Length structure of fishes from a protected area in the State of São Paulo, Southeastern Brazil

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ABTRACT. The aim of this work was to study the length distribution of some fish species from the Protected Area of São Pedro and Analândia, State of São Paulo, Southeastern Brazil. Length distributions were correlated to environmental conditions at each sample site. For the most abundant species, length structure was compared among the streams of each basin and between basins. Differences in length structure were related to differences in growth, habitats, and even population.

Key words: protected area of São Pedro and Analândia, growth.

RESUMO. Estrutura em comprimento dos peixes de uma área protegida no Estado de São Paulo, Sudeste do Brasil. O objetivo deste trabalho foi o de apresentar as distribuições de comprimentos para algumas espécies de peixes na Área de Proteção Ambiental de São Pedro e Analândia, relacionando-as com as condições prevalecentes em cada local de amostragem. A estrutura em comprimento foi analisada entre os ribeirões de cada bacia e entre as bacias, para as espécies mais abundantes. As diferenças nas estruturas de comprimentos para algumas espécies entre os locais de coleta e entre as bacias evidenciaram diferentes condições de crescimento, habitats ou até de populações.

Palavras-chave: área de proteção ambiental de São Pedro e de Analândia, crescimento.

Introduction

Size is one of the most important traits of an organism which determines the nature of interaction with other organisms and also demographic characteristics. Size exerts a great influence on animal energy expenditure potential to exploit resources and susceptibility for natural diseases (Werner and Gilliam, 1984). In general, tropical fishes tend to be smaller than fishes of colder places; this is due to their high metabolic rates (Pauly, 1998). The size some species can reach is partially genetically determined and partially due to environmental conditions (Lowe-McConnell, 1999).

Fish communities are not only structured by the species, but also by resource allocation correlated with fish size, within and among the different species (Holmgren and Appelberg, 2000). Although, such implications are ignored when dealing with interactions among species that exhibit different body sizes populations (Werner and Gilliam, 1984).

Fish communities probably are not responding to a specific factor of a given site, such as unique water characteristic or qualitative variable of the habitat, but instead, they respond to general conditions of aquatic ecosystem (Brown, 2000).

The aim of this work was to study the length distribution of some fish species at the Protected Area of São Pedro and Analândia, State of São Paulo, Southeastern Brazil. Length distributions were correlated to environmental conditions at each sample point, with the objective of verifying if the length distributions vary in different environmental conditions in the sample points and between basins.

Material and methods

The region under study is located in a protected area in the "*cuestas*" of São Pedro and Analândia. The protected area (APA) latitudes are between 22° and 23°S and the longitudes are 47° 30' and 48° 30'W. The area is on the *Depressão Periférica* and on the basaltic "*cuestas*", both in the interior of the State of São Paulo, southeastern Brazil. A tropical altitude climate (CWa) predominat in the region, which is characterized by mean annual temperatures between 18° and 22°C, with warm and wet summers and dry

winters. Rainfall varies from 1,400 mm in the upper parts to 1,100 mm. The study site has approximately 2,700 km² and comprises part of the municipalities of Itirapina, Brotas, São Pedro, Dois Córregos, Santa Maria da Serra, Torrinha, São Carlos, Analândia, Ipeúna, Mineiros do Tietê, Rio Claro, Barra Bonita, Corumbataí, and Itaqueri da Serra.

After preliminary analysis in the region, two study areas were determined: 1. Corumbataí River sub-basin, with four sample sites: Cabeça River - 22º 22' 49" S, 47º 39' 55" W, with 601 m of altitude, Lapa Stream - 22º 23' 38" S, 47º 47' 16" W, with 633 m of altitude, Passa-Cinco River - 22º 25' 02" S, 47º 42' 47" W, with 567 m of altitude, and Corumbataí River - 22º 08' 15" S, 47º 39' 37" W, with 615 m of altitude; 2. Jacaré-Pepira River basin, with three sample sites: Tamanduá Stream - 22º 21' 17" S, 47º 45' 00" W, with 642 m of altitude, Jacaré-Pepira River - 22º 17' 53" S, 48º 11' 35" W, with 490 m of altitude, and Água Branca Stream - 22º 26' 20" S, 48º 47' 45" W, with 841 m of altitude.

