The Fish Fauna of the Iwokrama Forest

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Abstract

Fish were collected from the rivers in and around the Iwokrama Forest during January-February and November-December 1997. Four hundred species of fish were recorded from forty families within ten orders. Many of these fish are new for Guyana and several thought to be endemic. The numbers of species recorded for the area is surprising given the low level of effort and suggests that this area may be particularly important from a fish biodiversity perspective. This paper focuses on species of particular interest from a management perspective including those species considered economically important, rare or endangered. This paper is also the basis for developing fisheries management systems in the Iwokrama Forest and Rupununi Wetlands.

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Introduction

Fish are key components of Amazonian rain forest ecosystems (Goulding 1983; Goulding, Smith et al. 1995; Lowe-McConnell 1995; Barthem and Goulding 1997; Lundberg 2001). Fish are linked to forests through nutrient flows into wetlands and by migrations of fish through forested ecosystems. In addition, fish are often critical traditional food sources that define human-forest relationships (Robinson and Redford 1991). Fish communities respond to changes in the physical and chemical characteristics of wetlands; in this context, human impacts through timber harvest, road building, and mining can transform fish communities. Padoch et al. (1999) describe the effects of “boom and bust” natural resource economic cycles on Varzéa flooded forests and express the need for forest management to include sustainable fishing, habitat conservation and management of long range fish migrations.

The aquatic systems within and around, the Iwokrama Forest are key components of the Iwokrama Forest ecosystem. Local people have been long aware of the linkages between flooding and the feeding and spawning cycles of fish in the Iwokrama Forest and Rupununi Wetlands (Forte, Janki et al. 1999). In addition, fish are important resources for the indigenous communities of the North Rupununi (Forte, Janki et al. 1999) and several fish (*Arapaima gigas*, *Cichla ocellaris*, and Pimelodid catfish) are sold commercially. These wetlands and their fish fauna are integral to deriving economic and social benefits from the Iwokrama Forest. Unfortunately, there have been few studies of the wetland resources in the Iwokrama Forest, or in Guyana as a whole (see Lowe-McConnell 1964; Lowe-McConnell 1967; Lowe-McConnell 1969; Eigenmann 1912).

The Study Site

Three watersheds are associated with the Iwokrama Forest: the Essequibo, Burro-Burro and Siparuni Rivers. The Iwokrama Forest is bordered to the east by the Essequibo River; and to the north and west by the Siparuni River. The Burro-Burro River runs through the central part of the Iwokrama Forest (see figure 1). Approximately, 1500 km^2 of the Iwokrama Forest drain directly to the Essequibo River, 1500 km^2 to the Burro-Burro and 900 km^2 to the Siparuni River (Hawkes & Wall 1993).

In the vicinity of the Iwokrama Forest the Essequibo River has main channels 250-500 metres wide and is at maximum approximately 1 km wide. It is characterized north of Kurupukari Falls by extensive sand bars that are visible during low water and in several places throughout the Iwokrama Forest is crossed by volcanic dykes forming rapids. The Essequibo has a probable maximum depth of 40 m (Hawkes & Wall 1993), and its banks are not high except where scouring has occurred (Hawkes & Wall 1993). The Essequibo drainage is seasonally linked to the Amazon drainage when the flooded savannas form a continuous expanse of water between the tributaries of the Rio Branco and the Rupununi River. The Burro-Burro and Siparuni Rivers are much smaller rivers with maximal widths of 100 m and 150 m respectively. As in the Essequibo, rapids are formed where the rivers cross over volcanic dykes. Both the Burro-Burro and Siparuni rivers are steep-sided, deep rivers with few sandbars, and little exposed shoreline. The Essequibo River has far more sand and silt substrates than do either the Siparuni or Burro-Burro. The Burro-Burro River floods extensively into the forest during the rainy season.

