ACTA
AMAZONICA | http://dx.doi.org/10.1590/1809-4392202501831

BIODIVERSITY AND CONSERVATION - ORIGINAL ARTICLE

Ecology and conservation of the Amazonian Manatee (*Trichechus inunguis*) from the perspective of fishers on the Purus River, Central Amazon: agreements and contrasts with scientific literature

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ABSTRACT

A lifetime of near-daily observations, as opposed to scientific sampling expeditions that are often limited in time and space, makes Local Ecological Knowledge (LEK) an extremely valuable source of information for understanding rare, threatened, or cryptic species. This study documents LEK about the Amazonian manatee (*Trichechus inunguis*) in the Purus River basin, Central Amazon. Based on interviews with 104 residents from 30 riverine communities, we access local manatee experts' perceptions of social behavior, activity patterns, habitat use, diet, and species conservation. LEK provided insights into Amazonian manatee ecology, such as the persistence of manatees in floodplain environments during the low-water season and occasional fish consumption. The main threats reported were fishing nets and hunting. However, extreme drought events driven by climate change were frequently mentioned, as these increase vulnerability to both hunting and food shortages. Most respondents strongly valued the role of Protected Areas in species protection and perceived a trend of population increase over the past two decades. Incorporating community-based observations and concerns into conservation strategies can therefore improve early-warning systems, guide habitat protection efforts, and support management of *T. inunguis* across protected and non-protected areas.

KEYWORDS: aquatic mammals, local ecological knowledge, protected areas, Sirenia, vulnerable species

Ecologia e conservação do peixe-boi-da-Amazônia (*Trichechus inunguis*) sob a perspectiva dos pescadores do rio Purus, Amazônia Central: convergências e contrastes com a literatura científica

RESUMO

Uma vida inteira de observações quase diárias — em contraste com expedições científicas geralmente limitadas no tempo e no espaço — torna o Conhecimento Ecológico Local (CEL) uma fonte extremamente valiosa de informações para compreender espécies raras, ameaçadas ou crípticas. Este estudo documenta o CEL sobre o peixe-boi-da-Amazônia (*Trichechus inunguis*) na bacia do rio Purus, Amazônia Central. Com base em entrevistas com 104 moradores de 30 comunidades ribeirinhas, investigamos as percepções de conhecedores locais de peixe-boi sobre o comportamento social, padrões de atividade, uso do habitat, dieta e conservação da espécie. O CEL revelou aspectos importantes da ecologia do peixe-boi-da-Amazônia, como a permanência da espécie em ambientes de várzea durante a estação seca e o consumo ocasional de peixes. As principais ameaças relatadas foram redes de pesca e caça. No entanto, eventos extremos de seca associados às mudanças climáticas foram frequentemente mencionados, pois aumentam a vulnerabilidade à caça e à escassez de alimento. A maioria dos entrevistados atribuiu grande importância ao papel das Unidades de Conservação na proteção da espécie e percebeu uma tendência de aumento populacional nas últimas duas décadas. Assim, incorporar as observações e preocupações das comunidades locais às estratégias de conservação pode aprimorar sistemas de alerta precoce, orientar ações de proteção de habitats e apoiar o manejo de *T. inunguis* em áreas protegidas e não protegidas.

PALAVRAS-CHAVE: mamífero aquático, conhecimento ecológico local, áreas protegidas, Sirenia, espécie vulnerável

CITE AS: Souza, D.A.; Venticinque, E.M.; da Silva, V.M.F. 2026. Ecology and conservation of the Amazonian Manatee (*Trichechus inunguis*) from the perspective of fishers on the Purus River, Central Amazon: agreements and contrasts with scientific literature. *Acta Amazonica* 56: e56bc25183.

INTRODUCTION

Local Ecological Knowledge (LEK) is defined as a set of knowledge, beliefs, and experiences accumulated over time through personal observations and interactions with ecological systems, and culturally transmitted among resource users (Berkes 1999; Berkes et al. 2000). LEK has significantly contributed to the management of Protected Areas (PAs) and the sustainable use of natural resources (Vieira et al. 2019; Braga-Pereira et al. 2022), to the assessment of hunting impacts on wildlife populations (Braga-Pereira et al. 2020; Sampaio et al. 2022), and has proven extremely important for evaluating the conservation status of threatened species with limited scientific data (Turbay 2002; Silvano and Begossi 2010; Ortega-Argueta et al. 2012; Mayaka et al. 2013; Rajamani 2013). In the case of the Amazonian manatee (*Trichechus inunguis* Natterer 1883) – the only exclusively freshwater sirenian species (Best 1984) – its cryptic behavior makes direct observation in the wild particularly difficult (Rosas 1994; Souza et al. 2021). Thus, LEK from riverine populations has been an important source of information on the biology and ecology of the species in the wild (Franzini et al. 2013; Crema et al. 2019a; Calvimontes and Marmontel 2022). However, existing studies remain geographically limited, and important knowledge gaps persist across several Amazonian river basins, including the Purus River. In addition, LEK may vary among regions due to differences in environmental conditions, cultural practices, and human–wildlife interactions (Ingold 2000; Braga-Pereira et al. 2024).

