Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 14 (1): 55–75
https://doi.org/10.15560/14.1.55

PENSOFT

Annotated list of freshwater fishes of the Limoncocha Lagoon, Napo river basin, northern Amazon region of Ecuador

Jonathan Valdiviezo-Rivera,[1, 2] Carolina Carrillo-Moreno,[1, 2] Enrique Gea-Izquierdo[3]

1 INABIO—Instituto Nacional de Biodiversidad, Calle Rumipamba 341 and Av. De los Shyris, Parque "La Carolina", Quito, Ecuador. **2** Associate Researcher, Universidad Internacional SEK—Ecuador, Calle Alberto Einsten s/n and 5th transversal, Campus Miguel de Cervantes, Quito, Ecuador. **3** Pontificia Universidad Católica del Ecuador, Dirección de Investigación, Av. 12 de octubre 1,076 and Roca, Quito, Ecuador.
Corresponding author: Jonathan Valdiviezo-Rivera, bioictiojona@yahoo.com

Abstract
An annotated list of the freshwater fishes of the Limoncocha Lagoon, in the Limoncocha Biological Reserve in the northern Amazon region of Ecuador is presented. Fishes were captured between March and July of 2012, and we combined these results with previous studies to provide a comprehensive list of fishes in the Limoncocha Biological Reserve. Thirty-three species belonging to 14 families distributed in 7 orders were collected. The most representative orders in number of species and specimens were Characiformes, Siluriformes, and Perciformes, respectively, being Characiformes as the most important in terms of richness and abundance of species. Characidae (Characiformes) exhibited the greatest abundance and broadest distribution in our samples. A short morphological description and morphometric measurements of each species are also presented.

Key words
Limoncocha Biological Reserve, Amazonian basin, Neotropical fauna, Ichthyofauna.

Academic editor: Bárbara Calegari | Received 25 February 2017 | Accepted 31 October 2017 | Published 5 January 2018

Citation: Valdiviezo-Rivera J, Carrillo-Moreno C, Gea-Izquierdo E (2017) Annotated list of freshwater fishes of the Limoncocha Lagoon, Napo river basin, northern Amazon region of Ecuador. Check List 14 (1): 55–75. https://doi.org/10.15560/14.1.55

Introduction

The diversity of freshwater fishes in the Neotropical region is among the greatest in the world, including 5,160 of the 32,000 valid species of fishes (Nelson et al. 2016) and an undescribed diversity estimated between 8,000 and 9,000 species (Reis et al. 2016). These numbers are almost certainly an underestimate since new species of Neotropical fishes are constantly being described, including from Ecuador (Barriga 2012, Román-Valencia et al. 2013, Escobar et al. 2015, Lujan et al. 2015). Currently, 951 intertidal and continental freshwater species have been identified in Ecuador, most of which occur in the Amazonian region. Although research on the Neotropical fishes of Ecuador is increasing (e.g. Jácome-Negrete and Guarderas 2005, Alverson et al. 2008, Jácome-Negrete 2013, Jiménez-Prado et al. 2015, Aguirre et al. 2016), there is still relatively little known about the distribution of species in many parts of the country. This is of great concern given the increasing threats to aquatic ecosystems throughout the country. Ecuador's northern Amazon region is of particular interest because it is the region most severely impacted by the development of the oil industry. This oil boom brought consequences, such as fragmentation of territories, which has caused an increase pressure on water resources and has changed the ways in which the fish are used (Vallejo 2014). After decades of

Table 1. Average values of the physicochemical parameters from the sampling sites in the Limoncocha Lagoon and its tributaries, Pishira and Playayacu rivers (March and July 2012) (*n* = number of sampled localities per site).

Physicochemical parameters	Sites		
	Limoncocha Lagoon (*n* = 14)	Pishira River (*n* = 2)	Playayacu River (*n* = 2)
Water temperature (°C)	26.4	23.1	11.9
pH	7.5	8.8	8.2
Conductivity (μS/cm)	87.3	88.8	56.1
Dissolved oxygen (mg/L)	11.1	6.6	4.0

exploitation, and the increase of other human activities like overfishing, deterioration of aquatic ecosystems is easily noticeable and is aggravated by the lack of policies and regulations related to fishes.

Oil exploitation began in the Limoncocha Biological Reserve (RBL) in 1985, but previous work on the fishes has been limited. Walsh (2003) identified 93 species in 30 families of freshwater fishes. Unfortunately, no species list was provided and the collection sites not specified, making comparisons difficult. Bastidas et al. (2014) collected 20 species in 9 families. Valdiviezo-Rivera et al. (2012), examined the fauna of the lagoon and recorded the presence of 80 species in 33 families based on field collections, photographic records, specimens deposited in the Instituto Nacional de Biodiversidad (INABIO), interviews with fishermen, and surveys of their catches. Herein, we aim to provide an annotated list of the freshwater fishes of the Limoncocha Lagoon, in the RBL, northern Amazon region of Ecuador.

Methods

Study site. We examined the fish fauna in RBL, an important protected area that is within the oil exploration Block No. 15, managed by the state company Petroamazonas.

The RBL is one of the smallest protected areas in Ecuador (4,613.3 ha). It is located in the province of Sucumbíos, Shushufindi canton, Limoncocha parish. It is within the Napo-Pastaza (NP) ichthyo-hydrographic zone. The annual average rain and temperature are 3,065 mm and 24.9 °C respectively. Within the RBL there are 5 types of plant formations: lowland evergreen forest, lowland evergreen forest flooded by white waters, lowland evergreen forest flooded by black waters, lowland floodplain forest (moretal or swamp forest), and lacustrine lowland grassland (Sierra 1999).

The hydrologic system in the RBL is formed by the Pishira and Playayacu rivers and the Limoncocha Lagoon (among other tributaries). The Limoncocha Lagoon has an area of 2.3 km^2. Its bottom is composed of mineral sediments such as sand, silt, clay, and a high content of organic matter. Macronutrients are high, and the water is a lemon-greenish color (Valdiviezo-Rivera et al. 2012).

The sampling sites in the Limoncocha Lagoon presents water flow and low to moderate amounts of immersed, emergent, marginal, and floating vegetation. The Pishira River is characterized by a bottom composed of rocks, pebbles, sand, leaves, and small logs; its water is moderately transparent to very clear and slow flowing. There are low to moderate amounts of immersed, emerging, and marginal vegetation. The bottom of the Playayacu River is characterized by mud, sand, leaves, and small to medium-sized logs; water transparency is low to moderate, water flow is moderate, and there is plenty of immersed, emerging, and marginal vegetation. All physochemical parameters were determined during the rainy season, March to July 2012, and site data are listed in Table 1. The average depth of the lagoon was 1.7 m, while the average depths of the Playayacu and Pishira rivers were only 0.4 m and 0.5 m, respectively.

Data collection. Fourteen sites were sampled (Table

Table 2. Location of sampling sites and sampling methods used to capture fish at the Limoncocha Lagoon and its tributaries, Pishira and Playayacu rivers.

No.	Site codes	Sites	Geographic coordinates		Elev. (m)	Sampling methods
			Latitude (S)	Longitude (W)		
1	LIM-01/LIM-08	Limoncocha Lagoon: outlet right margin	00°23′19.98″	076°35′50.39″	237	Gill nets, cast net, baits
2	LIM-02	Limoncocha Lagoon: 100 m from entrance of Supaycocha Cabins	00°22′53.15″	076°35′36.09″	232	Gill nets, cast net, baits
3	LIM-03	Limoncocha Lagoon	00°23′13.33″	076°36′32.59″	236	Gill nets, cast net, baits
4	LIM-04/LIM-06	Limoncocha Lagoon: entrance of Supaycocha Cabins	00°22′57.84″	076°35′36.51″	237	Gill nets, cast net, baits
5	LIM-05	Limoncocha Lagoon	00°23′2.72″	076°35′39.81″	236	Gill nets, cast net, baits
6	LIM-07	Limoncocha Lagoon: 100 m from right side of main pier	00°24′28.14″	076°37′8.89″	234	Gill nets
7	LIM-09	Limoncocha Lagoon	00°23′10.01″	076°36′23.76″	238	Gill nets, cast net, baits
8	LIM-10/LIM-14	Pishira River: next to road	00°21′58.76″	076°37′41.30″	250	Trawl net, baits
9	LIM-11	Limoncocha Lagoon	00°24′0.08″	076°36′32.83″	236	Gill nets
10	LIM-12/LIM-16	Playayacu River: entrance from lagoon, 100 m inside jungle	00°23′30.25″	076°36′48.54″	264	Trawl net, baits
11	LIM-13	Limoncocha Lagoon: river outlet	00°23′18.67″	076°36′16.55″	236	Gill nets
12	LIM-15	Limoncocha Lagoon: inlet	00°23′21.21″	076°35′49.61″	236	Gill nets
13	LIM-17	Limoncocha Lagoon	00°23′39.90″	076°36′15.46″	234	Gill nets, cast net, baits
14	LIM-18	Limoncocha Lagoon	00°23′26.93″	076°36′34.70″	234	Gill nets, cast net, baits

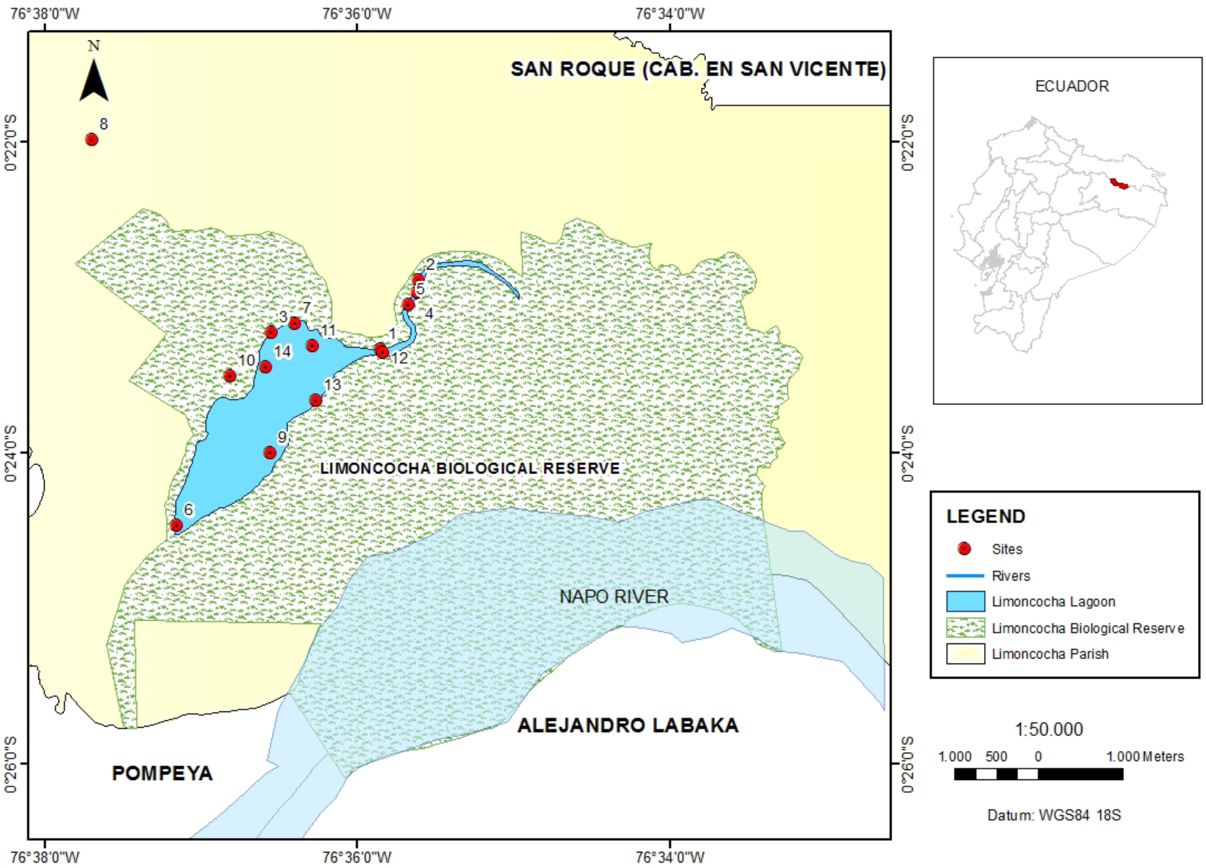

Figure 1. Map of study site showing the sampling sites in the Limoncocha Lagoon and its tributaries, Limoncocha Biological Reserve, Napo river basin, Sucumbíos province, Ecuador.

2, Fig. 1): 12 sites in the Limoncocha Lagoon, 1 site in the Pishira River, and 1 site in the Playayacu River. Fishes were captured with trawl net, cast net, gill nets, and baits of different sizes; gill net mesh size ranged between 2.8 cm and 7.5 cm. The specimens were anesthetized in 10% Lidocaine solution. In the field, fishes were fixed in formaldehyde 10%, and subsequently stored in ethanol 75%. We cataloged and deposited 37% of the specimens in the INABIO. Morphometric measurements were taken with an electronic caliper (precision ± 0.02 mm) following Román-Valencia et al. (2005) and Fischer et al. (1995a, 1995b). Morphometric measurements were done 2 times for each parameter. The summary statistics (means, minimum, maximum) for the morphometric measurements were included in Table 3. The coordinates and elevations were recorded with GPS receiver (Garmin Etrex Legend). The classification of species follows Eschmeyer et al. (2017). Finally, we combined our results with those of previous studies to give a comprehensive list of the freshwater fishes present in the RBL that will contribute to the knowledge of the ichthyofauna in this important area and provide data for future conservation measures.

Data analysis. Species identifications were performed consulting the taxonomic literature and identification keys (Géry 1977, Kullander 1986, Whitehead et al. 1988, Vari 1984, 1989, 1991, 1992a, 1992b, Vari and Harold 2001, Malabarba 2004, Armbruster and Page 2006, Vanegas-Ríos et al. 2011, Loeb 2012).

