

From river to plate: subsistence fishing activity in the middle Caeté, a lowland river in the Eastern Amazon, Pará, Brazil

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ABSTRACT

Amazonian people are highly dependent on fishing, which provides their main source of protein. Fishing in the middle Caeté, Eastern Amazon, Pará, Brazil, was described in terms of the sociodemographic profile of fishers, gear, and strategies used in catches. Semi-structured interviews were conducted with fishers in the region. Fishing occurs throughout the year, and to a lesser extent during the closed season. It is characterized as subsistence fishing, although a small percentage (20%) sell part of their catch to supplement their income. Fishing gear is diverse and varies according to the seasons, with gillnets and set longlines being the most common. Transportation is carried out aboard small canoes powered by oars or outboard motors. The most important commercialized species are the giant Malaysian prawn, *dourada*, and *piramutaba*, while *traíra*, *mandií*, *tuvi*, *anujá*, *aracu*, *piranha*, among others, are intended for family consumption. A change in fishers' habits is expected in terms of increasing the mesh size of gillnets to be more selective and to comply with fishing regulations.

Keywords: Subsistence fishing; Fisheries comanagement; Sociodemographic profile; Freshwater ecosystem.

Do rio ao prato: a pesca de subsistência no médio curso do Caeté, um rio de planície na Amazônia Oriental, Pará, Brasil

RESUMO

Os povos da Amazônia dependem fortemente da pesca, que constitui sua principal fonte de proteína. A pesca no curso médio do Rio Caeté, na Amazônia Oriental, estado do Pará, Brasil, foi descrita em termos de perfil sociodemográfico dos pescadores, artes de pesca e estratégias utilizadas nas capturas. Foram realizadas entrevistas semiestruturadas com pescadores da região. A pesca ocorre durante todo o ano e, em menor escala, durante a época de defeso. Caracteriza-se como pesca de subsistência, embora uma pequena porcentagem (20%) venda parte de sua captura para complementar a renda. As artes de pesca são diversificadas e variam de acordo com as estações do ano, sendo as redes de emalhar e os espinhéis as mais comuns. O transporte é realizado a bordo de pequenas canoas movidas a remo ou motores de popa. As espécies comercializadas mais importantes são o camarão-gigante-da-malásia, a *dourada* e a *piramutaba*, enquanto a *traíra*, o *mandií*, o *tuvi*, o *anujá*, o *aracu*, a *piranha*, entre outros são destinados ao consumo familiar. Espera-se uma mudança nos hábitos dos pescadores no sentido de aumentar a abertura da malha das redes de emalhar para serem mais seletivas e cumprir as normas de pesca.

Palavras-chave: Pesca de subsistência; Cogestão da pesca, Perfil sociodemográfico; Ecossistema de água doce.

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INTRODUCTION

The Amazon region has the greatest diversity of freshwater fish in the world, and fishing is essential for the livelihoods of thousands of families in rural areas (Begossi et al., 2019; Sirén & Valbo-Jørgensen, 2022). Fish provide proteins and micronutrients necessary for the food security of these families (Dias et al., 2023; Funge-Smith & Bennett, 2019; Golden et al., 2016). In some cases, fishing provides income from the sale of fish, contributing to poverty reduction (Poissant et al., 2023). In other cases, it is a means of subsistence, without necessarily resulting in extra income (Arruda et al., 2018). Furthermore, fishing is a way of life for the Amazon riverside communities (Begossi, 2004). The fisher's lifestyle determines the quality of life and health of those who practice it (Rahaman et al., 2021). Despite its importance, freshwater fishing in the Amazon is neglected in governmental fisheries management programs due to structural problems (Gonçalves Neto et al., 2021; Lopes et al., 2019), especially subsistence fishing, which suffers from neglect in terms of the guarantee of economic, social, cultural, and environmental rights, and lacks participatory management models (Doria et al., 2018).

From the mid-20th century onward, measures were introduced to increase fishing productivity and economically stimulate the sector, including the reformulation of the legal framework (Goularti Filho, 2021). As a result, new technologies were employed, and the federal government began to grant tax incentives and financing for the purchase of diesel engines, boats, and iceboxes, enabling large fishing companies to expand production, quickly leading to the over-exploitation of many species (Castello et al., 2015; Ruffino, 2005) and a rapid reduction in stocks of commercially important species in the Amazon (Batista & Petrere Júnior, 2003; Pereira et al., 2023). The increase in commercial fishing has significantly affected the livelihoods of traditional fishers, who exploit the same fishing areas for subsistence, raising important questions about sustainability and the management of freshwater fisheries in the Amazon (Cardoso & Freitas, 2012; Castro & McGrath, 2003).

In addition, subsistence fishing in the Amazon faces serious threat from factors indirectly related to fishing, including environmental and socioeconomic threats (Alho et al., 2015). The reduction of fish stocks to very low levels may compromise the food security of many riverside communities who use fishery resources (Dias et al., 2023; Lopes et al., 2023), which will result in increased pressure on terrestrial resources (Orr et al., 2012). Therefore, it is urgent that we expand our knowledge of how fisheries management in the Amazon may prevent a food supply collapse among rural families (Goulding et al., 2019).

