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Conservation of Amazonian manatee (Sirenia: Trichechidae): the case of Extractive Reserve Verde para Sempre, Brazil

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ABSTRACT

Found in the main rivers of the Amazon Basin, the Amazonian manatee (*Trichechus inunguis*) is the largest aquatic freshwater mammal in South America. The objective of this study was to describe the ecological knowledge and uses of the Amazonian manatee in the Extractive Reserve Verde para Sempre, Porto de Moz, Brazilian Amazon. This study was conducted through semi-structured interviews, free interviews, participant observation and image capture. Thirty-one residents were interviewed in 21 communities, using snowball sampling method. The interviewees were previously identified by local informants and selected according to their level of knowledge of the species. We collected information on the morphology, behavioral characteristics and feeding habits of manatees, and on the uses of the species by communities. Our findings suggest three hypotheses on the biology of Amazonian manatee: 1- the existence of three phenotypic patterns based on skin color and amount of fat; 2- changes in land use by agriculture, livestock and the installation of the hydroelectric plant affect their spatial distribution and seasonal migration; 3- they show reproductive behavior during the rainy season, in a polygamous way as a strategy of maintenance and genetic variability of the species. One third of the interviewees learned of the prohibition of manatee poaching during the implementation of the reserve. Poaching and consumption of manatees are rare, and entanglement of calves in fishing nets is accidental. These results reinforce the interest of local ecological knowledge in understanding the biology of the Amazonian manatee and their contribution to the delimitation of protected areas.

Keywords: *Trichechus inunguis*; Ethnoecology; Protected Area; Poaching; Amazon.

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SIGNIFICANCE STATEMENT

The main motivation of this work is to show the role of traditional communities who live in protected areas in the conservation of the Amazonian manatee. The ecological knowledge of the interviewees about this vulnerable species is useful to develop a scenario for the conservation of the species.

INTRODUCTION

The loss of biodiversity, the degradation of the productive capacity of water cycling and carbon storage ecosystems affect the human populations that inhabit the Brazilian Amazon (Fearnside 2003). The growing territorial occupation of this region has led to deforestation to develop ranching, family and mechanized agriculture. The current challenge is to elaborate sustainable strategies that aim to order the socioeconomic development through the management of natural resources (Alencar et al. 2004). Amazonia is the most diverse tropical forest zone (Da Silva et al. 2005) with numerous endemic species (Kress et al. 1998). The endemic Amazonian manatee, *Trichechus inunguis*, occurs in a large part of the amazon basin, but are patchily distributed in nutrient-rich areas (Marmontel et al. 2016). The species is threatened by anthropic actions (Venter et al. 2016) such as deforestation (Ripple et al. 2016), the construction of hydroelectric plants (Lees et al. 2016), mining activities (Tófoli et al. 2017) and intense navigation and fishing (Isaac et al. 2015).

The hunting of the Amazonian manatee was widely practiced by the native population of the Amazon for their food subsistence. Its exploitation by non-indigenous populations probably began in 1542 and continued until 1954 (Marmontel et al. 2012; Antunes et al. 2016). Professional hunting and trading of wild fauna has been prohibited in Brazil since 1967 by Law 5197/67 (BRASIL 1967), but manatees are still hunted today on a much smaller scale (Marmontel et al. 2012). The Amazonian manatee has been listed as vulnerable to extinction by IUCN since 1982, primarily due to poaching pressure, coupled with climatic, environmental and anthropic factors (Marmontel et al. 2016). In addition to its consumption, parts of the animal are used as medicine and magical-religious symbols (Rosas and Pimentel 2001; Zaniolo 2006; Castelblanco-Martínez et al. 2016).

There are still gaps to be filled about the biology of the Amazonian manatee (Kendall et al. 2014; Silva et al. 2014; Castelblanco-Martínez et al. 2016). For example, there is little information about reproduction, behavior, nutrition, and poaching of this species in the lower Xingu river, Brazil. The understanding of some of these biological and environmental aspects, related to population dynamics, is fundamental to know the basic requirements of the species, and consequently its conservation.