A non-parametric jack-knife estimator was used to determine the number of possible species at the study site.

Results

A total of 264 specimens belonging to 7 orders, 14 families, and 33 species were collected (Table 4). Of the 33 species collected, 26 were present exclusively in the Limoncocha Lagoon, 2 in the Pishira River, and 1 in the Playayacu River (Table 4). One species, *Bujurquina* sp., was common at all 3 locations.

The predominant orders were the Characiformes (21 spp.), Perciformes (5 spp.), and Siluriformes (3 spp.), representing 63.3%, 15.3%, and 9.1%, respectively of

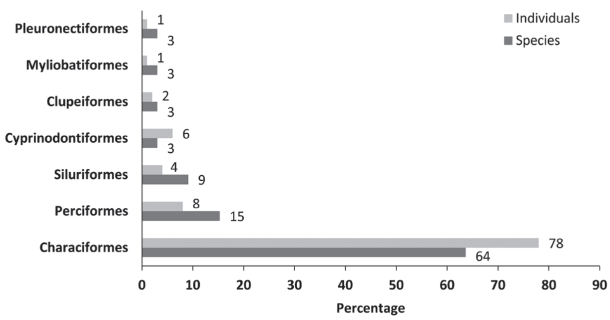

Figure 2. Percentage of individuals and species per order at the Limoncocha Lagoon.

Table 3. Summary statistics of morphometric measurements. Morphometric measurements (mm) and its respective acronyms: TL = total length, SL = standard length, PL = caudal peduncle length, BD = body depth, OD = orbital diameter, LS = snout length, HL = head length, Weight = weight in alcohol, LOD = lower orbital diameter, LT = tail length, DW = disc width, DL = disc length, PO = pre-oral length, POD = pre-orbital distance.

	Morphometric measurement (mm)																	
	TL		SL		PL		BD		OD		LS		HL		Weigth		LOD	
Species	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max
Family Engraulidae																		
Anchoviella alleni	66.5	64.3–68.7	50.3	49.7–50.9	8.4	8.2–8.6	6.7	3.5–10.4	5.7	5.7–5.8	3.6	3.3–3.9	11.6	10.5–12.6	1.4	1.2–1.5	—	—
Family Curimatidae																		
Curimata aspera	125.6		97.4		7.3		29.4		9.5		4.9		25.0		25.5		—	—
Curimata vittata	166.11		129.4		9.5		48.5		10.4		6.9		33.5		74.9		—	—
Potamorhina altamazonica	212.2	260–186.0	162.5	140.5–194.8	12.6	11–15.1	61.4	50.4–83.3	11.5	11.1–11.9	10.6	8.1–14.6	50.4	41.8–63.8	142.5	66.7–281.8	—	—
Steindachnerina bimaculata	124.6	49.8–166.5	98.0	35.9–132.1	8.4	1.7–11.0	33.0	10.0–45.3	7.8	3.4–11.3	6.4	3.7–8.9	25.6	9.9–36.1	36.8	1.0–60.4	—	—
Family Anostomidae																		
Leporinus friderici	177.9	173–182.9	141.8	140.8–142.7	7.4	7.3–7.5	48.0	48–48.1	8.8	8.8–8.8	12.4	12.1–12.6	37.6	37.2–37.9	87.5	86.7–88.3	—	—
Family Serrasalmidae																		
Pygocentrus nattereri	174.0	120.1–215.6	144.9	94.2–180	9.4	5.2–11.9	76.3	52.5–91.6	9.7	7.4–11.6	14.1	6.4–21.1	54.2	35.4–71.4	161.3	38.4–266.9	—	—
Serrasalmus rhombeus	141.6		119.1		10.5		65.1		8.6		9.1		42.7		8.6		—	—
Family Characidae																		
Aphyocharax sp.	39.3		30.0		2.7		9.2		3.1		1.9		8.6		0.5		—	—
Astyanax abramis	83.0	60.1–105.9	64.3	46.6–82.0	3.2	2.7–3.7	26.1	19.8–32.4	7.1	5.6–8.7	4.7	3.5–5.9	19.8	14.1–25.5	8.8	2.6–14.9	—	—
Astyanax bimaculatus	71.3		53.5		2.9		21.9		5.2		4.5		5.0		4.6		—	—
Astyanax henseli	47.5		36.8		1.3		16.5		4.2		1.9		10.2		0.9		—	—
Bryconamericus sp.	63.9	40.8–101.9	48.2	31.4–75.7	3.7	2.5–4.5	18.9	11.7–33	4.5	2.7–8.3	2.9	1.7–4.5	12.9	8.1–22.4	3.1	0.6–13.3	—	—
Chrysobrycon hesperus	37.6	21.2–54.9	30.4	16.2–44.9	3.2	1.9–4.4	11.3	5.9–17.1	2.4	1.7–3.4	2.4	1.4–3.6	7.76	4.2–9.8	0.5	0.1–1.1	—	—
Creagrutus sp.	41.6	40.3–43.3	31.3	30.2–32.2	4.0	3.5–4.4	9.5	9.0–10.3	3.8	3.8–3.9	1.6	1.3–2.0	8.3	7.8–9.1	0.7	0.5–0.9	—	—
Ctenobrycon hauxwellianus	63.7	41.2–77.2	52.2	31.1–61.7	3.6	3.3–5.4	25.8	14.8–31.0	4.8	3.2–6	3.0	2.0–3.8	13.4	8.8–15.6	19.9	0.6–56.0	—	—
Moenkhausia dichroura	76.4		57.8		3.5		21.1		5.3		2.6		14.4		3.7		—	—
Moenkhausia oligolepis	33.2	19.2–45.6	24.6	14.5–33.7	1.5	1.0–2.2	9.6	4–13.0	3.4	1.6–4.5	1.6	1.0–2.3	7.9	4.6–11.0	0.4	0.1–0.8	—	—
Roeboides myersii	153.4	108.7–183.1	123.3	91–149.6	6.1	2.8–9.4	50.5	34.4–60.4	9.4	7.6–10.8	6.9	5.4–9.2	33.5	24.7–41.6	45.3	12.6–65.2	—	—
Tetragonopterus argenteus	73.7	66.5–82.4	57.8	48.5–65.2	3.3	2.1–4.8	29.2	24.8–34.2	5.6	4.7–6.7	2.6	1.5–3.5	14.4	12.5–16.2	4.9	3.0–6.3	—	—
Family Triportheidae																		
Triportheus elongatus	243.6		183.6		13.9		66.2		12.5		14.9		49.2		85.1		—	—
Family Crenuchidae																		
Characidium sp.	72.0		56.3		7.0		13.1		3.7		2.2		13.4		2.4		—	—
Family Auchenipteridae																		
Trachelyopterus galeatus	199.7		160.9		20.3		59.9		4.4		14.5		4.2		167.1		—	—
Family Loricariidae																		
Pterygoplichtys pardalis	343.9		243.8		28.9		51.4		9.4		34.6		61.5		406.5		—	—
Pterygoplichtys weberi	244.3	244.2–244.4	129.8	87.3–172.4	35.6	31.0–40.2	48.8	47.4–50.1	7.1	6.0–8.3	26.3	23.8–28.8	40.2	35.6–44.8	156.3	153.2–159.3	—	—
Family Cynolebiidae																		
Anablepsoides cf. *urophthalmus*	36.2	26.3–45.3	29.1	24.9–34.2	5.8	4.2–8.5	8.8	6.9–11.3	2.7	1.9–3.9	2.5	2.1–3.7	7.7	6.2–8.5	0.4	0.1–0.7	—	—
Family Sciaenidae																		
Plagioscion squamosissimus	257.5		208.1		42.3		63.3		14.4		16.4		71.3		186.1		—	—
Family Cichlidae																		
Aequidens tetramerus	38.5		27.3		2.9		12.4		3.8		2.7		10.7		1.0		—	—
Astronotus ocellatus	231.4		187.3		14.7		89.2		12.8		14.1		59.9		258.7		—	—

Table 3. *Continued.*

Species	Morphometric measurement (mm) TL		SL		PL		BD		OD		LS		HL		Weigth		LOD	
	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max	mean	min–max
Bujurquina sp.	36.8	24.5–49.1	26.3	17.4–35.1	2.2	1.7–2.7	18.5	6.9–31.9	5.7	2.5–8.6	4.0	2.0–7.6	16.0	7.5–27	6.0	0.2–16.2	—	—
Crenicichla cincta	213.8		168.1		16.8		43.6		9.6		17.9		58.3		102.9		—	—
Family Achiridae																		
Apionichtys menezesi	272.9		211.7		—	—	124.4		—	—	18.9		64.6		331.8		2.8	

Species	Morphometric measurement LT		DW		DL		PO		POD		Weigth	
	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max
Family Potamotrygonidae												
Potamotrygon motoro	229.5		240.9		209.4		56.5		49.7		779.0	

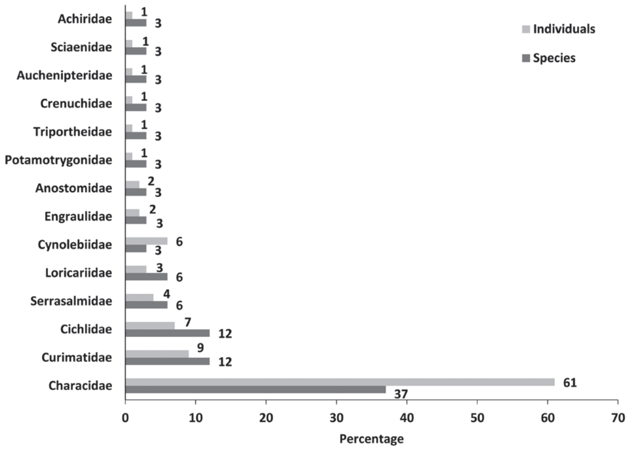

Figure 3. Percentage of individuals and species per family sampled at the Limoncocha Lagoon.

the total fish species captured (Fig. 2). The most diverse families were Characidae (36.4%), followed by Curimatidae (12.1%), Cichlidae (12.0%), Serrasalmidae (6.3%), Loricariidae (6.2%), and Cynolebiidae (6.2%). The most abundant species collected were *Moenkhausia oligolepis* (14.4%) and *Tetragonopterus argenteus* (9.3%) (Fig. 3).

The accumulation curve indicated that the observed species richness (33 spp.) represented 75% of the species predicted by the jack-knife estimator (44 spp.) (Fig. 4).

All the collected specimens were small to medium-sized. The majority of captured specimens were small, less than 100 mm total length (TL) but greater than 50 mm TL (18 spp., 54.5%). The species with the largest average standard length (SL) was *Pterygoplichtys pardalis*, 243.8 mm SL, and it was followed by *Plagioscion squamosissimus*, 208.1 mm SL. Three spatially segregated fish communities were distinguished from the lagoon. The first community inhabited the water layer closest to the surface and constituted 12% (4 spp.) of the species recorded. The species in this community were *Anchoviella alleni*, *Chrysobrycon hesperus*, *Triportheus elongatus*, and *Anablepsoides* cf. *urophthalmus*. The second was a mid-water community and included 70% (23 spp.) of the species recorded. Representatives of this group included *Curimata aspera*, *Astyanax bimaculatus*, *Ctenobrycon hauxwellianus*, *Leporinus friderici*, *Serrasalmus rhombeus*, *Roeboides myersii*, and *Astronotus ocellatus.* Finally, there was a benthic community that included

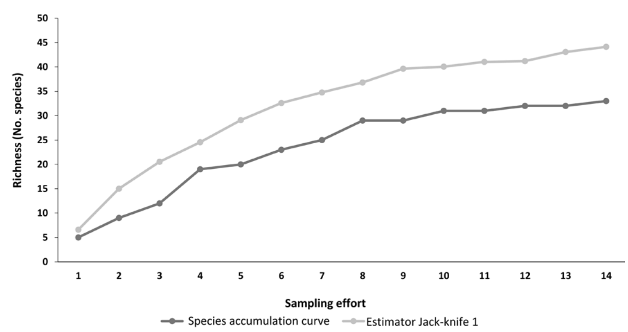

Figure 4. Species accumulation curve generated by non-parametric estimator jack-knife 1 based on collections made in the Limoncocha Lagoon, Sucumbíos province, Ecuador.

