

Sociodemographic profile, ecoepidemiological aspects, and environmental perception of the residents of the environmental protection area of Combu Island regarding the chiropteran fauna, Belém, Pará, Brazil

Perfil sociodemográfico, ecoepidemiológico e percepção ambiental dos residentes da área de proteção ambiental da Ilha do Combu com relação à quiropterofauna, Belém, Pará, Brasil

Neuder Wesley França da Silva¹ , Carlos Elias de Souza Braga¹ , Ana Lúcia Nunes Gutjahr¹ 

ABSTRACT

Bats, the only flying mammals, exhibit remarkable species diversity, ecological functions, and public health relevance. However, throughout the history of many cultures, they have faced numerous, often unfair stereotypes, generating negative perceptions that impact their conservation and local coexistence. This study established the socioeconomic, ecoepidemiological, and perception profile of residents in the Combu Island Environmental Protection Area, in Pará, regarding bats. The descriptive quali-quantitative study involved semi-structured interviews with 120 riverine residents. Quantitative data were analyzed using the χ^2 Test ($p < 0.05$) in BioEstat 5.3, and qualitative data were examined through Content Analysis. Most residents had observed bats, and many feared diseases and aggression, despite recognizing their ecological importance. Results revealed cultural diversity, a predominance of adults, followed by children, in family units, and significant plant extractivism in the local economy, with few reports of the folklore surrounding bats. Residents often recognized the importance of bats in seed dispersal, but many were unaware of their role in insect control. Environmental education is essential to correct misinformation and foster a balanced understanding of bats. Perceptions varied with personal and cultural experiences, reflecting the complexity of human-bat interactions. It was concluded that awareness regarding the ecological relevance of bats is essential for understanding the island's biodiversity. However, the implementation of educational programs integrated into the school curriculum as well as awareness campaigns is recommended to foster a harmonious coexistence between residents and the local fauna, reinforcing the importance of bats in maintaining ecological balance.

Keywords: bats; conservation unit; ecology; biodiversity; environmental conservation.

RESUMO

Os morcegos, únicos mamíferos voadores com notável diversidade de espécies, funções ecológicas e relevância na saúde pública, atravessam a história de muitas culturas com inúmeros estereótipos, frequentemente injustos, gerando percepções negativas que impactam sua conservação e a coexistência local. Diante desse cenário, foi estabelecido o perfil socioeconômico, ecoepidemiológico e da percepção dos residentes da Área de Proteção Ambiental da Ilha do Combu, no Pará, sobre os quirópteros. O estudo, descritivo quantiquantitativo, realizou entrevistas semiestruturadas com 120 moradores em vias fluviais. Os dados quantitativos foram analisados via teste χ^2 ($p < 0,05$) no BioEstat 5.3, e os dados qualitativos submetidos à análise de conteúdo. Observou-se que a maioria já havia visto morcegos, e muitos temiam doenças e agressões, mesmo reconhecendo sua importância ecológica. Os resultados indicaram diversidade cultural, predominância de adultos e secundariamente crianças no grupo familiar, além de significativa contribuição do extrativismo vegetal na economia local, com poucos relatos de lendas sobre morcegos. Os moradores frequentemente reconheceram a importância dos morcegos na dispersão de sementes, mas muitos desconheciam seu papel no controle de insetos. Destaca-se a necessidade de educação ambiental para corrigir desinformações e promover uma compreensão equilibrada sobre morcegos. As percepções variaram conforme experiências pessoais e culturais, refletindo a complexidade das interações humano-morcego. Concluiu-se que a conscientização da relevância ecológica dos morcegos é essencial para o conhecimento da biodiversidade na ilha. Contudo, recomenda-se a implementação de programas educativos integrados ao currículo escolar e campanhas para fomentar uma convivência harmônica entre os moradores e a fauna local, reforçando a importância dos morcegos na manutenção do equilíbrio ecológico.

Palavras-chave: morcegos; unidade de conservação; ecologia; biodiversidade; conservação ambiental.

¹State University of Pará – Belém (PA), Brazil.

Corresponding author: Neuder Wesley França da Silva – Centro de Ciências Naturais e Tecnologia, Universidade do Estado do Pará – Travessa Doutor Enéas Pinheiro, 2626 – Marco – CEP 66095-100 – Belém (PA), Brazil. E-mail: nwwet@hotmail.com

Received on: 05/26/2025. Accepted on: 04/28/2026

<https://doi.org/10.5327/Z2176-94782611>



This is an open access article distributed under the terms of the Creative Commons license.

Introduction

Bats (Order Chiroptera) have always fascinated humans, and their nocturnal habits have fueled many of the mysteries surrounding them, aside from being the only mammals capable of true flight (Bredt et al., 2012). These animals represent the second most diverse group of mammals in the world, with 1,386 species, surpassed only by the Order Rodentia, which has 2,552 species (Burgin et al., 2018).

In Brazil, 178 species of chiropterans are recognized, with the highest richness found in the state of Pará, which hosts 120 different types of bats (Bernard et al., 2011; Nogueira et al., 2014). They are present on all continents, except for isolated islands in the Pacific Ocean and in regions of extreme temperatures, such as the Arctic, Antarctica, and high-altitude areas (Laurindo and Novaes, 2015).

The dietary diversity of bats is broad and determines their ecological relevance, as their diet may include various types of insects, fruits, nectar, arthropods, seeds, frogs, fish, small mammals, birds, crustaceans, and blood (Clare and Oelbaum, 2024). These animals play important roles in controlling insect populations and dispersing seeds, but some cause economic damage, such as frugivores in cultivated areas and hematophagous species that can transmit rabies to humans and animals, notably *Desmodus rotundus* Geoffroy, 1810 (Bredt et al., 2012). Furthermore, bats also display a diversity of colors as varied as their feeding habits, with pelage ranging from orange, gray, and red, to entirely white (Laurindo and Novaes, 2015).

Beyond their ecological aspects, bats are present in various cultures, encompassing symbolic, mythological, or folkloric elements. Due to their nocturnal habits, they are often regarded as sinister, demonic creatures, almost always undesirable, and are frequently targeted by misguided narratives, such as the popular belief that they are bloodsuckers or vampires (Bredt et al., 1998) or that they are “rats with wings,” although there is no direct kinship between bats and rodents (Laurindo and Novaes, 2015).

In addition to myths and incorrect popular beliefs, the collective imagination about bats is also strongly influenced by historical and religious references. In this regard, the Torah and the Bible mention the word “bat” in their dietary codes (Leviticus and Deuteronomy),¹ classifying it as an “abominable bird” unfit for consumption by Israelites. However, it is in the prophetic book of Isaiah, present in the biblical canon, that its meaning appears to relate to spiritual or moral impurity.² These mentions contribute significantly to the construction and perpetuation of a negative perception and stereotypes about these animals throughout history, shaping the public opinion.

It can be acknowledged that the image of bats is often permeated by preconceived conceptions and notions, mostly stemming from what is known as perception. In the philosophical field, perception is the primary mechanism of accessing the external world, questioning the nature of this central mental process, exploring whether the

different senses represent reality in commensurable ways, the extent of our environmental awareness, and which aspects of perception are objective or subjective, as well as investigating the distinction between what is genuinely perceptual and what is cognitive inference, and the relationship between perceived reality and the observer’s perspective (Morales and Firestone, 2023).