A total of 12 samples were collected bimonthly, from February 2000 to December 2001.

Individuals were collected in many parts of the water course at each sample point, using gill nets with mesh sizes of 1.5; 2.0; 2.5, and 3.0 cm, measured between adjacent knots, with 5 m in length and 1.5 m high. Each set of nets totalized 30 m². Besides the nets, purse seine with mesh sizes of 1.5 cm and 1.5 m high, sieves, and traps were also used whenever possible.

Sample effort was standardized keeping time and quantity of fishery instruments employed at each point constant. The gill nets were submerged from the end of the day up to the next morning. Afterwards, specimens were kept in plastic containers with 10% formalin. Each container received a label describing date and sample site. Fishes were identified in the laboratory up to the lowest taxonomic level. Total lengths were measured in centimeters (Braga, 1990).

Length structure was analyzed for the most abundant species. Length distribution of fishes was analyzed through the Kruskal-Wallis (more than two sites) (Siegel, 1975) and Kolmogorov-Smirnov to two sites (Vanzolini, 1993) tests, which were compared among streams in the same basin (Corumbataí and Jacaré-Pepira Basins) and sometimes between basins.

Results

Analyzed species were: *Hypostomus strigaticeps* (Regan, 1907), *Astyanax altiparanae* Garutti and Britski, 2000, *Astyanax scabripinnis* (Eigenmann, 1914), *Characidium* aff. *zebra* Eigenmann, 1909, *Piabina argentea* (Reinhardt, 1867), *Hypostomus ancistroides* (Ihering, 1911), *Hypostomus* sp1., and *Astyanax* sp1.

Families and species names, with their respective numeric and occurrence site, are listed in Table 1.

Table 1. Species analyzed and their occurrences in each sample site: Corumbataí Basin: 1. Cabeça River, 2. Lapa Stream, 3. Passa-Cinco River, 4. Corumbataí River; Jacaré-Pepira Basin: 5. Tamanduá Stream, 6. Jacaré-Pepira River, and 7. Água Branca Stream.

Family	Species	1	2	3	4	5	6	7
Characidae	*Astyanax altiparanae*	26	145	65		40	28	
Characidae	*Astyanax scabripinnis*		427	97				
Characidae	*Astyanax* sp1.		114	73				762
Characidae	*Piabina argentea*		90	239				
Crenuchidae	*Characidium* aff. *zebra*			52		2	4	
Loricariidae	*Hypostomus ancistroides*	43	77	21				
Loricariidae	*Hypostomus* sp1		12	13			21	
Loricariidae	*Hypostomus strigaticeps*	34	113	74	83	21	38	

Parameters of environmental conditions at each sample point are shown in Table 2.

Table 2. Parameters of environmental conditions in each sample point: Corumbataí Basin: 1. Cabeça River, 2. Lapa Stream, 3. Passa-Cinco river, 4. Corumbataí River; Jacaré-Pepira Basin: 5. Tamanduá Stream, 6. Jacaré-Pepira River, and 7. Água Branca Stream.

Parameters	1	2	3	4	5	6	7
Width (m) Mean±S.D	10.9±1.7	4.4±0.8	11.2±1.3	7.1±0.8	9.2±2.4	14.8±2.3	1.2±1
Depth (cm)	30-100	0-30	30-100	30-100	30-100	>100	30-100
Current speed (m/s)	0.2-0.4	0.05-0.2	0.2-0.4	0.4-1	0.4-1	0.4-1	<0.05

Results of statistical tests (Kruskal-Wallis and Kolmogorov-Smirnov) for the eight species analyzed in both basins are shown in Table 3.

Length distribution of the species *Hypostomus strigaticeps*, *Astyanax altiparanae*, *Astyanax scabripinnis*, *Characidium* aff. *zebra*, *Piabina argentea*, and *Hypostomus* sp.1 did not differ significantly among streams of the Corumbataí River basin ($p > 0.05$), but for the species *Hypostomus ancistroides* and *Astyanax* sp.1 differences were significant ($p < 0.05$).

Table 3. Length structure analysis of the most abundant species captured in the streams of the Corumbataí and Jacaré-Pepira basins.