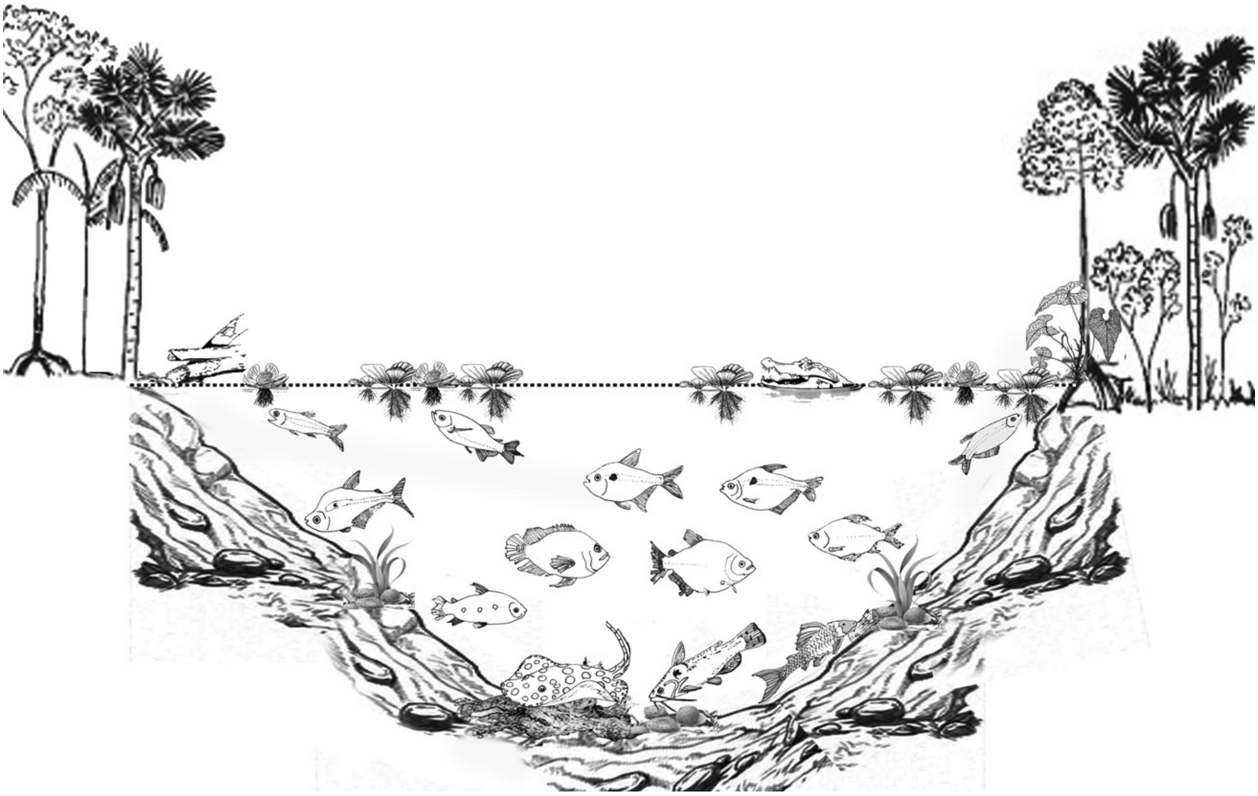

Figure 5. Diagram indicating the vertical distribution of representative fish species in the Limoncocha Lagoon. Fish community is distributed in surface, middle and benthic layers of the water. Surface water layer included (from left to right) *Anchoviella alleni*, *Triportheus elongatus* and *Chrysobrycon hesperus*; and middle water layer took in (from left to right) *Roeboides myersii, Leporinus friderici*, *Astronotus ocellatus, Astyanax bimaculatus, Serrasalmus rhombeus, Ctenobrycon hauxwellianus* and *Curimata aspera*. Finally, benthic community included (from left to right) *Potamotrygon motoro*, *Trachelyopterus galeatus* and *Pterygoplichthys pardalis.*

18% (6 spp.) of the species recorded and consisted of *Potamotrygon motoro*, *Characidium* sp., *Pterygoplichthys pardalis*, *Pterygoplichthys weberi*, *Trachelyopterus galeatus*, and *Apionichtys menezesi* (Fig. 5).

Annotated list of the freshwater fishes of the Limoncocha Lagoon

Order Myliobatiformes
Family Potamotrygonidae

Potamotrygon motoro (Müller & Henle, 1841): Figure 6A

Taeniura motoro Müller and Henle 1841: 197–198—Lasso et al. 2013: 209–210.
Trygon mulleri Castelnau 1855: 102.
Potamotrygon circularis Garman 1913: 419.
Potamotrygon laticeps Garman 1913: 417.

Material examined. Table 4.

A fish with a disk-shaped body, small head, and long tail with sharp thorns and prickles. Its back is brown to yellowish, with brown or yellow colored ocelli, edged with black. The average length of the specimens captured in the lagoon is 35 cm TL (Valdiviezo-Rivera et al. 2012). This fish has commercial value in aquariums; local people catch them for their own consumption and in many cases the fishes are even returned to the lagoon (Valdiviezo-Rivera et al. 2012).

Order Clupeiformes
Family Engraulidae

Anchoviella alleni (Myers, 1940): Figure 6B

Amplova alleni Myers 1940: 441—Whitehead et al. 1988: 324–325.
Anchoviella alleni—Loeb 2012: 16–17.

Material examined. Table 4.

This is a small fish with silvery hues, and an elongated and slightly compressed body. This species is recognized by its moderately long snout, short maxilla (Whitehead et al. 1988), and upper jaw with its posterior margin extending beyond the posterior margin of the pupil (Loeb 2012).

Order Characiformes
Family Curimatidae

Curimata aspera (Günther, 1868): Figure 6C

Curimatus asper Günther 1868: 478–479—Géry 1977: 230; Vari 1989: 50–54.
Curimatus simulatus Eigenmann and Eigenmann 1889: 430.

Material examined. Table 4.

This is a silver-colored species that lacks teeth in its jaws. It is medium-sized, reaching 20 cm TL (Valdiviezo-Rivera et al. 2012). It usually swims in large groups and is especially abundant near the bottom and along the banks of the lagoon. It displays migratory habits. It feeds

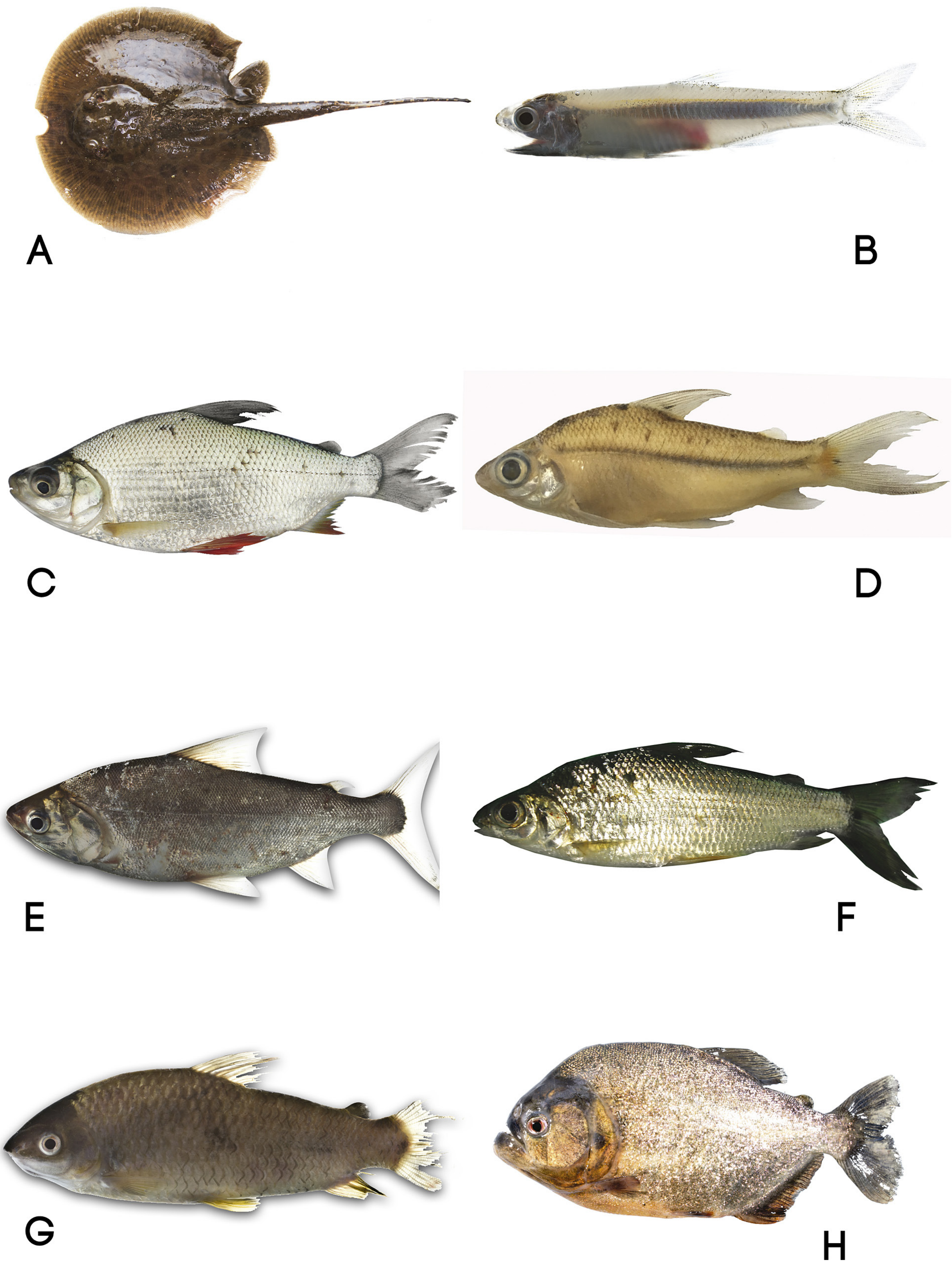

Figure 6. Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Potamotrygon motoro* (photograph by Santiago Calero). **B.** *Anchoviella alleni* (photograph by Santiago Calero). **C.** *Curimata aspera* (photograph by Cecilia Puertas). **D.** *Curimata vittata* (photograph by Jonathan Valdiviezo-Rivera). **E.** *Potamorhina altamazonica* (photograph by Santiago Calero). **F.** *Steindachnerina bimaculata* (photograph by Carolina Carrillo-Moreno). **G.** *Leporinus friderici* (photograph by Santiago Calero). **H.** *Pygocentrus nattereri* (photograph by Santiago Calero).

Table 4. Annotated list of the freshwater fishes of Limoncocha and their respective capture sites L = Limoncocha Lagoon, PI = Pishira River, PL = Playayacu River.

Species	Sites			Voucher material (no. of specimens)
	L	PI	PL	
Myliobatiformes				
Potamotrygonidae				
Potamotrygon motoro	X			MECN-DP: 2462 (1)
Clupeiformes				
Engraulidae				
Anchoviella alleni	X			MECN-DP: 2466 (2)
Characiformes				
Curimatidae				
Curimata aspera	X			MECN-DP: 2291 (1)
Curimata vittata	X			MECN-DP: 2311 (1)
Potamorhina altamazonica	X			MECN-DP: 2280 (2)
				MECN-DP: 2317 (1)
Steindachnerina bimaculata	X			MECN-DP: 2315 (1)
				MECN-DP: 2318 (1)
				MECN-DP: 2467 (1)
				MECN-DP: 2468 (1)
Anostomidae				
Leporinus friderici	X			MECN-DP: 2309 (2)
Serrasalmidae				
Pygocentrus nattereri	X			MECN-DP: 2294 (1)
				MECN-DP: 2313 (1)
				MECN-DP: 2464 (1)
Serrasalmus rhombeus	X		X	MECN-DP: 2293 (1)
Characidae				
Aphyocharax sp.	X			MECN-DP: 2470 (1)
Astyanax abramis	X		X	MECN-DP: 2471 (1)
				MECN-DP: 2475 (1)
Astyanax bimaculatus	X			MECN-DP: 2282 (1)
Astyanax henseli	X			MECN-DP: 2286 (1)
Bryconamericus sp.		X	X	MECN-DP: 2314 (1)
				MECN-DP: 2477 (7)
Chrysobrycon hesperus		X	X	MECN-DP: 2476 (4)
				MECN-DP: 2483 (2)
Creagrutus sp.		X		MECN-DP: 2479 (3)
Ctenobrycon hauxwellianus	X			MECN-DP: 2279 (2)
				MECN-DP: 2284 (2)
				MECN-DP: 2472 (2)
Moenkhausia dichroura	X			MECN-DP: 2283 (1)
Moenkhausia oligolepis		X		MECN-DP: 2319 (1)
				MECN-DP: 2480 (5)
				MECN-DP: 2481 (5)
				MECN-DP: 2482 (3)
Roeboides myersii	X			MECN-DP: 2278 (1)
				MECN-DP: 2287 (1)
				MECN-DP: 2312 (4)
				MECN-DP: 2465 (1)
Tetragonopterus argenteus	X			MECN-DP: 2295 (1)
				MECN-DP: 2469 (2)
				MECN-DP: 2583 (3)
				MECN-DP: 2584 (3)
Triportheidae				
Triportheus elongatus	X			MECN-DP: 2310 (1)
Crenuchidae				
Characidium sp.			X	MECN-DP: 2474 (1)
Siluriformes				
Auchenipteridae				
Trachelyopterus galeatus	X			MECN-DP: 2281 (1)
Loricariidae				
Pterygoplichtys pardalis	X			MECN-DP: 2290 (1)
Pterygoplichtys weberi	X			MECN-DP: 467 (2)
Cyprinodontiformes				
Cynolebiidae				
Anablepsoides cf. *urophthalmus*	X			MECN-DP: 2297 (3)
				MECN-DP: 2484 (3)
Perciformes				
Sciaenidae				
Plagioscion squamosissimus	X			MECN-DP: 2289 (1)
Cichlidae				
Aequidens tetramerus	X			MECN-DP: 2296 (1)
Astronotus ocellatus	X			MECN-DP: 2288 (1)
Bujurquina sp.	X	X	X	MECN-DP: 2285 (1)
				MECN-DP: 2473 (1)
				MECN-DP: 2478 (1)
Crenicichla cincta	X		X	MECN-DP: 2308 (1)
Pleuronectiformes				
Achiridae				
Apionichtys menezesi	X			MECN-DP: 2463 (1)

on bottom-dwelling microorganisms. This fish are highly prized as food and has a high commercial potential. Very little is known about the natural history of this species.

Curimata vittata (Kner, 1858): Figure 6D

Curimatus vittatus Kner 1858a: 76—Géry 1977: 230-232; Vari 1989: 27–30.

Curimata murieli Allen in Eigenmann and Allen 1942: 298–299.

Material examined. Table 4.

This is a silver-colored species that lacks teeth in its jaws. It can be easily recognized from other Curimatidae by its black transverse bands on the back of its body. This species usually travels in large groups and has migratory habits (Vari 1989). These fish are highly prized as a food and have a high ornamental potential (Valdiviezo-Rivera et al. 2012). Very little is known about their natural history.

Potamorhina altamazonica (Cope, 1878): Figure 6E

Curimatus altamazonicus Cope 1878: 684—Vari 1984: 19–23.

Material examined. Table 4.

This is a medium-sized fish with a moderately elongate and robust body, silver color, and with small scales and transparent fins. The mouth is toothless. This species migrates for breeding purposes (Carvalho de Lima and Araújo-Lima 2004) and feeds on algae and organic detritus from the bottom. This is one of the most important food fishes for local villagers (Valdiviezo-Rivera et al. 2012).

