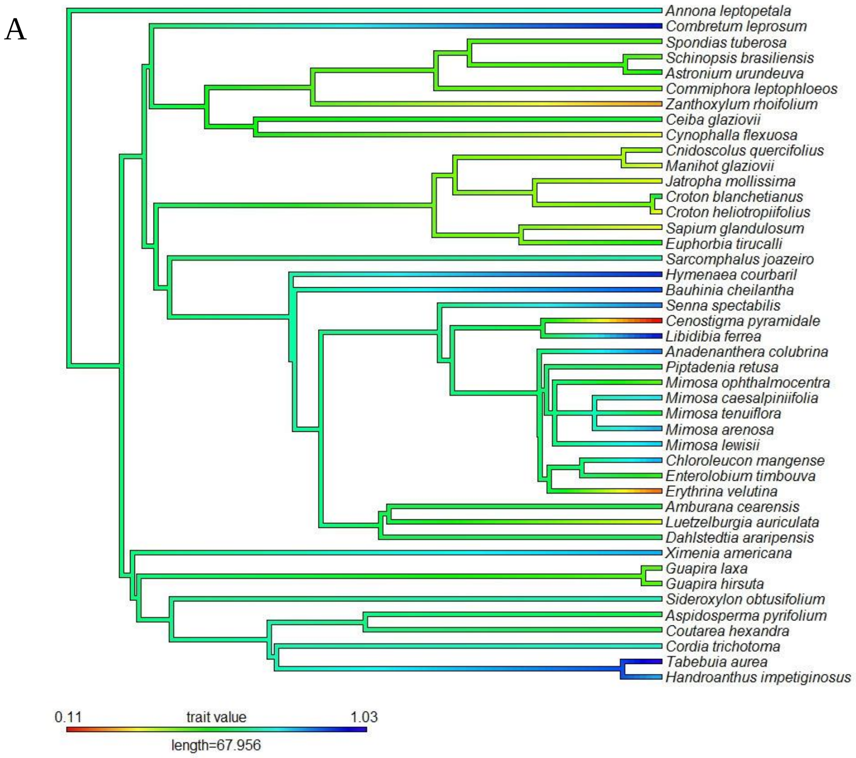


Figure 2. Hypothetical phylogenetic tree of timber species cited by research participants. This phylogenetic hypothesis was developed through the v. phylo.maker (Qian & Jin, 2019), and constructed from a comprehensive phylogeny with vascular plants from around the world (Qian & Jin, 2019). The resulting ultrametric phylogenetic hypothesis has 44 tip labels and 43 internal nodes. The tree shows the evolutionary relationship of the mentioned plants for timber purposes. The uses are arranged in the blue color of the figure and correspond to the initials of each use, where: F (firewood), R (roof), HF (hedge fencing), WF (wire fencing), D (door), TH (tool handle), HI (household items) and C (crafts).

We found a moderate degree of phylogenetic clustering for species redundancy (λ=0.78, p = 0.25), but not significant, indicating that the redundant species were phylogenetically closer than expected. The phylogenetic clade containing *Schinopsis brasiliensis* and *Astronium urundeuva* presents the highest values for species redundancy (Figure 3A). An intermediate species redundancy was found in the clade containing the species of the *Mimosa* genus. On the other hand, *Amburana cearensis* and *Ceiba glaziovii*, which are exclusive species for each clade, have low redundancy (Figure 3A). The phylogenetic signal for the wood density of the cited species was weak (λ=0.24, p = 0.23), indicating that the cited species with the wood density values are not phylogenetically close (Figure 3B). However, the clade containing *Tabebuia aurea* and *Handroanthus impetiginosus* are species that presented higher wood density.

The phylogenetic signal was weak when relating the wood density for each subcategory: firewood (λ = 0.24, p = 0.26), roof (λ = 0.50 p = 0.73), hedge fencing (λ = 4.4382e-05 p = 1), wire fencing (λ = 0.07, p = 0.77), door: (λ = 4.26083e-05, p = 1), household items (λ = 1.69, p = 0.07), crafts (λ = 6.84751e-05, p = 1) and tool handle (λ = 0.01, p = 0.95). Furthermore, we found no correlation between species redundancy and wood density (β_{PGLS} = 0.45 ± 0.47, t_{PGLS} = 0.94, p_{PGLS} = 0.34).

-05



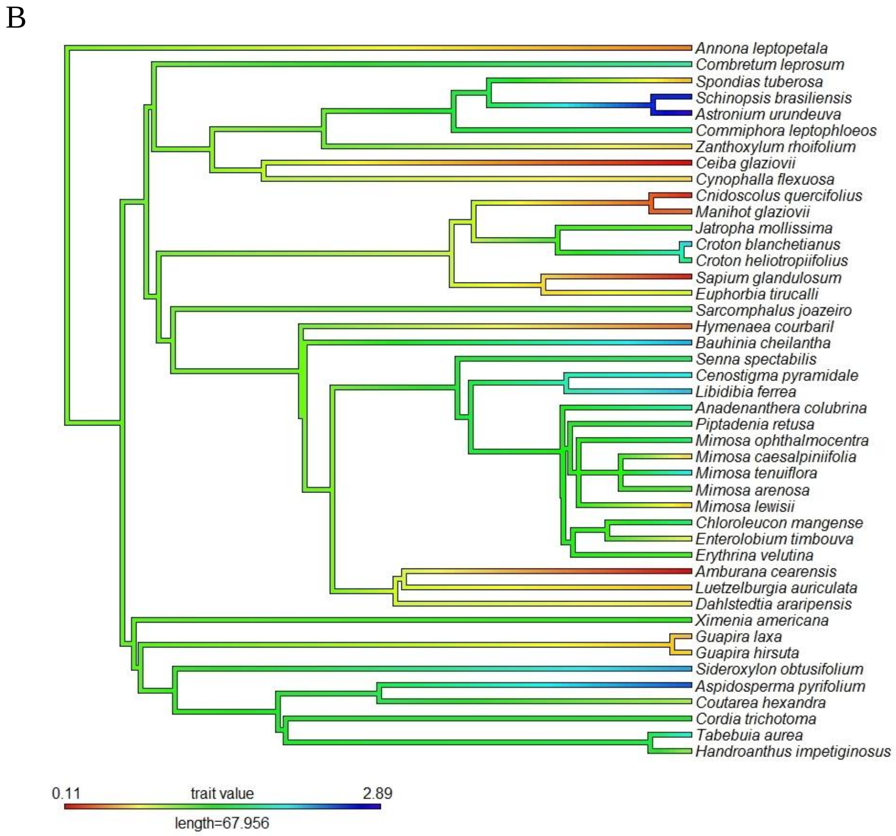


Figure 3. Hypothetical phylogenetic representation of the species cited by local experts in a semi-arid region of the state of Paraíba, northeastern Brazil. (A) Distribution of species redundancy values along the phylogeny. (B) Distribution of wood density values along the phylogenetic tree of 44 plants cited.

