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# Ethnoichthyology and Ethnotaxonomy of the Kichwa Indigenous People of *Arawanu* (Arajuno), in the Ecuadorian Amazon

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The Amazon Basin is home to a great number of Indigenous nationalities that have coevolved with aquatic habitats and fish resulting in a precise traditional ecological knowledge. Nevertheless, this biocultural heritage is threatened by the degradation of rivers and fisheries, and cultural erosion. This research was designed and carried out in the community of *Arawanu* (Arajuno in Spanish), in the Ecuadorian Amazon, and was requested by the local Kichwa people looking for guidance to gather, systematize and disseminate their ethnoichthyological knowledge. Data collection was carried out through participatory workshops using the pile sorting technique in group dynamics, to identify, name and classify local fish and compile biocultural information about them. From the Linnaean taxonomic perspective, 86 taxa were identified, included in 26 families, and corresponded with 16 Kichwa ethnofamilies and 58 ethnospecies. Five classification levels were identified: (I) *Aycha*: unique beginner–Animalia kingdom; (II) *Yaku Aycha*: life form–Pisces superclass; (III) *Ayllukuna*: ethnofamilies–Linnaean families; (IV) Ethnogenera–Linnaean genus; and (V) Ethnospecies–Linnaean species. A one-to-one correspondence was registered between 35 Kichwa ethnospecies and Linnean species, along with one case of over-differentiation and 21 cases of subdifferentiation (Type A: 7; Type B: 14). The Kichwa ethnoichthyological classification is multidimensional and considers attributes like skin and scales, fishbones and spines, meat quality, body shape, diet, and salience. Of the 58 ethnospecies, 38 were valued for consumption, while medicinal and spiritual uses were mentioned for 40 of them. The participatory work created a forum to discuss the value and threats to ichthyofauna and freshwater systems, enabled the dissemination of their biocultural heritage, and highlighted the cultural relevance of hydro-social ecosystems in their livelihood. The collected information may be critical to adapt local education systems to the Kichwa worldview and to pass down traditional ecological knowledge to future generations, fostering a respectful, careful and conscious relationship between humans and nature. Our results offer a solid and novel information compilation and practical guidance for participatory ethnobiological surveys. Additionally, the ethnobiological and the ethnotaxonomical information establishes the basis to develop sustainable fishing strategies and promote conservation of the local ichthyofauna.

**Keywords: ethnoclassification, traditional ecological knowledge, fish, Amazon Basin, Indigenous community, folk taxonomy, biocultural diversity**

## INTRODUCTION

The Amazon Basin is one of the global hotspots of biocultural diversity, nurtured by the Indigenous communities living in the rainforest and along the riverbanks of an intricate water system (Loh and Harmon, 2005). Rivers play a key socio-cultural role for many of these human groups. They are a source of food and medicines, are used as waterways, and have important spiritual relevance while the identity of many of the local native cultures emerges from their relationship with water and rivers (Angarita-Baéz et al., 2017).

The Amazon River system supports the greatest freshwater biodiversity on Earth, with more than 2,200 strictly freshwater species, representing around 15% of all freshwater fish worldwide (Jézéquel et al., 2020). However, many basins and large territories remain poorly studied and a great number of species are yet unknown to western science (Antonelli et al., 2018). Fishing is an important subsistence activity for many human groups in the Amazon and reflects a deep relationship between humans and water landscapes (Alves, 2012). It also indicates both a precise and diverse traditional ecological knowledge (*corpus*); is the source and inspiration for a wide variety of tools, techniques and practices (*praxis*); and is crucial to understand the worldview and spiritual links (*kosmos*) of numerous Indigenous people related to fish and rivers (Alves and Souto, 2011; Jácome-Negrete, 2012; Toledo and Alarcón-Cháires, 2012).

Fishing is transcendental in the Amazon, since fish represent the main protein source for the local inhabitants and guarantee the food sovereignty of many human cultures (Mertens et al., 2015; Val et al., 2017). Specifically, the Amazonian Kichwas stand out as a culture with extraordinary fishing skills and detailed knowledge about fish and other aquatic organisms. Above other uses, fish are the key alimentary source for them. Vasco and Sirén (2019) estimated a fish consumption among the Kichwas in Pastaza of 104 g/person/day. This is the result of a historical cohabitation and coevolution between fish, rivers, and people, and points out the critical dependence on this resource (Vacacela, 2007; Jácome-Negrete, 2013).

The study of local classification systems is a practical way to address ethnobiological knowledge and understand traditional cultures and their world view (Posey, 1985; Berlin, 1992; Lepofsky, 2009; Hunn, 2014). The ethnoclassification approach has also proven to be an effective way to compile and assess ethnoichthyological information (Forth, 2017). It is a good starting point to unveil a wide variety of traditional ecological knowledge related to fish species, fishing techniques, biological and ecological information, fishing areas, social norms, beliefs and even the history of the local community and the rivers around them (Alves and Souto, 2011; Previero et al., 2013). It also allows us to approach the sociocultural mindset of the community, expressed in the naming and ordering of the natural world, the basis that determines the way humans relate and interact with their environment (Berlin, 1992; Kakudidi, 2004; Hunn, 2014). Therefore, the ethnotaxonomic approach is crucial to register, classify and value biodiversity from the local point of view, and stands out as a keystone discipline to adapt and foster biocultural conservation strategies (Mourão and Barbosa Filho, 2018; Barbosa-Filho et al., 2021). It also stands out as a crucial tool for academics to disclose the diverse and complex ichthyofauna of the Amazon and to protect and manage it (Alves, 2012).

However, Pauly et al. (2005) and Pinto et al. (2013) warn us about how the accelerated degradation of hydrosocial systems and fisheries drastically affects those communities that rely on subsistence fishing, such as the Amazonian Kichwas in Ecuador, whose livelihood and the conservation of their culture is severely threatened (Cevallos, 2020). The traditional ecological knowledge they retain is also suffering from the arrival of new external actors and accelerated globalization processes related to this connection to the "outside world" that triggers rapid socio-cultural changes. The imposition of a generic nationwide education system, not adapted to the local cultural and environmental context (even been bilingual), is also hampering intergenerational transmission of local knowledge and homogenizing their culture (Weckmüller et al., 2019).

To face the challenge of fighting against this environmental degradation and acculturation, while conserving the biocultural heritage related to fish and rivers, the Kichwa leaders of the *Puka Rumi* Community Center, part of the Community Organization of the Kichwa of Arajuno (*Arawanu Kichwa Ayllu Tantanakuy*) in the Pastaza Province of the Ecuadorian Amazon, asked the authors for guidance and help. Specifically, they needed advice and assistance to gather and systematize their ethnoichthyological knowledge for conservation management and educational purposes. Therefore, this project was designed and carried out through participatory processes involving academics and local inhabitants, seeking solutions that could help tackle the ongoing threats to the local environment and culture.

In this collaborative context, many questions arose from the beginning: how is the relation between the Kichwas, fish and rivers? How deep and precise is the knowledge they have about fish? How do they identify and classify fish? How do they capture and use fish? How relevant are the fish ecologically, culturally and socially for the Kichwas in Arajuno? How can the ethnotaxonomy and classification help to address sustainable fishing and the conservation of biocultural diversity?

## MATERIALS AND METHODS

This collaborative research process combining western science and traditional knowledge was inspired and guided by two deep-rooted Kichwa concepts, *mink'a* and *randi-randi*. The workshops were presented to the Kichwa participants as a *mink'a*, a gathering of the community working together for the common good, without any economic benefit. They shared their time and information to help us collect all the common knowledge around fish and make it available for everyone afterward. The relation between the scientists and the Kichwa participants was guided by the *randi-randi*, giving and giving, a reciprocal relational principle that encourages people to share. The authors offered help to organize workshops and prepare popular science materials for the community, while the Kichwa offered their time and knowledge and their permission to use the information for scientific purposes, like this manuscript. As one of the Kichwa leaders said when presenting us to the community, "These scientists have come to work with us like many others before them, but this time they won't leave without previously returning to us all the results of the research." The project began in October 2018, and the presentation of the results along with the environmental education materials were handed out to the community on November 29, 2019, thus fulfilling our promises.

To facilitate the intercultural relations and guide the research, our team included three experienced ethnoichthyologists who have been working with the Ecuadorian Kichwas in the Amazon for years (Iván Jacóme-Negrete and Lida Guarderas-Flores since 2001, and Carolina Carrillo-Moreno since 2012) and have published many scientific and technical documents (Jácome-Negrete, 2012, 2013, 2021; Valdiviezo-Rivera et al., 2012; Jácome-Negrete and Guarderas-Flores, 2015; Carrillo-Moreno, 2017). Their knowledge about the Kichwa culture and their relationship with fish was crucial to facilitate data collection and interpretation.

### Study Area

The study was carried out in the Arajuno Canton (*Arawanu*, in Kichwa), in the Ecuadorian province of Pastaza, in the territory of the *Puka Rumi* Community Center (1°14′0.89″S; 77°42′6.63″W) (**Figure 1**). *Puka Rumi* covers an area of more than 600 ha within the upper basin of the Arajuno River, a tributary of the Napo River, inside the Amazon River system. The territory is not yet legally recognized as property of the community and the boundaries are in the process of being officially established.

According to zoogeographic criteria, this area is part of the Eastern Tropical Floor (Albuja, 2011). It comprises ecosystems of evergreen forest of the peneplain in the Napo-Curaray area, floodplain forests of the alluvial plain rivers in the Andean and Amazonian Mountain ranges, and flooded palm forests in the Amazonian floodplains (MAE, 2012). The studied ecosystems were the Arajuno River and its tributaries. The sampled rivers flow along the Andean-Amazonian foothills, in an altitude range between 460 and 491 m.a.s.l. and belong to the Alto Napo ichthyohydrographic zone (Barriga, 2012). The sampled rivers were the Arajuno River (*Arawanu Mayu* in Kichwa), Huapuno River (*Wapunu Mayu*), and Inayaku River (*Inayaku Mayu*) (**Figure 1**).