Steindachnerina bimaculata (Steindachner, 1876): Figure 6F

Curimatus bimaculatus Steindachner 1876: 76—Vari 1991: 29–30; Galvis et al. 2006: 159–160.

Curimatus trachystethus Cope 1878: 684.

Curimata melaniris Fowler 1940: 253.

Material examined. Table 4.

This body of this species is somewhat compressed and silvery with a dark longitudinal, somewhat diffuse lateral band. Their color pattern consists of small irregularly shaped dark spots on the back of the body, a most noticeable feature of adults of this species (Vari 1991). It has a small toothless mouth. This fish have high commercial value for the aquarium trade. This species is not of major importance in subsistence fishing (Valdiviezo-Rivera et al. 2012).

Family Anostomidae

Leporinus friderici (Bloch, 1794): Figure 6G
Salmo friderici Bloch 1794: 94—Géry 1977: 163; Galvis et al. 2006: 130.

Material examined. Table 4.

This medium-sized species has a robust body with a color pattern consisting of 3 dark oval spots on the midline of the body and a series of less intense vertical bands in the dorsal region. During the breeding season these fish migrate to headwaters to spawn. This species has commercial significance; adult specimens are used for human consumption and juveniles are used as ornamentals (Valdiviezo-Rivera et al. 2012).

Family Serrasalmidae

Pygocentrus nattereri Kner, 1858: Figure 6H
Pygocentrus nattereri Kner 1858b: 166—Galvis et al. 2006: 173–174.
Pygocentrus altus Gill 1870: 93.

Material examined. Table 4.

The body of this species is rhomboid in shape and laterally compressed, with a very robust head. It is dark silver when adult. The jaws are prominent and with strong, sharp teeth. These fish have an excellent olphatory sense (Ghosh and Chakrabarti 2016). They are carnivores and scavengers. They are caught in subsistence fishing.

Serrasalmus rhombeus (Linnaeus, 1766): Figure 7A
Salmo rhombeus Linnaeus 1766: 514—Galvis et al. 2006: 177–178.
Serrasalmo immaculatus Cope 1878: 692.
Serrasalmo boekeri Ahl 1931: 406.

Material examined. Table 4.

This species has a rhomboid-shaped body and an intensely silver color with small rounded dark spots. They have large, sharp teeth, which are used by several Amazonian communities as arrowheads and as scissors to cut hair and meat. These fish feed on scales, aquatic insects, crustaceans, and other smaller fish, but they also eat cyperacean seeds (Machado-Allison and Garcia 1986). Piranhas are prized as food by local people; they have commercial and ornamental value (Valdiviezo-Rivera et al. 2012).

Family Characidae

***Aphyocharax* sp.**: Figure 7B

Material examined. Table 4.

This is a small, elongate, silver-colored species with a deep red caudal fin and the remaining fins yellow; there is a somewhat diffuse longitudinal band, which extends from the eye to the median caudal-fin rays (Galvis et al. 2006). This species has an adipose fin and incomplete lateral line. The dorsal fin is located in the posterior half of its body. These fish have no commercial value but have great potential as ornamental fish due to their striking coloration.

Astyanax abramis (Jenyns, 1842): Figure 7C
Tetragonopterus abramis Jenyns 1842: 123—Géry 1977: 409, 427.

Material examined. Table 4.

This species has a deep, compressed body, and silver coloration, with an oval black spot behind the head and another spot at the base of the caudal fin, which continues to the end of it. Small individuals tend to be omnivorous, preferring plant material and insects, while larger fish are carnivores, preferring microcrustaceans and insects (Barros 2004).

Astyanax bimaculatus (Linnaeus, 1758): Figure 7D
Salmo bimaculatus Linnaeus 1758: 311—Géry 1977: 426-430.
Tetragonopterus bartlettii Günther 1866: 30.
Astyanax bimaculatus borealis Eigenmann 1908: 96.
Astyanax bimaculatus incaicus Tortonese 1942: 62.

Material examined. Table 4.

This species has a compressed body, silver color, and an oval humeral spot. It is a migratory species that lives in rivers, streams, and lakes. It has ornamental value for its color, peaceful disposition, and gregarious behavior (Valdiviezo-Rivera et al. 2012).

Astyanax henseli de Melo & Buckup, 2006: Figure 7E
Astyanax henseli de Melo and Buckup 2006: 46–48.
Tetragonopterus aeneus Hensel 1870: 87–88.

Material examined. Table 4.

The body is dark silver colored dorsally; there is a well-marked black spot on the caudal fin and extending over the central rays, as well as 2 vertically elongated humeral spots. The maxilla has 2–5 teeth in the anterior side (de Melo and Buckup 2006). Very little is known of its natural history.

***Bryconamericus* sp.**: Figure 7F

Material examined. Table 4.

This species has large scales and a silver-colored body, with a dark longitudinal band that increases in intensity towards to the base of the caudal-fin. The base of the caudal fin lacks scales. The lateral line is complete. The maxilla has 4 teeth. This is one of the most common species in the lagoon (Valdiviezo-Rivera et al. 2012). It feeds on aquatic invertebrates (benthos) and terrestrial invertebrates, like ants, wasps and bees, that fall into the water. The natural history of this species is still unknown and nothing can be said about its taxonomy.

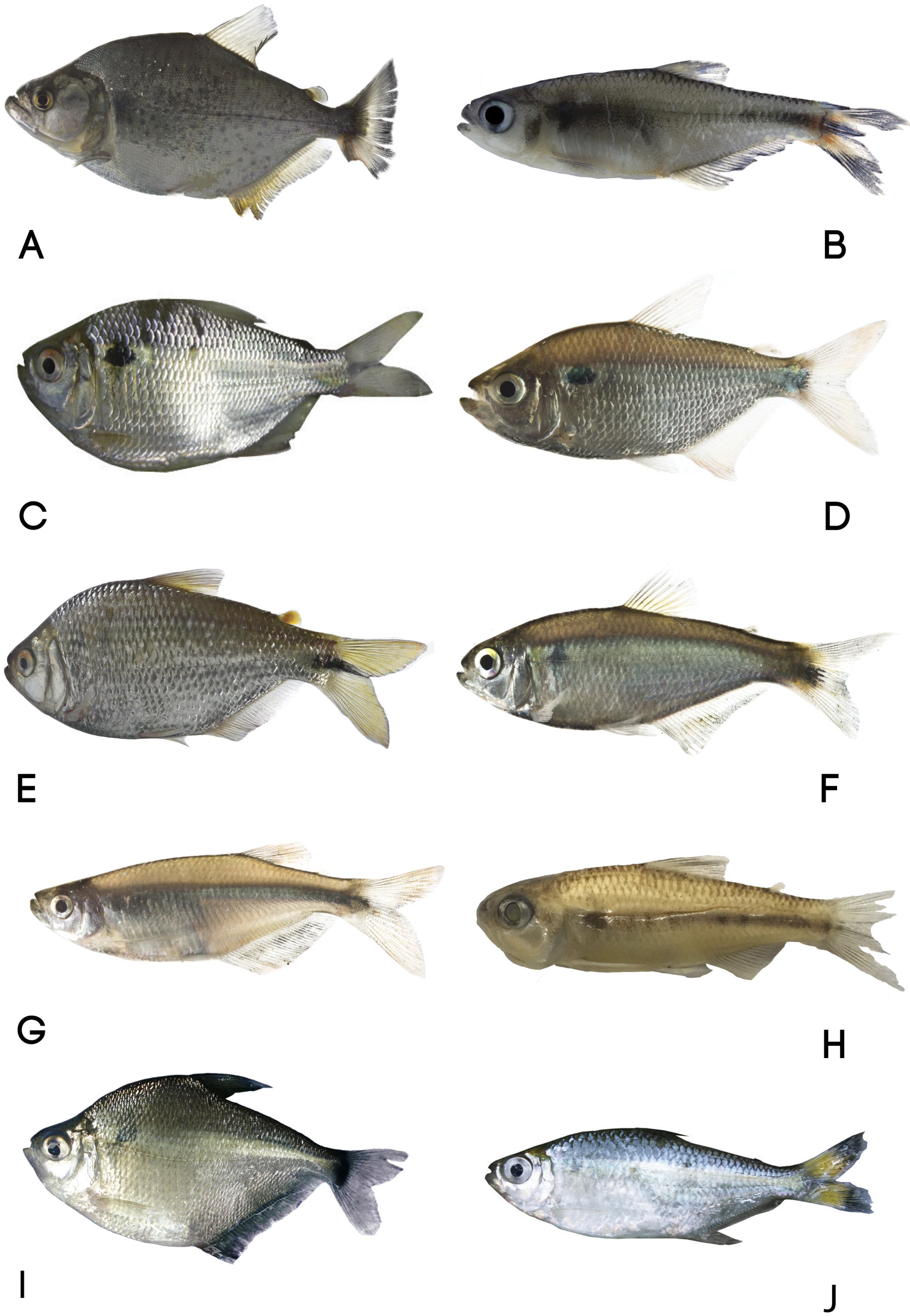

Figure 7. Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Serrasalmus rhombeus* (photograph by Santiago Calero). **B.** *Aphyocharax* sp. (photograph by Carolina Carrillo-Moreno). **C.** *Astyanax abramis* (photograph by Jonathan Valdiviezo-Rivera). **D.** *Astyanax bimaculatus* (photograph by Santiago Calero). **E.** *Astyanax henseli* (photograph by Santiago Calero). **F.** *Bryconamericus* sp. (photograph by Santiago Calero). **G.** *Chrysobrycon hesperus* (photograph by Santiago Calero). **H.** *Creagrutus* sp. (photograph by Jonathan Valdiviezo-Rivera). **I.** *Ctenobrycon hauxwellianus* (photograph by Cecilia Puertas). **J.** *Moenkhausia dichroura* (photograph by Jonathan Valdiviezo-Rivera).

Chrysobrycon hesperus (Böhlke, 1958): Figure 7G

Hysteronotus hesperus Böhlke 1958: 35—Géry 1977: 351–358.

Material examined. Table 4.

This species has an elongated and laterally compressed body with a straight dorsal profile. It is a small species, maximum SL to 8.18 cm (Reis et al. 2003). This species is not very abundant in catches since individuals prefer to stay along the margins among submerged vegetation; they are usually found in areas with moderate current. This species is known to feed on insect larvae, but otherwise, very little is known about its natural history. *Chrysobrycon* spp. present 3–16 teeth in the maxilla, except for *Chrysobrycon guahibo*. In contrast, *Gephyrocharax* has fewer than 6 teeth in the maxilla (Géry 1977, Vanegas-Ríos et al. 2011, Vanegas-Ríos and Urbano-Bonilla 2017).

Ctenobrycon hauxwellianus (Cope, 1870): Figure 7I

Tetragonopterus hauxwellianus Cope 1870: 560—Géry 1977: 431–432, Galvis et al. (2006): 198.

Ctenobrycon rhabdops Fowler 1913: 537.

Material examined. Table 4.

This silver-colored species has a deep, diamond-shaped, laterally compressed body. It inhabits along the banks of rivers with moderate current and a sandy-muddy bottom. It occupies the middle zone of the water column, where it swims upstream on the central canal in schools of 15 or more individuals; overnight it retreats in marginal areas with reduced water flow (Galvis et al. 2006). It has potential as an ornamental fish.

***Creagrutus* sp.**: Figure 7H

Material examined. Table 4.

This is a small undescribed species, which belongs to the genus *Creagrutus*, one of the most diverse genera of Neotropical characins (Harold and Vari 1994). Distinctive features of this genus include the presence of 3 rows of teeth in the premaxilla and a short jaw (Bölhke and Saul 1975 cited by Román-Valencia and Cala 1997). The anal fin has up to 16 rays. This species has no substantial importance for subsistence or commercial fishing (Valdiviezo-Rivera et al. 2012).

Moenkhausia dichroura (Kner, 1858): Figure 7J

Tetragonopterus dichourus Kner 1858a: 80—Géry 1977: 438–442, Galvis et al. 2006: 218.

Material examined. Table 4.

This species has an elongated, silver body, with fins having yellow hues. It is recognized by the silvery line that runs the length of the body from the operculum to the base of the caudal fin. The lobes of the caudal fin have a black band, which do not cover the extremes. It is unimportant in commercial and subsistence fishing due to their small size (Valdiviezo-Rivera et al. 2012). However, this species is used as fishing bait (Valdiviezo-Rivera et al. 2012). It has ornamental potential due to the striking coloration.

Moenkhausia oligolepis (Günther, 1864): Figure 8A

Tetragonopterus oligolepis Günther 1864: 327—Géry 1977: 438–443, Galvis et al. 2006: 222.

Material examined. Table 4.

This is a silver-colored fish; its body is somewhat elongate and compressed. It is recognized by its blood-red upper iris. There is also a black band around the caudal fin from the base to about half the length of the fin. This species has omnivorous habits; it feeds on worms, insects, crustaceans and plant material. This species is an important part of the diet of many birds and other fish. These fish are used as bait (Valdiviezo-Rivera et al. 2012), and they are highly valued as ornamental fish, due to their striking coloration and gregarious behavior.

Roeboides myersii Gill, 1870: Figure 8B

Raeboides myersii Gill 1870: 92—Géry 1977: 315–318, Galvis et al. 2006: 229.

Roeboides rubrivertex Cope 1872: 265.

Charax hasemani Steindachner 1915: 348.

Material examined. Table 4.

This silver-colored fish has a compressed body. The head is pointed and flattened. On the outer part of the upper jaw, there are teeth projecting outward with which they use to feed on the scales of other fish (Galvis et al. 2006). This species inhabit low-current water, where it swims in schools. It is caught, mostly incidentally, by subsistence fishing (Valdiviezo-Rivera et al. 2012).

Tetragonopterus argenteus Cuvier, 1816: Figure 8C

Tetragonopterus argenteus Cuvier 1816: 166—Géry 1977: 450–451, Galvis et al. 2006: 233–234.

Material examined. Table 4.