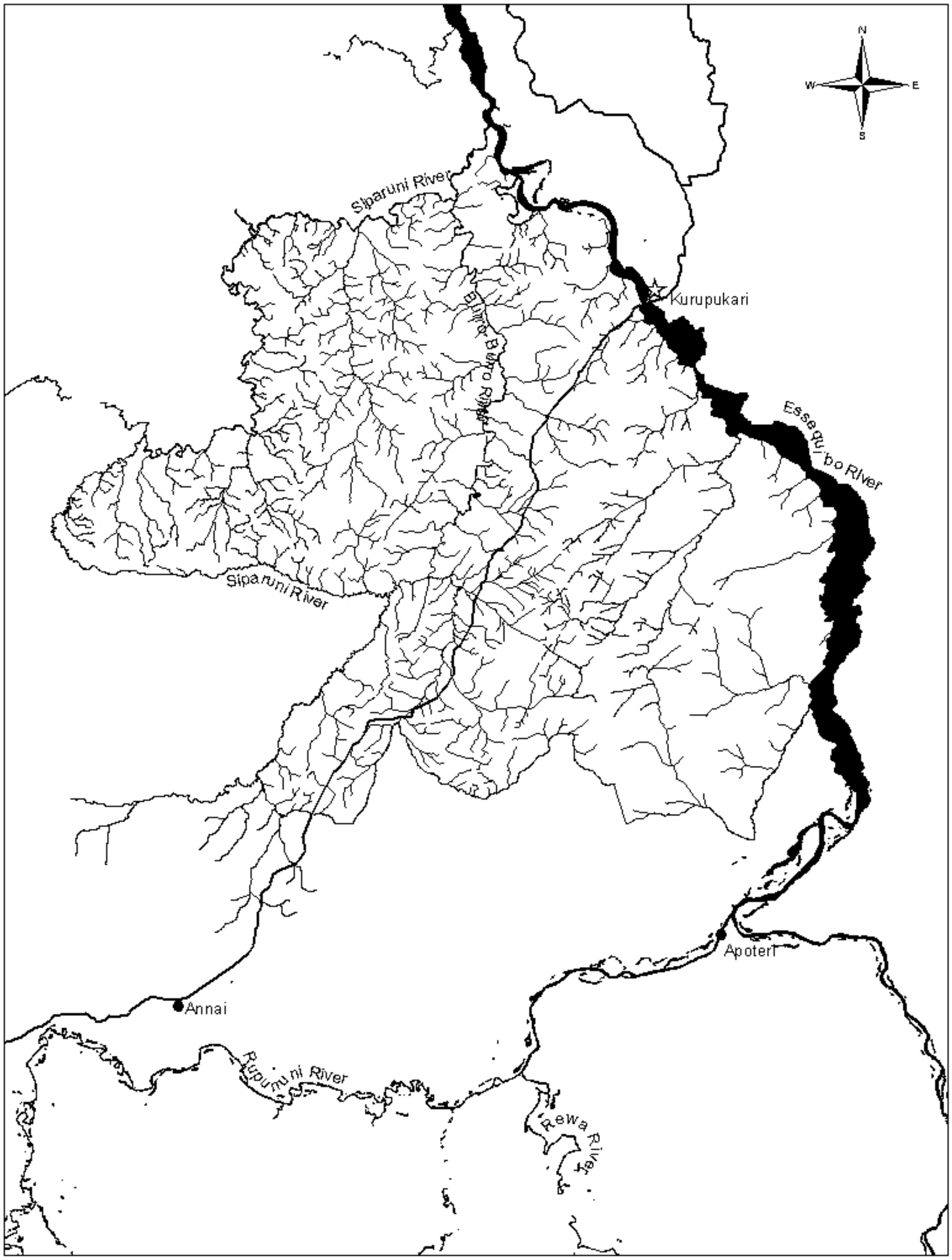

Figure 1: The river systems in and around the Iwokrama Forest

Amazonian and other South American river systems are often categorized as white, black, or clear waters. Similarly, Carter (1934) describes the rivers of Guyana as either black water or white water. Black waters are acidic, have high carbon dioxide and low oxygen content. White waters are turbid, have low carbon dioxide, high silica, and low acidity. Unfortunately, the rivers near the Iwokrama Forest do not neatly fall into these categories. The Essequibo has high sediment loads and can be considered as a white water river along its borders with the Iwokrama Forest. This is partly due to the fact that the white water Rupununi River drains into the Essequibo just south of the Iwokrama Forest. Secchi disc visibility ranges from approximately 0.2 to 1.0 metre in the main channels. Despite this, water colour and turbidity change seasonally and spatially sometimes appearing much like what is considered to be black water. For example, south of the confluence between the Rupununi and Essequibo rivers, the upper Essequibo is considerably darker than the lower Essequibo. Changes in the relative contributions from the different tributaries can substantially alter the waters of the Essequibo near the Iwokrama Forest. The Burro-Burro and Siparuni are predominantly black water rivers, with the Siparuni being slightly darker; however the transparency of these rivers is highly variable. All of the main rivers are fed by small third order creeks which are more definable as black, white, or clear waters.

Mean annual rainfall at Kurupukari is approximately 3000 mm per year (Hawkes & Wall 1993). Annai and Apoteri have recorded mean annual rainfall of 1600 mm and 1900 mm respectively (Hawkes & Wall 1993). The Iwokrama Forest therefore experiences a rainfall gradient decreasing from north to south. Rains peak at both Kurupukari and Annai between May to September. However, while in Annai there is generally only one rainy season – Kurupukari is affected by coastal weather patterns giving a short rainy season, in December to January.

Essequibo River levels respond to seasonal patterns of rainfall over the whole Essequibo drainage of 50,000 km^2. The Burro-Burro and Siparuni however, have more immediate responses to local rainfall and the extreme level rises are restricted to the lower reaches of these rivers. River levels in the Siparuni and Burro-Burro are almost certainly affected by both rainfall in their catchments and changes in the levels of the Essequibo River. Waters in the Essequibo generally rise from April, and recede from August to October. In total, an average water-level change of six-metres occurs on an annual basis. This could have substantial consequences for fish communities in the Rupununi (Lowe-McConnell 1995) and the Amazon (Barthem & Goulding 1997).

Methods

Fish were collected during two expeditions to the rivers in and around the Iwokrama Forest during January-February and November-December of 1997. During January-February, the Essequibo and Burro-Burro drainages were surveyed; in November-December the Essequibo, Burro-Burro, and Siparuni drainages were surveyed. In addition, data from earlier collections by the Royal Ontario Museum were used to develop a species list for the area.

Several survey methods were used including stationary and moving gill nets, seines, dip and hoop nets, hook and line, and chemo-fishing (Noxfish Fish Toxicant Liquid Emulsion - Rotenone). Hook and line were used extensively to record larger species and the use of rotenone for smaller species in the steep sided, deep sections. Seines proved ineffective in the steep-sided Burro-Burro and Siparuni.

Due to time constraints and difficulty of access, only 41 sites were surveyed in the Burro-Burro and Siparuni drainages, while 84 were surveyed in the Essequibo. Sampling was restricted to the lower order rivers and creeks.

Specimens from collections were deposited at the Centre for the Study of Biological Diversity, University of Guyana, and the Academy of Natural Sciences, Philadelphia. Specimens collected in 1990 by the Royal Ontario Museum and Youth Challenge International were deposited at the Royal Ontario Museum. Several species were not collected because they were too large or protected in Guyana (*Brachyplatystoma vaillantii, Brachyplatystoma filamentosum, Arapaima gigas,* and *Zungaro zungaro)*.

Results

Four hundred species of fish were recorded (see Appendix-Table 1) from forty families within ten orders. Many of these fish are new for Guyana and several thought to be endemic. Diversity would seem to be high in this area compared with other much larger Amazonian drainages (Rio Negro: 600 species, Madeira River: 398 species) (Revenga et al 2000). Twenty percent of the sites surveyed contained over 30 species, and three sites contained over 50 species. The majority of these species rich sites were either small creeks or sand bars in the Essequibo River.

EstimateS.5 (Colwell 1997) was used to estimate fish species richness for the areas surveyed. The Abundance-based Coverage Estimator of species richness estimates that the surveyed area contains 462 species; the Incidence-based Coverage Estimator estimates 747 species. Figure 2 represents the accumulated number of species found in collection lots (a lot is a set of specimens of the same species collected at any one field site), and supports estimate calculations as the number of species continues to increase throughout. Note step-wise pattern of species accumulation in Figure 2 indicates new communities in habitats.