Trichechus inunguis is the largest aquatic mammal in the Amazon, reaching up to 275 cm in length and 420 kg in weight (Amaral et al. 2010). The species is endemic to the Amazon basin, inhabiting major rivers and tributaries in Peru, Ecuador, and Colombia, and extending to the mouth of the Amazon River in Brazil (Best and Teixeira 1982; Junk and da Silva 1997; Bonvicino et al. 2020). It feeds on a wide variety of aquatic and semi-aquatic plants (Colares and Colares 2002; Guterrez-Pazin et al. 2014; Crema et al. 2019b; Carvalho et al. 2022), and therefore plays an important ecological role by fertilizing aquatic environments, promoting plant productivity, dispersal, colonization, and succession (Guterrez-Pazin et al. 2024).

Historical records indicate that manatees were once abundant throughout their range (Amaral et al. 2023). However, exploitation of their meet for food, their hide for manufacturing machine belts, and their oil and various body parts (i.e., bones and fat) for medicinal purposes since pre-colonial times (Ferreira 1903; Pereira 1944; Best 1984; Miranda 2014) has drastically reduced populations to below the species' ecological carrying capacity (Domning 1982; Antunes et al. 2016). Although protected under national and international legislation (Brum et al. 2021), the species remains targeted by subsistence hunting in riverine and indigenous communities, as well as by the illegal meat trade in several Amazonian urban markets (El Bizri et al. 2019). As a result, the species is currently classified as "Vulnerable" on both the Brazilian (MMA 2022) and international (Marmontel et al. 2016) endangered species lists.

While population estimates are unavailable, the combined impacts of illegal hunting, low reproductive potential (Best 1982; Domning 1982; Antunes et al. 2016), and ongoing degradation of aquatic habitats constitute an unprecedented set of threats to the long-term survival of *T. inunguis* (Brum et al. 2021). Given its ecological role and historical relevance to Amazonian peoples, integrating LEK and scientific knowledge is essential to better understand its ecological interactions and to develop effective conservation strategies for this charismatic and iconic species. Therefore, this study aims to document local ecological knowledge about the Amazonian manatee in the Purus River (Amazonas state, Brazil), and to access local perceptions regarding the species' conservation.

MATERIAL E METHODS

Study area

The study was conducted along a 550 km stretch of the middle and lower Purus River, between the municipalities of Beruri and Tapauá, in the state of Amazonas, Brazil (Figure 1). The region has a humid tropical climate, with average monthly temperatures around 28 °C and annual rainfall ranging from 2.000 to 2.600 mm (Deus et al. 2003; IBGE 2010). The high-water season occurs from January to June, followed by the low-water season from July to December (Goulding et al. 2003). The area includes *terra-firme* forest (non-floodable plateaus) and extensive floodplain (*várzea*) habitats characterized by streams, lakes, and channels (IPI 2010; Hawes et al. 2012). The Purus River is classified as a white-water river (Sioli 1984), rich in suspended sediments and nutrients of Andean origin (Goulding et al. 2003). The high aquatic productivity of white-water system results in a greater abundance of aquatic macrophytes, which serve as an important food source for the Amazonian manatee. The region is known for its intense fishing activity, which supplies a significant portion of the fish consumed in Manaus - the largest fish market in the Amazon (Batista and Petrere 2003).

The study area includes two adjacent Protected Areas (PAs) and their surrounding regions: the Piagaçu-Purus Sustainable Development Reserve (PP-SDR) and the Abufari Biological Reserve (REBIO-A). The PP-SDR (latitude -4.265270º, longitude -61.797510º) is a sustainable-use PA created in 2003, covering 834.245 hectares. Approximately 5.203 people live in PP-SDR, distributed across 67 communities and villages (SEMA 2020). The REBIO-A (latitude -5.177770º, longitude -63.049678º) is a strictly protected federal reserve with 223.864 hectares (ICMBio 2018). Despite its designation for full protection without human interference, REBIO-A maintains a population of

