

*RESEARCH ARTICLE*

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## **Database of the marine-derived aquatic biota of the Amazon Basin**

### **Banco de dados da biota aquática de origem marinha da Bacia Amazônica**

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**Resumo** Um banco de dados integrado, desenvolvido com ferramentas de software livre, é apresentado para catalogar e documentar a diversidade biológica das espécies da biota aquática de origem marinha da Bacia Amazônica, com informações sobre nomenclatura, distribuição geográfica, habitats, situação de conservação, sequências genômicas e bibliografia relevante para 225 espécies válidas de Porifera, Mollusca, Arthropoda e Chordata. O banco de dados completo encontra-se disponível para consulta em <http://mar.biotupe.org>.

**Palavras-Chave:** Bacia Amazônica, bancos de dados, informática para biodiversidade.

**Abstract** An integrated database, developed with free software tools, is presented to catalog and document the biological diversity of the marine-derived species of the aquatic biota of the Amazon Basin, with information on nomenclature, geographic distribution, habitats, conservation status, genomic sequences, and bibliography relevant for 225 valid species of Porifera, Mollusca, Arthropoda e Chordata. The complete database is available for querying at <http://mar.biotupe.org>.

**Keywords:** Amazon Basin, databases, biodiversity informatics.

## Introduction

The Amazon Basin has the highest known aquatic biodiversity, larger than any other comparable area on Earth (Webb, 1995). The Amazon also presents a larger proportion of marine-derived species, as aquatic mammals, fishes, crustaceans, mollusks, bryozoans, and sponges, than other major tropical river basins (Géry, 1969; Roberts, 1972; Fink & Fink, 1979; Lovejoy, 1997; Lovejoy *et al.*, 1998). However, little is yet known about the geographic distribution patterns of those organisms, what creates difficulties for the understanding of the historical events responsible for the huge differentiation observed in this fauna.

The understanding of the history of the Amazon Basin at the end of Tertiary is not yet well known (Sioli, 1964; Hoorn, 1993, 1994; Hoorn *et al.*, 1995, 2010; Räsänen *et al.*, 1997; Monsch, 1998). Many explanations were suggested, for example, for the tidal sediments found in the State of Acre. Some authors (*eg.* Räsänen *et al.*, 1995) presented the hypothesis that these deposits would result from an inner (epicontinental) sea in South American, the Amazon Sea. Another hypothesis for the origin of these sediments is that they could represent the deltaic deposition of a great lake, the Amazon Lake (Frailey *et al.* 1988; Marroig & Cerqueira, 1997) from Pleistocene-Holocene age, or the Pebas Lake (Wesselingh, 2006; Wesselingh & Salo, 2006; Wesselingh *et al.* 2002) from Miocene age. The modifications in open environments along the coast of this inner sea or lake would

facilitate the migration of aquatic animals, promoting the integration of faunas during the geological history of the South American continent. Brooks *et al.* (1981), Nelson (1984), Lovejoy (1996, 1997), Lovejoy *et al.* (1998, 2006), Lovejoy & Araújo (2000), Lovejoy & Collette (2001), Boeger & Kritsky (2002), Cooke *et al.* (2012), and Bloom & Lovejoy (2017) presented studies on the phylogeny and biogeography of freshwater stingrays (Potamotrygonidae), sardines (Engraulidae), needlefishes (Belonidae), and drums (Sciaenidae) in South America, suggesting that the marine incursions in Amazonia, during the Miocene, were crucial to the evolution of these groups. With regard to speciation patterns of freshwater fishes, Lowe-McConnell (1969), Lundberg (1998), Lundberg *et al.* (1998), and Hubert & Renno (2006) suggested that large tropical river systems like the Amazon would allow that some species developed geographic isolation in the headwaters of tributaries, postulating that tectonic movements could lead to alterations in the ecological conditions of the rivers (Hoorn *et al.*, 1995; Räsänen *et al.*, 1997; Albert *et al.*, 2006), which in turn would propitiate the development of physical, chemical, or biotic barriers among the populations and allowing the occurrence of geographic isolation within a hydrographic system. Hamilton *et al.* (2001) and Domning (1982) presented similar inferences in relation to freshwater cetaceans and sirenians, respectively.

A huge volume of data is available today in the major biological collections of Amazonia (Magalhães *et al.*, 2001; Magalhães & Bonaldo, 2003) and in large online biodiversity databases

(Constable *et al.*, 2010; Edwards *et al.*, 2000; Telenius, 2011). If adequately integrated and analyzed by means of data-mining techniques and statistical methods that make possible to detect patterns and to identify factors and trends, these data can provide valuable subsidies to the conservation and sustainable use of the biological resources represented by this biota. However, a major challenge to achieving this goal is that, though easily accessible from different sources, these data are not available as integrated subsets for specialized target groups as the marine-derived aquatic biota of the Amazon Basin.

The goal of this study was to implement a tool for cataloging and documenting the biological diversity of the marine-derived species of the aquatic biota of the Amazon Basin which could provide such an integrated database with information on nomenclature, geographic distribution, habitats, conservation status, genomic sequences, and bibliography relevant for each species, compiled from several different sources.