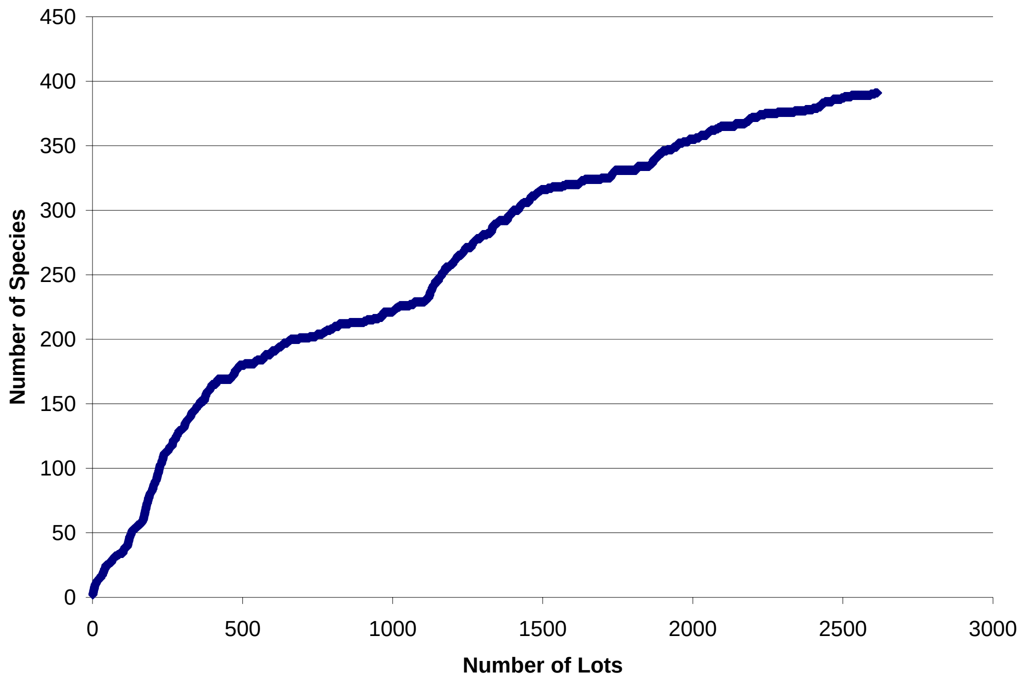

Figure 2: Number of species recorded as the number of lots increases over time

Discussion

Why So Many Species?

Fish species richness is unusually high in the rivers near the Iwokrama Forest. Two factors potentially cause this elevated diversity. The first factor is the wide range of habitats represented within the sampling area; this factor was suggested by Lowe-McConnell (1964) as a major cause of the high species richness in the Rupununi savannas. In the area, fish have a huge choice of habitats offering opportunities for speciation including flooded forests & savannas, rivers, creeks, ponds and ox-bow lakes.

The second factor is that the Essequibo River is situated between three major ichthyofaunal regions: the Orinoco, eastern Guiana Shield, and Amazon. Flooding during the annual high water period enables an exchange in fish species between these three systems.

Distribution & Migration

The Siparuni, Burro-Burro and Essequibo Rivers are physically and chemically distinct, though variable, and many creeks have quite distinct origins. Water transparency is an important predictor of fish community structure in Orinoco floodplain lakes (Rodriguez & Lewis 1997). In general, fish with sensory adaptations to low light such as Gymnotiformes and Siluriformes tend to be dominant in turbid lakes, whereas visually oriented fish such as Characiformes, Clupeiformes, and Perciformes tend to be dominant in transparent lakes. Similar patterns have been described in Amazonian systems (Lowe-McConnell 1995) and the Rupununi (Lowe-McConnell 1964). Turbid waters in the rivers near the Iwokrama Forest were dominated by catfish – 78 species of catfish were almost exclusively found in white waters as opposed to 18 species that were found most frequently in black and clear waters. Auchenipterids, Pimelodids, Loricariids, and Doradids were regularly found in samples from white waters, while they were almost absent from black and clear waters. Seventy percent of the 63 species that were most frequently encountered in black and clear waters were Characoids or Gymnotids.

As with Amazon and Orinoco fish communities, the key to understanding the Iwokrama Forest fish fauna is the migration, feeding, and spawning patterns that are controlled by seasonally changing water levels and availability of oxygen (Lowe-McConnell, 1964; Lowe-McConnell, 1995; see Table 2). Many of the fish species in the Iwokrama Forest undertake trophic dispersals and spawning migrations based on changes in water levels. These changes in water levels seasonally modify the available habitats in the area (Table 2).

Table 2: Seasonal cycles in the Rupununi and Iwokrama Forest (after Lowe-McConnell (1977)

Month	Jan-Feb	Mar-Apr	May-July	Aug-Oct	Nov-Dec
Rainfall	Dry Season		Rains		Dry Season
Water Levels	Low		High		Low
Land Covered with Water	Small	Expanding	Maximal	Declining	Low
Food levels		Nutrients washed in by first rains increase food and plant growth for cover	Access to flooded forest areas for food		
Reproductive Strategy		Spawning and the growth of young	Feeding and Growing	Beginning High Mortality	Stranding and Predation; Deoxygenation of pools
Fish Movements	Confinement to pools	Lateral and Longitudinal migrations up rivers and creeks	Dispersal on floodplains	Movements back to the river	Confinement to pools
Fishing	Catch fish in ponds – that are normally dry season refuges	Catch upstream migrants – before spawning	No fish available	Catch again as fish move back	Catch fish in ponds – that are normally dry season refuges

The majority of fishes in the Iwokrama Forest migrate in response to changing water levels. The dry season and the lower water levels have been described as a "physiological winter" for fish (Lowe-McConnell 1967). A general characteristic of lowland, low-nutrient forest waterways is that allochthonous fruit and leaves form the major food base. Food availability for fish therefore increases in high water when flooded areas become accessible. To deal with this, fat reserves are built up during the rainy season in preparation for the dry season. Oxygen levels and available habitats also decrease substantially during the dry season. Some species migrate back to the larger ponds and main rivers to avoid these harsh conditions; despite this many fish are trapped in drying ponds. Consequently, several species have adaptations, such as air breathing (*Arapaima*, *Electrophorus*) and terrestrial locomotion (e.g., *Erythrinus*, *Hoploerythrinus*, and *Hoplosternum*). These drying ponds, particularly in the savannas, are thought to be ecologically important as a food base for wild cats, birds and other scavengers.

Several species migrate towards spawning sites in the headwaters of small creeks, at the confluences of rivers and creeks, and in the flooded savannas. These migrations occur when waters rise at the beginning of the rainy season; fish begin returning from the flooded areas at the end of the rainy season as waters recede. Exact migration movements are currently unknown, but it is thought that fish travel from the main rivers in the dry season, to adjacent ponds and creeks in the wet season. They may also travel along the Essequibo or up into the Rewa and Rupununi Rivers. Unfortunately, little information is available on tropical fish migratory, feeding, and spawning behaviour.