Most research on freshwater fishing has been conducted in a manner that only considers activity in the large Amazon basin and its main tributaries (Isaac et al., 2015; Hallwass et al., 2023; Keppeler et al., 2020; Mesquita & Isaac-Nahum, 2015). Meanwhile, fishing in small river basins is not always included in fisheries research. Fishing and its social actors in the lower Caeté, which is located in the Salgado Paraense region of the Eastern Amazon, has been relatively well studied in the estuarine section, as it is an important commercial fishing area (Bentes et al., 2012; Lutz et al., 2016; Nascimento et al., 2022; Pereira et al., 2020). However, the middle course of the Caeté has a relatively dense riverside population that practices freshwater fishing, which has not been characterized yet. It is known that fishery resources in this region have been declining, which led communities to demand local management regulations (locally known as a fishing agreement) to reduce overfishing and limit encroachment of non-local fishers (Tavares et al., 2022). However, no study so far has sought to characterize this fishery and identify the social actors in the activity. Characterizing fishing activity is important for identifying fishing effort patterns, target species, and socioeconomic vulnerabilities (Thiault et al., 2017). This is essential for informing strategies for the sustainable use of resources, management and conservation policies and ensuring local food security for dependent communities (Cooke et al., 2016; Funge-Smith & Bennett, 2019).

The objectives of this study were to describe the sociodemographic profile of the fishers, identify the species of interest, and describe the fishing gear and strategies used in the middle Caeté.

METHODS

Study area and research context

The Caeté is a lowland river formed by alluvial deposits, located in the northeast of the state of Pará, Brazil, draining an area of 2,195 km², along approximately 150 km, flowing directly into the Atlantic Ocean (Costa & Sombra, 2021; Gorayeb & Pereira, 2014) (Fig. 1). The region's climate is tropical humid, with two seasons defined by the rainfall pattern. The rainy season generally extends from January to July and the dry season from July to December, with rainfall subject to reductions due to climate change (Blanco et al., 2023). Annual precipitation in the region varies between 2,500 and 3,000 mm (Menezes et al., 2015). Eighty percent of precipitation occurs during the rainy season, which also determines the flood period of the region's rivers including the Caeté River floodplain (Ferreira & Botelho, 1999). Over the last few decades, the landscape of the Caeté River basin has undergone intense changes that have caused serious