Due to the difficulty in sighting Amazonian manatees, it is essential to develop alternative techniques to direct observation that can provide information about the ecology of this species. Traditional ecological knowledge has provided relevant data to assist the development of sustainable management models (Jepson and Ladle 2009; Jenkins et al. 2011; Zappes et al. 2014; Ramirez-Gomez et al. 2015), suggesting new biological and ecological hypotheses (Silvano and Valbo-Jørgensen 2008; Silvano and Begossi 2010; Ruddle and Davis 2011). For example, a hypothesis on the availability and distribution of the parrotfish green humphead (*Bolbometopon muricatum*) in a lagoon in the Western Solomon Islands was elaborated based on local indigenous ecological knowledge and corroborated by biological studies (Aswani and Hamilton 2004). However, hypotheses generated from local ecological knowledge can also be refuted: claims by Canadian fishermen that white hake (*Urophycis tenuis*) was the main predator of juvenile lobster (*Homarus americanus*) have not been confirmed by a multidisciplinary scientific study (Ruddle and Davis 2011). In addition, ethnozoological studies are useful to investigate the different motivations and ways of using wildlife by human populations (Bezerra et al. 2013; Morsello et al. 2015; Alves and Rocha 2018). Therefore, we consider that the local ecological knowledge on the Amazonian manatees can contribute to the conservation of the species and improve its management by providing new information on the ecology of the species, including its distribution, diet, reproduction, and uses by human communities.

The main objectives of this study are: (1) to describe the local ecological knowledge and the uses of the Amazonian manatee by residents of a Federal Conservation Unit; (2) to characterize the spatial distribution of Amazonian manatees during the dry and rainy seasons according to reproductive status and forage availability; (3) assess the pattern of poaching of manatees.

MATERIAL AND METHODS

This study was conducted in the extractive reserve RESEX Verde para Sempre (meaning green forever), a Federal Conservation Unit established in 2004, with an area of 1.289.363 ha, one of the largest extractive reserves in the Brazilian Amazon. The reserve is located in the municipality of Porto de Moz in the lower Xingu region, Pará, Brazil (01º31'50" and 02º47'55"S,

and 52º06'43" and 53º23'06"W), in the western region of the state of Pará, Brazil (ICMBio 2013). The reserve aims to ensure the sustainable use and conservation of renewable natural resources, protecting the livelihood and culture of the local population (ICMBio 2013), made up of 8964 residents in 57 rural communities.

The RESEX is bordered to the north by the Amazon river, to the east by the Xingu river, and cut by the Acarai, Jauruçu and Guajará rivers and their various tributaries (Figure 1). Porto de Moz has an average annual rainfall of 2337 mm and is characterized by a rainy season (December to May) and a dry season (June to November) (De Paula and Da Silva 2019).

The research was carried out in 21 communities, from September 2015 to August 2016: we conducted two field trips during the rainy season and three during the dry season. The purposes of the study were clarified to the residents, then the interviews were applied only to those who agreed to participate in the research.

Data collection consisted in the application of semi-structured interviews, free interviews, participant observation and image capture (Albuquerque et al. 2014). Participants (n = 31) were initially suggested by local leaders and then by the first interviewees, using the snowball sampling method (Bailey 1994). This inexpensive method is usable in a specific population and with difficult access. Since the focus of study of this work is ethno knowledge, we consider the snowball approach appropriate. However, because it is a non-probabilistic technique, it does not allow to determine the degree of precision and the representativeness of the sample size.

Before the application of the questionnaire, the participants were informed about the objective and methodology of the survey. The participants were assured of the confidential and private character of the interviews, through the signature of a Free and Informed Consent Form, guaranteeing the non-use of the information for other purposes than the study itself. The application of an interview was suspended when discomfort related to embarrassing questions was perceived, respecting the habits and customs of the local society.

The present study investigated the socioeconomic profile of the interviewees, identifying sex, age, profession, education, time of local residence, fishing and farming, aiming to relate the impacts caused by these activities to the ecosystem and, consequently, the Amazonian manatee conservation. Ethnoecological knowledge about phenotype, reproduction, behavior and uses of the species by communities (poaching, demand and trade) was also investigated. The potential food items of the Amazonian manatee were identified, based on the traditional knowledge of the participants. The plant species consumed by the Amazonian manatees were identified through images and the literature (Best 1981; Colares 1991; Colares and Colares 2002; Guterres-Pazin 2010).

The level of experience and knowledge about the Amazonian manatee considered the time of coexistence of the participants with the species in the places where they could supposedly observe manatees and their habits for a long period of time. Furthermore, there was a male predominance (n = 30) due to the transmission of fishing and hunting techniques by fathers and grandfathers during the practice of these activities. The data collected were analyzed through qualitative exploratory analysis, which is characterized by the research of phenomena that occur at the study site, as well as the existing empirical knowledge (Vergara 2012).

Ethical Aspects

We conducted our study following the rules and guidelines of the National Health Council (Resolution 466/12) (BRASIL 2013). This work was approved by the Chico Mendes Institute for Biodiversity Conservation (ICMBio), Ministry of the Environment (SISBIO - 50636-1 / 2015), and by the Research Ethics Committee of the Health Sciences Institute of the Federal University of Pará (CAAE-52449315.3.0000.0018).

