
HABITAT USE BY TWO SPECIES OF *HYPOSTOMUS* (PISCES, LORICARIIDAE) IN SOUTHEASTERN BRAZILIAN STREAMS

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Abstract

In this study, habitat use of the armored catfishes *Hypostomus ancistroides* and *Hypostomus* sp. was investigated in 21 streams from the Upper Rio Paraná system in São Paulo State, Brazil, a pasture dominated region. The abundance of *Hypostomus* sp. was positively correlated with the amount of riffles and riparian vegetation condition, whereas *H. ancistroides* abundance was negatively correlated with riparian vegetation condition. Thirteen ecomorphological attributes analyzed by principal component analysis showed that when compared to *H. ancistroides*, *Hypostomus* sp. presented a wider mouth and more flattened body, suggesting an adapted body to faster waters. The most abundant populations of *Hypostomus* sp. were predominantly associated with good riffle availability and good riparian quality, suggesting that populational features of this species may be incorporated in the stream biotic integrity assessment in that region.

Key words: armored catfishes, upper Rio Paraná, ecomorphology, diet, habitat partitioning

Resumo

Neste estudo investigamos o uso do hábitat dos cascudos *Hypostomus ancistroides* e *Hypostomus* sp. em 21 riachos localizados em uma paisagem dominada por pastagens no sistema do Alto Rio Paraná no Estado de São Paulo, Brasil. A abundância de *Hypostomus* sp. foi positivamente correlacionada com a extensão de corredeiras e condição da vegetação ripária enquanto que a abundância de *H. ancistroides* foi negativamente correlacionada com a condição da vegetação ripária. Treze atributos ecomorfológicos, processados em uma análise de componentes principais, mostraram que quando comparada com *H. ancistroides*, *Hypostomus* sp. possui abertura bucal mais ampla e corpo mais achatado, sugerindo uma forma de corpo adaptada a ambientes correntosos. Populações mais abundantes de *Hypostomus* sp. estiveram predominantemente associadas a riachos com boa disponibilidade de corredeiras e boa qualidade ripária, sugerindo que atributos populacionais dessa espécie possam ser posteriormente incorporados à avaliação da integridade biótica dos riachos de nossa região.

Palavras-chave: cascudos, Alto Rio Paraná, ecomorfologia, dieta, partilha de hábitat

Introduction

As part of aquatic ecosystems with well defined physical features, streams are useful models for developing ecological concepts related to distribution, abundance, and coexistence of organisms, as well as for evaluating the influence of physical disturbances affecting the biota (Esteves & Aranha 1999). In stream fish communities, resource partitioning is one of the most important ecological aspects, because it allows the comprehension of the inter-relations between species, showing the main resource dimensions in which species segregate (Ross 1986).

In small streams, many fishes present broad tolerance to habitat types and relative flexibility in their feeding behaviour, sharing many resources with other species (Lowe-McConnell 1987). Resource partitioning can also be suggested by ecomorphological models, which predict that one species is correspondent to its morphological mosaic (Miller 1984) and, therefore, species with similar morphological

patterns could be able to use similar resources, maximizing resource partitioning to avoid competition.

With the rapid and widespread decline and the endangerment of drainages, there is an urgent need to define fish habitat requirements to elaborate adequate species management and future habitat restoration (Rosenfeld 2003), especially in those environments seriously threatened by anthropogenic pressures such as the northeastern portion of the São Paulo State in Brazil, where pasture represents more than 70% of the land use. In a recent survey on that area, we registered that the armored catfishes *Hypostomus* sp. and *H. ancistroides* (Fig. 1) show a non congruent pattern of distribution among streams, suggesting habitat partitioning. Aiming to investigate the habitat use for both species, we correlated their abundances with stream habitat features. Because habitat occupation is notably correlated to fish morphology and feeding, we also analyzed these two niche dimensions.

