Spatial distribution of characidiin fishes (Teleostei, Crenuchidae) in the Ribeirão Grande system, a tributary of Paraíba do Sul river basin, Brazil

Francisco Manoel de Souza Braga

Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista (Unesp), Av. 24A, 1515, 13506-900, Rio Claro, São Paulo, Brazil. e-mail: fmsbraga@rc.unesp.br

ABSTRACT. This study analyses the spatial distribution of characidiin fishes *Characidium lauroi* and *Characidium alipioi* (Crenuchidae) in a forest stream system located in southeastern Brazil. Fish were sampled from July 2001 to April 2002. Collections were made with an electro-fishing device in five stream reaches of the Ribeirão Grande system. Conductivity, pH, water temperature and dissolved oxygen were measured at each site. The species have different distributions in Ribeirão Grande system. *Characidium lauroi* is abundant in montane-piedmont zones and *Characidium alipioi* occurs mainly in piedmont-plain zones. Streams' different features contribute to these species' distribution in the system.

Key words: Crenuchidae, spatial distribution, Atlantic forest, *Characidium lauroi*, *Characidium alipioi*.

RESUMO. Distribuição espacial de peixes characidíneos (Teleostei, Crenuchidae) no sistema do Ribeirão Grande, um tributário da bacia do rio Paraíba do Sul, Brasil. Este estudo analisa a distribuição espacial de peixes characidíneos, *Characidium lauroi* e *Characidium alipioi*, no sudeste do Brasil. Os peixes foram amostrados de julho de 2001 a abril de 2002. As coletas foram feitas com um aparelho de pesca-elétrica em cinco trechos de riachos do sistema do Ribeirão Grande. A condutividade, pH, temperatura da água e oxigênio dissolvido foram medidos em cada trecho. As espécies têm distribuições diferentes no sistema do Ribeirão Grande. *Characidium lauroi* é abundante na zona da encosta-pediplano, e *Characidium alipioi* ocorre principalmente na zona do pediplano-planície. Diferentes características dos riachos contribuem para a distribuição dessas espécies no sistema do Ribeirão Grande.

Palavras-chave: Crenuchidae, distribuição espacial, floresta Atlântica, *Characidium lauroi*, *Characidium alipioi*.

Introduction

The neotropical genus *Characidium* is a group of small fishes that inhabit streams and creeks. This group was recently removed from Characidae and included in a separate monophyletic family Crenuchidae, widely distributed between Panama and eastern Argentina (Buckup and Reis, 1997).

Characidium lauroi was described from Rio das Pedras, State of Rio de Janeiro, southeastern Brazil (Travassos, 1949). This stream is also a tributary of the Paraíba do Sul drainage, and the type-locality is at about 2,000 m above sea level. *Characidium alipioi* was described from the river Paraíba do Sul, State of Rio de Janeiro, in the Paraíba Vale, at low altitude (Travassos, 1955).

Characidim lauroi and *Characidium alipioi* have been found in the Ribeirão Grande system, a tributary of the rio Paraíba do Sul located at the Serra da Mantiqueira southeastern slope, southeastern Brazil. The East-Brazilian basin is formed by small rivers with a high number of endemic species (Lowe-McConnell, 1975). In eastern State of São Paulo, Brazil, the landscape is topographically expressed by Serra do Mar and Serra da Mantiqueira, with the river Paraíba do Sul running between them.

Fish communities in streams have their diversity, ecology and dynamics not satisfactorily studied in Brazil, and their habitats are vulnerable to degradation. Paraíba do Sul tributaries have been partially destroyed and well preserved sites have become rare (Garavello and Santana, 1998). Some studies were carried out in southeastern Brazil, in small tributaries of river Paraná basin (Castro and Casatti, 1997; Uieda and Barreto, 1999; Lemes and Garutti, 2002a, b), concerning ichthyofauna structure and composition. However, ecology and population dynamic of fish communities in Serra da Mantiqueira are not discussed in detail.

The present work aims at characterizing the distribution and length structure of two Characidiinae species, *Characidium lauroi* and *Characidium alipioi*, in Ribeirão Grande system, tributary of the Paraíba do Sul left margin, southeastern Brazil.

Material and methods

Study area

The slope of the Serra da Mantiqueira is covered by remains of Atlantic forest. The forest is formed by species that belong to Leguminosae, Bignoniaceae, Sapotaceae, Lauraceae, Myrtaceae and others (Hueck, 1972). The streams that form the Ribeirão Grande system (and other systems around it) run between crests of slopes, formed by faults during the late Pleistocene to Holocene tectonic reactivations (8,000 – 13,000 years BP) (Modenesi-Gauttieri *et al.*, 2002), surrounded by Atlantic forest. From the base of the slope through the valley (piedmont), there are remains of natural forests and also farms and plantations.