Environmental perception, a consolidated and constantly evolving field of study in Brazil, emerges as an essential tool for management, biodiversity conservation, and the planning of environmental education strategies (Santos, 2020; Santos et al., 2022). By enabling the diagnosis of knowledge gaps and the identification of beliefs and values that shape the relationship of communities with the environment, perception analysis supports the development of contextualized educational programs that value local knowledge and promote changes in attitude and behavior toward sustainability, from a national to a regional scale (Zanini et al., 2021; Rodrigues et al., 2023).

Epistemologically, perception is shaped by sensory experiences and environmental influences, molding the understanding of the world. The interconnection between perception and knowledge suggests that the ability to perceive is fundamental to the construction of both objective and subjective knowledge. Thus, perception is described not only as a sensory experience but also as a cognitive process involving interpretation and understanding (Mora et al., 2021).

In Brazil, studies on environmental perception are strategic for Environmental Education and the management of Conservation Units (Santos, 2020; Zanini et al., 2021; Rodrigues et al., 2023), yet they still remain understudied in more rural areas (Santos et al., 2022). Community engagement is urgent, as strictly protected areas are insufficient to safeguard chiroptero fauna, conferring upon sustainable use Conservation Units, such as APAs, an indispensable complementary role (Pessoa da Silva and Marco Júnior, 2023). Advancing to a regional scale, these approaches become essential for formulating conservation actions integrated with riverine communities in the Amazon.

Despite the breadth and complexity of the concept of perception, its analysis has been widely employed in various scientific fields, including environmental issues. However, there are no reports of studies exploring the perceptions, beliefs, and knowledge of the communities in the Conservation Units in the Amazon regarding bats (Moraes-Ornellas and Ornellas, 2023). This gap impedes the understanding of the complex human-bat interactions and, consequently, the formulation of effective conservation actions.

In this context, the socioeconomic, ecoepidemiological, and perception profiles of the residents of the Combu Island Environmental Protection Area were established, aiming to comprehend the ecological relationships between the riverine community and the chiroptero fauna.

¹ Leviticus 11:19, Deuteronomy 14:18.

² Isaiah 2:20.

Methods

Study area

The study was conducted in the Combu Island Environmental Protection Area (APA), which constitutes one of the 39 islands belonging to the municipality of Belém, state of Pará (Silva et al., 2025). The APA, created under Law No. 6,083 of November 13, 1997, covers approximately 15 square kilometers, being located 1.5 km in a straight line south of the city of Belém, and situated on the banks of the Guamá River to the north, the São Benedito channel to the south, and the Paciência channel to the east—channels locally known as *furos*, which are natural connections between rivers and streams in the Amazonian floodplain—and the Guajará Bay to the west, with access to the island exclusively by waterways (Figure 1) (IDEFLOR-BIO, 2021). The map was created using QGIS version 3.40.7 (Bratislava), a free and open-source software.

Combu Island has approximately 1,500 inhabitants, with an average air temperature of 26.7°C, a relative humidity of 84%, and two rainy

periods, a wetter season occurring between December and August, and a drier season between the months of September and November, in addition to featuring an extensive vegetation of Alluvial Dense Ombróphilous Forest, composed of trees, shrubs, herbaceous plants, lianas, and understory species, as well as many fruit species of economic value, such as *açaí* (*Euterpe oleracea* Mart.), cocoa (*Theobroma cacao* Linnaeus), and banana (*Musa* spp. Linnaeus) (IDEFLOR-BIO, 2021; Silva et al., 2025).

Design and interview

This is a descriptive study of a quali-quantitative nature with non-probabilistic sampling (Creswell and Clark, 2015; Gil, 2019). To obtain the data, a semi-structured interview was conducted, based on a printed form, previously prepared by the authors and administered in person. The instrument consisted of closed-ended questions for the sociodemographic survey, as well as closed-ended, open-ended, and dependent questions to investigate the ecoepidemiological character and local understanding about bats.

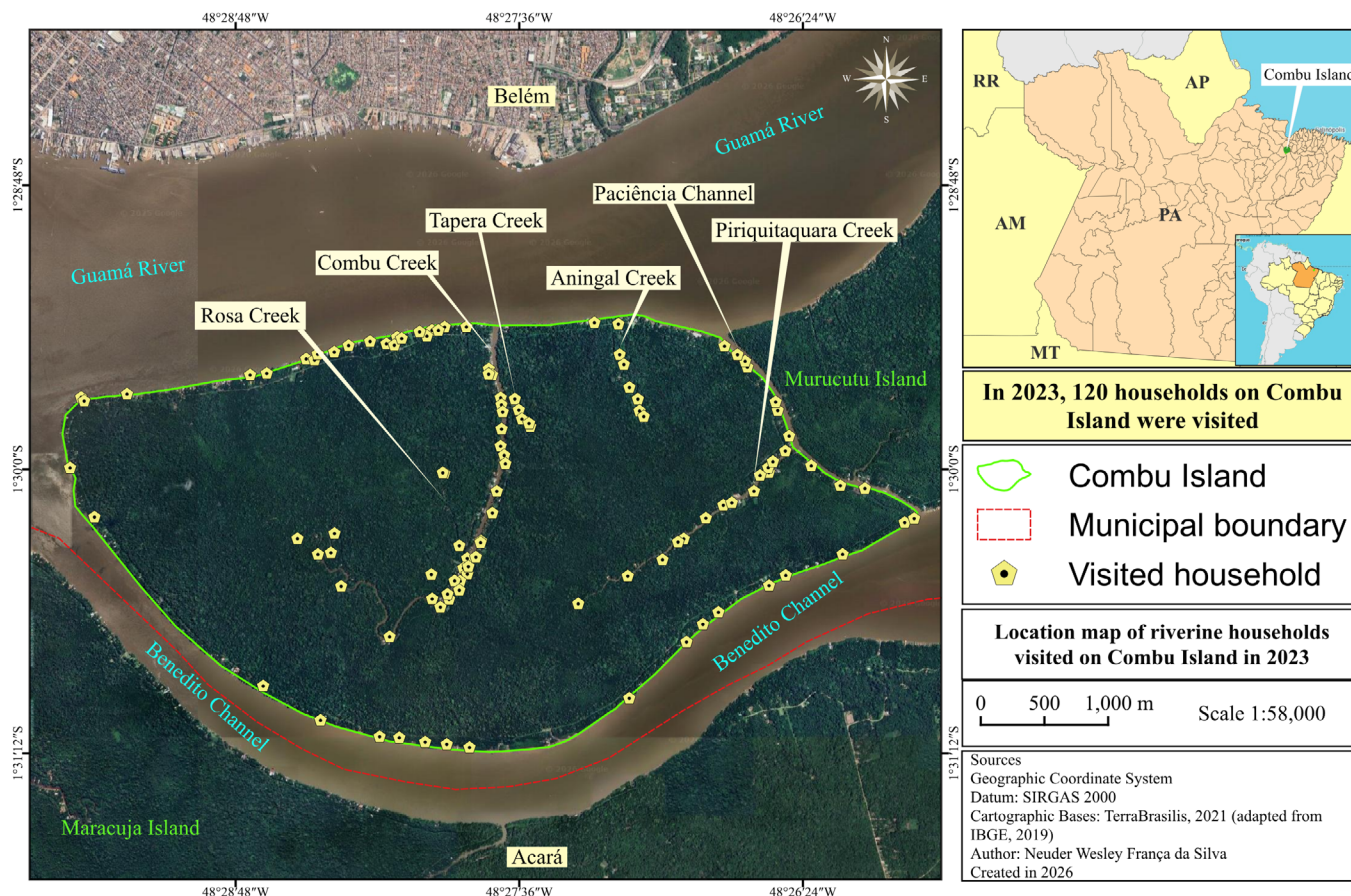


Figure 1 – Location and surveyed households of the Combu Island EPA, Belém, Pará.