Species	Corumbataí	Jacaré -Pepira	Between basin
A. altiparanae	H=5.16 (p>0.05)	x^2=24 (p<0.05)	x^2=12.1 (p<0.05)
A. scabripinnis	H=5.85 (p>0.05)		
Astyanax sp1.	x^2=9.38 (p<0.05)		x^2=173.1 (p<0.05)
P. argentea	x^2=2.61 (p>0.05)		
C. aff. *zebra*	x^2=0.79 (p>0.05)		x^2=1.61 (p>0.05)
H. ancistroides	H=7.74 (p<0.05)		
Hypostomus sp1	x^2=0.74 (p>0.05)		x^2=3.32 (p>0.05)
H. strigaticeps	H=0.70 (p>0.05)	x^2=2.25 (p>0.05)	x^2=3.27 (p>0.05)

H = result of the Kruskal – Wallis test; x^2 = result of the Kolmogorov-Smirnov test; p>0.05 = similar length structures; p<0.05 = different length structures.

A. altiparanae occurred in greater quantity in the Lapa stream. There were not specimens with length superior to 14 cm or inferior to 6 cm in the three sampled sites (Cabeça River, Lapa Stream, and Passa-Cinco River). *Astyanax altiparanae* occurred in the Tamanduá and Jacaré-Pepira rivers and exhibited significant differences ($p < 0.05$); the inferior length classes were more frequent in the former river (Figure 1).

For *A. scabripinnis*, few specimens inferior to 4 cm were captured, but length classes showed less amplitude in the Passa-Cinco River population compared to the Lapa Stream (Figure 2).

