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FISHES OF THE LOWER CAURA RIVER, ORINOCO BASIN, VENEZUELA

Douglas RODRÍGUEZ-OLARTE, Donald C. TAPHORN B.,
Carlos LASSO A. and Conrad R. VISPO

Douglas Rodríguez O.

Abstract

The lower Caura River is part of a great fluvial ecosystem, the Orinoco Basin. Its tannin-stained waters drain the northern flank of the Guayana Shield in southern Venezuela, a region so far spared from most human interventions. However, pressure is mounting to develop the drainage for hydropower to supplement the Guri complex with additional water, and to mine the valuable timber from dense tropical forests that clothe most tributary watersheds. To generate current information for aquatic resource management, in 1996 and 1997 we determined the number of species, distribution and abundance of the fishes of the lower stretch of the Caura River. The fish samples were made with nets of different sizes, rotenone, and harpoons. Samples were taken near shore in the main channel, from floodplain lagoons and *moriche* palm creeks in the savanna. Standardized sampling using fine-mesh seines was carried out during low water only in river sites. We found 438 species of fish, from 39 families and 10 orders, with Characiformes (49%), Siluriformes (31%), Perciformes (9%), and Gymnotiformes (5%) being the most important. In relation to the general distribution of the fish among the sites sampled, 2 species were widespread, 183 dispersed among most ecosystems sampled and 41 restricted to only a few sites. For the entire study we collected an average of 78.4 individuals per sample. Relative abundance was evaluated only in standardized quantitative samples. We classify 5 species as dominant, 21 as common, 39 as frequent and 102 as occasional. Of the fishes for which data are available on use, we found that 31 (7%) are sold commercially for human consumption, 171 (39%) are ornamental, 48 (11%) are used by criollo communities for subsistence, 123 (28%) are used by indigenous peoples for subsistence. About 64% of the 438 species identified have some use. We note that most fish species have life histories that require the fluctuating environmental variations associated with a free river ecosystem. For example, reproductive activities of most species peaks at the initiation of the rainy season and many fish undertake longitudinal and lateral movements during falling or rising water. The fish diversity of the lower Caura is among the highest of the Orinoco tributaries, exceeding the diversity predicted by extrapolation from the area of the drainage. Projected uses for this basin as a catchment to divert water to the Guri hydroelectric complex would considerably alter the hydrological cycle. If that happens, a considerable reduction of the annually flooded aquatic habitat available to the mostly migratory commercial species will occur in the lower section of the river near the Orinoco. As a result, local loss of fish diversity is inevitable in the directly impacted areas, and the deterioration of the spawning grounds in the floodplain lagoons in the lower Caura could reduce recruitment for the entire Orinoco system, reducing commercial catches from the main river channel.

Key words: Caura, Orinoco, Venezuela, Neotropical river, fish biodiversity, species richness, impact, conservation, abundance, density.

Resumen

El bajo Río Caura es parte del gran sistema fluvial, que conforma el Río Orinoco. Sus aguas oscuras, color té, drenan el lado norte del Macizo de Guayana en el sur de Venezuela, una región que hasta el momento ha sido poco intervenida por el desarrollo humano. Sin embargo, la presión aumenta para implementar proyectos hidroeléctricos que suplementen el proyecto de Guri con aguas adicionales, y para cosechar la valiosa madera de los bosques que cubren la mayor parte de la cuenca. Para planear un manejo de los recursos acuáticos, se realizó un estudio entre 1996 y 1997 que ofrece información de riqueza, composición, distribución y abundancia de la ictiofauna en la parte baja de la cuenca del Río Caura. Las muestras se tomaron con redes de diferentes tamaños, ictiocidas y arpón; en ambientes litorales del canal principal, los afluentes, las lagunas y los morichales. Aquí se reportan 438 especies de peces, agrupados en 39 familias y 10 órdenes, siendo los Characiformes (49%), Siluriformes (31%), Perciformes (9%) y Gymnotiformes (5%) los órdenes más importantes. En relación con la distribución geográfica de los peces, 22 especies fueron difundidas (presentes en la mayoría de los sitios muestreados), 183 dispersas y 141 restringidas a unos pocos sitios de muestreo. En todo el estudio se encontró un promedio de 178,4 individuos por muestra. En muestras estandarizadas de playa se halló que 5 especies fueron dominantes, 21 comunes, 39 frecuentes y 102 ocasionales. De los peces para los cuales obtuvimos información, encontramos 31 (7%) en las ventas de peces comerciales para el consumo humano, 171 (39%) potencialmente útiles para la pesca ornamental, 48 (11%) son utilizados por las comunidades criollas para subsistencia, y 123 (28%) en uso por los pueblos indígenas para subsistencia. Alrededor del 64% de las 438 especies identificadas tienen algún uso reportado. Notamos que la mayoría de los peces tiene estrategias

de vida que requieren las fluctuaciones anuales de nivel de agua que se asocian con un río natural. Por ejemplo, la reproducción tiene su pico al inicio del período de lluvias; muchos peces se mueven entre el canal principal y la planicie de inundación durante los períodos climáticos de transición (aguas subiendo o bajando). La biodiversidad de peces en el bajo Caura es una de las más elevadas del Orinoco, superando aun los cálculos teóricos en base del área total de la cuenca. Esta gran riqueza de peces está amenazada por cualquier proyecto que pueda cambiar el ciclo hidrológico o el flujo natural del río. Al realizarse tales proyectos, se espera una reducción del hábitat disponible para los peces, y la consecuente pérdida local de ictiofauna. Al eliminar las zonas de inundación en la parte más baja de la cuenca, que sirven como zona de desove y cría para muchos peces, se podrían reducir las cosechas comerciales para el consumo humano.

Palabras Claves: Caura, Orinoco, Venezuela, río neotropical, biodiversidad de peces, riqueza de especies, impacto, conservación, abundancia, densidad.

Introduction

The continental fish fauna of Venezuela, with over 1,200 species (Taphorn *et al.* 1997), is still in the discovery phase of study, especially in regards to definitive identifications at the species level and comprehensive species lists from remote regions. This is particularly true for the rivers that drain the Guayana Shield in the states of Bolivar and Amazonas. Although recent studies have shed some light on this ichthyological diversity, we are just beginning to get to know the fish faunas from these regions. The Caroní drainage is relatively well known (Lasso *et al.* 1989, Lasso 1989, Taphorn and García 1991), but its lower reaches have now been dammed and reduced to a series of hydropower dams and reservoirs. Early reports indicated the presence of 119 species in the lower Caura (Machado-Allison *et al.* 1997) and around 130 from the Caura's tribuatry, the Nichare (Taphorn 1996), but high levels of diversity (450 species) were predicted based on literature references and comparison to similar regions in Venezuela (Balbás and Taphorn 1996). Most of the upper watershed still remains very poorly sampled.

There are growing pressures for the use of the rich and largely unexploited natural resources of the Caura basin. CVG-EDELCA has plans to divert the water of the upper Caura to the Guri hydroelectrical complex through a canal connecting the upper Caura to the Paragua. Gold and diamond mining is a serious environmental problem in the region, deforestation, high pressure hose mining in riverbanks, and mercury poisoning have had devastating effects on riparian vegetation, water quality and human health in neighboring watersheds. The dense tropical forests have also attracted politicians and developers with designs to cut and sell lumber. Besides the direct damage to aquatic communities, many researchers have shown that human impacts on river floodplains generate negative consequences in the associated terrestrial ecosystems (Junk *et al.* 1989, Poff *et al.* 1997). The reduction of the area inundated year after year (precisely the area most valuable to the fish community) affects nutrient flow and balance in the forests. Most commercial fish species use the floodplain as feeding and reproductive areas. For example, *Prochilodus mariae*, the most important commercial species in the Orinoco Basin, and *Piaractus brachypomus*, the most important fish in the Caura's fishery, depend on annual access to floodplains in order to complete their life cycles (see Daza and Vispo, this volume). A reduction in the extent of the floodplain reduces reproductive success in those species which are tightly linked to the hydrocycle.

The main objective of this study was to determine the number of species present in the lower Caura drainage. We also gathered preliminary data on the distribution and relative abundance of these fishes. In the hope to call attention to the ecological importance of this fluvial ecosystem as one of the best-conserved wild rivers remaining in the tropics, we show how hydrological events affect the life cycle of fishes. The baseline data we provide is necessary for successful fishery resource management and aquatic ecosystem conservation.

Study Area

The Caura River drainage in the state of Bolivar, Venezuela ranks third in the nation in water flow and drainage size (45,350 km^2), and is probably the best-conserved river drainage in all of the tropics (Huber 1996). The lower stretch flows some 270 km from Para Falls (a natural boundary that stops river traffic and separates the upper and lower fish faunas) to its mouth at the Orinoco (**Figure 4.1**). The lower river channel runs through rolling hills below the falls that give way to extensive lowland floodplains where the channel becomes braided. The main channel meanders considerably as it collects its major tributaries, the Nichare, Mato and Sipao. In the lowermost section, extensive floodplains with numerous annual lagoons flank the main channel of the Caura (Peña 1996). This river contributes approximately 3,500 m^3/s to the Orinoco (Vargas and Rangel 1996b) but because of the ancient nature of the watershed and the relatively few human impacts, suspended sediments are relatively low at 2 $\infty 10^6$ t/a (Meade *et al.* 1990). On first inspection the water would be classified as blackwater, but it is actually a dark reddish tea color, with an average pH of 6.5, much more alkaline than true blackwater rivers of the Amazon drainage. Clarity is high, with an average transparency of 1.2 m. Precipitation in the lower Caura is unimodal and the temperature is isothermic. According to Vargas and Rangel (1996a), a climatic gradient exists from north to south. Notable variation exists between the values for the town of Maripa in the lowest stretch which is dryer and hotter (precipitation: 1,980 mm; temperature: 27.7 °C; evaporation: 2,142 mm; relative humidity: 75%) and those from the cooler and wetter village at Para Falls at the upper end (precipitation 2,970 mm; temperature: 26.6 °C; evaporation: 1,395 mm; relative humidity: 85%).