The interviews occurred in the month of June 2023, in eight localities on Combu Island (Combu Creek, Rosa Creek, Piriquitaquara Creek, Aningal Creek, Tapera Creek, Paciência Channel, Benedito Channel, and Guamá Riverbank) (Figure 1). The number of interviewed residents was defined based on the quantity of families on Combu Island, corresponding to 448 inhabitants in 2019. This information was obtained from a spreadsheet provided by the Combu Family Health Unit and, subsequently, subjected to Slovin's calculation, resulting in a sample of 120 interviewees.

For better data collection, only one adult per family nucleus/household would answer the form, regardless of the length of residence on the island, thus ensuring the representativeness of the families. The interviews occurred at the local residences, where it was clarified that they were participating in a study on bats on the island. At that moment, the Informed Consent Form (ICF) was presented and signed by the interviewee, formalizing the consent to participate in the research.

The selection of residences occurred based on visualizing open houses and/or a boat moored at their banks, which indicated the presence of the resident, with access to the families exclusively via waterway navigation by motorboat. Residents of the island who wished to participate in the research upon hearing the questions asked were excluded from the interviews. These exclusions had the purpose of preventing the influence of one interviewee's answer on another.

Data analysis

Regarding the open-ended questions on the form, the statements were fully transcribed, followed by the categorical Content Analysis proposed by Bardin (2011), in order to identify the main perceptions.

The variables and closed-ended responses were compiled into spreadsheets of the Microsoft Excel® software, version 2019, to produce tables and charts. Subsequently, quantitative statistical analysis was performed using the BioEstat software, version 5.3, with the application of the χ^2 test (goodness-of-fit and contingency table), with $p < 0.05$ considered statistically significant.

Ethical precepts

The interviewees only participated in the research voluntarily and after signing the ICF. The study was then submitted to and approved by the Research Ethics Committee of the Center for Biological and Health Sciences of the State University of Pará (CCBS/UEPA), under the opinion number 6,089,501. Furthermore, authorization was obtained from the Institute for Forest Development and Biodiversity of the State of Pará (IDEFLOR-BIO), under the number 006/2023 due to the nature of the research in an APA.

Results

The majority of the interviews were conducted with residents of Combu Creek, and the minority with residents of Rosa Creek, with the number of interviews per locality being statistically significant ($p < 0.0001$) (Figure 2).

Among the respondents, a higher participation of female individuals was obtained, although no statistically significant difference was found between the sexes. Regarding educational level, the majority presented an incomplete elementary education. Furthermore, the respondents were usually natives of Combu Island, while the age group per family (family nucleus) most frequently was composed of adults and, secondarily, of children (Table 1).

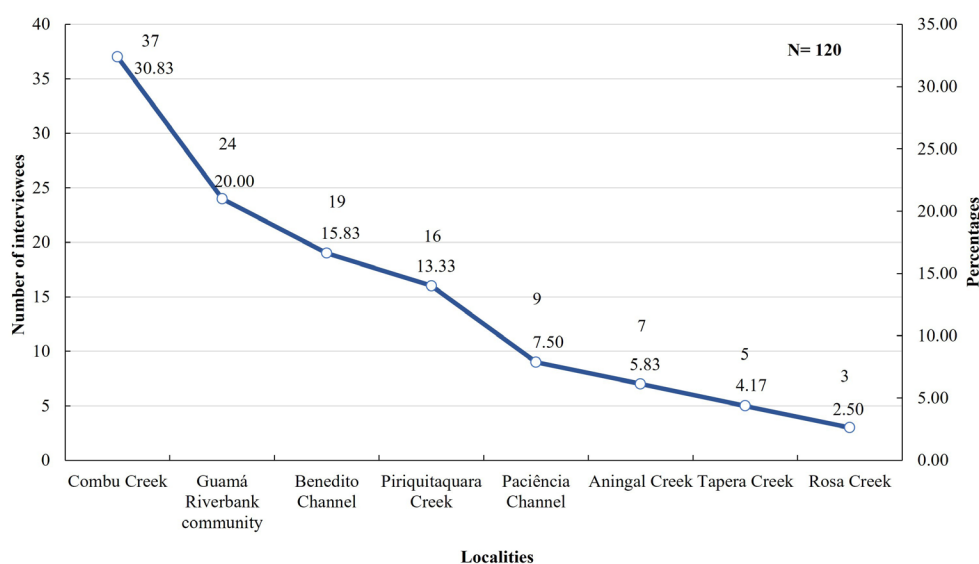


Figure 2 – Distribution of the interviewed residents by locality on Combu Island.

Table 1 – Distribution regarding the sociodemographic variables of the residents on Combu Island.

Sociodemographic variable	n	%	p-value
Sex			
Male	52	43.33	0.1441
Female	68	56.67	
Educational level			
Illiterate	6	5.00	<0.0001
Complete Elementary Education	15	12.50	
Incomplete Elementary Education	61	50.83	
Complete High School	24	20.00	
Incomplete High School	7	5.83	
Complete Higher Education	6	5.00	
Incomplete Higher Education	1	0.83	
Always lived on the island?			
Yes	77	64.17	0.0019
No	43	35.83	
Age group per family of the interviewees (in years)*			
Children (0–12)	112	24.14	<0.0001
Adolescents (13–18)	56	12.07	
Adults (19–59)	243	52.37	
Elderly (≥60)	53	11.42	

*Including the interviewees.

Plant extractivism was the predominant labor activity among the residents of Combu, with *açaí* (*Euterpe oleracea* Mart.) being primarily cited, secondarily homemaker and retiree (Figure 3).

