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Faith healing: the threat of "Surucucu" and the local cure of Amazon floodplain dwellers

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Abstract

Background Snakebites are considered a neglected tropical disease responsible for many accidents, some fatal, and are related to poverty. The Brazilian Amazon has the highest incidence of snakebites per inhabitant, with the state of Pará having the most reported cases. For those who have difficult access to hospitals and pharmacies, this issue is even more urgent.

Methods In this research, we worked together with the population of five riverine communities in Aritapera (Santarém-PA), a fluvial island located in the Lower Amazon floodplain (*várzeas*), in order to identify the species of venomous snakes and create a record of snakebites in the region and treatments carried out.

Results Dwellers reported a high frequency of encounters throughout the year and mentioned five venomous ethnospecies, although we identified only *Bothrops atrox*. Approximately 28.7% of the participants had already been bitten, and in 15.8% of the interviews, they mentioned deaths from snakebites. The treatments varied between hospitalization (42.8%), home treatments (23.8%), both together (25.4%) and healers (7.9%). There were cases where no treatment, or just religious treatment, was performed. In general, no serious sequelae were reported. Although home treatments were more common in the past, many people maintained the practice of using them before going to the hospital. Among the most used are Pau X and the fat of the Amazon River Dolphin. The latter appears to be a recent discovery by locals and is considered very efficient both for humans and animals.

Conclusion Difficult access to health centers, a lack of energy to store antivenom and a high rate of encounters with snake place Aritapera dwellers in a vulnerable situation regarding snakebite accidents. In this context, they discovered treatments that improved their well-being until hospitalization. As the Amazon River dolphin is an endangered species, the use of its fat requires attention. In this sense, the dissemination of this knowledge is important to encourage studies that investigate which properties of this fat act as counterpoisons. By discovering substitutes that can be incorporated in other rural and remote communities, an economic and ecologically viable option for the health of residents can be promoted, in addition to valuing traditional knowledge.

Keywords Natural medicine, Home treatment, Snake, Amazon River dolphin fat, Zootherapy, Folk medicine, Snakebite accident, *Várzeas*, Jararaca, *Bothrops atrox*

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Background

Brazil has 412 snake species [1]. Among them, 66 are venomous, distributed in six genera: *Bothrocophias* (2 species); *Bothrops* (27 species); *Crotalus* (1 species) and *Lachesis* (1 species)—family Viperidae—and *Leptomicrurus* (3 species) and *Micrurus* (32 species)—family Elapidae [1, 2]. According to the World Health Organization, snakebites are considered a neglected tropical disease [3]. In 2022, the Brazilian Ministry of Health [4] reported 29,543 accidents caused by snakes, recorded on the Notifiable Diseases Information System (Sistema de Informação de Agravos de Notificação—SINAN).

Research shows that snakebite accidents are related to poverty [5] and that the Brazilian Amazon has a high incidence of snakebites per inhabitant [6]. In 2022, the incidence of ophidism in the northern region of Brazil was 55.26/100,000 inhabitants—approximately 4.1 times the incidence coefficient of the whole country [4]. According to the Brazilian Ministry of Health (2023), this same year, Pará was the state that reported most cases of snakebites (5695 cases – 19.28%), followed by Bahia (3002–10.16%) and Minas Gerais (2880–9.75%).

Species of the genus *Bothrops* are among the most widespread snakes in northern Brazil and are responsible for most cases of snakebites [6, 7]. The victim's clinical condition depends on the size and species of the snake responsible for the bite, the part of the body that was affected, the person's age and health status, and the accessibility to health care and waiting time for medical treatment [3, 6]. For those who have difficult access to hospitals and pharmacies, this subject is even more urgent.

In the year 2022, 14 snakebite deaths were recorded in the state of Pará, the highest number of snakebite deaths reported in the country [4]. The number of accidents is influenced by the number of snakes, which, in turn, is related to the suitable environment for the development of the species, climate, and human population density [6]. However, underreporting is also a reality, especially in rural areas such as riverine and indigenous communities [8]. Difficult accessing health centers, deaths along the way, and carrying out treatments other than snake antivenom are factors that contribute to data underestimation, resulting in a percentage that underrepresents the true incidence of snakebite accidents in the population [3, 8].

Cities situated in the Amazon Basin, such as Santarém, Cametá, Breves, Marabá and Portel, all in Pará State, are among those that reported most cases of bothropic accidents in Brazil [4]. Santarém, western Pará, has already been classified as the city of Pará that stand out with the higher number of notification of accidents with venomous animals, being the genus *Bothrops* responsible for

90% of these cases [3]. Additionally, there are several traditional communities in Santarém that have limited access to city centers, such as the riverine community of Aritapera.

The Aritapera region has a high encounter rate with snakes, mainly with the genus *Bothrops* [9]—locally named “surucucu”, which leaves dwellers in a vulnerable situation. As an option to overcome this scenario, they usually resort to natural treatments [2, 3]. In the literature, there are many citations about the use of plants in snakebite events, but few have pharmacologically tested their properties [2, 3, 10, 11]. However, those that were tested indeed helped to neutralize the activities of the venom [3, 10, 11].