This silver-colored species has a compressed, disc-shaped body. There are 2 vertically elongated humeral spots. In shape, this species is similar to *Ctenobrycon hauxwellianus* and *Gymnocorymbus thayeri* (Galvis et al. 2006), found previously in RBL (Valdiviezo-Rivera et al. 2012), but it differs by its larger eyes and scales and their stepped lateral line (Galvis et al. 2006). This species feeds on plant material such as seeds and fruits. It is a valued ornamental fish, and it is also used as fishing bait (Valdiviezo-Rivera et al. 2012).

Family Triportheidae

Triportheus elongatus (Günther, 1864): Figure 8D

Chalcinus elongatus Günther 1864: 342—Géry 1977: 342–343; Galvis et al. 2006: 236–237.

Chalcinus elongatus iquitensis Nakashima 1941: 63.

Chalcinus amazonensis Miranda Ribeiro 1941: 174.

Chalcinus cruzi Miranda Ribeiro 1941: 173.

Material examined. Table 4.

The body of this medium-sized species is elongate, compressed and with ventral keel. Although this fish does not represent a large percentage of the fish consumed by locals, they are highly valued for their special flavor, which is thought to result from their omnivorous diet (Goulding et al. 2003).

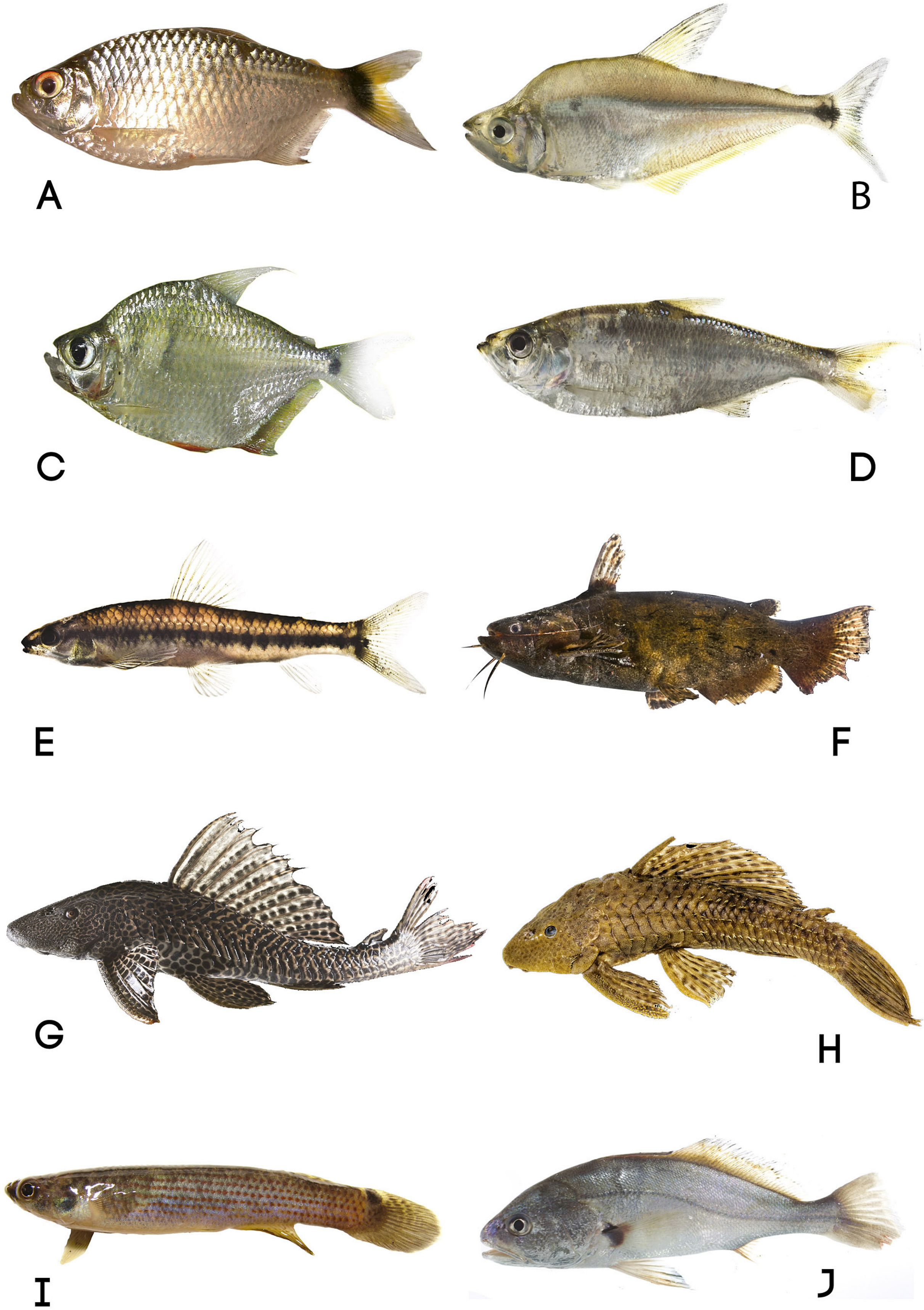

Figure 8. Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Moenkhausia oligolepis* (photograph by Jonathan Valdiviezo-Rivera). **B.** *Roeboides myersii* (photograph by Santiago Calero). **C.** *Tetragonopterus argenteus* (photograph by Jonathan Valdiviezo-Rivera). **D.** *Triportheus elongatus* (photograph by Santiago Calero). **E.** *Characidium* sp. (photograph by Santiago Calero). **F.** *Trachelyopterus galeatus* (photograph by Santiago Calero). **G.** *Pterygoplichthys pardalis* (photograph by Santiago Calero). **H.** *Pterygoplichthys weberi* (photograph by Santiago Calero). **I.** *Anablepsoides* cf. *urophthalmus* (photograph by Jonathan Valdiviezo-Rivera). **J.** *Plagioscion squamosissimus* (photograph by Santiago Calero).

Family Crenuchidae

***Characidium* sp.**: Figure 8E

Material examined. Table 4.

This species has an elongated body. It is light brown with a dark stripe extending from the snout to the base of the caudal-fin; there are 9 transverse bands along its body. There are 2 or more unbranched rays in the mesial portion of the pectoral fin. The lower jaw presents a row of prominent teeth and a second row with much smaller teeth (Maldonado-Ocampo et al. 2005). It lives in both fast-flowing and still water. It is valued as an ornamental fish.

Order Siluriformes
Family Auchenipteridae

Trachelyopterus galeatus (Linnaeus, 1766): Figure 8F
Silurus galeatus Linnaeus 1766: 503–504—Galvis et al. 2006: 275–276.

Material examined. Table 4.

This species has an elongate, robust brown body, with irregular dark brown blotches. It feeds on small fish, worms, insects, and sometimes fruit (Le Bail et al. 2000). This fish is highly valued for food in subsistence fishing but is not important at commercial fishery (Valdiviezo-Rivera et al. 2012).

Family Loricariidae

Pterygoplichthys pardalis (Castelnau, 1855): Figure 8G
Hypostomus pardalis Castelnau 1855: 42—Burgess 1989: 714–747, Galvis et al. 2006: 347–348.
Liposarcus varius Cope 1872: 284.
Liposarcus jeanesianus Cope 1874: 135.

Material examined. Table 4.

Adults of this species present a geometric pattern of light lines on head and lateral spots coalescing to form chevrons that outline the posterior border of the lateral plates; these are mostly discrete spots on the venter and chevrons on the caudal peduncle (Armbruster and Page 2006). The buccal papilla is a single, tongue-shaped structure (Armbruster and Page 2006). The dorsal fin usually bears a strong spine and 11 rays (Armbruster and Page 2006). This benthic, nocturnal species feeds on detritus and periphyton attached to submerged logs and aquatic macrophytes. While it can be found in rivers with current, it prefers backwater areas. It is valued as food but also has commercial value as an ornamental fish (Valdiviezo-Rivera et al. 2012).

Pterygoplichthys weberi Armbruster & Page, 2006: Figure 8H
Pterygoplichthys weberi Armbruster and Page 2006: 406.

Material examined. Table 4.

The buccal papilla is shallowly divided; the dorsal fin usually has a strong spine and 11 rays; and keels are present on all plate rows. The lateral keel odontodes are almost perpendicular to the plates, and in adults, the longest keel odontodes are longer than the lateral line plates (Armbruster and Page 2006). This species, which lives in stream bottoms, mainly feeds on algae and detritus. It has a great importance in subsistence fishing and are highly prized as ornamental fish for their striking color pattern (Valdiviezo-Rivera et al. 2012).

Order Cyprinodontiformes
Family Cynolebiidae

Anablepsoides* cf. *urophthalmus: Figure 8I

Material examined. Table 4.

This is a small, distinct species with a subcylindrical, elongate body; the caudal fin is rounded. It is very tolerant of adverse environmental conditions such as poor water quality and changes in salinity and temperature (Valdiviezo-Rivera et al. 2012). It is highly valued as an aquarium fish.

Order Perciformes
Family Sciaenidae

Plagioscion squamosissimus (Heckel, 1840): Figure 8J
Sciaena squamosissima Heckel 1840: 438—Galvis et al. 2006: 390.
Plagioscion squamosissimus iquitensis Nakashima 1941: 68.

Material examined. Table 4.

This species has an elongate body, an intensely silvery color, and dark spots on all fins. The mouth is terminal and oblique in lateral view (Casatti 2005). The teeth are conical, externally visible in many specimens; the teeth in the inner series of premaxilla are large and conical (Casatti 2005). Scales ctenoid, except for cycloid scales on snout, preopercle, lachrymal, and second to fourth infraorbitals. There are large scales along the lateral line covered by smaller scales. The caudal fin is almost completely covered by scales (Casatti 2005). There are elongate gill rakers on first gill arch (Casatti 2005). When out of water this species can produce noises using its swim bladder. It is valued for human consumption, given the excellent quality of the meat. Despite its commercial importance and potential for fish farming, little is known about its natural history.

Family Cichlidae

Aequidens tetramerus (Heckel, 1840): Figure 9A
Acara tetramerus Heckel 1840: 341—Kullander 1986: 339–347, Galvis et al. 2006: 393.
Chromys uniocellata Castelnau 1855: 15.
Acaronia trimaculata Allen in Eigenmann and Allen 1942: 389.

Material examined. Table 4.

This species has an oval body that varies in color depending on the habitat. It shows 2 oval spots: 1 at the middle of its body and other at the base of the caudal fin. It feeds on insects but also fish and algae (Galvis et al. 2006). This species is valued as an ornamental fish due to its bright colors and its ease of reproduction in captivity. It is

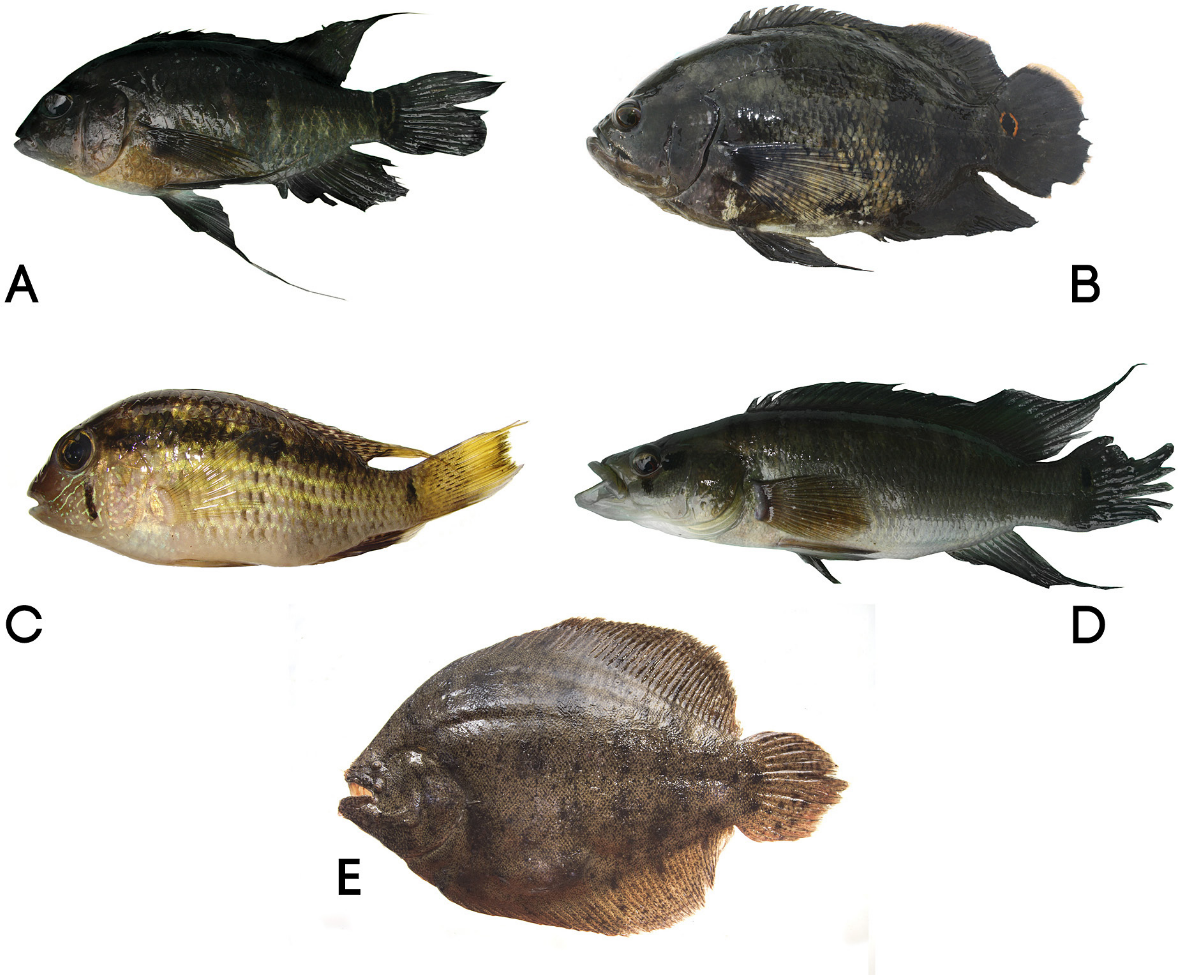

Figure 9. Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Aequidens tetramerus* (photograph by Carolina Carrillo-Moreno). **B.** *Astronotus ocellatus* (photograph by Carolina Carrillo-Moreno). **C.** *Bujurquina* sp. (photograph by Jonathan Valdiviezo-Rivera). **D.** *Crenicichla cincta* (photograph by Carolina Carrillo-Moreno). **E.** *Apionichthys menezesi* (photograph by Santiago Calero).

also important for local subsistence fishing (Valdiviezo-Rivera et al. 2012).