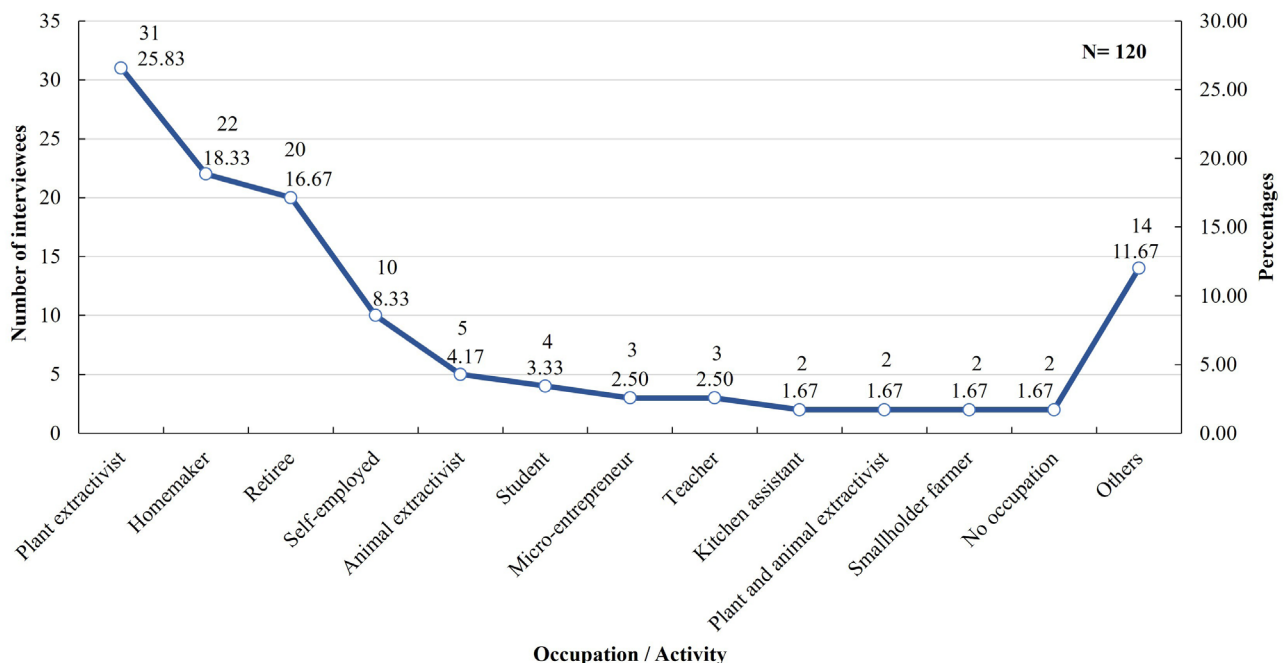
Regarding specific knowledge about bats, the portion of residents who had already seen a bat predominated, which commonly occurred both inside and outside their homes (Table 2).

Regarding the fear of bats, there was no significant difference between the interviewees who stated they felt fear and those who reported against it. However, among those who stated they were afraid, the reasons were predominantly associated with aggression and/or the possibility of contracting diseases. A minority reported reasons for their fear, related to the phenotype and other aspects of bats (Table 3).

Regarding the question of whether bats were harmless, aggressive, both, or if they did not know, the interviewees frequently stated that these animals could be both, that is, harmless or aggressive ($p<0.0001$) (Figure 4).

All the interviewees responded that they had never used or currently use bats in anything involving beliefs and/or mixtures for healing; furthermore, the majority stated they were unaware of any myth and/or legend about bats; however, some residents cited examples (Table 4).

Regarding the feeding habits of bats, the majority of the interviewees stated they were aware of them, predominantly citing the consumption of fruits and blood jointly. The banana stands out, frequently stored in bunches or clusters inside the houses, as the food most sought after by bats during nocturnal incursions (Table 5).



Others: Community health agent, gate attendant, sales attendant, barman, boatman, cashier, carpenter, cook, mineral water production assistant, street market vendor, waitress, urban driver, night school guard, and disability retirement.

Figure 3 – Distribution of occupation/activity of the residents on Combu Island.

Table 2 – Frequency distribution of the location where bats were sighted on Combu Island.

Variable	n	%	p-value
Have you ever seen a bat?			
Yes	119	99.17	0.0001
No (Never saw one)	1	0.83	
If “Yes,” where did it occur?			
Inside and outside the home	78	65.00	<0.0001
Inside the home	8	6.67	
Outside the home	33	27.50	
Never saw one	1	0.83	

Table 3 – Distribution regarding the fear of the residents towards bats and their reasons on Combu Island.

Variable	n	%	p-value
Are you afraid of bats?			
Yes	64	53.33	0.4652
No	56	46.67	
If “Yes,” what is the reason for fearing bats?			
Related to aggression and/or contracting diseases	49	76.53	-
May be bitten or attacked	13	20.31	
May suck blood	12	18.75	
Transmit disease, bacteria, viruses	7	10.94	
Cause rabies	2	3.13	
Has already been bitten	4	6.25	
May bite and transmit disease	4	6.25	
Knows someone who was bitten	3	4.69	
May be attacked by the type of bat that sucks blood ^a	1	1.56	
Others (dangerous, the bite hurts a lot and is fatal, bites without feeling the pain)	3	4.69	
Related to phenotype and others	15	23.44	0.0455
“Ugly, flies low, dislike bats, looks like a vampire, may touch people, only when they enter the house, somewhat afraid”	9	60.00	
Could not explain	6	40.00	

^a In this case, a specific “type” of bat that sucks blood was mentioned, differing from the response “May suck blood,” which encompassed any bat.

According to the majority of the interviewees, bats are not all the same, with “size and color” being the identified as the primary differentiating factors among them and, secondarily, the “size” of the animals. However, the minority who considered them alike could not provide a justification (Table 6).

Frequently, the interviewees stated that bats are important in the APA, although the majority could not explain and/or exemplify this importance. Of those who could explain, the responses can be classified based on the type of importance, mainly as: seed dispersers, followed by control of vectors/synanthropic animals, general importance, and others. In contrast, a minority stated and could explain that bats had no importance on the island (Table 7).

Regarding diseases, the interviewees frequently stated they believe that bats can transmit diseases to humans, primarily citing rabies. Some residents believe that bats could also cause diseases to domestic or livestock; however, the majority could not inform the name of an illness. Nevertheless, among those who responded, rabies was once again the most cited (Table 8).

Regarding bat shelters, there was no significant difference ($p=0.3613$) between the interviewees who knew ($n=55$; 45.83%) and those who answered they did not know ($n=65$; 54.17%). However, among those who exemplified the shelters, both natural and artificial shelters could be identified.

Of the natural shelters reported, as the following trees or plants were mentioned: shelters under green or old banana leaves (*Musa* spp.) or in the “banana tree eye,” that is, the location from which the green leaves of the banana tree emerge, lemon tree (*Citrus* spp.), palm tree, coconut tree, murumuru palm (*Astrocaryum murumuru* Mart.), munguba (*Pachira aquatica* Aubl.), buçu palm that covers houses (*Manicaria saccifera* Gaertn.), buriti palm leaf (*Mauritia flexuosa* L.), and kapok tree (*Ceiba pentandra* L.), as well as fallen, leaning, or crooked trees along the riverbanks, hollow trees, tree trunks, and dry stumps.

Regarding the artificial shelters, the following were reported: abandoned houses or under construction, interior of a bathroom in an unoccupied house, house attics and parts of lined house dependencies, bathroom of an inactive restaurant, external wall of houses, house roof and roof edge, house veranda, *malocas*, little-used kitchen, house of temporary workers, under the floor of an inn restaurant, under a bridge along the stream providing access to the church, active and semi-active boat, interior of a church, and a celebration shed annexed to the church. On that occasion, non-hematophagous bats were visually identified, individually or lined up, belonging to the families Phyllostomidae Gray, 1825 and Emballonuridae Gervais, 1856 (genera *Saccopteryx* Illiger, 1811 and *Rhynchonycteris* Peters, 1867).

