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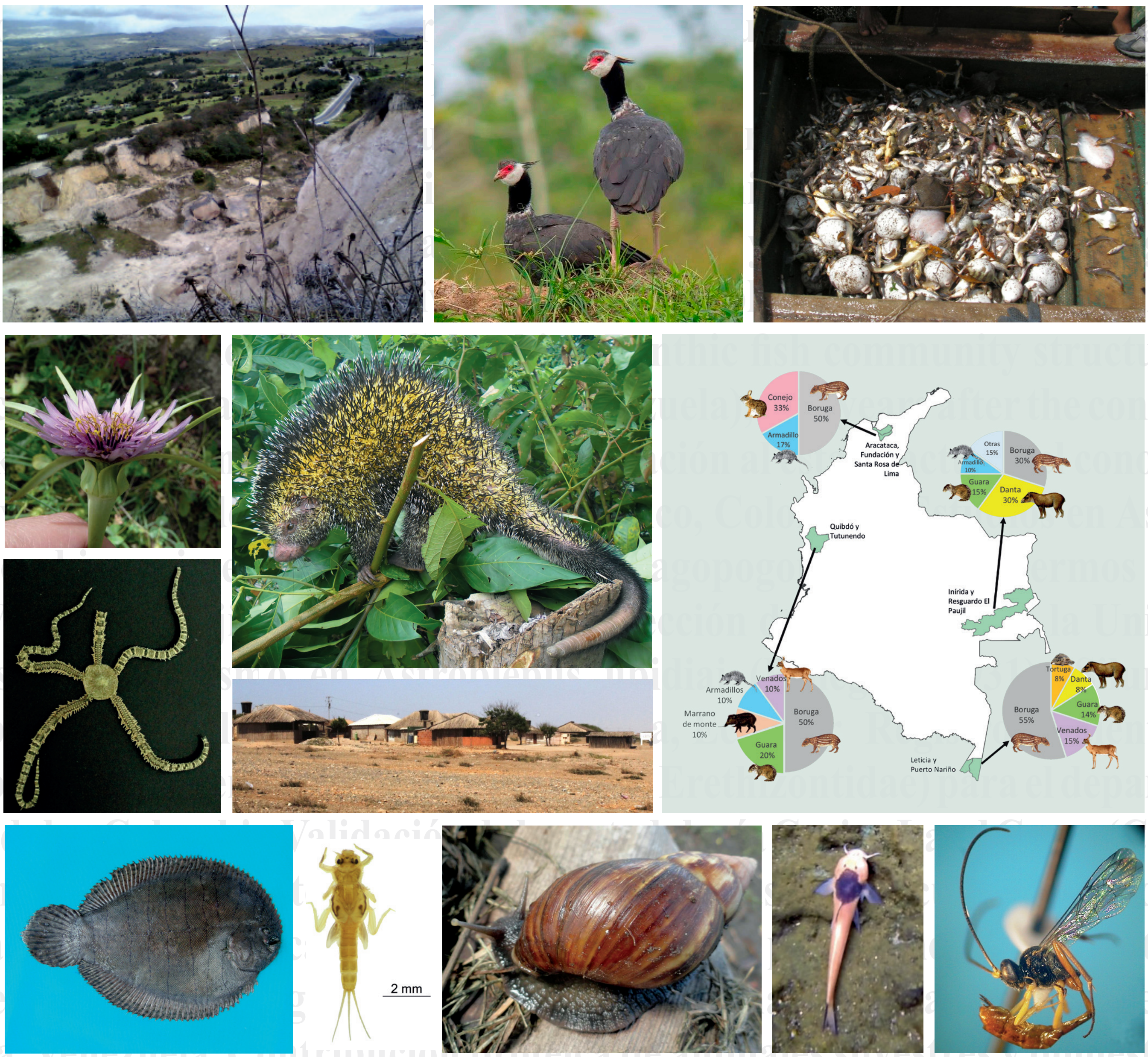

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# Benthic fish community structure in the Orinoco River Delta and Gulf of Paria (Venezuela), fifty years after the construction of a dike across Manamo Channel

Estructura comunitaria de la ictiofauna bentónica del delta del Orinoco y Golfo de Paria (Venezuela), 50 años después de la construcción del dique del caño Manamo

**Paula Sánchez-Duarte y Carlos A. Lasso**

## Abstract

To evaluate the impacts of water flow restriction and regulation caused by the construction of a dike across Manamo Channel, variations in the benthic fish communities were studied in the mouths of three streams or channels (Pedernales, Angostura and Manamo) of the Orinoco River Delta and one stream (Venado) that flows directly into the Gulf of Paria, during one (annual) hydrological cycle. Fishes were sampled with a shrimp trawl net. Of the 78 species collected, five were resident, 12 temporary and 62 occasional. Juvenile phases of all species were collected. Species with greater IVI values were *Cathorops* sp., *Achirus achirus, Stellifer naso* and *Colomesus psittacus*. No significant differences were obtained for the physical and chemical habitat parameters measured: depth, salinity and transparency, nor in the water levels of the streams even in different hydro-phases of the year. Salinity never dropped to zero and no changes in fish species composition were detected. These results lead us to hypothesize that the impacts of the dike constructed in Manamo Channel also extend to other streams of the Orinoco River Delta and even the one studied (Venado) that empties into the Gulf of Paria, where estuarine conditions prevailed during the entire study period of one year, with no observed changed in the hydrological regimen.

**Key words.** Community structure. Estuary. Fishes. Manamo Channel. Shrimp trawl.

## Resumen

Con el objetivo de evaluar el efecto de la regulación de las aguas del caño Manamo (por la construcción de un dique), sobre la ictiofauna bentónica de algunos caños del delta del río Orinoco y Golfo de Paria, se estudió la variación de la estructura comunitaria de peces bentónicos en la desembocadura de tres caños del delta del río Orinoco (Pedernales, Angostura y Manamo) y un caño del golfo de Paria (Venado) durante un ciclo hidrológico anual. De las 78 especies colectadas, cinco fueron residentes, 12 temporales y 61 ocasionales; todas registraron ejemplares en estado juvenil. Las especies con mayores valores de IVI fueron *Cathorops* sp., *Achirus achirus, Stellifer naso* y *Colomesus psittacus*. No se observaron diferencias significativas entre los parámetros físico-químicos analizados (profundidad, salinidad y transparencia), ni a nivel de caños, ni entre hidrofases. La salinidad nunca registró valores menores de 4 % y no se observaron cambios en la composición de especies de la comunidad. Con los resultados obtenidos se plantea la hipótesis de que la construcción del dique sobre el caño Manamo en los años 60, afectó el comportamiento natural de este sistema y de otros caños del delta e incluso del golfo de Paria (caño Venado), registrando en las desembocaduras de todos los caños características de un estuario continuo (sin cambios en el régimen hidrológico y salinidad) durante todo el año.

**Palabras clave.** Caño Manamo. Estuario. Estructura comunitaria. Peces. Red camaronera de arrastre.

## Introduction

The Orinoco is one of the largest rivers in the world, occupying third place in water discharge (38,000 $m^3s^{-1}$), behind only the Amazon and the Congo (Rodríguez *et al.* 2007). Its drainage basin encompasses 1,080,000 $km^2$, shared by Colombia and Venezuela. Traditionally the basin has been divided according to physiographic and limnological criteria into the upper, middle and lower sections, with the delta included in the last (Lasso *et al.* 2004 a). After flowing some 2000 km, at the city of Barrancas, which is about 50 km from its mouth, the Orinoco River divides into two major branches (Novoa y Cervigón 1986). From there, the principal Orinoco flow is carried west to east by the Río Grande and discharges into the Atlantic Ocean at Boca Grande. The remaining flow is transported mainly by Manamo and Macareo channels, two large distributary channels that carry water to the north and northeast respectively. Since 1966, the flow through Manamo Channel diminished considerably due to the construction of a flow control dike that restricted flow to just 200 $m^3s^{-1}$, and so impeded floodwaters from overflowing into surrounding floodplains (Novoa y Cervigón 1986).

As a consequence of the flow regulation, Manamo Channel has a situation that differs from the other channels in the delta; it does not behave as a positive estuary because having lost most of its freshwater flow, its upper reaches receive a greater saltwater penetration and as a result, greater dispersion of marine and brackish water fishes (Flores *et al.* 2004). The composition of the fish fauna does not have significant seasonal changes, and estuarine species prevail as temporary visitors or permanent residents in these habitats, as has been documented by Novoa and Cervigón (1986), Novoa (2000 a) and Lasso *et al.* (2004 b).

The Gulf of Paria drainage is situated between the Paria Peninsula and the Orinoco River Delta in the north-eastern part of Venezuela. The Guanipa River is part of this drainage, its headwaters originate in the state of Anzoátegui, its waters then flow some 340 km before emptying into the Gulf of Paria where it forms the northernmost border of the Orinoco Delta and is known as Venado Channel (Flores *et al.* 2004).

The streams studied were selected because of their accessible location, which permitted the collection of data about the benthic fish fauna throughout the year and to extend the study of Venado Channel, where only a few studies have been done (Lasso *et al.* 2004a).

The objective of this study was to compare the structure (composition, abundance, diversity and richness) of the benthic fish communities during one annual hydro-cycle at the mouths of Venado Channel (Gulf of Paria drainage) with those of the Angostura, Manamo and Pedernales channels (Orinoco River Basin), affected by the dam on Manamo Channel.

## Materials and methods

### Study area

From a hydrographic perspective, two major drainages are recognized in the deltaic region of coastal south-eastern Venezuela: the Gulf of Paria and the Orinoco River Delta. The first has an area of approximately 21,000 $km^2$, which is a little more than 2 % of the country (Lasso y Meri 2003). The second has a surface of about 40.200 $km^2$, of which the deltaic alluvial fan of the Orinoco occupies 18.810 $km^2$ (PDVSA 1993).

Hydrographically, the delta of the Orinoco River can be divided into 12 drainages (Ponte *et al.* 1999), in this study we analyze the drainages of the Pedernales, Manamo and Angostura channels. The Guanipa River – Venado Channel belongs to the Gulf of Paria basin.

Freshwater flow is determined by the alteration of the wet and dry seasons. The greatest water discharges occur from June to September, and minimum flows from December to April, causing seasonal variation in salinity (Novoa 2000a). This is the normal behaviour of the majority of streams or channels in the Orinoco River delta, such as for example Macareo Channel (Figure 1). However, as mentioned above, on Manamo Channel a dike was installed to control water flow that reduces its flow to only 1 % of the total (Macareo and Boca Grande channels discharge 13 % and 86 % of the total, respectively) (Ponte *et al.* 1999), thus impeding the overflow and flooding of freshwaters onto its

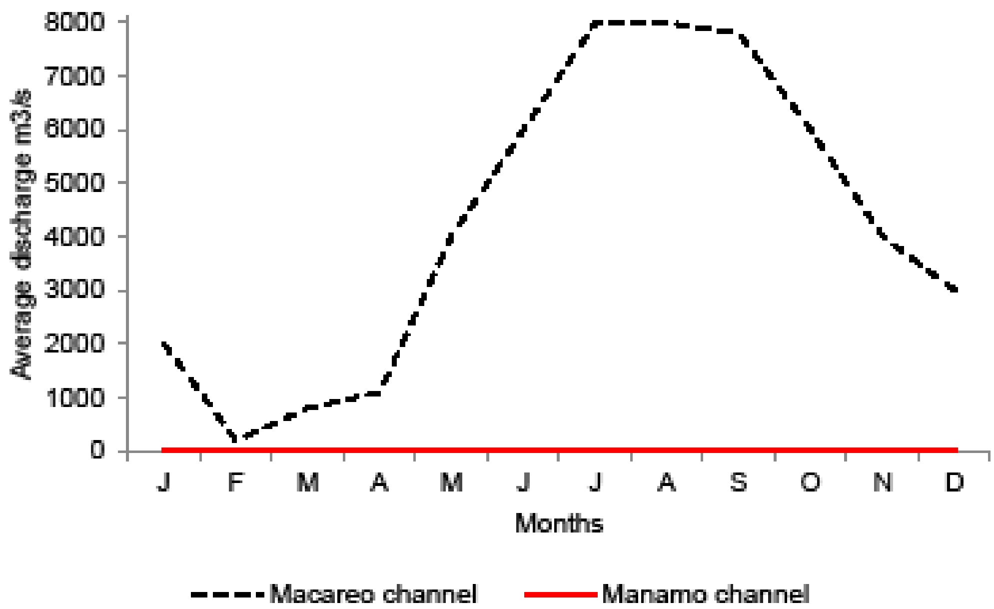


**Figure 1.** Annual hydrological cycle of Macareo and Manamo channels. Adapted from Novoa (2000a).

floodplain. With no seasonal variation in freshwater discharge (Figure 1), no significant variation is observed in salinity (Olivares y Colonnello 2000).

It is important to keep in mind that this study was done in the estuarine delta and not the fluvial delta, as defined by Lasso and Sánchez-Duarte (2011). The upstream ecological boundary of the estuary would be the limit of the influence of brackish water in the main channels of the channels. The lower limit with the sea would be a narrow band of variable width, that forms below the sand and mud bars found in front of the channel's mouths (Lasso y Sánchez-Duarte 2011).

Figure 2 shows the geographic position of the study area, which is bounded by the Guanipa River - Venado Channel to the west, Manamo Channel to the south, Pedernales Channel in the southeast and the Gulf of Paria and Caribbean Sea to the north.

## Sampling

Samples were collected during each of the four annual hydro-phases (high water, falling water, low water and rising water). Samples were collected with a shrimp trawl, locally known as "chica", that is used exclusively to fish for shrimp in the mouths of some of the channels of the delta. In our case the net was 11 m long and 8 m wide, with mesh size of 2 cm. It was pulled by a small boat powered by an outboard motor (Novoa 2000 a). The benthic fish fauna of the Orinoco River has been studied by various authors that have used shrimp trawls as experimental sampling gear (Ramos *et al.* 1982, Cervigón 1982, 1985, Novoa and Cervigón 1986, Novoa 1982, Novoa 2000 a – b, Lasso *et al.* 2004 b, 2008). Each trawl pull lasted ten minutes at constant velocity and for each operation, initial and final geographic coordinates, date, hour, depth, Secchi transparency, salinity and bottom type were recorded (Figure 3). Sampling effort was the same as used in previous studies of this area (Lasso *et al.* 2004b, 2008).

