

Ichthyofauna of the megadiverse Madidi National Park in the Bolivian Andean Amazon

Ictiofauna del megadiverso Parque Nacional Madidi en los Andes Amazónicos de Bolivia

RESEARCH ARTICLE / ARTÍCULO CIENTÍFICO

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ABSTRACT

This study presents the results of a compilation of the existing fish records for the Madidi National Park and Natural Area for Integrated Management (PNANMI Madidi), as well as extensive ichthyological sampling by the Identidad Madidi expedition, and species identified in ichthyoplankton by the metabarcoding approach. The current list has a total of 333 species for the protected area, across 43 families and within 13 orders. The list also includes 35 new candidate species still to be described. The highest number of species is found within the order Characiformes (139 species; 41.7%), followed by Siluriformes (137 species; 41.1%), and Cichliformes (19 species; 5.7%), which together represent 88.6% of total species richness. The remaining species (11.4%) are distributed across another 10 orders. The families with the highest number of species are Characidae (73 species; 21.9%), Loricariidae (36; 10.8%), Heptapteridae (21; 6.3%), Pimelodidae (21; 6.3%), and Cichlidae (19; 5.7%). The list of 333 species presented here doubles the previously known ichthyofauna (161 species) in the PNANMI Madidi. The area covers 1.3% of the Madeira basin, but conserves 25% of the

known species in the basin. Similarly, PNANMI Madidi covers 1.8% of Bolivian territory, and conserves almost 40% of known Bolivian ichthyofauna.

Keywords: biodiversity, conservation, fish, Madeira River, protected areas

RESUMEN

Este estudio presenta los resultados de una compilación de los registros de peces existentes para el Parque Nacional y Área de Manejo Natural Integrado Madidi (PNANMI Madidi), además, se basa en un amplio muestreo ictiológico realizado por la expedición Identidad Madidi, y las especies identificadas en el ictioplancton mediante caracterización genética (“metabarcoding”). Se obtuvo un total de 333 especies para el área protegida distribuidas en 43 familias y 13 órdenes. La lista incluye 35 posibles especies nuevas para la ciencia. El mayor número de especies se encuentra en el orden de los Characiformes (139 especies; 41.7%), seguido de los Siluriformes (137 especies; 41.1%), y los Cichliformes (19 especies; 5.7%), que en conjunto representan el 88.6% de la riqueza de especies. El 11.4% restante se distribuye en otros 10 órdenes. Las familias con mayor número de especies son Characidae (73 especies; 21.9%), Loricariidae (36; 10.8%), Heptapteridae (21; 6.3%), Pimelodidae (21; 6.3%) y Cichlidae (19; 5.7%). La lista de 333 especies presentada aquí duplica la ictiofauna previamente conocida (161 especies) en el PNANMI Madidi. El área cubre sólo el 1.3% de la cuenca del Madeira, pero conserva el 25% de las especies conocidas en la cuenca. Del mismo modo, el PNANMI Madidi representa el 1.8% del territorio boliviano, pero conserva casi el 40% de la ictiofauna boliviana registrada.

Palabras clave: biodiversidad, conservación, peces, Río Madeira, áreas protegidas

INTRODUCTION

The 1 373 fish species recorded in the Madeira basin so far make it the most fish-diverse basin in the Amazon, hosting 50% of the known fish diversity inhabiting the entire Amazon basin (Dagosta & Pinna 2019, Jézéquel *et al.* 2020a). Taxonomic revisions continue to increase the known fish diversity including the description of new species, as well as to uncover significant endemism in this distinctive basin (Oberdorff *et al.* 2019, Dagosta *et al.* 2020). The exceptional ichthyological diversity

is in part explained by an altitudinal gradient running from less than 100 m on the Amazonian floodplain to Andean peaks of more than 6 000 m.

Madidi National Park and Natural Area for Integrated Management (PNANMI Madidi: Bolivian Supreme Decree No 24123) covers an area of 18 957.5 km² in Bolivia (representing just 1.3% of the Madeira basin area) and follows an altitudinal gradient ranging from 184 m (Heath River) to 6 044 m (at the Chaupi Orko peak) (Figure 1). Due to its high habitat diversity mostly resulting from the altitudinal gradient, PNANMI Madidi is considered the most biodiverse protected area in the region (Identidad Madidi, SERNAP 2020). The PNANMI Madidi is drained by watersheds belonging to the Beni and Madre de Dios rivers. Previous studies have listed 192 fish species within the park (Conservation International RAP 1991, 2002, Sarmiento *et al.* 2001, Barrera *et al.* 2002, Sarmiento *et al.* 2012), although a total of around 300 species was estimated (Sarmiento *et al.* 2012).

The objective of the Identidad Madidi expedition and communication campaign (www.identidadmadidi.org), started in 2015, was to systematize, increase and share biodiversity knowledge on plants, butterflies and vertebrates from PNANMI Madidi. Here, we propose a list of fish species whose presence in the PNANMI Madidi has been confirmed, including species registered during the Identidad Madidi expedition and a compilation of species occurrences listed in previous studies, providing an estimate of the total ichthyological richness for this protected area.



FIGURE 1. Map of Madidi National Park and its location in Bolivia and the Madeira basin. The number of species follows Carvajal-Vallejos *et al.* (2014) for Bolivia, Jézequel *et al.* (2019) for the Madeira basin and Dagosta & Pinna (2019) for the Beni and Madre de Dios basins, respectively.

METHODS

Prior to the Identidad Madidi fieldwork, we revised the baseline for confirmed ichthyofauna within the geographical limits of PNANMI Madidi (Sarmiento *et al.* 2001), considering recent taxonomic changes, but also revising existing specimens and incorporating the most recent records.