Discussion

Sociodemographic aspects

The distribution of the residences on Combu Island, predominantly concentrated along the Combu Creek, where the majority of the interviews occurred, and along the riverbanks, reflecting a common pattern in riverine communities, where proximity to water is essential for transportation and subsistence.

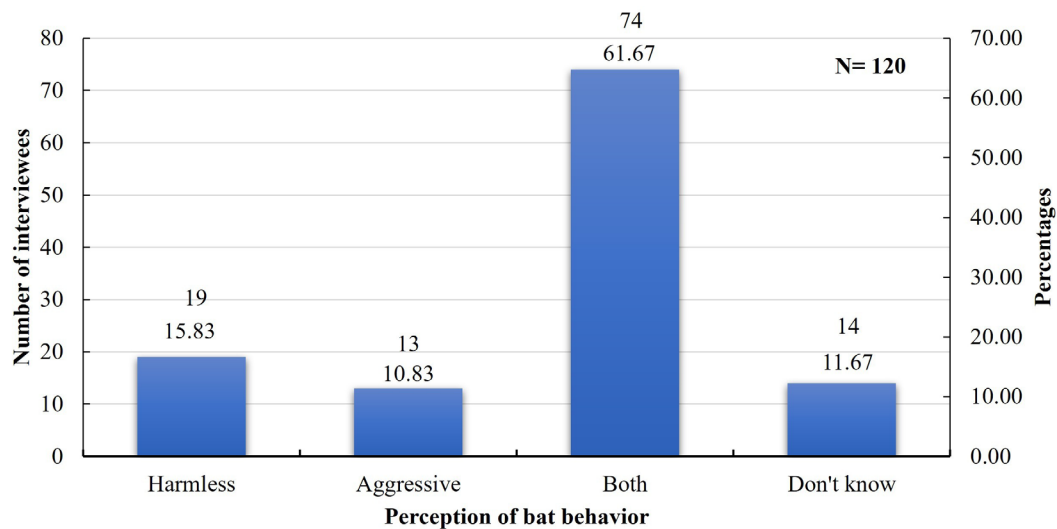


Figure 4 – Distribution of the residents who consider bats harmless and/or aggressive on Combu Island.

Table 4 – Distribution of the residents regarding their knowledge of beliefs, healing mixtures, and myths involving bats on Combu Island.

Variable	n	%	p-value
Do you know any myth/legend about bats?			
Yes	11	9.17	<0.0001
No	109	90.83	
If “Yes,” which myths/legends?			
“Dracula or vampire turns into a bat or transforms into a man with wings”	7	63.64	-
“The bat fans its wings over the spot it will bite to anesthetize the area”	2	18.18	
“Heard from a grandmother that when a bat enters the house, you must call it out loud by the name ‘dry straw’ so that the bat leaves”	1	9.09	
“Bat turns into a rat”	1	9.09	

This settlement pattern observed in the study may influence access to health services, directly impacting the dissemination of health and environmental information (Heufemann et al., 2024).

The gender distribution among the interviewees, with a slight female predominance, may reflect the central role of women in community life on Combu. This active participation influences the perception and transmission of knowledge regarding the local fauna, including bats, as Amazonian women frequently defend the territory and reproduce practices that connect the community with the forest challenging the view of the Amazon as a space to be exploited (Sempértgui, 2020). However, the absence of a significant difference between the sexes suggests that both men and women share similar experiences and perceptions regarding bats, indicating a uniformity in beliefs and in knowledge within the community.

Table 5 – Distribution of the residents regarding the knowledge of the bats’ feeding habits on Combu Island.

Variable	n	%	p-value
Do you know the feeding habits of bats?			
Yes	113	94.17	<0.0001
No	7	5.83	
Which foods are used by bats?			
“Blood”	22	19.47	<0.0001
“Fruits” ^a	6	5.31	
“Insect”	1	0.88	
“Seed”	1	0.88	
“Fruit ^a and blood”	59	52.21	
“Blood and flowers”	2	1.77	
“Blood and fish” or “Blood and insect”	2	1.66	
Three to four foods cited (fruit, blood, fish, insects, small animals, seeds, greens)	20	17.70	

^aThe banana was the most referenced fruit by the interviewees, mainly when stored inside the houses to ripen.

The significant presence of children in the family nucleus of the interviewees on Combu highlights the importance of educational efforts directed to this age group, considering their vital role in the future of the community and in the intergenerational transmission of knowledge. Despite the existence of elementary schools on the island, it is uncertain that formal education alone ensures that children achieve the same level of environmental understanding as their parents, especially on topics such as chiropterofauna, if the school curriculum does not incorporate traditional knowledge and local ecological relevance.

Table 6 – Distribution of the residents regarding the similarity of bats on Combu Island.

Variable	n	%	p-value
Do you think all bats are the same? ^a			
Yes	21	17.50	0.0001
No	89	74.17	
Don't know	10	8.33	
If "Yes," why?			
"Thinks they are all the same in Pará"	1	4.76	0.0001
"Because they all feed on blood"	1	4.76	
Could not explain	19	90.48	
If "No," in what ways are bats different?			
"Size and color"	27	30.34	0.0001
"Size"	23	25.84	
"Color"	6	6.74	
"Size and face"	2	2.24	
Three or more differences (size, color, face, teeth, wings, diet)	5	5.62	
Others*	13	14.61	
Could not explain	13	14.61	

^aDifferentiation in response regarding feeding habits was considered; *there was no reference to morphological aspects, only that they differ in terms of diet, species, and environment.

Table 8 – Distribution of the residents regarding the perception of disease transmission to humans and animals by bats on Combu Island.

Variable	n	%	p-value
Do you believe bats cause any disease to people?			
Yes	105	87.50	<0.0001
No	4	3.33	
Don't know	11	9.17	
If "Yes," which diseases?			
Rabies	40	38.10	<0.0001
Do not remember	28	26.67	
Do not know	35	33.33	
"Yellow fever, mycosis, athlete's foot, and monkeypox, because they stay together"	1	0.95	
"Cancer, because they suck blood from other animals that have toxins"	1	0.95	
Do you believe bats cause any disease to animals?			
Yes	82	68.91	<0.0001
No	4	3.36	
Did not know	33	27.73	
If "Yes," which diseases?			
Rabies	26	31.71	<0.0007
Did not remember	14	17.07	
Could not say	42	51.22	<0.0001

Table 7 – Distribution of the residents regarding the perception of the importance of bats on Combu Island.

Variable		n	%	p-value
Do you think bats have any importance on Combu island?				
Yes		55	45.83	0.0036
No		25	20.83	
Don't know		40	33.33	
If “Yes,” what is the explanation?				
Seed dispersal	“They sow, disperse seeds, eat fruit, help the forest reproduce by carrying fruit and sowing, disperse or spread seeds after eating fruit, carry the fruit of the Paxiúba ^a , plant seeds after eating fruit, e.g., Guava tree ^b . They sow seeds by defecating in various places. They plant seeds on the island”	16	29.09	0.0001
Vector or synanthropic animal control	“They eat insects, mosquitoes, rats, venomous insects”	5	9.09	
General importance	“Ecological, balance of nature, food chain, all animal species have importance”	4	7.27	
Other	“They act like bees, they eat little because they are different from monkeys that eat a lot, and they couldn’t remember”	2	3.64	
Could not explain	-	28	50.91	
If “No,” what is the explanation?				
“They only cause damage,” “They bring no benefit at all,” “They’re an animal almost nobody cares about,” “Nobody talks about them,” “They’re not that important,” “Because they are dangerous”		6	24.00	0.0093
Could not explain		19	76.00	

^a*Socratea exorrhiza* (Mart.) H. Wendl.; Arecaceae; ^b*Psidium guajava* L.; Myrtaceae.