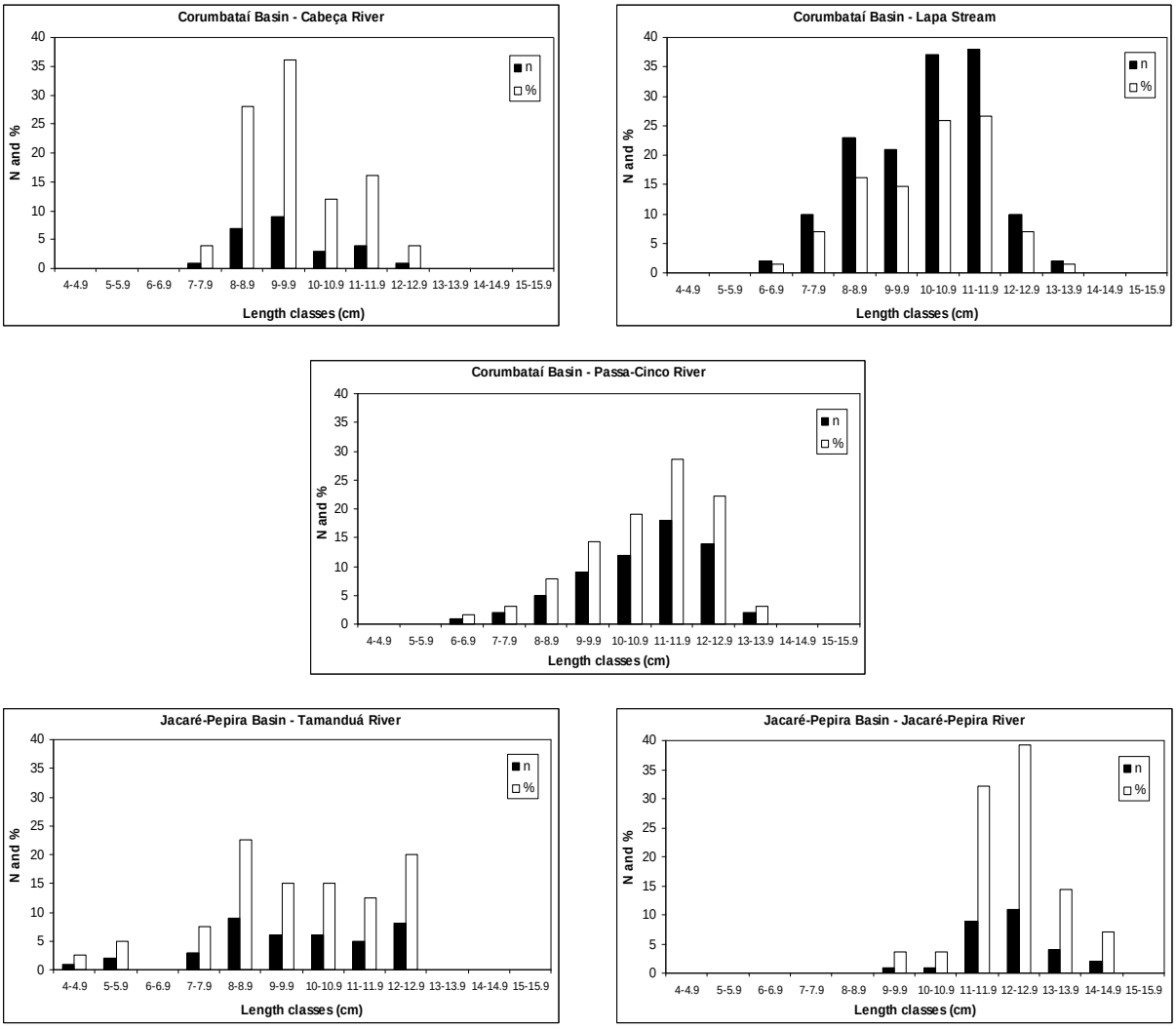

Figure 1. Length distribution of *Astyanax altiparanae* in the sampled sites in the Corumbataí and Jacaré-Pepira basins.

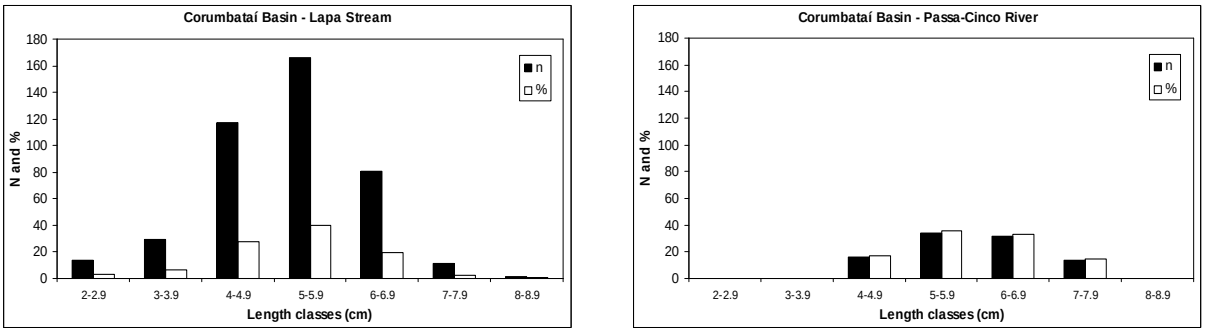

Figure 2. Length distribution of *Astyanax scabripinnis* in the sampled sites in the Corumbataí basin.

Individuals of *Astyanax* sp.1 were smaller in the Passa-Cinco River, but showed greater amplitude of length classes compared to the Lapa Stream. We verified polimodal distributions at both sites (Figure 3).

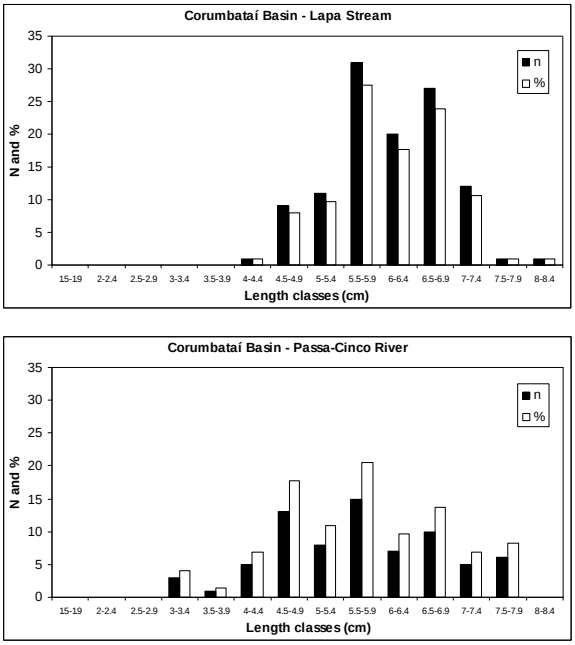

Figure 3. Length distribution of *Astyanax* sp1 at the sampled sites in the Corumbataí basin.