The Rupununi River and the surrounding savannas are likely to be vital for the healthy maintenance of fish populations in the nutrient poor Essequibo River. It is likely that food availability in the flooded Rupununi savanna drives many of the spawning and feeding migrations in the Essequibo. Flooding along the border of the Essequibo itself is much less extensive than in the Rupununi savannas; as such major food resources become accessible during the rainy season.

Fisheries Management

Several species in the Iwokrama Forest have economic and social values. Certain species have been used locally for subsistence and commerce. For some, there is an urgent need to develop management systems, and there is now potential to develop other uses for fish including sport fishing and aquarium fisheries. The major commercial species in the area is Arapaima (*Arapaima gigas*). Populations of this species have declined dramatically since the 1960s when harvesting began in earnest for sale to Brazil. Arapaima are found mainly in lakes and large creek pools and are more abundant in the Rupununi and the Essequibo near the south-eastern border of the Iwokrama Forest. The Arowana (*Osteoglossum bicirrhosum*) is also an important subsistence and commercial fish that is relatively abundant in the area. Arowana are important both for food and for the aquarium trade and is considered under pressure in the area. The freshwater drum or Basha (*Plagioscion squamosissimus*) is also an important commercial species that lives in deeper water and near falls and is thought to be declining close to villages. The Erythrinids including Haimara (*Hoplias macrophthalmus*), Huri (*Hoplias malabaricus*), Yarrow (*Hoplerythrinus unitaeniatus*), and Bush Yarrow (*Erythrinus erythrinus*) are also important species for local subsistence, and the Haimara is also sold commercially. Of the Pimelodid catfish, the Skeete or Banana Fish (*Phractocephalus hemioliopterus*), Lao-Lao (*Brachyplatystoma filamentosum*), Blinka (*Brachyplatystoma vaillantii*), Siana

(*Zungaro zungaro*) and Jon-Jon (*Pinirampus pirinampu*) are the largest, but commercially exploited at lower levels than the Long Head Cullet (*Pseudoplatystoma tigrinum*) and the Short Head Cullet (*Pseudoplatystoma fasciatum*). The Baiaras (*Cynodon gibbus*, *Hydrolycus armatus*, *Hydrolycus tatauaia* and *Roestes ogilviei*), Lukanani (*Cichla ocellaris*), Yakutu (*Prochilodus rubrotaeniatus*), and Boots (*Trachycorystes trachycorystes*) are also important food fishes.

Many of the fish species found in the Iwokrama Forest play important and complex ecological roles. While little is known about the role of fishes in Guianan terrestrial ecosystems, Goulding (1983) has argued that characoids and catfish play important roles in Amazonian flooded forests as fruit eaters and dispersers; and fish distributions could readily affect forest plant distributions, in particular palms and other key flooded forest species. Characoids tend to be seed destroyers because of their well developed teeth, whereas catfish tend to be good dispersers. In particular, Characoid genera such as *Myleus, Serrasalmus, Pygocentrus, Brycon, Leporinus* and *Triportheus* may be important seed eaters and dispersers. The Siluriformes *Phractocephalus*, *Pseudodoras*, *Trachycorystes, Pimelodus, Pimelodella,* and *Zungaro* are seed dispersers in Amazonian waterways and are likely to play a similar role in the Iwokrama Forest. Clearly, gaining an understanding of the biology, in particular diet and seed dispersal capacities, of these species in the Iwokrama Forest will help in management decisions.

Conclusions

The Iwokrama Forest clearly encompasses an ichthyofauna of global significance. The high diversity and pristine condition of the ecosystem makes this area a refuge for large numbers of Amazonian fishes threatened elsewhere.

Due to the lengthy migration of fish in these watersheds, the management of the fisheries in the Rupununi savannas is likely to be important to the management of fisheries in the Iwokrama Forest. Clearly, fish migration, spawning, and feeding strategies are complex and may have far reaching terrestrial and aquatic ecosystem consequences. Successful management of the fisheries of the Iwokrama Forest will therefore require substantial effort to understand migration, spawning and feeding. For example, the major fish harvest periods presently include the spawning runs and the periods when ponds are drying.

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Appendix

Table 1: Fish of the Iwokrama Forest (updated and checked using Reis et al 2003)

Order, Family, Genus and Species	**Authority**	**Essequibo**	**Siparuni**	**Burro-Burro**
ELASMOBRANCHII				
MYLIOBATIFORMES				
POTAMOTRYGONIDAE				
Potamotrygon orbignyi	(Castelnau 1855)	1	0	0
Potamotrygon sp		1	0	1
OSTEICHTHYES				
OSTEOGLOSSIFORMES				
OSTEOGLOSSIDAE				
Arapaima gigas	(Cuvier 1829)	1	1	1
Osteoglossum bicirrhosum	(Cuvier 1829)	1	1	1
CLUPEIFORMES				
CLUPEIDAE				
ENGRAULIIDIDAE				
Anchoviella jamesi	(Jordan & Seale 1926)	1	0	0
Anchoviella guianensis	(Eigenmann 1942)	1		1
Anchoviella sp		1	1	1
Jurengraulis sp		1	0	0
CHARACIFORMES		0	0	0
ACESTRORHYNCHIDAE		0	0	0
Acestrorhynchus falcatus	(Bloch 1794)	1	1	1
Acestrorhynchus falcirostris	(Cuvier 1819)	1	1	0
Acestrorhynchus heterolepis	(Cope 1878)	1	0	0
Acestrorhynchus microlepis	(Schomburgk 1841)	1	1	1
Acestrorhynchus nasutus	Eigenmann 1912	1	0	0
Acestrorhynchus sp		0	1	1