In this context, environmental education emerges as a key tool to fill this gap, since studies such as that of Castilla et al. (2020) indicate that the positive perception regarding bats increases with age and educational level, reinforcing the need for educational interventions starting from childhood.

Teaching about the role of bats as pollinators and insect controllers can influence families and communities, promoting a cultural shift toward valuation and protection. Thus, school programs that incorporate local biodiversity can correct erroneous perceptions and form a new generation of conservation advocates.

In riverine communities, environmental education is essential to ensure a sustainable coexistence with the local fauna, including bats, focusing on traditional management practices, on the respect for natural cycles, and on the importance of bats for the health of the ecosystem on which the community depends (Castilla et al., 2020; Caiza-Villegas et al., 2024).

Plant extractivism, which is predominant on the island, is certainly linked to a practice rooted in the local culture, associated with the sustainable use of natural resources, for example, *açaí*, and to the biodiversity on Combu. The coexistence with bats occurs through the contact with the natural shelters of these animals during their activities. It is emphasized that the extractivist profile of the riverine occurs since the colonial period, maintaining the base of the economy in the Amazon (Fernandes and Moser, 2021). In this aspect, bats play a role of great relevance in this ecosystem, as they act as pollinators and seed dispersers, especially of plants of economic and ecological importance, for example, the Arecaceae, Malvaceae, and Musaceae families (Bredt et al., 2012), present on the island.

On the other hand, the housewives, the second category of activity on Combu, familiarize themselves with bats through domestic interactions and extractivist activities, influencing their perception of the behavior of these animals. In this context, it is emphasized that factors such as age, educational level and experiences with bat-related diseases shape the knowledge and attitude of these individuals, indicating that the perception of bats is not uniform, and may vary according to individual and contextual factors (Hassan et al., 2020).

Ecoepidemiological aspects

The results obtained in this study demonstrated a predominance of residents who have seen bats at some point in their lives, either inside or outside their residences. However, the responses regarding the fear of bats were divided among the interviewees, yet it was associated more often with the possibility of aggression and/or of contracting diseases caused by these animals, which evidences fear, misinformation, and the belief in myths that contribute to the formation of negative attitudes toward bats, reinforcing the need for environmental education to demystify these perceptions (Boso et al., 2020; MacFarlane and Rocha, 2020).

Furthermore, for the minority of the interviewees, the fear was associated with the phenotype of bats and other aspects, which was

observed in phrases such as: “an ugly animal,” “I do not like bats,” and “animal that causes disgust,” all possibly related to the appearance and absence of beauty, which corroborates with observations by Castillo-Huitrón et al. (2020), stating that only beautiful and attractive animals that cause “positive” emotions (for example, happiness and surprise) receive special attention, driving *in situ* and *ex situ* conservation actions.

In the perception of the interviewees, bats can be harmless or aggressive, which would depend, apparently, on someone “messing with them or not,” and, therefore, it would be best not to disturb them. This perception of the aggressiveness of the bats is usually linked to the lack of knowledge, previous experiences, and myths, which can be demystified through environmental education actions (Hoffmaster et al., 2016; Boso et al., 2020; Castilla et al., 2020). Corroborating this perspective, the fact that no interviewee on the island mentioned the use of bats in rituals, beliefs, or mixtures with curative purposes suggests that misinformation, and not deep cultural practices, is one of the main factors that shape the negative perception about these animals.

The presence of bats in homemade mixtures does not seem to fit within the riverine culture, at least on Combu, as they are usually composed of parts or the whole body of venomous animals and arthropods (Silva, 2014). As for the legends and/or myths involving bats on the island, although diminutive, they may formulate negative perceptions against bats (Low et al., 2021; Ejotire et al., 2022), but they represent a universe of possibilities for research on this topic, due to their profound relationships with nature that poetically fertilize the imagination and offer explanations regarding the human relationship with the environment (Ribeiro and Silva, 2020).

On Combu, the perception regarding the feeding habits of bats was centered on the binomial “fruits and blood” as the main foods. Bananas stored at home, usually in bunches or clusters, are the most sought-after fruit by the bats that routinely enter the houses during the night, therefore generating waste, as the bananas with signs of animal bites cannot be consumed by the residents.

In general, the interviewees expressed doubts about whether frugivorous and hematophagous bats are distinct species or whether they can consume both foods, reflecting a simplification of the complex feeding ecology of bats, where specialization predominates. As the study by Potter et al. (2021) demonstrates, only the family Phyllostomidae, with over 180 species, exhibits a remarkable diversity of diets, which may lead to the mistaken perception that a single bat would be capable of consuming both fruits and blood.

Are bats not all the same? The interviewees on Combu perceive the diversity among bats, highlighting morphological distinctions such as size and color, mainly through personal observation or reports of third parties. This perception of diversity is considered superficial compared to the knowledge of communities with greater interaction with these animals. Furthermore, although there is awareness about different

types of bats, the knowledge regarding their diets and ecology is limited, therefore education and awareness is essential for a more complete understanding of the diversity of bats, beyond the visual characteristics (Tataw et al., 2024).

On Combu Island, the interviews showed that, although bats are recognized for their ecological importance as seed dispersers, there is also concern regarding diseases such as rabies. This balance between ecological recognition and fear of diseases reflects local complexities, similar to what was observed by Tataw et al. (2024), where knowledge regarding bats coexists with misconceptions about public health. Ejotire et al. (2022) demonstrated, during a study of negative perception aggravated by the SARS-CoV-2 pandemic, that awareness campaigns can be effective tools to protect bats in the short term.

To mitigate the fear and stigmas associated with bats, the application of “citizen science” in local Environmental Education actions is suggested, uniting empirical knowledge to academic data collection (Sheldrick et al., 2026). Carefully designed participatory projects usually improve public understanding and decrease negative perceptions (Barlow et al., 2015), acting as a transformative tool that converts the fear of zoonoses into ecological belonging, making the community a protagonist in conservation.

The interviewees from Combu Island demonstrated extensive knowledge about bat shelters, citing natural and artificial locations. Studies suggest that communities near conservation areas focus more on natural shelters (Tataw et al., 2024) and that conservation strategies should be adapted, considering the protection of natural shelters and the management of artificial shelters in urban and rural areas (Ninsii-ma et al., 2024; Tataw et al., 2024).

Regarding natural shelters, the interviewees reported occasions of shelter destruction through felling and fire, when many bats were detected, and that they apparently associated them with *D. rotundus*. However, the routine presence of bats inhabiting the external walls of the houses does not seem to bother the residents of the island, for example, the main most visualized genera (*Rhynchonycteris* and *Saccolpteryx*), which are insectivorous animals and of great distribution including in Pará, and can be found in natural and artificial shelters (Reis et al., 2017).