Fish species records from the Identidad Madidi expedition were obtained using different sampling techniques; i.e. electrofishing, gillnets, trawls, line and hook, and ichthyoplankton nets. We sampled 13 sites between 2015 and 2018. Specimens were deposited in the Colección Boliviana de Fauna (CBF) under the codes: P-00224, P-00225, P-00226, P-00227, P-00228, P-00229, P-00230, P-00231, P-00232 and P-00233. Ichthyoplankton species were identified by metabarcoding following the methodology described by Maggia *et al.* (2017) and Mariac *et al.* (2018). Probable new species not matching any already known species were included in the list. The list also includes introduced species. Taxonomy follows Abe *et al.* (2014), Betancur-R *et al.* (2017), Mirande (2019) and Van der Laan *et al.* (2021). An estimate of the total number of species expected for PNANMI Madidi was made using the Vegan for R. package.

RESULTS

The taxonomic review of the previously estimated species list for PNANMI Madidi (Sarmiento *et al.* 2012) reduced the number of species registered within the protected area boundaries from 192 to 161. The Identidad Madidi expedition registered 257 species across the 13 study sites, plus an additional 21 species registered only from larvae and eggs. Of these registered species, 172 were additional to the taxonomic review. The PNANMI Madidi has 333 species confirmed within the protected area (S1), belonging to 45 families within 12 orders and one *sedis mutabilis* in Perciformes (Scianidae). Fifty species belong to taxonomic uncertainty categories (sp., cf., or aff.), including 35 taxa that are potentially new species for science (Appendix 1).

Characiformes is the order with the highest number of species (139 species; 41.7%) followed by Siluriformes (137 species; 41.1%) and Cichliformes (19 species; 5.7%), which together represent 88.6% of the total species richness recorded in the PNANMI Madidi. The remaining 11.4% of species are distributed in 9 orders and one *sedis mutabilis*. The families with the highest number of species are Characidae (73 species; 21.9%), Loricariidae (36; 10.8%), Pimelodidae (21; 6.3%), Heptapteridae (21; 6.3%) and Cichlidae (19; 5.7%). Together, these five families account for 51.1% of the total species list. The distribution of species adult body size ranges from miniature species of less than 3 cm Standard Length (SL), such as *Hyphessobrycon eques* and *Tyttocharax tambopatensis* (1.6 cm SL), to the giant goliath catfish *Brachyplatystoma filamentosum* (> 3 m SL), and the invasive *Arapaima aff. gigas* that can reach 4 m. The presence of medium- and long-distance migratory species such as the goliath catfish (*Brachyplatystoma* spp. and *Zungaro zungaro*) is of conservation interest.

The species accumulation curve, drawn using species captured during the *Identidad Madidi* expedition, shows a break point between 260 and 270 species (Figure 2). The estimated richness according to Chao2 (331 species) is very similar to the total number of species when adding species captured during the expedition, species previously registered in the protected area, as well as the ichthyoplankton additions. The maximum richness expected by the second-order Jack-knife estimator (Jack2) is 375 species (Figure 2).

Four alien species (1.2%) are confirmed as present in the PNANMI Madidi: *Arapaima* aff. *gigas*, *Oncorhynchus mykiss*, *O. aguabonita* and one *Orestias* species of the *agassii* group.

Identidad Madidi registered the *Ernstichthys*, *Glandulocauda*, *Microgenys* and *Stegophilus* genera for the first time in Bolivia. A high cryptic diversity was registered for a number of genera having only a few valid species so far registered in Bolivia, such as *Astroblepus*, *Hypostomus*, and *Trichomycterus*, especially in Andean montane and foothill streams.

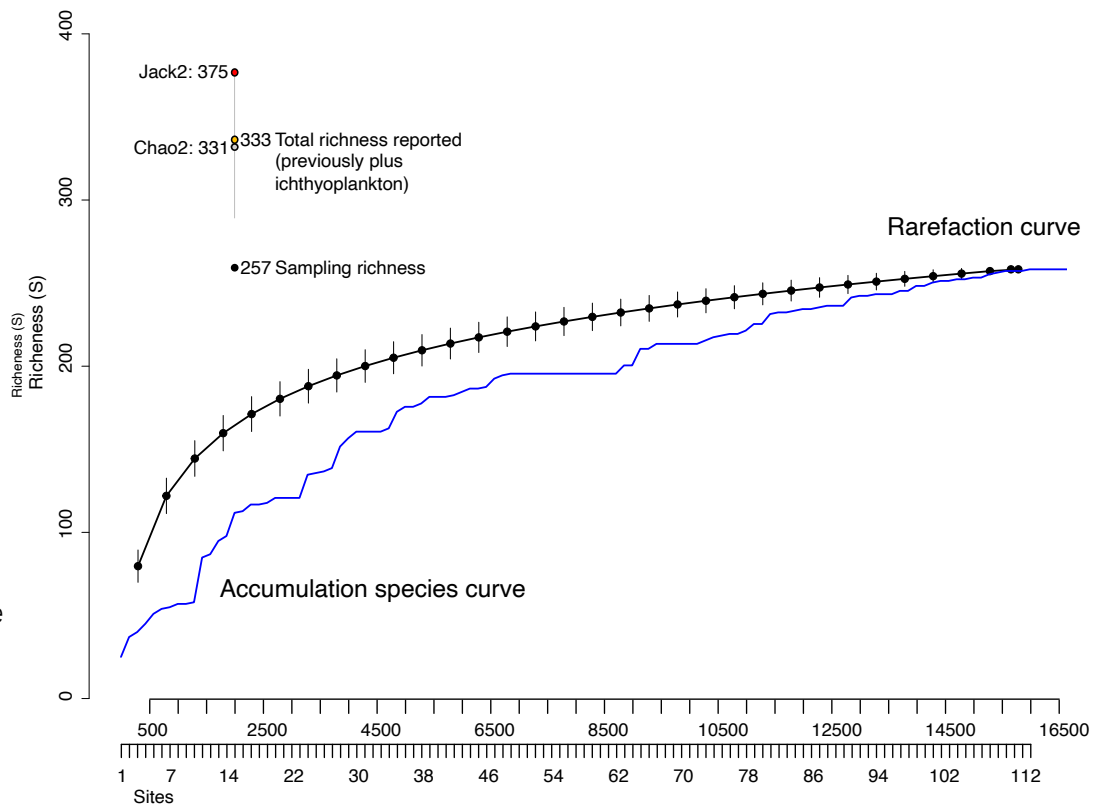


FIGURE 2. Rarefaction, species accumulation curve and estimation of the number of species (Chao2 and Jack2) present in Madidi National Park.