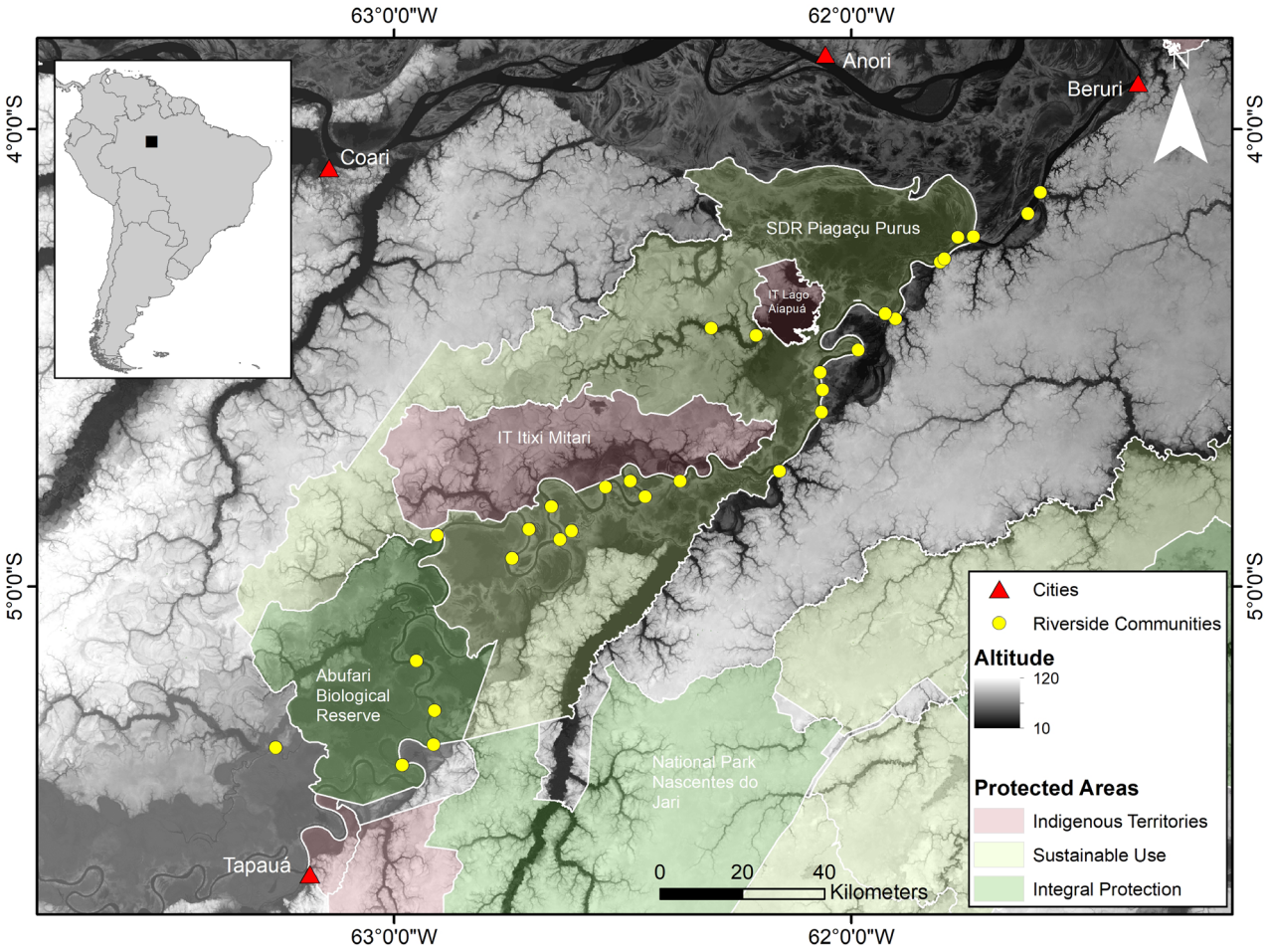

Figure 1. Location of the 30 riverside communities sampled in the Purus River, between the municipalities of Beruri and Tapauá, Amazonas, Brazil.

approximately 1.400 people across 31 communities, who continue to use natural resources within the area, leading to social and environmental conflicts. Despite differences in protection category and regulation regarding resource use, the two PAs are similar in terms of environmental and socioeconomic characteristics.

Residents engage in small-scale commercial and subsistence activities such as fishing, hunting, agriculture, and the extraction of forest products such as timber, Brazil nuts, and açaí (ICMBio 2018; SEMA 2020). In the PP-SDR, community-based management of the *pirarucu* (*Arapaima gigas* Schinz 1822) has been implemented (Arantes and Freitas 2016; Petersen et al. 2016), contributing significantly to household incomes. Since 2008, some communities have adopted a zoning system to regulate local fishing practices, classifying areas as either "Preservation" (where only enforcement and research activities are allowed) or "Use" zones (where commercial and subsistence fishing is permitted to support local livelihoods) (IPI 2010; SEMA 2020). In the REBIO-A, community-based fisheries management is absent.

Legal requirements

The study was registered in Plataforma Brasil and approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (nº. 6.093.585), the Chico Mendes Institute for Biodiversity Conservation (ICMBio; SISBIO nº. 86945-1), and the Department of Climate Change and Management of Conservation Units of the Amazonas State (DEMUC/SEMA; nº. 09/2023). Prior informed consent was obtained from all participants before the interviews were conducted.

Interviews

Interviews were conducted between January and February 2024 with 104 residents from 30 riverine communities distributed throughout the study area (Figure 1). Communities selected for participation were identified based on prior knowledge and previous contact with a resident or community leader. All selected communities were located within the PP-SDR, the REBIO-A, or their surrounding areas. The study used a non-random sampling approach (Albuquerque et al. 2014), targeting

individuals considered "local manatee experts", represented by experienced fishers, hunters, and former manatee hunters.

In each community, the first interviewee was suggested by the community leader. Subsequently, the snowball sampling method was applied (Bailey 1994; Bernard 2006), whereby each interviewee indicated other individuals to participate in the study. Each interview lasted an average of 30 minutes and was conducted individually using a structured questionnaire composed of both open- and closed- questions (Vietler 2002; Boni and Quaresma 2005). The questionnaire addressed socioeconomic information about the interviewees, as well as their local ecological knowledge and perceptions regarding the conservation of the Amazonian manatee.

LEK related to the diet of *T. inunguis* in the Purus River was assessed using the free-listing method (Albuquerque et al. 2014; Crema et al. 2019a). During the interviews, participants were asked two questions on the subject: (1) Please, list the food items that manatees eat most during the high-water season, and (2) Please, list the food items that manatees eat most during the low-water season. Subsequently, a book with photographs of plant species consumed by the Amazonian manatees (Guterrez et al. 2008) was presented to the interviewees to confirm and identify the cited tems. In addition, the guided tour technique was employed, which involved accompanying the informant in the field to identify the plant species previously mentioned during the interviews. This approach helps confirm and clarify the common names of the plants cited by interviewees (Albuquerque et al. 2010). All interviews were conducted by the lead author, who has worked in the region for over 10 years and has built a good relationship with most of the communities.