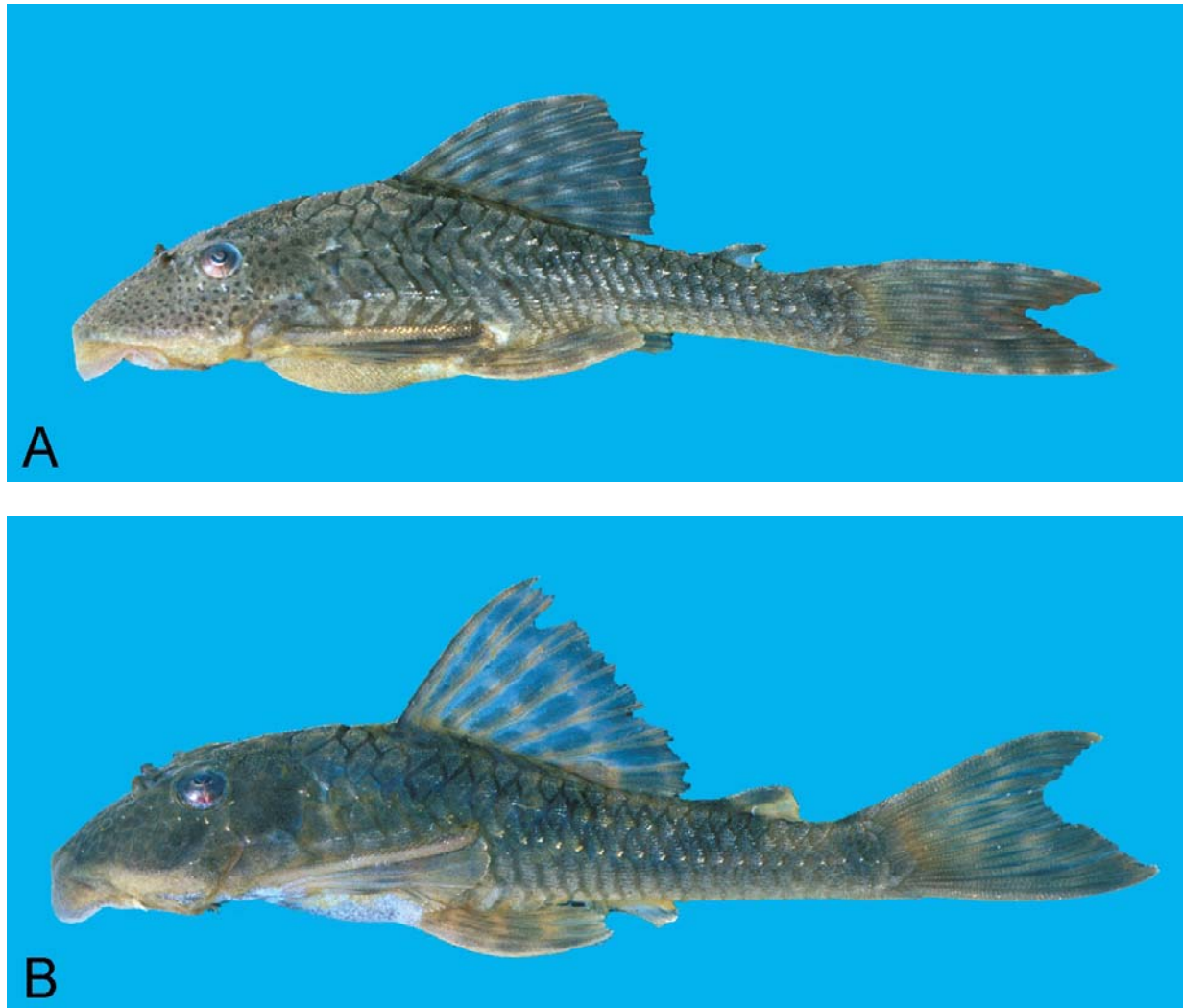


Figure 1. (A) *Hypostomus ancistroides* (LIRP 2716, 55.2 mm standard length). (B) *Hypostomus* sp. (LIRP 2672, 86.7 mm standard length) collected in the Rio São José dos Dourados system, southeastern Brazil (photos: Ricardo M.C. Castro).

Material and methods

Study sites and sampling

The study area is located at the northwestern portion of São Paulo State, southeastern Brazil, and encompasses the Rio São José dos Dourados system, which covers 6,805 km² (IPT 2000). Climate presents a wet season from October to March (January and February are the wettest months, with 53.7% of the annual rainfall), and a dry season from April to September (Barcha & Arid 1971). The maximum mean temperature is recorded in January (32°C) and the minimal in July (13°C) (IPT 2000). From the original vegetation in that river system (Semi-Deciduous forests and Savannah), only 3.3% remains, a percentage that is very altered, fragmented, and unconnected (SMA / IF 2005).