## Materials and Methods

For building the database, we used a list of species of selected taxonomic groups (sponges, mollusks, crustaceans, fishes, and aquatic mammals) representative of the marine-derived aquatic biota of the Amazon Basin, compiled from literature data, from the biological collections of the major Amazonian research institutions, and from those available in online databases. This list was previously checked against the Catalogue of Life ([www.catalogueoflife.org](http://www.catalogueoflife.org)) taxonomic database to

identify and correct possible synonyms and other nomenclatural problems.

The system was entirely based on open source, freely available software tools. The database was implemented using the database management system MySQL ([www.mysql.com](http://www.mysql.com)), on the basis of the generic scheme for biodiversity databases ACACIA ([sites.google.com/site/acaciadb](http://sites.google.com/site/acaciadb)). A specialized software tool developed in the Python programming language ([www.python.org](http://www.python.org)) was used to populate the database tables from several sources available on the Internet which provide interfaces to application programs, including five data classes: (1) nomenclature and literature data: CoL ([www.catalogueoflife.org](http://www.catalogueoflife.org)), FishBase ([www.fishbase.org](http://www.fishbase.org)), and WoRMS ([www.marinespecies.org](http://www.marinespecies.org)); (2) genomic sequence data: Genbank/NCBI ([www.ncbi.nlm.nih.gov/genbank](http://www.ncbi.nlm.nih.gov/genbank)); (3) geographic distribution data: Global Biodiversity Information Facility ([www.gbif.org](http://www.gbif.org)), VertNet ([www.vertnet.org](http://www.vertnet.org)), and iDigBio ([www.idigbio.org](http://www.idigbio.org)); (4) conservation status data: IUCN Red List ([www.iucnredlist.org](http://www.iucnredlist.org)); (5) free text notes: Wikipedia ([en.wikipedia.org](http://en.wikipedia.org)).

Searches and analyses of these data can be performed by means of a user-friendly Web interface written in the language PHP ([www.php.net](http://www.php.net)), with simple menus for browsing and querying the database and generating statistical reports (Fig. 1). Distribution maps are automatically generated by the OpenLayers ([www.openlayers.org](http://www.openlayers.org)) integrated tool, on the basis of the georeferenced occurrence records available in the database (Fig. 2). Results of all database queries can be exported to files in Excel,

CSV or KML standard formats for use with other

software as GIS and statistical packages, for more elaborate display and further analysis.

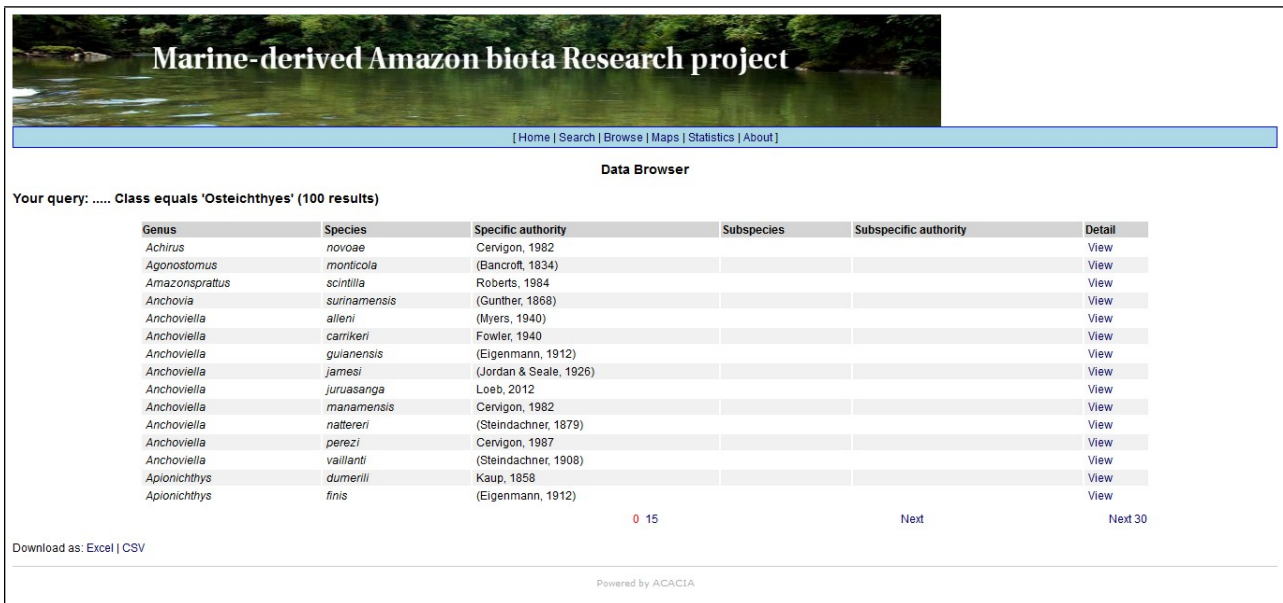


Figure 1 – Database browser, displaying the results of a simple query.



Figure 2 – Distribution map for a selected species.

