Bogotá-Gregory *et al.*
Journal of Ethnobiology and Ethnomedicine (2024) 20:101
https://doi.org/10.1186/s13002-024-00737-1

Journal of Ethnobiology and Ethnomedicine

RESEARCH Open Access

Ethnoecology and use of fishes by the Cubeo people from the Cuduyarí River, Colombian Amazonia

Juan David Bogotá-Gregory[1*], Luis Fernando Jaramillo Hurtado[1], Juan Felipe Guhl Samudio[1] and Edwin Agudelo Córdoba[1]

Abstract

Background Ethnoichthyology studies the knowledge of human communities about the uses, perception, and behavioral characteristics of fish, based on their cosmology, cosmogony, and culture. This study focused on the Cubeo (Pâmiwâ) ethnic group that inhabits the Cuduyarí River (Vaupés, Colombia) provides information on fishing activities, use of fishes, its ecological distributions (occurrence in rivers, pools, and/or streams) and seasonality (occurrence in low and/or high waters). Additionally, names in the Central Tukano language (Cubeo) are provided.

Methods The compilation of information was based on a visual catalog prepared from rapid ecological evaluations, previously carried out by the Amazon Institute of Scientific Research SINCHI. Workshops with the indigenous people were held in communities in the lower, middle, and upper sections of the basin to collect information. Network analyses were done to determine the fishing gear selectivity of the most common species and gears used regarding ecosystems. The coherence in the perception of fish resources among the three communities was assessed via multivariate analyses.

Results The results showed that a large percentage (89%) of the species are consumed. There is a generalized perception of resource decline, and there is no coherence regarding the ecological and seasonal distributions of fish reported by the three communities. These differences may be due to an effect of the structural characteristics of the basin in the different sectors where the communities are located.

Conclusions Species consumed by the Cubeo in the Cuduyarí do not represent a high commercial value at the Amazon River basin scale. Nevertheless, locally, they are the main source of animal protein and most of the time, the sole source of income. The importance of these species must be recognized and must be a priority for conservation. Knowledge related to the fish resource by indigenous groups, including basic information and its usage, is essential to guide and implement management and conservation strategies specific to each region under study.

Keywords Freshwater fishes, Ecology, Traditional knowledge, Folk taxonomy

Background

The Amazonian aquatic systems are recognized as an important source of biodiversity [1–3]. These systems host the most diverse freshwater ichthyofauna in the world [4]. Approximately 2700 species have been described, but the real number most probably super pass the 3500 species [5–8].

*Correspondence:
Juan David Bogotá-Gregory
juandbogota@gmail.com
[1] Instituto Amazónico de Investigaciones Científicas SINCHI, Calle 20 # 5–44, Bogotá, Colombia

The high species diversity of freshwater fish translates into essential ecosystem services (ESs) that affect human welfare and provide benefits to local communities [9–12]. Freshwater fishes in the Amazon represent demand-derived ES, such as recreational values [11]. Some of the species are familiar to the ornamental trade: cardinal tetras, discus, angel cichlids, armored “pleco” catfish, and stingrays. Amazonian fishes represent also fundamental ES because are indispensable for the provision of most of the animal protein sources for human consumption in the region [9, 11, 13, 14]: peacock bass, black prochilodus, branquinha, goliath catfishes, tambaquí, and pirarucu [5].

Although very few species might represent the most important fisheries of the Amazon at the regional scale [15], many other species constitute the sole source of income and animal protein for indigenous and non-indigenous human settlements at the local scale. Thus, although some species do not represent a great commercial value for the Amazonian big-scale fisheries, locally they provide humans with direct or indirect social, economic, and environmental benefits. That is the common case for the human settlements that inhabit the surrounding areas of less productive waters [16, 17], the so-called “blackwaters”, where biomass, species richness, and abundance are relatively low [18–20].

The territories of the Vaupés department, located in the Colombian Amazon Basin, contain predominantly typical Amazonian blackwaters that drain well-preserved *terra firme* forests and savannas [21, 22]. The river networks in this region are characterized by tea-colored waters, with sandy substrates exposed during the low-water season [21–23]. The Cuduyarí River, near Mitú City, is part of this river network of the Vaupés Department and one of the affluents of the Vaupés River; one of the main systems of the upper Rio Negro, which is one of the main affluents of the Amazon River Basin [24, 25].

The Cuduyarí is predominantly inhabited by various groups of the Cubeo ethnicity [26]. For most of the Cubeo people, this area is recognized as its origin epicenter [26, 27]. Nevertheless, over time, other groups arrived integrating with the groups originating from the Cuduyarí River [26]. The basin’s main channel is the principal transportation route system to Mitú City – the department’s capital – and other areas of the Vaupés department. Therefore, traditional and economic activities rely on the navigability of the main channel. The economic activities of the indigenous communities in the basin are subsistence agriculture, extraction of wild fruits, fishing and hunting, and craftsmanship; mainly in a traditional way, without the using materials and equipment introduced by modern colonizers [27–29].

The increase of the indigenous population in the Cuduyarí River basin generates an increase in demand for animal protein, and therefore, an increase in fishing pressure [28]. This situation not only concerns the human settlements located in the basin but also concerns the inhabitants of Mitú since Cuduyarí’s fishery products represent about half of its fishery trade in the city. Therefore, the fishing activities in the Cuduyarí are not only relevant at the local scale, but they are also of great relevance at the regional scale.

The perception of indigenous communities about fish concerning spatial and temporal dynamics, basic knowledge, and use is essential to guiding and implementing conservation and management strategies for these resources [30]. Fisheries management requires a comprehensive approach to the resources, the society that uses them, the economic dynamics, and the natural conditions that support them [31]. Carrying out participatory and inclusive research with non-specialized personnel, seeking in this case to incorporate local ecological knowledge, to generate answers on basic issues associated with fish and their use, is fundamental to contribute to their sustainable management [32].

To document traditional knowledge of the Cubeo ethnicity about fishing activities and fish basic ecology, work with local community members was carried out in the Cuduyarí river basin in the lower, middle, and upper sections at the Pituna, San Javier, and Wacurabá Cubeo communities, respectively (Fig. 1). We aimed to provide information on the fishing areas and other details of the fishing events; gears and materials used and targeted species. From an ecological perspective, we evaluated the congruence in the traditional knowledge among the three indigenous communities, regarding fish species abundance and decay in recent history, seasonality, and fish distributions in the aquatic ecosystems (i.e., river channels, pools, streams, and rapids). Additionally, considering the pervasive loss of traditional knowledge in the Amazon region [33, 34], we provide a list of fish names used in the Cubeo language. We envisage that the documented knowledge herein will be fundamental for the management and conservation plans for the responsible use of Cuduyari’s fish resources.

Methods

The Cuduyarí study area and Indigenous territory

The Cuduyari basin is located within the Mitú municipality, department of Vaupés. The basin has an elongated shape in a West to East direction with the following dimensions: an area of 1731 km^2, a perimeter of 272 km, a length of 101 km, and a width of 27.4 km (Fig. 1). The river flows into the Vaupés River a few kilometers downstream of the urban area of the Mitú city. According to the data obtained by cartography created by its inhabitants, the basin is made up of 272 streams, 48 pools, and

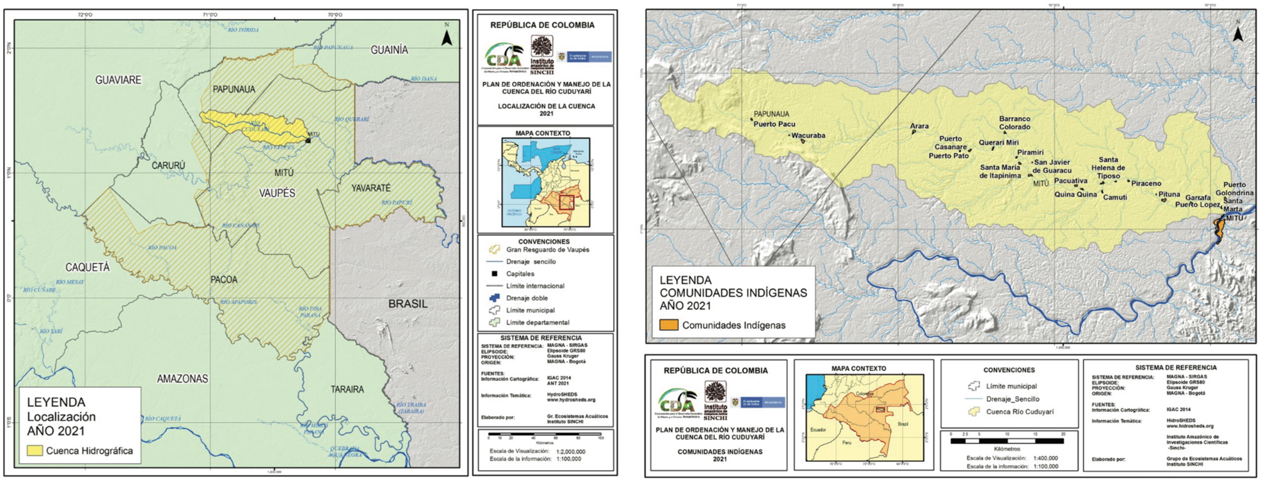

Fig. 1 Location of the Cuduyarí River basin in the department of Vaupés and its hydrographic limits. *Location of the three communities, Pituna, San Javier, and Wacurabá, in the lower, middle, and upper basin, respectively

13 ponds [27]. The Cuduyarí waters are typically Amazonian blackwaters, poor in nutrients, and characterized by the tea color, although they present seasonal variations in their color. The blackwaters are also characterized by a low pH (3.5–6.0) [20, 35].

The Cuduyarí river basin is part of the Great Vaupés Indigenous Guard, created by Resolution No. 086 in 1982. The basin is populated by 21 Indigenous communities organized as the "Association of Traditional Authorities ~ pamijabova of the Cuduyarí River—ASOUDIC", settled mainly on the banks from the headwaters to its mouth in the Vaupés River [27]. The dynamics of the population present in the Cuduyarí River basin is rural, mostly made up of members of the Cubeo ethnic group belonging to different clans, with a total of 1246 people [26].

As most of the indigenous communities from the Amazon, the Cubeo people have been under the influence of the Catholic Church [36]. Their language is one of the two most common languages used along the Vaupés River Basin [36]. Like other indigenous ethnicities in the Amazon, they have a strong relationship with nature. Their economy is organized by an ecological calendar that is associated with the seasonality of the environment [26].