### Study Population

Our research was carried out with the collaboration of the Community Organization of the Kichwa of Arajuno, comprising 26 communities inside the Arajuno Canton, totaling 2648

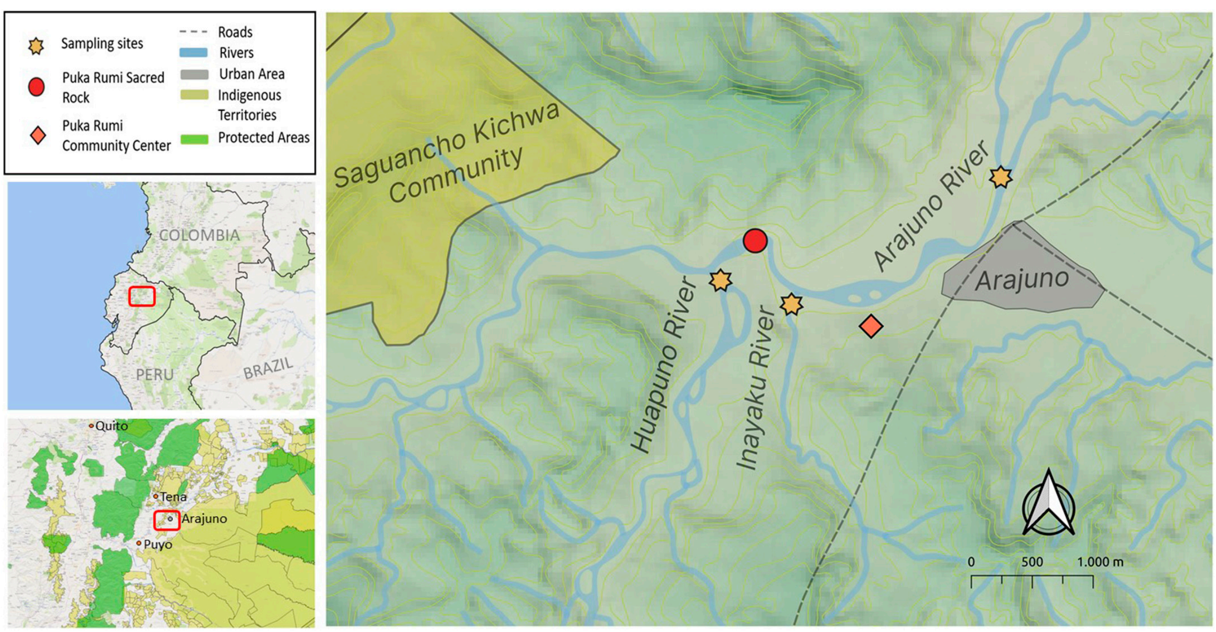



**FIGURE 1 |** Map of the study area and study sites in Arajuno, in the Ecuadorian Amazon (IGM, 2020; Ministerio del Ambiente, Agua y Transición Ecológica, 2021; Raisg, 2021).

inhabitants (GADMCA, 2014). Many of the participants were part of the *Puka Rumi* Community Center, formed by 24 families (whose leaders were the promoters of the project), and from other communities close to the Arajuno village. All the collaborators were of Kichwa origin: their mother tongue is Kichwa, while Spanish is their second language and they use it fluently. Their main activities are principally for subsistence, which include: fishing, hunting, agriculture and the gathering of wild fruits, and materials (GADMCA, 2014). The Kichwa of *Puka Rumi* settled in the area in 1907 migrating from the surrounding areas of Tena, an Amazonian city north of Arajuno (**Figure 1**). They established their village around the *Puka Rumi* (red rock), a big boulder in the Arajuno River, which the Kichwa considered sacred, and represents the spiritual core of the community (**Figure 1**). The Community Center was created to centralize and guide governance efforts in the territory. It describes itself as: "A life project that aims to contribute and guide the joint action for the conservation, recovery and sustainable use and management of natural resources, strengthening the Kichwa cultural identity through the transference of local knowledge."

## Data Collection

The project was designed following the previous successful experiences of the authors work with other Kichwa communities in the Amazon. The leaders of *Puka Rumi* knew about these other projects and they also knew two of the authors personally thanks to those previous works, and they wanted to replicate them in Arajuno. This predisposition made it easy to come to the terms of collaboration and sign an agreement between the community representatives and the research team.

Besides the general agreement with community authorities, before every workshop we also explained the objectives and activities to be carried out in that session as well as the products to be generated, which were later checked and approved by the attendees. At each session, the participants signed a letter where they authorized us to compile and use the information gathered for environmental education materials and scientific publications. The entire research process, the data collection, the analysis of the results and the publication of this manuscript followed the guidelines of the Code of Ethics for Ethnobiological Research in Latin America (Argueta et al., 2018).

### Participatory Community Fishing

Participatory fishing was carried out with local community members during five sampling days in October and November 2018 (**Figure 2**). Two adult women and four adult men helped us throughout the surveys. We combined artisanal fishing techniques like hooks, throw nets and harpoons, with electrofishing, trawl and trammel nets, including some night samplings too. Captured fish were kept alive in an aquarium with an oxygen pump, identified using both Kichwa and Linnaean taxonomy, photographed and released back to the river at

**FIGURE 2 |** Participatory fishing surveys: **(A)** Throw net; **(B)** Free diving; **(C)** Trawl net; **(D)** Electrofishing.

the end of the sampling (**Figure 2**). Those fish specimens difficult to be correctly identified in the field were anesthetized (2% lidocaine hydrochloride) and fixed (10% formol) for their subsequent analysis in the Museum of Zoology of the Universidad Tecnológica Indoamérica, located in Quito. The laboratory identification was carried out using the following publications: Gèry (1977), Kullander (1986), Chernoff and Machado-Allison (1990), Vari and Harold (2001), Armbruster (2005), de Melo and Buckup (2006), Jácome-Negrete and Guarderas-Flores (2015), Lujan et al. (2015), van der Sleen and Albert (2017), and Provenzano and Barriga-Salazar (2018).

## Ethnobiological Workshops

After the fishing campaign, three participatory workshops were organized in the community to identify and classify local fish, and to gather ethnobiological, ethnoecological and ethnotaxonomical information. The first one was carried out on October 27, 2018, in the Community Organization of the Kichwa of Arajuno facilities (**Figure 3**). For the identification of the ichthyofauna, photographs were used as visual stimuli (Ellen, 1986; Albuquerque et al., 2014) following the pile sorting technique (Gollin et al., 2004). Twenty-three Kichwa people attended this workshop, twelve women and eleven men, ranging from 7 to 71 years old. All of them practiced subsistence fishing, and four of them had helped us during the previous sampling campaign. Six researchers participated in the process: two of them guided the group dynamics, two took notes of the important information during the group discussion and the remaining two recorded the workshop on video and took pictures. A total of 60 color photographs of fish were used, including the photographs taken during the fishing campaigns (24) and additional photographs of other species potentially inhabiting the rivers and tributaries in the area (**Figure 3**). One of the photographs was a species from another biome, *Oncorhynchus mykiss* (Walbaum, 1792), which was included to confirm that the attendees could recognize fish that were not found in the community. Additionally, some books and posters containing a wider set of pictures were used to complement the photographs. In some cases, some additional information about the size of the fish was given by the researchers to facilitate the identification without interfering too much in the process.

During the pile-sorting dynamic (**Figure 3**), all the participants worked as a group selecting the pictures of the fish they could recognize as local. The researchers interceded when trying to give voice to everybody and encouraged the participation and the debate of all the attendees. For each one of the fish, participants would discuss and agree on the local name, the recognizable attributes, the common uses and other relevant biological and practical information (habitat use, reproduction, migration, trophic niche, and fishing techniques). The Kichwa names of the species were written on the front of each picture and the rest of the information was written on the back. While


**FIGURE 3 |** Ethnobiological workshops: **(A)** First workshop: pile sorting; **(B)** First workshop: local fish identification and discussion about their names and information; **(C)** First workshop: grouping fish within their families, including the description of classification criteria and additional information; **(D)** Second workshop: revision and correction of the data collected during the first workshop; **(E)** Third workshop: final revision and validation of the ethobiological and ethnotaxonomical information; **(F)** Public presentation of the results and the poster.

identifying and naming, the first steps of the classification were made simultaneously because the Kichwa would immediately group the fish usually repeating "this fish is from the same family as this one here." Once all the local fish were placed on a wall, a large paper was stuck next to the pictures to be used like a blackboard, where participants grouped the fish, one by one, into each of their families (**Figure 3**). Once all the fish were classified, the common characteristics of each family were discussed and written on the "blackboard." The entire process was easy to follow as all the information was visible, so all participants could check and verify details throughout the process. Finally, the attendees were asked about the importance of fish and rivers in their culture, including spirituality and the human actions that may affect river ecosystems, helping us to better understand their cultural bonds with fish. It also created a forum where all the Kichwas could share and debate their individual perspective and build a collective agreement.

The second workshop was organized on November 17, 2018 (**Figure 3**). The aim of this workshop was to corroborate and validate the information collected and systematized during the first meeting. Six Kichwa participants assisted in this workshop (three men and three women, four of them were present in the first workshop) ranging from 33 to 71 years old. Here, all the names, classification, characteristics, and additional information of every fish were verified using the photograph collage created during the first session, supported by books and a laptop with additional pictures. The attendees worked together and were guided by three researchers that registered the comments and corrections. A fourth researcher video recorded the session.

The third workshop was held April 13, 2019, to present all the available data and allow community members to give their final validation of the information. Eleven Kichwa people assisted this last workshop (one child, one teenager, and nine adults, ranging from 7 to 71 years old, seven men and four women). All of them had participated on the first workshop, while the six participants from the second workshop were also present. Apart from the final review of all the ethnotaxonomic and ethnobiologic information, a poster created for environmental education purposes and to foster public outreach of the research was presented and discussed (**Figure 4**). Once the materials were validated and accepted, the informative posters were printed in Kichwa and Spanish and handed over to the community in a public presentation on November 29, 2019 (**Figure 3**).

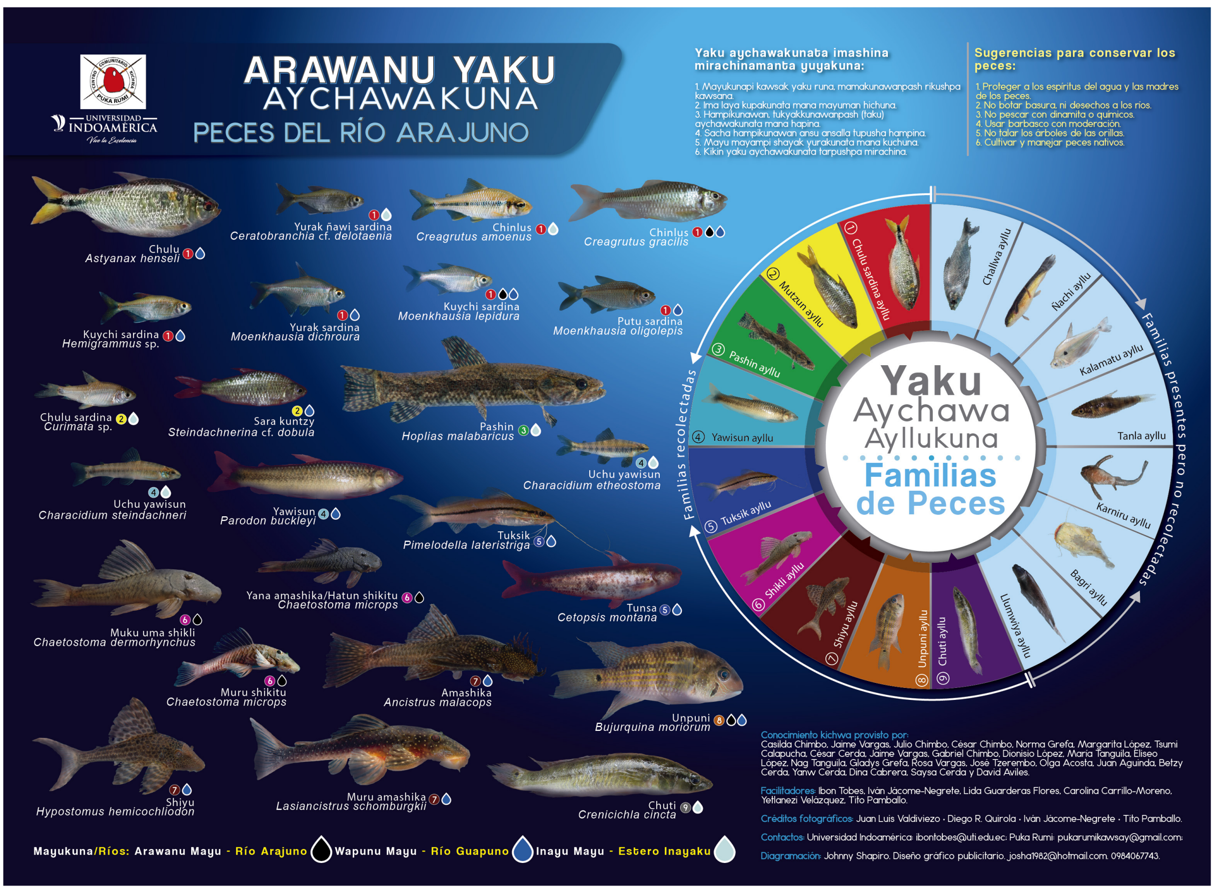



**FIGURE 4 |** Bilingual poster designed with the Kichwa participants. Includes a schematic diagram with the sixteen ethnofamilies, pictures of the 24 fish taxa captured during the field sampling and the recommendations of the Kichwa collaborators for conserving fish and rivers. The poster can be found and downloaded in high resolution from this link: https://figshare.com/articles/figure/Poster_Peces_Arajuno_png/19364306.