DISCUSSION

The present study updates fish species records for PNANMI Madidi, one of the most important protected areas in the world given the record-breaking biodiversity it hosts (Dagosta *et al.* 2020). Before the Identidad Madidi expedition, 161 species were confirmed for Madidi (Sarmiento *et al.* 2012). We found an additional 172 species during our Identidad Madidi fieldwork (including ichthyoplankton). Comparing the 333 registered species with species richness from other Bolivian protected areas (www.sernap.gob.bo) makes the PNANMI Madidi the richest Bolivian protected area for ichthyofauna. The number of 333 confirmed species is close to the Jack2 estimated species richness (Jack2 = 375 species) (Figure 2). However, expected species richness may increase if studies in more isolated watersheds would be conducted, including methods that promote the registration of more cryptic species, such as interstitial and benthic species within the main river channels.

The most recent estimate for Bolivia listed a total of 908 fish species (Carvajal-Vallejos *et al.* 2014), a number that will increase with this study, as predicted with Jack2 estimator reaching 375 species. The PNANMI Madidi houses 24.3% of the known ichthyofauna of the Madeira basin and 36.7% of the documented Bolivian ichthyofauna (Carvajal-Vallejos *et al.* 2014). For the Beni and Madre de Dios watersheds, a total of 509 fish species have been reported (Dagosta & Pinna 2019), of which 65.4% are present in the PNANMI Madidi.

The number of potentially new species for science (10.5% of total known species for the PNANMI Madidi) is an indication that PNANMI Madidi is also a protected area rich in endemic species due to its diverse topography and watershed connectivity that together provide a great variety of habitats for fish. Exhaustive reviews of the genera with the largest number of potential new species (*Astroblepus*, *Cetopsorhamdia*, *Characidium*, *Hypostomus*, *Trichomycterus*) are an urgent priority in order to complete species descriptions. Another priority genus is *Salminus*, for which we report a second species, distinguished as different from *S. brasiliensis* by the metabarcoding approach (S1). The *Orestias* sp. case is particularly interesting as, according to declarations from the Puina community, the populations registered in high mountain lakes (>4 500 m) were introduced together with trout fry by local people in different lakes along the Apolobamba mountain range. This yet unproven information may explain the confirmed presence of this genus on eastern slopes of Andes (Sarmiento & Barrera 1997, Loayza *et al.* 2021).

The mountain streams of Madidi constitute a particularly rich habitat for species as reported by Jezequel *et al.* (2020a, 2020b) and Dagosta *et al.* (2020). These mountain streams require particular attention in future ichthyofaunistic studies. Mountain streams are difficult to access, and eDNA studies are a good alternative for the registration of known species at new sites. However, they depend on updating reference databases with well-determined species that can only be achieved with integrative taxonomy approaches. With these results, and the descriptions of the high number of potential new species, the PNANMI Madidi might be categorized as Endemic Amazonian Fish Area (EAFA) as proposed by Dagosta *et al.* (2020), of urgent conservation priority.

The current species list (S1) more than doubles the previously known ichthyofauna within PNANMI Madidi (161 species). The species list may grow further as descriptions and taxonomic reviews are conducted, including specimens already deposited in scientific collections, as previously found for Neotropical and Amazonian ichthyofauna (Birindelli & Sidlauskas 2018).

Finally, it is important to highlight that, although it covers only 1.4% of the Madeira Basin area, PNANMI Madidi conserves 24% of known fish species of the basin, and 40% of the Bolivian ichthyofauna. Although Madidi is one of the protected areas with the best conservation status in Bolivia, with deforestation rates less than 0.3% (Painter *et al.* 2013), it is also one of the protected areas with the highest number of threats, such as the growing gold mining activity affecting the core area of the protected area (Heck & Tranca 2014), planned infrastructure (Anderson *et al.* 2018), and unsustainable fishing with devastating methods such as dynamite, driftnets and overfishing at breeding sites (CRTM Pilón Lajas & SERNAP



FIGURE 3. Some of the fish species recorded in the Madidi National Park and Integrated Management Natural Area, Bolivia. a) *Helogenes marmoratus*, b) *Potamotrygon motoro*, c) *Synbranchus madeirae*, d) *Sternarchorhynchus hagedornae*, e) *Leporinus pearsoni* and f) *Amaralia hypsiura*. Photographs by Rob Wallace/WCS (a, c, d, f) and Guido Miranda/WCS (b, e).

2019, Miranda-Chumacero *et al.* 2020). These threats are potentially exacerbated by current climate change which is particularly relevant for temporary water bodies that are abundant in PNANMI Madidi. We recommend that conservation efforts for PNANMI Madidi include aquatic ecosystem considerations, especially headwater connectivity, to ensure that this important component of biodiversity is preserved together with the rest of the biological treasures of Madidi.