Sites (Table 1, Fig. 2) were randomly selected in a 1:50,000 map base, aiming to cover the entire extension of the São José dos Dourados system. Four habitat descriptors (amount of riffles, mean depth, large wood debris, and riparian vegetation condition, see Table 1) for each site were taken. The amount of riffles for each stream reach was visually estimated as (1) absent, (2) present (occurring in less than 50% of the stream reach), (3) extensive (occurring in more than 50% of the stream reach). Mean depth was evaluated by bathymetry in all mesohabitat. Large wood debris were estimated as (1) absent, (2) present (occurring only in isolated pools), (3) extensive (occurring in the majority of pools). Riparian vegetation condition was scored (from 0 to 20) according to previous published physical habitat protocols (Barbour et al. 1999, Roth et al. 2001), considering both width and integrity of riparian vegetation.

Table 1. Coordinates, habitat descriptors, and number of specimens collected in 21 stream reaches studied in the Rio São José dos Dourados system, southeastern Brazil. Riparian condition was scored from 0 to 20 according to Barbour et al. (1999) and Roth et al. (2001).

Streams	Coordinates	Riffles	Mean depth (cm)	Large wood debris	Riparian condition	<i>Hypostomus ancistroides</i>	<i>Hypostomus</i> sp.
1	49°34'52.2"W 20°46'45.7"S	present	70	absent	0	24	0
2	49°42'36.0"W 20°42'53.0"S	present	100	extensive	3	11	0
3	49°48'41.5"W 20°43'02.5"S	present	70	present	3	6	0
4	49°53'05.7"W 20°41'16.5"S	present	60	present	3	5	0
5	49°58'05.7"W 20°36'46.4"S	absent	140	present	0	21	0
6	50°01'15.9"W 20°40'27.4"S	present	110	present	2	1	1
7	50°01'17.4"W 20°37'53.3"S	present	90	extensive	4	2	8
8	50°16'54.2"W 20°35'51.3"S	absent	120	absent	0	25	0
9	49°53'13.1"W 20°28'32.6"S	extensive	40	present	2	1	1
10	50°15'47.8"W 20°26'39.2"S	extensive	100	absent	3	6	56
11	50°17'03.9"W 20°19'45.9"S	present	70	absent	3	1	0
12	50°23'04.8"W 20°18'51.7"S	present	40	absent	5	0	1
13	50°19'15.0"W 20°31'41.6"S	extensive	40	present	3	7	20
14	50°25'20.0"W 20°36'08.9"S	present	80	absent	0	8	0
15	50°22'17.8"W 20°37'43.1"S	absent	40	absent	0	10	0
16	50°34'05.0"W 20°36'20.7"S	absent	30	absent	0	8	0
17	50°45'29.2"W 20°35'49.5"S	present	20	absent	5	3	0
18	50°35'08.6"W 20°22'58.6"S	present	70	absent	3	4	2
19	50°35'06.1"W 20°27'48.5"S	present	15	absent	2	1	0
20	50°40'42.6"W 20°20'51.3"S	absent	100	absent	3	1	0
21	50°55'37.1"W 20°31'08.1"S	extensive	60	absent	0	23	0

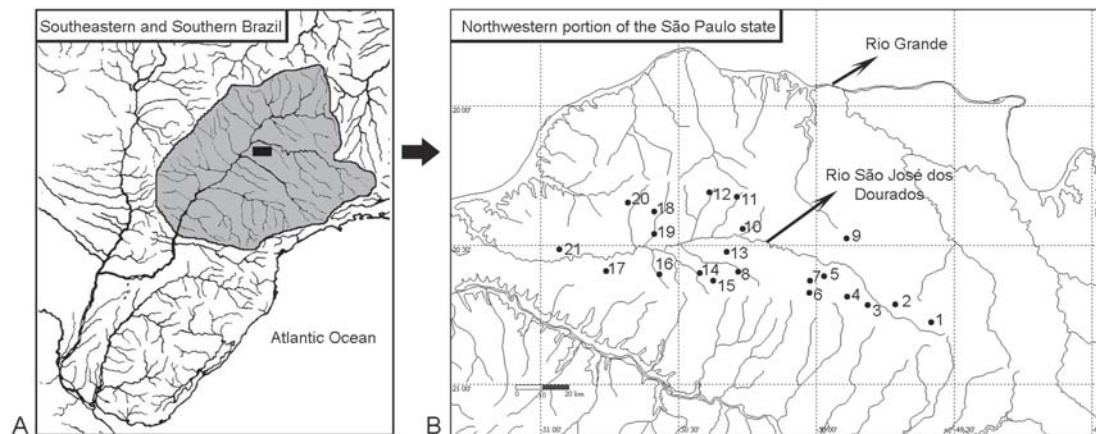


Figure 2. (A) Location of the studied area in the upper Rio Paraná system (grey). (B) Location of the stream reaches studied in the São José dos Dourados system.