In the Corumbataí basin, length classes of *P. argentea* were very similar both in the Lapa Stream and in the Passa-Cinco River. However the species were more abundant in the Passa-Cinco River (Figure 4).

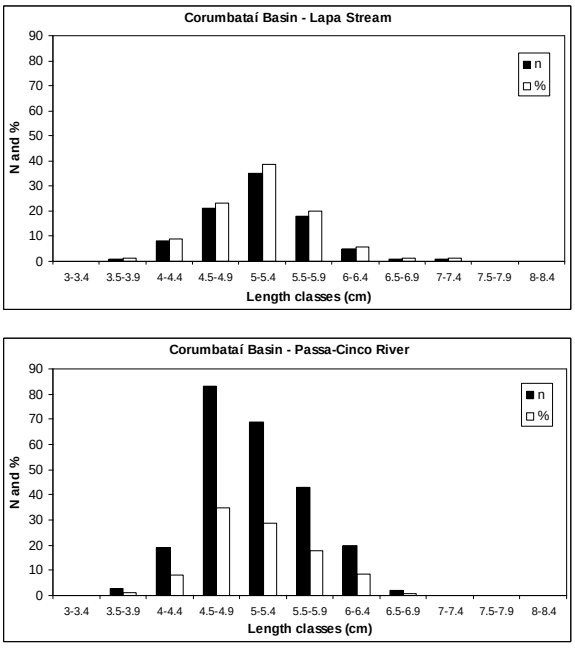

Figure 4. Length distribution of *Piabina argentea* at the sampled sites in the Corumbataí basin.

The species *C.* aff. *zebra* occurred in sufficient number to be analyzed only in the Passa-Cinco River, where distribution showed to be unimodal.

Another cascudo, *H. ancistroides*, occurred in the Cabeça River, Lapa Stream, and Passa-Cinco River. Length class distribution was very different among these rivers (Figure 5).

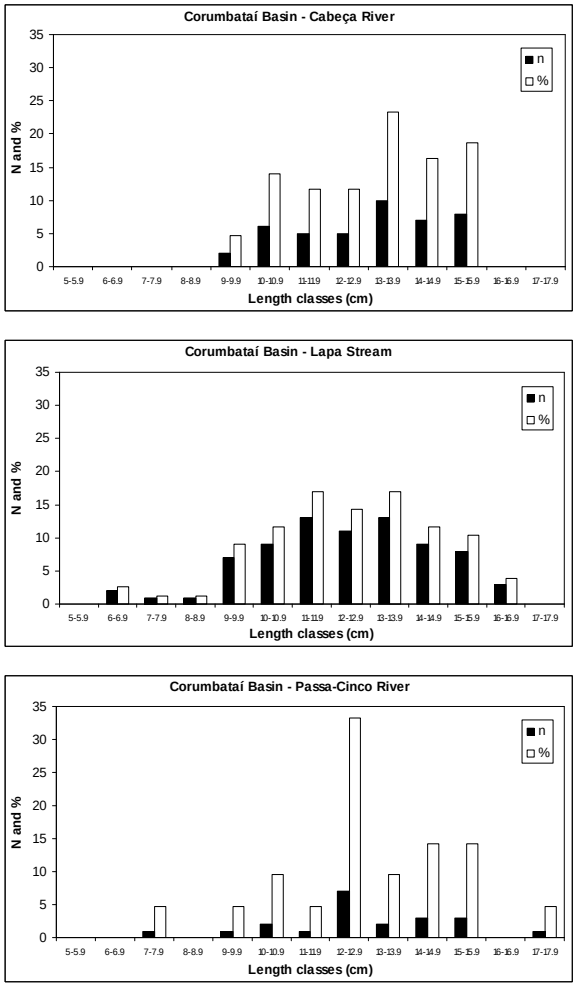

Figure 5. Length distribution of *Hypostomus ancistroides* at the sampled sites in the Corumbataí basin.

The cascudo Hypostomus sp.1 occurred in the Lapa Stream and Passa-Cinco River, however amplitude of distribution was higher in the Passa-Cinco River.