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REFERENCES

- Abe K.T., Mariguela T.C., Avelino G.S., Foresti F., Oliveira C. 2014. Systematic and historical biogeography of the Bryconidae (Ostariophysi: Characiformes) suggesting a new rearrangement of its genera and an old origin of Mesoamerican ichthyofauna. *BMC Evolutionary Biology*, 14: 152–15. doi:10.1186/1471-2148-14-152
- Anderson E.P., Jenkins C.N., Heilpern S., Maldonado-Ocampo J.A., Carvajal-Vallejos F.M., Encalada A.C., Rivadeneira J.F., Hidalgo M., Cañas C.M., Ortega H., Salcedo N., Maldonado M., Tedesco P.A. 2018. Fragmentation of Andes-to-Amazon connectivity by hydropower dams. *Scientific Advances*, 4: eaao1642.
- Barrera S, Sarmiento J, Tejada R. 2002. Diagnóstico de ictiofauna del Parque Nacional y Área Natural de Manejo Integrado Madidi. Plan de Manejo del PNANMI Madidi.
- Betancur-R, R., Wiley, E.O., Arratia, G., Acero A., Bailly N., Miya M., Lecointre G., Ortí G. 2017. Phylogenetic classification of bony fishes. *BMC Evolutionary Biology* 17: 162.
- Birindelli J.L.O, Sidlauskas B.L. 2018. Preface: how far has Neotropical Ichthyology progressed in twenty years? *Neotropical Ichthyology*, 16 (3): e180128.
- Carvajal-Vallejos F.M., Zeballos-Fernández A.J., Sarmiento J., Bigorne R. 2014. Species recorded in Bolivia. pp. 183-193 in: Sarmiento J. et al. (Eds) *Peces de Bolivia / Bolivian fishes*. IRD-BioFresh (EU), Plural Editores, Bolivia.
- Consejo Regional T´simane Mosekene Pilón Lajas, Servicio Nacional de Áreas Protegidas. 2019. Plan de Manejo y Plan de Vida de la Reserva de la Biosfera y Tierra Comunitaria de Origen Pilón Lajas 2018-2028. CRTM- SERNAP – WCS. Rurrenabaque, Bolivia.

- Conservation International RAP. 1991. A Biological Assessment of the Alto Madidi Region and Adjacent Areas of Northwest Bolivia May 18-June 15 of 1990. Conservation International.
- Conservation International RAP. 2002. Informes de las evaluaciones biológicas Pampas del Heath, Perú, Alto Madidi, Bolivia y Pando. Conservation International.
- Dagosta F.C.P., Pinna M. 2019. The fishes of the Amazon: distribution and biogeographical patterns, with a comprehensive list of species. *Bulletin of the American Museum of Natural History*, 431: 163.
- Dagosta F.C.P., Pinna M., Peres C.A., Tagliacollo V.A. 2020. Existing protected areas provide a poor safety-net for threatened Amazonian fish species. *Aquatic Conservation*, 16: e180023–23.
- Heck C., Tranca J. 2014. La realidad de la minería ilegal en países amazónicos SPDA, Lima, Perú.
- Identidad Madidi, SERNAP. 2020. Informe de la expedición científica Identidad Madidi 2017. Relevamientos de biodiversidad en el Parque Nacional y Área Natural de Manejo Integrado Madidi. La Paz, Bolivia.
- Jézéquel C., Tedesco P.A., Bigorne R., Maldonado-Ocampo J.A., Ortega H., Hidalgo M., Martens K., Torrente-Vilara G., Zuanon J., Acosta A., Agudelo E., Barrera Maure S., Bastos D.A., Bogotá Gregory J., Cabeceira F.G., Canto A.L.C., Carvajal-Vallejos F.M., Carvalho L.N., Cella-Ribeiro A., Covain R., Donascimento C., Doria C.R.C., Duarte C., Ferreira E.J.G., Galuch A.V., Giarrizzo T., Leitão R.P., Lundberg J.G., Maldonado M., Mojica J.I., Montag L.F.A., Ohara W.M., Pires T.H.S., Pouilly M., Prada-Pedrerros S., de Queiroz L.J., Rapp Py-Daniel L., Ribeiro F.R.V., Ríos Herrera R., Sarmiento J., Sousa L.M., Stegmann L.F., Valdiviezo-Rivera J., Villa F., Yunoki T., Oberdorff T. 2020a. A database of freshwater fish species of the Amazon Basin. *Scientific Data*, 7: 96, 9p.
- Jézéquel C., Tedesco P.A., Darwall W., Dias M.S., Frederico R.G., Hidalgo M., Hugueny B., Maldonado-Ocampo J., Martens K., Ortega H., Torrente-Vilara G., Zuanon J., Oberdorff T. 2020b. Freshwater fish diversity hotspots for conservation priorities in the Amazon Basin. *Conservation Biology*, 34: 956-965.
- Loayza E., Alvestegui D., Herbas K., Ibañez C., Zepita C., Miranda-Chumacero G. 2021. Ecomorphological variations of *Orestias* sp. (gr. *agassizii*, Cyprinodontiformes, Cyprinodontidae) from Eastern slope of the Andes. *Ecología en Bolivia* 56, 36–41.
- Maggia M.E., Vigouroux Y., Renno J.F., Duponchelle F., Desmarais E., Nuñez J., García-Dávila C., Carvajal-Vallejos F.M., Paradis E., Martin J.F., Mariac C. 2017. DNA Metabarcoding of Amazonian Ichthyoplankton Swarms. *PLoS ONE*, 12 (1): e0170009.
- Mariac C, Vigouroux Y, Duponchelle F, García-Dávila C, Nuñez J, Desmarais E, Renno JF. 2018. Metabarcoding by capture using a single COI probe (MCSP) to identify and quantify fish species in ichthyoplankton swarms. *PLoS One*, 13: e0202976.
- Miranda-Chumacero G., Mariac C., Duponchelle F., Painter L., Wallace R., Cochonneau G., Molina-Rodriguez J., Garcia-Davila C., Renno J.F. 2020. Threatened fish spawning area revealed by specific metabarcoding identification of eggs and larvae in the Beni River, upper Amazon. *Global Ecology and Conservation*, 24: e01309.
- Mirande J.M. 2019. Morphology, molecules and the phylogeny of Characidae (Teleostei, Characiformes), *Cladistics*, 35 (3): 282-300.
- Oberdorff T., Dias M.S., Jézéquel C., Albert J.S., Arantes C.C., Bigorne R., Carvajal-Vallejos F.M., De Wever A., Frederico R.G., Hidalgo M., Hugueny B., Leprieur F., Maldonado M., Maldonado-Ocampo J., Martens K., Ortega H., Sarmiento J., Tedesco P.A., Torrente-Vilara