## Results and Discussion

Data were obtained for 225 valid species of marine-derived taxonomic groups, included in 4 phyla, 6 classes, 19 orders, 29 families, and 74

genera (Table 1). These species present 621 names, with 317 synonyms. Chordata (58,7%) is the phylum of the highest species frequency, followed by Arthropoda (22,17%), Porifera (18,7%), and Mollusca (0,43%). The most

frequent classes are Osteichthyes (43,48%), Crustacea (22,17%), Demospongiae (18,7%), and Chondrichthyes (12,17%). Decapoda (22,7%), Haplosclerida (18,7%), Perciformes (18,7%), Rajiformes (10,87%), and Clupeiformes (10%)

are the orders with the highest species frequency, whereas Trichodactylidae (19,13%), Potamotrygonidae (10,87%), Sciaenidae (8,7%), and Spongillidae (7,39%) are the most frequent families.

Table 1 – Checklist of the marine-derived aquatic biota of the Amazon Basin

PORIFERA

DEMOSPONGIAE

HAPLOSCLERIDA

Incertae Sedis

*Acanthotylotra alvarengai* Volkmer-Ribeiro et al., 2009  
*Balliviaspongia wirrmani* Boury-Esnault & Volkmer, 1992

Metaniidae

*Acalle recurvata* (Bowerbank, 1863)  
*Drulia batesii* (Bowerbank, 1863)  
*Drulia brownii* (Bowerbank, 1863)  
*Drulia conifera* Bonetto & Ezcurra de Drago, 1973  
*Drulia cristata* (Weltner, 1895)  
*Drulia ctenosclera* Volkmer & Mothes, 1981  
*Drulia geayi* (Gravier, 1899)  
*Drulia uruguayensis* Bonetto & Ezcurra de Drago, 1969  
*Metania fittkau* Volkmer-Ribeiro, 1979  
*Metania kiliani* Volkmer-Ribeiro & Costa, 1992  
*Metania melloleitaoi* (Machado, 1948)  
*Metania reticulata* (Bowerbank, 1863)  
*Metania spinata* (Carter, 1881)  
*Metania subtilis* Volkmer-Ribeiro, 1979

Potamolepididae

*Oncosclera atrata* (Bonetto & Ezcurra de Drago, 1970)  
*Oncosclera intermedia* Bonetto & Ezcurra de Drago, 1973  
*Oncosclera jewelli* (Volkmer, 1963)  
*Oncosclera navicella* (Carter, 1881)  
*Oncosclera petricola* Bonetto & Ezcurra de Drago, 1967  
*Oncosclera ponsi* (Bonetto & Ezcurra de Drago, 1968)  
*Oncosclera schubarti* (Bonetto & Ezcurra de Drago, 1967)  
*Oncosclera spinifera* (Bonetto & Ezcurra de Drago, 1973)  
*Oncosclera stolonifera* Bonetto & Ezcurra de Drago, 1973  
*Oncosclera tonollii* (Bonetto & Ezcurra de Drago, 1968)

Spongillidae

*Corvoheteromeyenia australis* (Bonetto & Ezcurra de Drago, 1966)  
*Corvoheteromeyenia heterosclera* (Ezcurra de Drago, 1974)  
*Pottsiela pesae* Volkmer-Ribeiro et al., 2010  
*Pottsiela spoliata* (Volkmer-Ribeiro & Maciel, 1983)  
*Saturnospongilla carvalhoi* Volkmer-Ribeiro, 1976  
*Trochospongilla amazonica* (Weltner, 1895)  
*Trochospongilla delicata* Bonetto & Ezcurra de Drago, 1967  
*Trochospongilla gregaria* (Bowerbank, 1863)  
*Trochospongilla lanzamirandai* Bonetto & Ezcurra de Drago, 1964  
*Trochospongilla minuta* (Potts, 1887)  
*Trochospongilla paulula* (Bowerbank, 1863)  
*Trochospongilla repens* (Hinde, 1888)  
*Trochospongilla tenuissima* Bonetto & Ezcurra de Drago, 1970  
*Trochospongilla variabilis* Bonetto & Ezcurra de Drago, 1973  
*Uruguayella macandrewi* (Hinde, 1888)  
*Uruguayella pygmaea* (Hinde, 1888)  
*Uruguayella ringueleti* (Bonetto & Ezcurra de Drago, 1962)

MOLLUSCA

## BIVALVIA

## PHOLADOMYOIDA

## Lyonsiidae

*Anticorbula fluviatilis* (H. Adams, 1860)

## ARTHROPODA

## CRUSTACEA

## DECAPODA

## Pseudothelphusidae

*Brasiliothelphusa dardanelosensis* Magalhaes & Turkay, 2010*Brasiliothelphusa tapajoense* Magalhaes & Turkay, 1986*Fredius fittkawi* (Bott, 1967)*Kingsleya gustavo* Magalhaes, 2004*Kingsleya junki* Magalhaes, 2003*Kingsleya siolii* Bott, 1967*Kingsleya ytupora* Magalhaes, 1986