The species H. strigaticeps, in the Corumbataí basin, showed the highest total length in the Corumbataí River and the smallest in the Lapa Stream and Passa-Cinco River. In the Jacaré-Pepira basin, H. strigaticeps occurred mainly in the Jacaré-Pepira River, with polimodal distribution, and did not show significant differences among streams ($p > 0.05$).

In the Corumbataí basin, length distributions of H. strigaticeps showed that larger individuals occurred in large rivers, as the Passa-Cinco River and Corumbataí River (Figure 6).

Comparing the two basins, *H. strigaticeps*, *C.* aff. *zebra*, and *Hypostomus* sp.1 did not show significant differences in length distribution ($p > 0.05$); however, length distribution of the species *A. altiparanae* and *Astyanax* sp.1 differed significantly ($p < 0.05$).

Length class distribution was uniform for the three first species when all specimens from each basin were considered. The lambaris *A. altiparanae* and *Astyanax* sp.1 had distinct distributions in both basins. In the Jacaré-Pepira basin, amplitude of occurrence in the length classes was higher due to the presence of juveniles of both species (Figure 7).

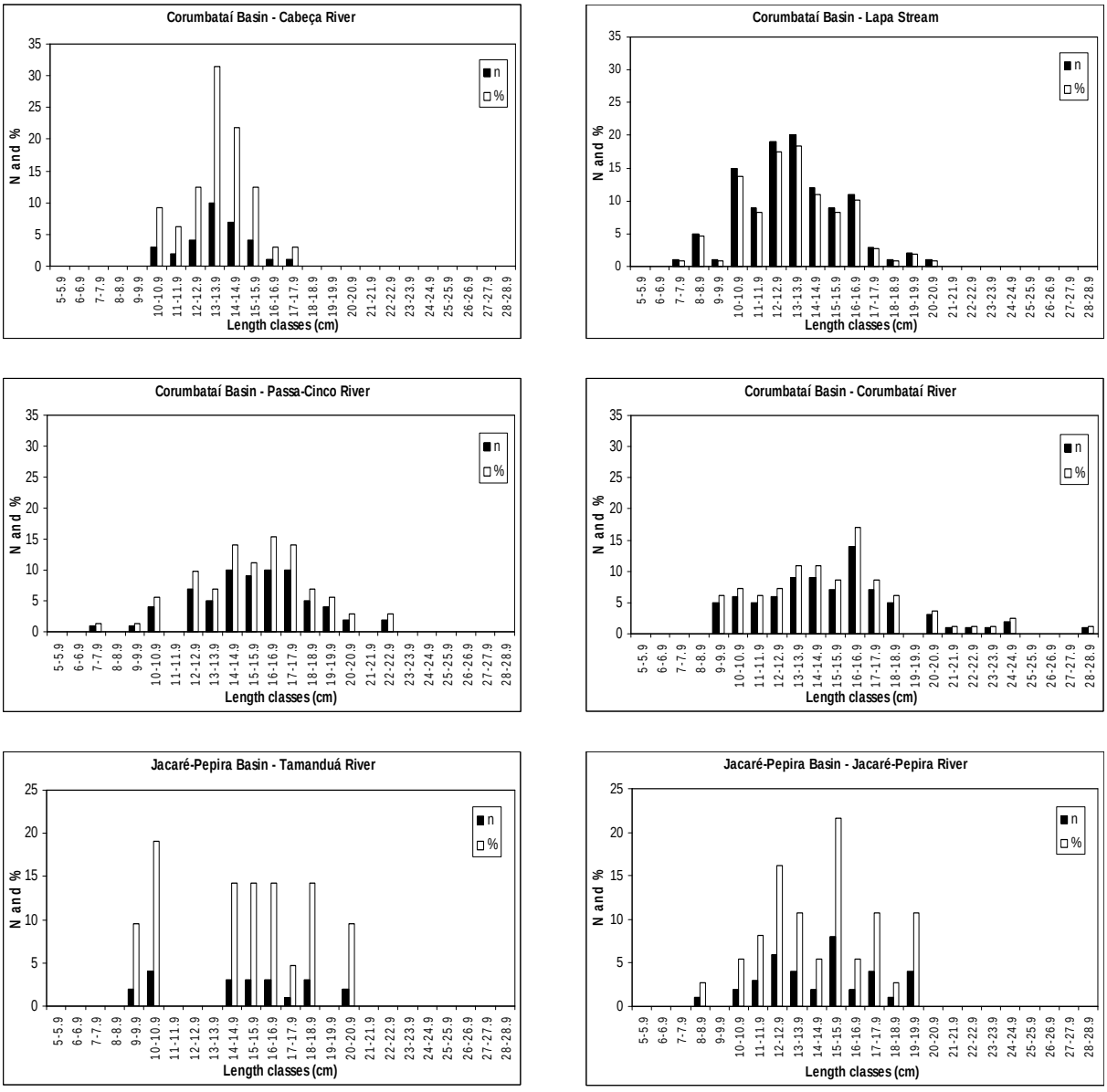

Figure 6. Length distribution of *Hypostomus strigaticeps* at the sampled sites in the Corumbataí and Jacaré-Pepira basins.