Some samples were immediately field processed and released. Others were fixed in formalin and taken to the Museo de Historia Natural La Salle (MHNLS) in Caracas for identification and processing.

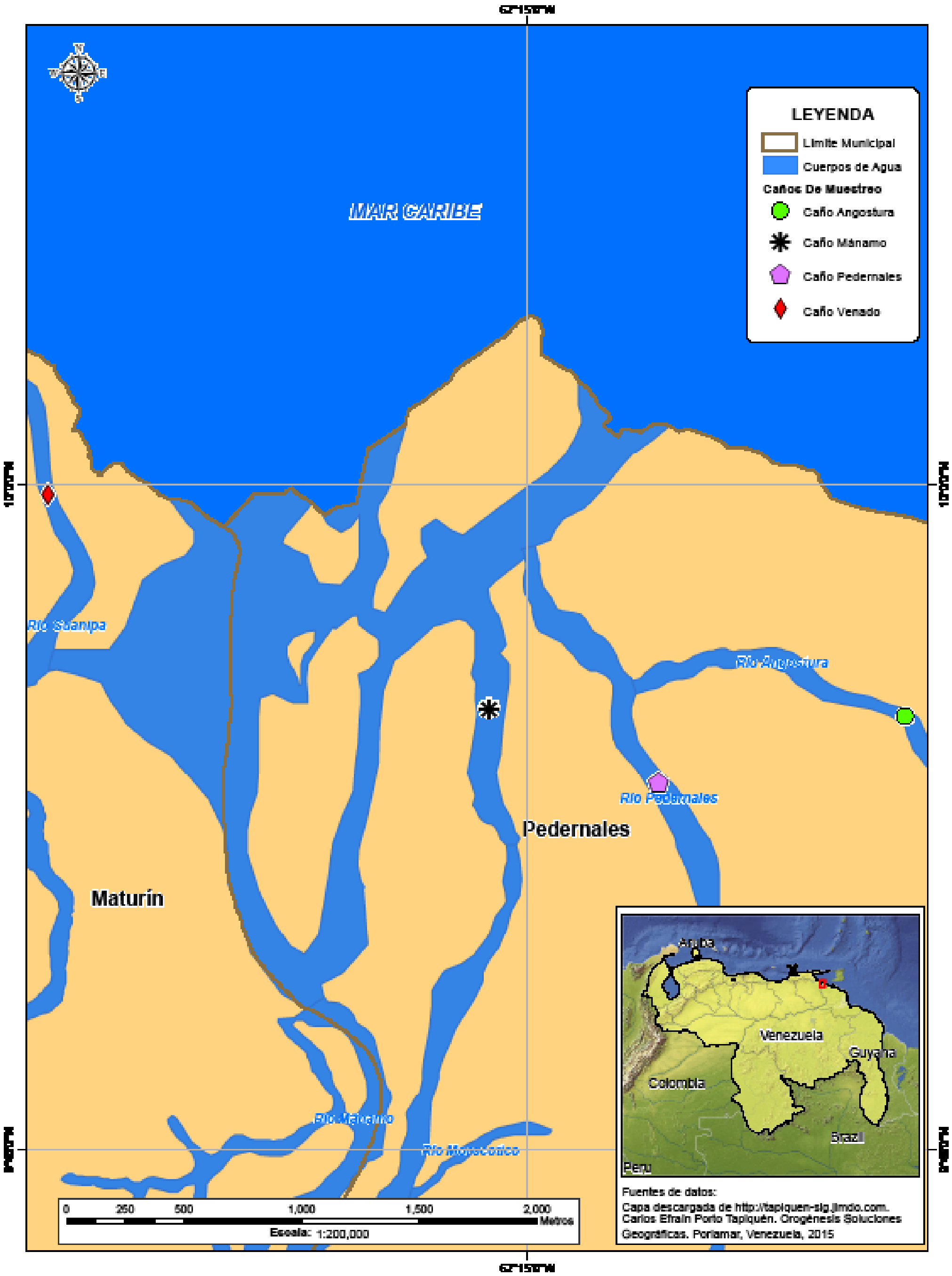


**Figure 2.** Study area. Angostura, Manamo, Pedernales channels (Orinoco Basin) and Venado Channel (Gulf of Paria drainage).


**Figure 3.** a) Panoramic view of Pedernales Channel, b) fishing with shrimp trawl, c - d) samples collected by shrimp trawl, note puffers (*Colomesus psittacus*) and seabass (*Epinephelus itajara*). Photos: P. Sánchez-Duarte (a), J. Hernández (b – d).

## Data analysis

Relative abundance (%) and relative biomass (%) were estimated for each trawl sample, based on capture per unit effort. Biomass and fish density were expressed as kg/ha and ind/ha, respectively (Lasso *et al.* 2004 b). Alpha diversity was calculated using the Shannon-Wienner index (H) (1963), equity index of Pielou (J) and richness index of Margalef (R1) (1969). The following indices were also calculated:

- Importance Value Index (IVI) (Lasso *et al.* 2008).

  This index permits the evaluation of the importance of each species in the aquatic ecosystem, globally integrating the abundance, biomass and relative frequency of each in just one index using the following formula : IVI = FR + AR + BR. Since the result is the sum of three index percentage values, this IVI index varies from 1 – 300 %.

- Community Dominance Index (IDC) (McNaughton 1968).

  Where IDC = (Y1 + Y2 / Y) • 100 Y1 + Y2= sum of the abundance of the two dominant species Y= total abundance of all species. Values above 40 % abundance are indicative of true community dominance (Goulding *et al.* 1988).

- Constancy of the species (C).

  To determine the permanence of species in each channel, the Constancy (C) formula of Bohdenheiner and Balogh (Krebs 1972) was used. Species are classified as residents (C > 50 %), temporary (25 % ≤ C ≤ 50 %) or occasional (C < 25 %).

Keeping in mind that in samples collected using shrimp trawls, a large percentage of the capture corresponds to juveniles of benthic species, the specimens captured were measured, recording the disc width (DW) or standard length (SL) for species of special ecological or commercial interest.

Similarity dendrograms were made using SAS ® and PAST software version 1.34 (Hammer *et al.* 2001).

Physical and chemical habitat parameters and ecological community parameters were compared among hydro-phases having previously evaluated the homoscedasticity among the samples. Data with homogeneous variance among groups were evaluated using analysis of variance (ANOVA) at significance level $p< 0.05$ and not inferior to $p< 0.01$. When significant differences were found, the differing hydro-phases, environmental o ecological parameters causing the differences were identified using the Tukey test (Montgomery 1984). When the homogeneity of variance was less than $p< 0.01$ data were analyzed using a non-parametric Kruskal-Wallis test (Barletta *et al.* 2003).

## Results

### Physical and chemical habitat characteristics

The variations of basic physical and chemical characteristics (depth, salinity and transparency) in each of the four channels studied during the annual hydrological cycle are given in Table 1.

In Pedernales Channel, an analysis of variance comparing physical and chemical parameters measured detected no significant differences for any of them during any of the four hydrophases depth ($\alpha = 0.05$; $p = 0.79$); salinity ($\alpha = 0.05$; $p = 0.72$) and transparency ($\alpha = 0.05$; $p = 0.84$).

For Manamo, Angostura and Venado channels (due to the non normality of the data), a Kruskal-Wallis analysis was used to compare the values obtained for the physical and chemical parameters measured during the four hydrophases. In no case were any significant differences detected (Table 2).

The variations of basic physical and chemical characteristics (depth, salinity and transparency) of the four channels studied during the annual hydrological cycle are given in Table 3.

Because data were not normally distributed, Kurskal-Wallis analyses were used to compare among hydro-phases the values obtained for physical and chemical parameters recorded. No significant differences were detected for any parameter: depth ($\alpha = 0.05$; $p = 0.95$); salinity ($\alpha = 0.05$; $p = 0.72$) and transparency ($\alpha = 0.05$; $p = 0.96$).

A dendrogram of similarity, drawn based on physical and chemical habitat parameters recorded for the four annual hydro-phases shows greater similarity between Manamo and Angostura channels, and those two grouped together with Pedernales Channel. The most dissimilar channel was Venado (Figure 4).

### Composition and species richness

During the four hydro-phases sampled, 78 benthic fishes were collected (Appendix I). The total corresponds to 29 families in eight orders; of these, Perciformes were the most diverse group with 34 species, followed by Siluriformes (16 species) and Clupeiformes (14 species); the other orders contained one to four species. The four families with the greatest species richness were Sciaenidae (12 species), Engraulidae (10 species), Carangidae (9 species) and Ariidae (7 species); the remaining families had three or fewer species.

Following the proposal of Lasso *et al.* (2009) species were classified based on salinity preference (Appendix I), and five habitat groups were distinguished. These are: primary freshwater families (F) that are physiologically intolerant of salinity; occasional freshwater (OF) families that are found in freshwater habitats but that can tolerate ample intervals in salty water (euryhaline) or that need estuarine areas for reproduction or feeding; estuarine (E) species that live in the estuary throughout the year; estuarine occasional (EO) species are marine species that enter the estuary for reproduction or feeding; and finally the strictly marine species (M). It was found that the majority of the species were estuarine-marine (41 sp. - 52 % of the total), followed by freshwater occasional (18 sp. – 23 %); in third place the strictly freshwater species (7 sp. – 9 %) followed by the estuarine occasional species (5 sp. – 6 %). The four groups comprised 90 % of all species identified.

Using presence-absence data for each species collected from the four channels during the sampling period and similarity dendrogram was made using the Jaccard Index, that grouped the channels in accordance with the species present (Figure 5).

**Table 1.** Characterization of the physical and chemical parameters measured in each of the channels studied during the four annual hydro-phases. Average values are given with ranges in parentheses.

| Channel | Hidrophase | Depth (m) | Salinity (%) | Transparency (cm) |
|---|---|---|---|---|
| Pedernales | I | 5.15 (3.7 - 6.6) | 10 | 15 (10 - 20) |
| | II | 3 (1.5 - 4.5) | 6.5 (6 - 7) | 20 (15 - 25) |
| | III | 3.8 (2.9 - 4.7) | 16 (15 - 17) | 20 |
| | IV | 4.2 (3.8 - 4.5) | 22.5 (22 - 23) | 27.5 (24 - 31) |
| Manamo | I | 1.98 (0.8 - 3.7) | 5.5 (4 - 7.5) | 21.9 (13.5 - 27) |
| | II | 1.84 (1.1 - 2.2) | 5.2 (5 - 6) | 24.4 (22 - 25) |
| | III | 2.3 (1.1 - 4.1) | 11.2 (9 - 14) | 24 (15 - 30) |
| | IV | 2.1 (0.5 - 3.7) | 17.6 (14 - 20) | 63.8 (50 - 78) |
| Angostura | I | 1.18 (0.4 - 1.9) | 4.8 (4 - 5) | 16 (15 - 20) |
| | II | 1.78 (0.7 - 3.9) | 5.6 (5 - 6) | 16 (10 - 25) |
| | III | 1.82 (1.3 - 3.9) | 9.4 (9 - 11) | 28 (25 - 30) |
| | IV | 2.9 (2.6 - 3.8) | 16.6 (16 - 17) | 35.4 (30 -39) |
| Venado | I | 2.17 (1 - 4) | 7.75 (5 - 10) | 27.2 (19 - 35) |
| | II | 2.24 (1 - 3.4) | 8.8 (8 - 10) | 30.2 (25 - 30) |
| | III | 2.78 (2 - 5.2) | 18.2 (16 - 19) | 37 (15 - 50) |
| | IV | 2.3 (1.04 - 3.2) | 21.7 (20 - 25) | 50.9 (15 - 80) |

**Table 2.** Results of p-value in the Kruskal-Wallis analyses applied to the physical and chemical parameters measured during the four hydrophases, in three of the channels studied α = 0.05.

| Channel | Parameter | | |
|---|---|---|---|
| | Depth (m) | Salinity (%) | Transparency (cm) |
| Manamo | p = 0.99 | p = 0.91 | p = 0.98 |
| Angostura | p = 0.93 | p = 0.99 | p = 0.74 |
| Venado | p = 0.17 | p = 1.00 | p = 0.89 |

**Table 3.** Characterization of the physical and chemical parameters measured in the channels studied during the four annual hydro-phases. Average values are given with ranges in parentheses.

| Channel | Parameter | | | |
|---|---|---|---|---|
| | Depth (m) | Salinity (%) | Transparency (cm) | Sustrate |
| Pedernales | 4<br>(1.5 - 6.6) | 13.8<br>(6 - 23) | 20.6<br>(10 - 31) | Mud |
| Manamo | 1.1<br>(0.6 - 1.7) | 14<br>(9 - 22) | 18.1<br>(10 - 25) | Mud |
| Angostura | 1.9<br>(0.4 - 3.9) | 9.1<br>(4 - 17) | 23.8<br>(10 - 39) | Mud |
| Venado | 2.4 | 14.1<br>(5 - 25) | 36.3<br>(15 - 80) | Mud |

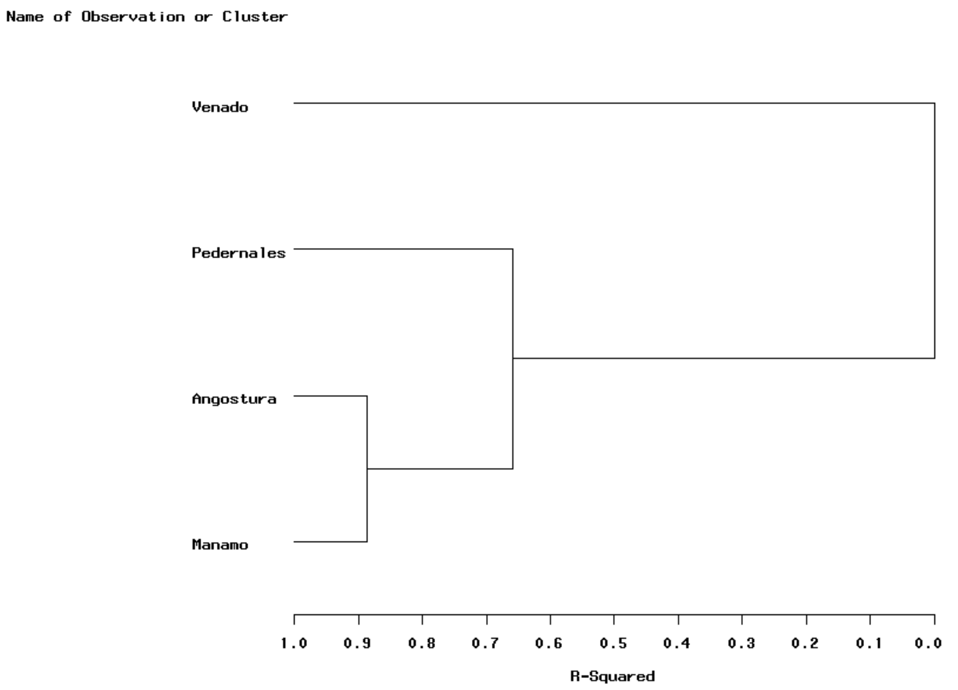


**Figure 4.** Dendrogram of similarity among the four channels based on physical and chemical habitat parameters (depth, salinity and transparency) recorded during the four annual hydro-phases. Cluster analysis performed using minimum variance of Ward (SAS).