RESULTS

The 31 residents of RESEX Verde para Sempre interviewed were between 30 and 78 years old and almost all were born in the community (97%, n = 30). The levels of education observed were as follows: 32% (n = 10) illiterate; 42% with incomplete elementary education; 13% with complete elementary education; 3% with incomplete secondary education; 6% with complete secondary education; and 3% with incomplete higher education.

The main socioeconomic activities were the following: farming (manioc, *Manihot esculenta*; watermelon, *Citrullus lanatus*; corn, *Zea mays*; rice, *Oriza* sp.; and pumpkin, *Cucurbita* spp.), breeding (water buffalo, *Bubalus bubalis* and cattle, *Bos taurus*), fishing (pirarucu, *Arapaima gigas*; tambaqui, *Colossoma macropomum*; and streaked prochilod, *Prochilodus lineatus*, among others), and plant extraction (titica vine, *Heteropsis* spp., and Brazil nut, *Bertholletia excelsa*). Breeding of large domestic animals (*B. bubalis* and *B. taurus*) was practiced by 77% (n = 24) of the interviewees.

The Amazonian manatee was recognized as a large animal with mouth, snout, small eyes, fin (called a paddle) and a paddle-shaped tail. The difference between males and females was determined by the size of

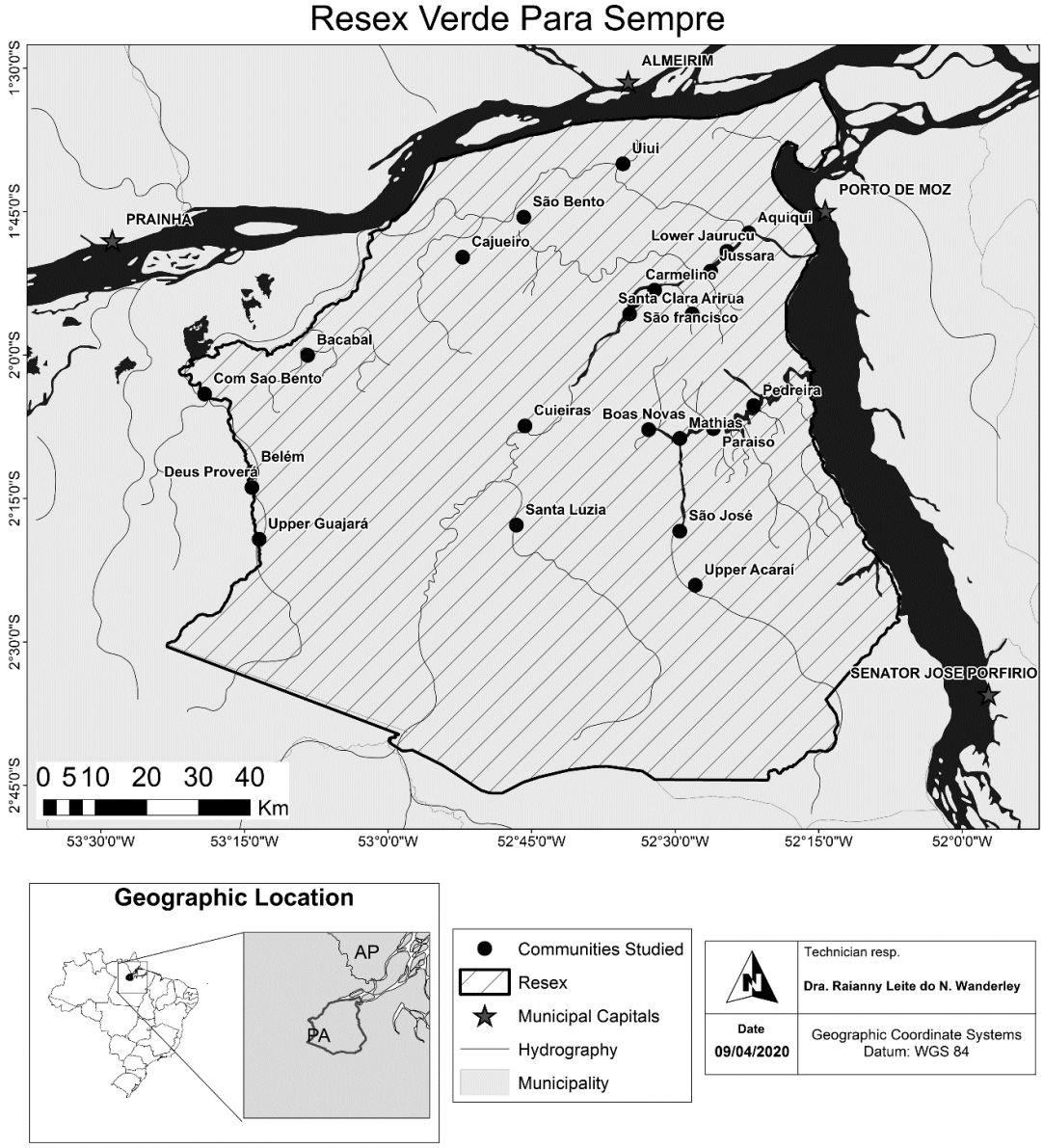

Figure 1. Extractive Reserve RESEX Verde para Sempre, Porto de Moz, Pará.

the snout exposed out of water, when the animal surfaces to breathe: the male exposes most of the muzzle, while the female only leans against the surface of the water. According to 30% ($n = 9$) of the respondents, the meat of Amazonian manatee tastes like beef in the anterior part and fish in the posterior part of the body (Figure 2).