## Sergestidae

*Acetes marinus* Omori, 1975*Acetes paraguayensis* Hansen, 1919

## Trichodactylidae

*Bottiella cucutensis* (Pretzmann, 1968)*Bottiella medemi* (Smalley & Rodriguez, 1972)*Bottiella niceforei* (Schmitt & Pretzmann, 1968)*Dilocarcinus pagei* Stimpson, 1861*Dilocarcinus septemdentatus* (Herbst, 1783)*Dilocarcinus truncatus* Rodriguez, 1992*Fosteria venezuelensis* (Rathbun, 1905)*Fredilocarcinus apyratii* Magalhaes & Turkay, 1996*Fredilocarcinus musmuschiae* (Pretzmann & Mayta, 1980)*Fredilocarcinus raddai* (Pretzmann, 1979)*Fredius denticulatus* (H. Milne-Edwards, 1853)*Fredius reflexifrons* (Ortmann, 1897)*Goyazana castelnaui* (H. Milne Edwards, 1853)*Moreirocarcinus chacei* (Pretzmann, 1968)*Moreirocarcinus emarginatus* (H. Milne-Edwards, 1853)*Moreirocarcinus laevifrons* (Moreira, 1901)*Poppiana argentiniana* (Rathbun, 1905)*Poppiana bulbifer* Rodriguez, 1992*Poppiana dentata* (Randall, 1840)*Rotundovaldivia latidens* (A. Milne-Edwards, 1869)*Sylviocarcinus australis* Magalhaes & Turkay, 1996*Sylviocarcinus devillei* H. Milne-Edwards, 1853*Sylviocarcinus maldonadoensis* (Pretzmann, 1978)*Sylviocarcinus pictus* (H. Milne-Edwards, 1853)*Sylviocarcinus piriformis* (Pretzmann, 1968)*Trichodactylus borellianus* Nobili, 1896*Trichodactylus crassus* A. Milne-Edwards, 1869*Trichodactylus dentatus* H. Milne Edwards, 1853*Trichodactylus ehrhardti* Bott, 1969*Trichodactylus faxoni* Rathbun, 1905*Trichodactylus fluviatilis* Latreille, 1928*Trichodactylus kensleyi* Rodriguez, 1992*Trichodactylus panoplus* (von Martens, 1869)*Trichodactylus parvus* Moreira, 1912*Trichodactylus petropolitanus* (Goldi, 1886)*Trichodactylus quinquentatus* Rathbun, 1893*Valdivia camerani* (Nobili, 1896)*Valdivia haraldi* Bott, 1969*Valdivia novemdentata* (Pretzmann, 1968)*Valdivia serrata harttii* (Rathbun, 1905)*Valdivia serrata serrata* White, 1847*Zilchiopsis collastinensis* (Pretzmann, 1968)*Zilchiopsis cryptodus* (Ortmann, 1983)*Zilchiopsis oronensis* (Pretzmann, 1968)

## CHORDATA

## CHONDRICHTHYES

- CARCHARHINIFORMES  
Carcharhinidae  
*Carcharhinus leucas* (Muller & Henle, 1839)
- PRISTIFORMES  
Pristidae  
*Pristis pectinata* Latham, 1794  
*Pristis pristis* (Linnaeus, 1758)
- RAJIFORMES  
Potamotrygonidae  
*Heliotrygon gomesi* Carvalho & Lovejoy, 2011  
*Heliotrygon rosai* Carvalho & Lovejoy, 2011  
*Paratrygon ajereba* (Muller & Henle, 1841)  
*Plesiotrygon iwamae* Rosa, Castello & Thorson, 1987  
*Plesiotrygon nana* Carvalho & Ragno, 2011  
*Potamotrygon boesemani* Rosa, Carvalho & Almeida Wanderley, 2008  
*Potamotrygon brachyura* (Gunther, 1880)  
*Potamotrygon constellata* (Vaillant, 1880)  
*Potamotrygon falkneri* Castex & Maciel, 1963  
*Potamotrygon henlei* (Castelnau, 1855)  
*Potamotrygon humerosa* Garman, 1913  
*Potamotrygon hystrix* (Muller & Henle, 1841)  
*Potamotrygon leopoldi* Castex & Castello, 1970  
*Potamotrygon magdalenae* (Dumeril, 1865)  
*Potamotrygon marinae* Deynat, 2006  
*Potamotrygon motoro* (Muller & Henle, 1841)  
*Potamotrygon ocellata* (Engelhardt, 1912)  
*Potamotrygon orbignyi* (Castelnau, 1855)  
*Potamotrygon schoederi* Fernandez-Yepe, 1958  
*Potamotrygon schuhmacheri* Castex, 1964  
*Potamotrygon scobina* Garman, 1913  
*Potamotrygon signata* Garman, 1913  
*Potamotrygon tatariana* Silva & Carvalho, 2011  
*Potamotrygon tigrina* Carvalho, Sabaj Perez & Lovejoy, 2011  
*Potamotrygon yepesi* Castex & Castello, 1970
- OSTEICHTHYES  
ANGUILIFORMES  
Ophichthidae  
*Stictorhinus potamius* Bohlke & McCosker, 1975
- ATHERINIFORMES  
Belonidae  
*Belonion apodion* Collette, 1966  
*Belonion dibranchodon* Collette, 1966  
*Potamorrhaphis eigenmanni* Miranda Ribeiro, 1915  
*Potamorrhaphis guianensis* (Jardine, 1843)  
*Potamorrhaphis petersi* Collette, 1974  
*Pseudotylorus angusticeps* (Gunther, 1866)  
*Pseudotylorus microps* (Gunther, 1866)
- BATRACHOIDIFORMES  
Batrachoididae  
*Potamobatrachus trispinosus* Collette, 1995  
*Thalassophryne amazonica* Steindachner, 1876
- BELONIFORMES  
Hemiramphidae  
*Hyporhamphus brederi* (Fernandez-Yepe, 1948)
- CLUPEIFORMES  
Clupeidae  
*Rhinosardinia amazonica* (Steindachner, 1879)  
*Rhinosardinia bahiensis* (Steindachner, 1879)
- Engraulidae  
*Amazonsprattus scintilla* Roberts, 1984  
*Anchovia surinamensis* (Gunther, 1868)  
*Anchoviella alleni* (Myers, 1940)  
*Anchoviella carrikeri* Fowler, 1940  
*Anchoviella guianensis* (Eigenmann, 1912)  
*Anchoviella jamesi* (Jordan & Seale, 1926)  
*Anchoviella juruasanga* Loeb, 2012  
*Anchoviella manamensis* Cervigon, 1982  
*Anchoviella nattereri* (Steindachner, 1879)