Fieldwork and data compilation

Our study was performed simultaneously with the research project "Pesca en el Río Cuduyarí: uso y conocimiento de los peces en las comunidades de la etnia Cubeo". The main purpose of the project was to carry out a citizen science exercise within the framework of the ICTIO initiative (https://ictio.org), to monitor species of commercial importance for the Cuduyarí river basin. Permits for ethnological studies are not required in Colombia. However, before fieldwork, data collection on traditional knowledge was authorized by the indigenous community leaders.

To gather information regarding traditional knowledge, 48-h workshops were done in the three communities: Pituna (located at 1° 17′ 44″ N, 70° 18′ 39″ W, altitude is 179 m a.s.l.;), San Javier (located at 1° 21′ 59″ N, 70° 33′ 38″ W, altitude is 192 m a.s.l.), and Wacurabá (located at 1° 23′ 26″ N, 70° 54′ 02″ W, altitude is 206 m a.s.l.). According to official data, two decades ago, each of the communities is composed of 77, 55, and 159 people, respectively [26, 36]. By 2022, the numbers increased to 198, 140, and 215 people [27]. The workshops were strategically structured for rapid documentation from a comprehensive perspective. These workshops included the participation of children, young people, and adults, both men and women. The members of each community were divided into groups for the compilation of information about fishing areas, recognized species, use of species, and aspects of ecology such as abundance, seasonality, and distribution in aquatic ecosystems (i.e., rivers, streams, rapids, and pools). The consensual ideas were shared orally among all the participants and discussed when the working groups considered it appropriate to debate within the framework of the Indigenous Life Plan of the Cubeo Indigenous Group from the Cuduyarí-ILPCC [26]. The ILPCC deals with the development of the Colombian Society, which emphasizes planning as a regulatory tool between ethnic societies and the government's institutions.

Fishing areas

At the beginning of the workshop sessions, the criteria or guidelines for the delimitation of the geographical areas where the members of each of the communities carry out fishing were debated. Also, a timeline was discussed to identify if the criteria for defining the fishing zones were stated by their ancestors, or if they corresponded to modern delimitation criteria, including current competent entities for conservation and management purposes.

Fishing gears

Open lists were structured by each of the participants to write down common fishing gear used. The open lists included traditional arts and those recently introduced by modern colonizers. We use network graphs to be able to identify the use of the different gears regarding ecosystems (rivers, pools, and streams) and gear selectivity of the most common species. Additionally, some of the participants created diagrams of each of the identified gears.

Fish species recognized and use

We proceeded with the preparation of open lists of the species that each of the participants recognized. These lists included the Spanish common names and the names in the Cubeo language to consolidate a list of scientific names used by the modern classification system. The symbology of the Cubeo language was revised by Luis Jorge Barbosa Hernández who is a certified reviewer by ASOUDIC.

For the definition of the use of the species, a fish catalog of the Cuduyarí River prepared before the project was used as a reference. The information that makes up this catalog (natural history and images) derives from an exhaustive bibliographic review and field work previously carried out in the Cuduyarí River basin by the Amazonian Scientific Research Institute SINCHI. The 87 species of fish that make up this catalog have scientific reference specimens deposited in the Ichthyological Collection of the Colombian Amazon-CIACOL, which is part of the biological collections of the SINCHI Institute located at the main headquarters in Leticia, Amazonas.

Ecological aspects

The compilation of the information referred to in this section was based on the catalog of species of the basin mentioned above. Therefore, the participants' perception of the ecology of the 87 recorded species was consulted. These ecological aspects included spatial and temporal components.

As for the spatial components, they include the fishing sites according to the aquatic ecosystems of the basin (main channel of the river, pools, and streams tributaries of the main channel) and whether they correspond to a common or rare species. To complement the lists of distributions according to aquatic ecosystems, drawings were prepared that included fish occurrences in the ecosystems. The temporal components included: seasonality and whether they are present throughout the annual hydrological cycle or only in one of the two phases (high-water or low-water); and historical changes in abundance, if a decrease in fish and fishing resources is perceived over time.

Data analysis

A series of multivariate analyses were carried out to evaluate the similarity between communities in the species recognized with a name in Spanish and Cubeo, its uses, and the different ecological aspects. For the evaluation of recognized species and their use, the Bray–Curtis index [37] was used, which is a common tool to evaluate differences between biological communities, for which we assumed the same comparative principle. This index calculates values between 0 and 1, where 0 demonstrates equality in the comparison. To evaluate aspects of ecology (abundances, seasonality, changes in abundance over time, and ecological distributions) a co-inertia analysis (COIA) was used [38]. The COIA is a multivariate analysis that allows evaluating the costructure of two data matrices that have been previously ordered, which in this case is a qualitative factor ordering method [39]. Additionally, to identify plausible associations of the most common fishes with a specific ecosystem, we use a species indicator index [40].

Data management and statistical tests for analysis and interpretation of the results were carried out with the R software [41], using the statistical packages igraph [42], vegan [43], and ade4 [44].

Results

The approach in the workshops was intended to compile information on the aspects to be documented according to three proposed age groups: children, youth, and adults. However, the internal dynamics of the communities, family ties, and to avoid the exclusion of community members, the workshop's activities were carried out together and not by age groups. The information presented herein reflects consensual traditional knowledge generated by the working groups from all age groups without separation between them, including men and women (see Annex 1 for attendance lists of adult participants in the working groups). Groups contained mixed members in terms of age and included a total of 99 participants from which 65 were males, 34 were females, and six participants were children.

Fishing areas

In all cases, the communities reported that fishing activities are done in all the aquatic ecosystems, with the Cuduyarí main channel prevailing as the main capture site. According to the meetings held with the participants of the Pituna community, before the inference of the government's environmental authority (Corporation for the Development of the North and East of the Amazon-CDA), there was no delimitation of fishing in terms of the areas. The movement of fishermen was free throughout the entire Cuduyarí system. Only after the formulation of the Indigenous Life Plans, fishing areas were delimited. Afterward, fishermen from a given community must fish in a delimited area determined by a common agreement between adjacent communities. In the communities of San Javier and Wacurabá, on the contrary, it was mentioned that these limits of the fishing zones have always existed and have been defined by common agreement between the adjacent communities. However, historically, there has been disrespect for these limits by some of the territory's inhabitants.

Fishing gears

The participants of the working groups recognized a total of 21 fishing gears and implements in the communities of Pituna, San Javier, and Wacurabá (Table 1; see Fig. 2 for diagrams of the ancestral fishing gears drawn by the participants of the workshops). In the community of Pituna, nine gears were recognized, 14 in the community of San Javier, and 12 in the community of Wacurabá. Of the total of 21 recognized arts and gears, five correspond to arts or gears recently introduced by the colonists. Most of the arts and gears are traditional, and very few have been introduced by the colonists (see their corresponding names in Cubeo and Spanish and English when applied (Table 1).

Network analysis with the most common fish used by the communities revealed very few cases of gear-fish selectivity (Fig. 3a). The *kurupio*, *jujico*, *nuritaco*, and *jujico picudo* are those fishes that require specialized fishing gear. Overall, fishing gears are implemented in all ecosystems. Only the small matapí and the *espinel* are specialized gears to use in one of the ecosystem types (Fig. 3b).

Fish names and use

Most of the species in the catalog were recognized by community members (see Fig. 4, for diagrams of some of the species recognized); only seven of the species were not assigned names in Spanish or Cubeo (see Table 2 for corrected Cubeo names and Annex 2 for Cubeo names before correction). Regarding the open lists of fish made by 99 participants (Annex 3), they made up a compiled list of 97 different names (Annex 2) in Spanish with their respective names in Cubeo. The similarity analysis according to the species that are recognized by the members of each of the communities demonstrates greater similarity between Pituna and San Javier and less similarity between San Javier and Wacurabá (Table 3).

Of the 87 species included in the catalog, 77 species were recognized for consumption in the community of Pituna, 71 in San Javier, and 70 species in Wacurabá (Table 2). Regarding the use of the 87 species in the catalog, the overall results demonstrate that the three communities use the same species from the fishes that are represented in the catalog (see use comparison values in Table 3).

Ecological aspects

The raw data for each of the ecological aspects show differences in what is perceived in terms of abundance. Regarding seasonality, there is a general consistency in the species that are perceived to be presented throughout the entire annual hydrological cycle and in the dry season, but there is no consistency in the species that are believed to be presented only in the wet season. The timeline demonstrates a trend in the perception of a general decrease in abundance as one moves toward the upper part of the channel. That is, in Pituna, a smaller number of species were recognized that are believed to have decreased in abundance, and in Wacurabá, it is believed that most of the species have decreased in abundance.

In general, the results of the COIA analyses (Table 3) carried out for the information matrices of all ecological aspects together (Table 4) demonstrate a low correlation between the perception of the three communities. However, the knowledge or perception about these aspects presents greater consistency between the communities of San Javier and Wacurabá (RV = 0.19).

The distribution patterns of the species according to the aquatic ecosystems are not clear, since there are very few species that present agreement in distribution in the three communities. Only for most species of the Characidae family, which includes most of the fish that they define as sardines, is there a concordance between the lower section (Pituna) and the middle section (San Javier) (see Table 4 and Fig. 5 to identify distributions in the different ecosystems according to the drawings made by the participants).