Astronotus ocellatus (Agassiz, 1831): Figure 9B

Lobotes ocellatus Agassiz in Spix et al. 1831: 129—Kullander 1986: 61–70, Galvis et al. 2006: 396.
Acara compressus Cope 1872: 256.
Acara hyposticta Cope 1878: 697.

Material examined. Table 4.

This species has an oval, dark body. There is a vertical black ocellus, which is bordered by an orange stripe on the upper part of the caudal-fin base. This species feeds on small fish, large invertebrates, fruits, and seeds (Saul 1975). This is a popular species in subsistence fishing and is highly sought for local consumption (Valdiviezo-Rivera et al. 2012).

***Bujurquina* sp.**: Figure 9C

Material examined. Table 4.

This species is very similar to *Aequidens tetramerus* but it has a black longitudinal band that extends from the eye to the last ray of the dorsal fin, 6 diffuse vertical bands along the body and a teardrop-shaped band extending from the eye to the operculum (Galvis et al. 2006). *Bujurquina* spp. are omnivores, feeding on fish, aquatic and terrestrial invertebrates, plant material, algae, and detritus; they are very adaptable and their diet varies according to food availability in each season (Keenleyside 1991). They are highly valued as ornamental fish because of their attractive colors and are popular in subsistence fishing.

Crenicichla cincta Regan, 1905: Figure 9D

Crenicichla brasiliensis fasciata Pellegrin 1904: 383.
Crenicichla cincta Regan 1905: 166—Kullander 1986: 44–98.

Material examined. Table 4.

This species has an elongated body and large protractile mouth. The head is depressed, its width and depth about equal behind the orbit (Kullander 1986). The snout is relatively long compared to other small-scaled *Crenicichla* spp. The jaw teeth are simple, conical, and a little recurved (Kullander 1986). The preoperculum is serrated, the interorbital narrower than mouth, and the caudal ocellus prominent (Kullander 1986). Scales are ctenoid; the head, chest, and median abdominal scales are smaller than the flank scales. There are 40–43 horizontal scale series around the caudal peduncle (Kullander 1986). This species eats small fish and other invertebrates. In the breeding season, it seeks out caves in which to lay eggs (Keenleyside 1991). It is a relatively important species in commercial and subsistence fisheries (Valdiviezo-Rivera et al. 2012).

Order Pleuronectiformes
Family Achiridae

Apionichthys menezesi Ramos, 2003: Figure 9E
Apionichthys menezesi Ramos 2003: 111.

Material examined. Table 4.

This species has an oval and compressed body. The eyes are conspicuous and juxtaposed, with contiguous orbits. There are 31–37 anal-fin rays and 27–30 vertebrae. Eyed side with gill opening. Scales are absent from the lips, nasal area, first rays of dorsal fin, and interradial membranes on all fins, except for narrow proximal stripe on caudal fin (Ramos 2003). Most species of *Apionichthys* feed on bottom invertebrates but occasionally they will eat other small fish. This species has no value in the commercial fishery, and although edible, it is not appreciated for subsistence fishing (Valdiviezo-Rivera et al. 2012).

A complete list of the fishes of the Limoncocha Lagoon (RBL) is presented in Table 5. Included are species reported by Walsh (2003) in an unpublished technical report. We identified 81 species from 33 families and 8 orders.

Discussion

Thirty-three species captured in this study comprise almost 5% of the species reported by Barriga (2012) for the NP ichthyographic zone. The most abundant groups are Characiformes (21 spp., 64%), Perciformes (5 spp., 15%) and Siluriformes (3 spp., 9%). These are also the most diverse fish groups in Neotropical ecosystems and occupy many different ecological environments and niches (Lowe-McConnell 1987). Characidae, which is the most species-rich family within Characiformes (Oliveira et al. 2011, Mariguela et al. 2013), was particularly well represented in this study.

The number of species (33) gives a representativeness value of 75%. According to Urbina-Cardona et al. (2008), major or equal values to 70% are valid for infer the community snakes, while for other groups of terrestrial species it is proposed 80% (Colwell and Coddington 1995), although representativeness values have not been determined for estimating the richness of Neotropical fish.

The accumulation curve shows an increasing tendency. One hopes that with a major number of field works, an increase of the effort of sampling and manage of different fishing-tackles would extend the richness value of this lagoon. According to Murillo-Moreno et al. (2006), because the curve does not estabilize, this can be related to low population sizes, low abundance, rare species, and behavior of the organisms. Lowe-McConnell (1975) showed that freshwater habitats with no extreme fluctuation in water level, the fauna is less diverse.

One of the most heavily exploited species is *Prochilodus nigricans*, the Bocachico. *P. nigricans* is a major species in the industrial fisheries of the Amazon, comprising about 20% of the annual catch (Krause et al. 2000). In the Peruvian Amazon, Bocachicos represent 44.7% of the commercial catch landed at Iquitos (Montreuil et al. 2001).

Anchoviella alleni had not been previously documented from the lagoon. According to Whitehead et al. (1988) and Reis et al. (2003), the geographical distribution of this species includes the Morona and Marañón rivers; Barriga (2012) wrote that it occurs throughout the NP ichthyo-hydrographic zone. However, Barriga did not document specific locations, so our data are the first report for *A. alleni* in the Limoncocha Lagoon.

Short (SM) and medium range migratory species (MM) were collected (Zapata and Usma 2013) and included 6 characiform and one perciform species: *Leporinus friderici* (SM), *Tetragonopterus argenteus* (SM), *Curimata aspera* (SM), *Curimata vittata* (SM), *Potamorhina altamazonica* (MM), *Prochilodus nigricans* (MM), and *Plagioscion squamosissimus* (MM). These species inhabit rivers and lacustrine ecosystems, have high fertility rates, and diverse feeding habits (Barthem and Fabre 2004).

The size distribution of individuals is skewed towards smaller size classes probably because younger, smaller ones are typically more abundant than large individuals within fish species. Exploitation of fish species for human consumption may be preventing fish from attaining their maximum size.

Some Neotropical species are difficult to identify because their taxonomy is unclear. For example, Escobar et al. (2015) reported several species of *Moenkhausia*, *Aphyocharax* (Characidae), *Thoracocharax*, *Gasteropelecus* (Gasteropelecidae) and *Triportheus* (Triportheidae) from Yasuní National Park, Ecuador, have complex phylogenetic histories and potentially high cryptic diversity. Likewise, there are multiple species of *Characidium* that are not yet formally described (Da Graça and Pavanelli 2008), which makes their identification extremely difficult.

The government has not adopted fish conservation measures such as minimum catch sizes, closed fishing seasons, and regulations to limit by-catch, etc. These measures could reduce affects of fishing on the ichthyofauna of the RBL, especially for commercially important migratory species.

Our study builds on previous work by Walsh (2003), Valdiviezo-Rivera et al. (2012) and Bastidas et al. (2014) by sampling at a different time of year than previous studies, providing detailed information on the distribution of the fishes in the rivers and lagoon, and also a comprehensive list of the fishes in the RBL, adding *Astyanax*

Table 5. Comprehensive list of the fishes of the Limoncocha Lagoon, Napo river basin, northern Amazon region of Ecuador (including our own data and bibliographic revision).

Species	Source
Order Myliobatiformes	
Family Potamotrygonidae	
Potamotrygon motoro (Müller & Henle, 1841)	Walsh (2003), Valdiviezo-Rivera et al. (2012), present study
Potamotrygon scobina (Garman, 1913)	Valdiviezo-Rivera et al. (2012)
Order Clupeiformes	
Family Engraulidae	
Anchoviella alleni (Myers, 1940)	Valdiviezo-Rivera et al. (2012), present study
Order Characiformes	
Family Hemiodontidae	
Hemiodus unimaculatus (Bloch, 1794)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Curimatidae	
Curimata aspera (Günther, 1868)	Valdiviezo-Rivera et al. (2012), present study
Curimata vittata (Kner, 1858)	Walsh (2003), Valdiviezo-Rivera et al. (2012), present study
Curimatella alburna (Müller & Troschel, 1844)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Curimatopsis macrolepis (Steindachner, 1876)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Potamorhina altamazonica (Cope, 1878)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Psectrogaster amazonica (Eigenmann & Eigenmann, 1889)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Steindachnerina bimaculata (Steindachner, 1876)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Family Prochilodontidae	
Prochilodus nigricans (Spix & Agassiz, 1829)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014)
Family Anostomidae	
Leporinus friderici (Bloch, 1794)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Schizodon fasciatus (Spix & Agassiz, 1829)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Erythrinidae	
Hoplerythrinus unitaeniatus (Spix & Agassiz, 1829)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Hoplias malabaricus (Bloch, 1794)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014)
Family Lebiasinidae	
Copeina guttata (Steindachner, 1876)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Pyrrhulina semifasciata (Steindachner, 1876)	Valdiviezo-Rivera et al. (2012)
Family Gasteropelecidae	
Carnegiella strigata (Günther, 1864)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Thoracocharax stellatus (Kner, 1858)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Ctenoluciidae	
Boulengerella maculata (Valenciennes, 1850)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Acestrorhynchidae	
Acestrorhynchus lacustris (Lütken, 1875)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Cynodontidae	
Hydrolycus cf. *scomberoides*	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Rhaphiodon vulpinus (Spix & Agassiz, 1829)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Serrasalmidae	
Mylossoma duriventre (Cuvier, 1818)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Piaractus brachypomus (Cuvier, 1818)	Valdiviezo-Rivera et al. (2012)
Pygocentrus nattereri Kner, 1858	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Serrasalmus rhombeus (Linnaeus, 1766)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Family Characidae	
Aphyocharax sp.	Walsh (2003), Valdiviezo-Rivera et al. (2012), present study
Astyanax abramis (Jenyns, 1842)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Astyanax bimaculatus (Linnaeus, 1758)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Astyanax henseli de Melo & Buckup, 2006	Present study
Brachychalcinus nummus (Böhlke, 1958)	Valdiviezo-Rivera et al. (2012)
Bryconamericus sp.	Valdiviezo-Rivera et al. (2012), present study
Charax tectifer (Cope, 1870)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Chrysobrycon hesperus (Böhlke, 1958)	Valdiviezo-Rivera et al. (2012), present study
Creagrutus sp.	Present study
Ctenobrycon hauxwellianus (Cope, 1870)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Gymnocorymbus thayeri (Eigenmann, 1908)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Moenkhausia dichroura (Kner, 1858)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Moenkhausia oligolepis (Günther, 1864)	Valdiviezo-Rivera et al. (2012), present study

Table 5. *Continued.*

Species	Source
Roeboides myersii Gill, 1870	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Tetragonopterus argenteus Cuvier, 1816	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Family Triportheidae	
Triportheus angulatus (Spix & Agassiz, 1829)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014)
Triportheus elongatus (Günther, 1864)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Family Crenuchidae	
Characidium sp.	Valdiviezo-Rivera et al. (2012), present study
Order Siluriformes	
Family Doradidae	
Oxydoras niger (Valenciennes, 1821)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Auchenipteridae	
Ageneiosus sp.	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Auchenipterus nuchalis (Spix & Agassiz, 1829)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Trachelyopterus galeatus (Linnaeus, 1766)	Walsh (2003), Valdiviezo-Rivera et al. (2012), present study
Family Pimelodidae	
Calophysus macropterus (Lichtenstein, 1819)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Leiarius marmoratus (Gill, 1870)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Pimelodus pictus (Steindachner, 1877)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Heptapteridae	
Pimelodella sp.	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Rhamdia quelen (Quoy & Gaimard, 1824)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Callichthyidae	
Callichthys callichthys (Linnaeus, 1758)	Valdiviezo-Rivera et al. (2012)
Corydoras arcuatus (Elwin, 1938)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Loricariidae	
Ancistrus alga (Cope, 1872)	Valdiviezo-Rivera et al. (2012)
Aphanotorulus unicolor (Steindachner, 1908)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Farlowella platorynchus (Retzer & Page, 1997)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Hypostomus oculeus (Fowler, 1943)	Valdiviezo-Rivera et al. (2012)
Loricaria simillima (Regan, 1904)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Panaqolus sp.	Valdiviezo-Rivera et al. (2012)
Peckoltichthys bachi (Boulenger, 1898)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Pterygoplichthys pardalis (Castelnau, 1855)	Valdiviezo-Rivera et al. (2012), present study
Pterygoplichthys weberi Armbruster & Page, 2006	Walsh (2003), Valdiviezo-Rivera et al. (2012), present study
Rineloricaria cf. *lanceolata*	Valdiviezo-Rivera et al. (2012)
Sturisoma sp.	Valdiviezo-Rivera et al. (2012)
Order Gymnotiformes	
Family Sternopygidae	
Sternopygus macrurus (Bloch & Schneider, 1801)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Family Gymnotidae	
Electrophorus electricus (Linnaeus, 1766)	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Gymnotus carapo (Linnaeus, 1758)	Valdiviezo-Rivera et al. (2012)
Order Cyprinodontiformes	
Family Cynolebiidae	
Anablepsoides cf. *limoncochae*	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Anablepsoides cf. *urophthalmus*	Valdiviezo-Rivera et al. (2012), present study
Order Perciformes	
Family Sciaenidae	
Plagioscion squamosissimus (Heckel, 1840)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Family Cichlidae	
Aequidens tetramerus (Heckel, 1840)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Astronotus ocellatus (Agassiz, 1831)	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Bujurquina sp.	Valdiviezo-Rivera et al. (2012), present study
Cichla monoculus Spix & Agassiz 1831	Walsh (2003), Valdiviezo-Rivera et al. (2012)
Crenicichla cincta Regan, 1905	Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study
Crenicichla johanna (Heckel, 1840)	Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014)
Order Pleuronectiformes	
Family Achiridae	
Apionichthys menezesi Ramos, 2003	Valdiviezo-Rivera et al. (2012), present study

henseli and *Creagrutus* sp. to the faunal list. We failed to find *Arapaima gigas*, a species that has been identified by local fishermen and park rangers (pers. com. I Cerda 2015, D Paredes 2015). It is probable that additional species can be collected with continued sampling efforts.