In an ethnobotanical survey conducted in communities of Santarém by Silva et al. (2017), among the 24 species of plants cited as possessing anti-ophidic properties, twelve were able to reduce, in different percentages, the hemorrhagic activity induced by *Bothrops* sp. envenomation. The survey of phytotherapy and other natural treatments used for snakebites is of short importance to the well-being and survival of rural residents. In this sense, studies developed together with traditional people are fundamental. The use of folk medicine, or traditional medicine, for different illnesses is integrated to the life experiences of these people for generations as the result of a process of discovery that continues to evolve [12, 13].

In this paper, we intend to analyze the relationships between floodplain dwellers in the Aritapera region and local venomous snake species. Through case history analysis, we intend to better understand the scenario of dwellers in relation to ophidic accidents and the importance of the use of traditional medicine in cases of snakebites. To this end, three main objectives were considered: (i) to determine the species and folk categories (“ethnospecies”) of venomous snakes in the region; (ii) to make a record of snakebites—recording the meeting situation, number of cases, treatment carried out (natural or hospitalization), number of deaths and other information that can improve the research; and (iii) to relate the natural treatment realized to the victims' symptoms and sequelae.

Methods

Study area

Aritapera is a fluvial island located in the Lower Amazon floodplain (2°06'–2°09'S/54°34'–54°46'W), approximately 50 km from Santarém [14, 15]. The floodplain areas have undergone a historical process of sedimentation, in which the “white waters” from the Amazon River—turbid and muddy water, loaded with particles—fill the valleys with their own sediments, forming a floodable and constantly modified terrain, the so-called floodplain [16]. The river's

flood/dry cycle directly interferes with the dynamics of local fauna [e.g., 17–19], affecting many aspects of the lives of dwellers.

The region of Aritapera includes 13 riverine communities: Ilha de São Miguel; Costa do Aritapera; Mato Alto; Água Preta; Carapanatuba; Centro do Aritapera; Enseada do Aritapera; Boca de Cima; Cabeça D’Onça; Surubiaçu; Centro do Surubiaçu; Ponta do Surubiaçu; and Quilombo. The houses in these communities do not have electricity, depending on generators (if any), and it takes dwellers 4 to 7 h to reach the city, depending on the community or type of vessel. Due to time constraints and available funding for the project, the research was developed in five out of these 13 communities, namely: Água Preta, Carapanatuba, Centro do Aritapera, Costa do Aritapera and Cabeça D’Onça (Fig. 1).

Data collection

Data were collected in 2023 during visits carried out between February 18 and 25 and April 8 to June 4 and in a return in October. Thus, immersion in the communities included the end of the flood, the flood, the beginning of the river’s ebb (1st campaign) and the height of the drought (return). Before immersion, the presidents of all communities provided authorization for entry and research. The immersion took between 5 to 14 days in each community, talking to dwellers, totaling 70 days of interaction.

In this meantime, 215 people were interviewed. Due to the local seasonality of river water levels, some residents have the custom of relocating to the mainland during the flood season. Therefore, to structure our sample group, all houses inhabited during the data collection period were visited with the help of community members.

The interviews were semi structured; that is, they had a predefined theme around which the dialogs were developed, but the conversation was open to give participants more freedom to narrate their own experiences and knowledge [20]. For this reason, we did not have a minimum or maximum time for the conversation, which could last from a few minutes ($\cong 5$ min) to more than one hour. To avoid identifying participants, the interviews were designated by a combination of uppercase and lowercase letters, which were different for each community and dweller. This project was approved by the Ethics Committee and licensed by Plataforma Brasil (CAAE: 66,400,022.0.0000.0018).

Data organization

The information obtained was spreadsheeted, systematized and separated by themes, aiming to make better use of the subject. The research on venomous snakes revealed five main topics—appearance, encounter,

accidents, treatments and healers—that were divided into minor subtopics (5–9 each). There were carried out 22 interviews in Água Preta, 23 in Carapanatuba, 37 in Centro, 30 in Costa and 27 in Cabeça D’Onça, totaling 139 reports in the five communities. As they were open interviews resembling informal conversations [20], the reports involved an open number of participants, varying between 1 and 4 people in the same interview. Therefore, the percentages presented here are derived from the number of reports collected and not from the number of participants involved.

Species analysis

To learn about venomous snakes of the region, we asked dwellers the names of the folk categories known to them. As, unfortunately, killing snakes is a common practice in many regions [21–24], concomitantly with the interviews, 50-L containers, containing a prepared formaldehyde solution, were left in three communities (Carapanatuba, Costa do Aritapera and Água Preta) so that dwellers could place snakes that perhaps could have been killed during the period. The locations were strategically chosen based on geography and the reported appearances of the snakes. The containers were left in the beginning of June and collected at the end of October.