Order, Family, Genus and Species	**Authority**	**Essequibo**	**Siparuni**	**Burro-Burro**
ANOSTOMIDAE				
Anostomus anostomus	(Linnaeus 1758)	0	1	1
Anostomus plicatus	Eigenmann 1912	1	0	1
Anostomus ternetzi	Fernández-Yépez 1949	1	0	0
Laemolyta proxima	(Garman 1890)	1	0	0
Leporinus alternus	Eigenmann 1912	1	0	0
Leporinus arcus	Eigenmann 1912	1	1	1
Leporinus fasciatus	(Bloch 1795)	1	0	1
Leporinus friderici	(Bloch 1794)	1	1	1
Leporinus maculatus	Müller &Troschel 1844	0	1	1
Leporinus nigrotaeniatus	(Jardine 1841)	1	1	1
Leporinus. pellegrini	Steindachner 1910	1	1	1
Pseudanos irinae	Winterbottom 1980	1	0	0
Pseudanos trimaculatus	(Kner 1858)	0	1	0
Schizodon fasciatus	Spix & Agassiz 1829	1	0	0
CHARACIDAE				
Acanthocharax microlepis	Eigenmann 1912	1	0	0
Agoniates halecinus	Müller & Troschel 1845	1	1	1
Aphyocharax erythrurus	Eigenmann 1912	1	0	0
Aphyocharax sp		1	0	0
Aphyodite grammica	Eigenmann 1912	1	0	0
Aphyodite sp		1	0	0
Astyanax bimaculatus	(Linnaeus 1758)	0	0	1
Astyanax guianensis	Eigenmann 1909	1	1	0
Brachychalcinus orbicularis	(Valenciennes 1850)	0	1	1
Brycon falcatus	Müller & Troschel 1844	1	1	1
Brycon pesu	Müller & Troschel 1845	1	1	0
Bryconamericus hyphesson	Eigenmann 1909	1	0	0
Bryconamericus sp		0	0	1
Bryconops affinis	(Günther 1864)	1	1	1

Order, Family, Genus and Species	Authority	Essequibo	Siparuni	Burro-Burro
Bryconops alburnoides	Kner 1858	1	0	0
Bryconops caudomaculatus	(Günther 1864)	1	1	1
Bryconops melanurus	(Bloch 1794)	1	1	1
Bryconops sp 1		1	0	0
Bryconops sp 2		0	1	0
Catoprion mento	(Cuvier 1819)	1	0	0
Chalceus macrolepidotus	Cuvier 1816	1	1	1
Charax gibbosus	(Linnaeus 1758)	1	1	0
Charax hemigrammus	(Eigenmann 1912)	1	0	0
Creagrutus melanzonus	Eigenmann 1909	1	0	0
Creagrutus sp		1	0	0
Ctenobrycon spilurus	(Valenciennes 1850)	1	1	1
Cynopotamus essequibensis	Eigenmann 1912	1	0	1
Gnathocharax steindachneri	Fowler 1913	1	0	0
Hemigrammus analis	Durbin 1909	1	0	0
Hemigrammus belottii	(Steindachner 1882)	1	1	1
Hemigrammus cylindricus	Durbin 1909	1	0	0
Hemigrammus gracilis	(Lütken 1875)	1	0	0
Hemigrammus guyanensis	Géry 1959	0	0	1
Hemigrammus iota	Durbin 1909	1	0	0
Hemigrammus levis	Durbin 1908	1	0	0
Hemigrammus ocellifer	(Steindachner 1882)	1	1	1
Hemigrammus ocellifer-gr	(Steindachner 1882)	1	0	0
Hemigrammus orthus	Durbin 1909	1	0	0
Hemigrammus schmardae	(Steindachner 1882)	1	0	0
Hemigrammus sp		1	0	0
Heterocharax macrolepis	Eigenmann 1912	1	0	0
Hyphessobrycon gr. agulha	Fowler 1913	1	0	0
Hyphessobrycon bentosi	Durbin 1908	1	0	1
Hyphessobrycon gr. bentosi	Durbin 1908	0	1	0

Order, Family, Genus and Species	**Authority**	**Essequibo**	**Siparuni**	**Burro-Burro**
Hyphessobrycon bentosi- rosaceus	Durbin 1909	1	1	1
Hyphessobrycon eos	Durbin 1909	1	1	0
Hyphessobrycon minimus	Durbin 1909	1	0	0
Hyphessobrycon minor	Durbin 1909	1	0	0
Hyphessobrycon rosaceus	Durbin 1909	1	0	0
Hyphessobrycon sp		1	0	1
Iguanodectes spilurus	(Günther 1864)	1	0	1
Jupiaba abramoides	(Eigenmann 1909)	1	1	1
Jupiaba essequibensis	(Eigenmann 1909)	1	1	1
Jupiaba pinnata	(Eigenmann 1909)	0	1	1
Jupiaba polylepis	(Günther 1864)	1	1	1
Jupiaba potaroensis	(Eigenmann 1909)	0	0	1
Knodus heteresthes	(Eigenmann 1908)	1	0	0
Knodus sp		1	1	0
Metynnis argenteus	Ahl 1923	1	0	0
Metynnis hypsauchen	(Müller & Troschel 1844)	1	0	0
Metynnis luna	Cope 1878	1	0	0
Microschemobrycon casiquiare	Böhlke 1953	1	0	1
Microschemobrycon geisleri	Géry 1973	0	1	1
Microschemobrycon sp		1	0	0
Moenkhausia chrysargyrea	(Günther 1864)	1	1	1
Moenkhausia gr. chrysargyrea	(Günther 1864)	1	0	0
Moenkhausia collettii	(Steindachner 1882)	1	1	1
Moenkhausia copei	(Steindachner 1882)	1	1	1
Moenkhausia cotinho	Eigenmann 1908	1	0	0
Moenkhausia dichroura	(Kner 1859)	1	0	0
Moenkhausia georgiae	Géry 1965	0	1	1
Moenkhausia grandisquamis	(Müller & Troschel 1845)	1	0	0
Moenkhausia lepidura	(Kner 1858)	1	1	1
Moenkhausia megalops	Eigenmann 1907	1	0	1

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Moenkhausia oligolepis	(Günther 1864)	1	1	1
Moenkhausia shideleri	Eigenmann 1909	0	1	0
Moenkhausia surinamensis	Géry 1965	0	1	0
Moenkhausia sp 1		1	0	0
Moenkhausia sp 2		1	0	0
Moenkhausia sp 3		1	0	0
Moenkhausia sp 4		1	0	0
Myleus rhomboidalis	(Cuvier 1818)	1	1	1
Myleus rubripinnis	(Müller & Troschel 1844)	1	0	1
Myleus torquatus	(Kner 1858)	1	0	1
Myleus sp		1	1	1
Oxybrycon sp		1	0	0
Parapristella aubynei	Eigenmann 1909	1	0	0
Phenacogaster megalostictus	Eigenmann 1909	1	1	1
Phenacogaster microstictus	Eigenmann 1909	1	0	0
Phenacogaster sp		1	0	1
Piaractus brachypomus	(Cuvier 1818)	1	0	0
Poptella compressa	(Günther 1864)	1	0	1
Pristella maxillaries	(Ulrey 1894)	1	0	0
Pristobrycon sp		1	0	0
Pristobrycon striolatus	Steindachner 1908	1	1	1
Pygocentrus nattereri	Kner 1858	1	0	0
Pygopristis denticulate	(Cuvier 1819)	1	0	0
Roeboides thurni	Eigenmann 1912	1	1	0
Serrasalmus rhombeus	(Linnaeus 1766)	1	0	1
Serrasalmus serrulatus	(Valenciennes 1850)	1	1	1
Serrasalmus sp		1	1	1
Tetragonopterus argenteus	Cuvier 1816	1	0	1
Tetragonopterus chalceus	Spix & Agassiz 1829	1	0	1
Thrissobrycon sp	Böhlke 1953	1	0	0