While there are some data on fish richness and abundance in the RBL (e.g., Walsh 2003, Valdiviezo-Rivera et al. 2012, Bastidas et al. 2014), and despite the important contributions of the present study, further research on the taxonomy, systematics, diversity, and the impacts of fishing are needed, and particularly more study on the use of fishes by local communities for food and commercialization is required.

Acknowledgements

We acknowledge Universidad Internacional SEK - Ecuador for the financial support of this study. We also thank for their collaboration: Verónica López (Fig. 1), Glenda Pozo and Mario Yánez (Fig. 5), Francisco Mosquera (Figs 6–9). Windsor Aguirre read the manuscript and made suggestions for its improvement. We are grateful to anonymous reviewers.

Authors' Contributions

JV and CC collected the fish specimens, made the data analysis. All authors wrote and corrected the text.

References

Aguirre WE, Navarrete R, Malato G, Calle P, Loh MK, Vital WF, Valadez G, Vu V, Shervette VR, Granda JC (2016) Body shape variation and population genetic structure of *Rhoadsia altipinna* (Characidae: Rhoadsiinae) in southwestern Ecuador. Copeia 104 (2): 554–569. https://doi.org/10.1643/CG-15-289

Ahl E (1931) Diagnosen einiger neuer südamerikanischer Süßwasserfische. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1930: 405–409.

Albuja L, Almendáriz A, Barriga R, Montalvo LD, Cáceres F, Román JL (2012) Fauna de Vertebrados del Ecuador, 1st edition. Instituto de Ciencias Biológicas, Escuela Politécnica Nacional, Quito, 485 pp.

Alverson WS, Vriesendorp C, del Campo A, Moskovits DK, Stotz DF, García-Donayre M, Borbor LA (Eds) (2008) Ecuador-Perú: Cuyabeno-Güeppí. Rapid Biological and Social Inventories Report 20. The Field Museum, Chicago, 150 pp.

Armbruster JW, Page LM (2006) Redescription of *Pterygoplichthys punctatus* and description of a new species of *Pterygoplichthys* (Siluriformes: Loricariidae). Neotropical Ichthyology 4 (4): 401–409. https://doi.org/10.1590/S1679-62252006000400003

Barriga R (2012) Lista de Peces de agua dulce e intermareales del Ecuador. Revista Politécnica 30 (3): 83–119.

Barros SE (2004) Alimentación de *Astyanax abramis* (Characiformes: Characidae) en el Embalse Cabral Corral, Salta, Noroeste de Argentina. AquaTIC 20: 88–96.

Barthem R, Fabre N (2004) Biologia e diversidade dos recursos pesqueiros da Amazônia. In: Ruffino ML (Ed.) A pesca e os recursos pesqueiros na Amazônia brasileira. Ibama/ ProVárzea, Manaus, 17–56.

Bastidas O, Freire E, Puertas C, Bejarano P, Pozo G, Tinoco N In: Muñoz V, Gea-Izquierdo E (Eds) (2014) Estudio Socio Ambiental de la Reserva Biológica de Limoncocha: Línea Base para el Plan de Manejo Sostenible del Área Protegida. Ministerio del Ambiente, Quito, 142 pp.

Bloch ME (1794) Naturgeschichte der ausländischen Fische. Vol. 8. Auf Kosten des Verfassers und in Commission bei dem Buchhändler Hr. Hesse, Berlin, 174 pp.

Böhlke JE (1958) Studies on fishes on the family Characidae: No. 14. A report on several extensive recent collections from Ecuador. Proceedings of the Academy of Natural Sciences of Philadelphia 110: 1–121.

Bölhke RJ, Saul WG (1975) The characid fish new genus *Creagrudite* Myers a synonym of *Creagrutus* Günther, with the description of a new species from Amazonian Ecuador. Proceedings of the Academy of Natural Sciences of Philadelphia 127 (3): 25–28.

Burgess WE (1989) An Atlas of Freshwater and Marine Catfishes. A Preliminary Survey of the Siluriformes. T.F.H. Publications, Neptune City, 784 pp.

Cañadas L (1983) El Mapa Bioclimático y Ecológico del Ecuador. MAG-PRONAREG, Quito, 210 pp.

Carvalho de Lima A, Araújo-Lima CARM (2004) The distributions of larval and juvenile fishes in Amazonian rivers of different nutrient status. Freshwater Biology 49 (6): 787–800. https://doi.org/10.1111/j.1365-2427.2004.01228.x

Casatti L (2005) Revision of the South American freshwater genus *Plagioscion* (Teleostei, Perciformes, Sciaenidae). Zootaxa 1080 (1): 39–64. https://doi.org/10.11646/zootaxa.1080.1.4

Castelnau FL (1855) Poissons. In: Bertrand P (Ed.) Animaux nouveaux ou rares recueillis pendant l'expédition dans les parties centrales de l'Amérique du Sud, de Rio de Janeiro à Lima, et de Lima au Para; exécutée par ordre du gouvernement Français pendant les années 1843 à 1847, sous la direction du Comté Francis de Castelnau. P. Bertrand, Paris, i–xii, 1–112, pls. 1–50.

Colinvaux P (1985) Por qué son escasas las fieras. Una introducción a la ecología. Ediciones Orbis, Madrid, 245 pp.

Colwell RK, Coddington JA (1995) Estimating terrestrial biodiversity through extrapolation. In: Hawksworth DL (Ed.) Biodiversity Measurement and Estimation. Chapman & Hall, New York, 101–106.

Cope ED (1870) Contribution to the ichthyology of the Marañon. Proceedings of the American Philosophical Society 11: 559-570.

Cope ED (1872) On the fishes of the Ambyiacu River. Proceedings of the Academy of Natural Sciences of Philadelphia 23: 250–294.

Cope ED (1874) On some Batrachia and Nematognathi brought from the Upper Amazon by Prof. Orton. Proceedings of the Academy of Natural Sciences of Philadelphia 26: 120–137.

Cope ED (1878) Synopsis of the Fishes of the Peruvian Amazon, obtained by Professor Orton during his expeditions of 1873 and 1877. Proceedings of the American Philosophical Society 17 (101): 673–701.

Cuvier G (1816) Le Règne Animal distribué d'après son organisation pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée. Les reptiles, les poissons, les mollusques et les annélides, 1st edition. Vol. 2. Deterville Libraire Paris, 532 pp. https://doi.org/10.5962/bhl.title.41460

Da Graça WJ, Pavanelli CS (2008) *Characidium heirmostigmata,* a new characidiin fish (Characiformes: Crenuchidae) from the upper rio Paraná basin, Brazil. Neotropical Ichthyology 6 (1): 53–56.

de Melo FAG, Buckup PA (2006) *Astyanax henseli*, a new name for *Tetragonopterus aeneus* Hensel, 1870 from southern Brazil (Teleostei: Characiformes). Neotropical Ichthyology 4 (1): 45–52. https://doi.org/10.1590/S1679-62252006000100003

Eigenmann CH (1908) Preliminary descriptions of new genera and species of tetragonopterid characins (Zoölogical Results of the Thayer Brazilian expedition). Bulletin of the Museum of Comparative Zoology at Harvard College 52 (6): 91–106.

Eigenmann CH, Eigenmann RS (1989) A revision of the edentulous genera of Curimatinae. Annals of the New York Academy of Sciences 4 (12): 409–440.

Eigenmann CH, Allen WR (1942) Fishes of western South America. I. The intercordilleran and Amazonian Lowlands of Peru. II. The High

Pampas of Peru, Bolivia, and Northern Chile. With a revision of the Peruvian Gymnotidae, and of the genus *Orestias*. University of Kentucky, Lexington, 494 pp. https://doi.org/10.5962/bhl.title.11454

Eschmeyer WN, Fricke R, van der Laan R (Eds) (2017) Catalog of Fishes: Genera, Species, References. Version 31 May 2017. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed on: 2017-6-27.

Escobar-Camacho D, Barriga R, Ron SR (2015) Discovering hidden diversity of Characins (Teleostei: Characiformes) in Ecuador's Yasuní National Park. PLoS ONE 10 (8): e0135569. https://doi.org/10.1371/journal.pone.0135569

Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE, Niem VN (1995a) FAO Species Identification Guide for Fishery Purposes. Eastern Central Pacific. Vol. II. Vertebrates—Part 1. FAO, Rome, 553 pp.

Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE, Niem VN (1995b) FAO Species Identification Guide for Fishery Purposes. Eastern Central Pacific. Vol. III. Vertebrates—Part 2. FAO, Rome, 612 pp.

Fowler HW (1913) Fishes from the Madeira River, Brazil. Proceedings of the Academy of Natural Sciences of Philadelphia 65: 517–579.

Fowler HW (1940) A collection of fishes obtained by Mr. William C. Morrow in the Ucayali River Basin, Peru. Proceedings of the Academy of Natural Sciences of Philadelphia 91: 219–289.

Fowler HW (1943) A collection of fresh-water fishes from Colombia, obtained chiefly by Brother Nicéforo Maria. Proceedings of the Academy of Natural Sciences of Philadelphia 95: 223–266.

Galvis G, Mojica JI, Duque SR, Castellanos C, Sánchez-Duarte P, Arce M, Gutiérrez A, Jiménez LF, Santos M, Vejarano S, Arbeláez F, Prieto E, Leiva M (2006) Serie de Guías Tropicales de Campo: Peces del medio Amazonas Región de Leticia. Conservation International, Bogotá, 546 pp.

Garman S (1913) The Plagiostomia (Sharks, skates and rays). Memoirs of the Museum of Comparative Zoology at Harvard College 36: 1–546. https://doi.org/10.5962/bhl.title.43732

Géry J (1977) Characoids of the World. T.F.H. Publications, Nepture City, 672 pp.

Ghosh SK, Chakrabarti P (2016) Histological, topographical and ultrastructural organization of different cells lining the olfactory epithelium of Red Piranha, *Pygocentrus nattereri* (Characiformes, Serrasalmidae). Vestnik zoologii 50 (5): 447–456. https://doi.org/10.1515/vzoo-2016-0051

Gill TN (1870) On some new species of fishes obtained by Prof. Orton from the Maranon, or Upper Amazon, and Napo rivers. Proceedings of the Academy of Natural Sciences of Philadelphia 22: 92–96.

Goulding M, Cañas C, Barthem R, Forsberg B, Ortega H (2003) Las Fuentes del Amazonas: Ríos, vida y conservación de la Cuenca del Madre de Dios. ACCA-ACA, Lima, 139 pp.

Günther ACLG (1864) Catalogue of the Physostomi, containing the families Siluridae, Characinidae, Haplochitonidae, Sternoptychidae, Scopelidae, Stomiatidae in the collection of the British Museum. Catalogue of the fishes in the British Museum, vol. 5. British Museum, London, 455 pp.

Günther ACLG (1866) Remarks on some fishes from the river Amazons in the British Museum. Annals and Magazine of Natural History (series 3) 18: 30–31.

Günther ACLG (1868) Diagnoses of some new freshwater fishes from Surinam and Brazil, in the collection of the British Museum. Annals and Magazine of Natural History (series 4) 1: 475-481.

Harold AS, Vari RP (1994) Systematics of the Trans-Andean species of *Creagrutus* (Ostariophysi: Characiformes: Characidae). Smithsonian Contributions to Zoology 551: 1–31. https://doi.org/10.5479/si.00810282.551

Heckel J (1840) Johann Natterer's neue Flussfische Brasilien's nach den Beobachtungen und Mittheilungen des Entdeckers. Annalen des Wiener Museums der Naturgeschichte 2: 325–471. https://doi.org/10.5962/bhl.title.101457

Hensel R (1870) Beiträge zur Kenntniss der Wirbelthiere Südbrasiliens. Archiv für Naturgeschichte 36(1): 87-88. http://www.biodiversitylibrary.org/page/7082229#page/95/mode/1up

Jácome-Negrete I (2013) Etnoictiología Kichwa de las lagunas de la cuenca baja del río Curaray (Amazonia), Ecuador. Biota Colombiana 14 (1): 5–24.

Jácome-Negrete I, Guarderas L (Eds) (2005) Sumac Jita: Introducción al conocimiento de la diversidad, ecología y uso de los principales recursos biológicos de tres ecosistemas de lagunas de territorio quichua de Yana Yacu, Pastaza. Instituto Quichua de Biotecnología Sacha Supai, Quito, 110 pp.

Jenyns L (1842) Part IV: fish. In: Darwin C (Ed.) The Zoology of the Voyage of H.M.S. Beagle, Under the Command of Captain Fitzroy, R.N., During the Years 1832 to 1836. London: Smith, Elder and Co., London, 1–172. https://doi.org/10.5962/bhl.title.14216

Jiménez-Prado P, Aguirre W, Laaz-Moncayo E, Navarrete-Amaya R, Nugra-Salazar F, Rebolledo-Monsalve E, Zárate-Hugo E, Torres-Noboa A, Valdiviezo-Rivera J (2015) Guía de peces para aguas continentales en la vertiente occidental del Ecuador. PUCESE, UDA and INABIO, Esmeraldas, 416 pp.

Keenleyside MH (Ed.) (1991) Cichlid Fishes: Behaviour, Ecology and Evolution. Springer, Cambridge, 378 pp.