Discussion

The use of similar plants is a common activity among human populations (16). Although the causes that explain this phenomenon have been well evaluated in the literature (15,43,44), we are still moving towards understanding the influence of the evolutionary history of plants used by the traditional peoples of the Caatinga. Through our case study, we identified that the plant species cited for tool handles and handicrafts are phylogenetically close. Our results suggest that the characteristics of the species cited for these uses were similar. This becomes interesting because people over time may have realized that the characteristics of some species meet these demands. For example, it is expected that people look for resistant and strong plants for the use of tool handles considering that these artifacts are used for digging the soil, drilling walls and domestic cleaning. As in our study, (44) observed that useful woody plants, phylogenetically close, located on the Amalfi Coast in Italy, were preferred for domestic practices due to tool production.

Our results confirmed our prediction. The traits shared between the species mentioned for firewood and fences did not show a phylogenetic signal. Apparently this suggests that people tend to know less phylogenetically related species for these uses. Everything in the dry forest is useful in a situation of scarcity of species suitable for firewood. The literature shows that these uses demand larger amounts of plant biomass than categories that require less biomass, such as plants used in the production of technological artifacts (8,45). This may explain the reasons why there was no phylogenetic clustering.

Alternatively, it is plausible to mention that given the abiotic filters imposed by seasonality and frequent droughts in dry forests (46), the flora presents a strong niche conservatism and life history convergence (47). This convergence reflects the development of similar characters by distantly related species as an adaptive response to similar environmental pressures (48). As a result of these similarities, perhaps even if people know less related plants in the present study, the similarities can be useful for the same activity.

The previous results are interesting from the point of view of plant selection, as they can bring some notes on people’s behavior towards use. For example, the social-ecological theory of maximization predicts in the maximum environmental performance model that people tend to incorporate useful plants that offer the maximum return among the parameters that influence the use of resources (49). Herein, we did not verify variables that may be influencing the collection of useful plant species, but we verified possible approximations that may be favoring the use of some species over others when controlling the evolutionary parentage of the mentioned plants. Thus, the strong phylogenetic signal in the characteristics of the species indicated for the uses of the present study may suggest that the local human populations have some specificity in handling the species. This specificity usually guides people towards expert behavior due to the non-random nature of selecting such resources (49). On the other hand, the use of less related plants may suggest that people do not have specificity in choosing plants used as fences, firewood, roofs, doors and household items.

We also verified the importance of analyzing usage subcategories rather than general categories. Considering that each use of wood has different specificities (36), it is not interesting to verify the morphological traits and phylogenetic sign of plants cited for categories. We may lose information when considering the characteristics of the species cited in a general category. For example, people can mention a specific set of plants for the general category, but another set of species can be indicated for this when considering a subcategory. For example, (20) have already observed that people tend to use fewer traits of palm species in the subcategories when compared to the general usage category.

Our findings also show that given the moderate phylogenetic signal in species redundancy, it is likely that the selection of redundant plants could be partly encouraged by evolutionary history. The cited species probably exhibit similar functional traits which in turn make them redundant. Furthermore, the relatedness of cited plants in the literature explains that therapeutically less redundant species do not always face greater usage pressure (17), but lower redundancy in our case study does not explain this. On the contrary, the few cited species included in the clades tend to indicate a greater pressure of use on them. For example, we observed that *Amburana cearensis* has less redundancy, and this suggests that few species fulfill a certain function together with it.

Unlike studies that addressed utilitarian redundancy (21), herein we proposed to study the similarities in the functions of certain species cited by human groups (50). Studying the redundancy of useful species is an important step towards understanding the selection and differential use of plants. For example, two species are functionally redundant in ecology if they have similar information in terms of values of a given attribute (51); in contrast, species are functionally similar in ethnobotany when they are cited in a given use.

The weak signal of the wood density of the species mentioned in our study draws attention. In an attempt to analyze whether the phylogenetic signal of wood density could be present among the use subcategories, we also found that it was not. This suggests that it was not possible to verify specificity between the wood density of the mentioned species and the usage subcategory in our study. This result reinforces that the plant selection criterion cannot only be limited to phylogeny, as we know that different variables can influence local use. For example, (11) observed positive relationships between wood density and people's perceived quality of species for biofuel use in the Caatinga. Thus, not including the perception of all research participants on the characteristics of the known species for each usage subcategory may have been a limitation in our study.

The lack of relationship between the wood density of the cited species and the subcategories may be further evidence of generality in the flora of the Caatinga, where most woody plants have high wood density (33), and this may have created noise in our analyses. The mentioned species which presented low wood density in our study, namely *Cenostigma pyramidale, Sapium glandulosum, Euphorbia tirucalli* and *Jatropha mollissima*, are those precisely cited by people for producing hedge fencing. Species with low wood density in the Caatinga are those with the greatest capacity to store water in their stems (33). The characteristic of these species induces the ability to sprout and resistance to biodegradation (6). This may explain the reason for the use of these species as hedge fencing through planting trees to demarcate small rural properties (Figueirôa et al., 2005). On the other hand, species with higher wood density tend to be long-lived and have greater heights in dry forest regions (33). *Tabebuia aurea*, *Libidibia ferrea* and *Bauhinia cheilantha* are the species with the highest wood density cited in our study.

Conclusions

This study highlighted the importance of controlling the evolutionary history of useful plants by local populations inserted in a Caatinga region. We revealed that 44 useful species were indicated for eight subcategories. Tool handles and handicrafts presented cited plants which are phylogenetically close among the usage categories, while the plants cited for firewood and fences do not present a phylogenetic signal. We found that *Tabebuia aurea* was the species cited with the highest wood density value, while *Astronium urundeuva* has the highest redundancy value. We found a moderate degree of phylogenetic clustering for species redundancy and weak for wood density. These results may be useful to understand the selection of similar plants which have their wood demanded by human groups.

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Supporting information**:** List with the name of the species and wood usage considered in the study, and the works consulted to collect data on wood density.

Plant species	**Reference**
Amburana cearensis	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Anadenanthera colubrina	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Annona leptopetala	Pinho, B., Zorger, B., Rosado, B,, & Tabarelli, M. (2019). Functional organization of woody plant assemblages along precipitation and human disturbance gradients in a seasonally dry tropical forest. Dryad. Dataset, https://doi.org/10.5061/dryad.jwstqjq4r
Aspidosperma pyrifolium	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Astronium urundeuva	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado.