# RESULTS

## Participatory Fishing

The Kichwas of Arajuno showed outstanding fishing abilities. They were able to swim and walk in the river even against very strong water currents, they knew the best places for fishing and where they could find each species, and they were very skillful using all the fishing techniques. They were able to free dive for long periods of time, find fish underwater with low visibility and catch them using their bare hands, a machete or the harpoon, and also used hooks and throw nets with expertise. The combination of traditional fishing techniques with electric fishing, the trawl and trammel net, resulted in the collection of 24 Linnaean species, belonging to 19 genera (**Table 1**).

## Ethnoclassification

The participatory fishing and the use of photographs allowed us to record 58 Kichwa species recognized by the participants: 52 of them had Kichwa names, five species had mixed Kichwa-Spanish names (five adding *sardina* and one adding *lisa* to the Kichwa name), and one species was only named in Spanish, *Anguila*, *Electrophorus electricus* (Linnaeus, 1766). All the species were grouped in 16 families, called *ayllu* in Kichwa (*ayllukuna* in plural). From the perspective of the Linnaean taxonomy, 86 taxa were identified and included in 26 families. From those, 17 were identified at the genus level, one was identified as *affinis* and two as *confer* (**Table 1**). This under identification is related to the inability to precisely determine some of the captured fish and with the identification of some taxa during the workshops that were not included in the pile of photographs but could be somehow tracked using the additional books and materials. Considering all the recorded Kichwa names, 57% (33) had monomial names, while the remaining 43% (25) had polynomial names (23 binomial and two trinomial). No participant recognized the "trap species" as local.

To establish the relationship between the Kichwa and Linnaean classification systems we considered the types of correspondence proposed by Berlin (1973) (**Table 1**):

(a) One-to-one correspondence: 35 Kichwa species are related to 35 Linnaean species.
(b) Over-differentiation: three local species were related to one Linnaean species. The Kichwa nomenclature differentiates *Hatun shikitu, Yana shikitu*, and *Muru shikitu* from the Linnaean species complex *Chaetostoma microps* (Günther, 1864).
(c) Type A subdifferentiation: seven Kichwa species correspond to two or more Linnaean species of the same genus, such as *Chuti*, which includes *Crenicichla johanna* (Heckel, 1840), *Crenicichla saxatilis* (Linnaeus, 1758), and *Crenicichla cincta* (Regan, 1905).
(d) Type B subdifferentiation: 14 Kichwa taxa were identified that correspond to two or more Linnaean species of different genus, p. ex. *Uchu yawisun* and its relationship with *Characidium etheostoma* (Cope, 1872), *Characidium steindachneri* (Cope, 1878), and *Nannostomus eques* (Steindachner, 1876).

The sixteen families, or *ayllukuna*, mentioned by the Kichwa were also compared with the families of the Linnaean taxonomy: seven of them had 1:1 equivalence; four ethnofamilies grouped fish from two Linnaean families each with 1:2 equivalence; three Kichwa families had 1:3 equivalence; and two of them had 1:4 equivalence (**Table 2**).

The Kichwa ethnoichthyological classification is multidimensional. The most common classification criteria are morphological attributes, but other biological, ecological and gastronomical characteristics are also considered (**Table 3**). These include: (1) skin and scales (scutes, irregular scales, small scales, medium-sized scales, big scales, bare skin/no scales); (2) fishbones and spines (abundant fishbones, medium presence of fishbones, few fishbones/meaty, spiny); (3) meat quality (greasy and valued, lean and valued, not valued); (4) body shape (oval, elongated, "machete"-like, flat-belly); (5) diet (detritus, fruits, fish, blood, omnivore); (6) salience (upper lip tick, big eyes, strong teeth, parental care).

Morphological features are the most common ways the Kichwa name the local ichthyofauna. This includes: (1) size: *Hatun tiksa* (big *tiksa*), *Hatun shikitu* (big *shikitu*), *Hatun yayu* (big *yayu*); (2) color: *Yana shikitu* (black *shikitu*), *Puka kalamatu* (red *kalamatu*), *Muru amashika* (dotted *amashika*), *Muru shikitu* (dotted *shikitu*), *Kuychi sardina* (rainbow *sardina*), *Yurak ñawi sardina* (white eye *sardina*); (3) related to animals: *Ukucha bagri* (mouse *bagri*), *Manku tanla* (oriole *tanla*); (4) related to plants: *Uchu yawisun* (chili pepper *yawisun*), *Sara kuntzy* (corn *kuntzy*), *Putu sardina* (kapok tree *sardina*); (5) habitat: *Kucha lisa* (lake *lisa*), *Turu yayu* (swamp *yayu*), *Tiur anku* (sand liana); (6) related to tools: *Muku uma shikli* (*muku* head *shikli*; *muku* is the cudgel-like tool used to smash yuca and prepare *aswa*, chicha, a traditional drink).

In addition, this ichthyological classification recognizes the kinship between some *ayllukuna* (families). For example, fish from the *Bagri ayllu* are the parents of the *Tuksik* species, while fish from the *Challwa ayllu* are recognized as the parents of the species of the *Chulu sardina ayllu* and *Mutzun ayllu*. Furthermore, the anaconda, *Eunectes murinus* (Linnaeus, 1758), is the mother of all fish, and the common lancehead (*Bothrops atrox* Linnaeus, 1758), a terrestrial viper, is recognized as the mother of the *Pashin ayllu*.

## Cultural Relevance of Fish

To avoid any interference by the authors in trying to interpret the information related to the cultural relevance of fish for the Kichwa including the uses, prescriptions and advice, the comments recorded during the workshops were literally transcribed and translated and are cited in quotation marks bellow.

From the 58 Kichwa taxa, 38 are valued for consumption while the two species of the *Karniru* family, the *Amarun chuchu* (nipple snake), *Bunocephalus coracoideus* (Cope, 1874), and *Karniru, Vandellia* spp., are not accepted as food. No use was registered for the remaining 18 taxa. Three of the fish "are only eaten when there is nothing else": the *Pashin, Hoplias malabaricus* (Bloch, 1794), because "it's meat is sweet and with abundant fishbones," while the *Ñachi*, *Erythrinus erythrinus* (Bloch and Schneider, 1801) and the *Willi*, *Hoplerythrinus unitaeniatus* (Spix

**TABLE 1 |** Names and classification of Kichwa ethnofamilies, ethnogenera, and ethnospecies, compared to Linnaean families and species.

| Ethnofamily | Ethnogenus | Ethnospecies | Linnaean species | Linnaean family |
|---|---|---|---|---|
| Bagri ayllu | Bagri | Kumal Bagri | *Brachyplatystoma juruense* | Pimelodidae |
| | | | *Zungaro zungaro* | |
| | | Ukucha Bagri | *Brachyplatystoma tigrinum* | |
| | Pintarillu | Pintarillu* | *Pseudoplatystoma punctifer* | |
| | | | *Pseudoplatystoma tigrinum* | |
| Tuksik ayllu | | Kumparama | *Pimelodus blochii* | |
| | | Muta | *Calophysus macropterus* | |
| | | Tumsa | *Cetopsis oliveirai* | Cetopsidae |
| | | | ***Cetopsis montana*** | |
| | | Lunkutsu | *Rhamdia quelen* | Heptapteridae |
| | | Tuksik | ***Pimelodella lateristriga*** | |
| Challwa ayllu | | Hantya | *Brycon spp.* | Bryconidae |
| | | Shankatima | *Brycon melanopterus* | |
| | | | *Brycon amazonicus* | |
| | | Wal | *Salminus brasiliensis* | |
| | Challwa | Pita Challwa | *Rhaphiodon vulpinus* | Cynodontidae |
| | | Challwa | *Prochilodus nigricans* | Prochilodontidae |
| Mutzun ayllu | | Mutzun | ***Curimata spp.*** | Curimatidae |
| | | | *Cyphocharax spiluropsis* | |
| | | | *Steindachnerina argentea* | |
| | | | *Curimatella alburna* | |
| | Kuntzy | Sara Kuntzy | ***Steindachnerina* cf. *dobula*** | |
| | | | *Steindachnerina bimaculata* | |
| Chulu sardina ayllu | Sardina | Kuychi sardina | *Triportheus spp.* | Triportheidae |
| | | | ***Hemigrammus spp.*** | Characidae |
| | | | ***Moenkhausia lepidura*** | |
| | | | *Paragoniates alburnus* | |
| | | Putu sardina | ***Moenkhausia oligolepis*** | |
| | | | *Astyanax bimaculatus* | |
| | | Yurak sardina | ***Moenkhausia dichroura*** | |
| | | Yurak ñawi sardina | ***Ceratobranchia* cf. *delotaenia*** | |
| | Chinlus | Chinlus* | ***Creagrutus amoenus*** | |
| | | | ***Creagrutus gracilis*** | |
| | Chulu | Chulu* | ***Astyanax henseli*** | |
| | | Sichi | *Hyphessobrycon spp.* | |
| | | | *Bryconamericus spp.* | |
| | | Tawaki | *Astyanax spp.* | |
| Kalamatu ayllu | Tiksa | Hatun tiksa | *Charax gibbosus* | |
| | | Tiksa | *Roeboides myersii* | |
| | Kalamatu | Puka kalamatu | *Charax caudimaculatus* | |
| | | Kalamatu | *Ctenobrycon hauxwellianus* | |
| | Pirruru | Pirruru* | *Tetragonopterus argenteus* | |
| | | | *Thoracocharax spp.* | Gasteropelecidae |
| | | | *Gasteropelecus spp.* | |
| | | Sinkuana | *Acestrorhynchus lacustris* | Acestrorhynchidae |
| | | Tsakama | *Plagioscion squamosissimus* | Sciaenidae |
| Chuti ayllu | Chuti | Chuti* | ***Crenicichla cincta*** | Cichlidae |
| | | | *Crenicichla johanna* | |
| | | | *Crenicichla saxatilis* | |
| Unpuni ayllu | Unpuni | Unpuni* | *Bujurquina moriorum* | |
| | | | *Oreochromis mossambicus* | |
| | | | *Apistogramma spp. 1* | |
| | Uputasa | Uputasa* | *Apistogramma spp. 2* | |
| | | | *Cichlasoma spp.* | |
| | | | ***Aequidens tetramerus*** | |