Data analysis

Responses from interviewees regarding the biology and ecology of the Amazonian manatee were categorized into three themes: social behavior, activity patterns, and habitat use. Subsequently, LEK was contrasted with classical scientific literature for each theme using a Comparative Cognition Table (Marques 1995). The adherence by theme (AdT) between LEK and scientific knowledge (SK) was calculated as the proportion of responses that agreed with scientific literature, divided by the total number of citations within each theme (TC), as expressed by the formula: AdT= SK / TC.

The list of food items mentioned for each season was used to calculate the cognitive salience index (Sutrop 2001). This index (S) represents the relative importance of each item, by combining its frequency of mention (F) with its mean position across all lists (mP): S= F / (N × mP), where N is the total number of food items mentioned across all interviews (Crema et al. 2019a). Scientific names of plant species were standardized according to Reflora – Flora and Funga of Brazil (Reflora 2024). In addition, species identification were verified by a botanical expert based on photographic records.

RESULTS

Profile of interviewees and human communities

The interviewees (n= 104) were adult men aged between 21 and 81 years (mean= 49 ± 14 years), residing in 22 communities within the PP-SDR, five within the REBIO-A, and three in the surrounding areas of these two PAs. The average number of interviews per community was 3 ± 2 (range: 1-8 interviews), with most conducted in the PP-SDR (n= 78 interviews), followed by the REBIO-A (n= 17 interviews) and the surrounding areas (n= 9 interviews). The average fishing experience among interviewees was 35 ± 14 years (range: 6-70 years), and the average time living in the region was 41 ± 18 years. Fishing was the main source of income (n= 70; 67%), followed by retirement benefits (n= 19; 18%) and other sources (n= 15; 15%).

Knowledge about the Amazonian manatee

Regarding interviewees' knowledge of the Amazonian manatee, 100% (n= 104) were able to identify feeding traces left by the species on aquatic plants – locally known as *comedias* – and 96% recognized the animal's feces in the wild. For 87% of respondents, the most recent sighting of a manatee in the region occurred between 2020 and 2023. Although all the questions were posed to all interviewees, some individuals chose not to respond or were unfamiliar with certain topics, resulting in variation in the numbers of responses across questions.

Social behavior, activity pattern and habitat use

LEK regarding the social behavior and activity patterns of *T. inunguis* in the Purus River had low agreement with the scientific literature (Table 1). Most responses (57%) suggested that the Amazonian manatee lives in pairs, typically consisting of a male and female or a mother and calf. Additionally, 15% reported that they live in groups of three, 8% in larger groups (more than three individuals), and 6% considered the species to be solitary. Twenty-six interviewees mentioned that Amazonian manatees may form temporary aggregations of up to 15 individuals, particularly during the reproductive season or in the low-water period. Regarding activity patterns, 48 (46%) respondents reported that the *T. inunguis* is more active and moves longer distances at night; 25 (24%) stated that it is more active during the day; 21 (20%) reported similar activity during day and night; and 10 (10%) were unsure. The citation below illustrates the specie's behavior as perceived by local fishers:

> *"O peixe-boi faz menos zuada que uma jacinta molhando a bunda"* – Interviewee 8
>
> (The manatee makes less noise than a dragonfly wetting its butt).

Table 1. Comparative Cognition Table summarizing biological and ecological aspects of the Amazonian manatee (*Trichechus inunguis*) based on Local Ecological Knowledge (LEK) from residents of the Purus River, Brazil, contrasted with Scientific Knowledge (SK).

Theme	LEK	SK	Concordance	Citation	Adherence
Habitat use in the high-water season	*"Vive nos lagos, cacaias e igapó".*	Manatees remain in floodplain lakes and *igapó* forests (Best 1984; Arraut et al. 2010).	106	120	0.88
	"Fica lá porque têm muita comida".	Manatees live in association with macrophytes (Arraut et al. 2010), feeding on fresh plants (Best 1984).	69	98	0.70
Habitat use in the low-water season	*"Fica no poço e nos boiadores no canal do rio".*	Manatee migrate to lakes or river channels during the dry season (Best 1983; Arraut et al. 2010; Landeo-Yauri et al. 2017).	113	126	0.89
	"Gosta de ficar em lugar fundo".	Manatee remain in deep areas (Best 1983; Arraut et al. 2010), avoiding predation of the caimans, jaguars, and humans (Arraut et al. 2010).	77	93	0.82
Social behavior	*"O peixe-boi vive mais de casal".*	Manatee is relatively solitary, with low interaction among individuals (Rosas 1994).	5	104	0.05
	"Na seca do rio e na época da vadia vive de lote".	Aggregations may occur in feeding areas and during the reproductive period (Pereira 1944; Husar 1977; Best 1982).	27	104	0.26
Activity pattern	*"Durante o dia fica parado, e a noite sai pra comer".*	Manatees appear to be active both during the day and at night, with no diurnal/nocturnal pattern (Montgomery et al. 1981).	21	104	0.20
	"Na boca da noite e início da manhã é mais ativo".	They feed regardless of the time and may forage in the morning and afternoon (da Silva 2004).			