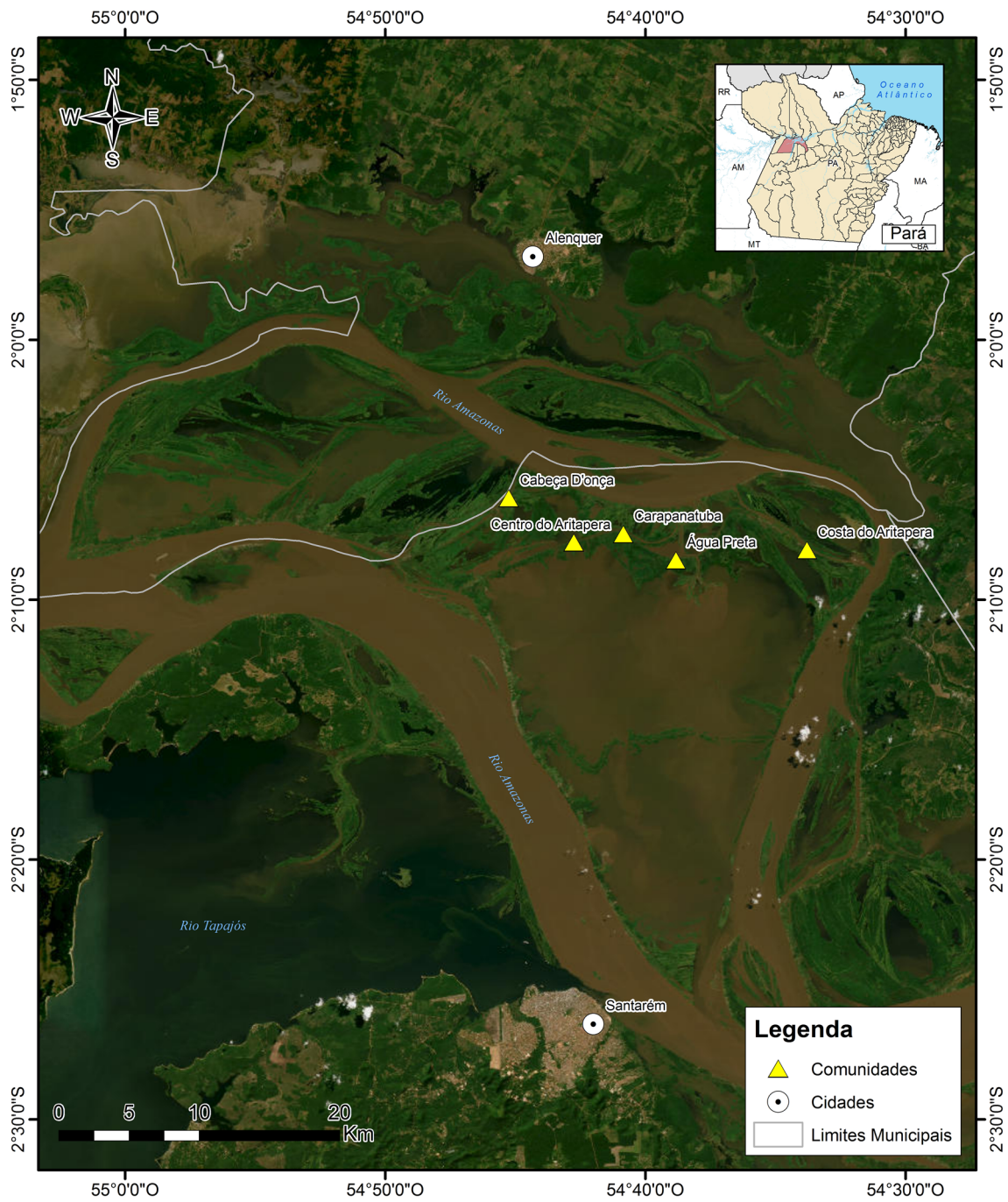
The snakes collected were carried out and analyzed in the Universidade Federal do Oeste do Pará (UFOPA) in collaboration with the Laboratório de Ecologia e Comportamento Animal. Each specimen was measured with the aid of a string and tape measure, and had its sex identified. The following measures were used: head length (HL), head width (HW), interocular distance (ID), snout-vent length (SVL), and tail length (TL). This project has SISBIO license number 86341–1 to work with killed animals.

Results

Accident context

The interviews resulted in a rich repertoire of ethnoherpetological information about local snakes. In general, dwellers mentioned a high frequency of encountering venomous snakes. In all communities, the main folk category cited was “surucucu”, being known, beyond the regular one, more three ethnospecies: surucucu de fogo (*fire surucucu*), surucucu marreca (*teal surucucu*), and rabo de mucura (*mucura’s tail surucucu*). Other venomous snakes mentioned were: *surucucu caninana*, *surucucu papagaio*, one with the same pattern as *Boa constrictor* Linnaeus 1758, and *jararaca d’água* (classified as non-venomous in Cabeça D’Onça).

Encounters with surucucu ethnospecies occur throughout the year. However, up to the date of the interviews, participants highlighted that 2023 was the




 <p>LAENA Laboratório de Análises Espaciais Prof. Dr. Thomas Peter Hurtienne</p>	 <p>UFPA</p>	<p>INFORMAÇÕES TÉCNICAS Fonte: IBGE, 2022; Trabalho de Campo, 2023. Sistema de Coordenadas Geográficas Datum Horizontal: SIRGAS 2000</p>	<p>ELABORAÇÃO Geógrafo: Wellington Fernandes Estagiário: Lucas Melo Data: 21/12/2023</p>
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Fig. 1 Map of the Aritapera region (Santarém-PA), highlighting the communities of Água Preta, Carapanatuba, Centro do Aritapera, Costa do Aritapera and Cabeça D'Oença

year with the fewest meetings. Among the participants who answered about the meeting period ($N=70$), 48.6% said that venomous snakes appear more often in the Amazon summer (dry season), 21.4% in the Amazon winter (flood season), and 30% regardless of the season. During winter, they specified that the encounter usually occurs over river's flood or ebb.