*(Continued)*

**TABLE 1 |** (Continued)

| Ethnofamily | Ethnogenus | Ethnospecies | Linnaean species | Linnaean family |
|---|---|---|---|---|
| Karniru ayllu | | Amarun chuchu | *Bunocephalus coracoideus* | Aspredinidae |
| | Karniru | Karniru | *Vandellia spp.* | Trichomycteridae |
| Llumwiya ayllu | Llumwiya | Llumwiya* | *Sternarchorhynchus curvirostris* | Apteronotidae |
| | | | *Apteronotus albifrons* | |
| | | Anguila | *Electrophorus electricus* | Gymnotidae |
| | Yayu | Turu yayu | *Gymnotus carapo* | |
| | | Hatun yayu | *Eigenmannia virescens* | Sternopygidae |
| | | Tiur anku | *Synbranchus marmoratus* | Synbranchidae |
| Yawisun ayllu | Yawisun | Yawisun | ***Parodon buckleyi*** | Parodontidae |
| | | | *Parodon pongoensis* | |
| | | Uchu yawisun | ***Characidium steindachneri*** | Crenuchidae |
| | | | ***Characidium etheostoma*** | |
| | | | *Nannostomus eques* | Lebiasinidae |
| Ñachi ayllu | | Ñachi | *Lebiasina erythrinoides* | |
| | | | *Erythrinus erythrinus* | Erythrinidae |
| | | Willi | *Hoplerythrinus unitaeniatus* | |
| Pashin ayllu | Pashin | Pashin | ***Hoplias malabaricus*** | |
| | | Rayu Pashin | *Rivulus spp.* | Rivulidae |
| Shikli ayllu | Shikli | Muku uma shikli | ***Chaetostoma dermorhynchus*** | Loricariidae |
| | Shikitu | Muru shikitu | ***Lipopterichthys carrioni*** | |
| | | | ***Chaetostoma microps*** | |
| | | Yana shikitu | | |
| | | Hatun shikitu | | |
| Shiyu ayllu | Amashika | Amashika | ***Ancistrus malacops*** | |
| | | | *Panaque spp.* | |
| | | Muru amashika | ***Lasiancistrus schomburgkii*** | |
| | Shiyu | Makana shiyu | *Loricaria spp.* | |
| | | Pinduk shiyu | *Farlowella platorynchus* | |
| | | | *Rineloricaria spp.* | |
| | | Shiyu | ***Hypostomus hemicochliodon*** | |
| Tanla ayllu | Lisa | Kucha lisa | *Schizodon fasciatus* | Anostomidae |
| | Tanla | Manku tanla | *Leporinus* aff. *fasciatus* | |
| | | Tanla | *Leporinus friderici* | |

*Names in bold indicate the species captured during the sampling campaign.*
*The asterisk indicates the ethnogenera whose ethnospecies couldn't be identified.*

and Agassiz, 1829), "are not recommended for children or people with delicate skin, because their consumption can produce irritation and rash." On the other hand, *Yawisun*, *Parodon buckleyi* (Boulenger, 1887) and *Parodon pongoensis* (Allen, 1942), are their favorite fish to eat, prepared as a traditional dish, the *maytu*, cooked wrapped with *bijao* leaves (*Calathea lutea*). Two other species need a special preparation before being eaten: the *Yana shikitu*, *Chaetostoma microps*, "has to be cooked wrapped in banana leaves to make the meat soft and edible," and the *Pita challwa*, *Rhaphiodon vulpinus* (Spix and Agassiz, 1829), "although its meat is the most appetizing, eating it during childhood can cause the hair to go gray, and to avoid that, one of the bones has to be braided in the hair of the person after eating it." Other fish have some prescriptions, like the *Tumsa*, fish from the *Cetopsis* genus, considered "blind fishes" due to their reduced eyes. Although they are valued and commonly eaten by adults, "they are not used to feed children because, as the fish have small eyes, they can cause blindness." Other prescriptions indicate that "women shouldn't eat fish while menstruating because it can cause cramping and increased bleeding, and neither should they after giving birth." It is also believed that "children and young people shouldn't be fed fish eggs, as their consumption can make them grow weaker." The participants mentioned that "this last rule is no longer respected, and it is causing more vulnerability among the youth."

## Fish and Health

The Kichwa consider some fish potentially dangerous for people. We identified two species that can be harmful: the *Tuksik*, *Pimelodella lateristriga* (Lichtenstein, 1823), "whose spines can cause serious poisoning," and the *Karniru*, *Vandellia* spp., believed to be "a human parasite that can enter the organism through corporal orifices (anus, penis, and vagina)." We also recorded some medicinal uses of fish like ingesting the intestine contents of the *Yana shikitu, Chaetostoma microps,* to treat

**TABLE 2 |** Correspondence between Kichwa ethnofamilies and Linnaean families, including the number of Linnaean species considered.

| Ayllu | Linnaean family | N° Linnaean species | Correspondence |
|---|---|---|---|
| Tanla | Anostomidae | 3 | 1:1 |
| Chuti | Cichlidae | 3 | |
| Unpuni | Cichlidae | 6 | |
| Mutzun | Curimatidae | 6 | |
| Shikli | Loricariidae | 3 | |
| Shiyu | Loricariidae | 7 | |
| Bagri | Pimelodidae | 5 | |
| Karniru | Trichomycteridae | 1 | 1:2 |
| | Aspredinidae | 1 | |
| Chulu sardina | Characidae | 13 | |
| | Triportheidae | 1 | |
| Ñachi | Erythrinidae | 2 | |
| | Lebiasinidae | 1 | |
| Pashin | Erythrinidae | 1 | |
| | Rivulidae | 1 | |
| Challwa | Bryconidae | 4 | 1:3 |
| | Cynodontidae | 1 | |
| | Prochilodontidae | 1 | |
| Tuksik | Cetopsidae | 2 | |
| | Heptapteridae | 2 | |
| | Pimelodidae | 2 | |
| Yawisun | Crenuchidae | 2 | |
| | Lebiasinidae | 1 | |
| | Parodontidae | 2 | |
| Kalamatu | Acestrorhynchidae | 1 | 1:4 |
| | Characidae | 5 | |
| | Gasteropelecidae | 2 | |
| | Sciaenidae | 1 | |
| Llumwiya | Apteronotidae | 2 | |
| | Gymnotidae | 2 | |
| | Sternopygidae | 1 | |
| | Synbranchidae | 1 | |
| **16** | **32** | **86** | **Total** |

diabetes. The *Tiur anku*, *Synbranchus marmoratus* (Bloch, 1795), is a "fish that has a slippery skin, and that characteristic, after been eaten, helps pregnant women to lubricate and facilitate labor." This species also has a medicinal-ritual use by men and "as it is a slippery fish, it is consumed before fighting to become more elusive." Fish of the *Unpuni* family (Cichlidae) like the *Unpuni*, *Aequidens tetramerus* (Heckel, 1840), *Chuti*, *Crenicichla saxatilis* and *Chinlus, Creagrutus gracilis* (Vari and Harold, 2001) "are used for *sasi* (a ritual and healthcare diet) due to their low-fat content."

### Spirituality

Fish and rivers have an important spiritual relevance for the Kichwa in Arajuno. In their worldview, "the rivers are inhabited and guarded by *Tzumi* (men of the water) and they are the fathers of the water." "Fish are protected and guided by *Amarun*, the anaconda, mother of all fish." The *Atakapi*, a giant stingray, is also believed to inhabit the rivers of Arajuno and "if cut by half or on the side, it releases human souls." Waterfalls, *pakcha*, and salt licks, *kachikuna*, are considered sacred places. Shamans are recognized as *Yachak*, wise persons with material, ancestral and spiritual knowledge: "they have the power to heal or to harm, and they can cast a barrier, a *nina amarun* (fire snake), to block fish migration upstream."

Every year fish migrate upstream through *Puka Rumi* to the headwaters of the Arajuno River. This migration, the *mijanada* or *mijanu*, is believed to be led by *Amarun*: "when the snake goes up the river carrying all the fish it is dangerous to enter the water." "The snake guides fish grouped in order: the small ones go first, followed by the medium ones and the largest ones last. *Amarun* leaves them spread along the lagoons connected to the main river, so they can lay their eggs in a safe environment."

Ritual uses of fish were registered for the *Karniru* (*Vandellia* spp.), "used by shamans to threaten or harm people." The *Anguila* (*Electrophorus electricus*), electric eel, "can be used to increase the strength of a fighter by sticking a needle in its lateral line." It can also be used for pest control "burying the skin of its head around palm trees to shoo away the animals that eat their fruits." Morevover, "to fish and cook the *Anguila* the Kichwa must previously undergo a fasting."

### Threats to Fish Conservation

The participants mentioned that during the last 30 years the fish population has significantly decreased and many of the species are gone, like the *Turu yayu, Gymnotus carapo* (Linnaeus, 1758) or *Hatun yayu*, *Eigenmannia virescens* (Valenciennes, 1836). Other fish were mentioned as locally extinct such as the *Tururu*, *Kinti yayu*, *Sara challwa*, and *Hantya*, but they couldn't be identified properly because they were not among the pile of photographs. These observations about the loss of fish species came spontaneously, while identifying the fish, illustrating that the participants are worried about the degradation of rivers and disappearance of certain fish species. The Kichwa believe "the spirits have taken these species elsewhere because the rivers and fish have been abused, fishing rules from the ancestors are no longer respected and many harmful and unruly activities are carried out, like overfishing, or the use of aggressive techniques (dynamite, chemical products, gillnets, diver goggles)." Over cultivation of tilapia was also mentioned as an increasing threat to local fish. The Kichwa feel somehow overwhelmed with the intensity of these new environmental issues related to the accelerated arrival of foreign people, but they lack any technical assistance from the local or national government to properly face them.

## Dissemination of the Results

To present the results of this research within the community and to promote biocultural conservation and environmental education, a bilingual poster (Kichwa-Spanish) was created and delivered to the people in Arajuno (**Figure 4**). It includes the sixteen *ayllukuna* and the 24 fish we could capture and photograph with their Kichwa and Linnean names. The local inhabitants also asked to include some basic norms to foster fish conservation. These are: (1) protect water spirits and the mothers of the fish, (2) don't pollute or throw garbage in the rivers, (3)

**TABLE 3 |** Classification criteria for the sixteen ethnofamilies.

| Ayllu | (1) Skin and scales | (2) Fishbones and spines | (3) Meat quality | (4) Body shape | (5) Diet | (6) Salience |
|---|---|---|---|---|---|---|
| Chulu sardina | Small and thin scales | Abundant and soft fishbones that can be eaten without problems | Greasy and very tasty meat. Cooked in "maytu" | Small size and diverse body shapes | Feed on any kind of food | - |
| Challwa | Medium-sized scales, soft to be taken out | Less fishbones than Chulu sardina ayllu. Adults have less spines | Very greasy meat, very tasty. Highly valued food | Diverse body shapes. Big and medium-sized fish | Feed on mud, algae and some of them on fruits and flowers | Fathers of Chulu sardina ayllu and Mutzun ayllu |
| Mutzun | Small and thin scales. Soft and easy to be taken out, forming bulks | Spinny | Valued and lean meat | Elongated body shape and diverse size, from small to medium | Feed on mud and lick rocks and clay walls | Can't be fished with hooks. Children of Challwa ayllu |
| Kalamatu | Small and delicate scales, generally silver colored. Hard fins. Kind of slimy. | Few fishbones | - | Oval-puffy shape. Some species are transparent | - | Strong and sharp teeth. Bad and slow swimmers |
| Tanla | Thick, big and hard scales | Spiny | Good and greasy meat | Elongated body shape | Feed on fruits | Upper lip thick with a greasy layer |
| Ñachi | Medium-sized scales | Spiny | Not valued meat. It can be harmful to people with delicate skin | Small sized | Gluttonous. Feed on any kind of food | Watery consistency |
| Pashin | - | Abundant fishbones | Sweet meat, not valued, only eaten when there is no other fish | Elongated body shape | - | Strong teeth |
| Yawisun | Hard scales | Abundant fishbones | - | Elongated body shape. Small size | Feed on mud | Fast swimmers. Only found in high current water |
| Tuksik | No scales. Slimy skin | Medium presence of fishbones, with strong, hard and dangerous spines in dorsal and pectoral fins | Valued and tasty meat | Small size | - | They can prick and cause hospitalization. They are children of Bagri ayllu |
| Bagri | No scales or small scales. Slimy skin | Few fishbones | Highly valued meat | Big size | - | Fathers of Tuksi ayllu |
| Llumwiya | Very thin and small scales | Abundant fishbones | Greasy and good for preparing "maytu" | Elongated with machete shape | - | - |
| Karniru | - | - | Not consumed | Elongated and thin like a spear. Hook-like fins with spines | Feed sucking blood | Parasites. They can enter corporal orifices in humans |
| Shikli | Scutes all along the body | Meaty. They have more meat than Shiyu ayllu | - | Small and thick | Feed on mud | - |
| Shiyu | Thicker scutes covering all the body | Less meat than Shikli ayllu | - | Elongated. Bigger than Shikli ayllu | Feed on mud | They live in wall holes, rocks and submerged trunks |
| Unpuni | Irregular scales | Abundant fishbones | Valued and lean meat, useful for "sasi" (diet) | Small and medium size | - | They have big eyes |
| Chuti | - | Less fishbones than Upunti ayllu | Very valued meat, especially for "sasi" (diet) | Elongated. Big and medium size | - | - |

don't fish with dynamite or chemicals, (4) use *barbasco* (*cubé* resin) moderately, (5) use native fish for aquaculture.