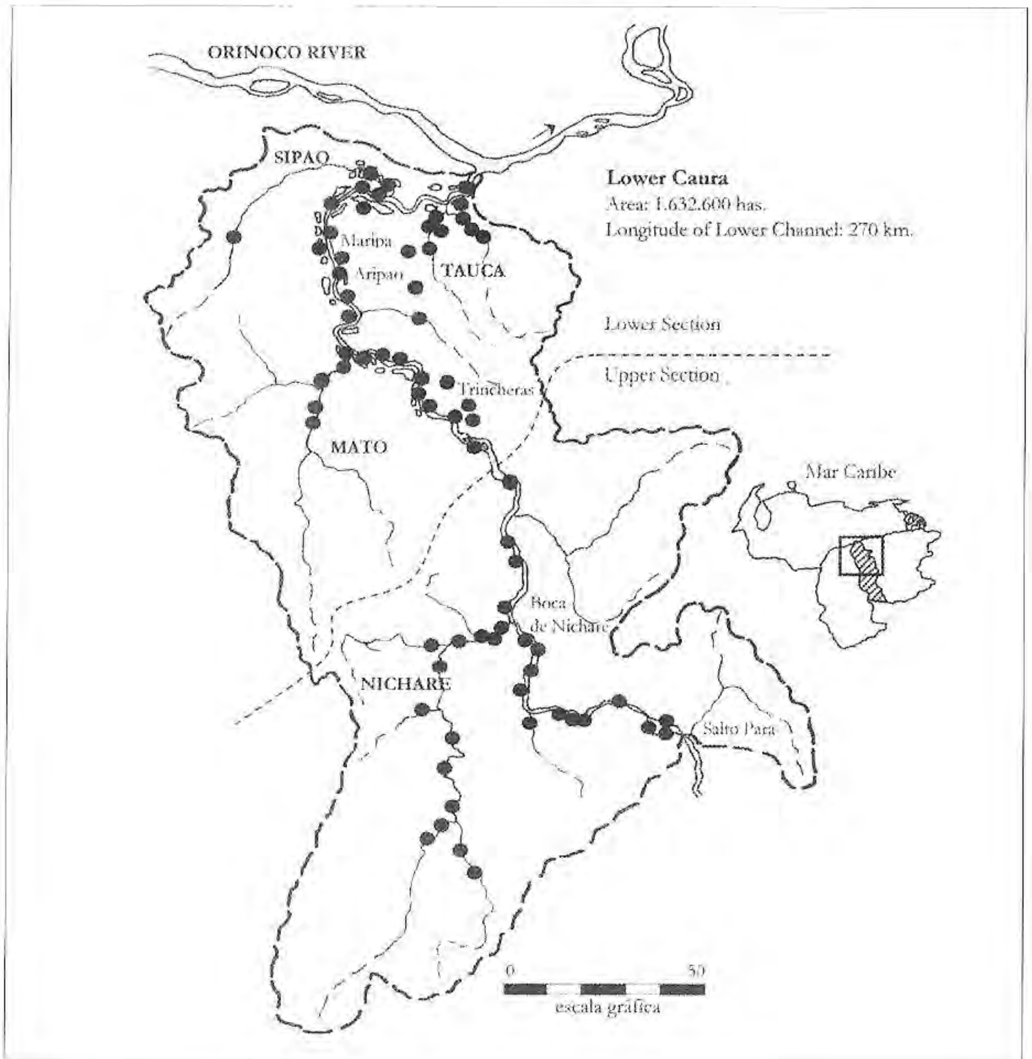

Fig. 4.1: The lower Caura, Orinoco drainage, Bolivar State, Venezuela.
Modified from Peña (1996). Each circle represents one or more sampling points.
Fig. 4.1: El bajo Caura, cuenca del Orinoco, Estado Bolívar, Venezuela.
Modificado de Peña (1996). Cada círculo representa una o más estaciones de muestreo.

Near the mouth, the dry season extends for three months (January, February and March) and the month with maximum precipitation is August; in Para Falls the dry months are February and March, and July has maximum precipitation. The lower Caura contains different types of forests, with Dry Tropical Forest prevailing, but Humid Tropical Forest and Very Humid Tropical Forests are also present (Martínez 1996). Near the mouth of the river, the predominant vegetation formations are macrothermic savannas (savannas with sparse trees) and gallery forests along the river channel. In this region, cattle ranchers set annual grassfires that have changed the natural vegetation, transforming large areas into pasture. In the upper reaches (up to Para Falls) tropophilous, ombrophilous, macrothermic, submesothermic and mesothermic forests cover the watershed (Marín and Chaviel 1996). In general, the basin is very little disturbed, encompassing immense forest extensions that are part of the Caura Forest Reserve (see Vispo and Knab-Vispo, this volume, for a more detailed introduction to the region).

The river stretch studied here is the most densely colonized by humans (OCEI 1993), but only around 2,500 people inhabit the riverside towns of Maripa, Aripao, Puerto Cabello, Trincheras and Jabillal (OCEI 1990). Around 300 aborigines, mainly of the Ye'kwana and Sanema tribes, are concentrated in the towns of Boca de Nichare, Las Pavas and Surapire. Preliminary economic studies of the lower Caura indicate that a large portion of the population is dedicated to small-scale itinerant agriculture, hunting and small-scale commercial fishing. The river's upper drainages remain poorly sampled ichthyologically, and are not included in this study.

Materials and Methods

To simplify data analysis, the lower Caura was divided into upper (upstream of the populations of Trincheras and Jabillal) and lower sections (downstream from the same populations). A total of 71 sampling stations was distributed among different habitats in the main channel, principal tributaries (Nichare, Mato, Sipao and Tauca), *morichales* (Tauca and Maripa), floodplain lagoons (Aricagua, Aripao, Laguna Linda) and seasonal ponds (Figure 4.1). The Nichare River samples are those previously reported by Taphorn (1996). In the rotenone samples the site was first blocked with nets above and below and then measured to permit the calculation of fish density per square meter. Some of the sampling stations were resampled up to five times during the study. Because of gear limitations, sampling was concentrated in lotic, nearshore habitats, with relatively few samples from lentic habitats, or the midriver channel. Samples were made both day and night using different fishing gear: nets (fine mesh, gillnets and cast nets), traps, rotenone (both commercial preparations as well as "*barbasco*" prepared by native people of the area), pneumatic harpoon, and hook and line. Gillnets with mesh sizes of 2 to 5 cm between knots were generally set during the night. The other methods were generally used during daytime. Sampling was bimonthly in 1996 and 1997, covering all hydrologic periods (high and low water as well as transition periods).

During the period of maximum drought (March and April 1997) quantitative beach sampling was carried out, to determine the presence, distribution, relative abundance and density of fish. For these samples, fine-meshed seines were used (10 meters long and 2 meters high), during day (8:00 am to 2:00 pm) and night (8:00 pm to 2:00 am). Each sample consisted of three passes with the seine, running downstream with the current on sand beaches, roughly coming in perpendicular to shore and covering an approximate area of 240 m^2 for each sample. Maximum depth was about 1.5 m. These samples were collected twice at each station (day and night). Thirty stations were established, 12 in the upper and 18 in the lower section (Figure 4.1). Seven sampling stations were located in the main channel in sites selected above and below the mouths of the three main tributaries (Nichare, Mato and Sipao).

Fish captured for taxonomic study were preserved in 10% formalin and later transferred to 70% ethanol and were identified at the Fish Collection of the Museo de Ciencias Naturales de Guanare -MCNG of the university UNELLEZ- where they were incorporated into the permanent collection. Identifications were based on references listed in the Literature cited section of this chapter. Reference collections (other than MCNG) consulted were Museo de Historia Natural La Salle (MHNLS), Museo de Biología de la Universidad Central de Venezuela (MBUCV) and the collection of the Academy of Natural Sciences of Philadelphia (ANSP).

Species distribution patterns were determined for all species collected from the lower Caura and tallied for the following habitat types: 1) main channel, 2) Nichare River, 3) Mato River, 4) Sipao River, 5) floodplain lagoons, and 6) *morichales* (blackwater creeks associated with *moriche* palm trees). The distribution categories used were RESTRICTED (found in only one habitat type), DISPERSED (two or three habitats) and WIDESPREAD (four or more habitats). Relative abundance was only tallied for standardized samples using the number of individuals per species per sample (considering the upper and lower reaches and the Nichare, Mato and Sipao Rivers separately following Lasso [1992]). Names for the relative abundance classes suggested by that author were used here but modified as follows: OCCASIONAL (present in less than 20% of the sites sampled), FREQUENT (between

21 and 40%), COMMON (between 41 and 70%) and DOMINANT (>71%). Density was expressed in individuals per square meter (ind/m^2).

Results

A total of 438 species of fish were identified from the lower Caura River. These are distributed among 234 genera, 39 families and 10 orders (**Tables 4.1** and **4.2**). The highest number of species (223) per habitat was found on beaches along the shore of the main channel of the Caura, where sampling was concentrated in this study. The Nichare River had 136 species, the Mato 95 and the Sipao 69. In the floodplain lagoons and *morichales* 65 and 48 species were found, respectively. Rotenone sampling produced high densities of species during the dry season when water was low. *Barbasco* applied in stretches of the upper drainage of the Nichare River with stony substrates produced results of 64 species in 175 m^2 (0.37 species for m^2). Samples made with commercial rotenone in habitats with abundant aquatic vegetation in the lower drainage of the Tauca River produced up to 32 species in 80 m^2 (0.40 especies/m^2). Nets used in beach habitats produced an average of 17.4 species per sample (max: 46; min: 2; n = 56) or 0.07 species/m^2.

For the standardized beach samples included in the statistical analysis (n = 60) the average number of species captured was 12.6 in the upper sector (max: 22; min: 1; n = 24), with averages of 4.1 species for daytime samples (max: 8; min: 1; n = 12) and 16.8 for night samples (max: 22; min: 5; n = 12). During the day, fish see the net and can more easily avoid capture. In the lower sector, we collected an overall average of 18.6 species per site (max: 28; min: 2; n = 36). The daytime average was 8.1 species (max: 12; min: 2; n = 18) and for night samples it was 21.1 (max: 28; min: 6; n = 18). The standardized beach sampling contributed 51% of the ichthyofauna reported in the lower Caura and species densities of 0.05 sp./m^2 and 0.08 sp./m^2 in the upper and lower sectors, respectively. The species saturation curve indicated that when approximately 50% of the systematized samples (n = 29; 6,960 m^2) were completed, more than 80% of all species eventually collected were already included.

In Table 4.2 we present the number of species per order and family. The Order Characiformes had the largest number of genera (92) and species (216, or 49% of the total), with most of these in the Family Characidae (126). In the second place were the catfishes (Siluriformes), with 88 genera and 136 species (31%), dominated by the families Pimelodidae (44 species) and Loricariidae (32 species).

We have included in our list a few identifiable species that we observed but did not capture such as the freshwater stingray, *Potamotrygon motoro*, the Striped Mije, *Leporinus* aff. *striatus* and the Leaffish, *Monocirrhus polyacanthus.*

Table 4.1: List of 438 fishes reported from the lower Caura River.

The uses considered are: **C** (Commercial), **O** (Ornamental), S (Subsistence in criollo towns) and **Si** (Subsistence in indigenous people's villages). Distribution categories are: W (Widespread), **D** (Dispersed) and **R** (Restricted). Frequency of Appearance categories are: **DO** (Dominant), **CO** (Common), **FR** (Frequent) and **OC** (Occasional). An asterisk (*) in the appearance categories indicates relative abundance in fish markets for commercially important species. Source includes museum catalog numbers from the Museo de Ciencias Naturales Guanare (MCNG) unless otherwise indicated; when no specimens are cited, the locality where observed or the author citing the species' presence in the lower Caura are given here. Collection abbreviations are: MHNLS = Museo de Historia Natural La Salle (Caracas), MBUCV = Museo de Biología de la Universidad Central de Venezuela (Caracas), and ANSP = Academy of Natural Sciences of Philadelphia.

Tabla 4.1: Lista de las 438 especies de peces reportadas en el bajo Caura.

*Los usos considerados son: **C** (Comercial), **O** (Ornamental potencial), S (Subsistencia en poblados criollos) y **Si** (Subsistencia en poblados indígenas). Las clases de distribución son W (Difundida), **D** (Dispersa) y **R** (Restringida). La abundancia se determinó solo en muestras estandarizadas y sus clases son: **DO** (Dominante), **CO** (Común), **FR** (Frecuente) y **OC** (Ocasional). Los recuadros con * indican la abundancia relativa de las especies comerciales. Las fuentes indican los números del Museo de Ciencias Naturales Guanare (MCNG) y las especies presentes en la cuenca pero no capturadas y reportadas en relación con otras colecciones (MHNLS, MBUCV, ANSP – ver siglas arriba) y/o los lugares de la cuenca en donde su presencia fue observada.*

Taxa		Author		Distribution			Abundance				Sources
			Uses	W	D	R	DO	CO	FR	OC	
CLASS ELASMOBRANCHII											
ORDER MYLIOBATIFORMES											
Potamotrygonidae (6)											
Paratrygon	*aiereba*	(Müller & Henle 1841)	C, S			X			*		Las Majadas
Potamotrygon	*motoro*	(Müller & Henle 1841)	O			X					Morichales
P.	*orbignyi*	(Castelnau 1855)			X						21894, 34584
P.	*schroederi*	Fernández-Yépez 1958	O			X					22700
P.	sp. 1										MHNLS
P.	sp. 2										MHNLS
CLASS OSTEICHTHYES											
ORDER CHARACIFORMES											
Anostomidae (23)											
Anostomus	*anostomus*	(Linnaeus 1758)	O, Si			X					2638