According to participants, this species looks for dry places; during high tide, it stays on tree branches or close to houses. Data showed that 32.3% of the encounters occurred on family farms and 27.8% occurred in houses. Other encounter sites were pathways (16.5%), plants such as branches, bananas trees or marajá (15.8%), "muri", grass brought by river water (4.1%), and fishing and chicken coops (1.5% each). In total, at least 25.9% ($N=36$) of the dwellers had already killed a surucucu ethnospecies.

Considering the five communities together, at least 33 dwellers had already been bitten by one of these ethnospecies; that is, approximately 28.7% of participants who responded this question ($N=115$ —Fig. 2). Furthermore, in 53 interviews, dwellers reported one or more acquaintances who had already been bitten in the region, totaling 77 reports of snakebites (Fig. 2). Among the dwellers or the acquaintance, some were bitten more than once. Overall, this species was not considered aggressive by the dwellers, only biting when bumped.

In 22 interviews (two in Água Preta, three in Carapanatuba, ten in Centro, two in Costa and five in Cabeça D'Onça), the participants mentioned deaths due to snakebite. One victim, who was repeatedly mentioned among the different communities, was the husband of a current dweller of Água Preta, a man in his 70 s, who was bitten approximately 2–3 years ago. Indeed, in 54.8% ($N=17$) of the reported cases, it was specified that the victim was a child or an elderly person and, in one case, a pregnant woman. For the remaining participants, it was either not possible to determine their age (38.7%), or they were in early adulthood or middle-aged (6.45%).

Treatment

The main symptoms mentioned in case of snakebites were pain, swelling and redness of the affected area and blood purging from different locations (bite, old scars, and pores such as hair, eyes, mouth, nails, among others). Some reported difficulty walking and sleeping, mental confusion, and short faints. Treatments, in turn, varied among going to the hospital (42.8%; 27/63), home treatments (23.8%; 15/63) and both (25.4%; 16/63); sometimes, treatments were carried out by healers (7.9%; 5/63). In another 4 interviews not included in this percentage, all in Cabeça D'Onça, participants said they could only be cured by God.

The length of hospital stay varied from 9 h to 18 days, with an average hospitalization of 7.5 ± 4.5 days. For the

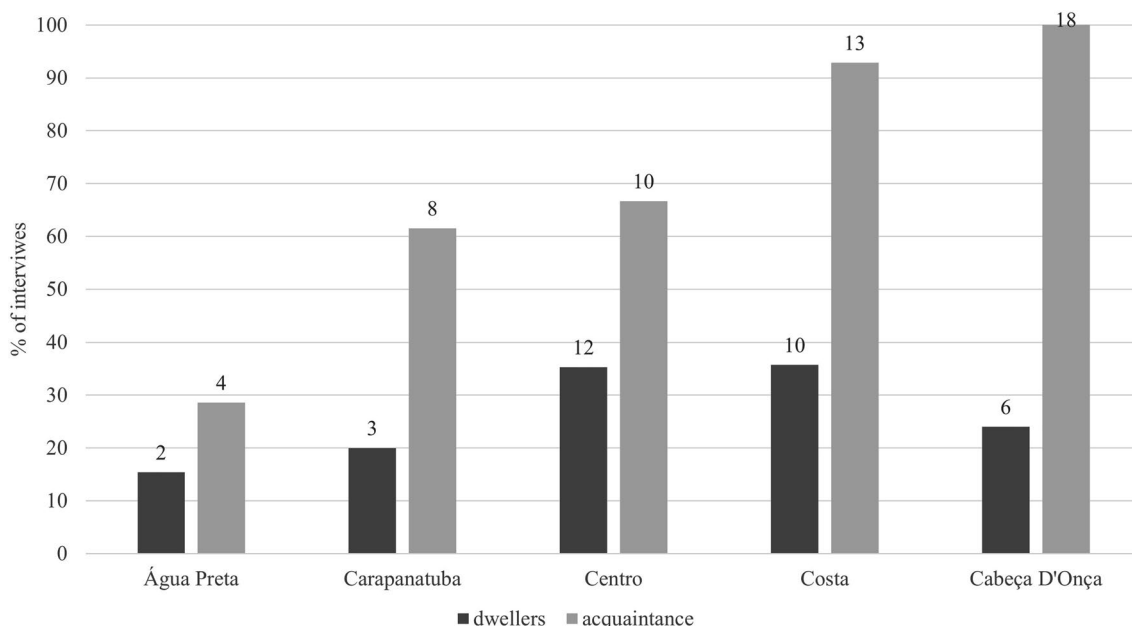


Fig. 2 Number of interviews in which residents said they had already been bitten by a snake (dwellers) or knew someone who had (acquaintance). The numbers above the bars indicate the raw number of positive responses, while the percentage refers to the number of positive responses in relation to the number of interviews that addressed this topic

most part, dwellers usually go to the hospital in Santarém. However, in Cabeça D'Onça, some participants said they preferred the hospital in Alenquer, not only due to the distance (in this case it is closer), but also because it is less crowded. Regardless of the chosen city, they always spend time commuting—it will depend on the facility to find transportation, the kind of transportation, the climate conditions, among others. There were cases in which patients went to hospital hours later or even in the next day.

They used to say that in the past healing depended greatly on faith. However, currently, this trip to the city would be easier due to the *ambulancha*, that is, a speedboat available to the community and used only for medical emergencies.