## DISCUSSION

### Strengths and Limitations of the Methods

The greatest strength of our research comes from the origin of the proposal: we were directly asked for help and were invited to work with the community. This starting point facilitated many of the previous steps that ethnobiological research needs to solve, like: making personal connections before entering the community, gaining the trust of the local inhabitants, agreeing to terms of the collaboration with the community and obtaining previous informed consent (Argueta et al., 2018; Medinaceli, 2018). The long and successful experience of some of the authors working in the Amazon with other Kichwa people (Jácome-Negrete, 2012, 2013, 2021; Valdiviezo-Rivera et al., 2012; Jácome-Negrete and Guarderas-Flores, 2015; Carrillo-Moreno, 2017) was the best way to gain the confidence of the community and facilitate the research process, thanks to the familiarity with the Kichwa culture. Investing time and effort to design the research in a collaborative way and listening to the advice and requirements of the participants, reinforced the trust and the involvement of the Kichwa community. Furthermore, the group dynamics created a forum that allowed the participants to share experiences and knowledge with people of different gender and ages, learn from each other, reinforce community bonds, discuss and identify their community needs and think about the best ways to meet them (Sieber et al., 2014).

Nevertheless, considering the number of participants (23 people in the first and most relevant workshop) and that most of them were from the *Puka Rumi* community, our sampling population was limited. Furthermore, although our results are solid thanks to the repeated review and correction process carried out with the participants, they should be expanded and complemented through replication of the research among other groups from the Community Organization of the Kichwa of Arajuno.

On the other hand, this participatory approach was also useful and enriching during the fish sampling (Previero et al., 2013). Working with fishermen and women, and the combination of scientific and artisanal techniques was essential to inventory ichthyological species in the area (Tobes et al., 2021). Particularly the free diving in rivers with high flow or deep pools was very useful as these conditions made those habitats poorly accessible with electric fishing, the trawl and trammel. This technique was especially effective to catch fish from the *Loricariidae* family, usually found attached to submerged wood, rocks or hidden in holes (Lujan et al., 2011). In addition, the Kichwa knowledge of the fish diet and ecology allows them to choose the best bait (usually other smaller fish or eggs) and choosing the best fishing grounds (Rebelo et al., 2010). Such is the case with members of the *Shikli* family (*Chaetostoma* genus), whose eggs are used for fishing of Characids. The detailed knowledge that fishermen have about the feeding habits and habitats was crucial to optimize sampling time, effort and costs while doing field sampling (Ramires et al., 2015). However, if we consider that we only collected 24 Linnaean species from the 86 fish identified using photographs, in an area were ichthyofauna is highly diverse and poorly known (Tobes et al., 2016, 2021), we believe that more fishing surveys are necessary to disclose the complete fish community.

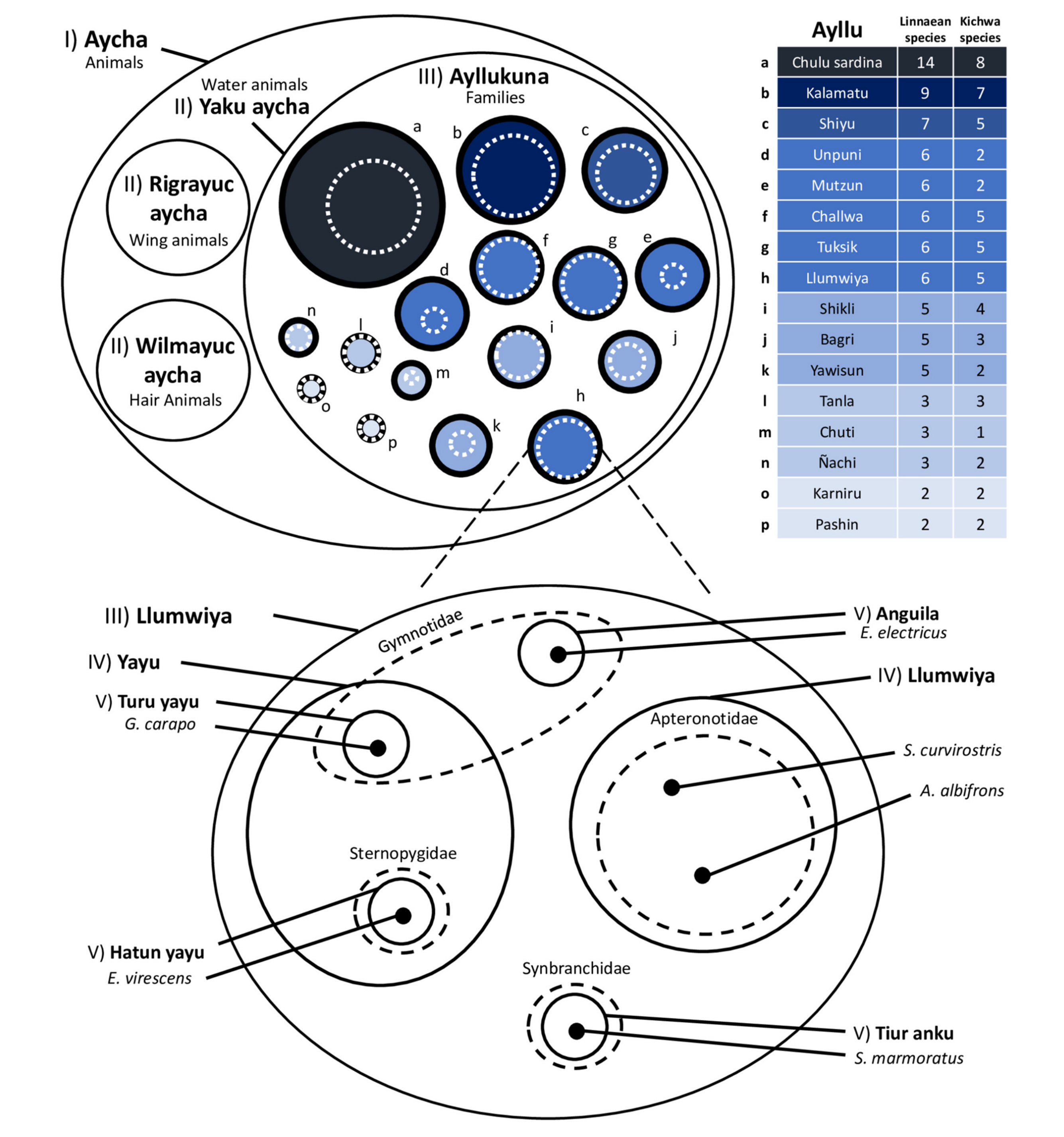
Despite of the good results we obtained with the pile sorting workshops, we consider that the use of photographs for fish identification may be a good cost-effective alternative, but it is not as precise as having the fish alive and available for the participants to observe, name and classify (Lahe-Deklin and Si, 2014). Accordingly, we recommend the use of this *ex situ* methodology for making a first approach to the ethnoclassification and ethnobiological knowledge, especially in very biodiverse areas, where capturing all the local species requires huge sampling efforts (Mourão and Nordi, 2002; Jácome-Negrete, 2013). As no western ichthyologist would guarantee the correct identification of many fish species only using a single photograph without a detailed analysis of a voucher specimen, neither do the Kichwas. If we consider the multidimensional classification system they have, involving sight, taste, and touch, it is essential to offer them the complete sensorial experience and the possibility for a detailed observation of the distinctive characters that support their identification and classification system (Jácome-Negrete, 2021).

## A Proposal of Taxonomic Categories

Berlin (1973) helped us to understand how humans perceive and classify nature through the discovery that some patterns are shared by many cultures worldwide. Those folk classification systems were the starting point and inspiration for the Linnaean system, and therefore, the concordances between both are common (Jácome-Negrete and Guarderas-Flores, 2015). Following that tendency, we found high levels of correspondence between the classification system of the Kichwa in Arajuno and the Linnaean classification. In general, the hierarchical levels of classification resemble those mentioned by other ethnoichthyological studies for other fishing cultures (Mourão and Nordi, 2002; Pinto et al., 2013, 2018; Mourão and Barbosa Filho, 2018) and specifically other classification systems reported for Kichwa communities in the Ecuadorian Amazon (Jácome-Negrete, 2012, 2013; Jácome-Negrete and Guarderas-Flores, 2015). Although the main goal of our research was to record the Kichwa classification system from their point of view, without interpretation or inference, returning it to them without any cultural meddling, we'll analyze and conceptualize it here from the perspective of western science in light of the theories and proposals of other academics.

Considering the information collected during the workshops and following the Berlinian hierarchy (Berlin, 2014), we identified five taxonomic categories (**Figure 5**). The superior category, the (I) Unique beginner, was *Aycha*, corresponding to the Animalia kingdom. *Aycha,* is subdivided into three subordinate groups of (II) life forms: *Yaku aycha* (water animals) = Pisces superclass; *Rigrayuc aycha* (wing animals) = Aves class; *Wilmayuc aycha* (hair animals) = Mammalia class (Jácome-Negrete, 2021). The Kichwa consider the entire fish superclass in the same life-form category, unlike other fishing communities that also consider turtles, crustaceans, mollusks, dolphins, whales, and anacondas as fish and group them together (Marques, 1991; Clément, 1995; Paz and Begossi, 1996; Costa-Neto and Marques, 2000; Pinto et al., 2013; Mourão and Barbosa Filho, 2018). This separation of fish and other aquatic animals has been recorded for other Amazonian cultures like the Aguaruna and Huambisa people (in Peru), who don't consider dolphins fish (Berlin and Berlin, 1983) and neither do other Kichwa communities in the Ecuadorian Amazon (Jácome-Negrete, 2012, 2013; Jácome-Negrete and Guarderas-Flores, 2015). We hypothesize that this could be related to the preeminence of the morphology in Kichwa classification, as having fish-shape and fins are essential criteria which exclude invertebrates and reptiles, combined with the presence of gills and the ability to breathe underwater, dismissing aquatic mammals. Nonetheless, we don't have enough evidence to prove this perception and further research should be done to understand the basis of this classification system.