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Triportheus angulatus	(Spix & Agassiz 1829)	1	0	0
Triportheus rotundatus	(Jardine 1841)	1	1	1
Unidentified		1	1	0
CHILODONTIDAE				
Caenotropus labyrinthicus	(Kner 1859)	1	0	0
Caenotropus maculosus	(Eigenmann 1912)	1	0	1
Chilodus punctatus	Müller & Troschel 1844	1	0	0
CRENUCHIDAE				
Ammocryptocharax lateralis	(Eigenmann 1909)	0	1	1
Amnocryptocharax vintonae	(Eigenmann 1909)	1	1	1
Characidium gr. fasciatum	Reinhardt 1866	0	1	1
Characidium pteroides	Eigenmann 1909	1	0	0
Characidium steindachneri	Cope 1878	1	0	0
Crenuchus spilurus	Günther 1864	1	1	1
Leptocharacidium sp		0	1	0
Melanocharacidium blennioides	(Eigenmann 1909)	1	1	1
Melanocharacidium dispilomma	Buckup 1993	0	1	1
Microcharacidium eleotrioides	(Géry 1960)	0	1	1
Microcharacidium sp		1	1	0
CTENOLUCIIDAE		0	0	0
Boulengerela cuvieri	(Agassiz 1829)	1	0	0
CURIMATIDAE		0	0	0
Curimata cyprinoides	(Linnaeus 1766)	1	0	0
Curimata roseni	Vari 1989	1	0	0
Curimata vittata	(Kner 1858)	1	0	0
Curimatella immaculate	(Fernández-Yépez 1948)	1	0	0
Curimatopsis crypticus	Vari 1982	1	0	0
Cyphocharax festivus	Vari 1992	1	1	0
Cyphocharax microcephalus	(Eigenmann & Eigenmann 1889)	1	0	0
Cyphocharax spilurus	(Günther 1864)	1	1	1

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Cyphocharax sp 1		1	0	0
Cyphocharax sp 2		1	0	0
Psectrogaster ciliata	(Müller & Troschel 1844)	1	0	0
Psectrogaster essequibensis	(Günther 1864)	1	1	0
Steindachnerina bimaculata	(Steindachner 1876)	1	0	0
Steindachnerina planiventris	Vari & Vari 1989	1	0	0
CYNODONTIDAE				
Cynodon gibbus	Spix & Agassiz 1829	0	1	1
Hydrolycus armatus	(Jardine & Schomburgk 1841)	1	0	0
Hydrolycus tatauaia	Toledo-Piza, Menezes & Santos 1999	1	1	0
Roestes molossus	(Kner 1858)	1	0	0
Roestes ogilviei	(Fowler 1914)	1	0	0
ERYTHRINIDAE				
Erythrinus erythrinus	(Bloch & Schneider 1801)	1	1	1
Hoplerythrinus unitaeniatus	(Agassiz 1829)	1	1	1
Hoplias macrophthalmus	(Pellegrin 1907)	1	1	1
Hoplias malabaricus	(Bloch 1794)	1	1	1
Hoplias sp		1	1	1
GASTEROPELECIDAE				
Carnegiella strigata	(Günther 1864)	1	1	1
HEMIODONTIDAE				
Argonectes longiceps	(Kner 1858)	1	0	0
Bivibranchia bimaculata	Vari 1985	1	0	0
Bivibranchia fowleri	Steindachner 1908	1	0	0
Hemiodus argenteus	(Pellegrin 1908)	1	0	0
Hemiodus gracilis	Günther 1864	1	0	0
Hemiodus gr. gracilis	Günther 1864	1	0	0
Hemiodus microlepis	(Kner 1858)	1	0	0
Hemiodopsis sp		1	0	0
Hemiodopsis sp 2		1	0	0

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Hemiodus quadrimaculatus	Pellegrin 1908	1	1	1
Hemiodus gr. semitaeniatus	Kner 1858	0	0	1
Hemiodus unimaculatus	(Bloch 1794)	1	0	1
LEBIASINIDAE				
Nannostomus eques	Steindachner 1876	1	1	0
Nannostomus harrisoni	Eigenmann 1909	0	0	1
Nannostomus marginatus	Eigenmann 1909	1	1	1
Nannostomus minimus	Eigenmann 1909	1	1	1
Nannostomus trifasciatus	Steindachner 1876	1	0	0
Nannostomus unifasciatus	Steindachner 1876	1	0	0
Pyrrhulina filamentosa	Valenciennes 1847	1	1	1
Pyrrhulina stoli	Boeseman 1953	1	0	0
Pyrrhulina sp.		1	0	0
PARODONTIDAE				
Parodon guyanensis	Géry 1959	0	1	1
PROCHILODONTIDAE				
Prochilodus rubrotaeniatus	Jardine & Schomburgk 1841	1	1	0
SILURIFORMES				
ASPREDINIDAE				
Bunocephalus amaurus	Eigenmann 1912	1	0	0
Bunocechalus coracoideus	Cope 1874	1	1	0
Bunocephalus verrucosus	(Walbaum 1792)	1	1	0
AUCHENIPTERIDAE				
Ageneiosus inermis	(Linnaeus 1766)	1	0	1
Ageneiosus pardalis	Lütken 1874	1	0	1
Ageneiosus piperatus	(Eigenmann 1912)	1	0	0
Auchenipterus demerarae	Eigenmann 1912	0	1	0
Auchenipterus nuchalis	(Spix & Agassiz 1829)	1	0	0
Centromochlus heckelii	(De Filippi 1853)	1	0	0
Centromochlus schultzi	Rössel 1962	1	0	0