The association analyses of the species with a given aquatic ecosystem show that only two species present a high probability of affinity to a single ecosystem; *Moenkhausia mikia*, to streams (p value: 0.022); and *Pimelodus blocchi*, to the rivers (p value: 0.014). These results suggest that, according to local perception or

Table 1 Different fishing gears and implements recognized, ecosystems where gears are used, and most common fishes caught per gear

Gear name	Community	Ancestral	Modern	Names in Cubeo	Ecosystems	Fishes caught (in Spanish)
Hook	Wacuarabá		X	jajovaiyo	Riv, Poo, Str	emive, wariko, ñapāko, borikakɨ, amarɨ, veaborɨ, dodé, jaime, yuparidɨ, veimaive, jocabo, vaviko, mūjadocarū
Line	San Javier		X	jajovaitētua	Riv, Poo, Str	borikakɨ, veaborɨ, jaime, dodé, jujico, jocabo, yuparidɨ, amarɨ, mɨãrɨ, vaviko, wariko, mūjadocarū, eobo
Arch	Pituna, San Javier, Wacurabá	X		tēmutarabü	Riv, Poo, Str	ñapāko, borikakɨ, dodé, parave, veaborɨ, vaviko
Barbasco*	Pituna	X		eo, eomu, eurüa	Riv, Poo, Str	emive, wariko, ñapāko, borikakɨ, amarɨ, veaborɨ, dodé, jaime, yuparidɨ, veimaive, jocabo, vaviko, mūjadocarū
*Cacuri**	Pituna, San Javier, Wacurabá	X		cubobü	Riv, Str	borikakɨ, ñapāko, dodé, jocabo, vaviko, yuparidɨ, veaborɨ, veimaive, nuritaco
Cacuri for tetras*	San Javier, Wacurabá	X		ēmido	Poo, Str	emive, mɨãrɨ
Canoe	Pituna, San Javier, Wacurabá	X		jiadocū	Riv, Poo, Str	
Rod	Pituna, San Javier		X	Jajodaime, jajovai ārādo	Riv, Poo, Str	wariko, emive, borikakɨ, veaborɨ, veimaive, yuparidɨ, vaviko
Diving mask	San Javier, Wacurabá		X	moā muīdü	Riv, Poo, Str	ñapāko, borikakɨ, dodé, veaborɨ, vaviko, yuparidɨ, tūmaidɨ, wariko
*Espiñel**	San Javier		X	jajodai-jaboime	Riv	jocabo, mūjadocarū, amarɨ, veimaive, kurupio, eobo
Arrow	Pituna, San Javier, Wacurabá	X		tēmuyo	Riv, Poo, Str	ñapāko, borikakɨ, dodé, parave, veaborɨ, vaviko
Flashlight	Pituna, San Javier		X	moā pēōdü	Riv, Poo, Str	
Gill net	San Javier, Wacurabá		X	moā boicü	Riv, Poo, Str	ñapāko, borikakɨ, dodé, veaborɨ, vaviko, yuparidɨ, tūmaidɨ, veimaive
*Matapí**	Pituna, San Javier, Wacurabá	X		dorīñu	Riv, Str	borikakɨ, ñapāko, dodé, vaviko, veaborɨ, parave, wariko, yuparidɨ
Small *Matapí**	San Javier, Wacurabá	X		dorido	Str	dodé, wariko, vaviko, borikakɨ
Trap	San Javier, Wacurabá	X		joquebü	Riv, Str	jaime, mɨãrɨ, wariko, yuparidɨ, borikakɨ
*Pimporro**	Pituna, San Javier	X		moā epeibü	Riv, Poo, Str	
*Pisá**	Pituna, Wacurabá	X		papicü	Poo, Str	emive, wariko, dodé, jujico picudo, parave
Paddle	Pituna, San Javier, Wacurabá	X		jiadove	Riv, Poo, Str	
*Sagaya**	Pituna, San Javier, Wacurabá	X		totaijarabo	Riv, Poo, Str	borikakɨ, veaborɨ, ñapāko, yuparidɨ, vaviko, wariko, dodé
Trap	San Javier, Wacurabá	X		jararí eoreíno	Riv, Poo	ñapāko, vaviko

Names in Cubeo are corrected by a linguistic authority. Gear names in English when translation exists, otherwise in Spanish*. For ecosystems: *Riv* rivers, *Poo* pools, *Str* streams, *Rap* rapids. Italic for gear names with no translation into Spanish or English

knowledge of species distributions, the other species are generalists as they are presented in all ecosystems.

Discussion

We provide information about the diversity, ecological aspects, and the use of fish by the Cubeo indigenous communities from the Cuduyarí River basin. This is the first integrative approach to exploring the traditional knowledge of the Cubeo people inhabitants of the Cuduyarí River basin. The information presented here, because of the workshops, constitutes a comprehensive strategy for citizen participation in local communities, which allows us to learn more about the fish from a blackwater system in an Amazonian pristine area.

Before the CDA's intervention, fishing areas of the Cubeo people in the Cuduyarí have no restrictions regarding the territory. Nevertheless, according to the Life Plan [26], in other river basins occupied by the Cubeo, there are restrictions to certain areas. Within the Cuduyarí, the lack of restrictions might reflect the loss of traditional knowledge or a consequence of population growth. The latter implies the increase of fishing pressures and fish resources in new areas that must fulfill the increase in demand. Although fishing restrictions do not

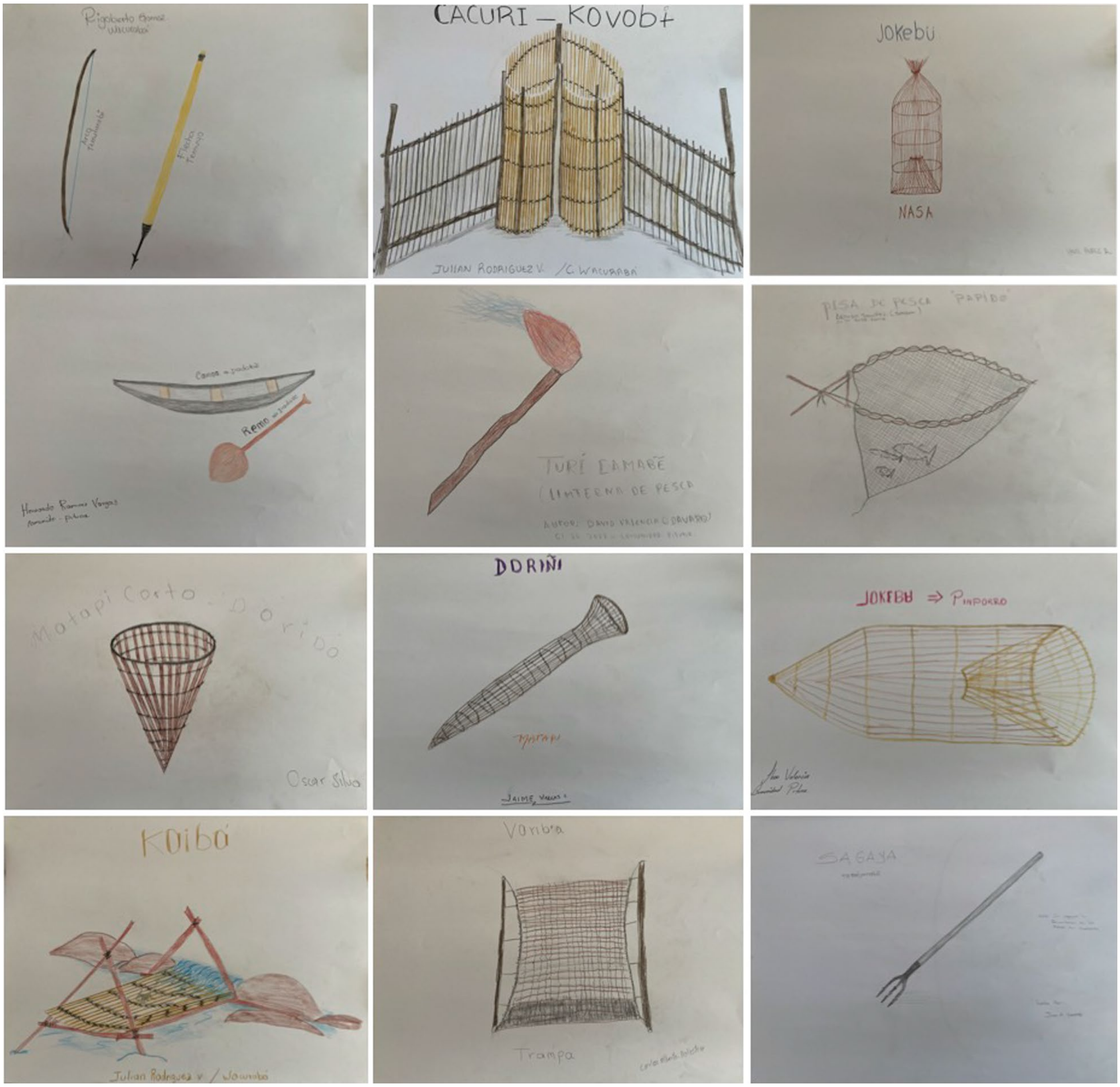

Fig. 2 Drawings of fishing gear made by the participants of the workshops. From top to bottom and left to right: arch and arrow, cacurí, dip net, canoe and paddle, flashlight, pisá, matapí, matapí, pimporro, cacurí, trap, and sagaya

exist and catches are carried out in all three aquatics ecosystem types (i.e., rivers, lakes, and streams), most of the fish resources consumed by the Cubeo in the Cuduyarí are caught in the main channel. This is the case of the fish resources traded in the main market of the region in Mitú city [14].

The Cubeo reported an ample of traditional gears to catch fish in the different aquatic ecosystems. Previous studies in the region have reported gear selectivity [45] for species that are traded in the ornamental market. Nevertheless, the use of fishing gear, for the most part, does not imply a targeted species and is used in all the ecosystems of the Cuduyarí river basin.

Previous studies have reported lower fish species richness in blackwater systems compared to nutrient-rich ecosystems [18, 20, 46]. However, blackwater has been shown to support relatively diverse ichthyofaunas composed mainly of small fish, adapted to survive in less productive habitats [47, 48]. Therefore, most of the species are small and a few correspond to larger species.