Within (II) *Yaku aycha*, we identified a third taxonomic level composed of 16 subordinate groups (**Figure 5**). Given that all of them comprise numerous sub-taxa, following the




| | Ayllu | Linnaean species | Kichwa species |
|---|---|---|---|
| a | Chulu sardina | 14 | 8 |
| b | Kalamatu | 9 | 7 |
| c | Shiyu | 7 | 5 |
| d | Unpuni | 6 | 2 |
| e | Mutzun | 6 | 2 |
| f | Challwa | 6 | 5 |
| g | Tuksik | 6 | 5 |
| h | Llumwiya | 6 | 5 |
| i | Shikli | 5 | 4 |
| j | Bagri | 5 | 3 |
| k | Yawisun | 5 | 2 |
| l | Tanla | 3 | 3 |
| m | Chuti | 3 | 1 |
| n | Ñachi | 3 | 2 |
| o | Karniru | 2 | 2 |
| p | Pashin | 2 | 2 |

**FIGURE 5 |** Schematic representation of the proposed hierarchical categories, detailed for the Llumwiya ethnofamily. On the upper area of the diagram white-dotted circles are proportional to number of ethnofamilies, and the continuous black line to Linnaean families. On the bottom, for the Llumwiya ayllu, circles with dotted lines encompass Linnaean families, while continuous lines are used for the Kichwa categories.

basis of the Berlinian classification system, other research carried out with the Ecuadorian Kichwa considered this level as an intermediate (Jácome-Negrete and Guarderas-Flores, 2015). However, in light of the diversity and the high subordinate complexity of this third level, following the ideas of Jensen (1985) and Jácome-Negrete (2012), due to the high correspondence with the Linnaean families (**Table 2**), and considering that the Kichwa name for this category is *ayllu*, family, we reconsider the groups on this level as (III) Ethnofamilies (**Table 1**). The ethnofamily level has also been proposed by other authors

(Costa-Neto and Marques, 2000; Montenegro, 2001; Ferreira et al., 2009) and our results support this equivalence between Kichwa ethnofamilies and Linnaean families (**Table 2**). All the ethnofamilies except one (*Chulu sardina*) have primary and simple names. The fish among each *ayllu* are separated from the species in other groups and share morphological, ecological, and cultural criteria. The ethnofamilies are appointed after the most outstanding fish of the group, usually the biggest or the most conspicuous, and are named adding the word *ayllu* to the name of the prototypical species. This name composition helps to avoid the polysemy between the ethnofamily and ethnogenus (Mourão and Barbosa Filho, 2018).

Comprising the ethnofamilies, we found 58 names related to 86 Linnaean species. Considering that many of those names were polynomial (25%) and that some of those compound names shared lexemes, these facts point out underlying categories (Mourão and Nordi, 2002). Therefore, we propose a fourth hierarchical level to be the (IV) Ethnogenus, following the ideas of Jensen (1985). We easily identified the ethnogenus among the polytypic groups like in the case of *Yayu* (**Figure 5**), subdivided in two inferior productive taxa: *Turu yayu and Hatun yayu* (Mourão and Barbosa Filho, 2018). Considering this subdifferentiation of the *Yayu* ethnogenus in two subordinate taxa, a fifth rank of classification comes to light, the (V) Ethnospecies. This category is easily identified looking at the twelve polytypic ethnogenera (*Bagri, Sardina, Challwa, Tiksa, Kalamatu, Yayu, Yawisun, Pashin, Shikitu, Amashika, Shiyu*, and *Tanla*) (**Table 2**). On the other hand, we found that some simple primary names were used for some ethnospecies and that they had no ethnogenus. We hypothesize that this may be the case of those fish species with salience due to some biological or cultural characteristics such as *Sinkuana, Tsakama, Anguila, Ñachi*, or *Willi*, or related with genera with few different species (Mourão and Nordi, 2002).

However, to shed some light to the complex ethnogeneric and ethnospecific categories we recalled previous research carried out by the authors with other Kichwa people on lowland Amazon, close to the Peruvian border, in isolated communities with more pristine and deep knowledge (Jácome-Negrete, 2012; Jácome-Negrete and Guarderas-Flores, 2015). This familiarity with the Kichwa ethnoclassification helped us identify some extra ethnogenera during the workshops. This is the case of *Pintarillu, Chinlus, Chulu, Pirruru, Chuti, Unpuni, Uputasa*, and *Llumwiya* (**Table 1**). Although they could be easily considered as monotypic groups and classified as ethnospecies (like the examples mentioned before), we realized that the participants didn't mention any specific name among these groups because they couldn't identify any of them with the pictures on hand, or because they may have lost the knowledge to subdivide fish ethnogenuses and precisely identify some of the underlying species.

Summing up, among the Kichwa ethnogenera, 50% (12) of them were monotypic while the other 50% (12) were polytypic. Nevertheless, as said before, eight of these monotypic ethnogenera were highlighted (marked with asterisc in **Table 1**) because they have more species besides the prototypical, the only ones we could record. This result contrasts with the statements of Berlin (1992), that expected more monotypic generics than polytypic, 80 and 20%, respectively, and also disagrees with the reports of other numerous ethnoichthyological research compiled by Mourão and Barbosa Filho (2018), with polytypic ethogenera ranging from 13 to 25%. The use of the ethnogeneric category has proven to be common and widely use by the Kichwa in Arajuno, which indicates a deep and intricated knowledge and taxonomic precision compared to other fishing communities.

## Correspondence, Sub-Differentiation and Over-Differentiation

Contrasting the Kichwa and Linnaean systems, one-to-one correspondence between species reached up to 41%. We identified seven cases of A sub-differentiation (17% of the Linnaean taxa) and 14 cases of B subdifferentiation (40% of the Linnaean taxa), which highlights the existing differences in taxa recognition between the two classification systems, although both perspectives can create synergies when discussed and contrasted, finally enriching the ichthyological knowledge (Pereyra et al., 2021). Pinto et al. (2013) explain that this over-differentiation in local classifications generally occurs with organisms that are culturally important and highlights the awareness and sensibility that deep-rooted cultures have in recognizing subtle attributes in their environment as described later. This is the case of three of the ethnospecies of the *Shikitu* ethnogenus, *Muru shikitu*, *Hatun shikitu*, and *Yana shikitu*. They are separately identified by the Kichwa, while for the Linnaean taxonomist they comprise the *Chaetostoma microps* species complex, a group of potentially different species that are still undefined. The distinct characteristics named by the Kichwa were: "*Muru shikitu* shows the dotted pattern in the frontal area, a more meaty maxilla and tastier meat; *Hatun shikitu* is bigger and taller than the others, without the dotted pattern in the frontal area and with reddish fins; *Yana shikitu* has a darker color, the meat is harder and dryer, the maxilla is smaller, it is not as meaty, the scutes are harder and it is rarer in the surroundings of Arajuno." This information could probably shed some light onto the identification problems experienced by Linnaean scientists and help us fill the gap of the taxonomic impediment of freshwater fish in the Neotropics (Benone et al., 2020). This fact evidences the importance of considering local knowledge and the accumulated experience of Indigenous people to enrich ichthyological inventories (Ramires et al., 2015; Aigo and Ladio, 2016).

## Multidimensional Classification and Idealistic and Utilitarian Approaches

The Kichwa ichthyological classification is built with multidimensional features, a concept proposed by Santos-Fita and Costa-Neto (2009). Besides morphological features (skin and scales, fishbones and spines, body shape) they also consider ecological criteria such as diet, habitat, and parental care, the quality of meat and whether fish are harmful or beneficial to health. This diversity of morphological, ecological, utilitarian, and relational characteristics recognized by the Kichwa in Arajuno coincides with what other authors have identified in other areas where fishing is an activity of great cultural importance (Begossi and Garavello, 1990; Marques, 1991; Mourão and Nordi, 2002; Jácome-Negrete, 2012; Pinto et al., 2013; Aigo and Ladio, 2016; Castro et al., 2016; Pinto et al., 2016; Castillo et al., 2018; Mourão and Barbosa Filho, 2018; Jimbo-Campoverde, 2019).

Fishermen identify and classify principally those species they eat (Jácome-Negrete, 2012, 2013; Jácome-Negrete and Guarderas-Flores, 2015). In this sense, Mourão and Barbosa Filho (2018) say that naming and classifying the species has a close relation with those organisms that have greater cultural relevance. While Mourão and Nordi (2002) reported that even though some fish were named, they were not included in the classification system. This is not the case for the Kichwa of Arajuno where 31% of the identified ethnospecies (18 out of 58) were named and classified, but they had no use reported. Furthermore, biological and ecological information was registered for 14 of those fish with no use. *Kuychi sardina*, *Yurak ñawi sardina*, *Sichi*, and *Tawaki*, part of the *Chulu sardina ayllu*, had no use but showed some cultural relevance as they were mentioned to be the "sons" of the *Challwa ayllu*. Something similar was also reported with the Aguaruna and Huambisa communities in Peru, where fish species showing similarities were considered "relatives" and called "brothers" or "members" of the same family (Berlin and Berlin, 1983). However, this kinship reported by the Kichwa was among fish of different families.

We didn't record any information beyond the names and families of four of the unused fish, which included: *Puka kalamatu*, *Charax caudimaculatus* (Lucena, 1987); *Hatun yayu, Eigenmannia virescens* (Valenciennes, 1836); *Rayu pashin*, *Rivulus* spp.; *Makana shiyu*, *Loricaria* spp. In light of these results, it seems that the Kichwa name fish for the sake of knowing and classifying them, sometimes even without a utilitarian reason, complementing their categorization using criteria from a practical point of view (benefits or danger). This may indicate a primarily idealistic approach to naming nature supported by the utilitarian perspective, while showing the coexistence of both classification systems as proposed by Boster and Johnson (1989).

## Biocultural Heritage and Conservation Challenges

The cohabitation and coevolution of the Kichwa of Arajuno with fish and rivers is the source of integrated perceptions and understandings of theses hydro-social ecosystems (Jácome-Negrete, 2013; Carrillo-Moreno, 2017). Through oral narratives, knowledge about ecology and the interrelationships between people, aquatic beings, spirits, rivers, and fish, is transmitted to the younger generations. Some glimpses of the Kichwa worldview came to light during the workshops. For example, *Amarun*, the big snake mother of all fish, is related to other similar and well-known myths involving fish, snakes and rivers registered for many Indigenous groups. This is the case of the myth of LIK, a huge snake full of fish, described by many cultures in remote regions in South America, some separated by centuries, and used by Claude Levi-Strauss to reveal the correspondences between distant cultures and highlight their strong bond to rivers and all their non-human inhabitants (Levi-Strauss et al., 1963). This fact highlights the deep-rooted and ancestral origin of the Kichwa culture.

Fishing enables the transmission of biological and ecological knowledge to new generations, such as the recognition, naming and classification of species, the use of ichthyofauna, the diversity of habitats in which they are found and appropriate fishing techniques (Silvano et al., 2006; Jácome-Negrete, 2013; Santos and Alves, 2016; Castillo et al., 2018; Pinto et al., 2018). Therefore, fishing activities of the Kichwa in Arajuno were an excellent ethnobiological approach to identify the broad ecological and cultural knowledge around the ichthyofauna and the importance that these animals and rivers have for the identity of this human group. However, all the ethnoichthyological knowledge, the cultural and identity relevance of fish, and the spiritual relationship that the Kichwa of Arajuno have with them are threatened by the accelerated cultural changes experienced during the past decades. Hence the urgency of getting involved in initiatives that revitalize and revalue local knowledge of biodiversity for future biocultural conservation.

In conclusion, although Arajuno has been heavily intervened by market dynamics and a non-adapted education system that does not consider local knowledge, the Kichwa maintain their knowledge and bonds to aquatic ecosystems and fish, and are aware of the value of this knowledge, the threats that they face and want to take action to tackle them. The ethnotaxonomical knowledge of the Kichwa has proven to be acute and reliable. It may be a useful tool to help with the taxonomic impediments the Linnaean classification is facing in trying to identify and classify Amazon fish (Carvalho et al., 2018). It could also help to strengthen conservation efforts owing to the correct identification and listing of the existing species, and unveil a great number of unknown species for the academic community. Moreover, the participatory work facilitated the identification of the threats for fish and rivers, related to harmful activities. In response to this, the recommendations included in the poster represent a first step toward the development of conservation strategies.

The Food and Agriculture Organization of the United Nations has declared 2022 The International Year of Artisanal Fisheries and Aquaculture, to focus world attention on the role of small-scale artisanal fishers, fish farmers and fish workers, who play a crucial role in food security, nutrition, and poverty eradication (Ljusenius et al., 2020). Fisheries are about people as much as they are about fish, thereby the role of local communities as resource stewards may be critical in ensuring the responsible management and sustainable use of aquatic biodiversity. Our work helped identifying the more valued and consumed species, a key information to design sustainable fishing strategies considering community needs and preferences.