Note: The original sentence of interview were kept in Portuguese to preserve the cultural and linguistic authenticity of the informants, which are essential to valuing their perspectives and maintaining the integrity of Local Ecological Knowledge (check the translation in the Appendix, Table A1).

LEK showed high concordance with scientific knowledge regarding seasonal habitat use of the Amazonian manatee (Table 1). During the high-water season of the Purus River, 66% of informants reported that the species inhabits flooded environments of the floodplain, such as lakes, *chavascais* (extensive areas of low, shrubby, swampy vegetation), and *cacaias* (forest dying due to sedimentation and excess water), while 23% also mentioned *igapós* (densely forested flood-tolerant habitats). These responses were primarily justified by the high availability of food during this period (71%). During the low-water season, 79% of interviewees reported that manatees consistently seek deeper areas. Of these, 61% indicated that manatees move to the *boiadores* (deep sections of the Purus River channel), while 21% stated that manatees remain in floodplain lakes.

Diet and feeding habits

Interviewees reported a total of 41 food items consumed by the Amazonian manatee in the Purus River, primarily including aquatic herbaceous plants, fruits, decaying plant material, and debris found in the substrate of water bodies. Despite seasonal variation in food items, seven species of aquatic herbaceous plants and one fruit from a riverine tree were cited as part of *T. inunguis* diet throughout the entire flood pulse (Table 2). The Poaceae family accounted for the greatest number of plant species (n= 6) in the Amazonian manatee diet in the Purus River.

During the high-water season, 29 food items were mentioned, with the most frequently cited being *Echinochloa polystachia* (Kunth) Hitchc. (n= 55; 23%), *Olyra* sp. (n= 42; 18%), and *Luziola subintegra* Swallen (n= 20; 8.5%). In contrast, during the low-water season, 22 food items were reported, with the most important being sand (n= 42; 35%) and clay (n= 11; 9%). Additionally, one interviewee mentioned fish consumption by *T. inunguis*; another reported that the manatee feeds on any available plant material or detritus on the river bottom; and three interviewees stated that the species fasts during the low-water season (Table 2). Six interviewees did not know what manatees eat during this period. The food item with the highest cognitive salience index during the high-water season was *E. polystachya*, followed by *Olyra* sp. - species with emergent and amphibious growth habits, respectively. During the low-water season, sand and clay presented the highest salience index values (Table 3).

Perceptions of Amazonian manatee conservation in the Purus River

According to interviewees, the main threats to Amazonian manatee conservation in the Purus River are fishing nets (31%; n= 29), followed by hunting (29%; n= 26), pollution (13%; n= 12), and noise (12%; n= 11). However, 14 (15%) respondents perceive no current threats to the species in the region. Regarding the impacts of climate change, 88.5% (n= 92) of interviewees reported that severe droughts pose

Table 2. List of food items consumed by the Amazonian manatee (*Trichechus inunguis*) according to interviewees during the high-water (H) and low-water (L) seasons of the Purus River, Brazil. Plant species were classified according to the nomenclature of Reflora (2024), and their growth habits were categorized based on the classifications proposed by Piedade et al. (2019).

Species	Vernacular name	Habit	Season
Aquatic herbaceous			
Apocynaceae			
Rhabdadenia madida (Vell.) Miers.	cipó-de-leite	Vine	H
Tassadia berteroana (Spreng.) W.D.Stevens	cipó-icica	Vine	H
Araceae			
Pistia stratiotes L.	mureru-pajé	Free floating	H
Convolvulaceae			
Ipomoea aquatica Forssk.	batatarana	Vine	H
Cyperaceae			
Eleocharis confervoides (Poir.) Steud.	capim-amã	Amphibious	H, L
Cyperus articulatus L.	piprioca	Amphibious	H, L
Eleocharis sp.	cebolinha	Amphibious	H
Hydrocharitaceae			
Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine	mureru-moeda	Free floating	H
Lentibulariaceae			
Utricularia foliosa L.	camarão-quiça	Free floating	H
Nymphaeaceae			
Victoria amazonica (Poepp.) J.E. Sowerby	vitória-régia	Rooted submerged with floating leaves	H
Poaceae			
Echinochloa polystachya (Kunth) Hitchc.	canarana	Emergent	H, L
Luziola subintegra Swallen	capim-arroz	Emergent	H, L
Paspalum repens P.J.Bergius	membeca	Emergent	H, L
Leersia hexandra Sw.	capim-navalha	Emergent	H
Oryza grandiglumis (Döll) Prod.	arroz-de-pato	Emergent	H
Olyra sp.	taboquinha	Amphibious	H, L
Not identified	capim-de-burro	-	H
Not identified	tabocaí	-	H
Pontederiaceae			
Pontederia crassipes Mart.	mureru-buchudo	Free floating	H
Not identified	mureru-mão-de-onça	-	H
Pontederia rotundifolia L.f.	aguapé	Rooted submerged with floating stems	H
Not identified	mureru	Rooted submerged with floating stems	H, L
Salviniaceae			
Azolla filiculoides Lam.	xibé-de-peixe-boi	Free floating	H
Trees			
Annonaceae			
Oxandra riedeliana R.E.Fr.	fruto-da-envira	Riverine tree	H, L
Chrysobalanaceae			
Couepia paraensis (Mart. & Zucc.) Benth.	fruto-da-uxirana	Riverine tree	H
Fabaceae			
Macrolobium acaciifolium (Benth.) Benth.	fruto-do-arapari	Riverine tree	L