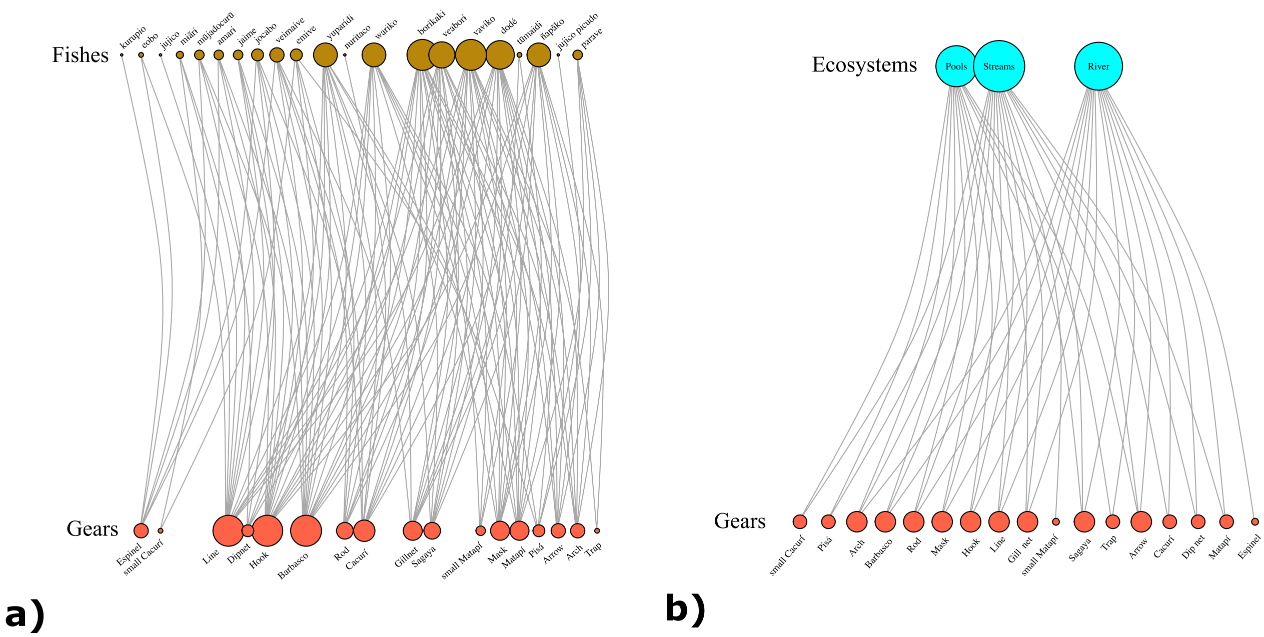

Fig. 3 Network diagrams for (**a**) fish and gears and (**b**) ecosystems and gears

The latter is marketed for human consumption locally and in the Mitú city [14]. However, given the decrease in catches that generally occur in the high-water season, smaller species end up being consumed locally because of the decrease in the supply of animal protein. This is reflected in the high number of species consumed in the Cuduyarí communities under study, which in all cases approximates a consumption of 80% of the species that have been identified for the basin.

Overall, species from the Cuduyari's fish catalog are recognized by the members of the Pituna, San Javier, and Wacurabá communities. Since childhood, Indigenous people have had a close relationship with the different nature components [26, 33]. Particularly fish, because they represent different ecosystem services that provide benefits to the communities and in some cases are part of their cosmogony and mythology [12, 49, 50]. Nevertheless, in the studied Cubeo communities, name designation for each of the species was not evidenced. Instead, although they recognized all species, they have a generic name for different groups of species that have common morphological characteristics.

There is a trend in the community perception of a decrease in fish resources as one moves upstream de Cuduyarí. The differences in abundance of the species could be related to the differences in connectivity along the Cuduyarí River channel. There is less connectivity derived from isolation in the upper areas due to the presence of physical barriers in the form of rapids, and the distance from the main channel of the Vaupés River. These two factors could explain the low species turnover in the upper reaches and a gradient in the structure of fish communities along the Cuduyarí River, as suggested in other areas of the Amazon basin [51–53].

Several studies have focused their efforts on documenting fish ecological distributions from the Amazonian aquatic ecosystems. Overall, modern studies in ecology suggested high fish affinities to ecosystem types [54, 55]. From an ethnological perspective, studies of fish distributions in the Colombian Amazon are very scarce [34, 56], where fish ecological distributions are recognized. Our results from the workshops do not show strong ecological linkages of fish from an ethnological perspective. These results might reflect low habitat heterogeneity of the Cuduyarí River that is associated with the relatively small extent of the basin compared to other river basins of the Amazon. Therefore, the fish ecological distributions might be recognized by the Cubeo at a different scales of study. For example, at a smaller scale considering the habitats (e.g., riffles, pools, and beaches).

Most studies focused on the seasonal dynamics of Amazonian aquatic ecosystems support a high species seasonality [57–59]. However, most of the species are recognized as present throughout the year by the Cubeo in our study area; there is not a perception of a clear seasonality in fish assemblage structure. This notion of stable fish communities throughout the year is consistent with previous studies in systems with low hydrological connectivity [60, 61] due to geographical isolation as the Cuduyarí system.

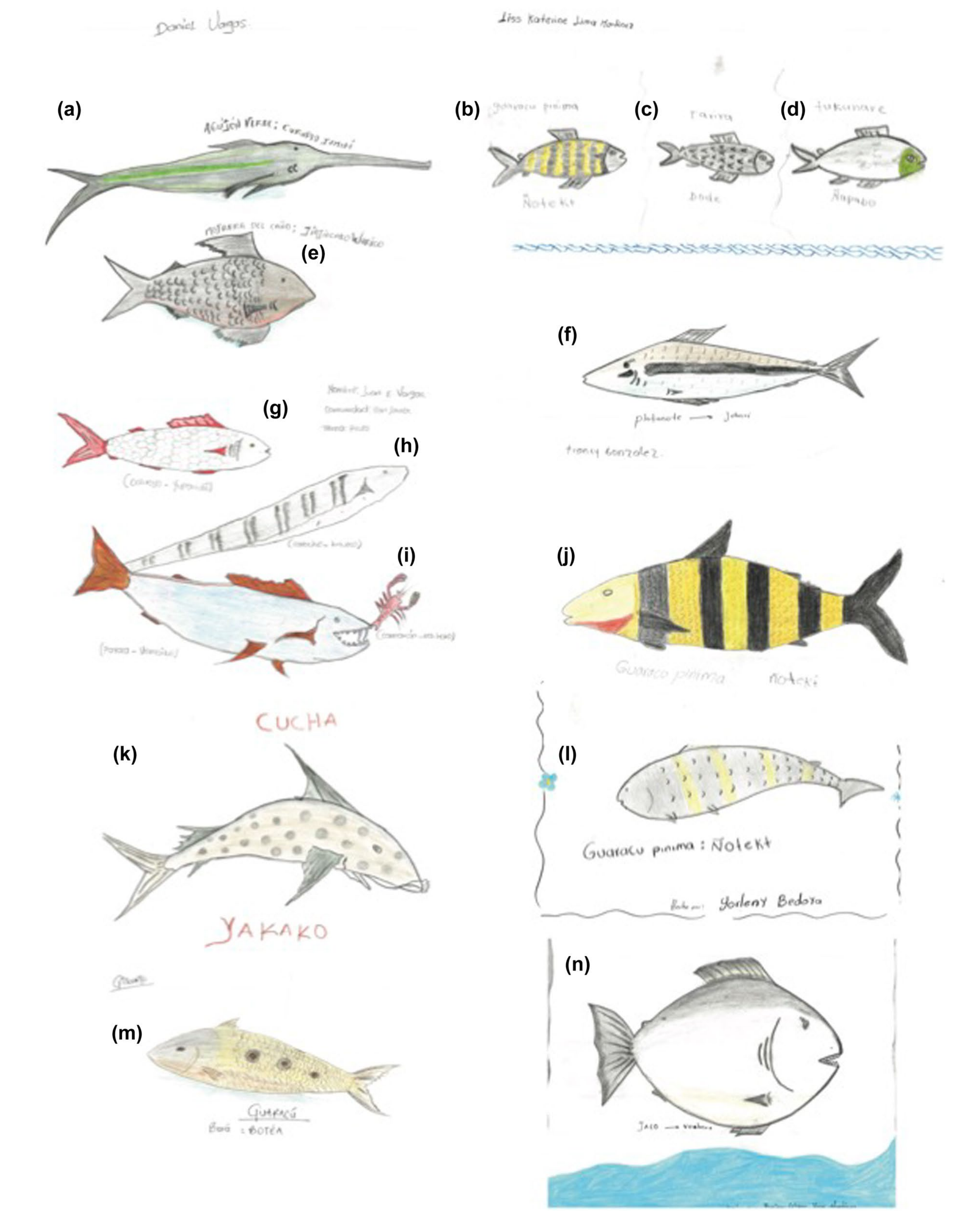

Fig. 4 Fish drawings of some of the recognized species (names in Cubeo): **a** kurupio, **b** borikakɨ, **c** dodé, **d** ñapãko, **e** wariko, **f** jũnarũ, **g** yuparidɨ, **h** jujico, **i** veimaive, **j** borikakɨ, **k** yacaco, **l** borikakɨ, **m** borikakɨ, **n** mũjadocarũ

Table 2 List of fish species, use, and names in Spanish and Cubeo

Taxa	Consumption			Names	
	Pituna	San Javier	Wacurabá	Spanish	Cubeo (corrected)
Orden Characiformes					
Familia Crenuchidae					
Characidium pellucidum Eigenmann 1909				sardina de playa	emive
Elachocharax pulcher Myers 1927					emive
Melanocharacidium pectorale Buckup 1993					emive
Poecilocharax weitzmani Géry 1965					emive
Familia Erythrinidae					
Hoplias malabaricus (Bloch 1794)	X	X	X	tarira	dodé
Familia Cynodontidae					
Hydrolycus wallacei Toledo-Piza, Menezes & Santos 1999	X	X	X	payala	veimaive
Familia Serrasalmidae					
Metynnis hypsauchen (Müller & Troschel 1844)	X	X	X	Jaco	mũjadocarũ
Myloplus rubripinnis (Müller & Troschel 1844)	X	X	X	Jaco	veaborɨ
Familia Hemiodontidae					
Argonectes longiceps (Kner 1858)	X	X	X	blanquillo	cobejodõ
Bivibranchia fowleri (Steindachner 1908)	X	X	X	curvinata	cũrũricarũ
Hemiodus immaculatus Kner 1858	X	X	X	blanquillo	cobejodõ
Hemiodus semitaeniatus Kner 1858	X	X	X	saltarín	cobejodõ
Hemiodus thayeria Böhlke 1955	X	X	X	ojón	cobejodõ
Hemiodus unimaculatus (Bloch 1794)	X	X	X	blanquillo	cobejodõ
Familia Anostomidae					
Anostomus ternetzi Fernández-Yépez 1949					
Laemolyta taeniata (Kner 1858)	X	X	X	platanote	jũnarũ
Leporinus brunneus Myers 1950	X	X	X	guaracú coli rojo	movaiyo
Leporinus friderici (Bloch 1794)	X	X	X	guaracú	borikakɨ
Leporinus klausewitzi Géry 1960	X	X		guaracú de caño	tũmaidɨ
Familia Chilodontidae					
Chilodus punctatus Müller & Troschel 1844	X				
Curimatopsis evelynae Géry 1964	X				
Curimatopsis macrolepis (Steindachner 1876)				sardina	emive
Cyphocharax festivus Vari 1992	X	X	X	sardina	emive
Cyphocharax multilineatus (Myers 1927)	X	X	X	sardina	emive
Cyphocharax spilurus (Günther 1864)	X	X	X	sardina	emive
Steindachnerina guentheri (Eigenmann & Eigenmann 1889)	X	X	X	sardina	emive
Familia Lebiasinidae					
Copella eigenmanni (Regan 1912)				sardina	emive
Nannostomus marginatus Eigenmann 1909				sardina	emive
Familia Ctenoluciidae					
Boulengerella maculata (Valenciennes 1850)	X	X	X	lapicero	umubaidɨ
Familia Chalceidae					
Chalceus macrolepidotus Cuvier 1818	X	X	X	coli rojo	yuparidɨ
Familia Triportheidae					
Triportheus albus Cope 1872	X	X	X	arenca	cũrũricarũ
Familia Gasteropelecidae					
Carnegiella strigata (Günther 1864)		X	X	barrigoncito	
Familia Bryconidae					
Brycon pesu Müller & Troschel 1845	X	X	X		