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution W	D	R	Abundance DO	CO	FR	OC	Sources
(Anostomidae)											
Anostomus	*ternetzi*	Fernández-Yépez 1949	O, Si			X					3481222807
Gnathodolus	*bidens*	Myers 1927									MHNLS
Laemolyta	*laticeps*	(Eigenmann 1912)	O								MHNLS 12830
L.	*orinocensis*	(Steindachner 1879)	O, Si								MHNLS 12831
L.	*taeniatus*	(Kner 1854)	S, Si	X						*	37121, 36174
Leporellus	*vittatus*	(Valenciennes 1849)	O, Si		X						34803
Leporinus	*brunneus*	Myers 1946	O								MHNLS
L.	*fasciatus*	(Bloch 1795)	Si		X					*	23274, 22809
L.	*friderici*	(Bloch 1794)	S, Si		X					*	37666, 23195
L.	cf. *granti*	Eigenmann 1912	O		X						34825, 35831
L.	cf. *lacustris*	Amaral Campos 1945	O, Si			X					37101, 36892
L.	cf. *maculatus*	Müller & Troschel 1844	Si			X					34811
L.	*punctatus*	Garavello 2000	O			X					20005, 36793
L.	sp. "mancha central"										MCNG
L.	sp. "y inversa"		O, Si			X					23274
L.	*steyermarki*	Inger 1956	Si		X						22421, 22808
L.	*striatus*	Kner 1859	O, Si		X						Nichare, Tauca
Pseudanos	*gracilis*	Kner 1859	O, Si			X					36871
P.	*irinae*	Winterbottom 1980	O, Si			X					22806, 17584
Schizodon	sp.		S		X					*	34787
Synaptolaemus	*cingulatus*	Myers & Fernández-Yépez 1950	O			X					MHNLS
Characidae (126)											
Acestrorhynchus	*falcatus*	(Bloch 1794)	Si		X					*	20990, 34609
A.	*falcirostris*	(Cuvier 1819)	Si		X					*	37146, 37116
A.	*grandoculis*	Menézes & Géry 1983	Si		X						22930, 35501
A.	*heterolepis*	(Cope 1878)	Si			X					36045, 37067
A.	*microlepis*	(Schomburgk 1841)	Si		X					*	21945, 37182
A.	*minimus*	Menézes 1969				X				X	37081

Agoniates	*anchovia*	Eigenmann 1914	Si		X					X	36891, 34612
Aphyocharax	*alburnus*	(Günther 1869)	O	X			X				37198, 34519
Asiphonichthys	sp.		O			X					2630
Astyanax	*bimaculatus*	(Linnaeus 1758)	Si	X				X			21058, 37337
A.	*integer*	Myers 1930	Si		X				X		34536, 37342
A.	*scintillans*	Myers 1928									MHNLS
Aulixidens	sp.					X					12052
Brachychalcinus	*orbicularis*	Valenciennes in Cuvier & Valenciennes 1849	O								MHNLS
Brycon	*bicolor*	Pellegrin 1909	S, Si	X					*		22929, 37323
B.	cf.. *cephalus*	(Günther 1869)							*		MHNLS
B.	*falcatus*	Müller y Troschel 1844	Si								MHNLS 12848
B.	*pesu*	Müller y Troschel 1845	S, Si	X						*	34006, 36757
Bryconamericus	*deuterodonoides*	Eigenamnn 1914			X				X		36879, 36865
B.	*hyphesson*	Eigenmann 1909		X			X				36176, 21424
B.	cf.. *megalepis*	Fowler 1941				X					20944, 20874
B.	sp. "línea"			X			X				34488, 36313
Bryconops	cf. *affinis*	(Günther 1864)	O								MHNLS
B.	*alburnoides*	Kner 1858	O, Si		X				X		35822, 37344
B.	*caudomaculatus*	(Günther 1864)	O, Si		X				X		33995, 367
B.	*giacopinii*	(Fernández-Yépez 1950)	O								MHNLS 13445
B.	*inpai*	Knöppel, Junk & Gèry 1998	O								MHNLS
Catoprion	*mento*	(Cuvier 1819)	O, Si		X						37180, 33863
Chalceus	*macrolepidotus*	Cuvier 1817	O, Si		X					X	36025, 22822
Charax	*gibbosus*	(Linnaeus 1758)	Si		X					X	37667, 22877
Cheirodon	*pulcher*	(Gill 1858)	O		X					X	37293, 34927
Colossoma	*macropomum*	(Cuvier 1819)	C			X				*	34859, 34467
Creagrutus	*bolivari*	Schultz 1944			X				X		36765, 23272
C.	*maxillaris*	(Myers 1927)									MHNLS
C.	sp.										MCNG
C.	*melanzonus*	Eigenmann 1909		X				X			23271, 23211
C.	*phasma*	Myers 1927									MHNLS 12856
Ctenobrycon	*spilurus*	(Valenciennes 1849)			X			X			37653, 3599

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution			Abundance				Sources
				W	D	R	DO	CO	FR	OC	
(Characidae)											
Cynopotamus	*essequibensis*	Eigenmann 1912			X					X	MHNLS 12846
Gephyrocharax	*valencia*	Eigenmann 1920				X				X	37669
Gnathocharax	*steindachneri*	Fowler 1913			X				X		37658, 37211
Gymnocorymbus	*hayeri*	Eigenmann 1908	O		X					X	37661, 22759
Hemibrycon	cf. *metae*	Myers 1930	Si			X				X	19931
Hemigrammus	*analis*	Durbin 1909			X			X			37088, 37513
H.	*bellottii*	(Steindachner 1882)	O		X					X	37145
H.	*elegans*	(Steindachner 1882)				X				X	23527, 22857
H.	*levis*	Durbin & Eigenmann 1908			X						MHNLS
H.	*marginatus*	Durbin 1911	O		X					X	23231, 22735
H.	*micropterus*	Meek 1907			X				X		23249, 23233
H.	*microstomus*	Durbin 1910	O		X					X	22734, 2272
H.	aff. *mimus*	Böhlke 1955									MHNLS 12962
H.	*newboldi*	(Fernández-Yépez 1949)	O		X			X			23265, 23241
H.	*rhodostomus*	Ahl 1924	O		X					X	37122
H.	*roduayi*	Durbin 1909	O		X			X			37288, 34484
H.	*schmardae*	(Steindachner 1882)	O	X			X				23268, 23997
H.	*stictus*	(Durbin 1909)	O			X				X	37507, 37125
H.	*unilineatus*	Gill 1858	O			X			X		23269, 23247
H.	*vorderwinkleri*	Géry 1963	O		X					X	22812, 21017
Heterocharax	*macrolepis*	Eigenmann 1912									MHNLS 13470
Hyphessobrycon	cf. *bentosi*	Durbin 1908	O		X					X	37285, 37199
H.	*metae*	Eigenmann & Henn 1914	O			X				X	26968, 21456
H.	*minimus*	Durbin 1909	O								MHNLS
H.	*minor*	Durbin 1909	O								MHNLS
H.	cf. *rosaceus*	Durbin 1909	O								MHNLS 12858
H.	cf. *serpae*	Durbin 1908	O								MHNLS 12859

Iguanodectes	*geisleri*	Géry 1970	O			X				X	36926
I.	*spilurus*	(Günther 1864)	O, Si		X					X	37125, 36907
Jupiaba	*abramoides*	(Eigenmann 1909)									MHNLS
J.	*anteroides*	(Géry 1965)	Si		X				X		21064, 37654
J.	*mucronata*	(Eigenmann 1909)									MHNLS
J.	*pinnata*	(Eigenmann 1909)			X					X	18818, 18822
J.	*polylepis*	(Günther 1864)	O		X				X		34854, 3733
J.	*scologaster*	(Weitzman & Vari 1986)									MHNLS
Knodus	*breviceps*	(Eigenmann 1908)									MHNLS 12868
K.	*ternetzi*	(Myers 1928)		X					X		36626, 36701
K.	*victoriae*	(Steindachner 1907)									MHNLS
Lonchogenys	*ilisha*	Myers 1927			X					X	21461
Markiana	*geayi*	(Pellegrin 1908)	Si			X				X	21045
Metynnis	*argenteus*	Ahl 1924	O, S, Si		X					*	36261
M.	*hypsauchen*	(Müller & Troschel 1844)	O, S, Si		X					*	36817, 3626
M.	*luna*	Cope 1878	O, S, Si		X					*	36818, 34931
Microschemobrycon	*callops*	Böhlke 1953			X			X			33994, 36929
M.	*casiquiare*	Böhlke 1953			X			X			36911, 36665
Moenkhausia	*browni*	Eigenmann 1909	Si		X			X			21554, 30349
M.	*chrysargyrea*	(Günther 1864)	Si			X				X	36845
M.	*colletti*	(Steindachner 1882)	O		X				X		37210, 34933
M.	*copei*	(Steindachner 1882)	O		X		X				37291, 37208
M.	*dichroura*	(Kner 1859)	O		X				X		34555, 33969
M.	*georgiae*	Géry 1966			X			X			19987, 33933
M.	*grandisquamis*	(Müller & Troschel 1845)									MHNLS 12950
M.	*intermedia*	(Eigenmann 1908)	O		X			X			37335, 36589
M.	cf. *lata*	Eigenmann 1908									MHNLS 12949
M.	*lepidura*	(Kner 1859)	O	X				X			37338, 37187
M.	*oligolepis*	(Günther 1864)	O		X					X	37339, 36177
M.	sp. "dorsal larga"		O			X				X	19995
M.	sp. "icutú"		O			X				X	22200
M.	sp. "pálida"					X				X	37290, 36578

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution W	D	R	Abundance DO	CO	FR	OC	Sources
(Characidae)											
Mylesinus	*schomburgki*	Valenciennes 1849	S, Si			X				*	34468, 36576
Myleus	*rubripinnis*	(Müller & Troschel 1844)	O, S, Si		X				*		36816, 34929
M.	*torquatus*	(Kner 1858)	O, S, Si			X			*		36787, 36312
M.	sp. "humeral"		O			X					22853, 22524
Mylossoma	*duriventre*	(Cuvier 1818)	C,O		X			*			36815, 3493
Parapristella	*georgiae*	Géry 1964	O		X					X	37136, 37089
Phenacogaster	*megalostictus*	Eigenmann 1909			X			X			36761, 36887
Piaractus	*brachypomus*	(Cuvier 1818)	C	X			*				36099
Poptella	*longipinnis*	(Popta 1901)	O		X				X		37277, 37166
Pristella	*maxillaris*	Ulrey 1894	O								MHNLS 12857
Pristobrycon	*calmoni*	(Steindachner 1908)	Si								MHNLS 13011
P.	*striolatus*	(Steindachner 1908)	Si								MHNLS 12871
Pygocentrus	*cariba*	Valenciennes 1849	S, Si		X				*		36819, 34917
Pygopristis	*denticulata*	(Cuvier 1819)	O, S, Si		X						37181, 33864
Roeboides	*affinis*	(Günther 1868)			X				X		37659, 36179
R.	*dientonito*	Schultz 1944				X					(12844) MHNLS
Serrabrycon	*magoi*	Vari 1986				X				X	37345, 3708
Serrasalmus	*altuvei*	Ramírez 1965	O, S, Si			X					36161, 34602
S.	*eigenmanni*	Norman 1928									MCNG
S.	*elongatus*	Kner 1860	O, S, Si			X				X	36043
S.	*irritans*	Peters 1877	O, S, Si			X				X	34551
S.	*rhombeus*	(Linnaeus 1766)	O, S, Si		X				*	X	36852, 3682
S.	n. sp. "amazonas"	Machado Allison pers. com.	Si								MHNLS 12894
Tetragonopterus	*argenteus*	Cuvier 1817	O, Si		X					X	37674, 36758
T.	*chalceus*	Agassiz 1829	O, Si		X			X			36882, 36872
Triportheus	*albus*	Cope 1872	Si		X					X	37159, 36535
T.	*angulatus*	(Spix 1829)	Si		X					X	36822, 34557
T.	*rotundatus*	(Schomburgk 1841)	Si			X					(12850) MHNLS
Xenagoniates	*bondi*	Myers 1942	O		X					X	36060, 21048