Table 2. Continued

Species	Vernacular name	Habit	Season
Myrtaceae			
Eugenia sp.	fruto-do-araça	Riverine tree	H
Picrodendraceae			
Piranhea trifoliata Baill.	fruto-da-piranheira	Riverine tree	H
Other food item			
Fruit (*fruto/caroço*)	-	-	H, L
Aquatic grass (*capim*)	-	-	H, L
Sand (*areia*)	-	-	L
Grass residue (*bagaço de capim*)	-	-	L
Clay (*barro*)	-	-	L
Leaf litter (*folha morta*)	-	-	L
Mud (*lama*)	-	-	L
Slime (*lodo/limo*)	-	-	L
Floating vegetation (*matupá*)	-	-	L
Rotten wood (*pau podre*)	-	-	L
Rice seed on the bottom (*semente de arroz no fundo*)	-	-	L
Old grass on the bottom (*capim velho no fundo*)	-	-	L
Fish (*peixe*)	-	-	L

Table 3. Frequency and mean citation position of each food item of the Amazonian manatee (*Trichechus inunguis*) diet mentioned by interviewees, according to the flood pulse of the Purus River, ordered by decreasing values of the cognitive salience index.

Food item	Citation frequency	Mean citation position	Cognitive salience index
High-water season			
E. polystachya (Kunth) Hitchc.	55	1.49	0.37
Olyra sp.	42	1.66	0.25
Aquatic grass	12	1.41	0.08
L. subintegra Swallen	20	2.71	0.07
C. articulatus L.	12	1.75	0.07
I. aquatica Forssk.	14	2.78	0.05
Mureru	14	2.14	0.06
P. repens P.J.Bergius	12	2.16	0.06
O. riedeliana R.E.Fr.	11	2.72	0.04
L. hexandra Sw.	6	2	0.03
A. filiculoides Lam.	6	2.33	0.03
Tabocaí	5	1.6	0.03
Mureru-mão-de-onça	6	3	0.02
P. stratiotes L.	3	2.33	0.01
Fruit	3	2	0.01
U. foliosa L.	2	3.5	0.01
E. confervoides (Poir.) Steud.	2	1.5	0.01
Capim-de-burro	1	1	0.01
Eleocharis sp.	1	1	0.01
C. paraensis (Mart. & Zucc.) Benth.	1	1	0.01

Table 3. Continued

Food item	Citation frequency	Mean citation position	Cognitive salience index
P. rotundifolia L.f.	1	2	0.00
O. grandiglumis (Döll) Prod.	1	2	0.00
R. madida (Vell.) Miers.	1	3	0.00
T. berteroana (Spreng.) W.D.Stevens	1	3	0.00
P. trifoliata Baill.	1	2	0.00
Eugenia sp.	1	3	0.00
P. crassipes Mart.	1	2	0.00
L. laevigatum (Humb. & Bonpl. ex Willd.) Heine	1	3	0.00
V. amazonica (Poepp.) J.E. Sowerby	1	2	0.00
Low-water season			
Sand	42	1.26	0.38
Clay	11	1.18	0.11
Slime	6	1	0.07
E. polystachya (Kunth) Hitchc.	8	1.37	0.07
Aquatic grass	7	1.28	0.06
Rice seed on the bottom	6	1.5	0.05
P. repens P.J.Bergius	6	1.66	0.04
C. articulatus L.	6	1.66	0.04
Grass residue	4	1.25	0.04
Leaf litter	3	1.33	0.03
Olyra sp.	3	1	0.03
Mud	4	2	0.02
Mureru	2	1	0.02
Old grass on the bottom	2	1	0.02
E. confervoides (Poir.) Steud.	1	2	0.01
L. subintegra Swallen	1	1	0.01
O. riedeliana R.E.Fr.	1	1	0.01
M. acaciifolium (Benth.) Benth.	1	1	0.01
Fruit	1	2	0.01
Floating vegetation	1	2	0.01
Fish	1	1	0.01
Rotten wood	1	1	0.01

a significant risk to manatee survival; 2% (n= 2) mentioned small floods; and 10% (n= 10) did not know how to respond.

The importance of Protected Areas for the protection of *T. inunguis* was recognized by 98% (n= 102) of respondents. Specifically, 73% (n= 57) of interviewees from the PP-SDR stated that aquatic zoning (i.e., designation of preservation and use areas) provides benefits and supports manatee protection; 14% (n= 11) believed it does not offer protection; 12% (n= 9) stated it provide only limited benefits (mainly during the high-water season); and 1% (n= 1) did not know how to respond. This question was not addressed in the REBIO-A or surrounding areas, as aquatic zoning is not implemented. Additionally, 94% (n= 98) of respondents perceived an increase in the *T. inunguis* population over the past 20 years; 3% (n= 3) stated the population has remained stable; 1% (n= 1) observed a decline; and 2% (n= 2) were unsure. The most frequently cited reasons for population recovery were the creation of PAs (78%; n= 70), management of *pirarucu* fisheries (10%; n= 9), reduction in hunting (10%; n= 9), and the manatee release program conducted by the National Institute of Amazonian Research (2%; n= 2).