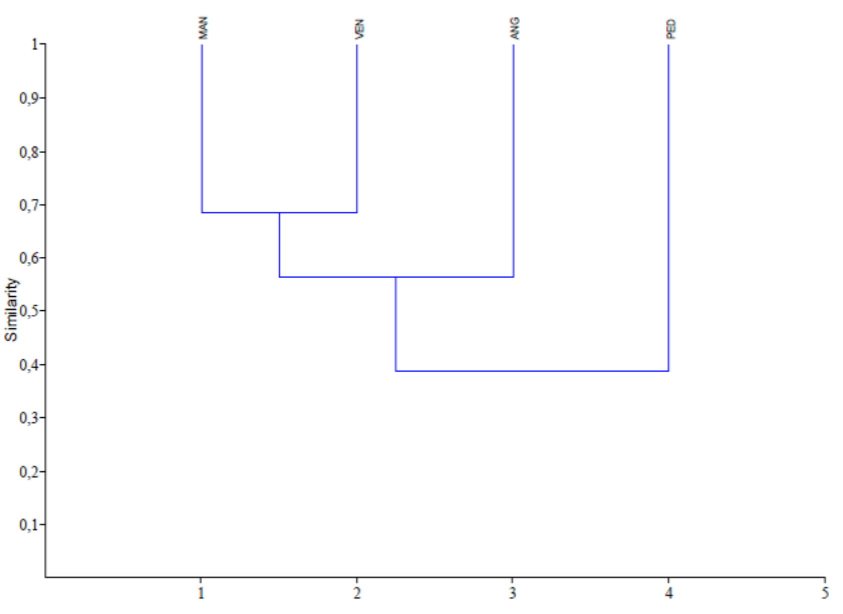


**Figure 5.** Similarity dendrogram of species presence - absence, for the channels studied, using the Jaccard Index (PAST version 1.34, Hammer *et al.* 2001).

Based on the abundance of each species collected from the four channels during the sampling period, a similarity dendrogram was made using the Morisita-Horn Index, that grouped the streams according the presence and abundance fo the species during the four annual hydrophases (Figure 6).

The two analyses gave the same results, indicating that the two most similar channels are Manamo and Venado, with Pedernales being the most dissimilar.

### Abundance and total biomass recorded during the annual hydrocycle

During the annual hydrocycle, of the 78 species collected, ten comprised 82 % of the total capture, and the 68 remaining, just 18 % (Figure 7).

Analysis of total biomass collected during the study for the 78 species collected showed that 15 species contributed 7.7 % of the total capture, and the remaining 64 species just 12.3 % (Figure 8).

### Ecological Indices

The variation in the Shannon diversity (H´), equity (J) and richness of Margalef (R1) during the four hydrophases studied, for each of the four channels studied is given below.

In Pedernales Channel the ecological indices had similar behaviour during the entire hydrocycle. An analysis of variance indicates that there are no significant differences in among any of the indices calculated, Shannon diversity ($\alpha$ = 0.05; p = 0.59), richness of Margalef ($\alpha$ = 0.05; p = 0.94) and equity ($\alpha$ = 0.05; p = 0.29) (Figure 9).

The variation in diversity, equity and richness for the four hydrophases in Manamo Channel are shown in Figure 10. Analysis of variance showed that there were no significant differences for the Shannon diversity index ($\alpha$ = 0.05; p = 0.15), or for the Margalef richness index ($\alpha$ = 0.05; p = 0.76). Because data were not normally distributed, a Kruskal-Wallis analysis was calculated that there were no significant differences in the equity index either ($\alpha$ = 0.05; p = 0.37).

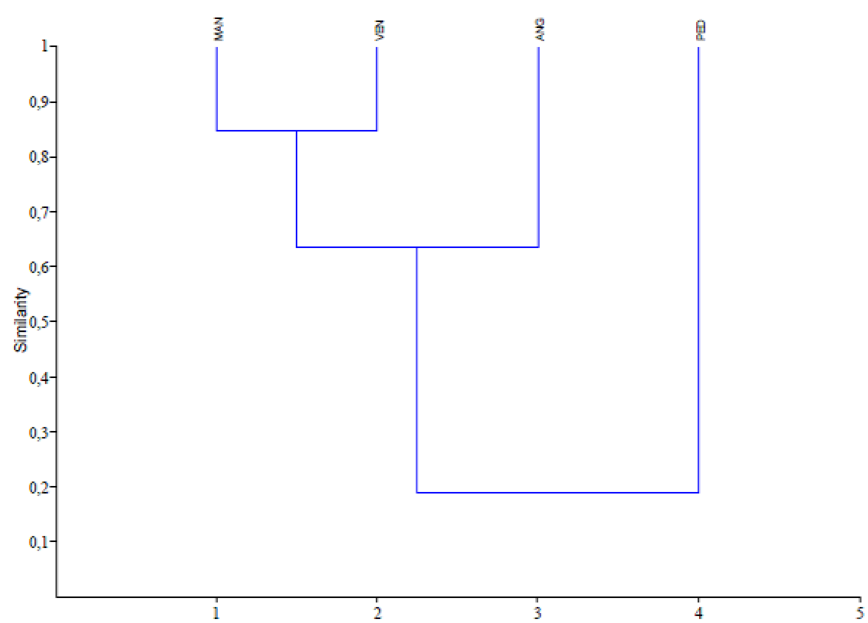


**Figure 6.** Similarity dendrogram for the channels according to the presence and abundance of fish species sampled during the study period, using the Morisita-Horn Index (PAST version 1.34, Hammer *et al.* 2001).

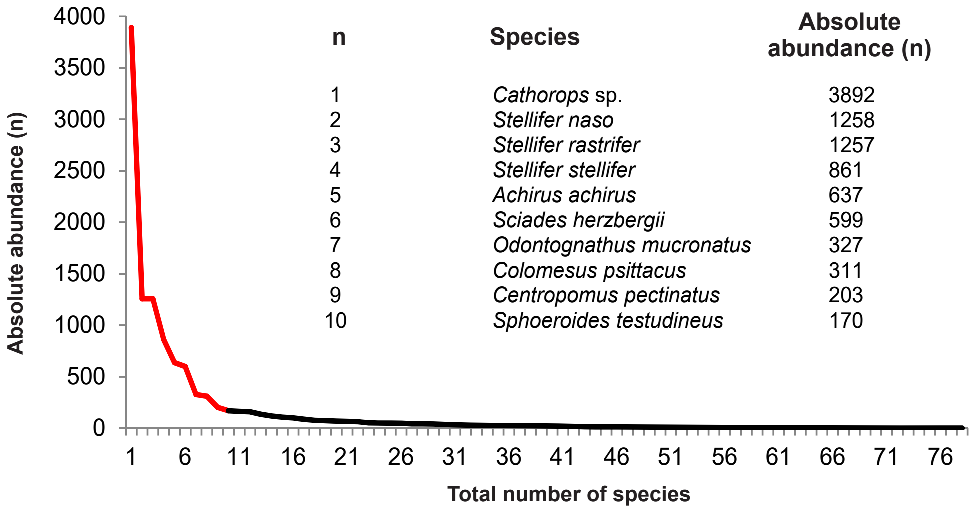


**Figure 7.** Distribution of the abundance of the 78 species collected from Pedernales, Manamo, Angostura and Venado channels during the hydrocycle studied.

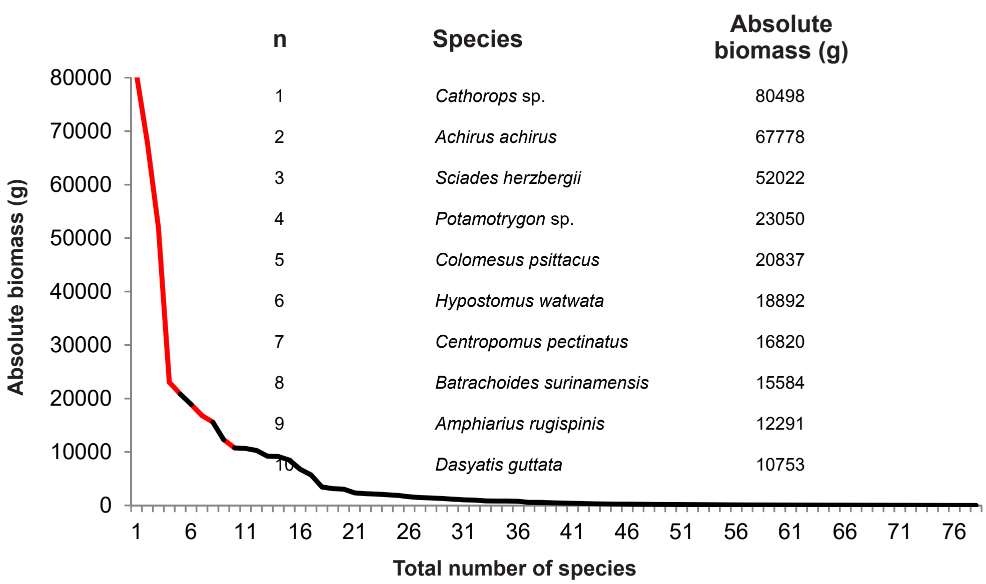


**Figure 8.** Distribution of biomass for the 78 fishes collected during the four hydrophases studied in Pedernales, Manamo, Angostura and Venado channels.

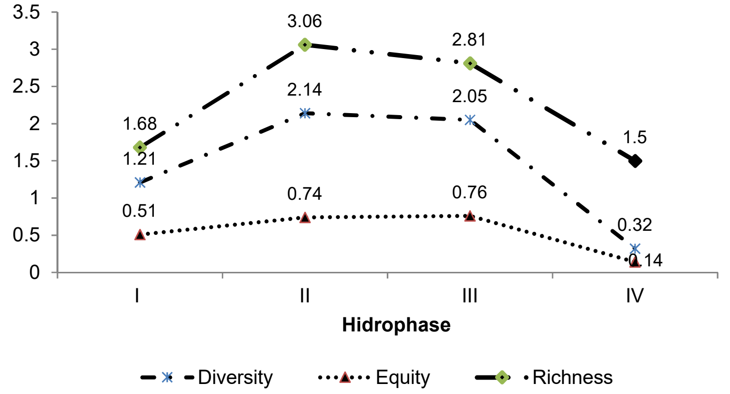


**Figure 9.** Variation in ecological indices (non significant) for Shannon diversity (H´), equity (J) and richness of Margalef (R1) in Pedernales Channel, during the annual hydrocycle.

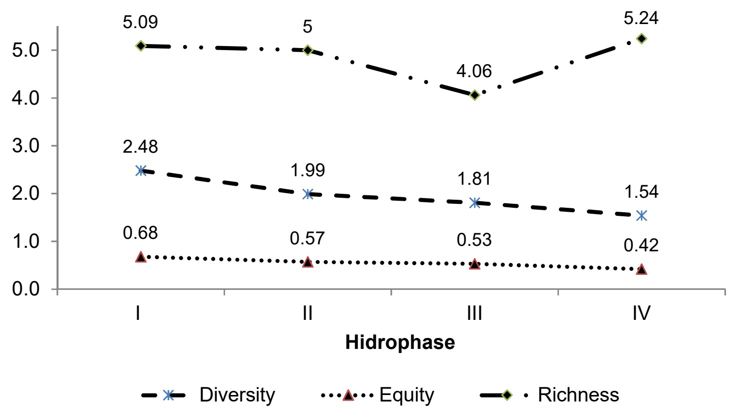


**Figure 10.** Variation in the Shannon diversity index (H´), equity (J) and Margalef richness (R1) in Manamo Channel, during the annual hydrocycle studied.

For Angostura Channel the variation in the diversity, equity and richness indices for the hydrophases studied are given in Figure 11. An analysis of variance detected no significant differences for the ecological indices calculated which were the Shannon diversity index ($\alpha = 0.05$; $p = 0.87$), equity ($\alpha = 0.05$; $p = 0.87$) and richness of Margalef ($\alpha = 0.05$; $p = 0.90$).

Variation in the ecological indices calculated for Venado Channel, Shannon diversity (H´), equity (J), and Margalef richness (R1) are given in Figure 12. An analysis of variance detected no significant differences for the Margalef richness index ($\alpha = 0.05$; $p = 0.77$). Because data were not normally distributed, a Kruskal-Wallis analysis was used to show that there were no significant differences in the Shannon diversity index ($\alpha = 0.05$; $p = 0.78$) or equity ($\alpha = 0.05$; $p = 0.39$), during the hydrocycle studied.

## Importance Value Index (IVI), Constancy Index (C) and Community Dominance Index (IDC)

To determine the dominant fish species present during the hydrocycle in the four channels studied, the IVI values were calculated for the 78 species collected. The species with IVI values greater than 100 % are shown in Figure 13.

To determine the permanence of fish species in the channels studied, the Constancy index was calculated for the 78 species collected. Five were found to be residents (6 %), 12 temporary (15 %), and the remainder, occasional (78 %) (Table 4).

The community dominance index recorded for each of the hydrophases in the four channels studied and the total are shown in Figure 14. A strong dominance was detected during three of the hydrophases (high water, low water and rising water) as indicated by abundance values above 40 % (Goulding *et al.* 1988), and for falling water phase the value was close to the cutoff point.