	Universidade Estadual da Paraíba.
Bauhinia cheilantha	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Ceiba glaziovii	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Cenostigma pyramidale	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Chloroleucon mangense	Pinho, B., Zorger, B., Rosado, B,, & Tabarelli, M. (2019). Functional organization of woody plant assemblages along precipitation and human disturbance gradients in a seasonally dry tropical forest. Dryad. Dataset, https://doi.org/10.5061/dryad.jwstqjq4r
Cnidoscolus quercifolius	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Combretum leprosum	Rocha, E.L.B. (2018). Indicação de madeiras da caatinga para uso na produção de brinquedo. Natural Resources, 8(1), 9-16. http://doi.org/10.6008/CBPC2237-9290.2018.001.0002
Commiphora leptophloeos	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Cordia trichotoma	Ribeiro, E.M.S., Lohbeck, M., Santos B.A., Arroyo-Rodríguez,

	V., Tabarelli, M., Leal, I.A. (2019). ata from: Functional diversity and composition of Caatinga woody flora are negatively impacted by chronic anthropogenic disturbance, Dryad, Dataset, https://doi.org/10.5061/dryad.0d1s343
Coutarea hexandra	attge, J., Díaz, S., Lavorel, S., Prentice, I.C., Leadley, P., Bönisch, G., Garnier, E., Westoby, M., Reich, P.B., Wright, I.J., Cornelissen, J.H.C., Violle, C., Harrison, S.P., Van Bodegom, P.M., Reichstein, M., Enquist, B.J., Soudzilovskaia, N.A., Ackerly, D.D., Anand, M.,... & Wirth, C. (2011). TRY - Um banco de dados global de características de plantas. *Global Change Biology*, *17* (9), 2905-2935. https://doi.org/10.1111/j.1365-2486.2011.02451.x
Croton blanchetianus	Lima and Silva, A.M., Lopes, S.F., Vitorio, L.A.P., Santiago, R.R., Mattos, E.A., & Trovão, D.M.B.M. 2014. Plant functional groups of species in semiarid ecosystems in Brazil: wood basic density and SLA as an ecological indicator. Brazilian Journal of Botany, 37, 229-237. https://10.1007/s40415-014-0063-4.
Croton heliotropiifolius	Lima and Silva, A.M., Lopes, S.F., Vitorio, L.A.P., Santiago, R.R., Mattos, E.A., & Trovão, D.M.B.M. 2014. Plant functional groups of species in semiarid ecosystems in Brazil: wood basic density and SLA as an ecological indicator. Brazilian Journal of Botany, 37, 229-237. https://10.1007/s40415-014-0063-4.
Cynophalla flexuosa	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.

Dahlstedtia araripensis	Trindade, D.P.F. (2017). Montagem de comunidades durante a sucessão secundária na caatinga: efeito da limitação de dispersão e recrutamento de plantas. Dissertação de mestrado. Universidade Federal de Pernambuco. Centro de Biociências. Programa de pós-graduação em Biologia Vegetal.
Enterolobium timbouva	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Erythrina velutina	Butz, P., Raffelsbauer, V., Graefe, S., Peters, T., Cueva, E., Holscher, D., & Brauning, A. (2017). Tree responses to moisture fluctuations in a neotropical dry forest as potential climate change indicators, Ecological Indicators, 83. https://doi.org/10.1016/j.ecolind.2016.11.021.
*Euphorbia tirucalli**	Nascimento, I.S. (2016). A coordenação funcional entre os diferentes órgãos das plantas arbóreas da floresta atlântica varia conforme e estratégia de uso e conservação dos recursos? Dissertação. Mestrado em Ciências Florestais
*Guapira hirsuta**	Nascimento, I.S. (2016). A coordenação funcional entre os diferentes órgãos das plantas arbóreas da floresta atlântica varia conforme e estratégia de uso e conservação dos recursos? Dissertação. Mestrado em Ciências Florestais
*Guapira laxa**	Nascimento, I.S. (2016). A coordenação funcional entre os diferentes órgãos das plantas arbóreas da floresta atlântica varia conforme e estratégia de uso e conservação dos recursos? Dissertação. Mestrado em Ciências Florestais

Handroanthus impetiginosus	Pinho, B., Zorger, B., Rosado, B,, & Tabarelli, M. (2019). Functional organization of woody plant assemblages along precipitation and human disturbance gradients in a seasonally dry tropical forest. Dryad. Dataset, https://doi.org/10.5061/dryad.jwstqjq4r
Hymenaea courbaril	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.
Jatropha molíssima	Lima, A.L.A. (2010). Tipos funcionais fenológicos de espécies lenhosas da Caatinga, nordeste do Brasil. Tese. Programa de Pós Graduação em Botânica. Universidade Federal Rural de Pernambuco.
Libidibia ferrea	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Luetzelburgia auriculata	Machado-Neto, A.P., Brandão, C.F.L.S., Duarte, B., Almir, J., Marangon, L.C., & Feliciano, A.L.P. (2015). Densidade e Poder Calorífico como Base para Prevenção de Incêndios Florestais sob Linhas de Transmissão. NATIVA, 3:10-15.
*Manihot glaziovii**	Lima, A.L.A. (2010). Tipos funcionais fenológicos de espécies lenhosas da Caatinga, nordeste do Brasil. Tese. Programa de Pós Graduação em Botânica. Universidade Federal Rural de Pernambuco.
Mimosa arenosa	Paes, J.B., Lima, C.R., Oliveira, E., & Medeiros-Neto, P.N. (2013). Características Físico-Química, Energética e

	Dimensões das Fibras de Três Espécies Florestais do Semiárido Brasileiro. Floresta e Ambiente, 20(4): 550-555.
Mimosa caesalpiniifolia	Gonçalves, C.A., Lelis, R.C.C., & Abreu, H.S. (2010). Caracterização físico-química da madeira de sabiá (*Mimosa caesalpiniaefolia* Benth.). Revista Caatinga, Mossoró, 23(1), 54-62.
Mimosa lewisii	Pinho, B., Zorger, B., Rosado, B,, & Tabarelli, M. (2019). Functional organization of woody plant assemblages along precipitation and human disturbance gradients in a seasonally dry tropical forest. Dryad. Dataset, https://doi.org/10.5061/dryad.jwstqjq4r
Mimosa ophthalmocentra	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Mimosa tenuiflora	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Piptadenia retusa	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Sapium glandulosum	Lima, A.L.A. (2010). Tipos funcionais fenológicos de espécies lenhosas da Caatinga, nordeste do Brasil. Tese. Programa de Pós Graduação em Botânica. Universidade Federal Rural de Pernambuco.
Sarcomphalus joazeiro	Ribeiro, E.M.S., Lohbeck, M., Santos B.A., Arroyo-Rodríguez,