The interviewees discriminated three Amazonian ethnospecies of manatee (Table 1), based on skin color and amount of fat: 1) the black manatee or *Poca* - a small, black and spotless animal; 2) the common manatee or *Rosilho* - a gray animal with a white or rosy chest spot (the most common type in the region); and 3) the butter manatee - large in size, with a high amount of fat.

According to interviewees, manatees can be found in all rivers of the reserve, but are predominantly observed in open and deep sections (called *Poços*) that are located near large flooded fields. Manatees remain in these places during the rainy season. According to the majority of the respondents (74%, $n = 23$), food supply decreases during the dry season, and the manatees move further away from human communities to an area located at the headwaters of the Acarai, Jauruçu and Guajará rivers, as well as to streams, such as Una (located in the middle Jauruçu River); or they migrate to the Amazon and Xingu rivers. They return to the open areas of large flooded fields at the

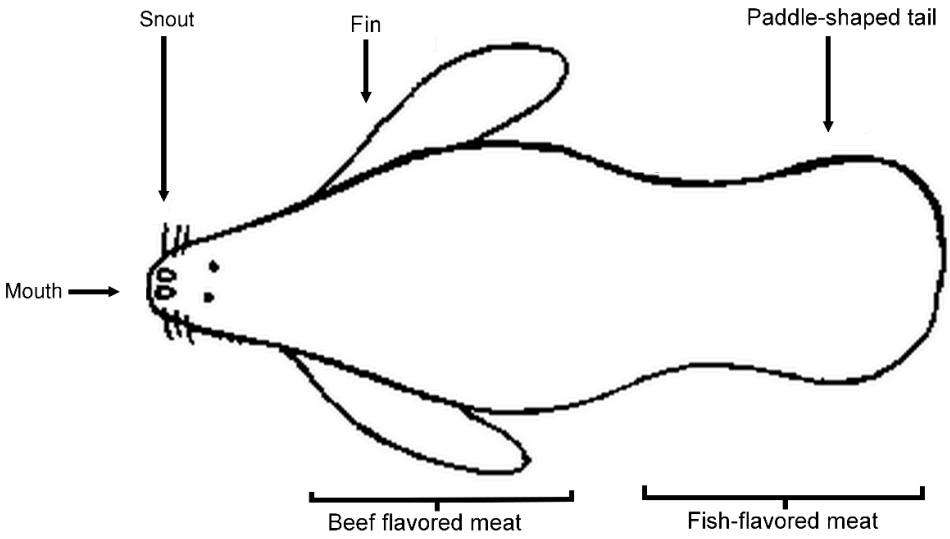

Figure 2. Body topography as identified by the interviewees of RESEX Verde para Sempre (source: adapted from drawing made by an interviewee).

Table 1. Comparative cognition regarding knowledge of ethnoecological aspects of the Amazonian manatee in RESEX Verde para Sempre in the Amazon.