During the high water phase, the marine catfish (*Cathorops* sp.) and a croaker (Stellifer naso) dominated, but during the falling water phase S. naso and S. stellifer were dominant. During the low water and rising water phases, the most important species were again *Cathorops* sp. and S. rastrifer.

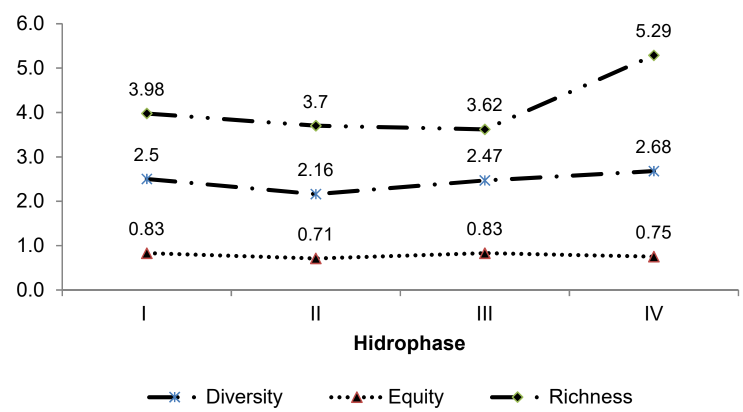


**Figure 11.** Variation in the Shannon diversity index (H´), equity (J) and Margalef richness (R1) in Angostura channel, during the hydrological cycle.

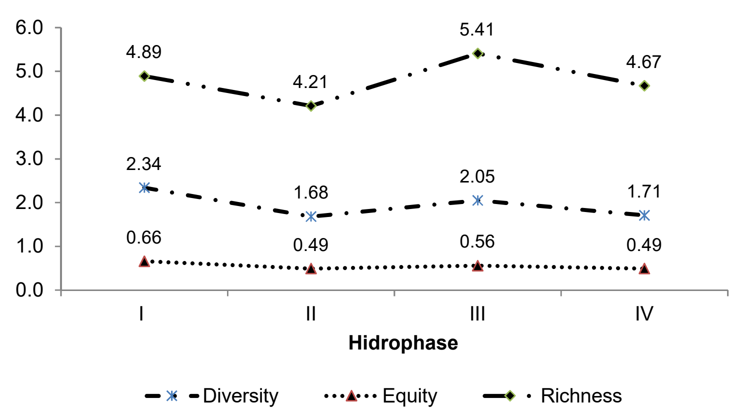


**Figure 12.** Variation in the Shannon diversity index (H´), equity (J) and Margalef richness (R1) in Venado channel during the hydrocycle studied.

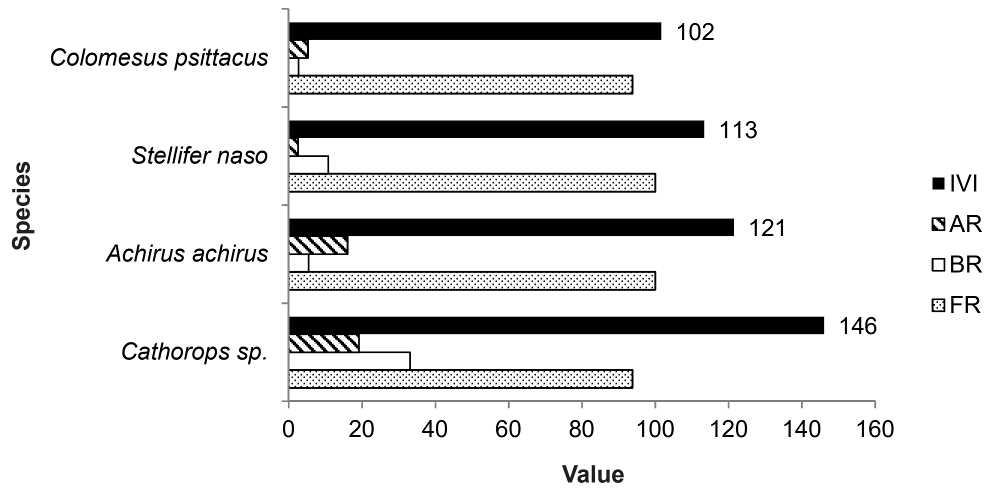


**Figure 13.** Importance value index (IVI) for the four dominant species in the Orinoco River Delta and Gulf of Paria channels studied during the hydrocycle. AR = relative abundance, BR = relative biomass, FR = relative frequency.

**Table 4.** Classification by constancy for the benthic fish species collected from Pedernales, Manamo, Angostura and Venado channels during the hydrocycle. Species are presented in alphabetical order.

| Resident species | Temporary species | Occasional species |
|---|---|---|
| *Achirus achirus* | *Apionichthys dumerili* | *Amphiarius rugispinis* |
| *Cathorops* sp. | *Bairdiella ronchus* | *Anchoa argenteus* |
| *Colomesus psittacus* | *Batrachoides surinamenesis* | *Anchovia clupeoides* |
| *Sciades herzbergii* | *Centropomus pectinatus* | *Anchovia surinamensis* |
| *Stellifer naso* | *Cynoscion acoupa* | *Anchoviella brevirostris* |
| | *Genyatremus luteus* | *Anchoviella guianensis* |
| | *Hypostomus watwata* | *Anchoviella lepidentostole* |
| | *Odontognathus mucronatus* | *Arius grandicassis* |
| | *Pseudauchenipterus nodosus* | *Aspredinichthys filamentosus* |
| | *Sphoeroides testudineus* | *Aspredo aspredo* |
| | *Stellifer rastrifer* | *Bagre bagre* |
| | *Stellifer stellifer* | *Brachyplatystoma rousseauxii* |

*Cont.* **Table 4.** Classification by constancy for the benthic fish species collected from Pedernales, Manamo, Angostura and Venado channels during the hydrocycle. Species are presented in alphabetical order.

| **Occasional species continued** | | |
|---|---|---|
| *Caranx hippos* | *Isopisthus parvipinnis* | *Pomadasys crocro* |
| *Centropomus ensiferus* | *Lagocephalus laevigatus* | *Potamotrygon* sp. |
| *Centropomus undecimalis* | *Lycengraulis batesii* | *Pterengraulis atherinoides* |
| *Chaetodipterus faber* | *Lycengraulis grossidens* | *Rhamdia quelen* |
| *Chloroscombrus chrysurus* | *Lycengraulis limnichthys* | *Rhinosardinia amazonica* |
| *Citharichthys spilopterus* | *Macrodon ancylodon* | *Sciades couma* |
| *Conodon nobilis* | *Micropogonias furnieri* | *Sciades passany* |
| *Cynoscion leiarchus* | *Nebris microps* | *Scomberomorus brasiliensis* |
| *Cynoscion microlepidotus* | *Oligoplites palometa* | *Selene vomer* |
| *Dasyatis geijskesi* | *Oligoplites saliens* | *Stellifer microps* |
| *Dasyatis guttata* | *Oligoplites saurus* | *Symphurus tesellatus* |
| *Diapterus rhombeus* | *Pellona flavipinnis* | *Trachinotus cayennensis* |
| *Epinephelus itajara* | *Pellona harroweri* | *Trachinotus falcatus* |
| *Gobionellus oceanicus* | *Piaractus brachypomus* | *Trichiurus lepturus* |
| *Gymnura micrura* | *Pimelodina flavipinnis* | *Triportheus auritus* |
| *Hemicaranx amblyrhynchus* | *Platystacus cotylephorus* | |
| *Hypophthalmus edentatus* | *Polydactylus virginicus* | |

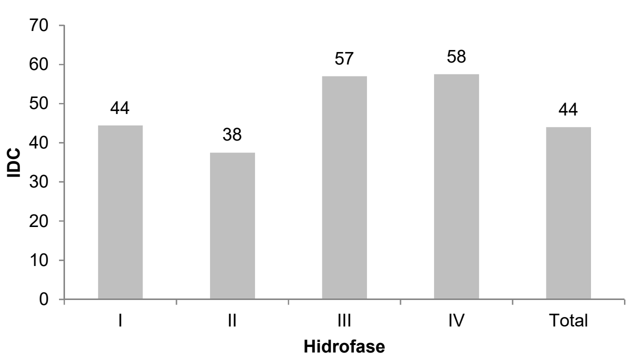


**Figure 14.** Community dominance index values (IDC) for the four channels studied during each of the four hydrophases and the total.

In Table 5 are given the data of disc width (DW) or standard length (SL) for species of special ecological or commercial interest collected using shrimp trawls.

In the case of the marine rays, Dasyatis geijskesi can reach more than 1 m disc width, Dasyatis guttata can reach 2 m (Cervigón 1994) and Gymnura micrura is commonly found at 90 cm but reaches more than 1 m disc width (Cervigón *et al.* 1992). All individuals of these species collected during this study were juveniles.

Of the marine catfishes, Amphiarius rugispinis, is the most abundant in the lower interior delta of the Orinoco River (Cervigón 1991), in this study it was present in samples from all four of the annual hydrophases but was much more abundant during high water.

**Table 5.** Lengths (DW or SL) of species of special ecological or commercial interest for Pedernales, Manamo, Angostura and Venado channels during the hydrological cycle.

| Order | Family | Species | Common Spanish Name | DW (cm) | | | n |
|---|---|---|---|---|---|---|---|
| | | | | Max. | Min. | Avg. | |
| Myliobatiformes | Dasyatidae | *Dasyatis geijskesi* | Raya hocicona | 60 | 42 | 51.7 | 3 |
| | | *Dasyatis guttata* | Raya blanca | 55 | 15.6 | 36.2 | 12 |
| | Gymnuridae | *Gymnura micrura* | Raya guayanesa | 31.5 | 15.5 | 22.8 | 11 |
| **Order** | **Family** | **Species** | **Common Spanish Name** | **SL (mm)** | | | **n** |
| | | | | **Max.** | **Min.** | **Avg.** | |
| Siluriformes | Ariidae | *Amphiarius rugispinis* | Bagre múcuro | 35 | 3.8 | 18.7 | 41 |
| | | *Cathorops* sp. | Bagre cuinche | 25.7 | 4 | 9.8 | 1196 |
| | | *Sciades couma* | Bagre cabezón | 33.5 | 4.2 | 22.3 | 7 |
| Batrachoidiformes | Batrachoididae | *Batrachoides surinamensis* | Sapo | 47.5 | 7.3 | 18.8 | 41 |

It reaches 42 cm SL, is frequently collected around 30 cm (Cervigón *et al.* 1992), but in this study many individuals (22 %) fell into the 5-10 cm range, followed by those of the 25-30 cm (20 %) interval. Sciades couma can reach 1 m SL and 30 kg weight (Cervigón 1991), in this study the smallest individual measured 4.2 cm and the largest 33.5 cm with an average size of 22.3 cm SL; so all could be considered juveniles.

The toadfish, Batrachoides surinamensis, is known to have been affected by shrimp trawling (Novoa 2000b; Lasso *et al.* 2004b). A total of 41 individuals were measured, with a minimum size of 7.3 cm SL and a maximum of 47.5, with an average of 18.8. The literature reports that this species reaches 50 cm SL, but that it is commonly collected around 35 cm (Cervigón *et al.* 1992). Most individuals captured during this study were smaller than 20 cm SL; 63.4 % of the total number of individuals were measured.

The most numerically abundant species was the marine catfish *Cathorops* sp. which also contributed the largest percentage of biomass captured (Figures 7 and 8). Of the 1196 individuals measured, the smallest was 4 cm and the largest 25.7 cm SL, with an average of 9.8 cm, with most (40.6 %) falling between 8-10 cm. Cervigón *et al.* (1992) reported a maximum size of 30 cm SL, with most specimens observed around 20 cm. Although the sizes found in this study agree with those reported, the maximum size found was much smaller, and only 1.6 % of the specimens had reached more than 20 cm SL, which was the most commonly observed size in Cervignón's study. Juveniles are commonly found around sand and mud bars near the mouths of channels where they form immense, dense aggregations; larger adults are typically found further out to sea (Cervigón 1991).

In contrast, just a few individuals of the stingray (Dasyatis guttata) significantly contributed to total biomass captured. Twelve specimens were measured of this species, with SL between 15-55 cm disc width, five of which in the 25- 5 cm size interval. This species can reach 2 m disc width, so the specimens captured in this study were all juveniles.

## Discussion

One of the major difficulties encountered when studying tropical estuarine fishes is the determination and quantification of the effects of abiotic parameters on the observed spatial and temporal variations in fish community composition (Andrade-Tubino 2008, Barreiros *et al.* 2009). The physical and chemical factors that affect the distribution of tropical and subtropical estuarine fishes are rainfall, salinity, turbidity, temperature and depth. With the exception of temperature, in tropical regions all of these are subject to greater fluctuations than those encountered in cold temperate estuaries (Blaber 1997). Temperature is the factor of greatest importance in temperate estuaries, and salinity is the most important in the tropics, where the seasonal cycles of abundance are related to salinity variations (Andrade-Tubino 2008, Barreiros *et al.* 2009).

The physical and chemical characteristics analyzed in this study did not show seasonal fluctuations during the hydrological cycle, contrary to what has been reported for other tropical and subtropical estuaries (Barletta *et al.* 2003, 2008, Arceo-Carranza and Vega-Candejas 2009, Yáñez-Arancibia *et al.* 1985, Zubiria *et al.* 2008). This is a consequence of being cut off from the influence of seasonal freshwater flooding by the construction of the dam on Manamo Channel (Novoa 2000a, Monente & Colonnello 2004). A consequence of this flood regulation was the transformation of a fluvial system into and estuarine system. The tide regime is now the dominant influence in the study area throughout the year, and the only positive influence of freshwater comes from local surface rainfall drainage from the island interiors when annual precipitation exceed the losses to evapotranspiration (Monente & Colonnello 2004).

As Ortaz *et al.* (2007) mentioned in general terms, the human alterations of the Orinoco River Delta have been few in number and of low intensity, with the exception of what occurred as a result of the closing of Manamo Channel in the 60's. The construction of that dike modified the hydrological regime of Manamo Channel and so eliminated the pattern of seasonal flooding (Novoa 2000 a, Monente and Colonnello 2004). Echezuría *et al.* (2002) mention that the flow reduction in Manamo Channel caused a series of hydrochemical changes in the water and in the area of influence, increasing estuarine characteristics in a large portion of the northern delta, including Manamo and Macareo channels. The mixture of the two water types (fresh and salt) has increased the concentrations of chlorine, sodium and magnesium sulphate. High values of those ions can be found many kilometers upstream, near the city of Tucupita.