Crenuchidae (15)									
Ammocryptocharax	*elegans*	Weitzman & Kanazawa 1976	O		X			X	36077, 23275
A.	*minutus*	Buckup 1993	O		X			X	12416, 16289
Characidium	*boaevistae*	Steindachner 1915	O		X			X	34514, 22268
Ch.	*declivirostre*	Steindachner 1915			X				22797, 22709
Ch.	*pellucidum*	Eigenmann 1909							MHNLS 12852
Ch.	*purpuratum*	Steindachner 1882	O		X				36684, 36557
Ch.	*steindachneri*	Cope 1878			X				36596, 23008
Ch.	*zebra*	Eigenmann 1909	O		X			X	37299, 20847
Elachocharax	*pulcher*	Myers 1927	O		X			X	37105, 15222
E.	*geryi*	Weitzman & Kanazawa 1978				X		X	41179
Melanocharacidium	*blennioides*	(Eigenmann 1909)							MHNLS
M.	*dispilomma*	Buckup 1993	O		X			X	36064, 34824
M.	*melanopteron*	Buckup 1993				X			34114
M.	*pectorale*	Buckup 1993							MHNLS
Poecilocharax	*weitzmani*	Gery 1965				X			MHNLS
Chilodontidae (3)									
Caenotropus	*labyrinthicus*	(Kner 1859)	O, Si	X			X		36008, 20922
C.	*mestomorgmatus*	Vari, Castro & Raredon 1995							MHNLS
Chilodus	*punctatus*	Müller & Troschel 1844	O			X		X	22821, 22003
Ctenoluciidae (4)									
Boulengerella	*cuvieri*	(Agassiz in Spix & Agassiz 1829)	S, Si		X			*	21946, 34115
B.	*lucius*	(Cuvier, 1816)	S, Si			X		*	21578, 36762
B.	*maculata*	(Valenciennes in Cuvier & Valenciennes) 1849	O			X		*	36095
B.	*xyrekes*	Vari 1995	S, Si		X			X	28760, 36007
Curimatidae (14)									
Curimata	*cyprinoides*	(Linnaeus 1766)	Si						MHNLS 12828
C.	*incompta*	Vari 1984	Si	X				X	34943, 36897
C.	*ocellata*	Eigenmann & Eigenmann 1889	O		X			X	37164
C.	*vittata*	Kner 1858	Si						MHNLS 12826

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution			Abundance				Sources
				W	D	R	DO	CO	FR	OC	
(Curimatidae)											
Curimatella	*dorsalis*	(Eigenmann & Eigenmann 1889)	Si		X					X	34588
C.	*immaculata*	(Fernández-Yépez 1948)	Si	X				X			34941, 36169
Curimatopsis	*macrolepis*	(Steindachner 1876)				X				X	37135
Cyphocharax	*festivus*	Vari 1992	Si		X			X			34591, 36683
C.	*oenas*	Vari 1992	Si		X				X		34589, 36012
C.	*spilurus*	(Günther 1864)	Si		X				X		20902, 34819
Potamorhina	*altamazonica*	(Cope 1878)	S, Si			X				X	21453
Psectrogaster	*ciliata*	(Müller & Troschel 1845)	S, Si		X				X	*	20955, 36821
Steindachnerina	*argentea*	(Gill 1858)	Si		X					X	21087, 22483
S.	*pupula*	Vari 1991	Si		X					X	21089, 21504
Cynodontidae (4)											
Cynodon	*gibbus*	Spix 1829	Si		X					X	36315, 36895
Hydrolycus	*armatus*	(Schomburgk 1841)	C, S, Si	X				*			20837, 34515
H.	*tatauaia*	Toledo,Piza, Menezes, &Mendes dos Santos 1999			X						35817, 37066
Rhaphiodon	*vulpinus*	Agassiz 1829	Si			X					34114, 3447
Erythrinidae (3)											
Hoplerythrinus	*unitaeniatus*	(Spix 1829)	Si		X					X	34604, 37195
Hoplias	*macrophthalmus*	(Pellegrin 1907)	S, Si			X					21610, 22879
H.	*malabaricus*	(Bloch 1794)	Si		X					X	21417, 37309
Gasteropelecidae (3)											
Carnegiella	*marthae*	Myers 1927	O			X				X	21468, 21954
C.	*myersi*	Fernández-Yépez 1950									
Thoracocharax	*stellatus*	(Kner 1859)	O			X				X	36052, 36136
Hemiodontidae (9)											
Anodus	*orinocensis*	(Steindachner 1888)	S, Si		X				*	X	20956, 37762

Argonectes	*longiceps*	(Kner 1859)	O			X		X	35473
Bivibranchia	*fowleri*	(Steindachner 1908)	O		X			X	19046, 36869
Hemiodus	*amazonum*	(Humboldt 1817)							MHNLS 12838
H.	*argenteus*	Pellegrin 1908							MHNLS 13053
H.	*immaculatus*	Kner 1859	O			X			37163
H.	*semitaeniatus*	Kner 1859	O, Si		X		X		37070, 37127
H.	sp.		O		X			X	20954, 34603
H.	*vorderwinkleri*	(Gèry 1964)	O						MHNLS
Lebiasinidae (6)									
Copella	*metae*	(Eigenmann 1914)	O		X			X	21144, 22002
Lebiasina	sp.		O		X			X	18910, 20912
Nannostomus	cf. *anduzei*	Fernández & Weitzman 1987	O						MHNLS
N.	*eques*	Steindachner 1876	O		X			X	37073, 37131
N.	*unifasciatus*	Steindachner 1876	O			X			37301
Pyrrhulina	cf. *lugubris*	Eigenmann 1922	O			X		X	21006, 37168
Parodontidae (2)									
Apareiodon	*orinocensis*	Bonilla *et al.* 1999							MHNLS
Parodon	sp. "barra"		O			X		X	22799, 1894
Prochilodontidae (4)									
Prochilodus	*mariae*	Eigenmann 1922	S, Si			X			23005, 3482
P.	*rubrotaeniatus*	Jardine & Schomburgk in Schomburgk 1841	S, Si			X		*	37307
Semaprochilodus	*kneri*	(Pellegrin 1909)	S, Si	X			*		22755, 36047
S.	*laticeps*	(Steindachner 1879)	S, Si		X			*	34511
ORDER CLUPEIFORMES									
Clupeidae (2)									
Pellona	*castelnaeana*	Valenciennes in Cuvier & Valenciennes 1847	C			X	*		22016
P.	*flavipinnis*	Valenciennes 1836	C			X	*		37158
Engraulidae (7)									
Anchovia	*surinamensis*	(Bleeker 1866)							MHNLS 12819
Anchoviella	*brevirostris*	Günther 1868							MHNLS
A.	*guianensis*	(Eigenmann 1912)				X		X	34569

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution			Abundance				Sources
				W	D	R	DO	CO	FR	OC	
(Engraulidae)											
Anchoviella	*perezi*	Cervigón 1987				X					MHNLS
A.	sp.				X				X		23259, 3656
Lycengraulis	*batesii*	(Günther 1868)	Si			X					36901
Pterengraulis	*atherinoides*	(Linnaeus 1766)									MHNLS
ORDER GYMNOTIFORMES											
Apteronotidae (4)											
Apteronotus	*leptorhynchus*	(Ellis 1912)	O		X					X	34826, 34542
A.	sp.					X					34827
Porotergus	sp.										MHNLS
Sternarchorhynchus	*curvirostris*	Boulenger 1887	O			X				X	34618
Gymnotidae (3)											
Electrophorus	*electricus*	Gill 1864	O		X					X	36132, 21895
Gymnotus	*carapo*	Linnaeus 1758	O		X					X	37298, 22742
G.	*stenoleucus*	Mago-Leccia 1994	O		X						22782, 22743
Hypopomidae (7)											
Brachyhypopomus	*beebei*	(Schultz 1944)									MHNLS
B.	*brevirostris*	(Steindachner) 1868	O			X					(12873) MHNLS
Hypopomus	sp.		O		X					X	19999, 37672
Hypopygus	*lepturus*	Hoedeman 1962	O			X					21137
Microsternarchus	*bilineatus*	Fernández-Yépez 1968	O			X					15231
Steatogenys	*duidae*	(La Monte) 1929	O			X					21136, 15232
S.	*elegans*	(Steindachner) 1880									MHNLS 12876
Rhamphichthyidae (2)											
Gymnorhamphichthys	*rondoni*	Miranda Riberio 1920	O		X					X	36783, 2301
Rhamphichthys	*marmoratus*	Castelnau 1855	O			X					36173
Sternopygidae (5)											
Eigenmannia	*macrops*	(Boulenger) 1897	O		X					X	34947, 37311
E.	*virescens*	(Valenciennes) 1847	O		X					X	36875, 34571

Eigenmannia	sp.			X				20909, 23217
Rhabdolichops	*electrogrammus*	Lundberg & Mago-Leccia 1986	O		X		X	33992
Sternopygus	*macrurus*	(Bloch & Schneider) 1801	O	X				23205, 22744
ORDER SILURIFORMES								
Aspredinidae (4)								
Bunocephalus	*amaurus*	Eigenmann 1912		X			X	37665, 3661
B.	sp. "redonda"				X			23668
B.	sp.			X			X	36075, 2108
Pseudobunocephalus	*lundbergi*	Friel 1994			X		X	21122
Auchenipteridae (18)								
Ageneiosus	*brevifilis*	Valenciennes 1840	C, S, Si	X				35830, 34113
A.	*ucayalensis*	Castelneau 1855	S, Si	X				34112, 34034
A.	sp.				X			37107
Asterophysus	*batrachus*	Kner 1858						MHNLS
Auchenipterichthys	*longimanus*	(Günther 1864)	O		X		X	36856
A.	*sp*							MHNLS
Auchenipterus	*ambyacus*		O		X			21454
A.	sp.							MHNLS
Centromochlus	*megalops*	Kner 1858	O		X			34031
C.	sp.							
Entomocorus	*gameroi*	Mago-Leccia 1983						MHNLS
Parauchenipterus	*galeatus*	Linnaeus 1766	O		X			MHNLS
Tatia	*galaxias*	Mees 1974	O		X		X	22749, 21024
T.	*musaica*	Royero 1992	O		X			21014
T.	*romani*	Mees 1974	O	X		X		21109, 23283
T.	sp.			X				37322, 36547
Tetranematichthys	*quadrifilis*	(Kner 1857)						MHNLS 13457
Trachycorystes	*trachycorystes*	(Valenciennes 1840)						MHNLS 12890
Callichthyidae (9)								
Corydoras	*aeneus*	(Gill 1858)	O		X		X	21110
C.	*blochi*	Nijssen 1971						MHNLS
C.	*boehlkei*	Nijssen & Isbrücker 1982						MHNLS

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution			Abundance				Sources
				W	D	R	DO	CO	FR	OC	
(Callichthyidae)											
Corydoras	*heteromorphus*	Nijssen 1970	O		X				X		36681, 34842
C.	*melanistius*	Regan 1912									MHNLS
C.	*osteocarus*	Böhlke 1951	O		X					X	21444, 3608
C.	*septentrionalis*	Gosline 1940	O		X					X	37673, 26959
Hoplosternum	*littorale*	Hancock 1828	O			X					MHNLS
Megalechis	*thoracata*	(Valenciennes 1840)	O			X					37106
Cetopsidae (3)											
Cetopsis	*coecutiens*	(Lichtenstein 1829)									MHNLS
Paracetopsis	sp.					X				X	37069
Pseudocetopsis	sp.					X			X		23226, 23016
Doradidae (16)											
Agamyxis	*pectinifrons*	(Cope 1870)	O								MHNLS
Amblydoras	*affinis*	(Kner 1855)	O			X			X		37157
Anduzedoras	*oxyrhynchus*	(Valenciennes 1821)									MHNLS
Doras	*micropoeus*	(Eigenmann 1912)			X				X		37321, 33982
Hassar	*affinis*	(Steindachner 1880)			X				X		37157, 20936
H.	*orestis*	(Steindachner 1875)	O			X				X	36796
H.	*ucayalensis*	(Fowler 1940)	O			X				X	35472
Leptodoras	*linnelli*	(Eigenmann 1912)	O		X				X		34003, 37404
Megalodoras	*uranoscopus*	(Eigenmenn & Eigenmann 1888)									MHNLS
Opsodoras	*ternetzi*	Eigenmann 1925	O			X			X		36310, 34001
Orinocodoras	*eigenmanni*	Myers 1927	O								MHNLS
Oxydoras	*niger*	(Valenciennes) 1821	C, S, Si		X			*			Puerto de Maripa
Platydoras	*costatus*	(Linnaeus 1766)	O		X				X		37129, 37102
Pterodoras	*angeli*	Fernández-Yépez 1968	C, S, Si		X			*			Puerto de Maripa
Scorpiodoras	*heckelii*	(Kner 1855)									MHNLS
Trachydoras	*nattereri*	(Steindachner 1881)				X					36797
Loricariidae (32)											
Acanthicus	sp.										MHNLS