Among the home treatments, we registered the use of phyto and zootherapeutics. As examples of plant-based products, we have the majority of counterpoisons, such as “Pau X”, “Específico Pessoa” (both in their original names) and cat claws (plants of the Rubiaceae family). Among these, Pau X was the most mentioned, cited in 22.3% of the interviews. The interviewees also commented on the use of plants to make liquid and greased solutions (such as “parra”, a species of vine from the region) or poultices (with a plant like aningas, a macrophyte of the family Araceae). On the other hand, a frequently cited zootherapy was the injectable use of Amazon River dolphin (*Inia geoffrensis* (Blainville, 1817)) fat (mentioned in 12.9% of interviews), whether for human or animal treatment. Other treatments of animal origin mentioned were black stone and little cane toad.

The black stone is made from the shin bone of the ox. After a process of preparation in the fire, the piece of bone (the so-called black stone) would have the capacity to suck out the poison from the person, serving both to snake bite as to stingray sting. After use, the stone must be kept in milk. In a similar way is used the little cane toad (a small, white frog). According to the dwellers, the animal must be placed above the wound; as the frog sucks the poison, it turns purple. More than one frog may be needed until all the poison is removed.

In addition to these treatments, participants mentioned ingesting coffee grounds diluted in water; eating raw eggs with mangerioba juice (*Senna* sp., a shrub from the Leguminosae family); drinking water from the hat (take water from the river with the crown of the hat and drink it); placing a boiled egg on the wound (which acts in a similar way to the cane toad); washing the area with coconut soap and obtaining a Tetanus shot; applying levomenthol-based medicine over the wound (which would be good for all kinds of insect bites); and the classics treatment, such as cutting the bite to remove the venom and making a tourniquet. In an interview, the participants

also reported that if the person is bitten twice in a row, the second snake bite would not cause much damage, as one venom cancels out the other.

Overall, no serious sequelae were reported. For those who still have a problem, it usually occurs according to the moon and can range from swelling and itching near the bite, malaise, and pain. The most problematic cases were those of a dweller from Centro do Aritapera who needed surgery because the blood clotted inside his knee and the father of an elderly dweller from Cabeça D'Onça. In the first case, the dweller said that, because the snake had not eaten anything yet, it injected all the venom into his knee, and that's why it became more swollen. In the second, the interviewee reported that the victim's neighbor, who was drunk on the occasion, carried out the wrong treatment with a plant, resulting in cooking the skin of the victim's foot and worsening the situation.

There have also been cases of snakebites in animals. Dogs, cattle, horses and chickens are among the bitten ones. For large mammals, it was also recommended the application of the Amazon River Dolphin fat. According to dwellers, this treatment was responsible for healing many cattle. Horses, however, were classified as very weak animal for snake bites, being rare saving one. Dogs, in turn, usually have the tip of the ear cut, to bleed the poison out—in addition to administering counterpoison or dolphin fat.

The healers

The participants also mentioned treatment by healers. In total, there were 50 reports about the passage of these “doctors” (term used among the interviewees) in the communities. In 30%, dwellers used their service, whether for themselves, relatives or to their land; in the other 70%, they commented that they knew about the existence of the healers and stated that they passed by but did not take their services. From the reports provided, we could propose a possible genealogical line of the main curators who passed through the region.

All healers appeared to be from the Assis family, except for Neuto, which was more recent, but apparently from another lineage. The Assis family came from Pacoval, a community originated of descendants of enslaved Africans in Brazil historically seeking autonomy and preservation of their culture, known as “quilombo”, in Alenquer–PA. Residents of this community are known for carrying out practices considered exoteric or spiritual. According to reports, Raimundo Assis was the first generation of snakebite healers to pass through the communities, and Didico Assis the most recent. In this middle ground, there is some confusion with the names Francisco Assis and Antônio Assis. It is not known whether it is a lineage of four generations (Raimundo father of

Antônio, grandfather of Francisco and great-grandfather of Didico), or if it is a three-generation lineage and Antônio and Francisco Assis would actually be the same person. In any case, currently all these members have passed away. There was also a mention of Gorete, possibly alive and a sister in the family.

The treatment provided by them can be performed in three ways: before the bite, after the bite, and on the land. People who undergo this procedure before any accident are called healed and become immune to any snakebite. None of the participants could say exactly what the procedure was like, as it is usually done during childhood. However, putting the stories together, it seems to be kind of a prayer, in which the healer drinks something, spits it out and gives it to the patient to drink and, at the end, ties a string in the patient's leg. Some also reported the use of candles, either to place in the patient's mouth, head or on the skin. Furthermore, it is recommended that cured people not kill snakes after that.

The treatment after a snake bite involved, above all, the use of Pau X (Fig. 3). During this procedure, patients said the healers clean a needle with alcohol, cut around the bite to get the poison out and give the patient the counterpoison to drink. Last, the healing of the land consists of driving the snakes out of it. According to reports, if the healers healed one quadrant of the land, the snakes went to another in front or behind it; that is, the quantity decreased in one area and increased in another. No one



Fig. 3 Bottle of Pau X found at Mercadão 2000, a local grocery store in Santarém, PA. There are no details about the composition on the label; it just says that it is made from medicinal herbs. Photo: the author

knew exactly how they did that, but they said that if the healer spat on the snake, the animal would remain still in the coiled position.

Not all interviewees believed in the healing of the land, and some said that healers were deceivers, that they charged too much, or that sometimes took the money and never came back. However, believing or not, there was a consensus that when they went to the region, the number of snakes increased somewhere nearby. However, with the death of the old members, there was a decrease in these practices, due to the distrust in the new healers.