Remarks from interviewees	Literature
large animal, black, very thick, two shovels and a tail that looks like a paddle (resident A).	The body is long and cylindrical, has a modified tail shaped like an oar, rounded, flat and horizontal, long snout, short thick neck and smooth skin (Best 1984).
it is an animal of 14 to 18 spans (1 span = 22 cm) (resident B).	At adult age, it reaches approximately 2.8 to 3.0 m in length (Rosas 1994).
is similar to cattle...measures 8 to 18 spans (resident C).	The Amazonian manatee is the largest freshwater aquatic mammal in South America (Best 1984).
the calf suck under the mother's arm, and is born five spans long (resident D).	The female has one teat under each pectoral flipper (Best 1982). At birth, it measures 85 to 105 cm in length (Rosas 1994).
the eyes are small (Gito), like lumps of lead (resident E).	It has small eyes, which are able to see colors (Griebel and Schmid1996).
it is a very cunning animal, that has time to float, to take breaths, but if notices any noise, it goes away (resident F).	Its auditory acuity allows the animal to detect danger and to escape from it without being seen (Chapla et al. 2007; Nummela 2009).

beginning of the rainy season where they reproduce. This period is considered the best to observe manatees and 58% (n = 18) of the interviewees indicated that they spotted females with calves during the rainy season.

Manatees were rarely sighted alone. When two animals were sighted, they were considered either a couple or the mother with a calf. When three individuals were observed, it was the couple with a calf; and when more than five animals were sighted it was because they were breeding.

The interviewees recognized the presence of the Amazonian manatee by observing their feeding location. They identified 14 types of plants eaten by these animals (Table 2), from which leaves or roots are consumed. The two most cited plants consumed by Amazonian manatee were *Eleocharis variegata* and *Paspalum repens*, in 32% and 22% of the reports, respectively.

All interviewees were aware that poaching Amazonian manatee is prohibited and stated that it was carried out by the elders of the community or people who had already died. Of these, 48% (n = 15) had learned of the prohibition of poaching before the

Table 2. Example Species of plants consumed by Amazonian manatees according to the 31 interviewees at RESEX Verde para Sempre.

FAMILY Species	Common name1	Part of plant consumed	% of citations
Poaceae			
Echinochloa polystachya	Canarana	Leaves	14,00%
Brachiaria purpurascens	Purpuruca	Leaves	6,00%
Oryza grandiglumis	Arroz	Leaves	3,00%
Hymenachne amplexicaulis	Rabo de rato	Leaves	6,00%
Paspalum repens	Peremembeca	Leaves	8,00%
Leersia hexandra	Pumunga	Leaves	6,00%
Cyperaceae			
Eleocharis sellowiana	Junquinho	Roots	3,00%
Eleocharis variegata	Junco	Roots	14,00%
Pontederiaceae			
Eichhornia crassipes	Mururé barrigudinho	Roots	15,00%
Nymphaeacea			
Nymphaea sp.	Apé	Roots	6,00%
Marantaceae			
Ischnosiphon arouma	Arumã	Roots	3,00%
Apocynaceae			
Rhabdadenia macrostoma	Cipó da beira	Leaves	3,00%
Lentibulariaceae			
Utricularia foliosa	Samambaia	Leaves and roots	7,00%
Convolvulaceae			
Ipomoea aquatica	Batatarana	Roots	6,00%

implementation of RESEX; 32% ($n = 10$) during the process of implementation of RESEX; 16% ($n = 5$) through radio and/or television programs; and, 3% ($n = 1$) by other means.

It should be emphasized that indications of manatee poaching during the period of this study were obtained. Hunting events were both intentional, to meet the need for protein during food shortages, and accidental, by mistake in attempts to spear pirarucu fish (*A. gigas*) or by entanglement in fishing nets. Most of the interviewees (61%, $n = 19$) admitted that they had hunted the Amazonian manatee in the past, and others reported that they participated indirectly in this practice, helping their father or close relatives. Of the 19 interviewees who had already killed manatees, 73.7% ($n = 14$) were former hunters. Among those, 15.7% ($n = 3$) reported accidental entanglement in fishing nets, and 10.5% ($n = 2$) speared the animals by mistake in attempt to catch pirarucu (*A. gigas*). Some respondents were not hunters (39%; $n = 12$) and reported that they had participated in poaching when they were young or had heard stories of capture events of the Amazonian manatee from their parents and grandparents. Thirteen percent ($n = 4$) of the interviewees reported the commercialization of its meat and 87% ($n = 27$) its consumption for subsistence. However, according to the interviewees, the commercialization and subsistence consumption of manatee meat has not been practiced for at least five years in the RESEX.

Many interviewees ($n = 27$) recalled that the events surrounding the practices of hunting Amazonian manatee were related to celebrations held by parents, grandparents and friends, strengthening social bonds in the community. The taste for manatee meat was highlighted in most reports. The sheets of skin and fat are used for the production of crackling, and oil is used for frying and preserving stewed meat. The oil can also be used as a medicine to relieve muscle pain, swelling, hernia and erysipelas. The skin serves as a plaster for muscle damage. The viscera are used with meat and fat to produce sausage. The tail and fins are cooked in *Tucupi*, a by-product of cassava. After the slaughter, some meat is roasted and consumed. The rest of the meat can be preserved salted or cooked. However, its consumption is not indicated for people with chronic diseases.