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Centromochlus sp		1	0	0
Pseudauchenipterus nodosus	(Bloch 1794)	1	0	1
Pseudauchenipterus sp		1	0	0
Tatia aulopygia	(Kner 1858)	1	0	0
Tatia creutzbergi	(Boeseman 1953)	0	1	0
Tatia sp 1		1	0	0
Tatia sp 2		1	1	1
Trachyelopterus galeatus	(Linneaus 1766)	1	0	0
Trachycorystes trachycorystes	(Valenciennes 1840)	1	0	0
Trachycorystes sp		1	0	0
Unidentified		0	0	1
CALLICHTHYIDAE				
Callichthys callichthys	(Linnaeus 1758)	1	0	0
Corydoras melanistius	Regan 1912	1	1	1
Corydoras punctatus	(Bloch 1794)	1	0	0
Corydoras gr. simulatus	Weitzman & Nijssen 1970	1	1	0
Corydoras sp.		1	0	0
Megalechis thoracata	(Valenciennes 1840)	1	1	1
CETOPSIDAE		0	0	0
Helogenes marmoratus	Günther 1863	1	1	1
Pseudocetopsis minuta	(Eigenmann 1912)	1	0	0
Unidentified		0	1	0
DORADIDAE				
Acanthodoras cataphractus	(Linnaeus 1758)	1	1	0
Acanthodoras spinosissimus	(Eigenmann & Eigenmann 1888)	1	0	1
Amblydoras affinis	(Kner 1855)	1	1	1
Doras carinatus	(Linnaeus 1766)	1	1	1
Doras micropoeus	(Eigenmann 1912)	1	0	0
Hassar orestis	(Steindachner 1875)	1	0	0
Leptodoras hasemani	(Steindachner 1915)	1	0	0

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Leptodoras linnelli	Eigenmann 1912	1	0	0
Nemadoras leporhinus	(Eigenmann 1912)	1	0	0
Oxydoras niger	(Valenciennes 1821)	1	1	0
Physopyxis lyra	Cope 1871	1	1	1
Platydoras cf. *costatus*	(Linnaeus 1758)	0	1	0
Trachydoras cf. *brevis*	(Kner 1853)	1	0	0
Trachydoras microstomus	(Eigenmann 1912)	1	0	0
HEPTAPTERIDAE				
Brachyglanis frenata	Eigenmann 1912	1	0	0
Chasmocranus brevior	Eigenmann 1912	1	0	0
Chasmocranus longior	Eigenmann 1912	1	1	1
Chasmocranus sp		0	1	0
Goeldiella eques	(Müller & Troschel 1848)	1	0	1
Heptapterus sp 1		0	0	1
Heptapterus sp 2		1	1	0
Heptapterus sp 3		1	0	0
Pimelodella cristata	(Müller & Troschel 1848)	1	1	1
Pimelodella macturki	Eigenmann 1912	1	0	0
Pimelodella megalops	Eigenmann 1912	1	0	0
Pimelodella sp		0	1	0
Rhamdia laukidi	Bleeker 1858	0	1	1
Rhamdia quelen	(Quoy & Gaimard 1824)	1	1	1
Rhamdia sp		1	0	0
LORICARIIDAE				
Ancistrus hoplogenys	(Günther 1864)	0	1	0
Ancistrus lithurgicus	Eigenmann 1912	1	0	1
Ancistrus temmincki	(Valenciennes 1840)	1	0	0
Ancistrus sp		0	1	0
Ctenilor icaria platystoma	(Günther 1868)	1	1	1
Ctenilor icaria sp		1	0	0

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Dasyloricaria sp		0	1	0
Farlowella amazona	(Günther 1864)	1	0	0
Farlowella nattereri	Steindachner 1910	0	0	1
Farlowella rugosa	Boeseman 1971	0	1	0
Farlowella sp 1		1	0	0
Farlowella sp 2		1	0	0
Farlowella sp 3		1	0	0
Hemiodontichthys acipenserinus	(Kner 1853)	1	0	0
Hypoptopoma guianense	Boeseman 1974	1	0	1
Hypoptopoma sp		1	0	0
Hypostomus hemiurus	(Eigenmann 1912)	1	0	0
Hypostomus plecostomus	(Linnaeus 1758)	1	0	0
Hypostomus watwata	(Hancock 1828)	1	1	0
Limatulichthys griseus	(Eigenmann 1909)	1	0	0
Limatulichthys sp		1	1	0
Lithoxus lithoides	Eigenmann 1910	1	1	1
Loricaria cataphracta	Linnaeus 1758	1	0	0
Loricaria sp 1		1	0	0
Loricaria sp 2		1	0	0
Loricariichthys brunnea	(Hancock 1828)	1	0	0
Loricariichthys sp		1	0	0
Oxyropsis carinata	(Steindachner 1879)	1	0	0
Parotocinclus britskii	Boeseman 1974	1	1	1
Parotocinclus collinsae	Schmidt & Ferraris 1985	1	1	1
Psuedacanthicus leopardus	(Fowler 1914)	1	0	0
Pseudancistrus barbatus	(Valenciennes 1840)	1	1	1
Pseudancistrus nigrescens	Eigenmann 1912	1	0	1
Pseudancistrus sp 1		1	1	1
Rineloricaria sp 1		1	0	1
Rineloricaria sp 2		1	0	0

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Rineloricaria fallax	(Steindachner 1915)	1	0	0
Rineloricaria platyura	(Müller & Troschel 1848)	1	1	0
Rineloricaria stewarti	(Eigenmann 1909)	0	1	0
PIMELODIDAE				
Brachyplatystoma filamentosum	(Lichtenstein 1819)	1	0	0
Brachyplatystoma vaillantii	(Valenciennes 1840)	1	1	1
Hemisorubim platyrhynchos	(Valenciennes 1840)	1	1	0
Leiarius marmoratus	(Gill 1870)	1	1	0
Megalonema platycephalum	Eigenmann 1912	1	0	0
Phractocephalus hemiliopterus	(Bloch & Schneider 1801)	1	0	0
Pimelodus albofasciatus	Mees 1974	1	0	0
Pimelodus blochii	Valenciennes 1840	0	0	1
Pimelodus blochii- gr. A	Valenciennes 1840	1	1	1
Pimelodus blochii- gr. B	Valenciennes 1840	1	1	0
Pimelodus ornatus	Kner 1858	0	1	1
Pirinampus pirinampu	(Spix & Agassiz 1829)	0	1	0
Pseudoplatystoma fasciatum	(Linnaeus 1766)	1	1	0
Pseudoplatystoma tigrinum	(Valenciennes 1840)	1	0	0
Sorubim lima	(Bloch & Schneider 1801)	1	0	0
Zungaro zungaro	(Humboldt 1821)	1	0	0
PSEUDOPIMELODIDAE				
Batrachoglanis raninus	(Valenciennes 1840)	1	1	1
Microglanis poecilus	Eigenmann 1912	1	0	1
Pseudopimelodus sp		0	1	0
TRICHOMYCTERIDAE				
Haemomaster sp.		1	0	0
Henonemus punctatus	Boulenger 1887	1	0	0
Homodiaetus sp 1		1	0	0
Homodiaetus sp 2		1	0	0
Ituglanis gracilior	(Eigenmann 1912)	1	0	0