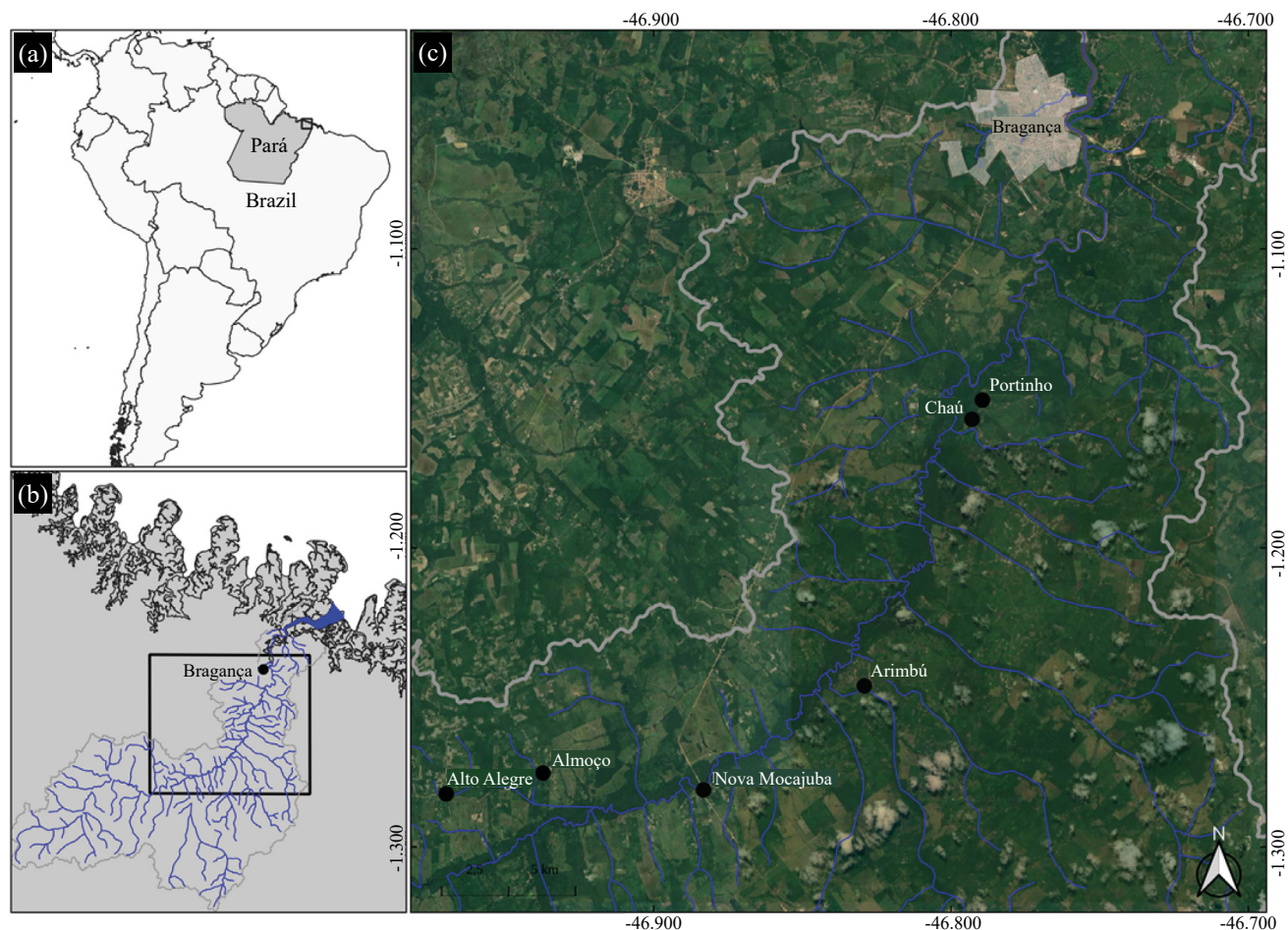


Figure 1. Location of (a) the state of Pará, (b) the Caeté River basin, in the northeast of the state, and (c) the traditional riverside communities in which 42 interviews were conducted to characterize fishing in the middle reaches of the Caeté River, Bragança, Pará, Brazil.

environmental problems, such as the extraction of non-metallic minerals, urbanization, and conversion to pasture, leaving only 11% of native forest remaining (Costa & Sombra, 2021). Since 2019, the region has had a fishing agreement in place that establishes rules for the activity, such as a minimum gillnet mesh size of 35 mm between knots, as well as a closed season between November and February (Pará, 2023).

Data collection

The data were collected between December 2023 and April 2024 through 42 interviews with fishers using a semi-structured questionnaire. Interviews aimed to capture sociodemographic information about the fishers, characteristics of the gear, techniques and vessels used, species of interest, and the destination of the fish (sale or consumption). Sociodemographic information concerned age, length of experience in fishing,

education, type of residence, and other activities besides fishing. Six riverside communities of the Caeté River were selected after prior telephone contact with the community leader, who indicated interest in participating in the research: Alto Alegre, Almoço, Nova Mocajuba, Arimbú, Chaú, and Portinho. The communities selected for this study are family clusters that house up to 30 to 50 families (IBGE, 2022), who obtain one of their main sources of food from locally caught fish. The contact with the community leader and the selection of the first interviewee occurred with the help of technicians from the Municipal Secretariat of Aquaculture and Fisheries of Bragança, who had been working in the area and had already established a relationship of trust with the fishers. The snowball sampling method was used to select more fishers (Naderifar et al., 2017).

In the initial approach with each fisher, a free and informed consent form was presented, indicating the institution responsible

for the research, the objective of the research, and the guarantee of anonymity. Each interview lasted about 30 minutes. The total number ($n = 42$) of interviews was considered sufficient, after which the inclusion of more interviewees in the study would likely not provide additional information. The research was authorized by the Research Ethics Committee of the Universidade Federal do Pará (opinion 7.208.175/CEP/UFPA).

Description of fishing gear and techniques

All fishing gear mentioned was characterized, and photographed, and the techniques used in the catches were described. To describe the technique, in addition to interviews, six fishing trips were monitored to observe the use of techniques (participant observation) (Anbleyth-Evans, 2021) and collect species for identification. The gear was classified, according to its components and the technique used, as follows: gillnets, line and hook gear, including rods, and traps (He, 2006). Gillnets are described by nylon type, length, total height, mesh size (mm), and deployment technique. Longlines are described by mainline and branchline lengths, and by the number and types of hooks. Fishing rods are characterized by rod type and construction material, whereas traps are described by material and capture technique. The species were identified with support of the literature (Espírito Santo et al., 2005) or with the help of ichthyologists with experience in the Caeté River.

Data analysis

Data on the sociodemographic profile were subjected to descriptive statistical analysis (mean and standard deviation) using

GNUR version 4.3.3 (R Core Team, 2024). All descriptive statistics were expressed as mean $\pm$ standard deviation, unless otherwise stated. Fishing gear was ranked based on the number of mentions during interviews (Serrão et al., 2022). The common names of the species mentioned were counted to determine the most important species based on the relative frequency of mentions. However, the common name often refers to more than one species, which could underestimate the actual number of species present in the locality. Also, it is common for fishers to assign several common names to the same species depending on the location, which can overestimate the richness (Freire & Pauly, 2005).

RESULTS

Sociodemographic profile of fishers

A total of 41 fishermen and one fisherwoman were interviewed in the six riverine communities in the middle Caeté. None of them are registered with the local fisher's association (Brazilian *colônias de pescadores*). Their ages ranged from 18 to 78 years old (44 ± 15.6). The length of experience in fishing ranged from three to 60 years (28.9 ± 14.1), indicating that fishers have accumulated knowledge about fishing and fishery resources in the Caeté River over decades. Fishing experience begins around the age of 10–12, and fishers between the ages of 25 and 30 have an average of 10.1 (± 2.30) years of activity. The average family size is 4.29 (± 1.67) people. The number of people from the same household who fish are one or two, they are almost exclusively men, although in the Chaú community women fish occasionally (Table 1).