Of the three physico-chemical parameters measured, the most important in a tropical estuary is salinity (Barletta *et al.* 2008), since it directly determines the presence of fish species in the different hydrophases, and favors changes in the composition of fish aggregations, leading to the alternating occurrence throughout the year of the species best adapted to the reigning conditions at any given time (Sánchez & Rueda 1999). In contrast to the usual situation, we never found 0 salinity values in any of the four channels studied. The lowest salinity value recorded was 4.8 % from Angostura Channel.

Based on the presence-absence data, a greater similarity was observed between Manamo (Orinoco River Basin) and Venado (Gulf of Paria Basin) channels. This was not the expected result since we expected to find a greater similarity among the Orinoco Basin channels studied rather than a highest correlation between one Orinoco Basin and one Gulf of Paria channels, as occurred with the physico-chemical parameters measured. The obtained result came about because of the 78 fishes collected, Manamo and Venado channels share 11, Manamo, Angostura and Venado share 16, and of the 27 species found in Pedernales Channel, 20 are widely distributed in all four channels.

Novoa (2000a) mentioned that in the mouths of the channels in the northern part of the Orinoco River Delta and southern part of the Gulf of Paria, a little more than half of the species are estuarine-marine species. Novoa and Cervigón (1986) indicated that the northernmost channels of the lower delta, during the rainy season, and with greater water flows, diverse freshwater species were frequently observed such as the juveniles of pimelodid catfishes, and some species of Sciaenidae and Characidae, although, even during the rainy season, the relative importance of these freshwater species is very low in these areas. This same result was obtained in our study of these four channels, where of the 78 species collected, few (7 species, 9 %), were strictly freshwater, and all had very low abundance (fewer than 10 individuals) throughout the entire hydrocycle. Juvenile "morocoto" (*Piaractus brachypomus*, Serrasalmidae) and catfishes of the family Pimelodidae: "bagre dorado" (*Brachyplatystoma rousseauxii*), "bagre paisano" (*Hypophthalmus edentatus*) and "mandi" (*Pimelodina flavipinnis*) were some of the species found.

In most tropical estuaries, seasonal changes in salinity determine the movement of fishes upstream and downstream in them. During the high water phase, the increase in fresh water causes a decrease in salinity that permits some freshwater species to move into estuarine zones, while marine species move towards the sea, looking for higher salinity waters (Neves *et al.* 2010). But in this study, no significant spatial or temporal changes in salinity were observed, and so, it is reasonable to assume, since there was no salinity fluctuation, there were no significant changes in the benthic fish community, which throughout the study period was dominate by estuarine-marine species. After the hydraulic regime was regulated in Manamo Channel a series of ecological changes began, among them was the elimination or substitution of the original freshwater fish with an estuarine one (Echezuría *et al.* 2002).

As for abundance, in all four channels, ten or fewer species comprised 80 % of the captures. The numerical dominance of just a few species is a characteristic observed in tropical and subtropical estuaries, as well as in coastal lagoons, that usually have low species diversity but high abundance of certain species (Whitfield 1999). Cervigón *et al.* (1992) observed this in different tropical and subtropical estuaries where usually fewer than six species comprised around 70 % of the fishes captured, a phenomenon also observed in other countries such as the estuary in Marañon state (Carvalho-Neta *et al.* 2011), and Laguna de los Patos in Brazil and the York River in Virginia, USA (Vieira 2006).

The same phenomenon as described above was also observed for biomass. In each of the four channels studied, just ten species contributed more than 80 % of the total catch weight, a characteristic also observed in other tropical and subtropical estuaries (Barletta *et al.* 2005, 2008).

Estuaries are of great ecological importance to fish communities, since they provide protection and refuge for juveniles and adults during the reproductive season (Andrade-Tubino *et al.* 2008, Blaber *et al.* 2000, Barletta-Bergan *et al.* 2001, Barletta *et al.* 2003). A large percentage of the captures obtained with shrimp trawls are juveniles of benthic fishes that may include more than 20 commercially valuable species, which after they mature may be captured as part of the oceanic fish catch (Ecology & Environment 2003, Lasso *et al.* 2004b). Lasso *et al.* (2004b) listed 64 commercially valuable benthic fish species that live in channel mouths and are captured as juveniles by shrimp trawlers. In this study, juvenile phases of all of the 78 fishes were collected from the mouths of the four channels sampled.

The Shannon-Wiener diversity index incorporates equity in its calculation and so is a better evaluation of diversity since it indicates whether a community is dominated by just a few species. Margalef (1974) stated that for fish communities normal values fall between 1.0 and 3.5. However, in estuaries, where marked differences in environmental parameters are the norm, with great fluctuations in physical, chemical and biological parameters, lower diversities are found when compared with other systems (Barros *et al.* 2011).

In the four channels studied during the annual hydrological cycle no significant differences were detected in any of the indices of diversity, equity or richness. Diversity values (H´) ranged from 0.32 (Pedernales Channel) and 2.68 (Angostura Channel). Magurran (2004) classified diversity as follows: H´1< very low, 1-2 low, 2-3 medium, 3-4 high y > 4 very high. Following this system the values obtained in this study are very low to medium. Lasso *et al.* (2004b) obtained values from a study done in the same study area between 0.63 a 2.68, that are also considered to be very low to medium, and indicates that these systems are dominated by just a few species.

The lowest equity value (0.14) was found in Pedernales Channel, during rising water phase and the largest (0.83) for Angostura Channel, during high and low water phases. The low equity registered for Pedernales Channel during rising water phase was caused by a small croaker (*Stellifer rastrifer*) that contributed 95 % of all specimens collected during that phase. The greatest values for Angostura Channel, during high and low water phases indicate that the 20 species collected during those phases had similar abundance, although another small croaker (*S. naso*) comprised 21 % of the captures during low water, and a flatfish (*Achirus achirus*) contributed 17 %. Lasso *et al.* (2004b) reported equity values between 0.29 and the maximum of 1.0.

The lowest richness value (1.5) was observed in Pedernales Channel during rising water phase with 10 species, and the largest were for Manamo Channel (5.24) with 34 species and Angostura Channel (5.29) with 39 species. Lasso *et al.* (2004b) reported from 1 to 24 species per trawl pull.

In the most recent list of fish species present in the Orinoco River Delta, Lasso *et al.* (2009) reported a total of 438 species, of which around 150 are benthic species found in the lower delta. The 78 species identified in this study are thus about 50 % of the species reported from the area.

To determine which species are of greatest importance in the community during the complete hydrological cycle, the ecological criteria of abundance, biomass and frequency of occurrence were considered. There is a direct relationship between these criteria and the species with higher IVI values (Figure 13), among which are included the species that are permanent residents in the community (Table 4) and at the same time those that are dominant in the community (Figure 14).

The importance value index (IVI) for the annual hydrological cycle studied indicates that the small marine catfish, *Cathorops* sp. (IVI = 146), an estuarine-marine species, alone contributed 33 % of the biomass captured, and 20 % of the individuals (abundance) (Figure 15a). In a study in the same area Lasso *et al.* (2004b) reported that *Cathorops spixii*, was the only species collected that had an IVI value above 100 %. It was also the species with the highest IVI value (160 %) reported in a similar study of Macareo, Cocuina and Mariusa channels (Lasso *et al.* 2008). This species predominates in saline waters of the delta, where large quantities of both juveniles and adults form large schools (Cervigón 1985) and it has been reported as the most abundant species in other studies in the region (Novoa 2000b, Lasso *et al.* 2004b). Species of marine catfishes (Ariidae) can be considered the most important in terms of number of species, density and biomass in tropical and subtropical estuaries (Araújo 1988, Barletta *et al.* 2003, 2005, 2008, Dantas *et al.* 2010, Dantas *et al.* 2011), as has been shown in studies of estuaries throughout the Americas such as Términos Lagoon in México (Lara-Domínguez *et al.* 1981), Bahía Sepetiba, Río de Janeiro, Brasil (Azevedo *et al.* 1998) and the Goiana estuary of north-eastern Brazil (Dantas *et al.* 2010), to name just a few. They are followed by the flatfish, *Achirus achirus* (IVI = 121), a freshwater, estuarine and marine species responsible for 16 % of the abundance collected and 5.4 % of the biomass captured (Figure 15b). It is one of the most characteristic and abundant species found on muddy substrates of the lower Orinoco River Delta, where both juveniles and adults are captured (Cervigón 1985). Lasso *et al.* (2004b) in a study done in the same area, that it was fourth in abundance, with an IVI value of around 80 %.

In third place for dominance is the estuarine-marine croaker species *Stellifer naso* (IVI = 113), with a relative abundance of 3% and biomass of 11 % (Figure 15c). The group of *Stellifer* species is dominant in terms of biomass of the fish community of the lower delta, with both juveniles and adults common (Cervigón 1985). Lasso *et al.* (2004 b, 2008) reported *Stellifer* juveniles as the second most important in dominance (IVI near 100 %) and adults in third place (IVI = 150). Finally, the pufferfish, *Colomesus psittacus* (IVI = 102), a characteristic species of the lower delta according to Cervigón (1985), placed fourth in dominance. It is an estuarine-marine species, occasionally entering freshwater responsible for 6 % of relative abundance and 3 % of biomass (Figure 15d).

Constancy of the 78 species collected in the channels studied varied. Only five species (6 %) were considered year long residents, 12 (15 %) temporary, and 61 occasional. The fish community is thus composed of many rare species and just a few dominants, which is typical of estuaries (Yañez-Arancibia *et al.* 1985, Barletta-Bergan *et al.* 2001) and consistent with the findings of Longhurst and Pauly (2007) who studied tropical systems. According to Day *et al.* (1989), estuaries are highly dynamic environments, where rapid physical and chemical changes cause high energy costs to the fishes that live there. Because of this, few species are residents in any given locality, and few remain in the estuary for their entire life cycle, with most being just temporary visitors (Santos *et al.* 2002). This behaviour has been observed in other estuaries, where about 64 % of the fishes captures were occasional visitors, and only 17 % residents (Freitas Jr. 2005).

Although the above situation is the norm for most estuarine fishes, there are a few that dominate in the channels studied throughout the year and all four hydrophases. During high, low and rising waters, the marine catfish Cathorops sp is the dominant species with a croaker species (Stellifer spp) in second place. The community dominance index value for all four channels studied was 44 %, with Cathorops sp and Stellifer naso dominant.

## Conclusion

During the hydrological cycle studied, in the mouths of three Orinoco channels (Pedernales, Manamo and Angostura) and one channel in the Gulf of Paria basin (Venado) no fluctuations in the abiotic parameters recorded (depth, turbidity and salinity) were found. Given that salinity is the determinant factor regulating tropical estuarine fish species distribution, no alteration of species present was detected in any of the four channels in any time of the four annual hydrophases. This supports the conclusion that the

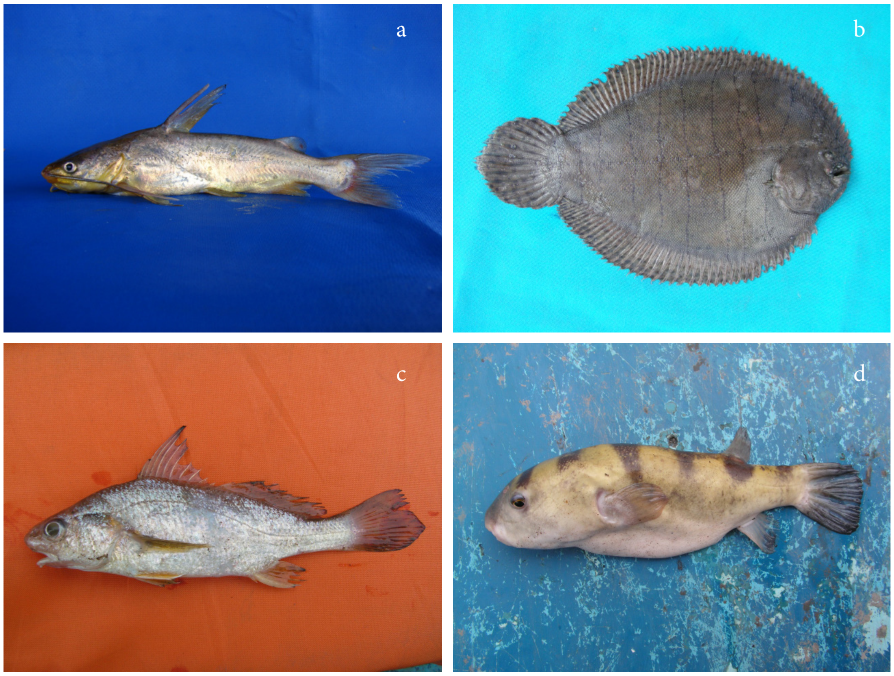


**Figure 15.** Most important fish in terms of abundance, biomass and relative frequency (IVI). a) *Cathorops* sp., b) *Achirus achirus*, c) *Stellifer naso* y d) *Colomesus psittacus*. Photos: J. Hernández (a), A. Giraldo (b – d).

construction of a dike in Manamo Channel 50 years ago, considerably affected its normal hydrological cycle, and that the impacts not only directly affect Manamo Channel, but extend to the entire Orinoco River subdrainge studied, which includes Pedernales and Angostura channels, and even one channel in the Gulf of Paria basin (Venado), making evident the importance of interconnections among Orinoco River Delta channels.