DISCUSSION

This study explores the biology and ecology of the Amazonian manatee in the Purus River basin from the perspective of local residents. Local Ecological Knowledge (LEK) provided valuable insights into Amazonian manatee behavior, including aspects not yet documented in the scientific literature and that warrant further investigation in the Purus River. While LEK showed strong agreement with the scientific literature regarding habitat use and aspects of feeding ecology, differences were observed in perceptions of social behavior and activity patterns.

Social behavior, activity pattern and habitat use

The agreement between LEK and scientific knowledge regarding the social behavior of *T. inunguis* was low. Most respondents stated that manatees live in pairs, contrasting with the solitary behavior reported in the literature (Rosas 1994). However, similar observations of manatees in pairs - usually a mother and calf - have also been reported in other regions of the Amazon, such as the Negro and Tapajós Rivers (Crema et al. 2019a) and the Xingu River (Hoffmann et al. 2021). Respondents additionally described temporary aggregations during the low-water season and the reproductive period, which aligns with LEK in other regions (Franzini et al. 2013; Crema et al. 2019a; Hoffmann et al. 2021), and early classical studies (Pereira 1944; Best 1982).

Regarding activity patterns, respondents reported that *T. inunguis* are more active and travel greater distances at night due to lower noise and reduced human disturbance. These observations differ from previous studies describing no clear diel pattern (Montgomery et al. 1981; da Silva 2004). In the Amanã Reserve (Japurá River), LEK also indicated nocturnal feeding (Calvimontes 2009), and hunters prefer night time for manatee encounters (Calvimontes and Marmontel 2022). In our study, one respondent based their answer on nocturnal interactions of manatee in fishing nets. Experiments in captivity showed that American manatees (*T. manatus*) avoid nets more during the day, likely due to better visual perception (Kikuchi et al. 2011). Thus, increased nigh time entanglements may reflect reduced visual acuity rather than intrinsic nocturnal activity. Manatee activity is likely shaped by human disturbance, habitat type, water level, and fishing pressure. There is no clear consensus on whether manatees are diurnal or nocturnal (Reynolds 1981; Kikuchi et al. 2011; Holguin-Medina et al. 2015; Erbs et al. 2025). Evidences suggests that manatees exhibit cathemeral behavior, with activity occurring both day and night - a pattern consistent with other aquatic mammals (Mukhametov et al. 1992; Holguin-Medina et al. 2015; Dias-Silva et al. 2025; Erbs et al. 2025).

In contrast, LEK regarding habitat use showed strong agreement with scientific literature (Best 1983; Arraut et al. 2010). However, a novel perception emerged, since a substantial fraction of respondents reported that a large number of manatees remain in floodplain "*várzea*" during the low-water season, diverging from patterns observed in other regions (Arraut et al. 2010; Landeo-Yauri et al. 2017; Crema et al. 2019b). The year-round persistence of manatees in várzea lakes during the low-water season may indicate a high degree of behavioral plasticity in *T. inunguis*, shaped not only by hydrological cycles but also by local habitat conditions. Seasonal habitat use by manatees remains poorly understood across the Amazon basin, and telemetry studies in the Purus River could improve the understanding of spatial dynamics and further explore the patterns described through LEK.

Diet and feeding habits

The frequent mention of plants in the Poaceae family in the Amazonian manatee diet is consistent with Colares and Colares (2002) and Guterres-Pazin et al. (2014), who reported over 90% of fecal and stomach samples contained Poaceae. Respondents described dietary shifts across the flood pulse of the Purus River, driven by resource availability. For instance, fruits from riverine trees consumed during high-water periods likely provide important nutrients for the species (Guterrez et al. 2014). The Amazonian manatee is an opportunistic feeder that consumes a wide range of aquatic and semi-aquatic plants (Best 1981; Colares and Colares 2002; Guterres et al. 2008; Franzini et al. 2013; Guterres-Pazin et al. 2014; Crema et al. 2019a), although diet may vary among individual preference (Crema et al. 2019a).

Echinochloa polystachya had the highest cognitive salience in the high-water season, likely reflecting both preference and high abundance (Junk and Piedade 1997). Stable isotope studies show that C4 grasses, particularly Poaceae, constitute much of the manatee diet in floodplain environments (Crema et al. 2019b; Carvalho et al. 2022). In the low-water season, sand and clay were the most salient items, highlighting the nutritional challenges imposed by extreme drought events. Intensifying droughts linked to climate change (Costa and Marengo 2023; Costa et al. 2024; Espinoza et al. 2024) may further reduce plant availability and increase physiological stress.

Although previously mentioned only anecdotally, this is the first study to quantitatively document and demonstrate the relevance of non-vegetal items (sand and clay) in the diet of *T. inunguis* during the low-water season. Also, one respondent mentioned fish consumption, a behavior not previously documented for the species. Although manatees are primarily herbivorous, opportunistic ingestion of fish, especially from nets, could occur during periods of food scarcity. Incidental ingestion of invertebrates is already known (Best 1981; Colares and Colares 2002; Guterres-Pazin et al. 2012). Carnivory has been documented in *T. manatus* (Powell 1978; Caicedo-Herrera et al. 2020; Vermelho et al. 2023)

and *T. senegalensis* (Keith-Diagne 2014). Thus, future studies of diet may clarify the frequency and seasonal relevance of opportunistic carnivory in *T. inunguis*.