- Anchoviella perezii* Cervigon, 1987  
*Anchoviella vaillanti* (Steindachner, 1908)  
*Jurengraulis juruensis* (Boulenger, 1898)  
*Lycengraulis batesii* (Gunther, 1868)  
*Lycengraulis limnichthys* Schultz, 1949  
*Pterengraulis atherinoides* (Linnaeus, 1766)
- Pristigasteridae  
*Ilisha amazonica* (Miranda Ribeiro, 1920)  
*Pellona altamazonica* Cope, 1872  
*Pellona castelnaeana* Valenciennes, 1847  
*Pellona flavipinnis* (Valenciennes, 1837)  
*Pristigaster cayana* Cuvier, 1829  
*Pristigaster whiteheadi* Menezes & de Pinna, 2000
- ELOPIFORMES  
Megalopidae  
*Megalops atlanticus* Valenciennes, 1847
- GOBIESOCIFORMES  
Gobiesocidae  
*Gobiesox juradoensis* Fowler, 1944  
*Gobiesox multitentaculus* (Briggs, 1951)  
*Gobiesox nudus* (Linnaeus, 1758)
- MUGILIFORMES  
Mugilidae  
*Agonostomus monticola* (Bancroft, 1834)  
*Mugil trichodon* Poey, 1875
- PERCIFORMES  
Eleotridae  
*Dormitator lophocephalus* Hoedeman, 1951  
*Dormitator maculatus* (Bloch, 1792)  
*Eleotris amblyopsis* (Cope, 1871)  
*Eleotris picta* Kner, 1863  
*Eleotris pisonis* (Gmelin, 1789)  
*Microphilypnus acangaquara* Caires & Figueiredo, 2011  
*Microphilypnus amazonicus* Myers, 1927  
*Microphilypnus macrostoma* Myers, 1927  
*Microphilypnus ternetzi* Myers, 1927
- Gobiidae  
*Awaous banana* (Valenciennes, 1837)  
*Awaous flavus* (Valenciennes, 1837)  
*Awaous tajasica* (Lichtenstein, 1822)  
*Gobioides broussonnetii* Lacepede, 1800  
*Gobioides grahamae* Palmer & Wheeler, 1955  
*Gobioides peruanus* (Steindachner, 1880)  
*Sicydium hildebrandi* Eigenmann, 1918  
*Sicydium punctatum* Perugia, 1896  
*Sicydium rosenbergii* (Boulenger, 1899)
- Percichthyidae  
*Percichthys chilensis* Girard, 1855  
*Percichthys colhuapiensis* MacDonagh, 1955  
*Percichthys laevis* (Jenyns, 1840)  
*Percichthys melanops* Girard, 1855  
*Percichthys trucha* (Valenciennes, 1833)
- Sciaenidae  
*Pachypops fourcroyi* (Lacepede, 1802)  
*Pachypops pigmaeus* Casatti, 2002  
*Pachypops trifilis* (Muller & Troschel, 1848)  
*Pachyurus adpersus* Steindachner, 1879  
*Pachyurus bonariensis* Steindachner, 1879  
*Pachyurus calhamazon* Casatti, 2001  
*Pachyurus francisci* (Cuvier, 1830)  
*Pachyurus gabrielensis* Casatti, 2001  
*Pachyurus junki* Soares & Casatti, 2000  
*Pachyurus paucirastrus* Aguilera, 1983  
*Pachyurus schomburgkii* Gunther, 1860  
*Pachyurus squamipennis* Agassiz, 1831  
*Pachyurus stewarti* Casatti & Chao, 2002  
*Petilipinnis grunniens* (Schomburgk, 1843)  
*Plagioscion auratus* (Castelnau, 1855)