- G., Winemiller K.O., Zuanon J. 2019. Unexpected fish diversity gradients in the Amazon basin. *Science Advances*, 5 (9): eaav8681.
- Painter L., Siles T., Reinaga A., Wallace R. 2013. Escenarios de deforestación en el gran paisaje Madidi-Tambopata. WCS, La Paz, Bolivia.
- Sarmiento J., Barrera S., Miranda G., Mendoza M. 2012. Los peces de Madidi. p. 110-121. En: Salinas E., Wallace R.B. (Eds.). *Conocimientos científicos y prioridades de investigación en el Parque Nacional y Área Natural de Manejo Integrado Madidi*. La Paz, Bolivia.
- Sarmiento J., Barrera S. 1997. Observaciones preliminares sobre la ictiofauna de la Vertiente Oriental Andina de Bolivia. *Revista Boliviana de Ecología y Conservación Ambiental*, 2: 77–99.
- Sarmiento J., Barrera S., Vargas J., Quiroga C., Cortez C. 2001. Evaluación de la fauna de vertebrados de la formación de bosque alto en la región de Alto Madidi (PNANMI-Madidi). CBF/CI.
- Van der Laan R., Fricke R., Eschmeyer W.N. (Eds.). 2021. *Eschmeyer's Catalog of Fishes: Classification*. <http://www.calacademy.org/scientists/catalog-of-fishes-classification/>. Electronic version accessed 30 April 2022.

APPENDIX 1

S1. Species list of PNANMI Madidi. The list includes the species registered during the Identidad Madidi Expedition (a), the previously known species (b) and the species identified by metabarcoding in ichthyoplankton (c). * = additional records for Bolivia, § = potential new species for science and β = Genera reported for the first time in Bolivia.

CLASS/ORDER/Family/Species

ELASMOBRANCHII

MYLIOBATIFORMES

Potamotrygonidae

Paratrygon aiereba (Walbaum 1792)^a

Potamotrygon cf. orbigny^{a§}

Potamotrygon motoro (Müller & Henle 1841)^b

Potamotrygon tatarianae Silva & Carvalho 2011^{a*}

ACTINOPTERI

OSTEOGLOSSIFORMES

Arapaimidae

Arapaima aff. gigas^b

ACTINOPTERI

CLUPEIFORMES

Engraulidae

Anchoviella jamesi (Jordan & Seale 1926)^{a*}

Anchoviella carrikeri Fowler 1940^b

Engraulisoma taeniatum Castro 1981^b

CLASS/ORDER/Family/Species**Pristigasteridae**

- Pellona flavipinnis* (Valenciennes 1837)^a
Pellona castelnaeana Valenciennes 1847^b

ACTINOPTERI

CHARACIFORMES

Acestrorhynchidae

- Acestrorhynchus altus* Menezes 1969^b
Acestrorhynchus falcatus (Bloch 1794)^b
Acestrorhynchus microlepis (Jardine 1841)^b
Acestrorhynchus pantaneiro Menezes 1992^a

Anostomidae

- Abramites hypselonotus* (Günther 1868)^a
Leporellus vittatus (Valenciennes 1850)^a
Leporinus pearsoni Fowler 1940^a
Leporinus arcus Eigenmann 1912^b
Leporinus friderici (Bloch 1794)^b
Leporinus striatus Kner 1858^b
Rhytiodus microlepis Kner 1858^b
Schizodon fasciatus Spix & Agassiz 1829^b
Leporinus desmotes Fowler 1914^c

Bryconidae

- Brycon cephalus* (Günther, 1869)^a
Brycon melanopterus (Cope 1872)^b
Chalceus guaporensis Zanata & Toledo-Piza 2004^a
Salminus brasiliensis (Cuvier 1816)^b
Salminus sp. 2^c

Characidae

- Acrobrycon ipanquianus* (Cope 1877)^a
Aphyocharax dentatus Eigenmann & Kennedy 1903^b
Aphyocharax pusillus Valenciennes 1847^b
Astyanax abramis (Jenyns 1842)^b
Astyanax bimaculatus (Linnaeus, 1758)^b
Astyanax boliviensis Ruiz-C., Román-Valencia, Taphorn, Backup & Ortega 2018^a
Astyanax fasciatus (Cuvier, 1819)^b
Astyanax lineatus (Perugia, 1891)^b
Astyanax multidentis (Pearson 1924)^b
Attonitus bounites Vari & Ortega, 2000^a
Bario steindachneri (Eigenmann 1893)^b
Brachychalcinus copei (Steindachner 1882)^b
Brycon amazonicus (Agassiz 1829)^b
Bryconacidnus ellisae (Pearson, 1924)^b
Bryconacidnus hemigrammus (Pearson, 1924)^a
Bryconamericus bolivianus Pearson 1924^a
Bryconamericus diaphanus (Cope 1878)^c
Charax caudimaculatus Lucena 1987^a