Table 1. Sociodemographic characteristics of 41 men and one woman who are artisanal fishers and their families from the middle reaches of the Caeté River, Bragança, Pará, Brazil.

Characteristic	Communities												Total	
	Alto Alegre		Almoço		Nova Mocajuba		Arimbú		Portinho		Chauú			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Not literate*	2	33.30	-	-	1	14.3	-	-	-	-	1	12.5	4	9.5
Incomplete elementary*	3	50.0	4	66.7	3	42.9	6	75	5	71.4	7	87.5	28	66.7
Complete elementary*	1	16.70	1	16.7	2	28.6	2	25	1	14.3	-	-	7	16.7
High school*	-	-	1	16.7	1	14.3	-	-	1	14.3	-	-	3	7.4
	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range
Age	53.5±20.9	22–78	47.2±12.5	29–57	50.4±14.6	27–65	44.4±13.0	24–60	31.5±10.3	19–50	43.4±16.5	18–61	45.0 ± 15.7	18–78
Fishing experience (years)	35.0±18.7	10–60	30.0±8.6	20–40	37.1±12.5	20–50	29.4±14.3	10–50	16.8±4.0	10–20	29.4±15.7	10–50	29.8 ± 14.2	10–60
Family size	3.2±1.8	2–5	3.8±1.0	3–5	4.3±0.9	3–5	4.3±0.7	3–5	5.0±1.9	2–7	5.0±2.5	1–8	4.3 ± 1.6	1–8

*Educational background; $\bar{x}$: mean; SD: standard deviation.

Origin, education, and housing conditions

The sociodemographic information on the fishers revealed that 73% were born in the same community in which they currently reside, 27% are from neighboring communities, having moved there through marriage, and none stated that they came from another region. The overall level of education was relatively low: 8.0% of respondents have completed high school, 13.5% have completed elementary school, 67.6% have only incomplete elementary school education, and 10.8% have no formal education (they are illiterate). Regarding housing conditions, all fishers own their own homes built of masonry (83.8%), wood (8.1%), or clay (8.1%). Among all, 51.4% reported that their homes do not have bathrooms with septic tanks, and since there is no garbage collection, 100% of respondents burn or bury their garbage in their own yards.

Income

The interviewees stated that they do not depend exclusively on fishing. Among them, 89.2% identified themselves as farmers, agricultural workers, or farmhands, which is their main source of income. They divide their time between fishing and family farming, mainly the cultivation of cassava (*Manihot esculenta*) and other crops for sale and domestic consumption, such as corn, watermelon, and *açaí* (*Euterpe oleracea*). Other activities such as running small grocery stores, and salaried work made up the income of 10.8% of fishers. The Brazilian Income Transfer Program (Bolsa Família), a conditional cash transfer program, is also a component of the family income of 67% of respondents, in which the woman of the house is responsible for receiving the benefit.

In the communities of Alto Alegre, Almoço, Nova Mocajuba, and Arimbú, all fishing production is destined exclusively for family consumption. Meanwhile, in Chaú and Portinho, 62% of fishers are engaged in catching giant Malaysian prawn (*Macrobrachium rosenbergii*, de Man, 1879), *piramutaba* (*Brachyplatystoma vaillantii*, Valenciennes, 1840) and *dourada* (*Brachyplatystoma flavicans*, Castelnau, 1855), species with high commercial value, with all other species, particularly those of low commercial value, being destined for family consumption. The production of these two communities is intended for sale in Bragança city. At the time of the interviews, fishers reported that giant Malaysian prawn fetched the highest price per kilo among all species sold, selling at R\$ 50.00 (about US\$ 8.09), while *piramutaba* and *dourada* were sold for R\$ 10.00 (about US\$ 1.61) per kilo. Sales were made directly to middlemen. By comparison, the catch yield for *piramutaba* and *dourada* is

higher than that for the giant Malaysian prawn, as a single day of fishing can yield an average of 12 to 15 kg of fish and up to about 1.5 kg of giant Malaysian prawn.

Consumption of animal-based foods

In the diets of these fishing communities, fish and manioc flour are the primary components of meals, with fish being the most frequently consumed animal-based food. The weekly frequency of consumption of locally caught fish in the meals varied from two to six days (mean $\pm$ standard deviation = 3.54 ± 1.19). Free-range chickens are consumed between one and three times week. Beef is consumed most twice a week. However, only 38% of families have access to this protein weekly. Other foods consumed, in decreasing order of consumption, are ducks, pig, free-range eggs, and canned food.

Fishing activity

Canoes

Canoes (locally called *cascos*) ranging from 3 to 6 m in length and with capacity of one to six crew members are used for fishing. They are mainly propelled by oars, but 18% of fishers use outboard motors with an engine of up to 6.5 HP when they want to fish further downstream or when they need to travel long distances along the river. Fishing trips are usually undertaken by only one fisher.