Ancistrus	*dolichopterus*	Kner 1854		X		X		36068, 34848
Ancistrus	*temmincki*	(Valenciennes 1840)						MHNLS
Aphanotorulus	*ammophilus*	Armbruster & Page 1996						MHNLS
Chaetostoma	*vasquezi*	Provenzano & Lasso 1997		X		X		34850, 22932
Cochliodon	*plecostomoides*	Eigenmann 1922	O		X			36074, 20875
Farlowella	*mariaelenae*	Martín 1964	O		X			20880
F.	*oxyrryncha*	Kner 1854	O		X			Retzer & Page 1996
F.	*vittata*	Myers 1942	O	X		X		36072, 34818
Hemiancistrus	sp. 1		O		X			34845, 22933
Hemiancistrus	sp. 2							MHNLS
Hypoptopoma	*steindchaneri*	Boulenger 1895	O	X		X		36834, 34914
Hypostomus	sp. 1	Linnaeus 1758	O		X			36689
H.	sp. "oscuro"		O		X			34018
H.	sp. 2		O					MHNLS
H.	*squalinus*	Schomburgk 1841	O		X		X	37044, 34016
Lamontichthys	*llanero*	Taphorn & Lilyestrom 1984			X			34613
Lasiancistrus	*anthrax*	Armbruster & Provenzano 2000	O					
L.	sp.			X				36071, 21596
Loricaria	*cataphracta*	Linnaeus 1758		X			X	36812, 34062
L.	sp.			X				21576, 34935
Loricariichthys	*brunneus*	(Hancock 1828)		X			X	36772, 33859
Nannoptopoma	*spectabilis*	(Eigenmann 1914)	O		X			33981, 20885
Panaque	*nigrolineatus*	(Peters 1877)	O	X				34583, 21892
Peckoltia	sp.			X			X	34615, 34598
Pseudancistrus	sp.			X				35829, 34849
Pterygoplichthys	*gibbiceps*	Kner 1854			X			36067, 36103
P.	*multiradiatus*	(Hancock) 1828		X				Puerto de Aripao
Rineloricaria	*caracasensis*	(Bleeker) 1862			X			34816
R.	*formosa*	Isbrücker & Nijssen 1979		X			X	36877, 36813
R.	cf. *platyura*	(Müller & Troschel 1848)			X			36687
Spatuloricaria	sp.		O		X			34817, 34614

Table/*Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution W	Distribution D	Distribution R	Abundance DO	Abundance CO	Abundance FR	Abundance OC	Sources
Pimelodidae (44)											
Brachyplatystoma	*filamentosum*	(Lichtenstein 1819)									
B.	*juruense*	(Boulenger 1898)	C			X				*	Puerto de Maripa
B.	*flavicans*	(Castelnau 1855)	C			X				*	Puerto de Maripa
B.	*vaillanti*	(Valenciennes 1840)									MHNLS
Calophysus	*macropterus*	Lichtenstein 1819	C		X		*				Puerto de Maripa
Cetopsorhamdia	*orinoco*	Schultz 1944				X					34834
C.	sp.					X					34841, 23017
Chasmocranus	sp.										MHNLS
Gladioglanis	*machadoi*	Ferraris & Mago-Leccia 1989				X					34832
Goeldiella	*eques*	(Müller & Troschel 1848)				X					37090
Goslinia	*platynema*	(Boulenger 1888)	C, S		X			*			Puerto de Aripao
Hemisorubim	*platyrhynchos*	(Valenciennes in Cuvier & Valenciennes 1840)	C, S, Si		X			*			36163
Heptapterus	aff. *tapahoniensis*	Mees 1974				X					15228
H.	sp. "caura"					X					34830, 3484
Hypophthalmus	*edentatus*	Agassiz in Spix & Agassiz 1829									MHNLS
H.	*marginatus*	Valenciennes 1840									MHNLS
Imparfinis	sp.					X					23010, 22517
Leiarius	*marmoratus*	Gill 1870	C, S, Si			X		*			34469
Megalonema	*platycephalum*	Eigenmann 1912				X					34510
M.	*psammium*	Schultz 1944				X					36057
Microglanis	*iheringi*	Gomes 1946	O		X					X	37091, 15227
Myoglanis	sp.					X					34836, 34592
Phractocephalus	*hemioliopterus*	(Bloch & Schneider 1801)	C	X			*				Salto Para
Pimelodella	*cristata*	(Müller & Troschel 1848)	Si		X				X		34501, 36633

Pimelodella	*imitator*	(Myers 1927)	O		X					X	36607, 21085
P.	*macturki*	Eigenmann 1912									MHNLS
P.	*metae*	Eigenmann 1917	Si		X			X			37316, 33987
Pimelodus	*albofasciatus*	Mees 1974									MHNLS
P.	*blochii*	Valenciennes 1840	Si	X						X	19928
P.	*ornatus*	Kner 1857	S, Si			X				X	18804
Pinirampus	*pirinampu*	(Agassiz in Spix & Agassiz 1829)	C		X		*				22726
Platynematichthys	*otatus*	(Schomburgk 1841)	C	X			*				Puerto de Maripa
Pseudopimelodus	*raninus*	(Valenciennes 1840)	C, S, Si			X			*		37092
P.	sp.		C, S, Si			X					34839
Pseudoplatystoma	*fasciatum*	(Linnaeus 1766)	C	X			*				36049
P.	*tigrinum*	(Valenciennes 1840)	C		X						36048, 2288
Rhamdella	sp.										MHNLS
Rhamdia	*laukidi*	Bleeker 1858	Si			X					135714 (ANSP)
R.	*muelleri*	Günther 1864	Si			X					149827 (ANSP)
R.	*quelen*	(Quoy & Gaimard 1824)	Si			X					141578 (ANSP)
Sorubimichthys	*planiceps*	(Agassiz 1829)	C			X				*	(12879) MHNLS
Sorubim	*elongatus*	Littmann, Burr, Schmidt, Ríos 2001	C			X				*	21135, 20925
Sorubim	*lima*	(Block & Schneider 1801)	C		X						36096, 34058
Zungaro	*zungaro*	Humboldt in Humboldt & Valenciennes 1821	C			X				*	34472
Trichomycteridae (10)											
Acanthopoma	*bondi*	Myers 1942				X				X	34038
Haemomaster	*venezuelae*	Myers 1927			X				X		36690, 23228
H.	sp.				X						36888, 34037
Homodiaetus	*haemomyzon*	Myers 1942			X						36711, 23227
Ochmacanthus	*alternus*	Myers 1927			X			X			37308, 21071
O.	*flabelliferus*	Eigenmann 1912									MHNLS
O.	*orinoco*	Myers 1927			X				X		34032, 21449
Paracanthopoma	*parva*	Giltay 1935			X					X	36634, 36602

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	USES	Distribution W	D	R	Abundance DO	CO	FR	OC	Sources
(Trichomycteridae)											
Trichomycterus	sp.					X					34599, 19998
Vandellia	*plazaii*	Castelnau 1855			X			X			36917, 33979
ORDER CYPRINODONTIFORMES											
Cyprinodontidae (1)											
Fluviphylax	*obscurum*	Costa 1996			X					X	37202, 37137
Poeciliidae (1)											
Poecilia	*reticulata*	Peters 1859			X				X		36833, 21041
Rivulidae (2)											
Rachovia	*maculipinnis*	(Weibezahn in Radda 1954)	O			X					21093
Rivulus	sp.		O			X					18815
ORDER BELONIFORMES											
Belonidae (2)											
Potamorrhaphis	*guianensis*	(Schomburgk 1843)	O		X						37109, 21182
Pseudotylosurus	*microps*	(Günther 1866)									
ORDER SYNBRANCHIFORMES											
Synbranchidae (1)											
Synbranchus	*marmoratus*	Bloch 1795			X						37656, 21091
ORDER PERCIFORMES											
Cichlidae (36)											
Acaronia	*vultuosa*	Kullander 1989			X					X	37318, 3714
Aequidens	*diadema*	(Heckel 1840)	O		X						37660, 37196
A.	cf. *pulcher*	Gill 1858	O		X						37029, 36988
A.	*tetramerus*	(Heckel 1840)	O		X				X		37314, 21114
A.	sp. "bolivar"					X					2644
Apistogramma	*hoignei*	Meinken 1965	O			X					37664, 37302
A.	sp. "caura"					X			X		36066, 23256
A.	sp. 2										MHNLS

Astronotus	sp. "common"		O, Si	X					Morichales
Biotodoma	*wavrini*	(Gosse 1963)							MHNLS
Bujurquina	sp.				X				36066, 33975
Chaetobranchus	*flavescens*	Heckel 1840			X				36101
Cichla	*intermedia*	Machado-Alison 1971	C, S, Si						MHNLS
Cichla	cf. *monoculus*	Spix 1831	C, S, Si						MHNLS
C.	*orinocensis*	Humboldt 1833	C, S, Si	X			*		37130, 37141
C.	*temensis*	Humboldt 1833	C, S, Si		X				33850
Cichlasoma	*orinocense*	Kullander 1983	O, Si	X					36078
Crenicichla	cf. *alta*	Eigenmann 1912	O, Si		X				37177
C.	cf. *geayi*	Pellegrin 1903	O, Si	X					37295, 37312
C.	cf. *lugubris*	Heckel 1840	O, Si	X					37147, 22754
C.	cf. *wallacii*	Regan 1905	O, Si	X					36552, 36562
C.	sp. "caura"		O, Si	X					20852, 20886
C.	sp. "lower caura"		O, Si	X					20117, 21019
Dicrossus	*filamentosus*	Ladiges 1958	O		X				37133
Geophagus	sp. "dirty"		O, Si	X					36769, 33976
G.	sp. "stripetail"		O, Si	X					36790, 38629
G.	*taeniopareius*	Kullander & Royero 1992	O, Si	X					34814, 22875
Heros	sp. "common"		O, Si	X					33849, 33868
Hoplarchus	*psittacus*	(Heckel 1840)	O, S, Si	X					33869
Hypselecara	*coryphaenoides*	(Heckel 1840)	O, Si	X					33870, 19043
Mesonauta	*egregius*	Kullander & Silfvergrip 1991	O, Si	X				X	37118, 34487
M.	*insignis*	(Heckel 1840)	O, Si	X					37149, 37119
Mikrogeophagus	*ramirezi*	(Myers & Harry 1948)	O	X		X			Morichales
Satanoperca	*daemon*	Heckel 1840	O, S, Si	X					37148, 37138
S.	cf. *leucosticta*	(Müller & Troschel in Schomburgk 1849)	O, S, Si						MHNLS
S.	*mapiritensis*	Fernández-Yépez 1950	O, S, Si	X					37155, 36831
Eleotridae (1)									
Microphilypnus	*macrostoma*	Myers 1927			X				36804, 36545

Table/ *Tabla* 4.1 (cont.)