As custodians of their biocultural landscape, the Kichwa people could make the difference to guarantee the conservation and sustainable use of their fisheries through practical and ethical lessons. But as much as they need visibility to make their voices heard to influence decisions and policies that shape their everyday lives and livelihoods, the support we can offer them gathering, systematizing, adapting, and applying their traditional ecological knowledge can foster positive change on the ground.

Therefore, complementary studies are necessary to endorse local organizations in designing and implementing sustainable strategies for fisheries management and conservation.

We take care of the things we value. We value and relate to what we can recognize and distinguish. The beings and the elements we can no longer name vanish before our eyes. Biodiversity extinction also takes place when nature fades away from our language. Therefore, ethnoclassification and ethno-nomenclature are key to helping us protect the names, signification and environmental knowledge treasured in our words. Furthermore, this approach to study Indigenous knowledge, using the loss of fish as unifying threat, allowed us to unveil their integrated understanding of the natural, cultural, and spiritual dimensions of reality, giving us the basic tools to foster biocultural diversity conservation from a holistic perspective.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Comité de Ética del Instituto de Investigación de la Universidad Tecnológica Indoamérica. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Permission was obtained from the individual(s) and minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article. The animal study was reviewed and approved by Comité de Ética del Instituto de Investigación de la Universidad Tecnológica Indoamérica.

## AUTHOR CONTRIBUTIONS

All the authors collaborated in the conception and design of the work, and during data collection. IJ-N and LG-F helped with curating field data, with the interpretation of the results, and with the revision of the manuscript. CC-M helped with digitalization, curation and data analysis, and with the revision of the manuscript. YV-C contributed with data analysis and interpretation, and wrote the first draft of the manuscript. IT obtained the funding for the project, formed the research team, wrote the final manuscript, prepared the figures, and lead the revision.

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## REFERENCES

Aigo, J., and Ladio, A. (2016). Traditional mapuche ecological knowledge in Patagonia, Argentina: fishes and other living beings inhabiting continental waters, as a reflection of processes of change. *J. Ethnobiol. Ethnomed.* 12:56. doi: 10.1186/s13002-016-0130-y

Albuja, L. (2011). *Lista de Mamíferos Actuales del Ecuador*. Quito: Escuela Politécnica Nacional.

Albuquerque, U. P., Ramos, M., de Lucena, R. F., and Alencar, N. (2014). "Methods and techniques used to collect ethnobiological data," in *Methods and Techniques in Ethnobiology and Ethnoecology*, eds U. Albuquerque, L. Cruz da Cunha, R. de Lucena, and R. Alves (New York, NY: Humana Press), 15–38. doi: 10.1007/978-1-4614-8636-7_2

Alves, R. R. (2012). Relationships between fauna and people and the role of ethnozoology in animal conservation. *Ethnobiol. Conserv.* 1, 1–69. doi: 10.15451/ec2012-8-1.2-1-69

Alves, R. R., and Souto, W. M. (2011). Ethnozoology in Brazil: current status and perspectives. *J. Ethnobiol. Ethnomed.* 7:22. doi: 10.1186/1746-4269-7-22

Angarita-Baéz, J. A., Pérez-Miñana, E., Beltrán Vargas, J. E., Ruiz Agudelo, C. A., Paez Ortiz, A., Palacios, E., et al. (2017). Assessing and mapping cultural ecosystem services at community level in the Colombian Amazon. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manage.* 13, 280–296. doi: 10.1080/21513732.2017.1345981

Antonelli, A., Ariza, M., Albert, J., Andermann, T., Azevedo, J., Bacon, C., et al. (2018). Conceptual and empirical advances in neotropical biodiversity research. *PeerJ* 6:e5644. doi: 10.7717/peerj.5644

Argueta, A., Sanabria-Diago, O. L., Cano-Contreras, E. J., and Medinaceli, A. (2018). Código de ética para la investigación etnobiológica en América Latina. *Ethnoscientia* 3, 1–6. doi: 10.18542/ethnoscientia.v3i2.10239

Armbruster, J. W. (2005). The loricariid catfish genus *Lasiancistrus* (Siluriformes) with descriptions of two new species. *Neotrop. Ichthyol.* 3, 549–569. doi: 10.1590/S1679-62252005000400013

Barbosa-Filho, M. L. V., Ramires, M., Mourão, J., de Souza Rosa, R., Alves, R. R. N., and Costa-Neto, E. M. (2021). Ethnotaxonomy of sharks by expert fishers from South Bahia, Brazil: implications for fisheries management and conservation. *Ethnobiol. Conserv.* 10:2. doi: 10.15451/ec2021-08-10.02-1-12

Barriga, R. (2012). Lista de peces de agua dulce e intermareales del Ecuador. *Rev. Politécnica* 30, 83–119.

Begossi, A., and Garavello, J. C. (1990). Notes on the ethnoichthyology of fishermen from the Tocantins River (Brazil). *Acta Amazon.* 20, 341–351. doi: 10.1590/1809-43921990201351

Benone, N. L., Leal, C. G., dos Santos, L. L., Mendes, T. P., Heino, J., and de Assis Montag, L. F. (2020). Unravelling patterns of taxonomic and functional diversity of Amazon stream fish. *Aquat. Sci.* 82:75. doi: 10.1007/s00027-020-00749-5

Berlin, B. (1973). Folk systematics in relation to biological classification and nomenclature. *Annu. Rev. Ecol. Evol. Syst.* 4, 259–271. doi: 10.1146/annurev.es.04.110173.001355

Berlin, B. (1992). *Ethnobiological Classification - Principles of Categorization of Plants and Animals in Traditional Societies*. Princeton, NJ: Princeton University Press.

Berlin, B. (2014). "The substance and evolution of ethnobiological categories," in *Ethnobiological Classification*, ed. B. Berlin (Princeton, NJ: Princeton University Press), 260–290. doi: 10.1515/9781400862597.260

Berlin, B., and Berlin, E. A. (1983). "Adaptation and ethnozoological classification: theoretical implications of animal resources and diet of the Aguaruna and Huambisa," in *Adaptive Responses of Native Amazonians*, eds B. Berlin and E. A. Berlin (New York, NY: Academic Press), 301–325. doi: 10.1016/b978-0-12-321250-4.50014-2

Boster, J. S., and Johnson, J. C. (1989). Form or function: a comparison of expert and novice judgments of similarity among fish. *Am. Anthropol.* 91, 866–889. doi: 10.1525/aa.1989.91.4.02a00040

Carrillo-Moreno, C. (2017). "¡Ésta es la laguna de limoncocha!: significados desde una perspectiva comunitaria," in *Naturaleza y Cultura: un Acercamiento Desde la Investigación*, eds A. Krainer and A. Chaves (Quito: FLACSO Sede Ecuador), 15–46.

Carvalho, A. P. C., Collins, R. A., Martínez, J. G., Farías, I. P., and Hrbek, T. (2018). From shallow to deep divergences: mixed messages from Amazon Basin cichlids. *Hydrobiologia* 832, 317–329. doi: 10.1007/s10750-018-3790-x

Castillo, T. I., Brancolini, F., Saigo, M., Correa, J. R., and Baigún, C. (2018). Ethnoichthyology of artisanal fisheries from the lower la Plata river basin (Argentina). *J. Ethnobiol.* 38, 406–423. doi: 10.2993/0278-0771-38.3.406

Castro, M. S., Martins, I. M., and Hanazaki, N. (2016). Trophic relationships between people and resources: fish consumption in an artisanal fishers neighborhood in Southern Brazil. *Ethnobiol. Conserv.* 5:4. doi: 10.15451/ec2016-7-5.4-1-16

Cevallos, S. (2020). Extractivism, pandemics and collective rights: the case of the indigenous peoples of the Yasuní (Ecuadorian Amazon). *Rev. Catalana Dret Ambient.* 11, 1–31. doi: 10.17345/rcda2920

Chernoff, B., and Machado-Allison, A. (1990). Characid fishes of the genus *Ceratobranchia*, with descriptions of new species from Venezuela and Peru. *Proc. Acad. Natl. Sci. Phila.* 142, 261–290.

Clément, D. (1995). Why is taxonomy utilitarian? *J. Ethnobiol.* 15, 1–44.

Costa-Neto, E. M., and Marques, J. G. W. (2000). A etnotaxonomia de recursos ictiofaunísticos pelos pescadores da comunidade de Siribinha, norte do estado da Bahia, Brasil. *Biociências* 8, 61–76.

de Melo, F. A. G., and Buckup, P. A. (2006). *Astyanax henseli*, a new name for *Tetragonopterus aeneus* Hensel, 1870 from southern Brazil (Teleostei: Characiformes). *Neotrop. Ichthyol.* 4, 45–52. doi: 10.1590/S1679-62252006000100003

Ellen, R. F. (1986). Ethnobiology, cognition and the structure of prehension: some general theoretical notes. *J. Ethnobiol.* 6, 83–98.

Ferreira, E. N., Mourão, J., Rocha, P. D., Nascimento, D. M., da, S. Q., and Bezerra, D. M. M. (2009). Folk classification of the crabs and swimming crabs (Crustacea–Brachyura) of the Mamanguape river estuary, Northeastern–Brazil. *J. Ethnobiol. Ethnomed.* 5:22. doi: 10.1186/1746-4269-5-22

Forth, G. (2017). 'Fish' and 'Non-Fish' in Lio and Nage: folk-Intermediates and folk-generics in the fish classification of two eastern Indonesian peoples. *Ethnobiol. Lett.* 8, 61–69. doi: 10.14237/ebl.8.1.2017.900

GADMCA (2014). *Actualización Plan de Desarrollo y Ordenamiento Territorial 2011-2025*. Arajuno: Gobierno Autónomo Descentralizado Municipal.

Gèry, J. (1977). *Characoids of the World*. Neptune City, NJ: TFH Publications Inc.

Gollin, L. X., McMillen, H., and Wilcox, B. (2004). Participant-observation and pile sorting: methods for eliciting local understandings and valuations of plants as a first step towards informed community participation in environment and health initiatives in Hawai'i. *Appl. Environ. Educ. Commun.* 3, 259–267. doi: 10.1080/15330150490882001

Hunn, E. (2014). To know them is to love them. *Ethnobiol. Lett.* 5, 146–150. doi: 10.14237/ebl.5.2014.297

IGM (2020). *Base Arajuno, Escala 1:50.000*. Available Online at: http://www.geoportaligm.gob.ec/portal/index.php/descargas/cartografia-de-libre-acceso/ [accessed November 15, 2021].

Jácome-Negrete, I. (2012). Etnoictiología Kichwa de los bagres del género *Pseudoplatystoma* (Siluriformes: Pimelodidae) en la Amazonía Central del Ecuador. *Rev. Amazon. Cienc. Tecnol.* 1, 36–50.

Jácome-Negrete, I. (2013). Etnoictiología Kichwa de las lagunas de la cuenca baja del río Curaray (Amazonia), Ecuador. *Biota Colomb.* 14, 5–24.

Jácome-Negrete, I. (2021). *Sacha Runa Yachay Kamu: Manual de Etnobiología Ecuatoriana*. Quito: Gráficas Iberia.

Jácome-Negrete, I., and Guarderas-Flores, L. (2015). Nomenclatura y clasificación kichwa de los peces lacustres en la Amazonía central de Ecuador. *Etnobiología* 13, 63–71.

Jensen, A. A. (1985). *Sistemas Indígenas de Classificação de Aves: Aspectos Comparativos, Ecológicos e Evolutivos*. Doctoral thesis. Campinas: Universidade Estadual de Campinas.