Table 2 (continued)

Taxa	Consumption			Names	
	Pituna	San Javier	Wacurabá	Spanish	Cubeo (corrected)
Familia Iguanodectidae					
Bryconops giacopinii (Fernández-Yépez 1950)	X	X	X	sardina	emive
Bryconops humeralis Machado-Allison, Chernoff & Buckup 1996	X	X	X	sardina	emive
Iguanodectes purusii (Steindachner 1908)	X	X	X	sardina	emive
Iguanodectes spilurus (Günther 1864)	X	X	X	sardina	emive
Familia Acestrohynchidae					
Acestrorhynchus falcatus (Bloch 1794)	X	X	X	diente de perro	ñajeve
Acestrorhynchus falcirostris (Cuvier 1819)	X	X	X	diente de perro	parave
Acestrorhynchus nasutus Eigenmann 1912	X	X	X	diente de perro	parave
Familia Characidae					
Bryconamericus orinocoensis Román-Valencia 2003	X		X	sardina	emive
Charax delimai Menezes & Lucena 2014	X	X	X	sardina	emive
Hemigrammus analis Durbin 1909	X	X	X	sardina	emive
Hemigrammus bellottii (Steindachner 1882)	X	X	X	sardina	emive
Hemigrammus microstomus Durbin 1918	X	X	X	sardina	emive
Hemigrammus schmardae (Steindachner 1882)	X	X	X	sardina	emive
Hemigrammus vorderwinkleri Géry 1963	X	X	X	sardina	emive
Hemigrammus yinyang Lima & Sousa 2009	X	X	X	sardina	emive
Hyphessobrycon bentosi Durbin 1908	X	X	X	sardina	emive
Hyphessobrycon copelandi Durbin 1908	X	X	X	sardina	emive
Hyphessobrycon dorsalis Zarske, 2014	X	X	X	sardina	emive
Jupiaba poekotero Zanata & Lima 2005	X	X	X	sardina	emive
Microschemobrycon geisleri Géry 1973	X	X	X	sardina	emive
Moenkhausia ceros Eigenmann 1908	X	X	X	sardina	emive
Moenkhausia collettii (Steindachner 1882)	X	X	X	sardina	neomivē
Moenkhausia cotinho Eigenmann 1908	X	X	X	sardina	Jūjūrimiebe
Moenkhausia mikia Marinho & Langeani 2010	X	X	X	sardina	emive
Moenkhausia oligolepis (Günther 1864)	X	X	X	sardina	turuburū, terõvõrū
Phenacogaster pectinatus (Cope 1870)	X	X		sardina ojo rojo	emive
Orden Gymnotiformes					
Familia Sternopygidae					
Sternopygus macrurus (Bloch & Schneider 1801)	X	X	X	caloche palo	nuritaco
Familia Gymnotidae					
Gymnotus carapo Linnaeus 1758	X	X	X	caloche	jujico
Hypopygus lepturus Hoedeman 1962	X	X	X	caloche	jujico
Orden Siluriformes					
Familia Callichthyidae					
Corydoras melanistius Regan 1912				apururu	
Corydoras melini Lönnberg & Rendahl 1930				apururu	
Megalechis picta (Müller & Troschel 1849)	X	X	X	corroncho	miãrɨ
Familia Loricariidae					
Hypostomus oculeus (Fowler 1943)	X	X	X	cucha	yacaco
Loricaria cataphracta Linnaeus 1758				cucha larga	
Familia Aspredinidae					
Bunocephalus knerii Steindachner 1882				catalina	~etaroko
Familia Auchenipteridae					
Ageneiosus polystictus Steindachner 1915	X	X	X	chancleto	kabokoro
Auchenipterichthys coracoideus (Eigenmann & Allen 1942)	X	X	X	misingo	amarɨ

Table 2 (continued)

Taxa	Consumption			Names	
	Pituna	San Javier	Wacurabá	Spanish	Cubeo (corrected)
Centromochlus heckelii (De Filippi 1853)	X	X	X	misingo	amarɨ
Tatia intermedia (Steindachner 1877)	X	X	X	misingo	amarɨ
Trachelyopterus galeatus (Linnaeus 1766)	X	X	X	misingo	amarɨ
Familia Doradidae					
Acanthodoras cataphractus (Linnaeus 1758)	X	X	X	lechero, sierra lechona	eobo
Amblydoras affinis (Kner 1855)	X	X	X	sierra	ijia coribedū
Familia Heptapteridae					
Mastiglanis asopos Bockmann 1994	X	X	X	guabina, barretón	jaime
Rhamdia laukidi Bleeker 1858	X	X	X	guabina, barbilla	jaime
Familia Pimelodidae					
Pimelodus blochii Valenciennes 1840	X	X	X	mandi	jocabo, jimidū
Familia Pseudopimelodidae					
Batrochoglanis villosus (Eigenmann 1912)	X	X	X	bocón, pez sapo	
Orden Synbranchiformes					
Familia Synbranchidae					
Synbranchus marmoratus Bloch 1795	X	X	X	anguila	bue
Orden Cichliformes					
Familia Cichlidae					
Apistogramma regani Kullander 1980		X	X	mojarra	wariko
Cichla temensis Humboldt 1821	X	X	X	tucunaré	ñapāko, ñapambo
Crenicichla anthurus Cope 1872	X	X	X	yacunda	vaviko
Crenicichla lenticulata Heckel 1840	X	X	X	yacunda	vaviko
Crenicichla lugubris Heckel 1840	X	X	X	yacunda roja, babucha roja	vavijūāko
Satanoperca jurupari (Heckel 1840)	X	X	X	hacha	joeco
Orden Beloniformes					
Familia Belonidae					
Potamorrhaphis guianensis (Jardine 1843)				agujón	kurupio

Table 3 Results of multivariate analyses: dissimilarity indices (Bray–Curtis) for species recognized and their use between communities (values close to zero assume greater similarity) and correlation coefficients (RV) between the data matrices of the ecological aspects between communities

		Species dissimilarity		Correlation ecological aspects			
				Pituna		San Javier	
		Pituna	San Javier	RV	*P* value	RV	*P* value
San Javier	Species recognized	0.3846		0.1148	0.1948		
	Use	0.0349					
Wacurabá	Species recognized	0.4118	0.5046	0.1196	0.3906	0.1956	0.0819
	Use	0.0423	0.0213				

Linking environmental characteristics to fish resources is fundamental for the conservation of fish in pristine areas such as the Cuduyarí River basin. The analysis of the association of species with specific ecosystems has great implications from the point of view of conservation since the transformation or degradation (e.g., deforestation and global warming) of these ecosystems can generate local extinctions [62, 63]. Future research in the study area should be focused on evaluating species affinities to certain environmental

Table 4 List of species with information on different ecological aspects recognized by the three communities