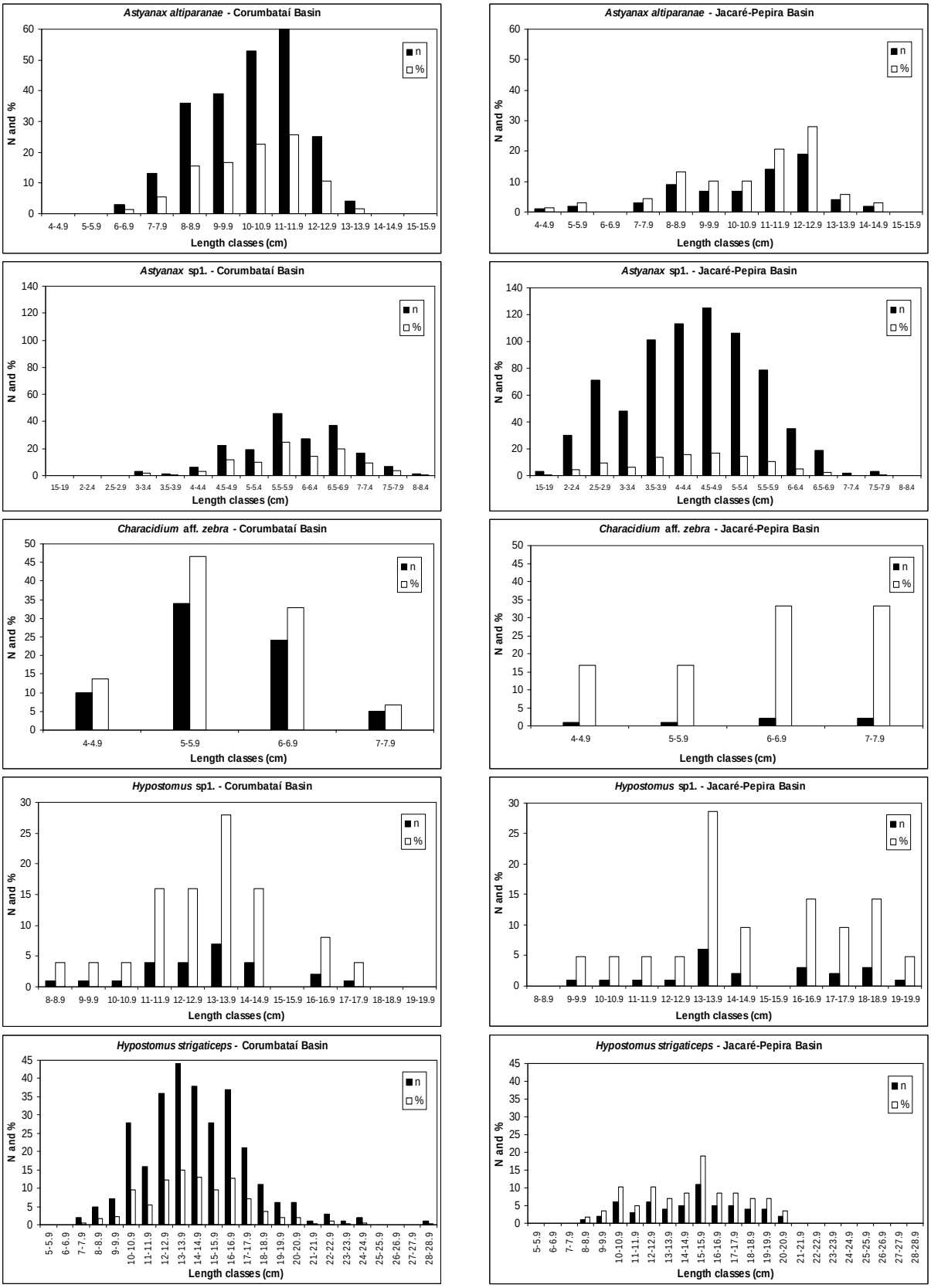

Figure 7. Length distributions of *Astyanax altiparanae, Astyanax* sp1*, Characidium* aff. *Zebra, Hypostomus* sp1 and *Hypostomus strigaticeps* at the samples sites in the Corumbataí and Jacaré-Pepira basins.

Discussion

The majority of the sampled fishes was small, which is a trait of small streams. Body size is directly influenced by local factors, such as water quality and water body morphometry (Holmgren and Appelberg, 2000).

As in Casatti *et al.* (2001), in Parque Estadual do Morro do Diabo, the majority of collected fishes was inferior to 15 cm (small size). The great majority of fishes inhabiting streams of upper Paraná River basin has small size, and this pattern is the only with real diagnostic value (Castro, 1999). The small size of species inhabiting streams certainly represents an adaptation to the small dimensions of headwater streams (Lemes and Garutti, 2002), allowing the species to use more efficiently spatial and food resources in these environments (Castro, 1999).

Species in the genus *Astyanax* showed differences concerning length distribution among streams and between basins. Species in this genus are known by their feeding habits plasticity and ability of making use of available resources (Sazima, 1986; Lobón-Cerviá and Bennemann, 2000; Andrian *et al.*, 2001), and this may influence the growth rates in the different sampled sites.

For *A. altiparanae* (=*bimaculatus*), length distributions may have been influenced by the selectivity of fish instruments used. However, in the large water bodies as the Jacaré-Pepira River and Passa-Cinco River, large individuals were more frequent. The occurrence of small specimens of this species in streams (Castro and Casatti, 1997; Uieda *et al.*, 1997) and large ones in reservoirs corroborates the idea proposed above (Rodrigues *et al.*, 1989; Santos *et al.*, 1995). In general, this species exhibits variable sizes in a variety of habitats (Garutti and Britski, 2000).

For *A. scabripinnis*, a typical fish of small streams, length distributions were similar to those registered for the Fazzari Stream, in the municipality of São Carlos, State of São Paulo (Barbieri, 1992), where individuals superior to 40 mm are mature.