Three techniques were reported to capture the Amazonian manatee: 1) harpoon and stumps in the nose; 2) *Pari*; 3) *Boiadores* and *Barrancos*. The first technique used a metal hook, a rope, stumps and floats (Figure 3), which formed the harpoon. The harpoon consisted of a sturdy, straight wooden rod, with the weight necessary to be thrown at a certain

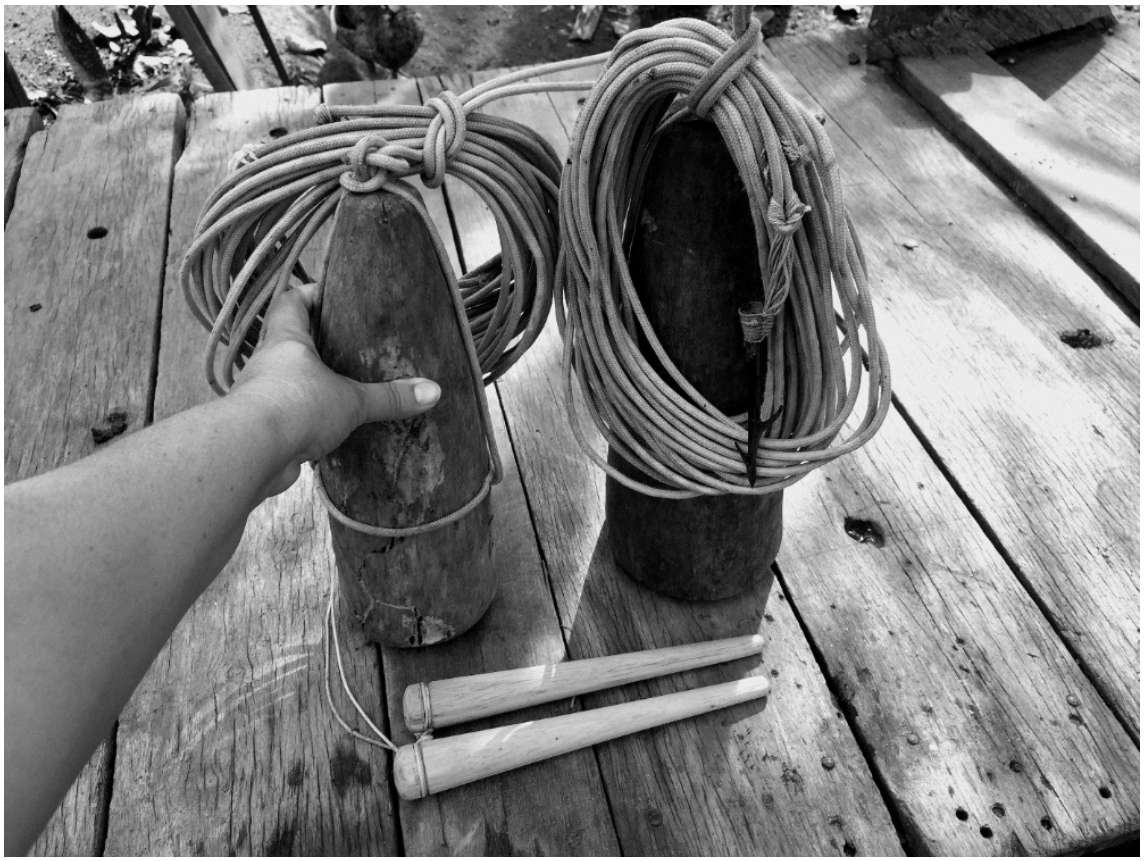

Figure 3. Floats, cord and stumps used to capture an Amazonian manatee, made just for visual demonstration.

distance. A metal hook with sharp tips was set at the end of this rod.

The hook was attached to a rope of 18 to 20 m, which was tied at the other extremity to a buoy, made with wood. The stumps (called *Tornos*) were made from any type of wood (Figure 3). This technique made it possible to harpoon and suffocate the animal, with the introduction of the stumps in the nostrils. The hunter observed the feeding site for about a week, recording the activity of the manatees and noting breathing intervals. This monitoring is easier in the breeding season or during migration periods because larger groups of more manatees are present. When he found the manatee, the hunter would harpoon and release the rope, which was attached to a light wood floating on the surface of the water. When tired, the animal usually wrapped around the rope, and, at that moment, the stumps were inserted in its nostrils.