Fishes were collected during a dry season by electrofishing (modified from Mazzoni et al. 2000 and Castro et al. 2003), and fixed in 10% formalin solution. Later, they were preserved in a 70% EtOH solution and deposited in the collection of the “Departamento de Zoologia e Botânica, Universidade Estadual Paulista”, São José do Rio Preto, São Paulo State, Brazil (DZSJRP 5844, 5853, 5865, 5879, 5888, 5911, 5932, 5948, 5949, 5967, 5979, 5997, 5998, 6007, 6007, 6016, 6036, 6037, 6048, 6055, 6071, 6083, 6105, 6106, 6118, 6136, 6174). Additional voucher specimens are deposited in the “Laboratório de Ictiologia de Ribeirão Preto, Universidade de São Paulo”, Ribeirão Preto, São Paulo State, Brazil (LIRP 2716, 2672).

Analysis

Niche width for mesohabitat was calculated through the standardized Levin's measure (B_A) (Krebs 1999), using proportional abundance for each species in each category of riffle availability (absent, present, extensive). To establish correlations between abiotic descriptors and species abundance in the sites where at least one species were collected ($n=21$), data set normality was initially tested and, afterwards, Spearman rank correlation coefficients were calculated (Zar 1999).

To investigate species segregation in the morphological space, 13 attributes were calculated for 18 individuals of each species belonging to similar size classes. Nine attributes were selected following previous ecomorphological studies (Mahon 1984, Watson & Balon 1984, Balon et al. 1986, Winemiller 1991, Beaumord & Petrere 1994): compression index, relative depth, relative caudal peduncle length, caudal peduncle compression index, relative area of dorsal fin, relative area of pectoral fin, pectoral fin aspect ratio, relative area of caudal fin, caudal fin aspect

ratio, relative head length, eye position, and relative mouth width. An additional attribute, oral disc area, calculated by its projection on millimetric paper, was included herein, because this structure helps armored catfishes to remain attached to substrates (Buck & Sazima 1995, Casatti & Castro 1998), and larger areas are hypothesized to help the fish to hold position in fast flowing waters. Measurements were made with digital caliper (0.1 mm) and fin areas were calculated by their projection on millimetric paper (Beaumord & Petrere 1994). Multivariate analysis of morphological data was conducted by principal component analysis using a log-transformed data and a correlation matrix according to Valentin (1995).

Stomach contents were examined from eight adult individuals with similar size of each species collected in the only two streams (10 and 13) where such conditions were found. The anterior 1 cm of each digestive tube was removed, the contents were divided in two microscope slides which were directly examined in optical microscope. The identification was conducted with the help of specialized literature (Bicudo & Bicudo 1970) and revised by a specialist. For each item the frequency of occurrence (Bowen 1992) was calculated.

Results

Hypostomus ancistroides ($n=168$) was more abundant than *Hypostomus* sp. ($n=89$) and occurred in 20 localities whereas *Hypostomus* sp. was registered in seven streams (Table 1). Abundance of *Hypostomus* sp. was positively correlated to the amount of riffles and riparian vegetation condition, whereas *H. ancistroides* abundance was correlated with riparian vegetation condition (Table 2). Niche width was 0.15 for *Hypostomus* sp. and 0.92 for *H. ancistroides*, indicating a higher specialization in using riffle areas for the former species.

The first two axis of the PCA explained 56% of the total variance. PCA plot showed complete segregation between two species, notably in the first component (Fig. 3). When compared to *H. ancistroides*, *Hypostomus* sp. presents more flattened bodies and wider mouths (Table 3).

Cyanobacteria, chlorophytes, diatoms, and vegetal debris were the most frequent items (75% of occurrence) in the stomach contents (Table 4), but no significative differences in the diet composition were detected ($U=28$, $p=0.67$).