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**Appendix 1.** List of fish species collected during one year of sampling in Pedernales, Manamo, Angostura and Venado channels, of the Orinoco River Delta and the Gulf of Paría. Freshwater (F), Occasional Freshwater (OF), Estuarine (E), Estuarine Occasional (EO) and Marine (M).

| Orden | Familia | Especies | Hábito |
|---|---|---|---|
| Myliobatiformes | Dasyatidae | *Dasyatis geijskesi (Boeseman 1948)* | E, M |
| | | *Dasyatis guttata* (Bloch y Schneider 1801) | E, M |
| | Gymnuridae | *Gymnura micrura* (Bloch y Schneider 1801) | E, M |
| | Potamotrygonidae | *Potamotrygon* sp. | F, EO |
| Clupeiformes | Clupeidae | *Odontognathus mucronatus* Lacepède 1800 | OF, E, M |
| | | *Rhinosardinia amazonica* (Steindachner 1879) | F |
| | Engraulidae | *Anchoa spinifer* (Valenciennes 1848) | OF, E, M |
| | | *Anchovia clupeoides* (Swainson 1839) | OF, E, M |
| | | *Anchovia surinamensis* (Bleeker 1865) | F, EO |
| | | *Anchoviella brevirostris* (Günther 1868) | OF, E, M |
| | | *Anchoviella guianensis* (Eigenmann 1912) | F, EO, MO |
| | | *Anchoviella lepidentostole* (Fowler 1911) | OF, E, M |
| | | *Lycengraulis batesii* (Günther 1868) | F, EO, MO |
| | | *Lycengraulis grossidens* (Spix y Agassiz 1829) | OF, E, M |
| | | *Lycengraulis limnichthys* Schultz 1949 | E, M |
| | | *Pterengraulis atherinoides* (Linnaeus 1766) | F, EO |
| | Pristigasteridae | *Pellona flavipinnis* (Valenciennes 1837) | F, EO |
| | | *Pellona harroweri* (Fowler 1917) | E, M |
| Characiformes | Characidae | *Piaractus brachypomu*s (Cuvier 1818) | F |
| | | *Triportheus auritus* (Valenciennes 1850) | F |
| Siluriformes | Ariidae | *Bagre bagre* (Linnaeus 1766) | E, M |
| | | *Cathorops* sp. | E, M |
| | | *Notarius grandicassi*s (Valenciennes 1840) | E, M |
| | | *Amphiarius rugispinis* (Valenciennes 1840) | E, M |
| | | *Sciades couma* (Valenciennes 1840) | OF, E, M |
| | | *Sciades herzbergii* (Bloch 1794) | E, M |
| | | *Sciades passany* (Valenciennes 1840) | E, M |
| | Aspredinidae | *Aspredinichthys filamentosus* (Valenciennes 1840) | F, E |
| | | *Aspredo aspredo* (Linnaeus 1758) | F, E |
| | | *Platystacus cotylephorus* Bloch 1794 | F, E |
| | Auchenipteridae | *Pseudauchenipterus nodosus* (Bloch 1794) | F, E |
| | Heptapteridae | *Rhamdia quelen* (Quoy y Gaimard 1824) | F |
| | Loricariidae | *Hypostomus watwata* Hancock 1828 | F, EO |
| | Pimelodidae | *Brachyplatystoma rousseauxii* (Castelnau 1855) | F |
| | | *Hypophthalmus edentatus* Spix y Agassiz 1829 | F |
| | | *Pimelodina flavipinnis* Steindachner 1876 | F |
| Batrachoidiformes | Batrachoididae | *Batrachoides surinamensis* (Bloch y Schneider 1801) | E, M |
| Perciformes | Carangidae | *Caranx hippos* (Linnaeus 1766) | E, M |
| | | *Chloroscombrus chrysurus* (Linnaeus 1766) | E, M |

*Cont.* **Appendix 1.** List of fish species collected during one year of sampling in Pedernales, Manamo, Angostura and Venado channels, of the Orinoco River Delta and the Gulf of Paría. Freshwater (F), Occasional Freshwater (OF), Estuarine (E), Estuarine Occasional (EO) and Marine (M).

| Orden | Familia | Especies | Hábito |
|---|---|---|---|
| Perciformes | Carangidae | *Hemicaranx amblyrhynchus* (Cuvier 1833) | EO, M |
| | | *Oligoplites palometa* (Cuvier 1832) | E, M |
| | | *Oligoplites saliens* (Bloch 1793) | E, M |
| | | *Oligoplites saurus* (Bloch y Schneider 1801) | E, M |
| | | *Selene vomer* (Linnaeus 1758) | E, M |
| | | *Trachinotus cayennensis* Cuvier 1832 | EO, M |
| | | *Trachinotus falcatus* (Linnaeus 1758) | OF, E, M |
| | Centropomidae | *Centropomus ensiferus* Poey 1860 | E, M |
| | | *Centropomus pectinatus* Poey 1860 | OF, E, M |
| | | *Centropomus undecimalis (Bloch 1792)* | OF, E, M |
| | Ephippidae | *Chaetodipterus faber* (Broussonet 1782) | E, M |
| | Gerreidae | *Diapterus rhombeus* (Cuvier 1829) | E, M |
| | Gobiidae | *Gobionellus oceanicus* (Pallas 1770) | E, M |
| | Haemulidae | *Conodon nobilis* (Linnaeus 1758) | E, M |
| | | *Genyatremus luteus* (Bloch 1790) | E, M |
| | | *Polydactylus virginicus* (Linnaeus 1758) | OF, E, M |
| | Sciaenidae | *Bairdiella ronchus* (Cuvier 1830) | E, M |
| | | *Cynoscion acoupa* (Lacepède 1801) | E, M |
| | | *Cynoscion leiarchus* (Cuvier 1830) | OF, E, M |
| | | *Cynoscion microlepidotus* (Cuvier 1830) | E, M |
| | | *Isopisthus parvipinnis* (Cuvier 1830) | E, M |
| | | *Macrodon ancylodon* (Bloch y Schneider 1801) | E, M |
| | | *Micropogonias furnieri* (Desmarest 1823) | E, M |
| | | *Nebris microps* Cuvier 1830 | OF, E, M |
| | | *Stellifer microps* (Steindachner 1864) | E, M |
| | | *Stellifer naso* (Jordan 1889) | E, M |
| | | *Stellifer rastrifer* (Jordan 1889) | E, M |
| | | *Stellifer stellifer* (Bloch 1790) | E, M |
| | Scombridae | *Scomberomorus brasiliensis* Collette, Russo y Zavala-Camin 1978 | E, M |
| | Serranidae | *Epinephelus itajara* (Lichtenstein 1822) | E, M |
| | Trichiuridae | *Trichiurus lepturus* Linnaeus 1758 | OF, E, M |
| Pleuronectiformes | Achiridae | *Achirus achirus* (Linnaeus 1758) | E, M |
| | | *Apionichthys dumerili* Kaup 1858 | F, E, M |
| | Paralichthyidae | *Citharichthys spilopterus* Günther 1862 | F, E, M |
| | Cynoglossidae | *Symphurus tessellatus* (Quoy y Gaimard 1824) | E, M |
| Tetraodontiformes | Tetraodontidae | *Colomesus psittacus* (Bloch y Schneider 1801) | E, M |
| | | *Lagocephalus laevigatus* (Linnaeus 1766) | OF, E, M |
| | | *Sphoeroides testudineus* (Linnaeus 1758) | E, M |

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Benthic fish community structure in the Orinoco River Delta and Gulf of Paria (Venezuela), fifty years after the construction of a dike across Manamo Channel

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Opcional. Párrafo sencillo y conciso entre el texto y la bibliografía. Evite títulos como Dr., Lic., TSU, etc.

### Fotografías, figuras, tablas y anexos

Refiera las figuras (gráficas, diagramas, ilustraciones y fotografías) sin abreviación (p. e. Figura 3) al igual que las tablas (p. e. Tabla 1). Gráficos (p. e. CPUE anuales) y figuras (histogramas de tallas), preferiblemente en blanco y negro, con tipo y tamaño de letra uniforme. Deben ser nítidas y de buena calidad, evitando complejidades innecesarias (por ejemplo, tridimensionalidad en gráficos de barras); cuando sea posible use solo colores sólidos en lugar de tramas. Las letras, números o símbolos de las figuras deben ser de un tamaño adecuado de manera que sean claramente legibles una vez reducidas. Para el caso de las fotografías y figuras digitales es necesario que estas sean guardadas como formato tiff con una resolución de 300 dpi. Es oportuno que indique en qué parte del texto desea insertarla.

Lo mismo aplica para las tablas y anexos, los cuales deben ser simples en su estructura (marcos) y estar unificados. Presente las tablas en archivo aparte (Excel), identificadas con su respectivo número. Haga las llamadas a pie de página de tabla con letras ubicadas como superíndice. Evite tablas grandes sobrecargadas de información y líneas divisorias o presentadas en forma compleja. Es oportuno que indique en qué parte del texto desea insertar tablas y anexos.

### Bibliografía

Contiene únicamente la lista de las referencias citadas en el texto. Ordénelas alfabéticamente por autores y cronológicamente para un mismo autor. Si hay varias referencias de un mismo autor(es) en el mismo año, añada las letras a, b, c, etc. No abrevie los nombres de las revistas. Presente las referencias en el formato anexo, incluyendo el uso de espacios, comas, puntos, mayúsculas, etc.

Artículo en revistas

Agosti, D., C. R. Brandao y S. Diniz. 1999. The new world species of the subfamily Leptanilloidinae (Hymenoptera: Formicidae). *Systematic Entomology* 24: 14-20.

Libros, tesis e informes técnicos

*Libros:* Gutiérrez, F. P. 2010. Los recursos hidrobiológicos y pesqueros en Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá, D. C., 118 pp.

*Tesis:* Cipamocha, C. A. 2002. Caracterización de especies y evaluación trófica de la subienda de peces en el raudal Chorro de Córdoba, bajo río Caquetá, Amazonas, Colombia. Trabajo de grado. Universidad Nacional de Colombia, Facultad de Ciencias, Departamento de Biología. Bogotá D. C., 160 pp.

*Informes técnicos:* Andrade, G. I. 2010. Gestión del conocimiento para la gestión de la biodiversidad: bases conceptuales y propuesta programática para la reingeniería del Instituto Humboldt. Informe Técnico. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá D. C., 80 pp.

*Capítulo en libro o en informe:* Fernández F., E. E. Palacio y W. P. MacKay. 1996. Introducción al estudio de las hormigas (Hymenoptera: Formicidae) de Colombia. Pp: 349-412. *En:* Amat, G. D., G. Andrade y F. Fernández (Eds.). Insectos de Colombia. Estudios Escogidos. Academia Colombiana de Ciencias Exactas, Físicas y Naturales & Centro Editorial Javeriano, Bogotá.

*Resumen en congreso, simposio, talleres:* Señaris, J. C. 2001. Distribución geográfica y utilización del hábitat de las ranas de cristal (Anura; Centrolenidae) en Venezuela. *En:* Programa y Libro de Resúmenes del IV Congreso Venezolano de Ecología. Mérida, Venezuela, p. 124.

Páginas Web

No serán incluidas en la bibliografía, sino que se señalarán claramente en el texto al momento de mencionarlas.

# *Guidelines for authors*

(*humboldt.org.co/es/bibliotecaypublicaciones/biota*)

### *Manuscript preparation*

Submitting a manuscript implies the explicit statement by the author(s) that the paper has not been published before nor accepted for publication in another journal or other means of scientific diffusion. Contributions are entire responsibility of the author and not the Alexander von Humboldt Institute for Research on Biological Resources, or the journal and their editors.

Papers can be written in Spanish, English or Portuguese and it is recommended not exceeding 40 pages (with paragraphs spaced at 1,5) including tables, figures and Annex. For special cases, the editor could consider publishing more extensive papers, monographs or symposium conclusions. New species descriptions for science, new geographic records and regional biodiversity lists are of particular interest for this journal.

Any word-processor program may be used for the text (Word is recommended). taxonomic list or any other type of table, should be prepared in spreadsheet aplication (Excel is recommended). To submit a manuscript must be accompanied by a cover letter which clearly indicate s:

1. Full names, mailing addresses and e-mail addresses of all authors. (Please note that email addresses are essential to direct communication).
2. The complete title of the article.
3. Names, sizes, and types of files provide.
4. A list of the names and addresses of at least three (3) reviewers who are qualified to evaluate the manuscript.

### *Evaluation*

Submitted manuscript will have a peer review evaluation. Resulting in any of the following: a) *accepted* (in this case we assume that no change, omission or addition to the article is required and it will be published as presented.); b) *conditional acceptance* (the article is accepted and recommended to be published but it needs to be corrected as indicated by the reviewer); and c) *rejected* (when the reviewer considers that the contents and/or form of the paper are not in accordance with requirements of publication standards of *Biota Colombiana*).

### *Text*

- The manuscript specifications should be the following: standard letter size paper, with 2.5 cm margins on all sides, 1.5-spaced and left-aligned (including title and bibliography).
- All text pages (with the exception of the title page) should be numbered. Pages should be numbered in the lower right corner.
- Use Times New Roman or Arial font, size 12, for all texts. Use size 10 text in tables. Avoid the use of bold or underlining. 40 pages maximum, including tables, figures and annex. For tables use size 10 Times New Roman or Arial Font (the one used earlier).
- The manuscripts must be completed with the following order: title, abstract and key words, then in Spanish Título, Resumen y Palabras claves. Introduction, Materials and Methods, Results, Discussion, conclusions (optional), acknowledgements (optional) and bibliography. Following include a page with the Table, Figure and Annex list. Finally tables, figures and annex should be presented and clearly identified in separate tables.
- Scientific names of genera, species and subspecies should be written in italic. The same goes for Latin technical terms (i.e sensu, *et al*.). Avoid the use of underlining any word or title. Do not use footnotes.
- As for abbreviations and the metric system, use the standards of the International System of Units (SI) remembering that there should always be a space between the numeric value and the measure unit (e.g., 16 km, 23 ºC). For relative measures such as m/sec, use m.sec$^{-1}$.
- Write out numbers between one to ten in letters except when it precedes a measure unit (e.g., 9 cm) or if it is used as a marker (e.g., lot 9, sample 7).
- Do not use a point to seperate thousands, millions, etc. Use a comma to separate the whole part of the decimal (e.g., 3,1416). Numerate the hours of the from 0:00 to 24:00. Express years with all numbers and without marking thousands (e.g., 1996-1998). In Spanish, the names of the months and days (enero, julio, sábado, lunes) are always written with the first letter as a lower case, but it is not this way in English.
- The cardinal points (north, south, east, and west) should always be written in lower case, with the excpetino of abbreviations N, S, E, O (in English NW), etc. The correct indication of geographic coordinates is as follows: 02º37´53´´N-56º28´53´´O. The geographic altitude should be cited as follows: 1180 m a.s.l.
- Abbreviations are explained only the first time they are used.
- When quoting references in the text mentioned author´s last names when they are one or two, and et al. after the last name of the first author when there are three or more. If you mention many references, they should be in chronological order and separated by commas (e.g., Rojas 1978, Bailey *et al.* 1983, Sephton 2001, 2001).
- Abstract: include an abstract of 200 words maximum, in Spanish, Portuguese or English.
- Key words: six key words maximum, complementary to the title.