The *Pari* technique consists of a physical barrier built with wooden sticks, placed in a stream to hide the hunter and prevent the animal from moving. *Pari* is the name of the waiting place used to keep the manatees in low waters.

The *Boiadores* and *Barrancos* techniques are characterized by open areas in the middle of aquatic vegetation, where manatees breathe. Animals usually use these areas for food and shelter. When food supply is scarce, hunters pull out part of the aquatic vegetation, drag it into the middle of the river, and wait in a rowing boat for the manatee to get close enough to catch it with a harpoon.

Illegal fishing was reported by 52% (n = 16) of the interviewees and is carried out with 70 mm and 80 mm mesh nets by RESEX residents and people outside this Federal Conservation unit, in the manatees' refuge places (lakes and streams). This activity contributes to the accidental bycatch of young Amazonian manatees. During the survey period, five cases of bycatch occurring over the last five years were reported. The rescue of a calf occurred in the community of Bacabal (middle Guajará River, Aruru River) in November 2016. Local residents frequently see manatees migrating in groups, as well as females with calves throughout the year in this area.

DISCUSSION

The present study suggests lines of research on the biology and ecology of the Amazonian manatee in the Xingu river region, based on local ecological

knowledge, as observed in the literature for others species (Silvano and Valbo-Jørgensen 2008; Silvano and Begossi 2010; Ruddle and Davis 2011).

Based on local ecological knowledge, three ethnic species of Amazonian manatees have been identified in the region. This corroborates previous statements of Calvimontes (2009) and Franzini et al. (2013) in other regions of the Amazon. According to Cantanhede et al. (2005), such characteristics are only expressions of the phenotypic variability of skin color, among individuals of a population. We suggest carrying out studies on the genotypic variability of this population to investigate the possible genetic origin of the phenotypic patterns reported by the interviewees.

Our findings showed the migration of the Amazonian manatee to the headwaters of the Acarai, Jauruçu and Guajará rivers during summer. These areas are distant from the community dwellings, thereby less subject to human influence. The migration of the manatees to these areas may be related to the search for food resources (Kendall et al. 2014; Castelblanco-Martinez et al. 2016), but also to avoid predation and poaching (Arraut et al. 2010). We propose that these areas serve as a wildlife refuge to remain as unimpacted as possible by human activities. It could be considered that is necessary to adopt specific measures in the RESEX Verde para Sempre, such as the implantation of a preservation zone, whose general objective is the maintenance of one or more ecosystems, of maximum degree of preservation, serving as restocking source (D'Amico et al. 2018).

As observed in the literature, the installation of hydroelectric power plants in the Amazon region can make the migration difficult and increase the mortality of the Amazonian manatee (Arraut and Marmontel 2016; Arraut et al. 2017). The Belo Monte hydroelectric plant on the Xingu river, the largest in operation in the Amazon region, may have secondary effects, facilitating the mining of bauxite, nickel, copper and gold (Lees et al. 2016). The hydroelectric power station, whose last turbine was activated at the end of 2019, is likely to affect the migration of many aquatic species and eventually have other indirect ecological impacts, such as the availability of food for wildlife.

Concerning to local ecological knowledge, the breeding season and the sighting of females with calf take place during the rainy season. Seasonal breeding may be related to the hydrological cycle and the increase in food supply during the rainy season, as the energy demand for reproduction and to raise calves is high. Best (1982) reported reproductive seasonality in Amazonian manatee and observed a higher frequency of mating and calving in the rainy season, when rivers are flooding, and the abundance of food favors the survival of the calf. Captive females also exhibit reproductive behavior during the rainy season (Amaral et al. 2015). According to Amaral et al. (2015), the reproductive cycle could be primarily triggered by photoperiod or daytime light intensity, while food availability would act as a temporal fine-tuner of reproduction. However, the relation between photoperiod and the reproductive seasonality of wild manatee has yet to be confirmed. These animals appear to present polygamous reproduction, since groups were sighted during the reproductive period (Calvimontes 2009; Carvalho et al. 2017). This sexual behavior would be a strategy to increase the genetic variability of the population. In addition, since female manatees do not cycle continuously, they would be less selective toward males.