Fishing period and duration

Although most fishers prefer to fish during the rainy season, fishing takes place year-round. However, with the entry into force of the fishing agreement (a set of local rules for managing fishing activity), fishers observe a closed season between November and February. The duration of fishing trips varies from a few hours to trips lasting eight days. The eight-day fishing trip is restricted to capture giant Malaysian prawn. However, most fishing trips last from 4 to 12 hours, depending on the type of equipment used and the fisherman's perception of the abundance and availability of fish.

Species caught

Thirty-two species were mentioned in the interviews, including three non-native species, such as the giant Malaysian prawn, tilapia (*Oreochromis* sp.), and tambaqui (*Colossoma* sp.). According to the fishers, the latter two reached the river through the rupture or overflow of dams used for their cultivation installed in the basin. *Traíra* (*Hoplias malabaricus*), *mandií* (*Pimelodus blochii*), *tuvi* or *tuí* (*Sternopygidae*), *anujá* (*Trachelyopterus galeatus*), and *aracu* (*Leporinus friderici*) were the species most mentioned by respondents, indicating

their importance for subsistence fishing in the middle Caeté (Table 2). The weight of the last catch monitored in the study, as reported by the fishers, ranged from 2 to 20 kg (mean $\pm$ standard deviation = 6.99 ± 3.83 kg).

Fishing gear and strategies

The fishing gear characterized in this study belongs to three categories: nets (gillnets and cast nets), lines and hooks (set longlines, rods/*caniço*, handlines, and *linha de espera*),

Table 2. Identification of species by common name, scientific classification, frequency of mentions, and destination of fish mentioned in interviews and caught by subsistence fishers in the middle Caeté River, Bragança, Pará, Brazil.

Common name	Family	Species or genus	Frequency of mention	Destination
Traíra	Erythrinidae	<i>Hoplias malabaricus</i>	91.0	Consumption
Mandií	Pimelodidae	<i>Pimelodus blochii</i>	64.7	Consumption
Tuvi, tubi or tuí	Sternopygidae	<i>Eigenmannia virescens</i> ; <i>Eigenmannia limbata</i> ; <i>Rhabdolichops troscheli</i> e <i>Sternopygus macrurus</i>	46.0	Consumption
Anujá	Auchenipteridae	<i>Trachelyopterus galeatus</i>	43.2	Consumption
Aracu	Anostomidae	<i>Leporinus friderici</i>	37.8	Consumption
Pacu	Serrasalminidae	<i>Myloplus nigrolineatus</i>	35.1	Consumption
Jacundá-coroa	Cichlidae	<i>Crenicichla</i> sp.	32.4	Consumption
Piramutaba	Pimelodidae	<i>Brachyplatistoma vaillantii</i>	32.4	Sale
Jandiá, jundiá	Heptapteridae	<i>Rhamdia quelen</i>	29.7	Consumption
Jacundá-piranga	Cichlidae	<i>Crenicichla</i> sp.	21.6	Consumption
Caratinga	Cichlidae	<i>Satanoperca jurupari</i>	18.9	Consumption
Gigante-da-malásia	Decapoda - Palaemonidae	<i>Macrobrachium rosenbergii</i>	18.9	Sale
Tambaqui	Serrasalminidae	<i>Colossoma</i> sp.	13.5	Consumption
Piranha	Serrasalminidae	<i>Serrasalmus rhombeus</i>	13.5	Consumption
Acará	Cichlidae	<i>Geophagus</i> spp.	10.8	Consumption
Sarapó	Not identified		8.1	Consumption
Piaba-fava	Characidae	<i>Poptella</i> sp.	8.1	Consumption
Mandií-bronze	Pimelodidae	<i>Pimelodella cristata</i>	8.1	Consumption
Camurin	Centropomidae	<i>Centropomus</i> sp.	8.1	Consumption
Piaba	Characidae	<i>Astyanax bimaculatus</i> e <i>Astyanax</i> spp.	8.1	Consumption
Pacamon	Batrachoididae	<i>Paulicea luetkeni</i> <i>Batrachoides surinamensis</i>	5.4	Consumption
Cururuca	Sciaenidae	<i>Plagioscion squamosissimus</i>	5.4	Consumption
Cara-rodo	Cichlidae	<i>Heros efasciatus</i>	5.4	Consumption
Acari	Loricariidae	<i>Hypostomus</i> spp.	5.4	Consumption
Jiju	Not identified		5.4	Consumption
Tilápia	Cichlidae	<i>Oreochromis</i> sp.	2.7	Consumption
Matara ou uéua	Acestrorhynchidae	<i>Acestrorhynchus falcatus</i>	2.7	Consumption
Papaisca	Serrasalminidae	<i>Serrasalmus eigenmanni</i>	2.7	Consumption
Cara-pedra	Cichlidae	<i>Geophagus altifrons</i>	2.7	Consumption
Tamatá	Callichthyidae	<i>Hoplosternum</i> sp.	2.7	Consumption
Carafuluca	Cichlidae	<i>Geophagus</i> sp.	2.7	Consumption
Dourada	Pimelodidae	<i>Brachyplatystoma flavicans</i>	2.7	Sale

and traps (*matapi* and *camina*). The most frequently used gear was the gillnet (79.4%), followed by set longlines (51.4%), cast nets (32%), handlines (24.3%), rods (29.7%), *linha de espera* (5.4%), *camina* (5.4%), and *matapi* (2.7%) (Table 3). The use of gear and fishing techniques varies according to the environment, species of interest, and season. In the rainy season, the most frequently used equipment are gillnets and set longlines, while in the dry season,

gillnets are mainly used. Gillnets and set longlines are placed in the floodplain during the rainy season. During the dry season, gillnets are placed in the deepest region of the riverbed, which usually coincides with the meander zone. Rods and handlines are used throughout the year, but mainly in the dry season because the main river channel offers more favorable conditions for using this technique (Santos et al., 2026).