	V., Tabarelli, M., Leal, I.A. (2019). ata from: Functional diversity and composition of Caatinga woody flora are negatively impacted by chronic anthropogenic disturbance, Dryad, Dataset, https://doi.org/10.5061/dryad.0d1s343
Schinopsis brasiliensis	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
*Senna spectabilis**	Ribeiro, E.M.S., Lohbeck, M., Santos B.A., Arroyo-Rodríguez, V., Tabarelli, M., Leal, I.A. (2019). ata from: Functional diversity and composition of Caatinga woody flora are negatively impacted by chronic anthropogenic disturbance, Dryad, Dataset, https://doi.org/10.5061/dryad.0d1s343
Sideroxylon obtusifolium	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.
Spondias tuberosa	Lima, A.L.A., Sampaio, E.V.S.B., Castro, C.C., Rodal, M.J.N., Antonino, C.D., & Melo, A.L. (2012). Do the phenology and functional stem attributes of woody species allow for the identification of functional groups in the semiarid region of Brazil? Brazil123Trees, 26:1605–1616DOI 10.1007/s00468-012-0735-2
Tabebuia aurea	Lorenzi, H.1992. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3. ed. Nova Odessa: Plantarum.

Ximenia americana	Ribeiro, E.M.S., Lohbeck, M., Santos B.A., Arroyo-Rodríguez, V., Tabarelli, M., Leal, I.A. (2019). ata from: Functional diversity and composition of Caatinga woody flora are negatively impacted by chronic anthropogenic disturbance, Dryad, Dataset, https://doi.org/10.5061/dryad.0d1s343
Zanthoxylum rhoifolium	Silva, A.M.L. (2012). Tipos funcionais de plantas no semiárido: Quais são os atributos chave?Dissertação de mestrado. Universidade Estadual da Paraíba.

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6. CAPÍTULO V - CONSIDERAÇÕES FINAIS

6.1 Principais conclusões

Os nossos resultados denotam como o conhecimento ecológico local é dinâmico e como direciona as pessoas para a seleção dos recursos vegetais. Em geral, (no segundo capítulo) os especialistas locais nas áreas estudadas indicaram um número variado de plantas. Verificamos que as áreas florestais próximas das comunidades rurais são acometidas por diferentes métricas de distúrbio antrópico crônico, o que possibilitou caracterizarmos os impactos antrópicos de cada área. Assim, observamos que as pessoas inseridas na área de maior distúrbio antrópico crônico citam uma menor riqueza de espécies. Além disso, verificamos que a riqueza de espécies conhecidas sugere influenciar a redundância em um nível individual das pessoas. Constatamos que a lenha e a cerca de arame tiveram uma maior redundância utilitária entre os especialistas locais. Em contraste com as preocupações associadas aos efeitos da extração de madeira pelas populações locais, as nossas inferências contribuem para compreender melhor a dinâmica do conhecimento ecológico local dos povos Caatinga diante do avanço dos distúrbios antrópicos crônicos nessas regiões de floresta seca.

No terceiro capítulo verificamos que as espécies úteis citadas pelos especialistas locais mostraram um sinal filogenético forte, sugerindo existir uma representatividade ou aproximação das linhagens filogenéticas com os dados de uso das plantas. Enquanto que no quarto capítulo identificamos que os usos para cabos de ferramentas e o artesanato apresentaram plantas citadas que estão filogeneticamente próximas entre as categorias de uso, enquanto as plantas citadas para lenha e cercas não apresentam um sinal filogenético. Verificamos que *Tabebuia aurea* foi à espécie citada com o maior valor de densidade de madeira, enquanto que *Astronium urundeuva* tem o maior valor de redundância. Encontramos um grau moderado de aglomeração filogenética para redundância de espécies e fraca para densidade de madeira. Estes resultados podem ser úteis para entender a seleção de plantas similares que têm sua madeira demandada por grupos humanos.

6.2 Contribuições teóricas e/ou metodológicas da tese

O interesse pelo conhecimento ecológico local tem crescido nos últimos anos, em parte devido ao reconhecimento de que tal conhecimento pode contribuir para a conservação da biodiversidade e pela necessidade de compreender quais os fatores envolvidos na seleção de plantas. O nosso trabalho reforça a importância de articular variáveis ecológicas e evolutivas para analisar o conhecimento ecológico local de populações da Caatinga. Argumentamos (capítulo 1) a importância de verificar a dinâmica do conhecimento ecológico local em ambientes com diferentes níveis de distúrbios antrópicos crônicos, tendo em vista que o uso das espécies tenderá ao longo das próximas décadas ser cada vez mais motivados pelas mudanças de escala local e global, podendo se tornar grandes desafios para as populações locais. Concomitantemente, a nossa pretensão (capítulo 1) em utilizar os modelos de redundância utilitária e redundância a nível individual das pessoas foi um passo importante para entender as estratégias do conhecimento dos povos. O nosso trabalho reforça as evidências presentes na literatura e prenche uma lacuna ao quantificamos o nível de impacto antropico crônico sobre as comunidades vegetais.

Ressaltamos (capítulo 2 e 3) que uso de hipóteses filogenéticas para estudar plantas úteis da Caatinga é relativamente novo. Embora o componente filogenético seja um importante recurso para descoberta de fármacos através das plantas medicinais usadas de forma não aleatória, verificamos que para o uso madeireiro de plantas existe especificidades. Verificamos (capítulo 3) que a proximidade filogenética de plantas utéis com menor redundância (redundância da espécie) pode sugerir uma maior pressão de uso, visto que poucas espécies cumprem a mesma função. Ainda com relação a redundância das espécies, é importante mencionar que adaptamos o índice proposto por COE e GAOUE (2021) em virtude do componente “W” aumentar o peso da versatilidade das espécies citadas.Verificamos, também, a importância de analisar as subcategorias de uso em vez de categorias gerais, pois considerando que cada uso da madeira tem especificidades distintas (SILVA et al., 2021), não é interessante verificar traços morfológicos e sinal filogenético de plantas citadas para categorias gerais. Embora exista uma vasta literatura etnobotânica sobre os recursos madeireiros, os nossos resultados preenche uma lacuna sobre como o parentesco evolutivo de plantas pode servir para entender a seleção de plantas da Caatinga.