Taxa		Author	Uses	Distribution			Abundance				Sources
				W	D	R	DO	CO	FR	OC	
Sciaenidae (3)											
Pachyurus	sp.		Si			X					35471
Pachyurus	*schomburgkii*	Guenther 1860			X					X	34035
Plagioscion	*squamosissimus*	(Heckel 1840)	O	X				*			36751, 34466
Nandidae (1)											
Monocirrhus	*polyacanthus*	Heckel 1840	O			X					Morichal Tauca
ORDER PLEURONECTIFORMES											
Achiridae (2)											
Apionichthys	sp.										MHNLS
Hypoclinemus	*mentalis*	(Günther 1862)	O			X					37315, 36782

Since the taxonomy of Venezuelan fishes is still in the descriptive phase, many species identifications remain doubtful. Names included here are in most cases supported by voucher specimens, but in many cases represent only our best approximation of the correct name. Lasso and Taphorn compared collections deposited in Caracas and Guanare and made every attempt to standardize name usage applied to each entity identified here as a distinct species. However, many genera such as *Moenkhausia, Hemigrammus, Hyphessobrycon, Hypostomus, Pimelodella* and *Crenicichla* include taxa that represent extremely challenging groups for alpha taxonomists. We have adopted code names to identify and separate different taxa identified as "sp." within the same genus in the hope that species richness calculation will not be unduly affected by high numbers of doubtful species, or inadverted "lumping" of morphologically similar taxa.

Habitat and Distribution

In Table 4.1 we present the distribution category for each species. Of the species captured, 294 are also present in the sediment-laden whitewater floodplain habitat of the middle Orinoco (floodplain lagoons of the lowest portion of the lower Caura). Most of these species belonged to the orders Characiformes (243 species) and Siluriformes (137 species). These species occur in all the habitats sampled from the lower Caura; nevertheless, they were most common in the tributaries of the lower sector and the floodplain lagoons. Examples of such ubiquitous species are: *Astyanax bimaculatus, Ctenobrycon spilurus, Cyphocharax spilurus, Bryconamericus deuterodonoides, Charax gibbosus, Moenkhausia copei, Mylossoma duriventre, Poptella compressa, Roeboides affinis, Steindachnerina argentea, Gymnotus carapo, Panaque nigrolineatus, Cochliodon plecostomoides, Pimelodus blochii, Cichla orinocensis* and *Aequidens pulcher*.

We found 56 species characteristic of the blackwater habitats that drain the Guayana Shield. These species were found in most of the habitats sampled (77%) in the upper sector of the river as well as the upland blackwater streams and *morichal* creeks (*moriche* palm lined gallery forest habitats usually found in savanna). Siluriformes (39%) was the dominant order present in these habitats, along with Characiformes (28%) and Perciformes (22%). Species indicative of these blackwater ecosystems are *Astyanax anteroides, Bryconamericus hyphesson, Iguanodectes geisleri, Microschemobrycon casiquiare, M. callops, Moenkhausia oligolepis, M. browni, Melanocharacidium dispilomma, Lebiasina uruyensis, Caenotropus labyrinthicus, Hoplias macrophthalmus, Semaprochilodus kneri, Anchoviella guianensis, Steatogenys duidae, Brachyrhamdia imitator, Heptapterus* aff. *tapahoniensis, Rineloricaria formosa, Megalonema platycephalum, Vandellia plazaii, Fluviphylax obscurum, Potamorrhaphis guianensis, Geophagus taeniopareius, Hypselacara coryphaenoides, Dicrossus filamentosus, Microphilypnus macrostoma* and *Monocirrhus polyacanthus*.

Widespread species (22): The family Characidae has the most species with a

Table 4.2: Tally of lower Caura River fishes by order and family.
Tabla 4.2: *Sumatoria de los peces del bajo Río Caura, presentado por orden y familia taxonómica.*

Order/Family		Order/Family	
Myliobatiformes	**6**	**Siluriformes**	**136**
Potamotrygonidae	6	Aspredinidae	4
Characiformes	**216**	Auchenipteridae	18
Anostomidae	23	Callichthyidae	9
Characidae	126	Cetopsidae	3
Characidiidae	15	Doradidae	16
Chilodontidae	3	Loricariidae	32
Ctenoluciidae	4	Pimelodidae	44
Curimatidae	14	Trichomycteridae	10
Cynodontidae	4	**Cyprinodontiformes**	**4**
Erythrinidae	3	Cyprinodontidae	1
Gasteropelecidae	3	Poeciliidae	1
Hemiodontidae	9	Rivulidae	2
Lebiasinidae	6	**Beloniformes**	**2**
Parodontidae	2	Belonidae	2
Prochilodontidae	4	**Synbranchiformes**	**1**
Clupeiformes	**9**	Synbranchidae	1
Clupeidae	2	**Perciformes**	**41**
Engraulidae	7	Cichlidae	36
Gymnotiformes	**21**	Eleotridae	1
Electrophoridae	4	Sciaenidae	3
Gymnotidae	3	Nandidae	1
Hypopomidae	7	**Pleuronectifomes**	**2**
Rhamphichthyidae	2	Achiridae	2
Sternopygidae	5	Orders	10
		Families	39
		Species	438

widespread distribution pattern and comprised 43% of all species included in this class. Among the most common were *Aphyocharax alburnus*, *Brycon bicolor*, *Bryconamericus hyphesson*, *Bryconamericus* sp. "línea", *Hemigrammus schmardae*, and *Moenkhausia lepidura*. Of the species with commercial importance, 28 were reported from several of the different habitats we sampled; among the most important are *Pseudoplatystoma fasciatum*, *Phractocephalus hemioliopterus*, *Piaractus brachypomus*, and *Platynematichthys notatus*. *Hydrolicus armatus*, an important sport fish, is also included in this group.

Dispersed species (183): The most abundant species (number of individuals collected) typically showed a "dispersed" distribution pattern, with some exceptions such as *Moenkhausia copei*, *Bryconamericus deuterodonoides*, *Knodus* sp. "baja" and *Vandellia plazaii*. Species associated with sandy beaches captured during the day had a dispersed distribution pattern and were present in almost the entire lower Caura. This was not the case for the species taken at the same beaches, but at night. In contrast, some species with high numerical abundance, especially those found in the floodplain lagoons, had fairly restricted distributions (sometimes limited to the lagoons); examples of these are *Cichla orinocensis*, *Semaprochilodus laticeps*, *Psectrogaster ciliata* and *Mikrogeophagus ramirezi*.

Restricted species (141): If we include in the tally the unidentified genera and species identified only by codes, this distribution class contained most of the species found from the lower Caura. For the main channel, the species with "restricted" distributions include *Mylesinus schomburgki*, *Amblydoras affinis*, *Haemomaster venezuelae* and *Boulengerella maculata*. In the *morichal* habitats the restricted species represented 64.6% of those reported, and the Cichlidae and Characidae were particularly well represented. In the Nichare River 37% of the species showed restricted distributions with Anostomidae and Characidae being the most abundant.

Abundance and Density

In the samples made with nets on sand beaches along the shore, the average number of individuals captured per sample for the lower Caura sites was 178.4 (max: 1352; min: 12; n = 56). The rotenone or "*barbasco*" samples resulted in a total of 2,195 fish (17.6 ind/m^2) in the Nichare River and 763 fish in the Tauca River (18.6 ind/m^2). For the standardized beach samples the number of individuals captured in the upper sector was significantly different from the lower, for both day and night samples. The average number of individuals captured in samples from the upper sector was 170.4 (max: 816; min: 27; n = 24) and in the lower it was 361 (max: 1,009; min: 96; n = 36). For the day samples the average was 72.3 fish (max: 161; min: 27; n = 12) in the upper sector and 114.8 (max: 713, min: 96; n = 18) in the lower. For the night samples we collected on average 341.8 individuals (max: 816; min: 189; n = 12) in the upper sector and 453.3 (max: 1009; min: 210; n = 18) in the lower. The average density in this type of sample was 1.64 ind/m^2 and 1.93 ind/m^2 for the upper and lower sectors, respectively. Table 4.1 shows the abundance classes from the standardized samples for each species.

Frequency of Appearance

Dominant species (5): (Present in >71% of the sites sampled). Very few species with this class of abundance were reported, and all belonged to the family Characidae; they were *Aphyocharax alburnus, Bryconamericus hyphesson, Bryconamericus* sp. " línea", *Hemigrammus schmardae* and *Moenkhausia lepidura.* Such species generally presented dispersed distribution and they were more frequent in the main channel.

Common species (21): (Present in 41–70% of the sites sampled). The family Characidae also dominated this class (76%), with species like *Hemigrammus analis, H. newboldi, Creagrutus melanzonus, Astyanax bimaculatus, Ctenobrycon spilurus, Microschemobrycon callops, M. casiquiare, Moenkhausia browni, M. copei* and *M.* sp. "palida", among others. Other "common" taxa include *Curimatella immaculata, Cyphocharax festivus, Pimelodella metae, Vandellia plazaii* and *Ochmacanthus alternus.*

Frequent species (39): (Present in 21–40% of the sites sampled). *Astyanax anteroides, Knodus* sp."caura", *Cyphocharax spilurus, Cyphocharax oenas, Caenotropus labyrinthicus, Bryconamericus deuterodonoides, Hemigrammus micropterus, Moenkhausia chrysargyrea, Bryconops alburnoides* and *B. caudomaculatus.* Other species included here are *Haemomaster venezuelae, Anchoviella* sp., *Corydoras heteromorphus, Leptodoras linnelli* and *Ochmacanthus orinoco.*

Occasional species (102): (Present in <20% of the sites sampled). Most of the species collected showed this type of abundance. Characidae with 33% of the total and Siluriformes with 26% dominated the group. Some taxa representative of this class are *Agoniates anchovia, Acestrorhynchus minimus, Hemigrammus stictus, H. rhodostomus, H. vorderwinkleri, Hyphessobrycon metae, Knodus* sp. "baja" and *Moenkhausia* sp."long dorsal". Most of the Crenuchidae, Gasteropelecidae, Loricariidae, Gymnotiformes, Cyprinodontiformes and Beloniformes were included in this class. Most occasional species showed a restricted distribution.

Events Associated with the Hydrological Regime

The lower Caura is subject to large variations in water level due to the great difference in rainfall between the wet and dry seasons. During the beginning of the rainy period (May to June) observations made from shore along the main channel indicated the existence of mixed schools of mature and juvenile fish moving upstream. We observed *Brycon* spp., *Astyanax* spp., *Poptella compressa, Psectrogaster ciliata* and *Leporinus* aff. *maculatus* swimming in the middle and upper water column, whereas *Pimelodella* spp. and *Corydoras* spp. were seen traveling along the bottom.

For the rainiest months of June and July, the floodplain lagoons were connected to the main river channel, and the wetlands associated with the outlets of the Mato and Sipao tributaries were flooded moderately. At the same time, water depth in the blackwater *morichal* creeks increased. Almost all fish of commercial importance had gonads in advanced states of maturity, and were ready to spawn. Other species also matured at this time: *Myleus, Metynnis, Ageneiosus, Liposarcus* and *Cochliodon.* Among the cichlids, which mainly occur in lagoons and *morichal* creeks, pairs of *Cichla orinocensis, Hypselacara, Cichlasoma, Heros* and *Geophagus* were observed protecting their nests or defending eggs or larvae during the early rainy season.

During full flood, between July and October, the alluvial plains were completely under water. One large extensively flooded area connected the outlets of the Caura and Sipao rivers, and a second extensively flooded area was found at the Mato's mouth (see Rosales *et al.,* this volume). In the flooded forest serrasalmines such as *Mylossoma, Pygopristis, Pygocentrus, Piaractus* and *Serrasalmus* were common. Small doradid catfish, *Leptodoras linnelli, Opsodoras ternetzi* and *Trachydoras nattereri* and the trychomycterids *Haemomaster* and *Ochmacanthus* were common in samples taken from sand beaches of the main channel at night.

During the falling water phase, from November to December, the floodwaters receded from the floodplain and flowed into the main channel. At this time large concentrations of fish were present in the outlets of the major tributaries and along the shore mixed schools were seen abandoning the floodplain. Juveniles of many species were captured during these months, especially in December.