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Ochmacanthus sp 1		1	0	0
Ochmacanthus sp 2		1	0	0
Ochmacanthus sp 3		1	0	0
Stegophilus sp		1	0	0
Trichomycterus sp.		0	0	1
Vandellia beccarii	Di Caporiacco 1935	1	0	0
Vandellia cirrhosa	Valenciennes 1846	1	0	0
Vandellia sp		1	0	0
GYMNOTIFORMES				
APTERONOTIDAE				
Apteronotus albifrons	(Linnaeus 1766)	0	1	1
Apteronotus leptorhynchus	(Ellis 1912)	1	0	0
Apteronotus sp		0	0	1
Porotergus gimbeli	Ellis 1912	1	0	0
Porotergus gymnotus	Ellis 1912	1	0	0
Sternarchorhynchus oxyrhynchus	(Müller & Troschel 1849)	1	0	0
GYMNOTIDAE				
Electrophorus electricus	(Linnaeus 1766)	1	1	1
Gymnotus anguillaris	Hoedeman 1962	1	1	1
Gymnotus carapo	Linnaeus 1758	1	1	1
Gymnotus sp		1	0	1
HYPOPOMIDAE				
Brachyhypopomus beebei	(Schultz 1944)	1	1	1
Brachyhypopomus sp		1	0	0
Hypopomus artedi	(Kaup 1856)	0	1	1
Hypopomus sp 1		0	0	1
Hypopomus sp 2		1	0	0
Hypopomus sp 3		1	0	0
Hypopomus sp 4		1	0	0
Hypopygus lepturus	Hoedeman 1962	1	1	1

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Hypopygus sp 1		1	0	0
Hypopygus sp 2		1	0	0
Microsternarchus sp 1		1	1	0
Microsternarchus sp 2		1	0	0
Platyurosternarchus macrostomus	(Günther 1870)	1	0	0
Steatogenys elegans	(Steindachner 1880)	1	0	1
RHAMPHYCHTHYIDAE				
Gymnorhamphichthys rondoni	(Miranda-Ribeiro 1920)	1	0	1
Gymnorhamphichthys sp		1	0	0
STERNOPYGIDAE				
Distocyclus conirostris	(Eigenmann & Allen 1942)	1	0	0
Eigenmannia limbata	(Schreiner & Miranda-Ribeiro 1903)	0	1	1
Eigenmannia macrops	(Boulenger 1897)	1	0	0
Eigenmannia virescens	(Valenciennes 1842)	1	1	1
Eigenmannia sp		0	0	1
Rhabdolichops sp		1	0	0
Sternopygus macrurus	(Bloch & Schneider 1801)	1	1	1
CYPRINODONTIFORMES				
POECILIIDAE				
Poecilia reticulata	Peters 1859	1	0	0
RIVULIDAE				
Rivulus waimacui	Eigenmann 1909	1	0	0
Rivulus sp		1	1	1
BELONIFORMES		0	0	0
BELONIDAE		0	0	0
Potamorrhaphis guianensis	(Jardine 1843)	1	1	1
Pseudotylosurus microps	(Günther 1866)	1	0	0
SYNBRANCHIFORMES				
SYNBRANCHIDAE				
Synbranchus marmoratus	Bloch 1795	1	1	0

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PERCIFORMES				
CICHLIDAE				
Acaronia nassa	(Heckel 1840)	1	0	0
Aequidens tetramerus	(Heckel 1840)	1	1	1
Apistogramma ortmanni	(Eigenmann 1912)	1	1	1
Apistogramma steindachneri	(Regan 1908)	1	1	1
Biotodoma cupido	(Heckel 1840)	1	0	1
Chaetobranchus flavescens	Heckel 1840	1	0	0
Cichla ocellaris	Bloch & Schneider 1801	1	0	1
Crenicichla alta	Eigenmann 1912	1	1	1
Crenicichla Johanna	Heckel 1840	1	1	1
Crenicichla lugubris	Heckel 1840	1	1	1
Crenicichla strigata	Günther 1862	0	0	1
Crenicichla wallaceii	Regan 1905	1	0	1
Crenicichla gr. wallaceii	Regan 1905	0	1	0
Crenicichla sp		1	1	1
Geophagus brachybranchus	Kullander & Nijssen 1989	1	0	0
Geophagus surinamensis	(Bloch 1791)	1	1	0
Guianacara geayi	(Pellegrin 1902)	1	0	0
Guianacara owroewefi	Kullander & Nijssen 1989	1	1	1
Heros efasciatus	Heckel 1840	1	0	0
Heros severus	Heckel 1840	1	0	0
Mesonauta festivus	(Heckel 1840)	1	0	0
Mesonauta cf. insignis	(Heckel 1840)	1	0	0
Pterophyllum scalare	(Schultze 1823)	1	0	0
Satanoperca jurupari	Heckel 1840	1	0	0
Satanoperca leucosticta	(Müller & Troschel 1849)	1	1	1
SCIAENIDAE				
Pachypops trifilis	(Müller & Troschel 1849)	1	0	0
Pachypops sp		1	0	0

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Pachyurus sp		1	0	0
Petilipinnis grunniens	(Jardine 1843)	1	1	0
Plagioscion squamosissimus	(Heckel 1840)	1	1	1
PLEURONECTIFORMES				
ACHIRIDAE				
Hypoclinemus mentalis	(Günther 1862)	1	0	0
Soleonasus finis	Eigenmann 1912	1	0	0
TETRAODONTIFORMES				
TETRAODONTIDAE				
Colomesus asellus	(Müller & Troschel 1849)	1	1	1