Jézéquel, C., Tedesco, P. A., Darwall, W., Dias, M. S., Frederico, R. G., Hidalgo, M., et al. (2020). Freshwater fish diversity hotspots for conservation priorities in the Amazon Basin. *Conserv. Biol.* 34, 956–965. doi: 10.1111/cobi.13466

Jimbo-Campoverde, M. A. (2019). *Caracterización de la Nacionalidad Kichwa Para el Fomento del Turismo Comunitario, Cantón Arajuno, Provincia de Pastaza*. Bachelor's thesis. Quito: Universidad Central del Ecuador.

Kakudidi, E. K. (2004). Folk plant classification by communities around Kibale National Park, western Uganda. *Afr. J. Ecol.* 42, 57–63. doi: 10.1111/j.1365-2028.2004.00462.x

Kullander, S. O. (1986). *Cichlid Fishes of the Amazon River Drainage of Peru*. Stockholm: Swedish Museum of Natural History.

Lahe-Deklin, F., and Si, A. (2014). Ex-situ documentation of ethnobiology. *Lang. Doc. Conserv*. 8, 788–809.

Lepofsky, D. (2009). The past, present, and future of traditional resource and environmental management. *J. Ethnobiol.* 29, 161–166. doi: 10.2993/0278-0771-29.2.161

Levi-Strauss, C., Jacobson, C., and Schoepf, B. G. (1963). *Structural Anthropology*. New York, NY: Basic Books.

Ljusenius, Å., Lovatelli, A., and Qabeel, B. (2020). The international year of artisanal fisheries and aquaculture is coming up in 2022. *FAO Aquac. Newsl.* 62, 13–15.

Loh, J., and Harmon, D. (2005). A global index of biocultural diversity. *Ecol. Indic.* 5, 231–241. doi: 10.1016/j.ecolind.2005.02.005

Lujan, N., German, D. P., and Winemiller, K. O. (2011). Do wood-grazing fishes partition their niche?: morphological and isotopic evidence for trophic segregation in Neotropical Loricariidae. *Funct. Ecol.* 25, 1327–1338. doi: 10.1016/j.ympev.2008.08.013

Lujan, N., Meza-Vargas, V., Astudillo-Clavijo, V., Barriga-Salazar, R., and López-Fernández, H. (2015). Multilocus molecular phylogeny for *Chaetostoma* clade genera and species with a review of *Chaetostoma* (Siluriformes: Loricariidae) from the Central Andes. *Copeia* 103, 664–701. doi: 10.1643/CI-14-194

MAE (2012). *Sistema de Clasificación de los Ecosistemas del Ecuador Continental. Subsecretaría de Patrimonio Natural*. Quito: Ministerio del Ambiente Ecuador.

Marques, J. G. W. (1991). *Aspectos Ecológicos na Etnoictiologia dos Pescadores do Complexo Estuarino-Lagunar Mandau-Manguaba, Alagoas*. Doctoral thesis. Campinas: Universidade Federal de Alagoas.

Medinaceli, A. (2018). Taking an early step in ethnobiological research: a proposal for obtaining prior and informed consent from indigenous peoples. *Ethnobiol. Lett.* 9, 76–85. doi: 10.14237/ebl.9.1.2018.1054

Mertens, F., Fillion, M., Saint-Charles, J., Mongeau, P., Távora, R., Passos, C. J. S., et al. (2015). The role of strong-tie social networks in mediating food security of fish resources by a traditional riverine community in the Brazilian Amazon. *Ecol. Soc.* 20:18.

Ministerio del Ambiente, Agua y Transición Ecológica (2021). *Mapa Interactivo*. Available Online at: http://ide.ambiente.gob.ec/mapainteractivo/ [accessed November 26, 2021].

Montenegro, S. C. S. (2001). *A Conexão Homem/Camarão (Macrobrachium carcinus e M. acanthurus) no Baixo São Francisco Alagoano: Uma Abordagem Etnoecológica*. Doctoral thesis. São Carlos: Universidade Federal de São Carlos.

Mourão, J., and Barbosa Filho, M. L. V. (2018). "Ethnotaxomy as a methodological tool for studies of the ichthyofauna and its conservation implications: a review," in *Ethnozoology Animals in our Lives*, eds R. R. Nóbrega Alves and U. P. Albuquerque (Cambridge, MA: Academic Press), 71–94. doi: 10.1016/b978-0-12-809913-1.00006-5

Mourão, J., and Nordi, N. (2002). Comparação entre as taxonomias folk e científica para Peixes do Estuário do Rio Mamanguape, Paraíba-Brasil. *Interciencia* 27, 607–612.

Pauly, D., Watson, R., and Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 360, 5–12. doi: 10.1098/rstb.2004.1574

Paz, V. A., and Begossi, A. (1996). Ethnoichthyology of galviboa fishermen of sepetiba bay, Brazil. *J. Ethnobiol.* 16, 157–168.

Pereyra, P. E. R., Hallwass, G., Poesch, M., and Silvano, R. A. M. (2021). 'Taking fishers' knowledge to the lab': an interdisciplinary approach to understand fish trophic relationships in the Brazilian Amazon. *Front. Ecol. Evol.* 9:723026. doi: 10.3389/fevo.2021.723026

Pinto, M. F., Mourão, J., and Alves, R. R. (2013). Ethnotaxonomical considerations and usage of ichthyofauna in a fishing community in Ceará state, Northeast Brazil. *J. Ethnobiol. Ethnomed.* 9, 17–25. doi: 10.1186/1746-4269-9-17

Pinto, M. F., Mourão, J., and Alves, R. R. (2016). How do artisanal fishermen name fish? An Ethnotaxonomic study in Northeastern Brazil. *J. Ethnobiol.* 36, 348–381. doi: 10.2993/0278-0771-36.2.348

Pinto, M. F., Oliveira, T. P. R., Rocha, L. A., and Alves, R. R. N. (2018). "People and fishery resources: a multidimensional approach," in *Ethnozoology animals in our lives*, eds R. R. Nóbrega Alves and U. P. Albuquerque (Cambridge, MA: Academic Press), 119–149. doi: 10.1016/B978-0-12-809913-1.00008-9

Posey, D. A. (1985). Indigenous management of tropical forest ecosystems: the case of the Kayapó Indians of the Brazilian Amazon. *Agrofor. Syst.* 3, 139–158. doi: 10.1007/BF00122640

Previero, M., Minte-Vera, C. V., and Moura, R. L. D. (2013). Fisheries monitoring in Babel: fish ethnotaxonomy in a hotspot of common names. *Neotrop. Ichthyol.* 11, 467–476. doi: 10.1590/S1679-62252013000200016

Provenzano, F., and Barriga-Salazar, R. (2018). Species of *Ancistrus* (Siluriformes, Loricariidae) from Ecuador, with the description of a new species from the Amazon River Basin. *Zootaxa* 4527, 211–238. doi: 10.11646/zootaxa.4527.2.4

Raisg (2021). *Datos Cartográficos*. Available Online at: https://www.amazoniasocioambiental.org/es/mapas/#!/descargas [accessed November, 26, 2021].

Ramires, M., Clauzet, M., Barrella, W., Rotundo, M. M., Silvano, R. A. M., and Begossi, A. (2015). Fishers' knowledge about fish trophic interactions in the southeastern Brazilian coast. *J. Ethnobiol. Ethnomed.* 11:19. doi: 10.1186/s13002-015-0012-8

Rebelo, S. R., Freitas, E. C., and Mota Soares, M. G. (2010). Fish diet from Manacapuru Big Lake complex (Amazon): a approach starting from the traditional knowledge. *Biota Neotrop.* 10, 39–44. doi: 10.1590/S1676-06032010000300003

Santos, C. A. B., and Alves, R. R. (2016). Ethnoichthyology of the Indigenous Truká people, Northeast Brazil. *J. Ethnobiol. Ethnomed.* 12:1. doi: 10.1186/s13002-015-0076-5

Santos-Fita, D., and Costa-Neto, E. M. (2009). "Sistemas de clasificación etnozoológicos," in *Manual de Etnozoología: Una Guía Teórico-Práctica Para Investigar la Interconexión del ser Humano con los Animales*, eds E. M. Costa-Neto, D. Santos-Fita, and M. Vargas Clavijo (Almenara: Tundra Ediciones), 67–94.

Sieber, S. S., da Silva, T. C., de Oliveira Campos, L. Z., Zank, S., and Albuquerque, U. P. (2014). "Participatory methods in ethnobiological and ethnoecological research," in *Methods and Techniques in Ethnobiology and Ethnoecology*, eds U. P. Albuquerque, L. V. F. C. da Cunha, R. F. P. De Lucena, and R. R. N. Alves (New York, NY: Humana Press), 39–58. doi: 10.1007/978-1-4614-8636-7_3

Silvano, R. A., MacCord, P. F., Lima, R. V., and Begossi, A. (2006). When does this fish spawn? Fishermen's local knowledge of migration and reproduction of Brazilian coastal fishes. *Environ. Biol. Fishes* 76, 371–386. doi: 10.1007/s10641-006-9043-2

Tobes, I., Gaspar, S., Peláez-Rodríguez, M., and Miranda, R. (2016). Spatial distribution patterns of fish assemblages relative to macroinvertebrates and environmental conditions in Andean piedmont streams of the Colombian Amazon. *Inland Waters* 6, 89–104. doi: 10.3390/w13081038

Tobes, I., Ramos-Merchante, A., Araujo-Flores, J., Pino-del-Carpio, A., Ortega, H., and Miranda, R. (2021). Fish ecology of the alto Madre de Dios river basin (Peru): notes on electrofishing surveys, elevation, palm swamp and headwater fishes. *Water* 13:1038. doi: 10.5268/IW-6.1.750

Toledo, V. M., and Alarcón-Cháires, P. (2012). La etnoecología hoy: panorama, avances, desafíos. *Etnoecológica* 9, 1–16. doi: 10.2307/j.ctv16b78qv.3

Vacacela, R. (2007). *Sumac Causai - Vida en Armonía. Instituto Quichua de Biotecnología Sacha Supai*. Quito: Ediciones Abya-Yala.

Val, A. L., Almeida-Val, V. M., Fearnside, P. M., dos Santos, G. M., Piedade, M. T. F., Junk, W., et al. (2017). "Amazonia: water resources and sustainability," in *Waters of Brazil*, eds C. de Mattos Bicudo, J. Galizia Tundisi, and S. Cortesão Barnsley (Cham: Springer), doi: 10.1007/978-3-319-41372-3_6

Valdiviezo-Rivera, J., Carrillo-Moreno, C., Madera Arends, R., and Albarracín Rodas, M. E. (2012). *Guía de Peces de Limoncocha*. Quito: Universidad Internacional SEK.

van der Sleen, P., and Albert, J. S. (2017). *Field Guide to the Fishes of the Amazon, Orinoco, and Guianas*. Princeton, NJ: Princeton University Press.

Vari, R. P., and Harold, A. S. (2001). *Phylogenetic Study of the Neotropical Fish Genera Creagrutus Giinther and Piabina Reinhardt (Teleostei: Ostariophysi: Characiformes), with a Revision of the Cis-Andean Species*. Washington, DC: Smithsonian Institution Press.

Vasco, C., and Sirén, A. (2019). Determinants of wild fish consumption in Indigenous communities in the Ecuadorian Amazon. *Soc. Nat. Resour.* 32, 21–33. doi: 10.1080/08941920.2018.1475587

Weckmüller, H., Barriocanal, C., Maneja, R., and Boada, M. (2019). Factors affecting traditional medicinal plant knowledge of the Waorani, Ecuador. *Sustainability* 11:4460. doi: 10.3390/su11164460

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