CLASS/ORDER/Family/Species

- Charax pauciradiatus* (Günther 1864)^b
Creagrutus beni Eigenmann, 1911^b
Creagrutus occidaneus Vari & Harold 2001^c
Creagrutus pearsoni Eigenmann, 1911^b
Ctenobrycon hauxwellianus (Cope 1870)^b
Curimatopsis macrolepis (Steindachner 1876)^b
Cynopotamus amazonus (Günther 1868)^b
Galeocharax gulo (Cope 1870)^b
Gephyrocharax major Myers 1929^b
Glandulocauda melanopleura (Ellis 1911)^c
Gnathocharax steindachneri Fowler 1913^b
Gymnocorymbus flaviolimai Benine, Melo, Castro & Oliveira 2015^{a*}
Gymnocorymbus thayeri Eigenmann 1908^a
Hemibrycon beni Pearson, 1924^b
Hemibrycon huambonicus (Steindachner 1882)^b
Hemibrycon jelskii (Steindachner, 1876)^a
Hemibrycon sp. 3 ^a
Hemigrammus lunatus Durbin 1918^b
Hemigrammus ocellifer (Steindachner 1882)^a
Hemigrammus unilineatus (Gill 1858)^b
Hyphessobrycon agulha Fowler 1913^a
Hyphessobrycon copelandi Durbin 1908^b
Hyphessobrycon eques (Steindachner 1882)^a
Hyphessobrycon iheringi Fowler 1941^b
Knodus breviceps (Eigenmann 1908)^b
Knodus heteresthes (Fowler, 1943)^a
Knodus mizquae (Fowler, 1943)^a
Knodus ortegasae (Fowler 1943)^c
Knodus smithi (Fowler, 1943)^a
Knodus sp. 2 (anal larga) ^{a§}
Microgenys sp. ^{a*§§}
Microschemobrycon sp. 1 (cf. *casiquiare*)^a
Moenkhausia chrysargyrea (Günther 1864)^b
Moenkhausia collettii (Steindachner 1882)^b
Moenkhausia comma Eigenmann 1908^b
Moenkhausia cotinho Eigenmann 1908^b
Moenkhausia dichroua (Kner 1858)^b
Moenkhausia intermedia Eigenmann 1908^a
Moenkhausia oligolepis (Günther 1864)^b
Moenkhausia sanctaefilomenae (Steindachner 1907)^b
Moenkhausia sp. 5 (cf. *chrysargyrea*)^{a§}
Monotocheiroduon pearsoni Eigenmann, 1924^b
Odontostilbe dierythura Fowler 1940^b
Odontostilbe fugitiva Cope 1870^b
Paragoniates alburnus Steindachner 1876^b
Phenacogaster beni Eigenmann 1911^a
Poptella compressa (Günther 1864)^b
Prionobrama filigera (Cope 1870)^b

CLASS/ORDER/Family/Species

Prodontocharax melanotus Pearson 1924^b
Rhaphiodon vulpinus Spix & Agassiz 1829^c
Roeboides affinis (Günther 1868)^b
Roeboides descalvadensis Fowler 1932^a
Serrapinnus micropterus (Eigenmann 1907)^a
Tetragonopterus argenteus Cuvier 1816^b
Tytocharax tambopatensis Weitzman & Ortega 1995^b

Crenuchidae

Characidium bolivianum Pearson, 1924^b
Characidium cf. *steindachneri*^b
Characidium fasciatum Reinhardt 1867^b
Characidium sp. 4 (cf. *heinianum*)^{aS}
Characidium zebra Eigenmann 1909^a

Curimatidae

Curimatella meyeri (Steindachner 1882)^b
Cyphocharax leucostictus (Eigenmann & Eigenmann 1889)^a
Cyphocharax plumbeus (Eigenmann & Eigenmann 1889)^a
Cyphocharax spiluroopsis (Eigenmann & Eigenmann 1889)^a
Potamorhina altamazonica (Cope 1878)^b
Potamorhina latior (Spix & Agassiz 1829)^a
Steindachnerina argentea (Gill 1858)^b
Steindachnerina bimaculata (Steindachner 1876)^a
Steindachnerina binotata (Pearson 1924)^b
Steindachnerina dobula (Günther 1868)^b
Steindachnerina guentheri (Eigenmann & Eigenmann 1889)^b
Steindachnerina hypostoma (Boulenger 1887)^b

Cynodontidae

Hydrolycus scomberoides (Cuvier 1819)^b

Erythrinidae

Erythrinus erythrinus (Bloch & Schneider 1801)^b
Hoplerythrinus unitaeniatus (Spix & Agassiz 1829)^b
Hoplias malabaricus (Bloch, 1794)^b

Gasteropelecidae

Carnegiella myersi Fernández-Yépez 1950^b
Gasteropelecus sternicla (Linnaeus 1758)^a
Thoracocharax stellatus (Kner 1858)^b

Iguanodectidae

Bryconops melanurus (Bloch 1794)^a

Lebiasinidae

Nannostomus trifasciatus Steindachner 1876^a
Pyrrhulina australis Eigenmann & Kennedy 1903^b
Pyrrhulina brevis Steindachner 1876^b
Pyrrhulina vittata Regan 1912^b

CLASS/ORDER/Family/Species**Parodontidae***Apareiodon* sp. ^{a5}*Parodon buckleyi* Boulenger, 1887^a**Prochilodontidae***Prochilodus argenteus* Spix & Agassiz 1829^c*Prochilodus costatus* Valenciennes 1850^c*Prochilodus lineatus* (Valenciennes 1837)^c*Prochilodus nigricans* Spix & Agassiz 1829^b*Prochilodus rubrotaeniatus* Jardine 1841^c**Serrasalmidae***Colossoma macropomum* (Cuvier 1816)^b*Mylossoma albiscopum* (Cope 1872)^a*Piaractus brachypomus* (Cuvier 1818)^b*Pygocentrus nattereri* Kner 1858^b*Serrasalmus compressus* Jégu, Leão & Santos 1991^a*Serrasalmus hollandi* Eigenmann 1915^a*Serrasalmus rhombeus* (Linnaeus 1766)^b*Serrasalmus spilopleura* Kner 1858^b**Triporthidae***Clupeacharax anchoveoides* Pearson 1924^b*Triporthes albus* Cope 1872^b*Triporthes angulatus* (Spix & Agassiz 1829)^b*Triporthes rotundatus* (Jardine 1841)^b