According to those who had already been bitten, the person can feel very thirsty; in these cases, it is recommended to drink only milk. Despite the different types of treatment, warnings of not drinking water after a snakebite accident were common because it can clot the blood. As explained by one participant:

My uncle didn't want to go to the city. It appeared some wound blisters that he pierced with needles. He got fever; he put ice on and drank cold water... that was what killed him. (interview Mrai, Centro do Aritapera—free translation)

Also, according to three reports in Cabeça D'Onça and one in Costa do Aritapera (by a nurse who worked with different indigenous ethnicities), snakebites cause more damage to pregnant and menstruating women due to blood clotting. Also, this last participant added that, in Marubo and Mayoruna ethnicities, women are forbidden from approaching snakebite victims, as the wound would hurt much more if they were close to a pregnant or menstruating woman.

Specimens collected

From the three containers, we collected seven snakes, of which 71.4% (5/7) were venomous; all from *Bothrops atrox* (Linnaeus, 1758) species. The others were *Erythrolamprus poecilogyrus* (Wied-Neuwied, 1824) and *Eunectes murinus* (Linnaeus, 1758). The snakes were deposited by residents who found them in various locations. We had no interference in the process of capturing the animals and did not have awareness or control over the specific circumstance where each animal was found.

We collected three specimens of *B. atrox* on Costa do Aritapera, one in Carapanatuba and one in Água Preta (Table 1); the non-venomous snakes were all collected in Água Preta. The average SVL for *B. atrox* collected was 84.3 ± 46.4 cm. The largest specimen collected was a male with 194.2 cm of SVL, and the smallest a female with 50.5 cm SVL. Females have a lower SVL mean than males ($F = 71.4 \pm 15$ cm X $M = 93.4 \pm 58.2$ cm). Males also had a higher mean of HL (4.4 ± 1.8 cm), ID (1.7 ± 1.5 cm),

Table 1 Measurements of snake specimens collected in the Aritapera region per site

SITE	SPECIES	SEX	HL	ID	HW	SVL	TL
Costa do Aritapera	<i>B. atrox</i>	F	4.0 cm	1.5 cm	3.1 cm	78.0 cm	11.5 cm
Costa do Aritapera	<i>B. atrox</i>	F	5.0 cm	2.3 cm	3.0 cm	85.6 cm	13.9 cm
Costa do Aritapera	<i>B. atrox</i>	M	4.0 cm	1.9 cm	2.0 cm	68.2 cm	3.6 cm
Carapanatuba	<i>B. atrox</i>	M	3.0 cm	1.2 cm	2.0 cm	51.9 cm	9.0 cm
Água Preta	<i>B. atrox</i>	M	3.1 cm	1.2 cm	1.8 cm	61.5 cm	10 cm
Água Preta	<i>B. atrox</i>	M	7.5 cm	2.5 cm	4.5 cm	194.2 cm	29 cm
Água Preta	<i>B. atrox</i>	F	2.8 cm	0.6 cm	1.2 cm	50.5 cm	10.1 cm
Água Preta	<i>E. murinus</i>	M	7.5 cm	2.5 cm	4.5 cm	194.2 cm	29 cm
Água Preta	<i>E. poecilogyrus</i>	F	2.8 cm	0.6 cm	1.2 cm	50.5 cm	10.1 cm

HL head length; ID interocular distance; HW head width; SVL snout-vent length; TL tail length

HW (2.6 ± 1.1 cm) and TL (12.9 ± 9.6 cm), while the mean of females for the same measurements were HL = 3.9 ± 0.9 cm; ID = 1.5 ± 0.7 cm; HW = 2.4 ± 0.9 cm; TL = 11.8 ± 1.6 .

Discussion

Despite five venomous ethnospecies, we only collected the venomous species *Bothrops atrox*, considered the predominant species in some regions of Pará and possibly throughout Amazonia [25]. In this sense, the nomenclature “surucucu” in the Aritapera communities, as well as in other municipalities of the Low Amazon River, is associated with the genus *Bothrops* and not with *Lachesis muta*, as expected [26].

In fact, it is interesting to know that some participants even describe that difference, explaining that “although we call the snake surucucu, it is not what is on the book” and “out there they call jararaca” (free transcription). Another vernacular name used to refer to *B. atrox* is “combóia”, when on the continent, and “trairambóia” (mentioned in Centro do Aritapera and Cabeça D’Onça), although this last one usually is related to *Lepidosiren paradoxa*, a snake-shaped fish [27].

By relating the collected species with their vernacular names and to related literature, we concluded that “surucucu” is an adult of *B. atrox* and *mucura’s tail surucucu* is a juvenile one, once it has the tip of the tail white, remembering a *mucura’s tail* (a marsupial relative of the opossum, from Didelphidae family) [28]. Concerning *teal surucucu*, we could not perform any associations once there were no specimens collected, nor observed in the field, or in literature citation. In turn, *fire surucucu* was equally not seen or collected in the field, but, according to literature, this vernacular name can be related to *Lachesis muta* [25, 29], to *Epicrates cenchria* [26], or to *Chironius scurrula* [30]. However, there is also a possibility of all categories of surucucu be, in fact, some variation of *B. atrox*, since this species has a wide range of colors,

with variations between sexes, life stages and individuals [25].