### *Pictures, Figures, Tables and Annex*

- Figures (graphics, diagrams, illustrations and photographs) without abbreviation (e.g. Figure 3) the same as tables (e.g., Table 1). Graphics and figures should be in black and white, with uniform font type and size. They should be sharp and of good quality, avoiding unnecessary complexities (e.g., three dimensions graphics). When possible use solid color instead of other schemes. The words, numbers or symbols of figures should be of an adequate size so they are readable once reduced. Digital figures must be sent at 300 dpi and in .tiff format. Please indicate in which part of the text you would like to include it.
- The same applies to tables and annexes, which should be simple in structure (frames) and be unified. Present tables in a separate file (Excel), identified with their respective number. Make calls to table footnotes with superscript letters above. Avoid large tables of information overload and fault lines or presented in a complex way. It is appropriate to indicate where in the text to insert tables and annexes.

### *Bibliography*

References in bibliography contains only the list of references cited in the text. Sort them alphabetically by authors and chronologically by the same author. If there are several references by the same author(s) in the same year, add letters a, b, c, etc. Do not abbreviate journal names. Present references in the attached format, including the use of spaces, commas, periodss, capital letters, etc.

Journal article

Agosti, D., C. R. Brandao y S. Diniz. 1999. The new world species of the subfamily Leptanilloidinae (Hymenoptera: Formicidae). *Systematic Entomology* 24: 14-20.

Book, thesis, technical reviews

*Book:* Gutiérrez, F. P. 2010. Los recursos hidrobiológicos y pesqueros en Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá, D. C. 118 pp.

*Thesis:* Cipamocha, C. A. 2002. Caracterización de especies y evaluación trófica de la subienda de peces en el raudal Chorro de Córdoba, bajo río Caquetá, Amazonas, Colombia. Trabajo de grado. Universidad Nacional de Colombia, Facultad de Ciencias, Departamento de Biología. Bogotá D. C. 160 pp.

*Technical reviews:* Andrade, G. I. 2010. Gestión del conocimiento para la gestión de la biodiversidad: bases conceptuales y propuesta programática para la reingeniería del Instituto Humboldt. Informe

Técnico. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá D. C. 80 pp.

*Book chapter or in review:* Fernández F., E. E. Palacio y W. P. MacKay. 1996. Introducción al estudio de las hormigas (Hymenoptera: Formicidae) de Colombia. Pp: 349-412. *En:* Amat, G. D., G. Andrade y F. Fernández (Eds.). Insectos de Colombia. Estudios Escogidos. Academia Colombiana de Ciencias Exactas, Físicas y Naturales & Centro Editorial Javeriano, Bogotá.

*Symposium abstract:* Señaris, J. C. 2001. Distribución geográfica y utilización del hábitat de las ranas de cristal (Anura; Centrolenidae) en Venezuela. *En:* Programa y Libro de Resúmenes del IV Congreso Venezolano de Ecología. Mérida, Venezuela, p. 124.

Web pages

Not be included in the literature, but clearly identified in the text at the time of mention.

# Guía para autores - Artículos de Datos

www.humboldt.org.co/es/bibliotecaypublicaciones/biota- biotacol@humboldt.org.co
www.sibcolombia.net - sib+iac@humboldt.org.co

El objetivo de esta guía es establecer y explicar los pasos necesarios para la elaboración de un manuscrito con el potencial de convertirse en artículo de datos para ser publicado en la revista *Biota Colombiana*. En esta guía se incluyen aspectos relacionados con la preparación de datos y el manuscrito.

## ¿Qué es un artículo de datos?

Un artículo de datos o *Data Paper* es un tipo de publicación académica que ha surgido como mecanismo para incentivar la publicación de datos sobre biodiversidad, a la vez que es un medio para generar reconocimiento académico y profesional adecuado a todas las personas que intervienen de una manera u otra en la gestión de información sobre biodiversidad.

Los artículos de datos contienen las secciones básicas de un artículo científico tradicional. Sin embargo, estas se estructuran de acuerdo a un estándar internacional para metadatos (información que le da contexto a los datos) conocido como el *GBIF Metadata Profile* (GMP)[1]. La estructuración del manuscrito con base en este estándar se da, en primer lugar, para facilitar que la comunidad de autores que publican conjuntos de datos a nivel global, con presencia en redes como la *Global Biodiversity Information Facility* (GBIF) y otras redes relacionadas, puedan publicar fácilmente artículos de datos obteniendo el reconocimiento adecuado a su labor. En segundo lugar, para estimular que los autores de este tipo de conjuntos de datos que aún no han publicado en estas redes de información global, tengan los estímulos necesarios para hacerlo.

Un artículo de datos debe describir de la mejor manera posible el quién, qué, dónde, cuándo, por qué y cómo de la toma y almacenamiento de los datos, sin llegar a convertirse en el medio para realizar un análisis exhaustivo de los mismos, como sucede en otro tipo de publicaciones académicas. Para profundizar en este modelo de publicación se recomienda consultar a Chavan y Penev (2011)[2].

## ¿Qué manuscritos pueden llegar a ser artículos de datos?

Manuscritos que describan conjuntos de datos primarios y originales que contengan registros biológicos (captura de datos de la presencia de un(os) organismo(s) en un lugar y tiempo determinados); información asociada a ejemplares de colecciones biológicas; listados temáticos o geográficos de especies; datos genómicos y todos aquellos datos que sean susceptibles de ser estructurados con el estándar *Darwin Core*[3] (DwC). Este estándar es utilizado dentro de la comunidad de autores que publican conjuntos de datos sobre biodiversidad para estructurar los datos y de esta manera poder consolidarlos e integrarlos desde diferentes fuentes a nivel global. No se recomienda someter manuscritos que describan conjuntos de datos secundarios, como por ejemplo compilaciones de registros biológicos desde fuentes secundarias (p.e. literatura o compilaciones de registros ya publicados en redes como GBIF o IABIN).

## Preparación de los datos

Como se mencionó anteriormente los datos sometidos dentro de este proceso deben ser estructurados en el estándar DwC. Para facilitar su estructuración, el Sistema de Información sobre Biodiversidad de Colombia (SiB Colombia), ha creado dos plantillas en Excel, una para registros biológicos y otra para listas de especies. Lea y siga detenidamente las instrucciones de las plantillas para la estructuración de los datos a publicar. Para cualquier duda sobre el proceso de estructuración de estos datos por favor contactar al equipo coordinador del SiB Colombia (EC-SiB) en sib+iac@humboldt.org.co.

[1] Wieczorek, J. 2011. Perfil de Metadatos de GBIF: una guía de referencia rápida. En: Wieczorek, J. The GBIF Integrated Publishing Toolkit User Manual, version 2.0. Traducido y adaptado del inglés por D. Escobar. Sistema de Información sobre Biodiversidad de Colombia, Bogotá D.C., Colombia, 23p. Disponible en http://www.sibcolombia.net/repositorio-de-documentos.

[2] Chavan, V. y L. Penev. 2011. The data paper: The mechanism to incentivize data publishing in biodiversity science. BMC Bioinformatics 12 (Suppl 15): S2.

[3] TDWG. 2011. *Darwin Core:* una guía de referencia rápida. (Versión original producida por TDWG, traducida al idioma español por Escobar, D.; versión 2.0). Bogotá: SiB Colombia, 33 pp. Disponible en http://www.sibcolombia.net/repositorio-de-documentos

## Preparación del manuscrito

Para facilitar la creación y estructuración del manuscrito en el estándar GMP, se cuenta con la ayuda de un editor electrónico (http://ipt.sibcolombia.net/biota) que guiará al autor en dicho proceso y que finalmente generará una primera versión del manuscrito. Se recomienda el uso del manual GMP, como una guía de la información a incluir en cada sección del manuscrito, junto con el anexo 1.

Pasos a seguir para la elaboración del manuscrito:

1 Solicite al correo sib+iac@humboldt.org.co el acceso al editor electrónico. El EC-SiB le asignará un usuario y contraseña.

2. Ingrese con su usuario y contraseña al editor electrónico, luego diríjase a la pestaña *Gestión de recursos* y cree un nuevo recurso asignando un nombre corto a su manuscrito usando el formato "AcrónimoDeLaInstitución_año_tipoDeConjuntoDeDatos", p.e. ABC_2010_avestinije y dar clic en el botón crear.

3. En la vista general del editor seleccione "editar" en la pestaña *Metadatos* (por favor, no manipule ningún otro elemento), allí encontrará diferentes secciones (panel derecho) que lo guiarán en la creación de su manuscrito. Guarde los cambios al finalizar cada sección, de lo contrario perderá la información. Recuerde usar el manual GMP. A continuación se presentan algunas recomendaciones para la construcción del manuscrito. Las secciones se indican en MAYUSCULAS y los elementos de dichas secciones en **negrilla**.

    - En PARTES ASOCIADAS incluya únicamente aquellas personas que no haya incluido en INFORMACIÓN BÁSICA.
    - Los DATOS DEL PROYECTO y DATOS DE LA COLECCIÓN son opcionales según el tipo de datos. En caso de usar dichas secciones amplíe o complemente información ya suministrada, p. ej. no repita información de la **descripción** (COBERTURA GEOGRÁFICA) en la **descripción del área de estudio** (DATOS DEL PROYECTO).
    - De igual manera, en los MÉTODOS DE MUESTREO, debe ampliar o complementar información, no repetirla. La información del **área de estudio** debe dar un contexto específico a la metodología de muestreo.
    - Es indispensable documentar el **control de calidad** en MÉTODOS DE MUESTREO. Acá se debe describir que herramientas o protocolos se utilizaron para garantizar la calidad y coherencia de los datos estructurados con el estándar DwC.
    - Para crear la **referencia del recurso**, en la sección REFERENCIAS, utilice uno de los dos formatos propuestos (Anexo 2). No llene el **identificador de la referencia,** este será suministrado posteriormente por el EC-SiB.
    - Para incluir la bibliografía del manuscrito en **referencias**, ingrese cada una de las citas de manera individual, añadiendo una nueva referencia cada vez haciendo clic en la esquina inferior izquierda.

4. Rectifique que el formato de la información suministrada cumpla con los lineamientos de la revista (p. ej. abreviaturas, unidades, formato de números etc.) en la Guía general para autores de *Biota Colombiana*.

5. Una vez incluida y verificada toda la información en el editor electrónico notifique al EC-SiB al correo electrónico sib+iac@humboldt.org.co, indicando que ha finalizado la edición del manuscrito. Adicionalmente adjunte la plantilla de Excel con los datos estructurados (elimine todas las columnas que no utilizó). El EC-SiB realizará correcciones y recomendaciones finales acerca de la estructuración de los datos y dará las instrucciones finales para que usted proceda a someter el artículo.

## Someter el manuscrito

Una vez haya terminado la edición de su manuscrito y recibido las instrucciones por parte del EC-SIB, envíe una carta al correo electrónico biotacol@humboldt.org.co para someter su artículo, siguiendo las instrucciones en la Guía general para autores de *Biota Colombiana*.

Recuerde adjuntar:

- Plantilla de Excel con la última versión de los datos revisada por el EC-SiB.
- Documento de Word con las figuras y tablas seguidas de una lista las mismas.

Cuando finalice el proceso, sus datos se harán públicos y de libre acceso en los portales de datos del SiB Colombia y GBIF. Esto permitirá que sus datos estén disponibles para una audiencia nacional e internacional, manteniendo siempre el crédito para los autores e instituciones asociadas.

**Anexo 1.** Estructura base de un artículo de datos y su correspondencia con el editor electrónico basado en el GMP.

| SECCIÓN/SUBSECCIÓN | CORRESPONDENCIA CON LOS ELEMENTOS DEL EDITOR ELECTRÓNICO |
|---|---|
| Título | Derivado del elemento **título**. |
| Autores | Derivado de los elementos **creador del recurso**, **proveedor de los metadatos** y **partes asociadas**. |
| Afiliaciones | Derivado de los elementos **creador del recurso**, **proveedor de los metadatos** y **partes asociadas**. De estos elementos, la combinación de **organización**, **dirección**, **código postal**, **ciudad**, **país** y **correo electrónico**, constituyen la afiliación. |
| Autor de contacto | Derivado de los elementos **creador del recurso** y proveedor de los metadatos. |
| Citación | Para uso de los editores. |
| Citación dele recurso | Derivada del elemento **referencia del recurso**. |
| Resumen | Derivado del elemento **resumen**. Máximo 200 palabras. |
| Palabras clave | Derivadas del elemento **palabras clave**. Máximo seis palabras. |
| Abstract | Derivado del elemento ***abstract***. Máximo 200 palabras. |
| Key words | Derivadas del elemento ***key words.*** Máximo seis palabras. |
| Introducción | Derivado del elemento **propósito** (de las secciones Introducción y Antecedentes). Se sugiere un breve texto para introducir las siguientes secciones. Por ejemplo, historia o contexto de la colección biológica o proyecto en relación con los datos descritos, siempre y cuando no se repita información en las subsecuentes secciones. |
| Datos del proyecto | Derivada de los elementos de la sección Datos del proyecto: **título**, **nombre**, **apellido**, **rol**, **fuentes de financiación**, **descripción del área de estudio** y **descripción del proyecto**. |
| Cobertura taxonómica | Derivada de los elementos de la sección Cobertura taxonómica: **descripción**, **nombre científico**, **nombre común** y **categoría**. |
| Cobertura geográfica | Derivada de los elementos de la sección Cobertura geográfica: **descripción**, **latitud mínima**, l**atitud máxima, longitud mínima, longitud máxima**. |
| Cobertura temporal | Derivada de los elementos de la sección Cobertura temporal: **tipo de cobertura temporal.** |
| Datos de la colección | Derivada de los elementos de la sección Datos de la colección: **nombre de la colección**, **identificador de la colección**, **identificador de la colección parental**, **método de preservación de los especímenes** y **unidades curatoriales**. |
| Material y métodos | Derivado de los elementos de la sección Métodos de muestreo: **área de estudio**, **descripción del muestreo**, **control de calidad**, **descripción de la metodología paso a paso**. |
| Resultados | |
| Descripción del conjunto de datos | Derivado de los elementos de las secciones Discusión y Agradecimientos, contiene información del formato de los datos y metadatos: **nivel de jerarquía**, **fecha de publicación** y **derechos de propiedad intelectual**. |
| Discusión | Se deriva del elemento **discusión**. Un texto breve (máximo 500 palabras), que puede hacer referencia a la importancia, relevancia, utilidad o uso que se le ha dado o dará a los datos en publicaciones existentes o en posteriores proyectos. |
| Agradecimientos | Se deriva del elemento **agradecimientos**. |
| Bibliografía | Derivado del elemento **bibliografía**. |