The small size of *C.* aff. *zebra* seems to be a characteristic species (Buckup and Reis, 1997; Castro and Casatti, 1997; Uieda *et al.*, 1997). However, in the Passa-Cinco River specimens were larger compared to size reported in literature, what could be attributed to populational differences. An alternative explanation can be related to the better conditions of the sampled sites, showing greater availability of food resources and shelter sites.

Lemes and Garutti (2002) reported that individuals of *P. argentea* attained 58.3 mm in length at small and very unstable sites. In the Lapa Stream and Passa-Cinco River, this species attained larger sizes, suggesting better environmental conditions at these sites compared to the Cedro Stream.

Length distributions of specimens of *H. ancistroides* captured in the three sites in the Corumbataí basin were larger than the specimens captured in small streams (Castro and Casatti, 1997; Lemes and Garutti, 2002). For other species of "cascudos", differences in habitat use were verified; larger specimens were found in the river channel and smaller ones occurred at the edge at shallow and sheltered sites (Mazzoni and Caramaschi, 1995). This pattern can be observed for the same "cascudo" species, with spatial segregation by length occurring in water bodies of different sizes.

Differences detected among streams in the same basin and between basins (Corumbataí and Jacaré-Pepira) may be related to differences in habitat, food resources, or even populational differences. Species growth rates vary according to habitat type (Lowe-McConnell, 1999), leading to differences in length distribution.

Differences in body size are important to avoid resource use overlap, moreover, size selective predation may be a primary force organizing some communities (Werner and Gilliam, 1984). Differences in length structure of some species among sites and between basins may be related to differences in growth, and habitats, or may be due to populational differences.

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