One way or another, these results show that a more in-depth study relating scientific and vernacular names is essential both for better understanding the region’s biodiversity and for ensuring the safety and well-being of dwellers. Due to fear, people tend to kill snakes, especially when they do not know the species or do not know whether it is venomous or not [23, 24, 26]. In the same way, dwellers from Aritapera tended to kill snakes, considering most of them venomous, as highlighted by a participant from Centro: “All snake, all venomous” (free translation). In relation to *B. atrox*, due to the threat they represent, for some, it is almost a crime to meet one and not kill it.

The encounter with *B. atrox* or with “surucucu” ethnospecies appeared to be regular, regardless the community or time of year. According to the data, during Amazon summer (August–March) snakes are more widespread, and it is common to find them on the roads—where dwellers walk—but even more in the fields. Thus, it was usual cases in which people killed more than 10 snakes when working with the grass trimmer in the fields, reaching 38 in one day. In turn, in Amazon winter (April–July) the snakes become more crowded, searching for the few dry shelter that remained. This way, it is during the flood that they usually get nearest to the houses or are most often seen in the branches of trees—when the tide is higher.

This variation can be explained by the relationship this species has with precipitation and temperature [25]. According to these authors, the mating period occurs during the last dry months of the year (around October–November), so the high frequency of juveniles occurs between April–June, precisely during the most intense period of rain. The mean SVL of the collected snakes was in accordance with the found in literature [31], although we found a high variance between sizes. According to

Cunha and Nascimento (1975), three of them could be juveniles (up to 60 cm), that is, almost 50% of the sampling. The high frequency of these animals may also be related to an environmental imbalance [25].

In the research year, however, the meeting rate was atypical. Despite not being aquatic, *B. atrox* has a strong relation with water [32] being usually found in branches near stream. During 2023' flood, between April and June, dwellers of all communities reported having found little or no specimens of *B. atrox* until that period. In October, date of the field returning (summertime), dwellers confirmed that the encounter rate was very below normal and related this fact to the great drought that occurred on the Amazon River [33].

Another fact to be highlighted is the large number of snakebites among those interviewed. Although Santarém and its surroundings have already been identified as places with a high rate of bothropic accidents [4], a contingent of almost 30% of the sample design is a rate that deserves attention and care from public health. Typically, fields and roads have a high rate of encounters, as well as accidents [25]. Bitten people were usually walking at night in the summer when stepped on an individual. When working, dwellers were generally careful to wear rain boots, but when walking at night this was not as common, and that's when most accidents happen.

Due to the absence of symptoms in some victims, mild symptoms, or successful generic treatments in others (such as healing the bite by washing the area with coconut soap and getting tetanus shot), it is assumed that not all reported cases were in fact *B. atrox* poisoning. The bite may have been consequence of a dry bite from the mentioned species, or an inflammatory response caused by the bite of a non-venomous snake [34].

An interesting fact was taken from the speech of a dweller of Água Preta, in which he explains that, between 6 and 9am, the bite of *B. atrox* does not cause as much damage because the animal has recently fed, but after that the venomous would be stronger. Generally, species of the genus *Bothrops* begin their activity in search of food at dusk, with their climax at night, decreasing significantly with the presence of sunlight warming the substrate [25]. So, indeed, during this period, the chances of a dry bite would be greater. However, this does not mean that this snake is not a threat in the community. On the contrary, serious cases of attacks and even deaths have been reported.

In the past, due to the difficult access to city center, dwellers usually resorted to home medicines (as zoo and phytoterapics) and healers, while others trusted (and still trust) their healing only in God. Currently, this commuting has become easier, once many dwellers have bajaranas (small, motorized boats) or due the availability of the

ambulancha. Still, it takes a few hours to reach Santarém, plus the waiting time at the hospital. Despite many of the mentioned treatments were not recommended, as ingesting coffee, cutting the wound and make a tourniquet [35], some of them are being studied and demonstrated a positive result [2, 3]. In this sense, the most widespread one is Pau X, very utilized and known by the dwellers for a long time [3, 26]. Besides, it is interesting to note that, as a participant explained, anti-venoms are used for any "insect" bite—snakes, stingrays, spiders, and scorpions are also considered here, since many traditional populations have another ethnosemantic domain [36].

Healers, specially from Assis family, were probably the main ones responsible for the fabrication of Pau X, as it came from Pacoval [3]. Nowadays its use is so widespread, that it is easily found in the city. However, until today, its composition is unknown (see Fig. 3 and MOURA & MOURÃO [11]), be knowing only the presence of medicinal plants in its composition. A dweller of Cabeça D'onça, who commented on the composition of Pau X, said it contained, among other ingredients he didn't remember, an Aninga-type plant, sugarcane spirit and the menstruation of the Assis' daughter. Regardless the official ingredients, the knowledge about the use of Pau X and Específico Pessoa for snakebite accidents, encouraged research into other plants with prophylactic or palliative therapeutic properties [2, 11].