ACTINOPTERI

GYMNOTIFORMES

Apterontidae*Apteronotus albifrons* (Linnaeus 1766)^b*Platyurosternarchus macrostomus* (Günther 1870)^a*Sternarchorhynchus hagedornae* de Santana & Vari, 2010^b**Gymnotidae***Electrophorus electricus* (Linnaeus 1766)^b*Gymnotus arapaima* Albert & Crampton 2001^a*Gymnotus carapo* Linnaeus 1758^b**Hypopomidae***Brachyhypopomus brevirostris* (Steindachner 1868)^a*Brachyhypopomus pinnicaudatus* (Hopkins, Comfort, Bastian & Bass 1990)^a*Brachyhypopomus* sp. 3 ^{a5}*Hypopomus artedi* (Kaup 1856)^a**Rhamphichthyidae***Gymnorhamphichthys rondoni* (Miranda Ribeiro 1920)^a*Hypopygus lepturus* Hoedeman 1962^a

CLASS/ORDER/Family/Species

Sternopygidae

Eigenmannia sp. 2 (cf. *trilineata*)^{a§}
Eigenmannia virescens (Valenciennes, 1836)^b
Sternopygus macrurus (Bloch & Schneider 1801)^a

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SILURIFORMES

Aspredinidae

Amaralia hypsiura (Kner 1855)^a
Bunocephalus aleuropsis Cope 1870^a
Bunocephalus coracoideus (Cope 1874)^a
Ernstichthys sp. ^{a*§§}
Pseudobunocephalus bifidus (Eigenmann 1942)^a
Pterobunocephalus depressus (Haseman 1911)^b

Astroblepidae

Astroblepus longiceps Pearson, 1924^a
Astroblepus sp. 1 (sin aleta adiposa)^{a§}
Astroblepus sp. 2 (disco bucal redondo-zona Hondo)^{a§}
Astroblepus sp. 3 (pedúnculo largo)^{a§}
Astroblepus sp. 4 (disco bucal redondo)^{a§}
Astroblepus sp. 5 (gr. trifasciatus)^{a§}

Auchenipteridae

Ageneiosus cf. *dentatus*^b
Ageneiosus inermis (Linnaeus 1766)^a
Auchenipterus ambyiacus Fowler 1915^b
Auchenipterus osteomystax (Miranda Ribeiro 1918)^c
Centromochlus heckelii (De Filippi 1853)^a
Centromochlus sp. 3^a
Duringlanis altae (Fowler 1945)^a
Duringlanis perugiae (Steindachner 1882)^a
Tatia aulopygia (Kner 1858)^a
Trachelyopterus galeatus (Linnaeus 1766)^b

Callichthyidae

Callichthys callichthys (Linnaeus 1758)^b
Corydoras acutus Cope 1872^b
Corydoras aeneus (Gill 1858)^b
Corydoras napoensis Nijssen & Isbrücker 1986^a
Corydoras sp. 3^{a§}
Corydoras stenocephalus Eigenmann & Allen 1942^b
Corydoras trilineatus Cope 1872^a
Hoplosternum littorale (Hancock 1828)^b
Leptoplosternum beni Reis 1997^b
Megalechis thoracata (Valenciennes 1840)^a

CLASS/ORDER/Family/Species**Cetopsidae**

- Cetopsis candiru* Spix & Agassiz 1829^b
Cetopsis coecutiens (Lichtenstein 1819)^c
Cetopsis gobioides Kner 1858^b
Cetopsis pearsoni Vari, Ferraris & de Pinna 2005^a
Cetopsis plumbea Steindachner 1882^a
Helogenes marmoratus Günther 1863^a

Doradidae

- Leptodoras linnelli* Eigenmann 1912^a
Megalodoras uranoscopus (Eigenmann & Eigenmann 1888)^b
Oxydoras niger (Valenciennes 1821)^c
Pterodoras granulosus (Valenciennes 1821)^b
Rhinodoras boehlkei Glodek, Whitmire & Orcés 1976^c

Heptapteridae

- Cetopsorhamdia iheringi* Schubart & Gomes 1959^c
Cetopsorhamdia sp. 1 ^{a§}
Cetopsorhamdia sp. 2 (aff. *molinae*) ^{a§}
Cetopsorhamdia sp. 3 ^{a§}
Cetopsorhamdia sp. 4 ^{a§}
Imparfinis cochabambae (Fowler 1940)^a
Imparfinis guttatus (Pearson 1924)^a
Imparfinis stictonotus (Fowler 1940)^b
Phenacorhamdia boliviana (Pearson 1924)^b
Pimelodella boliviana Eigenmann 1917^b
Pimelodella buckleyi (Boulenger 1887)^b
Pimelodella cf. *boliviana* ^a
Pimelodella cristata (Müller & Troschel 1849)^b
Pimelodella gracilis (Valenciennes 1835)^b
Pimelodella griffini Eigenmann 1917^b
Pimelodella howesi Fowler 1940^a
Pimelodella serrata Eigenmann 1917^a
Pimelodella sp. 3 (aff. *montana*) ^{a§}
Pimelodella sp. 4 (aleta corta) ^{a§}
Rhamdia quelen (Quoy & Gaimard 1824)^b
Rhamdia sp. 2 ^a

Loricariidae

- Ancistrus bolivianus* (Steindachner, 1915)^a
Ancistrus bufonius (Valenciennes 1840)^a
Ancistrus cirrhosus (Valenciennes 1836)^a
Ancistrus hoplogenyis (Günther 1864)^a
Ancistrus megalostomus Pearson 1924^a
Ancistrus montanus (Regan, 1904)^b
Ancistrus temminckii (Valenciennes 1840)^a
Aphanotorulus unicolor (Steindachner 1908)^b
Farlowella altocorpus Retzer 2006^a
Farlowella nattereri Steindachner 1910^b