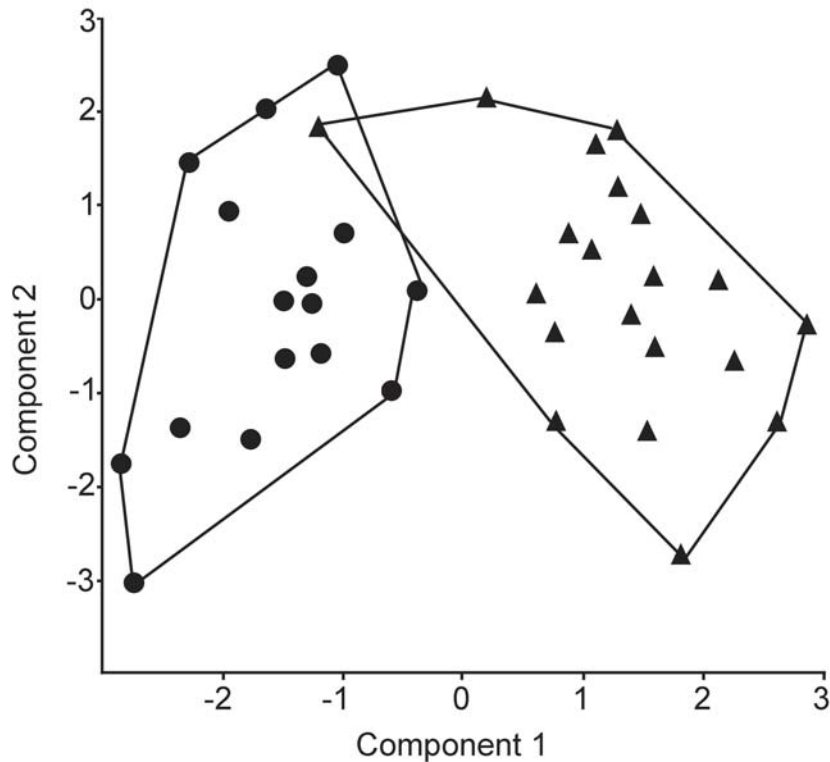


Figure 3. Principal component plot on ecomorphological data of *Hypostomus ancistroides* (circles) and *Hypostomus* sp (triangles).

Table 2. Spearman's rank correlations (p -values in parenthesis) between habitat descriptors and abundance of *Hypostomus ancistroides* and *Hypostomus* sp. in 21 stream reaches studied in the Rio São José dos Dourados system, southeastern Brazil. Bold values indicate significance at 0.05.

Descriptors	<i>Hypostomus ancistroides</i>	<i>Hypostomus</i> sp.
Riffles	-0.1896 (0.4103)	0.5438 (0.0108)
Mean depth	0.2667 (0.2424)	0.0594 (0.7982)
Large woody debris	-0.0384 (0.8688)	0.2549 (0.2647)
Riparian vegetation condition	-0.6370 (0.0019)	0.4340 (0.0492)

Table 3. Loadings of the 13 ecomorphological attributes on the first two principal components. Bold values indicate the highest loadings for each axis.

Attributes	Axis 1	Axis 2
Compression index	-0.5571	0.0054
Relative depth	-0.3382	-0.2544
Relative caudal peduncle length	-0.0293	0.3025
Caudal peduncle compression index	0.2700	0.1153
Relative area of dorsal fin	-0.3002	0.0876
Relative area of pectoral fin	0.2921	0.1594
Pectoral fin aspect ratio	-0.0365	-0.4889
Relative area of caudal fin	-0.0019	0.5158
Caudal fin aspect ratio	-0.0296	0.3234
Relative head length	0.0319	0.0789
Eye position	0.2890	0.0492
Relative mouth width	0.4655	-0.2009
Oral disk area	0.1506	-0.3724
Total variance (%)	32	24

Table 4. Frequency of occurrence (%) of the feeding items in the stomach of *H. ancistroides* and *Hypostomus* sp. in two stream reaches studied in the Rio São José dos Dourados system, southeastern Brazil.