Species	Abundance			Seasonality			Timeline			Ecosystems		
	Pit	SaJ	Wac	Pit	SaJ	Wac	Pit	SaJ	Wac	Pit	SaJ	Wac
Characidium pellucidum	Ra	Ra	Ra	Low	Low	Low	Dec	Sta	Dec	Rap	Rap	Riv
Elachocharax pulcher	Ra	Ra	Ra	Low	Low	Low	Dec	Sta	Sta	Riv, Str, Ch	Rap	Rap
Melanocharacidium	Ra	Ra	Ra	Low	Low	Low	Sta	Sta	Sta	Str	Rap	Rap
Poecilocharax weitzmani	Ra	Ra	Ra	Low	Low		Sta	Sta		Str	Rap	Str
Hoplias malabaricus	Ab	Ab	Ab	Ann	Ann	Ann	Dec	Dec	Dec	All	All	All
Hydrolycus wallacei	Ab	Ab	Ab	Ann	High	Low	Dec	Dec	Dec	Poo	Poo	Poo, Str
Metynnis hypsauchen	Ra	Ab	Ab	Ann	Ann	Ann	Sta	Sta	Dec	All	All	Poo, Str
Myloplus rubripinnis	Ra	Ab	Ab	Ann	Ann	Ann	Sta	Sta	Dec	All	All	All
Argonectes longiceps	Ra	Ab	Ab	Low	Low	Low	Dec	Dec	Dec	Riv, Poo	Riv, Str	All
Bivibranchia fowleri	Ra	Ra	Ab	Low	Low	High	Sta	Dec		Poo	Riv, Str	Riv, Poo
Hemiodus immaculatus	Ra	Ab	Ab	Low	Low	Ann	Sta	Dec	Dec	Poo	Riv, Str	Riv
Hemiodus semitaeniatus	Ra	Ab	Ab	Low	Low	Ann	Sta	Dec	Dec	Poo	All	Str
Hemiodus thayeria	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Poo	All	Riv
Hemiodus unimaculatus	Ra	Ab	Ab	Low	Low	Ann	Sta	Dec	Dec	Poo	Riv, Str	Riv, Str
Anostomus ternetzi	Ra	Ra	Ra	Ann	Low	Ann	Sta	Sta	Sta	All	Rap	Riv
Laemolyta taeniata	Ra	Ab	Ab	Low	Low	Low	Sta	Sta	Dec	Riv, Poo	All	Riv
Leporinus brunneus	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Dec	Dec	Riv, Poo	All	Riv
Leporinus friderici	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Dec	Dec	Riv, Poo	All	All
Leporinus klausewitzi	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Dec	Dec	Riv, Poo	All	All
Chilodus punctatus	Ab	Ra	Ra	Low	Low	Ann	Sta	Sta	Sta	Poo	All	Riv, Poo
Curimatopsis evelynae	Ab	Ra	Ra	Ann	Low	Low	Sta	Dec	Sta	Str	Poo	Str
Curimatopsis macrolepis	Ra		Ra	Low		High	Sta		Sta	Str		Str
Cyphocharax festivus	Ab	Ab	Ab	Low	Low	Low	Sta	Dec	Dec	All	All	Riv
Cyphocharax multilineatus	Ab	Ab	Ab	Low	Low	High	Sta	Dec	Dec	All	All	Riv, Poo
Cyphocharax spilurus	Ab	Ab	Ab	Low	Low	High	Sta	Dec	Sta	All	All	Riv
Steindachnerina guentheri	Ab	Ab	Ab	Low	Low	Ann	Sta	Dec	Dec	All	All	All
Copella eigenmanni	Ra	Ra	Ra	Low	Low	Ann	Sta	Sta	Sta	Str	Riv, Ch	Poo, Str
Nannostomus marginatus	Ra	Ra	Ra	Low	Low		Sta	Sta		Str	Riv, Ch	Str
Boulengerella maculata	Ra	Ab	Ab	Low	Ann	Ann	Sta	Dec	Dec	Riv, Poo	All	Riv
Chalceus macrolepidotus	Ra	Ab	Ab	Low	Ann	High	Sta	Dec	Dec	Riv, Poo	All	Riv
Triportheus albus	Ab	Ab	Ab	Ann	Ann	Si	Sta	Dec	Dec	Riv, Poo	All	Riv
Carnegiella strigata	Ra	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	All	Str	Riv
Brycon pesu	Ra	Ab	Ab	Low	Low	Low	Sta	Dec	Dec	Str	Riv, Poo	Poo
Bryconops giacopinii	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Sta	Dec	Str	All	Riv, Str
Bryconops humeralis	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Sta	Dec	Str	All	Riv, Str
Iguanodectes purusii	Ra	Ab	Ab	Ann	Ann	Low	Sta	Sta	Sta	Str	All	All
Iguanodectes spilurus	Ra	Ab	Ab	Ann	Ann	Low	Sta	Sta	Sta	Str	All	All
Acestrorhynchus falcatus	Ab	Ab	Ab	Ann	Ann	Low	Sta	Dec	Dec	Str, Poo	All	Riv, Str
Acestrorhynchus falcirostris	Ab	Ab	Ab	Ann	Ann	Low	Sta	Dec	Dec	Str, Poo	All	Riv, Str
Acestrorhynchus nasutus	Ab	Ab	Ab	Ann	Ann	Low	Sta	Dec	Dec	Str, Poo	All	Riv
Bryconamericus orinocoensis	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Sta	Dec	Riv, Str	Str	All
Charax delimai	Ra	Ab	Ab	Low	Ann	Low	Sta	Sta	Dec	Str	All	Str
Hemigrammus analis	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hemigrammus bellottii	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hemigrammus microstomus	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hemigrammus schmardae	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hemigrammus	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hemigrammus yinyang	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All

Table 4 (continued)

Species	Abundance			Seasonality			Timeline			Ecosystems		
	Pit	SaJ	Wac	Pit	SaJ	Wac	Pit	SaJ	Wac	Pit	SaJ	Wac
Hyphessobrycon bentosi	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hyphessobrycon copelandi	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Hyphessobrycon dorsalis	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Jupiaba poekotero	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	All
Microschemobrycon geisleri	Ra	Ab	Ra	Low	Ann	High	Sta	Sta	Dec	Str	Str	All
Moenkhausia ceros	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	Riv
Moenkhausia collettii	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	Str	Str	Riv
Moenkhausia cotinho	Ra	Ab	Ab	Low	Ann	Ann	Sta	Sta	Dec	All	Str	Poo, Str
Moenkhausia mikia	Ra	Ab	Ab	Low	Ann	Low	Sta	Sta	Dec	Str	Str	Str
Moenkhausia oligolepis	Ab	Ab	Ab	Ann	Ann	Low	Sta	Sta	Dec	All	Str	Str
Phenacogaster pectinatus	Ra	Ab	Ra	Low	Ann		Sta	Sta	Sta	All	Str	
Sternopygus macrurus	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	Poo	All	All
Gymnotus carapo	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	Str	All	All
Hypopygus lepturus	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	Str	Riv, Str	All
Corydoras melanistius	Ra	Ra	Ab	Ann	Low	Low	Sta	Dec	Sta	Riv	All	Riv
Corydoras melini	Ra	Ra	Ab	Ann	Low	Low	Sta	Dec	Sta	Riv	All	Riv
Megalechis picta	Ra	Ab	Ab	Ann	Ann	Ann	Sta	Dec	Dec	Str, Poo	All	All
Hypostomus oculeus	Ra	Ab	Ab	Low	Ann	Ann	Sta	Dec	Dec	Riv, Poo	Riv	Riv, Str, Ch
Loricaria cataphracta	Ra	Ab	Ab	Ann	Low	Ann	Sta	Sta	Sta	Riv	Riv, Str	Riv, Str, Ch
Bunocephalus knerii	Ra	Ra	Ab	Ann	Ann	High	Sta	Sta	Sta	All	All	Riv, Poo
Ageneiosus polystictus	Ab	Ab	Ab	Ann	Ann	Low	Sta	Dec	Sta	Riv, Poo	Riv, Poo	Riv, Str
Auchenipterichthys coracoideus	Ab	Ab	Ab	Ann	Ann	High	Sta	Dec	Sta	Riv	Str	Riv
Centromochlus heckelii	Ab	Ab	Ab	Ann	Ann	High	Sta	Dec	Dec	Riv	Str	Riv, Poo
Tatia intermedia	Ab	Ab	Ab	Ann	Ann	High	Sta	Dec	Dec	Str	Str	Riv, Poo
Trachelyopterus galeatus	Ab	Ab	Ab	Ann	Ann	High	Sta	Dec	Dec	All	Str	Riv, Poo
Acanthodoras cataphractus	Ra	Ab	Ab	High	Ann	High	Sta	Sta	Dec	Str	Poo, Str	Riv, Poo
Amblydoras affinis	Ra	Ab	Ab	High	Low	Ann	Sta	Dec	Dec	Str	Poo, Str	Riv
Mastiglanis asopos	Ra	Ab	Ab	Ann	Low	Ann	Sta	Dec	Dec	Riv, Poo	Str	Riv, Str
Rhamdia laukidi	Ra	Ab	Ab	Ann	High	Ann	Sta	Dec	Dec	Str	Str	Riv, Str, Ch
Pimelodus blochii	Ab	Ab	Ab	Ann	Ann	Ann	Sta	Dec	Dec	Riv	Riv	Riv
Batrochoglanis villosus	Ra	Ab	Ab	Ann	Ann	High	Sta	Dec	Sta	All	All	Riv
Synbranchus marmoratus	Ra	Ab	Ab	Low	Ann	Low	Sta	Dec	Sta	Str	All	All
Apistogramma regani	Ra	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	Str	All	All
Cichla temensis	Ab	Ab	Ab	Ann	Ann	Low	Sta	Dec	Dec	Riv, Poo	All	Riv
Crenicichla anthurus	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	All	Riv, Str	All
Crenicichla lenticulata	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	All	Riv, Str	Riv, Str
Crenicichla lugubris	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	All	Riv, Str	Riv, Str
Satanoperca jurupari	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Dec	Riv, Poo	Riv, Poo	Riv, Str
Potamorrhaphis guianensis	Ab	Ab	Ab	Ann	Low	Low	Sta	Dec	Sta	All	Poo, Str	Riv

For communities: *Pit* Pituna, *SaJ* San Javier, *Wac* Wacurabá. For abundance: *Ra* rare, *Ab* abundant. For seasonality: *High* high-water, *Low* low-water, *Ann* annual. For timeline: *Sta* Stable, *Dec* decrease. For ecosystems: *Riv* rivers, *Poo* pools, *Str* streams, *Rap* rapids

characteristics to determine the effects of habitat degradation on fish communities. These types of studies might reveal if there is a trend in the decrease in abundance per species, as suggested by the Cubeo people. Furthermore, to evaluate if these changes in fish assemblage structure are due to local drivers or mechanisms operating at bigger scales (e.g., climate change).

It is determined that, despite the importance of fish as a resource, little has been documented about them in the basin [26]. In general, little is known about the spatial and