- Plagioscion casattii* Aguilera & Rodrigues de Aguilera, 2001  
*Plagioscion montei* Soares & Casatti, 2000  
*Plagioscion squamosissimus* (Heckel, 1840)  
*Plagioscion surinamensis* (Bleeker, 1873)  
*Plagioscion ternetzi* Boulenger, 1895
- PLEURONECTIFORMES
- Achiridae
- Achirus novoae* Cervigon, 1982  
*Apionichthys dumerili* Kaup, 1858  
*Apionichthys finis* (Eigenmann, 1912)  
*Apionichthys menezesi* Ramos, 2003  
*Apionichthys nattereri* (Steindachner, 1876)  
*Apionichthys rosai* Ramos, 2003  
*Apionichthys sauli* Ramos, 2003  
*Apionichthys seripierriae* Ramos, 2003  
*Catathyridium garmani* (Jordan, 1889)  
*Catathyridium grandirivi* (Chabanaud, 1928)  
*Catathyridium jenynsii* (Gunther, 1862)  
*Catathyridium lorentzii* (Weyenbergh, 1877)  
*Hypoclinemus mentalis* (Gunther, 1862)  
*Pnictes asphyxiatus* (Jordan, 1889)
- TETRAODONTIFORMES
- Tetraodontidae
- Colomesus asellus* (Muller & Troschel, 1849)  
*Colomesus psittacus* (Bloch & Schneider, 1801)  
*Colomesus tocantinensis* Amaral et. al, 2013
- MAMMALIA
- CETACEA
- Delphinidae
- Sotalia fluviatilis* (Gervais & Deville, 1853)  
*Sotalia guianensis* (P.-J. van Beneden, 1864)
- Iniidae
- Inia araguaiensis* Hrbek et al., 2014  
*Inia geoffrensis boliviensis* d'Orbigny, 1834  
*Inia geoffrensis geoffrensis* de Blainville, 1817  
*Inia geoffrensis humboldtiana* Pilleri and Gühr, 1978
- SIRENIA
- Trichechidae
- Trichechus inunguis* Natterer, 1883

As of the geographic distribution of the species in the Amazon Basin, there are 5,689 occurrence records from 2,570 localities. *Potamorrhaphis guianensis* with 411 records (7,22%), *Percichthys trucha* with 351 records (6,17%), *Plagioscion squamosissimus* with 347 records (6,1%), *Colomesus asellus* with 241 records (4,24%), and *Amazonsprattus scintilla* with 203 records (3,57%) are the species with the highest number of records.

There are 2,502 nucleotide sequences and 1,507 protein sequences for 69 species (30% of the total) in the database, of which 18 species present more than 40 sequences and the remaining present from 2 to 36 sequences.

With relation to conservation status, following the criteria of IUCN, 3 species (*Bottiella cucutensis*, *Bottiella medemi*, and *Trichechus inunguis*) are included in category Vulnerable (VU), 2 (*Pristis pectinata* and *Pristis pristis*) in category Critically endangered (CR), 2 (*Carcharhinus leucas* and *Potamotrygon magdalenae*) in category Near threatened (NT) and 1 (*Trichodactylus crassus*) in category Endangered (EN), with 42 species included in category Least concern (LC), 29 in category Deficient data (DD) and 151 in category Not evaluated (NE). No species is included in the categories Extinct in the wild (EW) or Extinct (EX).

Caution is required in interpreting these figures on the conservation status of marine-derived species from the Amazon Basin, as there are no global estimates in the literature on how much of this biota is still unknown and not properly documented. Thus, the two species of *Pristis* listed as “Critically endangered” are not endemic of the Amazon Basin and, in fact, are not obligate freshwater species, despite their ability to live in freshwater habitats (Thorson, 1974); the same applies to *Carcharhinus leucas*, one of the species listed as “Near threatened” (Thorson, 1972). In both cases, the conservation status applies to these species as a whole and does not imply that they are endangered or threatened in the Amazon Basin: in this regard, Fernandez-Carvalho *et al.* (2014) found that the Amazon estuary harbors the largest remaining population of *P. pristis* in the Atlantic. On the other hand, *Trichodactylus crassus*, the only species listed as “Endangered”, comprises a sixth of the freshwater crabs of the world facing a high risk of extinction (Cumberlidge *et al.*, 2009), but its geographic distribution is restricted to localities of the Atlantic Forest and Caatinga (Almeida *et al.*, 2008; Souza-Carvalho, 2013), therefore outside the Amazon Basin. What should really be emphasized is the very large number of species (151 out of 225 species in the database, or 67% of the total) that have not even had their conservation status evaluated.

The complete database of the marine-derived aquatic biota of the Amazon Basin is available for querying at <http://mar.biotupe.org>.

## Conclusions

A major result of this study was the development and public availability of a comprehensive database on the marine-derived aquatic biota of the Amazon Basin. Currently, this database is the only such initiative even implemented in the world, consolidating the available data on this biota all over its geographic range from many distributed sources. Besides, the free, generic, and flexible information technology developed for implementing the database (the ACACIA scheme for taxonomic databases and associated software) can be used for the development of such integrated biodiversity databases targeting other biotas and taxonomic groups of interest, as for example, the marine-derived aquatic biotas of the Congo/Zambezi and Ganges/Mekong/Yangtze river basins.

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## References

- Albert, J. S., Lovejoy, N. R. & Crampton, W. G. R. 2006. Miocene tectonism and the separation of cis- and trans-Andean river basins: evidence from Neotropical fishes. *Journal of South American Earth Sciences* 21: 14-27.