Table 3. Fishing gear, frequency of mention, characteristics, and species of interest in subsistence fishing in the middle reaches of the Caeté River, Bragança, Pará, Brazil (Santos et al., 2026).

Fishing gear	% mention	Description	Species of interest
<i>Malhadeira</i>	79.4	Surface gillnet, made of monofilament nylon with a mesh size of 30 to 40 mm between knots, length varying between 10 and 30 m, and average height of 1.75 m	<i>Traíra</i> (<i>H. malabaricus</i>), <i>aracu</i> (<i>L. friderici</i>), <i>jacundá</i> (<i>Crenicichla</i> spp.), <i>acará</i> (<i>S. jurupari</i>)
<i>Piranheira/pacuzeira</i>	8.1	Surface gillnet with mesh size of 50 to 70 mm between knots. Length varying between 10 and 20 m and average height of 1.5 m, monofilament nylon thread with a diameter of 0.60 mm	Pacu (<i>Myloplus nigrolineatus</i>), <i>piranha</i> (<i>S. rhombeus</i>)
Encirclement net	24.3	Characterized in Chaú and Portinho only, made of 30 × 30 mm multi-filament polypropylene nylon between knots. Length from 300 to 500 m, height up to 4.5 m	Giant Malaysian prawn (<i>M. rosenbergii</i>), <i>piramutaba</i> (<i>B. vaillantii</i>), (<i>B. flavicans</i>)
Cast net	32.4	Circular net with a radius of 3 to 3.5 m, made of 30 × 30 mm monofilament mesh, with a lead weight on the outer edge of the circumference, which facilitates sinking onto the school of fish	<i>Piaba-fava</i> (<i>Poptella</i> spp.), <i>aracu</i> (<i>L. friderici</i>), <i>piaba</i> (Characidae)
Set longline	51.4	Main line made of 2.5 to 3 mm multi-filament polypropylene, with a total length of between 2 and 2.5 m, attached to a secondary line of multi-filament polyethylene up to 20 cm, equipped with 5 hooks of size 10, 12, 14 or 15, with worm bait (Annelida) and grasshopper (Insecta), pieces of fish, poultry, or beef	<i>Anujá</i> (<i>T. galeatus</i>), <i>jandiá</i> (<i>R. quelen</i>), <i>mandií</i> (<i>P. blochii</i>), <i>traíra</i> (<i>H. malabaricus</i>)
Hand-line	24.3	Nylon line 0.60 to 0.90 mm in diameter, up to 100 m long, weighted and with only one hook (size 6, 10, 12, or 15), depending on the species of interest	Pacu (<i>M. nigrolineatus</i>), <i>traíra</i> (<i>H. malabaricus</i>), <i>piranha</i> (<i>S. rhombeus</i>), <i>Tuvi</i> or <i>tui</i> (Sternopygidae)
<i>Canço</i>	29.7	Consisting of a bamboo rod up to 2.5 m long and 15 mm in diameter at its thickest end, 0.60-mm line, and a size 14 or 15 hooks without a sinker	<i>Tuvi</i> or <i>tui</i> (Sternopygidae), <i>pacu</i> , <i>acará</i> (<i>S. jurupari</i> and other Cichlidae)
<i>Linha de espera</i> (float)	5.4	Short line no more than 1 m long, 0.60 to 0.80 mm in diameter, hook size 9 to 15 tied to a piece of Styrofoam or bamboo stick	<i>Traíra</i> (<i>H. malabaricus</i>), <i>jacundá</i> (<i>Crenicichla</i> spp.), <i>pacu</i> (<i>M. nigrolineatus</i>)
<i>Camina</i>	5.4	Fishing trap consisting of a pole and a basket fixed to the riverbank through a line	<i>Traíra</i> (<i>H. malabaricus</i>), <i>piranha</i> (<i>S. rhombeus</i>)
<i>Matapi</i>	2.7	Cylindrical format trap made from strips of <i>guarimã</i> (<i>Ischnosiphon arouma</i>) or other suitable palm tree, tied together with rope vines.	<i>Mandií</i> (<i>P. blochii</i>), <i>piaba</i> (<i>Astyanax</i> spp.), <i>anujá</i> (<i>T. galeatus</i>), <i>acará</i> (<i>S. jurupari</i>)

Gillnets

Twenty-three gillnets were characterized, subdivided into four subtypes, according to the fisher's classification: *malhadaeira*, *piranheira/pacuzeira*, encirclement net, and cast net. Most of the gillnets identified have a 30-mm mesh size (Table 3). Fishers reported that they increased the mesh size of their nets from 20–25 to 30 mm, due to the fishing agreement. The gillnets are immersed for 12 hours. They are cast at dusk (around 6 p.m., shortly before dark) and retrieved shortly before dawn. However, in Chaú and Portinho, the encirclement net fishing occurs during the new and full moons due to the syzygy tide.