During the driest part of the year, January to March, the fishing diminished greatly and was concentrated in the Mato and Sipao rivers, as well as in the lagoons such as Aricagua and Aripao. Large concentrations of Characiformes (*Psectrogaster ciliata* and *Hemiodus orinocensis*) were captured in slack water eddies of the main channel. In the floodplain lagoons, the fishing harvest reached a brief peak and the species *Cichla orinocensis, Semaprochilodus kneri, S. laticeps, Astronotus* sp., *Pseudoplatystoma* sp., *Psectrogaster ciliata, Myleus* spp., *Metynnis* spp. and *Hoplias malabaricus* were most abundant. Several of these species showed preliminary gonad development at this time. By April, few fish could be observed in *morichales* and lagoons.

Discussion

The number of taxa present in the lower Caura is higher than most other Orinoco tributaries reported by other authors for habitats of the Orinoco floodplains and prairies (called "*Llanos*" in Venezuela) (Lasso [1988a,b, 1996], Lasso and Castroviejo [1992], Machado-Allison [1987], Machado-Allison *et al.* [1993], Rodríguez and Lewis [1990] and Pérez-Lozano [1996]). In those systems, Characiformes and Siluriformes were found to dominate the fauna with most species belonging to Characidae, Pimelodidae and Loricariidae (Table 4.2). These authors reported between 33% and 65% for the Characiformes and 13% to 34% for the Siluriformes of the total fish species present. From the Aguaro and Guariquito rivers, Machado-

Allison *et al.* (1993) reported the presence of 71 species of Characidae (Characiformes 191) and 10 of Pimelodidae (Siluriformes 36). Lasso (1992) identified a total of 41 species of Characidae and 16 Pimelodidae (Characiformes 74 and Siluriformes 41) from the Suapure river in northern Bolivar state.

Recent estimates of the neotropical fish diversity near 8,000 species. The 438 species reported here from the lower Caura represent around 36% of the total fish diversity known for Venezuela (Taphorn *et al.* 1997) and near 5% of the neotropical total (Vari and Malabarba 1998). Our total does not include the species known only from the upper Caura, which has yet to be well sampled. Even lacking data for the uppermost drainages, the known fish diversity of the Caura already surpasses that

Table 4.3: Species richness and approximate proportions of taxa in different rivers from north and south of the Orinoco River.
The values in percentages in parentheses are the averages of reported species richness, and/or calculated from the MCNG collection. Further explanation is given in the text.
Tabla 4.3: Riqueza y proporción aproximada de taxa en ambientes al norte y al sur del río Orinoco. Los números entre paréntesis son expresados en porcentajes. Los valores son el promedio de las riquezas reportadas y/o determinadas en la colección del MCNG. Explicación y fuentes se indican en el texto.

Drainage or System	Characiformes	Siluriformes	Gymnotiformes	Perciformes
North of the Orinoco River				
Apure River	138 (39)	137 (39)	31(9)	25(7)
Cojedes River	27 (33)	42 (52)	—	6 (7)
Aguaro-Guariquito Rivers	106 (68)	29 (18)	8 (5)	13 (8)
Guaritico Creek	75 (40)	65 (34)	21 (11)	14 (7)
Apure Modules	53 (52)	22 (21)	10 (10)	9 (9)
Maporal Creek	56 (50)	32 (28)	6 (5)	14 (12)
Cinaruco River	72 (69)	14 (13)	1 (1)	13 (12)
Caris y Pao Rivers	43 (58)	13(18)	9 (12)	7 (9)
Floo 'plain Lagoons of the	90 (55)	36 (22)	14 (8)	13 (8)
Midule and Lower Orinoco	40 (35)	38 (33)	7 (7)	20 (18)
South of the Orinoco River				
Gran Sabana Rivers	24 (46)	18 (35)	3 (6)	4 (8)
Raúl Leoni (Guri) Reservoir	40 (59)	13 (19)	2 (3)	12 (18)
Claro River	43 (53)	20 (25)	5 (6)	10 (12)
Atabapo River	91 (59)	36 (21)	9 (5)	26 (15)
Suapure River	74 (53)	41 (29)	8 (6)	13 (9)
Lower Caura	**216 (49)**	**136 (31)**	**21 (5)**	**41 (9)**

reported for the best studied Orinoco tributary, the Apure drainage (Taphorn 1992) where of the total 354 species has been reported, 138 Characiformes and 137 Siluriformes. For other Orinoco tributaries fewer species have been found (**Table 4.3**) (Matheus 1984, Taphorn 1995). Royero *et al.*(1992) reported 169 species from the Atabapo River and Lasso (1992) 140 from the Suapure. Normally more species are found in larger drainages, but the Caura, with only about 10% or the area of the Apure River drainage, will probably surpass it in total number of species once the upper drainage has be adequately sampled. (**Table 4.4**).

Because sampling density is still very low, it is still too early to make definitive conclusions about fish distribution patterns in Amazonas and Bolivar states in Venezuela, but early reports of unique undescribed species from the Caura indicate that the fish fauna of this river is special. Species present in the floodplain lagoons were different from those found in similar lagoons from the middle Orinoco (Lasso 1988a,b and Rodríguez and Lewis 1990). This suggests that the Caura is a region with environmental and faunistic differences that set it apart from neighboring basins (Caroní and Apure).

Many factors contribute to the high species diversity observed in the Caura. Perhaps the simplest explanation is that it is a large basin that contains very varied aquatic ecosystems in its different regions. It contains vast forested regions in the upper basin, where black, acid waters flow cool and well shaded beneath the foliage. The central sector of the drainage has intermediate conditions, and the lower basin has Orinoco like habitats with muddy floodplain lagoons with high productivity and biomass. The diversity may also result from the fact that this is a region of contact between the ancient geological formations of the Guayana Shield with the Quaternary and recent alluvial deposits of the whitewater Orinoco. Also, the wide variety of habitats permits many different species of fish to take advantage of many different niches. The Caura River drains areas with very different geological regions and substrates such as the Maigualida highlands or the Guanacoco-Ichún and Jaua-Sarisariñama mountains (Peña 1996). If each different geologic formation harbors somewhat different fish faunas, we might find species related to neighboring drainages such as the Caroní, Paragua, Ventuari and Ocamo that share similar geologic substrates. Taking into consideration the poor ichthyological exploration of the upper drainage, the estimate of 450 species for the entire drainage (Balbás and Taphorn 1996) seems reasonable, and may even be surpassed as collecting continues. The high diversity and relatively undisturbed nature of most of the Caura drainage make it one of the most important ichthyological reserves in the Orinoco Basin.

Sampling bias in this study might account for an underestimate of the total

Table 4.4: Relation between surface area and species richness reported for northern and southern Orinoco River tributaries.

A: estimated area for the drainage; **B:** length of the river; **C:** surface areas of the Aguaro-Guariquito and Capanaparo-Cinaruco National Parks, and the eastern sector of Canaima National Park; **D:** total surface area of the Apure Modules; **E:** estimated surface area for the floodplain of the Middle Orinoco; **F:** estimated surface area based on data presented by the authors.

Tabla 4.4: *Comparación entre las superficies o longitudes de algunos afluentes y/o sistemas al norte y al sur del río Orinoco, la riqueza de peces reportada y las especies comunes al Bajo Caura.*

A: *cuando no se indique lo contrario representa el área estimada de la cuenca;* ***B:*** *longitud del canal principal;* ***C:*** *superficies de los Parques Nacionales Aguaro-Guariquito, Capanaparo-Cinaruco y sector oriental del Parque Nacional Canaima;* ***D:*** *superficie total de los módulos;* ***E:*** *superficie de inundación lagunar aproximada aledaña al río Orinoco estimada para la cuenca media;* ***F:*** *superficie estimada en función del polígono de muestreo presentado por el autor.*

Drainage or System	Estimated surface (km^2)[A]	Reported species richness	Species in common with the lower Caura	Principal sources
North				
Apure	167,000	380	78%	(MCNG)
Cojedes	260[B]	81	48%	Hurtado (1996)
Aguaro-Guariquito	6,000[C]	255	90%	Machado-Allison *et al.* 1993 Taphorn 1995
Guaritico	930	210	72%	Lasso 1996, Pérez-Lozano 1996
Apure Modules	240[D]	103	66%	Taphorn y Lilyestrom 1984
Maporal	—	113	68%	Matheus 1984
Cinaruco	5,844[C]	178	90%	(MCNG), Jepsen 1997
Caris y Pao	—	74	89%	Machado-Allison *et al.* 1987
Lagoons of the lower and middle Orinoco	3,000[E]	200	78%	Rodríguez y Lewis 1990
		—	—	Lasso *et al.* 1988
South				
Gran Sabana	12,500[C]	52	34%	Lasso *et al.* 1989
Raúl Leoni (Guri) Reservoir	4,200	68	47%	Lasso *et al.* 1989
Claro	1,710	81	46%	Taphorn y García 1991
Atabapo	—	169	48%	Royero *et al.* 1992
Suapure	400[F]	140	58%	Lasso 1992
Lower Caura	**16,326**	**438**		This work
Caura Drainage	**47,500**	**450**		Estimate for the entire drainage

ichthyological diversity present. For example, in the upper portion of our study area, the substrate was usually rocky, causing great difficulty when handling the nets, and allowing many species to escape capture. The lower reaches were more nets, and allowing many species to escape capture. The lower reaches were more effectively sampled with nets because the substrate was sand or mud. In morichal creeks, the presence of flooded terrestrial vegetation, fallen limbs and other obstacles often hindered sampling, or recovery of all specimens affected by fish toxicants. Thus, the total number of species reported here, even though it is much higher than earlier reports (Taphorn 1996, Machado-Allison *et al.* 1999), may not represent the entire fauna. Species present in neighboring drainages (Cuchivero, Aro, Caroní, Parguaza) may eventually be found in the Caura.

The great variety of aquatic biotopes present in the lower Caura may explain the high number of species with restricted distribution patterns that were observed. The *morichal* creeks, with clear water, abundant macrophytes, and complex physical structure, are an ideal habitat for many species reported from similar habitats of the middle Orinoco tributaries (Marrero *et al.* 1997). Certain species abundant in the lower Caura, are typical Orinoco Basin whitewater species, these include *Aphyocharax alburnus, Astyanax bimaculatus, Ctenobrycon spilurus, Roeboides affinis, Cyphocharax festivus* and *Gymnocorymbus thayeri,* among others. Blackwater species shared with similar habitats north of the Orinoco included *Parapristella georgiae, Phenacogaster megalostictus, Curimatella immaculata, Semaprochilodus kneri, Moenkhausia lepidura* and *Moenkhausia copei,* as well as almost all the representatives of the genus *Hemigrammus* (Taphorn 1992, Machado-Allison *et al.* 1993).

Values reported here for fish density are low if compared with those found in Guaritico Creek of northern Apure State where Pérez-Lozano (1996) reported 59 ind./m^2 during the dry season. On the other hand, isolated blackwater systems like in the Claro River (Caroní River drainage) have considerably lower densities. There, Taphorn and García (1991) applied fish toxicants and found values to vary from 1 to 10 ind./m^2. Thus, the lower Caura, with its mixture of white and blackwater habitats has respectable fish densities when compared to other rivers.

As has been reported for other parts of the Orinoco basin, the life cycle of the fishes of the lower Caura is strongly tuned to the annual hydrocycle and the resulting annual flooding and dry season. Migration and reproduction, as reported in the floodplains (Machado-Allison 1987) for Guaritico Creek (Lasso *et al.* 1995, Lasso 1996, Pérez-Lozano 1996), in the high plains (Winemiller and Taphorn 1989) and floodplain lagoons of the lower Orinoco (Rodríguez and Lewis 1990) are synchronized with the hydrocycle. The lower stretch of the Caura River depth annually varies up to ten meters (Vargas and Rangel 1996a) between the periods of rain and drought, causing the temporary flooding of vast extensions of the floodplain. Around 220 species of those reported here occupy the floodplain lagoons (Lasso *et* *al.* in preparation), especially during the initial life stages (larvae and juveniles). Adults of many species such as *Piaractus, Brycon, Myleus* feed on terrestrial vegetation and seeds made available by the flooding in a manner similar to that reported by Goulding (1980) for the flooded forests of the Amazon.