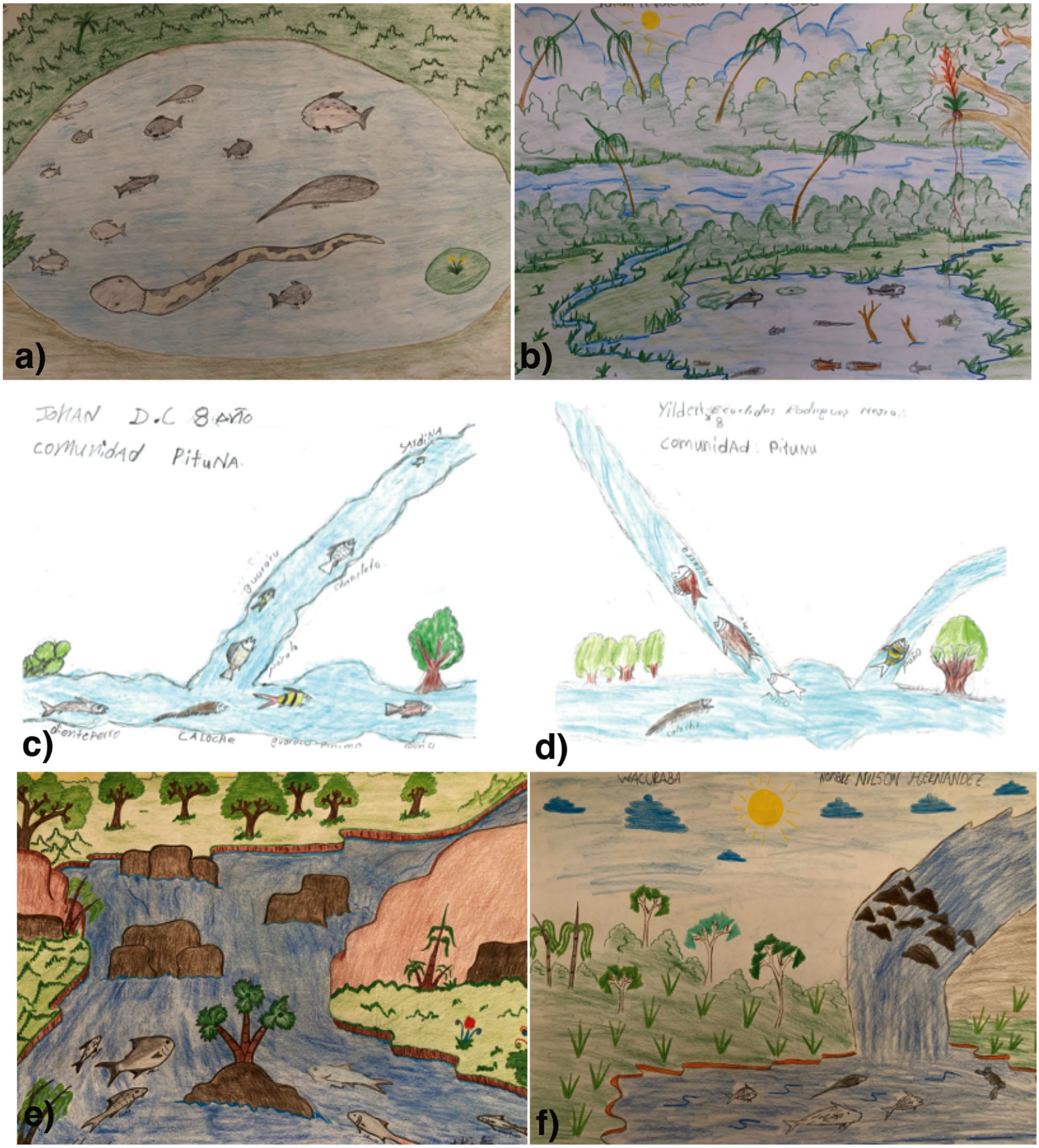

Fig. 5 Drawings of the aquatic ecosystems and associated species: pools (**a** and **b**), rivers and streams (**c** and **d**), and rapids (**e** and **f**)

temporal dynamics of communities that are composed of many species that are consumed and traded at a local and regional level. However, fish is a substantial source of animal protein for indigenous people and therefore vital to their nutrition. This suggests that this natural resource is the most heavily harvested for food, mainly in the dry season. However, there is a common interest in capturing fish from the Serrasalmidae, Anostomidae, and Cichlidae families, as has already been recorded [14]. Fifteen species were recognized, classified as abundant, and captured mainly in the river, of which nine species are accessible throughout the year.

The considerable number of species associated with the Amazonian landscapes that provide ES, mostly fish that is intensely exploited [14, 64], is correlated with the high species diversity they support. The ES provides direct or indirect social, economic, and environmental benefits to local populations [65]. Nevertheless, the ES is highly vulnerable to anthropogenic activities and in different regions of the world, its degradation and loss are evident [66–68].

The most recognized fisheries in the Colombian Amazon basin correspond to fish species that are associated with whitewater systems such as the Amazon River, Caquetá, and Putumayo rivers [69]. However, in regions where blackwater systems predominate, fishery products are also of great importance and sometimes the only source of animal protein. The consideration of species present in blackwater ecosystems in fisheries management and their recognition as a natural resource of high socio-environmental value would favor a better understanding of the dynamics of these blackwater species, which is essential for their management and conservation. In this sense, it becomes important to promote territorial entities and decentralized national entities, so that they can financially and technically support the implementation of research that contributes to documenting the use and knowledge of natural resources by the indigenous communities, for management and conservation purposes. Furthermore, the information provided is a fundamental input for the formulation of plans and strategies for the management and conservation of this natural resource that in the Pan Amazonia is under threat, due to deforestation, mining, canalization, and overfishing [70].

Conclusions

The present study provides support for the need to emphasize the importance of local fisheries as a source of income and food safety, based on non-commercial species at the Amazon basin scale. Our study also highlights the significance of investigation of local community's interactions with natural resources in remote areas that are prone to major changes due to global environmental changes. The compilation, systematization, and analysis of the information about the knowledge and use of fish are of great relevance to the problems faced by the region, in what has to do with the information gaps about the fish fauna, including its relationship with the Indigenous communities. Considering the increase in both Indigenous and settler settlements, which implies an increase in pressure on the fishing resource, a management plan is needed. These biological, ecological, and ethnological aspects of the problem in the region are associated with each other and are of great relevance for the updating or precision of management plans for natural resources or resources of common use.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13002-024-00737-1.

Additional file 1.

Acknowledgements

Our study was performed simultaneously with the research project "Pesca en el Río Cuduyarí: uso y conocimiento de los peces en las comunidades de la etnia Cubeo". This work would not have been conceivable without the support of the indigenous community members and the members of the headquarters of the Sinchi Institute at Mitú, Vaupés. We would like to thank William Castro Pulido for the map elaboration.

Author contributions

Conceptualization, conducting the research, and data analysis were contributed by JDBG and LJH. Developing methods was carried out JDBG, LJH, and EAC. Data interpretation was involved by JDBG, LJH, JFGS, and EAC. Preparation figures and tables and writing was performed by JDBG.

Funding

Our study was performed simultaneously with the research project "Pesca en el Río Cuduyarí: uso y conocimiento de los peces en las comunidades de la etnia Cubeo". This work was made possible thanks to the financial support of the project "Citizen Science for the Amazon" of the Wildlife Conservation Society and the Gordon and Betty Moore Foundation.

Availability of data and materials

No datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate

This study is a linguistic field survey and does not involve any human or animal-related experimental trials. Verbal consent was obtained from all respondents before data collection.

Consent for publication

Not applicable.

Competing interest

The authors declare no competing interests.

Received: 5 August 2024 Accepted: 19 October 2024
Published online: 22 November 2024

References

1. Junk WJ, Piedade MTF, Schöngart J, Wittmann F, Parolin P. Amazonian floodplain forests: ecophysiology, biodiversity and sustainable management. Dordrecht Heidelberg: Springer; 2010.
2. Bogotá-Gregory JD, Donascimiento C, Lima FCT, Acosta-Santos A, Villa-Navarro FA, Urbano-Bonilla A, et al. Fishes from the Colombian Amazonia region: species composition from the river systems within the rainforest biome. Biota Neotrop. 2022. https://doi.org/10.1590/1676-0611-bn-2022-1392.
3. Correa SB, Van Der Sleen P, Siddiqui SF, Bogotá-Gregory JD, Arantes CC, Barnett AA, et al. Biotic indicators for ecological state change in Amazonian floodplains. Bioscience. 2022;72:753–68.
4. Val AL, de Almeida VMF. Fishes of the Amazon and their Environment: Physiological and Biochemical Aspect. Berlin: Springer-Verlag; 1995.