The results obtained showed that the Amazonian manatee of this area preferentially eat roots and leaves of 14 species of grasses and water lilies, which would constitute the bulk of their diet. In other regions of the Brazilian Amazon, 31 (Anavilhanas National Park) to 37 (Tapajós – Arapiuns Extractive Reserve and Tapajós National Forest) plant species have been identified as the main component of the manatee diet (Crema et al. 2019). Four plants observed in the present work (*Brachiaria purpurascens, Ischnosiphon arouma, Rhabdadenia macrostoma, Ipomoea aquatica*) were not cited in the lists of the species consumed by Amazonian manatees in other protected areas. It should be mentioned that *B. purpurascens* and *I. aquatica* are not native Amazonian species. Possibly, the nutritional value of upland and floodplain plants may be one of the aspects that influence the migratory habit of this species. Roots provide the nutrients for survival in the dry season, while leaves are abundant during the flood season, when the water invades the floodplain areas, forming large fields of forage plants. Bromatological analysis of these foods is necessary to understand the metabolism and energy requirements of the Amazonian manatee.

It could be inferred that there is little evidence of Amazonian manatee hunting in the Xingu region, but that there is an intense human activity in the region, which may impact the production of the local ecosystem. It was shown in the present work that the majority of the participants in this study were adult men, with a low level of education, and the main occupations were farming and herding, fishing and plant extraction. These are the main traditional subsistence activities of the populations living in protected areas in the Amazon (Medina and Barbosa 2016). Quinzeiro Neto et al. (2014) estimated that there are 17 to 18 thousand B. bubalis in RESEX Verde para Sempre, but it should be mentioned that it is an illegal activity in Conservation Units (Brasil 2000). Water buffalo are bred in the RESEX Verde para Sempre, which can be a problem

for the conservation of the Amazonian manatee, as these animals depend on the floodplain fields for food. It has been observed in other areas of the Brazilian Amazon that extensive water buffalo farming leads to soil compaction, erosion, and the emergence of artificial channels, which accelerate the drainage process of these areas (Meirelles and Mochiutti 2000; Monteiro 2009). In this sense, the progressive replacement of native vegetation by invasive species and the deterioration of water quality have a negative impact on the ecosystem (Meirelles and Mochiutti 2000; Monteiro 2009).

The results of this work reinforce that conservation measures should be rapidly implemented in the region to guarantee that human activities strongly impacting the environment do not affect the migration and survival of the Amazon manatee. These measures include the establishment and protection of refuge areas, as mentioned earlier, and the expansion of the limits of protected areas already existing on the Xingu River region.

In another aspect related to this issue, poaching of Amazonian manatee is mainly for consumption and marketing by some traditional Amazonian communities (Franzini 2008; Calvimontes 2009). Another use involves traditional therapy, using fat for inflammatory problems, which is common throughout Latin America (Alves and Alves 2011). In this regard, the results obtained showed that poaching events seemed infrequent in the RESEX Verde para Sempre, when this study was carried out. As observed in the present study, poaching is an ancient practice currently linked only to the elderly, but this activity may not have been passed on to the younger generation. In addition, only one calf was rescued during the study period, which may indicate that anthropic impacts are not yet intense in this region. In contrast, a higher incidence of rescues is observed in other regions of the Amazon and would be associated with the poaching of mothers (Franzini 2008; Marmontel et al. 2012; Souza 2015).

CONCLUSION

The results of the study suggest three hypotheses on the biology and ecology of the Amazonian manatee that can be further investigated. The first is the existence of three patterns of phenotypic variability of the Amazonian manatee. The second is that changes in land use by agriculture, livestock and the installation of the hydroelectric plant affect the spatial distribution and seasonal migration of the Amazonian manatees. The third is that the Amazonian manatees show reproductive behavior during the rainy season, in a polygamous way as a strategy of maintenance and genetic variability of the species.

The creation of the RESEX Verde para Sempre has helped to raise awareness in the community that Amazonian manatee poaching is a prohibited activity, but its capture still occurs accidentally. In contrast, the existence of the reserve has not diminished other impacting human activities, such as the breeding of *B. bubalis*. The implementation of this protected area and the ban on poaching are positive strategies for conservation of Amazonian manatee. Likewise, it is necessary to implement sustainable activities for the maintenance of natural resources and guarantee the economic subsistence of the communities that live from agriculture and livestock. We suggest implementing the application of animal husbandry technologies that can be practiced in a more sustainable way. Our results point out the need of identification, delimitation and protection of important areas for Amazonian manatee. The local ecological knowledge acquired during this research may be useful for the development of effective management and conservation strategies for the Amazonian manatee, such as the integral protection of migration areas.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript.

CONTRIBUTION STATEMENT

Designed the original idea: CMMH; ALFR; DAAG
Carried out the experiment: CMMH
Carried out the data analysis: CMMH; YLP; DAAG
Wrote the first draft of the manuscript: CMMH; YLP; DAAG

Revised and edited the final version of the manuscript: SRS; YLP; PCBJ; DAAG
Supervised the study: DAAG; ALFR

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