6.3 Principais limitações do estudo

Selecionar as comunidades rurais através da cobertura vegetal, como mencionado na introdução geral da tese, foi um desafio encontrado durante a coleta do conhecimento local. O fato de não haver relacionamento ou aproximação entre os pesquisadores e os participantes das comunidades rurais dificultou o nosso primeiro contato, mas não inviabilizou a coleta. Além disso, em virtude do período pandêmico não foi possível alcançar um número amostral significativo com relação as áreas de estudo. Embora com a chegada das vacinas houvesse uma diminuição das taxas de transmissão do vírus, as pessoas não se sentiam seguras em participar da pesquisa. Por esses motivos optamos por utilizar os dados disponíveis para construção do objetivo inicial da tese. Isso justifica a nossa limitação em testar (capítulo 1) uma hipótese direta sobre como as variáveis de impactos antrópicos crônico influenciavam no conhecimento local das pessoas.

Em relação ao produto apresentado no terceiro capítulo da tese, destacamos que ao utilizar dados secundários (atributos das espécies vegetais citadas) podemos ter desvantagem em absorver as fragilidades dos trabalhos utilizados. Não inserir a percepção de todos os participantes da pesquisa sobre as características das espécies conhecidas para cada subcategoria de uso pode ter sido uma limitação no nosso estudo, pois, além do sinal filogenético, não foi possível comprender quais as características das espécies influenciam em cada uso. Além disso, embora as hipóteses filogenéticas sejam úteis em etnobotânica para interpretar como a seleção de plantas em um determinado uso podem influenciar no comportamento humano, não testamos as variáveis que podem influenciar tal comportamento.

6.4 Propostas de investigações futuras

Recomendamos que, em estudos futuros, possam ser avaliadas essas questões:

i) Utilizar a história ambiental para identificar como ocorreu os impactos antrópicos crônicos nas comunidades rurais da Caatinga e sua importância para a formação da paisagem local.

ii) As espécies com qualidade (ex.: durabilidade) percebida citada para um dado uso pelas pessoas tendem a apresentar maior redundância utilitária?

iii) Identificar a intensidade de uso de cada espécie geradora da redundância utilitária.

iv) Dentre as plantas utilizadas existem características agrupadas, bem como sobredispersas dentro da filogenia que vão guiar o comportamento humano para seleção de plantas?

6.5 Orçamento (custo do projeto)

Custos estimados para as amostragens fitossociológicas e entrevistados.

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ANEXOS

UNIVERSIDADE ESTADUAL DA PARAÍBA - PRÓ-REITORIA DE PÓS-GRADUAÇÃO E PESQUISA / UEPB - PRPGP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: EFEITOS AMBIENTAIS E FILOGENÉTICOS NA SELEÇÃO DE PLANTAS UTILIZADAS POR POPULAÇÕES LOCAIS DO SEMIÁRIDO DO BRASIL

Pesquisador: Kamila Marques Pedrosa

Área Temática:

Versão: 3

CAAE: 30657119.3.0000.5187

Instituição Proponente: Universidade Estadual da Paraíba - UEPB

Patrocinador Principal: FUNDACAO DE APOIO A PESQUISA DO ESTADO DA PARAIBA - FAPES

DADOS DO PARECER

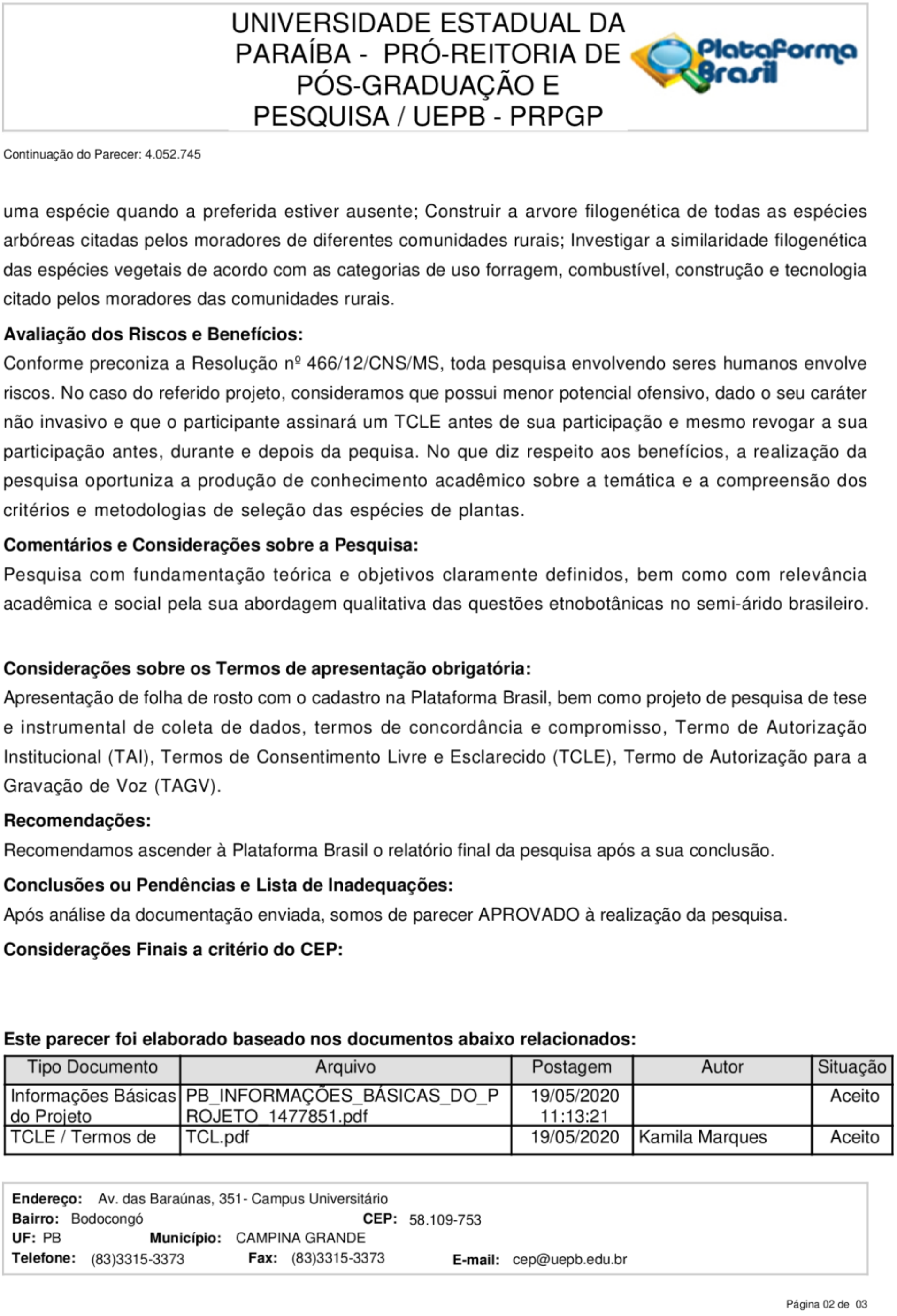
Número do Parecer: 4.052.745

Apresentação do Projeto:

Projeto de tese do Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza (PPGETNO/UFRPE/UEPB/URCA), encaminhado ao Comitê de Ética em Pesquisa envolvendo Seres Humanos da Universidade de Estadual da Paraíba (CEP-UEPB), a fim de obter permissão para a realização de pesquisa. O projeto intitulado "EFEITOS AMBIENTAIS E FILOGENÉTICOS NA SELEÇÃO DE PLANTAS UTILIZADAS POR POPULAÇÕES LOCAIS DO SEMIÁRIDO DO BRASIL", será desenvolvido pela doutoranda Kamila Marques Pedrosa, sob orientação do Prof. Dr. Sérgio de Faria Lopes.

Objetivo da Pesquisa:

O presente estudo tem como objetivo compreender como populações locais selecionam e maximizam as formas de uso das espécies vegetais arbóreas pela perspectiva biológica e filogenética em comunidades rurais do semiárido brasileiro sob diferentes regimes pluviométrico e distúrbio antrópico crônico. No que diz respeito aos objetivos específicos, estes são: Realizar uma revisão bibliográfica sobre o histórico do uso e ocupação na região semiárida do Cariri Paraibano; Realizar o levantamento etnobotânico em cada área selecionada sobre o uso das espécies vegetais; Realizar levantamento da riqueza e estrutura da vegetação arbustiva-arbórea de cada área selecionada; Realizar o cálculo do distúrbio antrópico crônico em cada área de estudo selecionado; Analisar as características das plantas citadas pelas populações locais nas categorias de uso forragem, construção, combustível e tecnologia; Identificar os critérios estabelecidos na escolha de



uma espécie quando a preferida estiver ausente; Construir a arvore filogenética de todas as espécies arbóreas citadas pelos moradores de diferentes comunidades rurais; Investigar a similaridade filogenética das espécies vegetais de acordo com as categorias de uso forragem, combustível, construção e tecnologia citado pelos moradores das comunidades rurais.

Avaliação dos Riscos e Benefícios:

Conforme preconiza a Resolução nº 466/12/CNS/MS, toda pesquisa envolvendo seres humanos envolve riscos. No caso do referido projeto, consideramos que possui menor potencial ofensivo, dado o seu caráter não invasivo e que o participante assinará um TCLE antes de sua participação e mesmo revogar a sua participação antes, durante e depois da pequisa. No que diz respeito aos benefícios, a realização da pesquisa oportuniza a produção de conhecimento acadêmico sobre a temática e a compreensão dos critérios e metodologias de seleção das espécies de plantas.

Comentários e Considerações sobre a Pesquisa:

Pesquisa com fundamentação teórica e objetivos claramente definidos, bem como com relevância acadêmica e social pela sua abordagem qualitativa das questões etnobotânicas no semi-árido brasileiro.

Considerações sobre os Termos de apresentação obrigatória:

Apresentação de folha de rosto com o cadastro na Plataforma Brasil, bem como projeto de pesquisa de tese e instrumental de coleta de dados, termos de concordância e compromisso, Termo de Autorização Institucional (TAI), Termos de Consentimento Livre e Esclarecido (TCLE), Termo de Autorização para a Gravação de Voz (TAGV).

Recomendações:

Recomendamos ascender à Plataforma Brasil o relatório final da pesquisa após a sua conclusão.

Conclusões ou Pendências e Lista de Inadequações:

Após análise da documentação enviada, somos de parecer APROVADO à realização da pesquisa.

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1477851.pdf	19/05/2020 11:13:21		Aceito
TCLE / Termos de	TCL.pdf	19/05/2020	Kamila Marques	Aceito

Assentimento / Justificativa de Ausência	TCL.pdf	11:08:41	Pedrosa	Aceito
Declaração de Instituição e Infraestrutura	institucional.pdf	19/05/2020 10:59:46	Kamila Marques Pedrosa	Aceito
Declaração de concordância	concordancia_pesquisa.pdf	19/05/2020 10:59:13	Kamila Marques Pedrosa	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.pdf	19/05/2020 10:58:49	Kamila Marques Pedrosa	Aceito
Folha de Rosto	folha_de_rosto.pdf	19/05/2020 10:57:39	Kamila Marques Pedrosa	Aceito
Outros	termo_de_compromisso.pdf	30/04/2020 14:21:12	Kamila Marques Pedrosa	Aceito
Cronograma	Cronograma_tese.pdf	16/12/2019 19:04:23	Kamila Marques Pedrosa	Aceito