Almost all respondents mentioned that manatees ingest decaying plant matter, sand and clay during the low-water season. These observations are consistent with previous assumptions that food scarcity during this period leads to fasting in *T. inunguis* (Best 1983). Sand and decaying material have also been reported in stomach contents of Amazonian manatees during the low-water season (Colares and Colares 2002), which may contribute to intestinal blockage. According to respondents, this condition may help explain the increased reports of manatee carcasses during extreme drought events, when food resources become even more limited and animals may resort to consuming low-quality or atypical food items.

Perceptions of Amazonian manatee conservation in the Purus River

Respondents identified fishing nets and hunting as the main threats to Amazonian manatee, consistent with the primary anthropogenic causes of sirenians' mortality reported globally (Castelblanco-Martínez et al. 2009; Marmontel et al. 2016; Machuca-Coronado et al. 2023).

Additionally, respondents strongly valued the role of Protected Areas and aquatic zoning in the PP-SDR in reducing hunting and promoting the recovery of *T. inunguis*. Reports of increased sightings and, in some cases, larger groups may indicate positive trends in local abundance of species, potentially associated with community-based fisheries management in the PP-SDR, which has been shown to support population growth of several non-target aquatic species (Campos-Silva et al. 2018). However, reports of population increases may reflect desirability bias (Bogner and Landrock 2016; Sampaio et al. 2022), as respondents may offer favorable narratives aligned with perceived expectations. Although novel methods such as passive acoustic monitoring, side scan sonar (Gonzalez-Socoloske and Olivera-Gómez 2023), and eDNA (Hunter et al. 2018) are being tested, the population size of T. inunguis remains unknown.

Extreme drought events were frequently cited as major threats. The severe 2023 drought, which resulted in widespread manatee hunting (Souza et al. 2024) and the direct natural death of more than 300 river dolphins in the Central Amazon, underscores the growing risk that climate change poses to Amazonian aquatic mammals (Marmontel et al. 2024; Fleischmann et al. 2025). Community concerns regarding prolonged droughts and hydrological instability highlight emerging pressures that are likely to intensify in coming decades (Marengo and Espinoza 2016; Sorribas et al. 2016).

CONCLUSIONS

Local Ecological Knowledge provided novel insights into the ecology of *T. inunguis* in the Purus River basin that remain poorly documented in the literature, including the persistence of manatees in floodplain lakes during the low-water season and the occasional consumption of fish. In addition, interviews with local resource users provided a valuable tool for understanding community perspectives on the conservation of the Amazonian manatee. These findings highlight the value of incorporating community-based observations to identify emerging threats, guide habitat protection, and support research and management of the species across protected and non-protected areas. Strengthening collaboration between scientists and riverine communities will be essential for developing effective conservation strategies for this endemic and vulnerable species in rapidly changing Amazonian river systems.

ACKNOWLEDGEMENTS

This study was supported by the *Fundo Brasileiro para a Biodiversidade* and Instituto Humanize through the grant *Bolsas FUNBIO – Conservando o Futuro*, and by the Zoological Society of Hertfordshire - Paradise Wildlife Park Conservation Fund. We thank the local riverine communities of the Purus River for their hospitality and essential contributions to this study. Our respect for the local knowledge holders. We thank the anonymous reviewers for their valuable contributions to the manuscript. DAS was supported by Fundação de Amparo à Pesquisa do Estado do Amazonas - FAPEAM (POSGFE nº. 012/2021).

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RECEIVED: 16/07/2025
ACCEPTED: 06/03/2026
ASSOCIATE EDITOR: Thiago Cardoso

DATA AVAILABILITY: The data supporting the conclusions of this study are available from the corresponding author, Diogo Alexandre de Souza, upon reasonable request. The dataset is not publicly available because it contains sensitive information that could compromise the privacy of research participants. In addition, the dataset includes unpublished data that will be used in future manuscripts.

AUTHOR CONTRIBUTIONS: Diogo Alexandre de Souza - conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, visualization, writing – original draft, writing – review & editing; **Eduardo Martins Venticinque** - conceptualization, formal analysis, methodology, supervision, visualization, writing – original draft, writing – review & editing; **Vera Maria Ferreira da Silva** - funding acquisition, resources, supervision, visualization, writing – original draft, writing – review & editing.

APPENDIX

Souza *et al*. Ecology and conservation of the Amazonian Manatee (*Trichechus inunguis*) from the perspective of fishers on the Purus River, Central Amazon: agreements and contrasts with scientific literature

Table A1. Translation of original statements from informants about the biology and ecology of the Amazonian manatee (*Trichechus inunguis*).

Theme	Original sentence in Portuguese	Translation
Habitat use in the high-water season	*"Vive nos lagos, cacaias e igapó".* *"Fica lá porque têm muita comida".*	"They live in lakes, cacaias, and igapó forests." "They stay there because there's a lot of food."
Habitat use in the low-water season	*"Fica no poço e nos boiadores no canal do rio".* *"Gosta de ficar em lugar fundo".*	"They stay in deep pools and boiadores in the river channel." "They prefer deep places."
Social behavior	*"O peixe-boi vive mais de casal".* *"Na seca do rio e na época da vadia vive de lote".*	"Manatees usually live in pairs." "During the dry season and mating period, they gather in groups."
Activity pattern	*"Durante o dia fica parado, e a noite sai pra comer".* *"Na boca da noite e início da manha é mais ativo".*	"During the day, they remain still; at night, they go out to feed." "They are more active at dusk and early morning."