DISCUSSION

According to the Brazilian legislation Law 11,959/2009 (Brasil, 2009) and the World Bank (2012), subsistence fishing is for family or community consumption without a motive for profit, even when the surplus production is sold. Thus, fishing in the middle Caeté can be characterized as artisanal subsistence fishing, in which catches are mainly for family consumption. This partly explains the lack of adherence to fisher's associations, as fishers do not see themselves as professional, or full-time fishers, or lack guidance on proper procedures. On the other hand, current Brazilian law does not require subsistence fishers to hold a professional fishers registration. Fishing is dominated by men, who begin their fishing experience in childhood and continue fishing traditions to support their families. The low number of women identified in the survey may indicate a particular characteristic of the middle Caeté region, in contrast to studies showing women's active participation in fresh water fishing, accounting for over 20% of those involved (Díaz-Reviriego et al., 2016; Funge-Smith, 2018). Although it is not an activity intended for commercialization, fishing is essential for the survival of local communities by providing quality food, protein, and other nutrients to families, which is evidenced by the high frequency of fish in meals. Isaac et al. (2015) highlight that fish is the main food consumed in riverside communities in the Amazon basin, highlighting the importance of this means of subsistence for rural populations.

Fishing activity in the middle Caeté is practiced based on extensive ecological knowledge but maintained by families with predominantly low levels of education. Given that, all fishers come from the community itself or from surrounding communities. The absence of secondary schools in the communities over decades is the likely reason for the low level of education among fishers. In addition, as fishers began their experience of fishing in childhood, this implies dedicating time to this activity,

since it provides immediate benefits (food and income), while dedicating less time to studies (Souza & Baumgartner, 2021). Low levels of education are common among subsistence fishers around the world. For example, Yasin et al. (2024) found low levels of education in Ethiopia. Sousa et al. (2017) reported that on Lake Maicá, in Santarém, Pará, Brazil, more than 60% of fishers have incomplete elementary education, very similar to that found in the Caeté region. Our results are consistent with those of Pereira et al. (2020), who reported that 73% of fishers in the lower Caeté region had incomplete elementary education, and help to paint a more realistic picture of the socioeconomic reality of fishers in this river basin. Educapesca, an educational program tailored to the fishers of the region, aims to address this gap by providing access to and ensuring retention in school, and thus continuity of formal education (Prefeitura de Bragança, 2021). Nonetheless, according to our study area this program only attends Chaú community.

Most fishers in the middle Caeté earn their income from farming. Peroni (2004) points out that the planting, management, and harvesting of *M. esculenta* by fishers in rural areas is a common activity in the Amazon, carried out in accordance with lunar and hydrological cycles. The diversification of livelihoods may be an adaptive response by fishers to fluctuations and low productivity of fishery resources, which are directly related to inefficiencies in the management of these resources, central to the sustainability of fishing communities (Allison & Ellis, 2001). Another interesting aspect from a socioeconomic point of view is that most families depend on the conditional cash transfer program (Bolsa Família), revealing the government's concern for low-income families and poverty in the region. Bolsa Família is paid to those in vulnerable situations, based on the essential condition of keeping children in school, helping to reduce school dropout rates (Neves et al., 2020). However, these families are not covered by the closed season allowance, *i.e.*, compensation for fishers who cease fishing during the seasonal closure. Although closed fishing season insurance from the government is a right granted to professional fishers, and fishing is essential for subsistence fishers in the middle Caeté region, the lack of compensation during the closed season may discourage compliance. However, there are reasons to question the effectiveness of the closed season payment. In the absence of enforcement, the closed season insurance program stimulates the number of fishers to increase, and many of them continue to operate during the closed season (Corrêa et al., 2014). Therefore, the program may unintentionally increase pressure on fish stocks.

Art and techniques of fishing

The use of canoes suggests that travel is generally over short distances without the use of technology. In fact, the fishing spots chosen by subsistence fishers in the Amazon are usually close to their homes, with relatively short trips (Silvano, 2020). It was not surprising to find gillnets in all the communities surveyed, as this is already the most widely used gear in freshwater fisheries (Petriki et al., 2014; Silvano et al., 2017). Thus, traditional communities in the middle Caeté are familiar with this equipment. Normally, this gear is chosen by subsistence fishers because it offers high productivity and great efficiency in catches (Hallwass et al., 2023). However, multi-filament gillnets were found only in communities that catch giant Malaysian prawn.