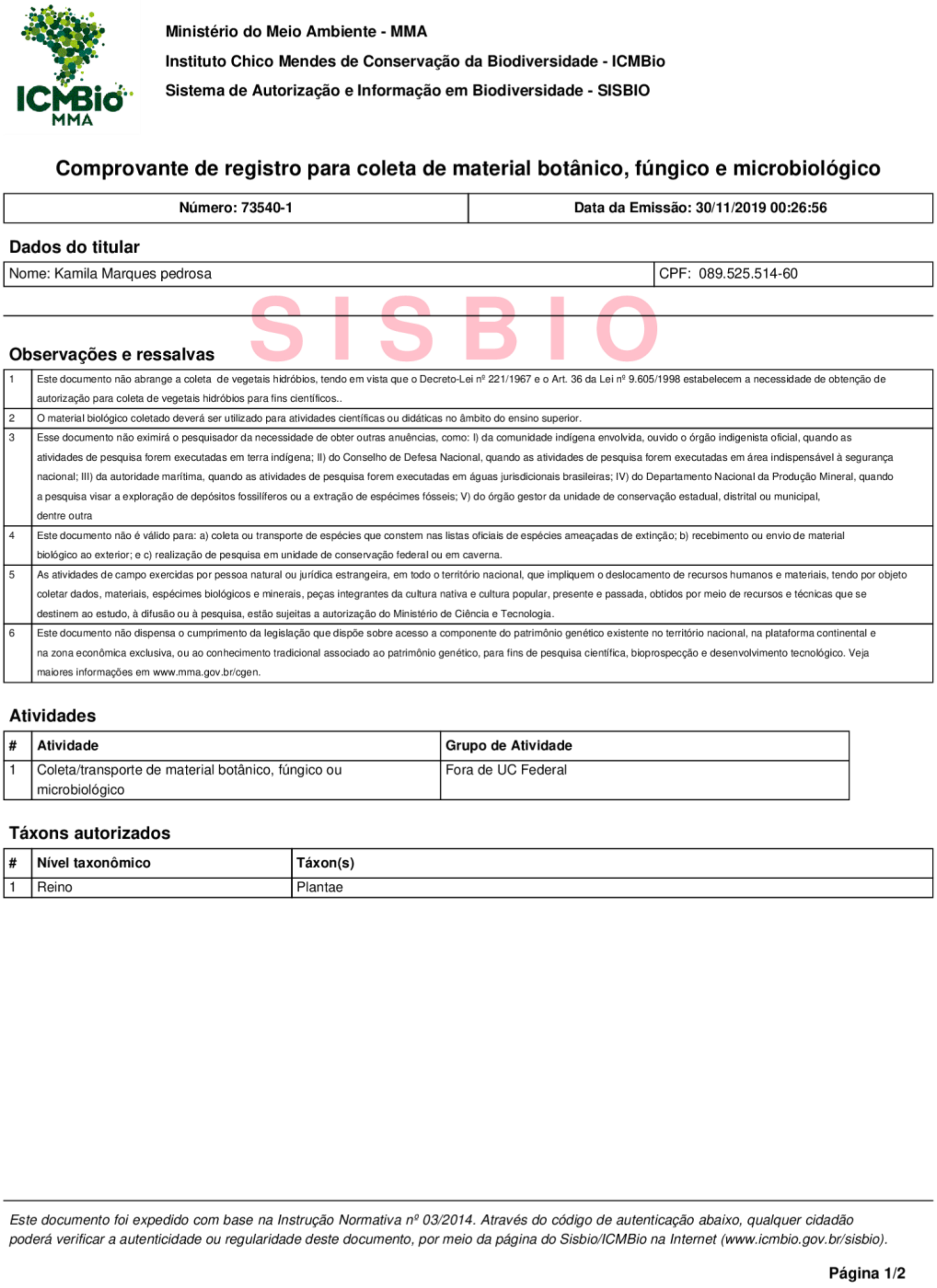
Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

CAMPINA GRANDE, 27 de Maio de 2020

Assinado por:
Dóris Nóbrega de Andrade Laurentino
(Coordenador(a))

ANEXO II



Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Comprovante de registro para coleta de material botânico, fúngico e microbiológico

Número: 73540-1	**Data da Emissão: 30/11/2019 00:26:56**

Dados do titular

Nome: Kamila Marques pedrosa	CPF: 089.525.514-60

Observações e ressalvas

1	Este documento não abrange a coleta de vegetais hidróbios, tendo em vista que o Decreto-Lei nº 221/1967 e o Art. 36 da Lei nº 9.605/1998 estabelecem a necessidade de obtenção de autorização para coleta de vegetais hidróbios para fins científicos..
2	O material biológico coletado deverá ser utilizado para atividades científicas ou didáticas no âmbito do ensino superior.
3	Esse documento não eximirá o pesquisador da necessidade de obter outras anuências, como: I) da comunidade indígena envolvida, ouvido o órgão indigenista oficial, quando as atividades de pesquisa forem executadas em terra indígena; II) do Conselho de Defesa Nacional, quando as atividades de pesquisa forem executadas em área indispensável à segurança nacional; III) da autoridade marítima, quando as atividades de pesquisa forem executadas em águas jurisdicionais brasileiras; IV) do Departamento Nacional da Produção Mineral, quando a pesquisa visar a exploração de depósitos fossilíferos ou a extração de espécimes fósseis; V) do órgão gestor da unidade de conservação estadual, distrital ou municipal, dentre outra
4	Este documento não é válido para: a) coleta ou transporte de espécies que constem nas listas oficiais de espécies ameaçadas de extinção; b) recebimento ou envio de material biológico ao exterior; e c) realização de pesquisa em unidade de conservação federal ou em caverna.
5	As atividades de campo exercidas por pessoa natural ou jurídica estrangeira, em todo o território nacional, que impliquem o deslocamento de recursos humanos e materiais, tendo por objeto coletar dados, materiais, espécimes biológicos e minerais, peças integrantes da cultura nativa e cultura popular, presente e passada, obtidos por meio de recursos e técnicas que se destinem ao estudo, à difusão ou à pesquisa, estão sujeitas a autorização do Ministério de Ciência e Tecnologia.
6	Este documento não dispensa o cumprimento da legislação que dispõe sobre acesso a componente do patrimônio genético existente no território nacional, na plataforma continental e na zona econômica exclusiva, ou ao conhecimento tradicional associado ao patrimônio genético, para fins de pesquisa científica, bioprospecção e desenvolvimento tecnológico. Veja maiores informações em www.mma.gov.br/cgen.