In the other way, what appears to be a recent and important discover of the dwellers of Aritapera is the use of Amazon River dolphin fat for snakebite accident. Although it is already used for other purposes, such as to treat whooping cough, amulet for money, luck and love [12, 37] and for cancer treatment (especially prostate one) among the dwellers, about 05 years ago they discovered it is also good for treat snakebites, both in humans and animals. This is relevant evidence of the nature of local knowledge as a dynamic and learning process through experimentation and evaluation. Horses, nonetheless, according to the participants are more difficult to save, because they are very fragile and die quickly after a snakebite, despite being the animal used to manufacture antivenom serum [38]. During the interviews, they mentioned the current nature of dolphin fat discovery for snakebite, saying they had treated themselves in other ways because they were not yet aware of this zootherapy. Furthermore, we did not find any record of this in the literature up to the present data.

These findings are very important for the dwellers, given the difficulty they have in accessing pharmacies and hospitals [13]. With those natural medicines, they guarantee a treatment that can help withstand until hospitalization and even prevent serious injuries, including member amputations, jeopardizing subsistence and

work, and even deaths. However, even with the low impact on biodiversity caused by the use of zootherapeutics [39], it is important to monitor the activity together with the local population, to guarantee the safety of threatened or overharvested species [40]. The dissemination of this knowledge is also important to encourage research to find plant or chemical substitutes for the compounds, ensuring the conservation of the species [41]. In this sense, holders of traditional knowledge have a very important role in the adequate management of resources [42].

Furthermore, conventional treatments usually involve applying antivenom serum as quickly as possible [43]. However, the reality of many communities makes this dynamic difficult. Besides the distance and transport difficulties, the Aritapera region does not have electrical energy to store any medicine, especially serum. Theoretically, electricity would reach the communities until the end of 2023, but it had not yet arrived by November. The lack of energy prevents the serum from being stocked, besides your application requiring a hospital structure for monitoring the patient [43]. Therefore, the discover of new properties that does not need to be storage in refrigerator, and that can be immediately applied, could prevent permanent sequelae and save lives [3].

This perspective is in line with the principles of the Sustainable Development Goals (SDG), which advocate strategies that aim to increase accessibility to counterpoisons; assist and strengthen health services; guarantee treatment for victims; and provide financial resources [4]. Of the fifty Brazilian municipalities that reported most snakebites cases until 2023, 44 are in the North Region, mainly in the State of Pará. A study published in 2020 estimated the annual expenditure of the Unified Health System related to direct medical costs with victims of snakebite in the Amazon (hospitalization, medicines, etc.) at more than 3 million dollars, and almost 270 thousand dollars in expenses for patients and their companions [4].

Since serotherapy is not as effective in treating local effects as it is for systemic effects, new methods that can be complementary to the current venom neutralization treatment are important to reduce the damage caused by the toxin, especially in relation to tissue destruction [3]. Thus, in addition to delaying side effects, they can have better local action. As shown in the results, no participant presented serious sequelae when treated with Pau X or Amazon Dolphin fat. In fact, this last medicine was considered very effective by them.

Therefore, palliative treatments, as mentioned above, have the potential to ensure well-being and guarantee the survival of residents in these situations. This inform adds a new zootherapeutic use of parts of an aquatic mammal

in Brazil, specifically the Amazon River dolphin fat, in the region of Santarém, not yet mentioned in the literature [44]. In this way, it can encourage research and discoveries of new properties with the potential to be used in other locations with the same limitations, expanding and valuing local knowledge.

Conclusion

This research shows the traditional knowledge of Aritapera riverine people about the ecology of *Bothrops atrox* and the natural treatments used for snakebites. Although we collected reports of five venomous ethnospecies, only one venomous species was collected, showing the necessity of further developing this investigation. For this, is necessary a greater and focused field sampling to visualizes the specimens, once the campaign of 2023, in terms of both sighting and collecting, was affected by the great drought. Regardless of the other possible species, Aritapera dwellers must live with *Bothrops atrox* in their daily lives, discovering the best way of protecting themselves. The combination of factors (difficult access to health center, lack of energy to store the antivenene, and high meeting rate with snakes) generates a dangerous situation for the dwellers. In this sense, besides individual protection equipment, they discovered treatments that, if not cure, at least aided with the waiting time for medical care and hospitalization. Some of those, as Pau X, has already been tested by its pharmacologically efficacy. However, other treatments, as the use of the Amazon River Dolphin fat, are a brand-new/unveiled discovery that require more attention, since this is from an endangered animal species. In this sense, studies that investigate which properties of this fat act against poison are required. Perhaps this way, medicines that do not require the death of the animal, but that could equally be used in communities that have difficult access to hospital and pharmacies and little infrastructure could be developed. To conclude, we are not saying here that conventional treatments are wrong or inefficacy, but just saying that others knowledge, such as natural medicine, should be considered. If valued and included as a real healing possibility, it could be expanded to other locations, being an economically and ecologically viable option to save lives.

Abbreviations

HL	Head length
ID	Interocular distance
HW	Head width
SVL	Snout-vent length
TL	Tail length

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Author contributions

Both authors played a fundamental role in finalizing this article. BNC was responsible for collecting and analyzing the data and writing the text, and JCBP collaborated with the theoretical foundation, writing and reviewing the manuscript.

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Availability of data and materials

No datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate

The president of each community was contacted before immersion in the field, requesting consent for the research. BNC participated in two resident meetings (recorded in the minutes), with the aim of explaining the research proposal to local respondents and asking for collaboration. This project was approved by the Ethics Committee and has a license from Plataforma Brazil (CAAE: 66400022.0.0000.0018) and SISBIO (86341–1).

Consent for publication

The authors agreed that this manuscript can be published.

Competing interests

The authors declare no competing interests.

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