Kner R (1858a) Beiträge zur Familie der Characinen. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe 30 (13): 75–80.

Kner R (1858b) Zur Familie der Characinen. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe 32 (22): 163–168.

Krause J, Chávez J, Espinoza W, Montreuil V (Eds) (2000) Desarrollo de la Acuicultura en la Amazonía Continental. Proyecto IICA-GTZ, Procitropicos, Fontagro, IIAP, Lima, 140 pp.

Kullander SO (1986) Cichlid fishes of the Amazon river drainage of Peru. Swedish Museum of Natural History, Stockholm, 431 pp.

Lasso CA, Rosa RS, Sánchez-Duarte P, Morales-Betancourt MA, Agudelo-Córdoba E (Eds) (2013) Rayas de agua dulce (Potamotrygonidae) de Suramérica. Parte I. Colombia, Venezuela, Ecuador, Perú, Brasil, Guyana, Surinam y Guayana Francesa: diversidad, bioecología, uso y conservación. Serie Recursos Hidrobiológicos y Pesqueros Continentales de Colombia, IX. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogotá, 368 pp.

Le Bail PY, Keith P, Planquette P (2000) Atlas des poissons d΄eau douce de Guyane. Tome 2, Fascicule II. Patrimoines naturels, Séries Patrimone génétique 43 (2): 307 pp.

Linnaeus C (1758) Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima. Laurentii Salvii, Holmiae, 824 pp. https://doi.org/10.5962/bhl.title.542

Linnaeus C (1766) Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio duodecima. Laurentii Salvii, Holmiae, 532 pp. https://doi.org/10.5962/bhl.title.68927

Loeb MV (2012) A new species of *Anchoviella* Fowler, 1911 (Clupeiformes: Engraulidae) from the Amazon basin, Brazil. Neotropical Ichthyology 10 (1): 13–18. https://doi.org/10.1590/S1679-62252012000100002

Lowe-McConnell RH (1975) Fish Communities in Tropical Freshwaters. Their Distribution, Ecology and Evolution. Longman, New York, 337 pp.

Lowe-McConnell RH (1987) Ecological Studies in Tropical Fish Communities. Cambridge University Press, Cambridge, 382 pp.

Lujan NK, Armbruster JW, Lovejoy NR, López-Fernández H (2015) Multilocus molecular phylogeny of the suckermouth armored catfishes (Siluriformes: Loricariidae) with a focus on subfamily Hypostominae. Molecular Phylogenetics and Evolution 82: 269–288. https://doi.org/10.1016/j.ympev.2014.08.020

Machado-Allison A, Garcia C (1986) Food habits and morphological changes during ontogeny in three serrasalmin fish species of the Venezuelan floodplains. Copeia 1986 (1): 193–195.

Malabarba LR, Weitzman SH (2003) Description of new genus with six new species from southern Brazil, Uruguay and Argentina, with a discussion of a putative characid clade (Teleostei: Characiformes: Characidae). Comunicações do Museu de Ciências e Tecnologia da PUCRS, Série Zoologia 16 (1): 67–151.

Malabarba MCSL (2004) Revision of the Neotropical genus *Triportheus* Cope, 1872 (Characiformes: Characidae). Neotropical Ichthyology 2 (4): 167–204. https://doi.org/10.1590/S1679-62252004000400001

Malabarba MCSL, Malabarba LR (1994) *Hypobrycon maromba*, a new genus and species of characiform fish from the upper rio Uruguay, Brazil (Ostariophysi: Characidae). Ichthyological Exploration of Freshwaters 5 (1): 19–24.

Maldonado-Ocampo JA, Ortega-Lara A, Usma Oviedo JS, Galvis Vergara G, Villa-Navarro FA, Vásquez Gamboa L, Prada-Pedreros S, Ardila Rodríguez C (2005) Peces de los Andes de Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogotá, 346 pp.

Mariguela TC, Ortí G, Avelino GS, Abe KT, Oliveira C (2013) Composition and interrelationships of a large Neotropical freshwater fish group, the subfamily Cheirodontinae (Characiformes: Characidae): a case study based on mitochondrial and nuclear DNA sequences. Molecular Phylogenetics and Evolution 68 (1): 23–24. https://doi.org/10.1016/j.ympev.2013.03.011

Miranda Ribeiro P (1941) Notas para o estudo dos Caracinideos Brasileiros (Peixes–genero *Chalcinus* Cuv. & Val. 1849). Papéis Avulsos de Zoologia (São Paulo) 1 (18): 159–174.

Montreuil V, García A, Rodríguez R (2001) Biología reproductiva de “Boquichico”, *Prochilodus nigricans,* en la Amazonía peruana. Folia Amazónica 12 (1–2): 5–13.

Müller J, Henle J (1841) Systematische Beschreibung der Plagiostomen. Verlag von Veit und Comp, Berlin, 350 pp. https://doi.org/10.5962/bhl.title.6906

Murillo-Moreno FJ, Rivas-Lara TS, Saldarriaga MM (2006) Caracterización taxonómica y aspectos ecológicos de la fauna de ofidios de la cuenca hidrográfica del río Cabí, Chocó-Colombia. Revista Institucional Universidad Tecnológica del Chocó Diego Luís Córdova 24: 43–53.

Myers GS (1940) The Neotropical anchovies of the genus *Amplova.* Proceedings of the California Academy of Sciences 23 (29): 437–442.

Nakashima S (1941) Algunos peces del Oriente peruano. Boletín del Museo de Historia Natural “Javier Prado” de la Universidad Nacional Mayor de San Marcos 5 (16): 61–78.

Nathan KL, Meza-Vargas V, Barriga R (2015) Two new *Chaetostoma* Group (Loricariidae: Hypostominae) sister genera from opposite sides of the Andes Mountains in Ecuador, with the description of one new species. Copeia 103 (3): 651–663. https://doi.org/10.1643/CI-15-246

Nelson JS, Grande TC, Wilson MVH (2016) Fishes of the World, 5th edition. John Wiley & Sons, Hoboken, 752 pp.

Oliveira C, Avelino GS, Abe KT, Mariguela TC, Benine RC, Ortí G, Vari RP, Correa e Castro RM (2011) Phylogenetic relationships within the speciose family Characidae (Teleostei: Ostariophysi: Characiformes) based on multilocus analysis and extensive ingroup sampling. BioMed Central Evolutionary Biology 11 (275): 1–25. https://doi.org/10.1186/1471-2148-11-275

Pellegrin J (1904) Contribution à l’étude anatomique, biologique et taxonomique des poissons de la famille des Cichlidés. Mémoires de la Société Zoologique de France 16: 41–400.

Ramos RTC (2003) Systematic review of *Apionichthys* (Pleuronectiformes: Achiridae), with description of four new species. Ichthyological Exploration of Freshwaters 14 (2): 97–126.

Regan CT (1905) A revision of the Fishes of the South-American cichlid genera *Crenacara, Batrachops,* and *Crenicichla*. Proceedings of the Zoological Society of London 1: 152–168. https://doi.org/10.1111/j.1469-7998.1905.tb08373.x

Reis RE, Kullander SO, Ferraris CJ Jr (2003) Check List of the Freshwater Fishes of South and Central America. EDIPUCRS, Porto Alegre, 729 pp.

Reis RE, Albert JS, Di Dario F, Mincarone MM, Petry P, Rocha LA (2016) Fish biodiversity and conservation in South America. Journal of Fish Biology 89 (1): 12–47. https://doi.org/10.1111/jfb.13016

Román-Valencia C, Cala P (1997) Las especies colombianas del género *Creagrutus* (Pisces, Characidae). Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 21 (79): 143–153.

Román-Valencia C, Ruiz RI, Barriga R (2005) Una nueva especie ecuatoriana del género de peces andinos *Grundulus* (Characiformes: Characidae). Revista de Biológica Tropical 53 (3–4): 537–544. https://doi.org/10.15517/rbt.v53i3-4.14668

Román-Valencia C, Ruiz RI, Taphorn B DC, García C (2013) Three new species of *Bryconamericus* (Characiformes, Characidae), with keys for species from Ecuador and a discussion on the validity of the genus *Knodus*. Animal Biodiversity and Conservation 36 (1): 123–139.

Saul WG (1975) An ecological study of fishes at a site in upper amazonian Ecuador. Proceedings of the Academy of Natural Sciences of Phildelphia 127: 93–134.

Sierra R (Ed.) (1999) Propuesta Preliminar de un Sistema de Clasificación de Vegetación para el Ecuador Continental. Proyecto INEFAN/GEF-BIRF and Ecociencia, Quito, 194 pp.

Silva JFP (2004) Two new species of *Bryconamericus* Eigenmann (Characiformes: Characidae) from southern Brazil. Neotropical Ichthyology 2 (2): 55–60. https://doi.org/10.1590/S1679-62252004000200002

Silva JFP, Malabarba LR (1996) Description of a new species of *Hypobrycon* from the upper rio Uruguai, Brazil (Ostariophysi: Characidae). Comunicações do Museu de Ciências e Tecnologia da PUCRS, Série Zoologia 9: 45–53.

Spix JB, Agassiz L, Martius FCP (1831) Selecta genera et species piscium quos in itinere per Brasiliam annis MDCCCXVII–MDCCCXX jussu et auspiciis Maximiliani Josephi I. bavariae regis augustissimi. Typis C. Wolf, Munich, part 1: i–xvi, i–ii, 1–82 pp., pls 1–48; part 2: 83–138 pp., pls 49–101. https://doi.org/10.5962/bhl.title.9366

Steindachner F (1876) Ichthyologische Beiträge (V). Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe 74 (6): 49–240.

Steindachner F (1915) Ichthyologische Beiträge (XVIII). Kaiserliche Akademie der Wissenschaften in Wien Mathematisch-naturwissenschaftliche Klasse 124: 567–591.

Tortonese E (1942) Ricerche ed osservazioni sui Caracidi delle sottofamiglie Tetragonopterinae, Glandulocaudinae e Stethaprioninae (Teleostei Plectospondyli). Bollettino dei Musei di Zoologia ed Anatomia Comparata della Reale Università di Torino (serie 4) 49 (117): 11–86.

Urbina JN, Londoño MC, García DG (2008) Dinámica espacio-temporal en la diversidad de serpientes en cuatro hábitats con diferente grado de alteración antropogénica en el Parque Nacional Natural Isla Gorgona, Pacífico colombiano. Caldasia 30 (2): 479–493.

Valdiviezo-Rivera J, Carrillo-Moreno C, Madera Arends R, Albarracín Rodas, ME (2012) Guía de peces de Limoncocha. Universidad Internacional SEK, Quito, 131 pp.

Vallejo I (2014) Petróleo, desarrollo y naturaleza: aproximaciones a un escenario de ampliación de las fronteras extractivas hacia la Amazonía suroriente en el Ecuador. Anthropologica 32 (32): 115–137.

Vanegas-Ríos JA, Azpelicueta MM, Ortega H (2011) *Chrysobrycon eliasi*, new species of stevardiine fish (Characiformes: Characidae) from the río Madre de Dios and upper río Manuripe basins, Peru. Neotropical Ichthyology 9 (4): 731–740. https://doi.org/10.1590/S1679-62252011000400004

Vanegas-Ríos JA, Urbano-Bonilla A (2017) A new species of *Chrysobrycon* (Characiformes, Characidae, Stevardiinae) from the Amazon river basin in Colombia, with a new diagnostic characteristic for the genus. Journal of Fish Biology 90 (6): 2344–2362. https://doi.org/10.1111/jfb.13317

Vannote RL, Minshall GW, Cummins KW, Sedell JR, Cushing CE (1980) The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37 (1): 130–137. https://doi.org/10.1139/f80-017

Vari RP (1984) Systematics of the Neotropical Characiform Genus *Potamorhina* (Pisces: Characiformes). Smithsonian Contributions to Zoology 400: 1–36. https://doi.org/10.5479/si.00810282.400

Vari RP (1989) Systematics of the Neotropical characiform genus *Curimata* Bosc (Pisces: Characiformes). Smithsonian Contributions to Zoology 474: 1–63. https://doi.org/10.5479/si.00810282.474

Vari RP (1991) Systematics of the Neotropical characiform genus *Steindachnerina* Fowler (Pisces: Ostariophysi). Smithsonian Contributions to Zoology 507: 1–118. https://doi.org/10.5479/si.00810282.507

Vari RP (1992a) Systematics of the Neotropical characiform genus *Cyphocharax* Fowler (Pisces: Ostariophysi). Smithsonian Contributions to Zoology 529: 1–137. https://doi.org/10.5479/si.00810282.529

Vari RP (1992b) Systematics of the Neotropical characiform genus *Curimatella* Eigenmann and Eigenmann (Pisces: Ostariophysi), with summary comments on the Curimatidae. Smithsonian Contributions to Zoology (533): 1–48. https://doi.org/10.5479/si.00810282.533

Vari RP, Harold A (2001) Phylogenetic study of the Neotropical fish genera *Creagrutus* Günther and Piabina Reinhardt (Teleostei: Ostariophysi: Characiformes), with a revision of the Cis-Andean species. Smithsonian Contributions to Zoology (613): 1–238. https://doi.org/10.5479/si.00810282.613

Walsh Environmental Scientists and Engineers (2003) Línea Base para la Actualización del Plan de Manejo de la Reserva Biológica Limoncocha [unpublished report]. Project number EC101-35. Walsh Environmental Scientists and Engineers, Quito, 382 pp.

Whitehead PJP, Nelson GJ, Wongratana T (1988) FAO Species Catalogue. Vol. 7. Cupleoid Fishes of the World (Suborder Clupeoidei). An Annotated and Illustrated Catalogue of the herrings, Sardines, Pilchards, Sprats, Anchovies and Wolf-herrings. Part 2. Engraulididae. FAO, Rome, 274 pp.

Zapata LA, Usma JS (Eds) (2013) Guía de las Especies Migratorias de la Biodiversidad en Colombia. Peces. Vol. 2. Ministerio de Ambiente y Desarrollo Sostenible/ WWF-Colombia, Bogotá, 1–486.