Although gillnets are highly efficient, the use of nets below the permitted standard — as most of the gillnets characterized in this study — can lead to unsustainable fishing, because they are not selective in terms of species (Bielli et al., 2020; Silvano et al., 2017), often capturing both target and non-target species (He, 2006). A small percentage of fishers in the area use gillnets with mesh sizes ranging from 50 to 70 mm. These nets are more selective in terms of fish size by reducing the proportion of undersized individuals (Zhang et al., 2024). The unrestricted use of gillnets in Amazonian inland fisheries has been identified as one of the causes of overfishing, in addition to preventing the recovery of over-exploited stocks (Castello et al., 2015; Silvano et al., 2017). Regarding the length of the nets, the variation is related to the fishers' adaptation to the environment. According to Moraes and Darnet (2022), artisanal fishers in the Amazon use a wide variety of techniques to adapt their gear and gillnets, of diverse types and lengths, to the environment in which they will be used.

Although gillnets and set longlines are the main gear used, older fishers still retain some more traditional methods represented in this study by *camina* and *matapi*. Although more selective, these are rarely used. Other fishers reported that they had used these methods in the past, suggesting that they are being replaced by more productive and less selective techniques such as gillnets. In addition, we found reports of the abandonment of harmful fishing techniques not covered in this study, such as water beating (to splash the water to drive the fish toward the nets) and the use of toxic substances. Although these techniques are prohibited in the region (Pará, 2023), there are reports of violations by some community members. However, peer pressure to change fishing behaviors may discourage these unsustainable practices (Battista et al., 2018). Regarding the fishing agreement, the main change adopted by the riverine communities refers to the adoption of a closed season. The increase in the mesh size

to the minimum required in this agreement has not been fully implemented yet, although it is unanimous among fishers, who have increased the minimum mesh size of their nets to 30 mm, based on the management rules.

Native versus non-native species

Various species of fish, including the non-native *tilapia* (*Oreochromis* sp.), *tambaqui* (*Colossoma* sp.) and giant Malaysian prawn (*M. rosenbergii*) are the fishery products exploited in the region (Table 2). *H. malabaricus*, *P. blochii*, *Eigenmannia* spp., and other less mentioned species are important for subsistence. *B. vaillantii*, *B. flavicans*, and *M. rosenbergii* are harvested for sale. Fishers from Chaú and Portinho have specialized in catching the giant Malaysian prawn, which has become part of the income for some families in these communities. This is due to the proximity to the estuarine zone of the Caeté River and the association with brackish water in which the larvae develop (Henriques et al., 2025). Fishing for exotic species has not always resulted in increased fishing productivity or fishers' income (Attayde et al., 2011). However, in the middle Caeté, fishing giant Malaysian prawn benefited some riverside families financially, although we have not measured the real extent of this income in the lives of fishers or the ecological impacts of this invasion. However, *M. rosenbergii* is already widespread in many basins in northeastern Pará, due to favorable climatic and environmental conditions (Oliveira & Santos, 2021). Research is needed to determine the economic benefits of giant Malaysian prawn caught for subsistence in the Caeté River and its impacts on fishing and the environment.

Other non-native species, such as *tilapia* (*Oreochromis* sp.) and *tambaqui* (*Colossoma* sp.) were mentioned. Although native to the Amazon Basin, the *tambaqui* was introduced to the Caeté River less than 10 years ago. *Tilapia* is considered a highly destructive species, because it has a highly varied diet (Litaiff et al., 2023) and high adaptability, often giving it an advantage over local species (Attayde et al., 2011; Shuai et al., 2023). Although *tilapia* farming is economically important, caution is needed, because it is considered an invasive species in Brazil. Furthermore, there is evidence that successful invasions of exotic species can destabilize natural communities, modifying the structure and stability of the food chain and trophic interactions in invaded ecosystems (Orlandi Neto et al., 2024; Shuai et al., 2023).

CONCLUSIONS

Fishing in the middle Caeté River is mainly carried out to provide food for families. The main species of interest are those intended for household consumption. Therefore, it is characterized as subsistence fishing, although in two

communities, fishers target species of high commercial value to supplement their income. Gillnets and set longlines are the most common types of gear, and are associated with the seasonality of the river flow and species of interest. A change in fishers' habits is expected in terms of increasing the mesh size of gillnets to select larger fish and comply with fishing regulations.

This study contributes to expanding our understanding of subsistence fishing in northeastern Pará by shedding light on fishing in a regional context that has been little studied up to now.

CONFLICT OF INTEREST

Nothing to declare.

DATA AVAILABILITY STATEMENT

Data associated with this manuscript is available on Figshare (<https://doi.org/10.6084/m9.figshare.32372253>).

AUTHORS' CONTRIBUTION

Conceptualization: Santos, C., Holanda, F.C.A.F.; **Investigation:** Santos, C.; **Methodology:** Santos, C., Holanda, F.C.A.F.; **Supervision:** Holanda, F.C.A.F., Beasley, C.R., Pezzuti, J.C.B.; **Data curation:** Santos, C.; **Project administration:** Santos, C.; **Writing – original draft:** Santos, C.; **Writing – review & editing:** Santos, C., Holanda, F.C.A.F., Beasley, C.R., Pezzuti, J.C.B.; **Final approval:** Santos, C., Holanda F.C.A.F., Beasley, C.R.

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DECLARATION OF USE OF ARTIFICIAL INTELLIGENCE TOOLS

No artificial intelligence was used during the preparation of this manuscript.

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