Items	<i>Hypostomus ancistroides</i>	<i>Hypostomus</i> sp.
Cyanobacteria:	100	87
<i>Lyngbya</i>	25	75
<i>Oscillatoria</i>	37	62
<i>Raphidiopsis</i>	-	12
<i>Merismopedia</i>	37	-
Undetermined genus	75	50
Bacillariophyceae:	100	100
Pennales	100	100
Clorophyta:	100	100
<i>Oedogonium</i>	62	62
<i>Closterium</i>	50	50
<i>Cosmarium</i>	-	12
<i>Pediastrum</i>	12	-
undetermined Desmidiaceae	62	50
Nematoda	-	25
Fungi spores	-	12
Vegetal debris	75	57
Vegetal organic matter	100	75

Discussion

Several hypostomins are known for a closer association with fast flowing environments where they display a bottom-dwelling behavior, feeding on attached algae (Garavello & Garavello 2004). Although *Hypostomus ancistroides* is considered a typical stream species (Castro & Casatti 1997), the occupation of faster mesohabitats seems not a pattern for it in this study. In our samples, this species was more abundant in slower streams, in contrast to *Hypostomus* sp., more abundant in faster waters. Similar segregation between *H. ancistroides* and a non-determined *Hypostomus* was firstly mentioned by Uieda et al. (1997) in a stream from the Alto Rio Paraná system, where the authors observed *H. ancistroides* foraging in pools reaches and *Hypostomus* sp. in riffles. Concordantly, in a pristine first order stream *H. ancistroides* was abundant in the inferior reaches where pools predominated, in contrast to *H. nigromaculatus*, abundant in the upper reaches dominated by riffles (Casatti 2005).

When cogenetics occur in the same stream, mesohabitats patches must shape the abundance of each species and such differential occupation can also be suggested by external morphology, suggesting that *Hypostomus* sp. has a body shape more adapted to fast flowing environments. In this species, a wider mouth can enhance grazing in faster waters and a more flattened body indicates a better capacity to maintain the position on the bottom (Mahon 1984).

Distinct mesohabitats dwelling could suggest distinct diet composition; we observed, however, high diet similarity between both species when collected in the same streams. This similarity indicates that periphyton is probably an abundant resource in the studied sites, and that partitioning, especially spatial, of feeding resources could be shaping the coexistence of both species. In Central America streams, Power (1984a) observed that periphyton grew faster in sunny pools than in dark pools, that the density of loriciariids corresponded to algae productivity and a positive correlation between annual density of loriciariids and canopy opening. None of the studied streams have dense canopies and periphyton must not be a limiting factor in these environments. Such availability of periphyton in streams was already suggested by Uieda et al. (1997) in southeastern Brazil.

Hypostomins are active mostly after sunset; during the day they remain under rocks or submerged logs (Weber 2003), but such a pattern is not a rule and it may vary according to body size (Power 1984b, Buck & Sazima 1995). For the species studied here, this pattern was not checked because the high water turbidity in the sampled streams restricted the use of underwater techniques for direct observation. Temporal segregation, however, was observed for another pair of *Hypostomus* species in a pristine stream, where *H. nigromaculatus* was active after the middle of the day up to the nightfall and *H. ancistroides* started foraging after nightfall, scraping periphyton off submerged large wood debris (Casatti 2002).

The main source of large wood debris for instream habitats is the riparian vegetation, influencing not only habitat features but also providing substrate for periphyton and aquatic invertebrates (Angermeier & Karr 1984). In the studied streams riparian vegetation do not play this role, because most localities are deforested and, even when riparian vegetation is present, its condition is poor (i.e., predominance of juvenile trees, bamboos, and arbustive vegetation). In pristine conditions, in contrast, woody fragments are abundant, being the preferable microhabitat, where *H. ancistroides* forages (Casatti 2002). In the absence of large wood debris, *H. ancistroides* - a more generalist species in respect to habitat occupation - forages in more diverse substrates, thus, probably representing a species which is less affected by structural habitat degradation, remarkably siltation enhancement that often is a consequence of riparian vegetation removal (Gregory et al. 1991, Rabeni & Smale 1995, Wichert & Rapport 1998). This assumption is reinforced by the negative correlation between riparian vegetation condition and *H. ancistroides* abundance. In contrast, expressive populations of *Hypostomus* sp. (15-20% of the ichthyocenosis abundance) were predominantly associated to streams with good riffle availability and good riparian quality, suggesting that populational features of this species may be incorporated in stream biotic integrity regional assessments.

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