Atividades

#	Atividade	Grupo de Atividade
1	Coleta/transporte de material botânico, fúngico ou microbiológico	Fora de UC Federal

Táxons autorizados

#	Nível taxonômico	Táxon(s)
1	Reino	Plantae

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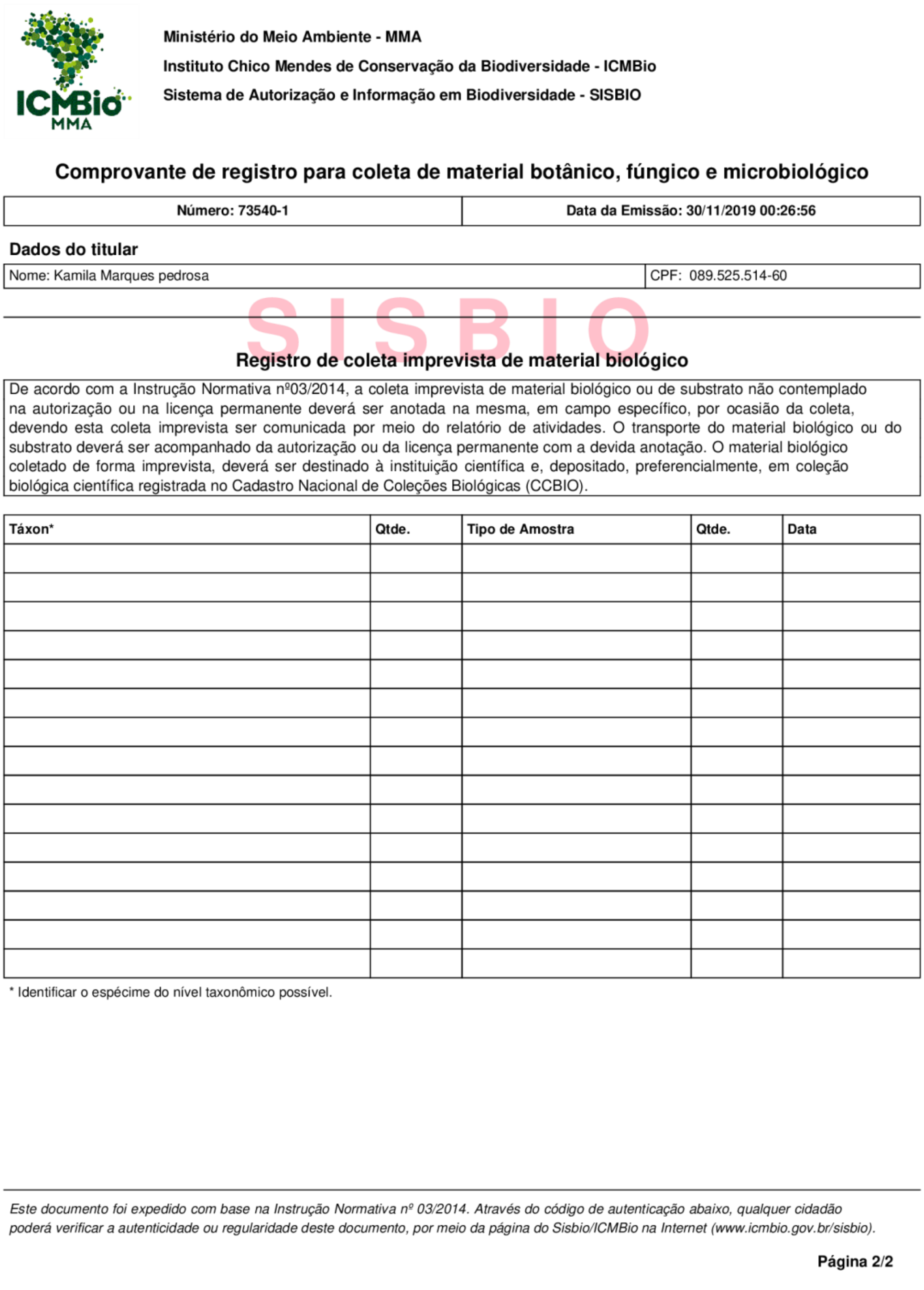

Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Comprovante de registro para coleta de material botânico, fúngico e microbiológico

Número: 73540-1	**Data da Emissão: 30/11/2019 00:26:56**

Dados do titular

Nome: Kamila Marques pedrosa	CPF: 089.525.514-60

Registro de coleta imprevista de material biológico

De acordo com a Instrução Normativa nº03/2014, a coleta imprevista de material biológico ou de substrato não contemplado na autorização ou na licença permanente deverá ser anotada na mesma, em campo específico, por ocasião da coleta, devendo esta coleta imprevista ser comunicada por meio do relatório de atividades. O transporte do material biológico ou do substrato deverá ser acompanhado da autorização ou da licença permanente com a devida anotação. O material biológico coletado de forma imprevista, deverá ser destinado à instituição científica e, depositado, preferencialmente, em coleção biológica científica registrada no Cadastro Nacional de Coleções Biológicas (CCBIO).

Táxon*	Qtde.	Tipo de Amostra	Qtde.	Data

* Identificar o espécime do nível taxonômico possível.

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ANEXO III

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO-TCLE

(OBS: para o caso de pessoas maiores de 18 anos e que não estejam inseridas nas hipóteses de vulnerabilidade que impossibilitam o livre discernimento com autonomia para o exercício dos atos da vida civil).

Pelo presente Termo de Consentimento Livre e Esclarecido eu, ________________________________, em pleno exercício dos meus direitos me disponho a participar da Pesquisa **“ Efeitos ambientais e filogenéticos na seleção de plantas utilizadas por populações locais do semiárido do brasil**”.

Declaro ser esclarecido e estar de acordo com os seguintes pontos:

O trabalho **“**Efeitos ambientais e filogenéticos na seleção de plantas utilizadas por populações locais do semiárido do Brasil” terá como objetivo compreender como populações locais selecionam e maximizam as formas de uso das espécies vegetais arbóreas pela perspectiva biológica e filogenética em comunidades rurais do semiárido brasileiro sob diferentes regimes pluviométrico e distúrbio antrópico crônico. Ao voluntário só caberá a autorização para solicitamos a sua colaboração para fornecer informações sobre as plantas da região por meio de entrevistas, como também sua autorização para apresentar os resultados deste estudo em eventos da área de ciências biológicas e ambientais, além de publicar em revista científicas nacionais e internacionais. Por ocasião da publicação dos resultados, seu nome será mantido em e não haverá nenhum risco ou desconforto ao voluntário.

- Ao pesquisador caberá o desenvolvimento da pesquisa de forma confidencial; entretanto, quando necessário for, poderá revelar os resultados ao médico, indivíduo e/ou familiares, cumprindo as exigências da Resolução Nº. 466/12 do Conselho Nacional de Saúde/Ministério da Saúde. - O voluntário poderá se recusar a participar, ou retirar seu consentimento a qualquer momento da realização do trabalho ora proposto, não havendo qualquer penalização ou prejuízo para o mesmo. - Será garantido o sigilo dos resultados obtidos neste trabalho, assegurando assim a privacidade dos participantes em manter tais resultados em caráter confidencial. - Não haverá qualquer despesa ou ônus financeiro aos participantes voluntários deste projeto científico e não haverá qualquer procedimento que possa incorrer em danos físicos ou financeiros ao voluntário e, portanto, não haveria necessidade de indenização por parte da equipe científica e/ou da Instituição responsável. - Qualquer dúvida ou solicitação de esclarecimentos, o participante poderá contatar a equipe científica no número (083) 9168-9271 com Kamila Marques Pedrosa, (83) 8803-2622 com Maiara Bezerra Ramos e (83) 9834-1415 com o Dr. Sérgio Faria Lopes (Professor) - Ao final da pesquisa, se for do meu interesse, terei livre acesso ao conteúdo da mesma, podendo discutir os dados, com o pesquisador, vale salientar que este documento será impresso em duas vias e uma delas ficará em minha posse. - Desta forma, uma vez tendo lido e entendido tais esclarecimentos e, por estar de pleno acordo com o teor do mesmo, dato e assino este termo de consentimento livre e esclarecido.

Assinatura do pesquisador responsável

Assinatura do Participante

Assinatura Dactiloscópica do participante da pesquisa
(OBS: utilizado apenas nos casos em que não seja
Possível a coleta da assinatura do participante da
Pesquisa).