- Bloom, D. D. & Lovejoy, N. R. 2017. On the origins of marine-derived freshwater fishes in South America. *Journal of Biogeography* 44: 1927-1938.
- Boeger, W. A. & Kritsky, D. C. 2002. Parasites, fossils and geologic history: historical biogeography of the South American freshwater croakers, *Plagioscion* spp. (Teleostei, Sciaenidae). *Zoologica Scripta* 32: 3-11.
- Brooks, D. R., Thorson, T. B. & Mayes, M. A. 1981. Freshwater stingrays (Potamotrygonidae) and their helminth parasites: testing hypotheses of evolution and coevolution. In: *Advances in Cladistics. Proceedings of the First Meeting of the Willi Henning Society*. Funk, V. A. & Brooks, D. R. (eds). New York Botanical Garden, New York, pp. 147-175.
- Brooks, D. R. 1995. Neotropical freshwater stingrays and their parasites: a tale of an ocean and a river long ago. *Journal of Aquaculture and Aquatic Sciences* 7: 52-61.
- Constable, H., Guralnick, R., Wieczorek, J., Spencer, C., Peterson, A.T. 2010. VertNet: a new model for biodiversity data sharing. *PLoS Biology* 8: e1000309.
- Cooke, G.; Chao, N. & Beheregaray, L. 2012. Marine incursions, cryptic species and ecological diversification in Amazonia: the biogeographic history of the croaker genus *Plagioscion* (Sciaenidae). *Journal of Biogeography* 39: 724-738.
- Costa, J.B.S.; Bemerguy, R.L.; Hasui, Y.; Borges, M.S.; Ferreira Júnior, C.R.P.; Bezerra, P.E.L.; Costa, M.L. & Fernandes, J.M.G. 1996. Neotectônica da região amazônica: aspectos tectônicos, geomorfológicos e deposicionais. *Geonomos* 4: 23-44.
- Domning, D.P. 1982. Evolution of manatees: a speculative history. *Journal of Paleontology* 56: 599-619.
- Edwards, J. L., Lane, M. A. & Nielsen, E. S. 2000. Interoperability of biodiversity databases: Biodiversity information on every desktop. *Science* 289: 2312-2314.
- Fernandez-Carvalho, J., Imhoff, J.L., Faria, V.V., Carlson, J.K. & Burgess, G.H. 2014. Status and the potential for extinction of theargetooth sawfish *Pristis pristis* in the Atlantic Ocean. *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 478-497.
- Fink, W. L. & Fink, S. V. 1979. Central Amazonia and its fishes. *Comparative Biochemistry and Physiology* 62A: 13-29.
- Frailey, C. D., Lavina, E. L., Rancy, A. & Souza Filho, J. P. 1988. A proposed Pleistocene/Holocene lake in the Amazon basin and its significance to Amazonian geology and biogeography. *Acta Amazonica* 18: 119-143.
- Géry, J. 1969. The freshwater fishes of South America. In: *Biogeography and Ecology in South America*, Vol.2. Fittkau, E. J. *et al.* (eds.). W. Junk, The Hague, pp. 828-848.
- Hamilton, H., Caballero, S., Collins, A. G. & Brownell, Jr., R. L. 2001. Evolution of river dolphins. *Proceedings of the Royal Society London, Biological Sciences* 268: 549-556.

- Horn, C. 1993. Marine incursions and the influence of Andean tectonics on the Miocene depositional history of northwestern Amazonia: results of a palynostratigraphic study. *Paleogeography, Paleoclimatology, Paleoecology* 105: 267-309.
- Horn, C. 1994. An environmental reconstruction of the paleo-Amazon River system (Middle-Late Miocene, NW Amazonia). *Paleogeography, Paleoclimatology, Paleoecology* 112: 187-238.
- Horn, C. 2006. Mangrove forests and marine incursions in Neogene Amazonia (Lower Apaporis River, Colombia). *Palaios* 21: 197-209
- Horn, C., Guerrero, J., Sarmiento, G. & Lorente, M. 1995. Andean tectonics as a cause for changing drainage patterns in Miocene northern South America. *Geology* 23: 237-240.
- Horn, C.; Wesselingh, F.; ter Steege, H.; Bermudez, M.; Mora, A.; Sevink, J.; Sanmartín, I.; Sanchez-Meseguer, A.; Anderson, C.; Figueiredo, J.; Jaramillo, C.; Riff, D.; Negri, F. R.; Hooghiemstra, H.; Lundberg, J.; Stadler, T.; Sarkinen, T. & Antonelli, A. 2010. Amazonia through time: Andean uplift, climate change, landscape evolution, and biodiversity. *Science* 330: 927-931.
- Hubert, N. & Renno, J.-F. 2006. Historical biogeography of South American freshwater fishes. *Journal of Biogeography* 33: 1414-1436.
- Latrubesse, E. M., Silva, S. A. F., Cozzuol, M. & Absy, M. L. 2007. Late Miocene continental sedimentation in southwestern Amazonia and its regional significance: biotic and geological evidence. *Journal of South American Earth Sciences* 23: 61-80.
- Lovejoy, N. R. 1996. Systematics of myliobatoid elasmobranchs: with emphasis on the phylogeny and historical biogeography of neotropical freshwater stingrays (Potamotrygonidae: Rajiformes). *Zoological Journal of the Linnean Society* 117: 207-257.
- Lovejoy, N. R. 1997. Stingrays, parasites, and neotropical biogeography: a closer look at Brooks et al.'s hypotheses concerning the origins of neotropical freshwater rays (Potamotrygonidae). *Systematic Biology* 46: 218-230.
- Lovejoy, N. R., Bermingham, E. & Martin, A. P. 1998. Marine incursion into South America. *Nature* 396: 421-422.
- Lovejoy, N. R. & Araújo, M. L. G. 2000. Molecular systematics, biogeography and population structure of Neotropical freshwater needlefishes of the genus *Potamorrhaphis*. *Molecular Ecology* 9: 259-268.
- Lovejoy, N. R. & Collette, B. B. 2001. Phylogenetic relationships of New World needlefishes (Teleostei: Belontiidae) and the biogeography of transitions between marine and freshwater habitats. *Copeia* 2001: 324-338.
- Lovejoy, N. R., Albert, J. S. & Crampton, W. G. R. 2006. Miocene marine incursions and marine/freshwater transitions: evidence from Neotropical fishes. *Journal of South American Earth Sciences* 21: 5-13.