5. Lundberg J. Freshwater richness of the Amazon. Nat Hist. 2001;110:36–43.
6. Junk WJ, Soares MGM, Bayley PB. Freshwater fishes of the Amazon River basin: their biodiversity, fisheries, and habitats. Aquat Ecosyst Health Manag. 2007;10:153–73.
7. Leveque C, Oberdorff T, Paugy D, Stiassny MLJ, Tedesco PA. Global diversity of fish (Pisces) in freshwater. Hydrobiologia. 2008;595:545–67.
8. Dagosta FCP, de Pinna MCC. Biogeography of Amazonian fishes: deconstructing river basins as biogeographical units. Neotrop Ichthyol. 2017;15:1–24.
9. Schindler S, Sebesvari Z, Damm C, Euller K, Mauerhofer V, Schneidergruber A, et al. Multifunctionality of floodplain landscapes: relating management options to ecosystem services. Landsc Ecol. 2014;29:229–44.
10. Pelicice FM, Agostinho AA, Azevedo-Santos VM, Bessa E, Casatti L, Garrone-Neto D, et al. Ecosystem services generated by Neotropical freshwater fishes. Hydrobiologia. Springer Science and Business Media Deutschland GmbH; 2023. p. 2903–26.
11. Holmlund CM, Hammer M. Ecosystem services generated by fish populations. Ecological Economics. 1999.
12. Jácome-Negrete I. Etnoictiología Kichwa de las lagunas de la cuenca baja del río Curaray (Amazonia), Ecuador. Biota Colomb. 2013;5–24.
13. Jácome-Negrete I. Etnoictiología Kichwa de las lagunas de la cuenca baja del río Curaray (Amazonia). Ecuador Biota Colombia. 2013;14:144.
14. Agudelo CE. La pesca en Amazonia, un servicio ecosistémico en riesgo. Revista Colombia Amazónica. 2015;8:181–7.
15. Tregidgo D, Parry L, Barlow J, Pompeu PS. Urban market amplifies strong species selectivity in Amazonian artisanal fisheries. Neotrop Ichthyol. 2021. https://doi.org/10.1590/1982-0224-2021-0097.
16. Lima FCT, Ramos L, Barreto T, Cabalzar A, Tenório G, Barbosa A, et al. Peixes do alto Tiquié: ictiologia e conhecimentos dos tuyuka e tukano. Peixe e gente no alto rio Tiquié: conhecimentos tukano/tuyuka, ictiologia/etnologia. São Paulo: Instituto Socioambiental; 2005. p. 111–282.
17. Goulding M, Venticinque E, de Ribeiro MLB, Barthem RB, Leite RG, Forsberg B, et al. Ecosystem-based management of Amazon fisheries and wetlands. Fish Fisher. 2019;20:138–58.
18. Saint-Paul U, Zuanon J, Correa MAV, Garcia M, Fabre NN, Berger U, et al. Fish communities in central Amazonian white- and blackwater floodplains. Environ Biol Fishes. 2000;57:235–50.
19. Goulding M, Carvalho ML, Ferreira EG. Rio Negro, rich life in poor water: Amazonian diversity and foodchain ecology as seen trough fish communities. The Hague: SPB Academic Publishing; 1988.
20. Bogotá-Gregory JD, Lima FCT, Correa SB, Oliveira CS, Jenkins DG, Ribeiro FR, et al. Biogeochemical water type influences community composition, species richness, and biomass in megadiverse Amazonian fish assemblages. Sci Rep. 2020;10:15349. https://doi.org/10.1038/s41598-020-72349-0.
21. Hamilton Rice BA. The river Uaupés. Geogr J. 1910;35:682–700.
22. Rudas Lleras A. Unidades ecogeográficas y su relación con la diversidad vegetal de la amazonia colombiana. Universidad Nacional de Colombia; 2009.
23. Salazar CA, Gutiérrez F, Franco M. Vaupés: Entre la colonización y las fronteras. Bogotá: Instituto Amazónico de Investigaciones Científicas SINCHI; 2006.
24. IDEAM. Guía técnico científica para la ordenación y manejo de cuencas hidrográficas en Colombia. 2008.
25. Latrubesse EM, Franzinelli E. The late Quaternary evolution of the Negro River, Amazon, Brazil: implications for island and floodplain formation in large anabranching tropical systems. Geomorphology. 2005;70:372–97.
26. UDIC-CDA. Plan Integral de Vida Indígena Pueblo Cubeo-Zonal UDIC "MAHJE APUEDE VORI JIPOKATEINO" en busca de nuestra vida futura. Mitú, Vaupés; 2005.
27. CDA-SINCHI. Gestión de Cuencas y Microcuencas Priorizadas en la Jurisdicción de la CDA/Apoyo y Asistencia Técnica al Ejercicio de Ordenación y Manejo de la Cuenca del Río Cuduyarí. Mitú, Vaupés; 2022.
28. Rodríguez LÁ, Roldán AM, Zuluaga P, Usma JS. El papel de los líderes en el manejo colectivo de los recursos naturales. Evidencia del experimento de la pesca en el río cuduyarí (Vaupés, Colombia). Desarro Soc. 2017;2017:155–88.
29. Cárdenas López D, Arias García JC, Vanegas Liévano JA, Jiménez Montoya DA, Vargas Romero O, Gómez Rodríguez L. Plantas útiles y promisorias en la Comunidad de Wacurabá (Caño Cuduyarí) en el departamento de Vaupés (Amazonía colombiana). Bogotá, D.C. Colombia: Instituto Amazónico de Investigaciones Científicas –Sinchi; 2007.
30. Berman Arévalo E, Ros-Tonen MAF. Discourses, power negotiations and indigenous political organization in forest partnerships: the case of selva de matavén. Colombia Hum Ecol. 2009;37:733–47.
31. Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, Lévêque C, et al. Freshwater biodiversity: importance, threats, status and conservation challenges. Biol Rev Camb Philos Soc. 2006. https://doi.org/10.1017/S1464793105006950.
32. McGrath DG, Cardoso A, Almeida OT, Pezzuti J. Constructing a policy and institutional framework for an ecosystem-based approach to managing the Lower Amazon floodplain. Environ Dev Sustain. 2008;10:677–95.
33. Cassú, E. Manejo indígena del mundo global: el caso de los tikuna de Yahuarcaca. Mundo Amazónico. 2015;6:47–71.
34. Bogotá-Gregory JD, Amorim de Barros NM, Navarro-Villa FA. Ethnoichthyology of the Piapoco, Piaroa, Puinave and Sikuani ethnic groups inhabitants of the Matavén Forest (Vichada, Colombia). Acta Amazon. 2024;54.
35. Sioli H. The Amazon: Limnology and Landscape Ecology of a Mighty Tropical River and its Basin. Dordrecht, Boston, Hingham, MA: W. Junk; 1984.
36. CDA. Diagnóstico, caracterización, evaluación, zonificación y Plan de Manejo Ambiental del Sistema de Humedales del área urbana y de expansión urbana del Municipio de Mitú. Mitú,Vaupés; 2010.
37. Bray JR, Curtis JT. An ordination of the upland forest communities of southern Wisconsin. Ecol Monogr. 1957;27:325–49.
38. Dray S, Chessel D, Thioulouse J. Co-inertia analysis and the linking of ecological data tables. Ecology. 2003;84:3078–89.
39. Tenenhaus M, Young FW. An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data. Psychometrika. 1985;50:91–119.
40. De Cáceres M, Jansen F. Package 'indicspecies' for R: Relationship Between Species and Groups of Sites. R Cran. 2016;1–31.
41. R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2021.
42. Csárdi G. Package "igraph" Title Network Analysis and Visualization. 2024.
43. Oksanen J. Vegan: an introduction to ordination. R-package Vegan. 2008;1:1–10.
44. Dray S, Dufour AB, Thioulouse J. Ade4. J Stat Sorftw. 2007;22:1–20.
45. Bogotá-Gregory JD, Provenzano F, Acosta-Santos A, Agudelo Córdoba E. New record of rineloricaria daraha Rapp Py-Daniel & Fichberg, 2008 from Rio Paca, upper Rio negro, Amazon river basin. Check List. 2016;12:2009–12.
46. Henderson PA, Crampton WGR. A comparison of fish diversity and abundance between nutrient-rich and nutrient-poor lakes in the Upper Amazon. J Trop Ecol. 1997;13:175–98.
47. Arbeláez F, Duivenvoorden JF, Maldonado-Ocampo JA, Arbelaez F, Duivenvoorden JF, Maldonado-Ocampo JA. Geological differentiation explains diversity and composition of fish communities in upland streams in the southern Amazon of Colombia. J Trop Ecol. 2008;24:505–15.
48. Bogotá-Gregory JD, Lima FCT, DoNascimiento C, Acosta-Santos A, Villa-Navarro FA, Usma-Oviedo JS, et al. Fishes of the Mitú Region: middle basin of the río Vaupés, Colombian Amazon. Biota Neotrop. 2022. https://doi.org/10.1590/1676-0611-bn-2021-1244.
49. Previero M, Minte-Vera CV, de Moura RL. Fisheries monitoring in Babel: fish ethnotaxonomy in a hotspot of common names. Neotrop Ichthyol. 2013;11:467–76.
50. Mahugnon BH, Hyppolite A, Belarmain AF, Houénafa ACG, Florent O. Ethnoichthyology: critical analysis and perspectives. Int J Frontline Res Sci Technol. 2022;1:38–47.
51. Fitzgerald DB, Sabaj Perez MH, Sousa LM, Gonçalves AP, Rapp Py-Daniel L, Lujan NK, et al. Diversity and community structure of rapids-dwelling fishes of the Xingu River: Implications for conservation amid large-scale hydroelectric development. Biol Conserv. 2018;222:104–12.
52. Lehmberg ES, Elbassiouny AA, Bloom DD, López-Fernández H, Crampton WGR, Lovejoy NR. Fish biogeography in the "Lost World" of the Guiana Shield: phylogeography of the weakly electric knifefish Gymnotus carapo (Teleostei: Gymnotidae). J Biogeogr. 2018;45:815–25.
53. Bogotá-Gregory JD, Jenkins DG, Lima FCT, Magurran AE, Crampton WGR. Geomorphological habitat type drives variation in temporal species

turnover but not temporal nestedness in Amazonian fish assemblages. Oikos. 2023;2023:1–13.
54. Crampton WGR. An ecological perspective on diversity and distributions. In: Albert JS, Reis RE, editors. Historical Biogeography of Neotropical Freshwater Fishes. Berkeley: University of California Press; 2011.
55. Carvalho LN, Zuanon J, Sazima I. Natural history of amazon fishes. InternationalCommission on Tropical Biology and Natural Resources. 2016. p. 1–32.
56. Prieto-Piraquive EF. Los hijos de Yoi: Pescadores y peces de los lagos de Yahuarcaca. Saarbrücken, Alemania: Editorial Académica Española; 2012.
57. Galacatos K, Stewart K, Ibarra M. Fish community patterns of lagoons and associated tributaries in the Ecuadorian Amazon. Copeia. 1996;4:875–94.
58. Galacatos K, Barriga-Salazar R, Stewart K. Seasonal and habitat influences on fish communities within the lower Yasuní River Basin of Ecuadorian Amazon. Environmen Biol. 2004;71:33–51.
59. Correa SB. Fish assemblage structure is consistent through an annual hydrological cycle in habitats of a floodplain-lake in the Colombian Amazon. Neotrop Ichthyol. 2008;6:257–66.
60. Buhrnheim C, Cox FC. Low seasonal variation of fish communities in Amazonian rain forest streams. Ichthyol Explor Freshw. 2001;12:65–78.
61. Bogotá-Gregory JD, Jenkins D, Lima FCT, Magurran A, Crampton WGR. Geomorphological habitat type drives variation in temporal species turnover but not temporal nestedness in Amazonian fish assemblages. Oikos. 2023;2023: e09967.
62. Shivanna KR. Climate change and its impacts on biodiversity and human welfare. Proc Indian Natl Sci Acad. 2022;88:160–71.
63. Pio Caetano Machado L, Caetano G, Gomes Lacerda Cavalcante VH, Miles D, Colli GR. Climate change shrinks environmental suitability for a viviparous Neotropical skink. Conserv Sci Pract. 2023;5:e12895.
64. Almeida O, Lorenzen K, McGrath D, Rivero S. The Amazon Várzea: the decade past and the decade ahead. Netherlands, Dordrecht: Springer; 2011.
65. FAO. Food and Agricultural Organization of the United Nations, State of the world's forests. Rome, Italy: Food and Agricultural Organization of the United Nations; 2014.
66. Steininger M, Tucker C, Ersts P, Killeen T, Villegas Z, Hecht S. Clearance and fragmentation of tropical deciduous forest in the Tierras Bajas, Santa Cruz, Bolivia. Conserv Biol. 2001;15:856–66.
67. Echeverria C, Coomes D, Sales J, Rey-Benayas J, Lara A, Newton A. Rapid deforestation and fragmentation of Chilean Temperate Forests. Conserv Biol. 2006;130:481–94.
68. Teixido A, Quintanilla L, Carreno F, Gutierrez D. Impacts of changes in land use and fragmentation patterns on Atlantic coastal forests in northern Spain. J Environ Manag. 2010;91:879–86.
69. Agudelo-Córdoba E, Sánchez C, Rodríguez C, Bonilla-Castillo C, Gomez G. II. Pesquerías continentales de Colombia: cuencas del Magda- lena-Cauca, Sinú, Canalete, Atrato, Orinoco, Amazonas y vertiente del Pacífico. Bogotá, Colombia: Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia. Instituto de Investigación de los Recursos Biológicos Alexander von Humboldt; 2011.
70. Reis R, Albert J, Di Dario F, Mincarone M, Petry P, Rocha L. Fish biodiversity and conservation in South America. J Fish Biol. 2016;89:12–47.

Publisher's Note