CLASS/ORDER/Family/Species

Farlowella oxyrryncha (Kner 1853)^a
Farlowella smithi Fowler 1913^b
Hemiodontichthys acipenserinus (Kner 1853)^b
Hypoptopoma incognitum Aquino & Schaefer 2010^a
Hypoptopoma sp. 2^a
Hypostomus bolivianus (Pearson, 1924)^b
Hypostomus levis (Pearson 1924)^a
Hypostomus pyrineusi (Miranda Ribeiro 1920)^a
Hypostomus sp. 4^{aS}
Hypostomus sp. 5^{aS}
Hypostomus sp. 6 (gr. *cochliodon*)^{aS}
Hypostomus sp. 7^{aS}
Lamontichthys filamentosus (LaMonte 1935)^b
Loricaria simillima Regan 1904^a
Loricariichthys maculatus (Bloch 1794)^b
Loricariichthys platymetopon Isbrücker & Nijssen 1979^a
Otocinclus vestitus Cope 1872^b
Pterygoplichthys lituratus (Kner 1854)^a
Pterygoplichthys punctatus (Kner 1854)^b
Rhadinoloricaria bahuaja (Chang & Castro 1999)^b
Rineloricaria beni (Pearson 1924)^b
Rineloricaria lanceolata (Günther, 1868)^b
Rineloricaria sp. 3^{aS}
Spatuloricaria evansii (Boulenger 1892)^a
Sturisoma graffini Londoño-Burbano 2018^{a*}
Sturisoma nigrirostrum Fowler 1940^b

Pimelodidae

Aguarunichthys torosus Stewart 1986^c
Brachyplatystoma filamentosum (Lichtenstein 1819)^b
Brachyplatystoma tigrinum (Britski 1981)^c
Calophysus macropterus (Lichtenstein 1819)^a
Cheirocerus eques Eigenmann 1917^a
Hemisorubim platyrhynchos (Valenciennes 1840)^b
Leiaris marmoratus (Gill 1870)^b
Phractocephalus hemioliopus (Bloch & Schneider 1801)^b
Pimelodus blochii Valenciennes 1840^a
Pimelodus maculatus Lacepède 1803^b
Pimelodus ornatus Kner 1858^b
Pimelodus pictus Steindachner 1876^b
Pinirampus pirinampu (Spix & Agassiz 1829)^b
Platystomatichthys sturio (Kner 1858)^a
Pseudoplatystoma fasciatum (Linnaeus 1766)^b
Pseudoplatystoma tigrinum (Valenciennes 1840)^b
Sorubim cuspidus Littmann, Burr & Nass 2000^c
Sorubim lima (Bloch & Schneider 1801)^b
Sorubimichthys planiceps (Spix & Agassiz 1829)^b
Zungaro jahu (Ihering 1898)^f

CLASS/ORDER/Family/Species*Zungaro zungaro* (Humboldt 1821)^b**Pseudopimelodidae***Microglanis* cf. *iheringi*^b*Microglanis* sp.^{a§}*Pseudopimelodus bufonius* (Valenciennes 1840)^{a*}*Pseudopimelodus mangurus* (Valenciennes 1835)^c**Trichomycteridae***Ituglanis* cf. *gracilior*^a*Ochmacanthus reinhardtii* (Steindachner 1882)^a*Plectrochilus machadoi* Miranda Ribeiro 1917^a*Pseudostegophilus nemurus* (Günther 1869)^b*Stegophilus* sp.^{a*b}*Trichomycterus barbouri* (Eigenmann 1911)^b*Trichomycterus fassli* (Steindachner, 1915)^a*Trichomycterus lauzannii* Miranda & Fernández 2020^{a*§}*Trichomycterus* sp. 3^{a§}*Trichomycterus* sp. 4^{a§}*Trichomycterus* sp. 6 (gr. *barbouri*)^{a§}*Vandellia cirrhosa* Valenciennes 1846^b

ACTINOPTERI

SALMONIFORMES

Salmonidae*Oncorhynchus aguabonita* (Jordan 1892)^a*Oncorhynchus mykiss* (Walbaum 1792)^a

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CARANGIFORMES

Achiridae*Apionichthys nattereri* (Steindachner 1876)^b*Hypoclinemus mentalis* (Günther 1862)^a

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CYPRINODONTIFORMES

Cyprinodontidae*Orestias* sp.^{a§}**Rivulidae***Anablepsoides beniensis* (Myers 1927)^a*Anablepsoides* sp. 2^a*Moema quiii* Huber 2003^b*Pterolebias longipinnis* Garman 1895^b

ACTINOPTERI

BELONIFORMES

Belonidae*Potamorhaphis eigenmanni* Miranda Ribeiro 1915^a

CLASS/ORDER/Family/Species

ACTINOPTERI
SYNBRANCHIFORMES

Synbranchidae

Synbranchus madeirae Rosen & Rumney 1972^a
Synbranchus marmoratus Bloch 1795^b

ACTINOPTERI
CICHLIFORMES

Cichlidae

Acaronia nassa (Heckel 1840)^b
Apistogramma cf. *agassizii*^b
Apistogramma luelingi Kullander 1976^b
Apistogramma resticulosa Kullander 1980^a
Astronotus crassipinnis (Heckel 1840)^b
Bujurquina cordemadi Kullander 1986^a
Bujurquina tambopatae Kullander 1986^{a*}
Cichla pleiozona Kullander & Ferreira 2006^b
Cichlasoma boliviense Kullander 1983^b
Crenicichla reticulata (Heckel 1840)^a
Crenicichla saxatilis (Linnaeus 1758)^b
Crenicichla semicincta Steindachner 1892^a
Crenicichla sp. 2 (gr. *saxatilis*)^{a§}
Crenicichla sp. 3 (gr. *lugubris*)^{a§}
Crenicichla sp. 4 (cf. *semicincta*)^{a§}
Laetacara dorsigera (Heckel 1840)^b
Mesonauta festivus (Heckel 1840)^b
Mikrogeophagus altispinosus (Haseman 1911)^b
Satanoperca jurupari (Heckel 1840)^a

ACTINOPTERI
PERCIFORMES *SEDIS MUTABILIS*

Sciaenidae

Plagioscion squamosissimus (Heckel 1840)^b