Conclusion

This pioneering study on the environmental perception of chiroptero-fauna in the Environmental Protection Area (APA) of Combu Island offers valuable data that can serve as a base for the management bodies of the APA and its management council in the development of actions aimed at the protection of the chiropteran fauna on the island. The destruction of entire bat colonies, one of the main components of the ecosystem of the island, may predispose to a significant imbalance in the ecoepidemiological chain, affecting the local biodiversity and the essential ecosystem services that bats provide, such as seed dispersal and the control of insect populations.

The perception of the residents regarding the ecological importance of bats is a fundamental point that needs to be expanded. However, the implementation of educational campaigns, utilizing folders, posters, and booklets distributed at strategic points such as inns, restaurants, and community centers, can also increase the awareness about the relevance of these animals. By disseminating clear and accessible information, the Combu APA not only reinforces the recognition of the importance of bats for the balance of the ecosystem but also promotes a more harmonious coexistence between the inhabitants of the island and the local fauna.

Furthermore, the robust and priority incorporation of environmental education in the schools of the island, associated to participatory methodologies such as citizen science, is essential. Practical workshops that encourage safe contact with nature evidence bats as allies in the ecological balance and in the promotion of human health, by minimizing the use of chemical interventions in pest control. This integration demystifies stereotypes and the fear of diseases, awakening in children and youth the need for protection of these mammals and cultivating a future generation with a modified, conscious, and engaged perception in environmental preservation.

Finally, it is essential that the preservation actions be accompanied by continuous research that monitors the bat population and the health of the ecosystem of the island. Furthermore, partnerships with academic and environmental institutions can provide the technical support necessary for the implementation of effective conservation measures, guaranteeing that the Combu APA continues to be an example of sustainable management and protection of the biodiversity in the Amazon.

Author's Contributions: Silva, N. W. F.: conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; visualization; writing - original draft; writing - review & editing. Braga, C. E. S.: formal analysis; funding acquisition; project administration; supervision; writing - review & editing. Gutjahr, A. L. N.: formal analysis; funding acquisition; methodology; project administration; supervision; validation; writing - original draft; writing - review & editing.

Conflicts of interest: the authors declare no conflicts of interest.

Funding: none.

Declaration of the use of AI tools: During the preparation of this manuscript, the AdaptOne platform was used for support in formatting adjustments, standardization of bibliographic references and identification of grammatical inconsistencies. All the suggestions provided by the tool were evaluated, reviewed and edited by the group of authors, which assumes full responsibility for the final content.

References

- Bardin, L., 2011. *Análise de conteúdo*. Edições 70, São Paulo.
- Barlow, K.E.; Briggs, P.A.; Haysom, K.A.; Hutson, A.M.; Lechiara, N.L.; et al., 2015. Citizen science reveals trends in bat populations: The National Bat Monitoring Programme in Great Britain. *Biological Conservation*, v. 182, 14-26. <https://doi.org/10.1016/j.biocon.2014.11.022>.
- Bernard, E.; Tavares, V. C.; Sampaio, E., 2011. Compilação atualizada das espécies de morcegos (Chiroptera) para a Amazônia Brasileira. *Biota Neotropica*, v. 11, (1), 35-46. <https://doi.org/10.1590/S1676-06032011000100003>.
- Boso, A.; Alvarez, B.; Pérez, B.; Imio, J.C.; Altamirano, A.; et al., 2020. Understanding human attitudes towards bats and the role of information and aesthetics to boost a positive response as a conservation tool. *Animal Conservation*, v. 24, (6), 937-945. <https://doi.org/10.1111/acv.12692>.
- Bredt, A.; Araújo, F.A.A.; Caetano Junior, J.; Rodrigues, M.G.R.; Yoshizawa, M.; et al., 1998. Morcegos em áreas urbanas e rurais: manual de manejo e controle. Fundação Nacional de Saúde, Brasília, 117 p.
- Bredt, A.; Uieda, W.; Pedro, W.A., 2012. Plantas e morcegos: na recuperação de áreas degradadas e na paisagem urbana. *Rede de Sementes do Cerrado*, Brasília, 273 p.
- Burgin, C.J.; Colella, J.P.; Kahn, P.L.; Upham, N.S., 2018. How many species of mammals are there? *Journal of Mammalogy*, v. 99, (1), 1-14. <https://doi.org/10.1093/jmammal/gyx147>.
- Caiza-Villegas, A.; Ginn, F.; Hoven, B., 2024. Learning to live with synanthropic bats: Practices of tolerance and care in domestic space. *Social & Cultural Geography*, v. 25, (6), 909-927. <https://doi.org/10.1080/14649365.2023.2209054>.
- Castilla, M.C.; Campos, C.; Colantonio, S.; Díaz, M., 2020. Perceptions and attitudes of the local people towards bats in the surroundings of the big colony of *Tadarida brasiliensis*, in the Escaba dam (Tucumán, Argentina). *Ethnobiology and Conservation*, v. 9, 1-14. <https://doi.org/10.15451/ec2020-03-9.09-1-14>.
- Castillo-Huitrón, N.M.; Naranjo, E.J.; Santos-Fita, D.; Estrada-Lugo, E., 2020. The importance of human emotions for wildlife conservation. *Frontiers in Psychology*, v. 11, 01277. <https://doi.org/10.3389/fpsyg.2020.01277>.
- Clare, E.L.; Oelbaum, P.J., 2024. The diets of bats: Think outside the guild. In: Russo, D.; Fenton, B. (Eds.), *A natural history of bat foraging* (pp. 233-260). Academic Press. <https://doi.org/10.1016/B978-0-323-91820-6.00013-9>.
- Creswell, J.W.; Clark, V.L.P., 2015. *Pesquisa de métodos mistos*. Penso, Porto Alegre.
- Ejotre, I.; Reeder, D.M.; Matuschewsk, K.; Kityo, R.; Schaer, J., 2022. Negative perception of bats, exacerbated by the SARS-CoV-2 pandemic, may hinder bat conservation in Northern Uganda. *Sustainability*, v. 14, (24), 16924. <https://doi.org/10.3390/su142416924>.
- Fernandes, J.S.N.; Moser, L., 2021. Comunidades tradicionais: a formação socio-histórica na Amazônia e o (não) lugar das comunidades ribeirinhas. *Revista Katálysis*, v. 24, (3), 532-541. <https://doi.org/10.1590/1982-0259.2021.e79717>.
- Gil, A.C., 2019. *Métodos e técnicas de pesquisa social*. 7th ed. Atlas, São Paulo.
- Hassan, M.M.; Kalam, A.; Alam, M.; Shano, S.; Faruq, A.A.; et al., 2020. Understanding the community perceptions and knowledge of bats and transmission of Nipah virus in Bangladesh. *Animals*, v. 10, (10), 1814. <https://doi.org/10.3390/ani10101814>.
- Heufemann, N.E.C.; Ferla, A.A.; Schweickardt, J.C.; Fonseca, F.R., 2024. Access to health services: territory, flows and borders of riverside populations of Boa Vista do Ramos, Amazonas, Brazil. *Saúde e Sociedade*, v. 33, (3), e230392pt. <https://doi.org/10.1590/S0104-12902024230392en>.
- Hoffmaster, E.; Vonk, J.; Mies, R., 2016. Education to action: improving public perception of bats. *Animals*, v. 6, (1), 6. <https://doi.org/10.3390/ani6010006>.
- Instituto de Desenvolvimento Florestal e da Biodiversidade do Estado do Pará (IDEFLOR-BIO), 2021. Área de proteção ambiental da Ilha do Combu. IDEFLOR-BIO (Accessed May 4, 2023) at: <https://ideflorbio.pa.gov.br/area-de-protecao-ambiental-da-ilha-do-combu-apa-da-ilha-do-combu/>.
- Laurindo, R.S.; Novaes, R.L.M., 2015. Desmitificando os morcegos. ISMECN, Monte Belo, 27 p. [Environmental Education Booklet Series] (Accessed May 4, 2023) at: https://www.researchgate.net/publication/303837222_Desmitificando_os_morcegos.
- Low, M.R.; Hoong, W.Z.; Shen, Z.; Murugavel, B.; Mariner, N.; et al., 2021. Bane or blessing? Reviewing cultural values of bats across the Asia-Pacific region. *Journal of Ethnobiology*, v. 41, (1), 18-34. <https://doi.org/10.2993/0278-0771-41.1.18>.
- MacFarlane, D.; Rocha, R., 2020. Guidelines for communicating about bats to prevent perception in the time of COVID-19. *Biological Conservation*, v. 248, 108650. <https://doi.org/10.1016/j.biocon.2020.108650>.
- Mora, M.C.G.; Vera-Monroy, S.P.; Mejía-Camacho, A.; Rueda, W.J.G., 2021. Perception channels and cognitive styles: opponents, followers or learning allies? *Heliyon*, v. 7, (2), e06242. <https://doi.org/10.1016/j.heliyon.2021.e06242>.
- Moraes-Ornellas, V.S.; Ornellas, R.B., 2023. Etnoconservação de morcegos em unidades de conservação de uso sustentável da Amazônia brasileira. *Biodiversidade Brasileira*, v. 13, (2), 1-14. <https://doi.org/10.37002/biodiversidadebrasileira.v13i2.2402>.
- Morales, J.; Firestone, C., 2023. Philosophy of perception in the psychologist's laboratory. *Current Directions in Psychological Science*, v. 32, (4), 307-317. <https://doi.org/10.1177/09637214231158345>.
- Ninsiima, L.R.; Nyakarahuka, L.; Kisaka, S.; Atuheire, C.G.K.; Mugisha, L.; et al., 2024. Knowledge, perceptions, and exposure to bats in communities living around bat roosts in Bundibugyo district, Uganda: implications for viral haemorrhagic fever prevention and control. *BMC Infectious Diseases*, v. 24, 311. <https://doi.org/10.1186/s12879-024-09162-x>.
- Nogueira, M.R.; Lima, I.P.; Moratelli, R.; Tavares, V.C.; Gregorin, R.; Peracchi, A.L., 2014. Checklist of Brazilian bats, with comments of original records. *Check List*, v. 10, (4), 808-821. <https://doi.org/10.15560/10.4.808>.
- Pessoa da Silva, F.; Marco Júnior, P., 2023. O papel das áreas protegidas na salvaguarda da diversidade de morcegos no Brasil. *Biodiversity and Conservation*, v. 32, 2909-2924. <https://doi.org/10.1007/s10531-023-02635-6>.
- Potter, J.H.T.; Davies, K.T.J.; Yohe, L.R.; Sanchez, M.K.R.; Rengifo, E.M.; et al., 2021. Dietary Diversification and Specialization in Neotropical Bats Facilitated by Early Molecular Evolution. *Molecular Biology and Evolution*, v. 38, (9), 3864-3883. <https://doi.org/10.1093/molbev/msab028>.
- Reis, N.R.; Peracchi, A.L.; Batista, C.B.; Lima, I.P.; Pereira, A.D., 2017. *História Natural dos Morcegos Brasileiros: Chave de identificação de espécies*. Technical Books, Rio de Janeiro, 416 p.
- Ribeiro, M.A.; Silva, J.C., 2020. Mitos ribeirinhos: múltiplos espaços na Amazônia. *Revista Presença Geográfica*, v. 7, (2), 76-90. <https://doi.org/10.36026/rpgeo.v7i2.5599>.
- Rodrigues, K.; Sereia, D.A.O.; Obara, A.T., 2023. Estudos de percepção ambiental em Unidades de Conservação: uma revisão sistemática da literatura. *Revista Ambiente & Educação*, v. 28, (2), 1-31. <https://doi.org/10.14295/ambeduc.v28i2.15768>.