**Anexo 2.** Formatos para llenar el elemento referencia del recurso.

La referencia del recurso es aquella que acompañará los datos descritos por el artículo, públicos a través de las redes SiB Colombia y GBIF. Tenga en cuenta que esta referencia puede diferir de la del artículo. Para mayor información sobre este elemento contacte al EC-SiB. Aquí se sugieren dos formatos, sin embargo puede consultar otros formatos establecidos por GBIF[4].

| TIPO DE RECURSO | PLANTILLA | EJEMPLO |
|---|---|---|
| El conjunto de datos que el manuscrito describe es resultado de un proyecto de carácter institucional o colectivo con múltiples participantes. | <Institución publicadora/ Grupo de investigación> <(Año)>, <Título del recurso/Artículo>. <Número total de registros>, <aportados por:> <parte asociada 1 (rol), parte asociada 2 (rol) (…)>. <En línea,> <url del recurso>. <Publicado el DD/MM/AAAA>. | Centro Nacional de Biodiversidad (2013). Vertebrados de la cuenca de la Orinoquia. 1500 registros, aportados por Pérez, S. (Investigador principal, proveedor de contenidos, proveedor de metadatos), M. Sánchez (Procesador), D. Valencia (Custodio, proveedor de metadatos), R. Rodríguez (Procesador), S. Sarmiento (Publicador), V. B. Martínez (Publicador, editor). En línea, http://ipt.sibcolombia.net/biota/resource.do?r=verte_orin, publicado el 01/09/2013. |
| El conjunto de datos que el manuscrito describe es resultado de una iniciativa personal o de un grupo de investigación definido. | <Parte asociada 1, parte asociada 2 (…)> <(Año)>, <Título del recurso/Artículo>, <Número total de registros>, <en línea,> <url del recurso>. <Publicado el DD/MM/AAAA> | Valencia, D., R. Rodríguez y V. B. Martínez (2013). Vertebrados de la cuenca del Orinoco. 1500 registros, en línea, http://ipt.sibcolombia.net/biota/resource.do?r=verte_orin. Publicado el 01/09/2001. |

# *Guidelines for authors - Data Papers*

www.humboldt.org.co/es/bibliotecaypublicaciones/biota- biotacol@humboldt.org.co |
www.sibcolombia.net - sib+iac@humboldt.org.co

The purpose of this guide is to establish and explain the necessary steps to prepare a manuscript with the potential to become a publishable data paper in Biota Colombiana. This guide includes aspects related to the preparation of both data and the manuscript.

## What is a Data Paper?

A data paper is a scholarly publication that has emerged as a mechanism to encourage the publication of biodiversity data as well as an approach to generate appropriate academic and professional recognition to all those involved in in the management of biodiversity information.

A data paper contains the basic sections of a traditional scientific paper. However, these are structured according to an international standard for metadata (information that gives context to the data) known as the *GBIF Metadata Profile* (GMP)[5]. The structuring of the manuscript based on this standard enables the community of authors publishing datasets globally, with presence in networks such as the Global Biodiversity Information Facility (GBIF) and other related networks, to publish data easily while getting proper recognition for their work and to encourage the authors of this type of data sets that have not yet published in these global information networks to have the necessary incentives to do so.

A data paper should describe in the best possible way the Whom, What, Where, When, Why and How of documenting and recording of data, without becoming the instrument to make a detailed analysis of the data, as happens in other academic publications. To deepen this publishing model, it is recommended to consult Chavan & Penev (2011)[6].

[4] GBIF (2012). Recommended practices for citation of the data published through the GBIF Network. Version 1.0 (Authored by Vishwas Chavan), Copenhagen: Global Biodiversity Information Facility. Pp.12, ISBN: 87-92020-36-4. Accessible at http://links.gbif.org/gbif_best_practice_data_citation_en_v1

[5] GBIF (2011). GBIF Metadata Profile, Reference Guide, Feb 2011, (contributed by O Tuama, E., Braak, K., Copenhagen: Global Biodiversity Information Facility,19 pp. Accesible at http://links.gbif.org/gbif_metadata_profile_how-to_en_v1.

[6] Chavan, V. y L. Penev. 2011. The data paper: The mechanism to incentivize data publishing in biodiversity science. BMC Bioinformatics 12 (Suppl 15): S2.

## Which manuscripts are suitable for publication as data paper?

Manuscripts that describe datasets containing original primary biological records (data of occurrences in a particular place and time); information associated with specimens of biological collections, thematic or regional inventories of species, genomic data and all data likely to be structured with the standard *Darwin CoreDarwin Core*[7] (DwC). This standard is used in the community of authors publishing biodiversity datasets to structure the data and thus to consolidate and integrate from different sources globally. It is not recommended to submit manuscripts describing secondary datasets, such as biological records compilations from secondary sources (e.g. literature or compilations of records already published in networks such as GBIF or IABIN).

## Dataset preparation

As mentioned above data submitted in this process should be structured based on DwC standard. For ease of structuring, the Biodiversity Information System of Colombia (SiB Colombia), created two templates in Excel; one for occurrences and other for species checklist. Carefully read and follow the template instructions for structuring and publishing data. For any questions about the structure process of data please contact the Coordinator Team of SiB Colombia (EC-SiB) at sib+iac@humboldt.org.co

## Manuscript preparation

To assist the creation and structuring of the manuscript in the GMP standard, an electronic writing tool is available (http://ipt.sibcolombia.net/biota) to guide the author in the process and ultimately generate a first version of the manuscript. The use of GMP manual as an information guide to include in each section of the manuscript, as well as the annex 1 is recommended.

Steps required for the manuscript preparation:

1 Request access to the electronic writing tool at sib+iac@humboldt.org.co. The EC-SiB will assign a username and password.

2. Login to the electronic writing tool, then go to the tab Manage Resources and create a new resource by assigning a short name for your manuscript and clicking on the Create button. Use the format: "InstitutionAcronym_Year_DatasetFeature", e.g. NMNH_2010_rainforestbirds.

3. In the overview of the writing tool click on edit in Metadata section (please, do not use any other section), once there you will find different sections (right panel) that will guide you creating your manuscript. Save the changes at the end of each section, otherwise you will lose the information. Remember to use the GMP manual. Here are some recommendations for editing the metadata, sections are indicated in CAPS and the elements of these sections in **bold**.
   - In ASSOCIATED PARTIES include only those who are not listed in BASIC INFORMATION.
   - PROJECT DATA and COLLECTION DATA are optional depending on the data type. When using these sections extend or complement information already provided, i.e. do not repeat the same information describing the **description** (GEOGRAPHIC COVERAGE) in the **study area description** (PROJECT DATA).
   - Likewise, in SAMPLING METHODS, you must expand or complete the information, not repeat it. The information in **study extent** should give a specific context of the sampling methodology.
   - It is essential to document the **quality control** in SAMPLING METHODS. Here you should describe what tools or protocols were used to ensure the quality and consistency of data structured with DwC standard.
   - To create the **resource citation** in the CITATIONS section, follow one of the two formats proposed (Annex 2). Do not fill out the **citation identifier,** this will be provided later by the EC-SiB.
   - To include the manuscript bibliography in **citations**, enter each of the citations individually, adding a new citation each time by clicking in the bottom left.

4. Check that the format of the information provided meets the guidelines of the journal (e.g. abbreviations, units, number formatting, etc.) in the *Biota Colombiana* Guidelines for Authors.

5. Once included and verified all information in the writing tool, notify to EC-SiB at sib+iac@humboldt.org.co, indicating that you have finished editing the manuscript. Additionally attach the Excel template with structured data (remove all columns that were not used). The EC-SiB will perform corrections and final recommendations about the structure of the data and give you the final instructions to submit the paper.

## Submit the manuscript

Once you have finished editing your manuscript and getting the instructions from EC-SIB, send a letter submitting your article to email biotacol@humboldt.org.co, following the instructions of *Biota Colombiana* Guidelines for Authors.

Remember to attach:

- Excel template with the latest version of the data reviewed by the EC-SiB.
- Word document with figures and tables followed by a list of them.

At the end of the process, your information will be public and freely accessible in the data portal of SiB Colombia and GBIF. This will allow your data to be available for national and international audience, while maintaining credit to the authors and partner institutions.

[7] Biodiversity Information Standards – TDWG. Accesible at http://rs.tdwg.org/dwc/terms/

**Annex 1.** Basic structure of a data paper and its mapping to the writing tool elements based on GM.

| SECTION/SUB-SECTION HEADING | MAPPING WITH WRITING TOOL ELEMENTS |
|---|---|
| Title | Derived from the **title** element. |
| Authors | Derived from the **resource creator**, **metadata provider**, and **associated parties** elements. |
| Affiliations | Derived from the **resource creator**, **metadata provider** and **associated parties** elements. From these elements combinations of **organization**, **address**, **postal code**, **city**, **country** and **email constitute the affiliation**. |
| Corresponding author | Derived from the **resource contact**, **metadata provider** elements. |
| Citation | For editors use. |
| Resource citation | Derived from the **resource citation** element. |
| Resumen | Derived from the ***resumen*** element. 200 words max. |
| Palabras clave | Derived from the ***palabras clave*** element. 6 words max. |
| Abstract | Derived from the **abstract** element. 200 words max. |
| Key words | Derived from the **key words** element. 6 words max. |
| Introduction | Derived from the **purpose** (Introduction and Background section). A short text to introduce the following sections is suggested. For example, history or context of the biological collection or project related with the data described, only if that information is not present in subsequent sections. |
| Project data | Derived from elements **title**, **personnel first name**, **personnel last name**, **role**, **funding**, **study area description**, and **design description**. |
| Taxonomic Coverage | Derived from the taxonomic coverage elements: **description**, **scientific name**, **common name** and **rank**. |
| Geographic Coverage | Derived from the geographic coverage elements: **description**, **west**, **east**, **south, north**. |
| Temporal Coverage | Derived from the temporal coverage elements: **temporal coverage type**. |
| Collection data | Derived from the collection data elements: **collection name**, **collection identifier**, **parent collection identifier**, **specimen preservation method** and **curatorial units**. |
| Materials and methods | Derived from the sampling methods elements: **study extent**, **sampling description**, **quality control** and **step description**. |
| Resultados | |
| Descripción del conjunto de datos | Derived from the discussion and acknowledgments, contains information about the format of the data and metadata: **hierarchy level**, **date published** and **ip rights.** |
| Discussion | Derived from the discussion element. A short text (max 500 words), which can refer to the importance, relevance, usefulness or use that has been given or will give the data in the published literature or in subsequent projects. |
| Acknowledgments | Derived from the **acknowledgments** element. |
| Bibliography | Derived from the **citations** element. |

**Annex 2.** Citation style quick guide for "resource reference" section.

The Resource Reference is the one that refer to the dataset described by the paper, publicly available through SiB Colombia and GBIF networks. Note that this reference may differ from the one of the paper. For more information about this element contact EC-SiB.

Here two formats are suggested; however you can consult other formats established by GBIF[8].

| TYPE OF RESOURCE | TEMPLATE | EXAMPLE |
|---|---|---|
| The paper is the result of a collective or institutional project with multiple participants. | <Institution/Research Group>. <Year>, <Title of the Resource/Paper>. <Number of total records>, <provided by :> <associated party 1 (role), associated party 2 (role), (…)>. <Online,> <resource URL>, <published on>. <Published on DD/MM/AAAA>. | National Biodiversity (2013). Vertebrates in Orinoco, 1500 records, provided by: Perez, S. (Principal investigator, content provider), M. Sanchez (Processor), D. Valencia (Custodian Steward, metadata provider), R. Rodriguez (Processor), S. Sarmiento (Publisher), VB Martinez (Publisher, Editor). Online, http://ipt.sibcolombia.net/ biota/resource.do?r=verte_orin, published on 01/09/2013. |
| The paper is the result of a personal initiative or a defined research group. | <associated party 1, associated party 2, (…)>. <Year>, <Title of the Resource/Paper>, <Number of total records>, <Online,> <resource URL>. <Published on DD/MM/AAAA>. | Valencia, D., R. Rodríguez and V. B. Martínez. (2013). Vertebrate Orinoco Basin, 1500 records, Online, http://ipt.sibcolombia.net/biota/resource.do?r=verte_orin, published on 01/09/2001 |

[8] GBIF (2012). Recommended practices for citation of the data published through the GBIF Network. Version 1.0 (Authored by Vishwas Chavan), Copenhagen: Global Biodiversity Information Facility. Pp.12, ISBN: 87-92020-36-4. Accessible at http://links.gbif.org/gbif_best_practice_data_citation_en_v1

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| The paper is the result of a personal initiative or a defined research group. | <associated party 1, associated party 2, (…)>. <Year>, <Title of the Resource/Paper>, <Number of total records>, <Online,> <resource URL>. <Published on DD/MM/AAAA>. | Valencia, D., R. Rodríguez and V. B. Martínez. (2013). Vertebrate Orinoco Basin, 1500 records, Online, http://ipt.sibcolombia.net/biota/resource.do?r=verte_orin, published on 01/09/2001 |

[8] GBIF (2012). Recommended practices for citation of the data published through the GBIF Network. Version 1.0 (Authored by Vishwas Chavan), Copenhagen: Global Biodiversity Information Facility. Pp.12, ISBN: 87-92020-36-4. Accessible at http://links.gbif.org/gbif_best_practice_data_citation_en_v1

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Missouri Botanical Garden

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