- Lowe-McConnell, R. H. 1969. Speciation in tropical freshwater fishes. *Biological Journal of the Linnean Society* 1: 51-75.
- Lundberg, J. G. 1998. The temporal context for the diversification of neotropical fishes. In: *Phylogeny and Classification of Neotropical Fishes*. Malabarba, L. R., Reis, R. E., Vari, R. P., Lucena, Z. M. S. & Lucena, C. A. S. (eds). EDIPUCRS, Porto Alegre, pp. 48-68.
- Lundberg, J. G., Marshall, L. G., Guerrero, J., Horton, B., Malabarba, M. C. S. L. & Wesselingh, F. 1998. The stage for neotropical fish diversification: a history of tropical South American rivers. In: *Phylogeny and Classification of Neotropical Fishes*. Malabarba, L. R., Reis, R. E., Vari, R. P., Lucena, Z. M. S. & Lucena, C. A. S. (eds). EDIPUCRS, Porto Alegre, pp. 13-48.
- Magalhães, C., Campos dos Santos, J. L. & Salem, J. I. 2001. Automação de coleções biológicas e informações sobre a biodiversidade da Amazônia. *Parcerias Estratégicas* 12: 294-312.
- Magalhães, C. & Bonaldo, A. B. 2003. Coleções biológicas da Amazônia: estratégias sugeridas para o desenvolvimento e plena realização das suas potencialidades. In: *Coleções Biológicas de Apoio ao Inventário, Uso Sustentável e Conservação da Biodiversidade*. Peixoto, A. L. (ed.). Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, pp. 149-167.
- Marroig, G. & Cerqueira, R. 1997. Plio-Pleistocene South American history and the Amazon lagoon hypothesis: a piece in the puzzle of Amazonian diversification. *Journal of Comparative Biology* 2: 103-119.
- Monsch, K. A. 1998. Miocene fish faunas from the northwestern Amazonia basin (Colombia, Peru, Brazil) with evidence of marine incursions. *Paleogeography, Paleoclimatology, Paleoecology* 143: 31-50.
- Nelson, G.J. 1984. Identity of the anchovy *Hildebrandichthys setiger* with notes on relationships and biogeography of the genera *Engraulis* and *Cetengraulis*. *Copeia* 1984: 422-427.
- Räsänen, M. E., Linna, A. M., Santos, J. C. R. & Negri, F. R. 1995. Late Miocene tidal deposits in the Amazonian foreland basin. *Science* 269: 386-389.
- Roberts, T. R. 1972. Ecology of fishes in the Amazon and Congo basins. *Bulletin of the Museum of Comparative Zoology, Harvard* 143: 117-147.
- Sioli, H. 1964. General features of the limnology of Amazonia. *Verhandlungen der internationalen Vereinigung für theoretische und angewandte Limnologie* 15: 1053-1058.
- Telenius, A. 2011. Biodiversity information goes public: GBIF at your service. *Nordic Journal of Botany* 29: 378-381.
- Thorson, T.B. 1972. The status of the bull shark, *Carcharhinus leucas*, in the Amazon River. *Copeia* 1972: 601-605.
- Thorson, T.B. 1974. Occurrence of the sawfish, *Pristis perotteti*, in the Amazon river, with notes on *P. pectinatus*. *Copeia* 1974: 560-564.
- Webb, S. D. 1995. Biological implications of the middle Miocene Amazon seaway. *Science* 269: 361-362.
- Wesselingh, F.P. 2006. Miocene long-lived lake Pebas as a stage of mollusc radiations, with

implications for landscape evolution in western Amazonia. *Scripta Geologica* 133: 1-17.

Wesselingh, F.P.; Räsänen, M.E.; Irion, G.; Vonhof, H.B.; Kaandorp, R.; Renema, W.; Romero Pittman, L. & Gingras, M. 2002. Lake Pebas: a palaeoecological reconstruction of a Miocene, long-lived lake complex in western Amazonia. *Cainozoic Research* 1: 1-2.

Wesselingh, F. & Salo, J.A. 2006. Miocene perspective on the evolution of the Amazonian biota. *Scripta Geologica* 133: 439-458.