Santos, L.B.; Sousa, R.O.; Ferreira, L.S.S.; Nápolis, P.M.M., 2022. Estudos sobre percepção ambiental no Brasil: Uma revisão. *Revista Brasileira de Educação Ambiental*, v. 17, (3), 131-148. <https://doi.org/10.34024/revbea.2022.v17.12270>

Santos, M.A.P., 2020. A percepção ambiental como ferramenta estratégica de gestão em Unidades de Conservação. *Revista Eletrônica Uso Público em Unidades de Conservação*, v. 8, (13), 42-50. <https://doi.org/10.47977/2318-2148.2020.v8n13p42>.

Sempértegui, A., 2020. Decolonizing the anti-extractive struggle: Amazonian women's practices of forest-making in Ecuador. *Journal of International Women's Studies*, v. 21, (7), 122-138 (Accessed December 23, 2023) at: <https://vc.bridgew.edu/jiws/vol21/iss7/10/>.

Sheldrick, K.; Steven, R.; Fleming, P.A., 2026. Citizen science for bat research and conservation: An international scoping review. *Ecological Solutions and Evidence*, v. 7, (1), e70225. <https://doi.org/10.1002/2688-8319.70225>.

Silva, N.C.F.; Xavier Júnior, S.R.; Corrêa, A.F.; Gomes, M.T., 2025. Matas ciliares da Ilha do Combu: preservação da biodiversidade e desafios da

degradação ambiental. *Periódico Técnico e Científico Cidades Verdes*, v. 13, (40), 306-320. <https://doi.org/10.17271/23178604134020255644>.

Silva, R.M., 2014. Etnozoologia e ofidismo na Área de Proteção Ambiental da ilha do Combu. Master's Thesis, Universidade Federal Rural da Amazônia, Belém (Accessed on: November 15, 2023) at: <https://repositorio.ufra.edu.br/jspui/handle/123456789/752>.

Tataw, G.-N.N.; Maurice, M.E.; Bumtu, K.P.; Nkwatoh, A.F.; Mbi, K.J.; et al., 2024. Leveraging local ecological knowledge for bat conservation: insights from a community-based study in the Ebo Forest Reserve, littoral region of Cameroon. *Journal of Agriculture and Ecology Research International*, v. 25, (5), 7-22. <https://doi.org/10.9734/jaeri/2024/v25i5624>.

Zanini, A.M.; Vendruscolo, G.S.; Milesi, S.V.; Zanin, E.M.; Zakrzewski, S.B.B., 2021. Estudos de percepção e educação ambiental: um enfoque fenomenológico. *Ensaio Pesquisa em Educação em Ciências*, v. 23, e32604. <https://doi.org/10.1590/1983-21172021230127>.