The local movements of the fish in the lower Caura indicate temporary habitat changes among the main channel, the tributaries and the lagoons, similar to those reported in the Machado and Negro rivers (Goulding 1980, 1981) and for the Mogi-Guassu (De Godoy 1975). The Mato River, which produces high harvest of commercial species throughout most of the year, seems to play a major role in the life cycle and habitat changes for many species of the lower Caura (see Daza and Vispo this volume).

The proposed diversion of water from the upper Caura watershed into the Caroní system via the Paragua River would undoubtedly alter the natural hydrocycle given the proposed removal of more than 25% of the Caura's flow. Since flooding of the lower Caura is critical to the completion of the life cycle of most commercial species, reduction in water levels will negatively affect these species. Numerous published results have proven the negative impacts caused by alteration of the natural hydrocycle (Taphorn and García 1991, Poff *et al.* 1997). The main impacts are: 1) a reduction in the aquatic habitat available to fish; 2) loss of ichthyological biodiversity in the floodplain lagoons and main channel; 3) reduced forest renewal due to the deposition of seeds in inappropriate substrates due to the loss of dispersal agents (fish) (Kubitzki and Ziburski 1994); 4) a decrease in the number of individuals in populations of species that are highly synchronized with the annual water cycle, and 5) decrease of the fishery harvests, loss of navigation routes and agricultural systems associated with floodplain use.

Because the life cycles of the fishes of the lower Caura are not very well known, prediction of possible impacts is difficult. We have no knowledge of total population sizes, normal annual population variations, with which we could predict with more validity the future effects of the proposed alterations to the natural regime. For this reason, it is urgent that these studies are undertaken immediately. In the meantime, and taking into consideration that at this time the Caura basin is still mostly in a natural state, we recommend strong fishery management efforts and maximum caution in the consideration of proposed hydrological projects. We suspect that the Caura plays an important role in replenishing the harvested fish stocks of the lower Orinoco River fisheries, and that impacts in this drainage could affect the entire fishery of the lower Orinoco.

There is still time to prevent the destruction of the wild Caura. An example of what can happen in a very short time can be inferred from a comparison with the Apure River drainage, which has already been highly altered. Dams exist on most of its major tributaries altering natural flow regimes, agricultural pollutants contaminate most of its streams, sediments from deforested highlands and high plains choke riverbeds with tons of topsoil lost forever, falling fishery harvests have changed species composition and there are signs of a fishery collapse in the not too distant future.

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LITERATURE CITED

Balbás, L. and D.C. Taphorn 1996.
Fauna: Los Peces. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* 6: 76–79.

De Godoy, M.P. 1975.
Peixes do Brasil, suborden Characoidei, Bacia do Rio Mogi Guassu. Edit. Franciscana. Brasil. 397 p.

Goulding, M. 1980.
The fishes and the forest. Explorations in Amazonian natural history. University of California Press, Berkeley - Los Angeles. 280 p.

Goulding, M. 1981.
Man and Fisheries on an Amazon Frontier. In: *Developments in Hydrobiology* (H.J. Dumont, ed.). Dr. W. Junk Publishers, The Hague. 132 p.

Huber, O. 1996.
Historia de la exploración científica. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 11–16.

Hurtado, N. 1996.
Aporte al inventario ictiofaunístico de las aguas dulces del Estado Cojedes. [Seminario Postgrado, Mimeografiado] Manejo de Fauna Silvestre y Acuática, UNELLEZ. 89 p.

Jepsen, D. 1997.
Fish species diversity in sand bank habitats of a neotropical river. *Environmental Biology of Fishes* **49**: 449–460.

Junk, W.J., P.B. Bayley and R E. Sparks 1989.
The flood pulse concept in river floodplain systems. In: *Proceedings of the International Large River Symposium* (D.P. Dodge, ed.). *Can. Spec. Publ. Fish. Aquat. Sci.* **106**: 110–127.

Kubitzki and Ziburski 1994.
Seed dispersal in floodplain forest in Amazonia. *Biotropica* **26**(1): 30–43.

Lasso, C. 1988a.
Inventario de la ictiofauna de nueve lagunas de inundación del bajo Orinoco, Venezuela. Parte I: Batoidei, Clupeomorpha, Ostariophysi (Characiformes). *Mem. Soc. Ci. Nat. La Salle* **48**(130): 121–141.

Lasso, C. 1988b.
Inventario de la ictiofauna de nueve lagunas de inundación del bajo Orinoco, Venezuela. Parte II: (Siluriformes, Gymnotiformes, Acanthopterygii). *Mem. Soc. Ci. Nat. La Salle* **48**(Supl.): 355–385.

Lasso, C.A. 1989.
Los peces de la Gran Sabana, Alto Caroní, Venezuela. *Mem. Soc. Ci. Nat. La Salle* **49/50**(131-134): 209–285.

Lasso, C. 1992.
Composición y aspectos ecológicos de la ictiofauna del bajo Río Suapure, Serranía de Los Pijiguaos (Escudo de Guayana), Venezuela. *Mem. Soc. Ci. Nat. La Salle* **52** (138): 5–56.

Lasso, C. 1996.
Composición y aspectos bioecológicos de las comunidades de peces del Hato El Frío y Caño Guaritico, Llanos de Apure, Venezuela. [Tesis Doctoral] Facultad de Biología, Universidad de Sevilla, España. 688 p.

Lasso C. and J. Castroviejo 1992.
Composition, abundance and biomass of the benthic fish fauna from the Guaritico River of a Venezuelan floodplain. *Annals of Limnology* **28**(1): 71–84.

Lasso, C., C. Señaris, O. Lasso-Alcalá and J. Castroviejo 1995.
Aspectos ecológicos de una comunidad de bagres (Pisces-Siluriformes) en los Llanos inundables de Venezuela. *Acta Biol. Venez.* **16**(1): 1–31.

Lasso, C.A., D. Novoa and F. Ramos 1989.
La ictiofauna del Lago de Guri: Composición, abundancia y potencial pesquero. Parte I: Consideraciones generales e inventario de la ictiofauna del Lago Guri con breve descripción de las especies de interés para la pesca deportiva y comercial. *Mem. Soc. Ci. Nat. La Salle* **49/50**(131-134): 141–158.

Machado-Allison, A. 1987.
Los peces de los Llanos de Venezuela: Un ensayo sobre su historia natural. Consejo de Desarrollo Científico y Humanístico, Universidad Central de Venezuela, Caracas. 144 p.

Machado-Allison, A., B. Chernoff, R Royero and P. Buckup 1993.
Las especies del género *Bryconops* Kner, 1858 en Venezuela (Teleostei: Characidae). *Acta Biol. Venez.* 14(3): 1–20.

Machado-Allison, A., Chernoff, B., Silvera, A., A. Bonilla, H. López Rojas C. Lasso, F. Provenzano, C. Marcano and D. Machado Aranda 1999.
Inventario de los peces de la cuenca del río Caura, Estado Bolivar. *Acta Biol. Venez.* **19**(4): 61–72.

Machado-Allison, A., Lasso, C. and R Royero 1993.
Inventario preliminar y aspectos ecológicos de los peces de los ríos Aguaro y Guariquito (Parque Nacional), estado Guárico, Venezuela. *Mem. Soc. Ci. Nat. La Salle* **53** (139): 55–80.

Marín, E. and A. Chaviel 1996.
Vegetación: Bosques de tierra firme. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 60–65.

Marrero, J.C., A. Machado-Allison, V. González, J. Velázquez and D. Rodríguez-Olarte 1997.
Los morichales del oriente de Venezuela: Su importancia en la distribución y ecología de los componentes de la ictiofauna dulceacuícola regional. *Acta Biol. Venez.* **17**(4): 65–79.

Martínez, M. 1996.
Clima: gradientes bioclimáticos. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 40–43.

Matheus, A. 1984.
Estudio sobre los peces del Caño Maporal (Estado Apure). Proyecto de Aplicación de Conocimientos, UNELLEZ, Guanare. 60 p.

Meade, R H., F.H. Weibezahn, W.M. Lewis, Jr. and D. Pérez-Hernández 1990.
Suspended-sediment budget for the Orinoco river. In: *El Río Orinoco como ecosistema* (F. H. Weibezahn, H. Alvarez and W. M. Lewis, Jr., eds.), pp. 55–79. CVG- EDELCA, Fondo Editorial Acta Científica Venezolana, CAVN, Universidad Simón Bolívar, Caracas.

OCEI 1990.
Censo del Estado Bolívar. Oficina Central de Estadística e Informática, Caracas.

OCEI 1993.
Censo indígena de Venezuela 1992. Tomo 1. Oficina Central de Estadística e Informática, Caracas. 331 pp.

Peña, O. 1996.
Hidrografía. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 29–33.

Pérez-Lozano, A. 1996.
Estudios sobre la reserva de pesca del Caño Guaritico, Edo. Apure, Venezuela. I. Determinación del potencial pesquero. *BioLlania* **12**: 71–98.

Poff, N.L., D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegsard, B. Richter, R. Sparks and C. Stromberg 1997.
The natural flow regime. *BioScience* 47(11): 769–784.

Rodríguez, M. and W. Lewis 1990.
Diversity and species composition of fish communities of Orinoco floodplain lakes. *National Geographic Research* **6**(3): 319–328.

Royero, R., A. Machado-Allison, B. Chernoff and D. Machado-Aranda 1992.
Peces del Río Atabapo, Territorio Federal Amazonas, Venezuela. *Acta Biol. Venez.* **14**(1): 41–55.

Taphorn, D.C. 1992.
The characiform fishes of the Apure river drainage, Venezuela. *BioLlania* Edición Especial **4**: 537 pp.

Taphorn, D.C. 1995.
Los peces del Parque Nacional Aguaro-Guariquito. Informe Técnico. Fundación Polar, Caracas. 67 p.

Taphorn, D.C. 1996.
Estimación de la biodiversidad de peces en la cuenca del Río Caura, Estado Bolívar, Venezuela. [Informe mimeografiado]. 10 p.

Taphorn, D.C. and J. García 1991.
El Río Claro y sus peces, con consideraciones de los impactos ambientales de las presas sobre la ictiofauna del bajo Río Caroní. *BioLlania* **8**: 23–45.

Taphorn, D.C., R. Royero, A. Machado-Allison and F. Mago-Leccia 1997.
Lista actualizada de los peces de agua dulce de Venezuela. In: *Vertebrados actuales y fósiles de Venezuela. Serie Catálogo Zoológico de Venezuela* (E. La Marca, ed.) **1**: 55–100. Museo de Ciencia y Tecnología de Mérida, Venezuela.

Vargas, H. and J. Rangel 1996a.
Clima: comportamiento de variables. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 34–39.

Vargas, H. and J. Rangel 1996b.
Hidrología y sedimentos. In: *Ecología de la cuenca del Río Caura. I. Caracterización general* (J. Rosales and O. Huber, eds.). *Scientia Guaianae* **6**: 48–53.

Vari, R.P. and L.R. Malabarba 1998.
Neotropical ichthyology: an overview. In: *Phylogeny and Classification of Neotropical Fishes* (L.R. Malabarba, R.E. Reis, R.P.Vari, Z.M. Lucena and C.A.S. Lucena, eds), pp. 1–11. Edipuers, Porto Alegre. 603 p.
Winemiller, K.O. and D.C. Taphorn 1989.
La evolución de las estrategias de vida en los peces de los Llanos occidentales de Venezuela. *BioLlania* **6**: 77–123.

Vispo, C. & C. Knab-Vispo (eds.). **2003**.
Plants and vertebrates of the Caura's riparian corridor: their biology, use and conservation.
In: *Scientia Guaianæ* **12**: Chapter 4, pp. 181–221. Caracas, Venezuela.