Five sites were surveyed in the Ribeirão Grande system (22º 47' 08" S, 45º 28' 17" W). There are five major tributaries that form the Ribeirão Grande system: the medium Ribeirão Grande stream, Cedro stream, Cajarana stream, Ferraz stream and Cachoeirão stream (not sampled) (Braga, 2004). Stream order segments in Ribeirão Grande system follow the Horton-Strahler classification (Allan, 1995; Matthews, 1998). The Serra da Mantiqueira is an east-west mountain range composed of granitic and metamorphic rocks. Streams in the Mantiqueira uplift have steep gradients and coarse substrata, bordered by rain forest (Atlantic forest). The low parts of the streams move on the Vale do Paraíba plain. The streams and creeks that form the Ribeirão Grande system are separated from other neighboring systems by slope faults, forming a left-side Paraíba do Sul drainage basin.

Sampling methods and treatments data

Fish were sampled four times in each site, from July 2001 through April 2002: winter (July 2001), spring (October 2001), summer (February 2002) and autumn (April 2002). Quantitative collections were made with an electro-fishing device, powered by a generator with a maximum capacity of 1,500 V and 8.7 A of 60 Hz alternating current. Five stream reaches were sampled. These reaches were selected to represent the range of habitats in the stream system. All specimens were preserved in 10% formalin and returned to the laboratory for identification and biometry. Conductivity, pH, water temperature and dissolved oxygen were measured in each site, and elevations in meters were taken by a GPS. Mann-Whitney U-tests were used to determine the significance (P=0.05) of the variables in distinguishing between locals occupied by one or other species, according to Sokal and Rohlf (1981).

Results

37 fish species belonging to the families were caught in individuals abundance order: Crenuchidae (2 species, n=1052), Loricariidae (12 species, n=696) Trichomycteridae (5 species, n=566), Characidae (5 species, n=294), Pimelodidae (4 species, n=162), Cichlidae (1 species, n=35), Gymnotidae (2 species, n=19), Poeciliidae (1 species, n=17), Callichthyidae (1species, n=12) Erythrinidae (2 species, n=5), Synbranchidae (1 species, n=3) and Anostomidae (1 species, n=1). *Characidium lauroi* and *Characidium alipioi* were the most abundant species, amounting 36.4% of the total catch (Figura 1).

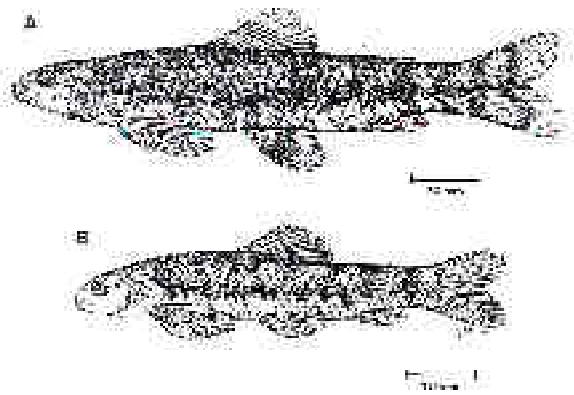

Figure 1. A. *Characidium alipioi* from low Ribeirão Grande stream. B. *Characidium lauroi* from low Cajarana stream.

Characidium lauroi is associated with upstream areas, being abundant in Cedro stream (second-order) and Cajarana stream (third-order). This species has a slender body and less pigments than *Characidium alipioi*. On the other hand, *Characidium alipioi* lives in downstream areas, being abundant in median and lower portions of Ribeirão Grande stream (fourth-order) (Tables 1 and 2). *Characidium alipioi* has a bigger body and more pigments than *C. lauroi*, with solid, dark brown, longitudinal midlateral stripes, accompanying lateral line.

Table 1. Abundance of characidiin fishes in Ribeirão Grande, in number of individuals.

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Characidium lauroi	127	382	17	6		532
Characidium Alipioi		3	51	212	254	520

Table 2. The order of the streams, sampled site, elevations and their features.

Stream	Order	Site	Elevation (m)	Features
Cedro	2	1	671	montane; forest
Cajarana	3	2	652	montane/piedmont; forest/field
Ferraz	2	3	630	piedmont; field
Ribeirão Grande	4	4	611	piedmont; field
Ribeirão Grande	4	5	577	plain; field

Mann-Whitney U-tests indicated that three parameters (conductivity, temperature, and elevation) separated the sites occupied by *Characidium lauroi* and *Characidium alipioi* ($P<0.05$) (Table 3).

Table 3. Medians and ranges of variables for sites where *Characidium lauroi* and *Characidium alipioi* occurred and significance of Mann-Whitney U-tests in distinguishing among both sets of sites based on five variables.

	Montane		Plain		
Variable	Median	Range	Median	Range	P
Conductivity (μS/cm)	10.0	7.0-17.0	16.0	9.0-20.0	0.0023
Temperature (°C)	18.6	16.0-21.9	20.0	13.0-23.1	0.0005
Dissolved oxygen (mg/l)	9.7	8.8-12.8	9.4	6.8-11.8	0.1020
pH	7.7	7.2-8.0	7.5	6.8-7.9	0.4325
Elevation (m)	652	630-671	611	577-630	0.0500

The species length composition has been determined for each sex. Females of *Characidium lauroi* ranged in total length from 3.0 to 7.8 cm; males, from 3.6 to 6.3 cm; males are slender than females. Data imply a rather unimodal size distribution for both sexes (Figura 2). In *Characidium alipioi*, total length in females ranged from 5.1 to 11.4 cm and in males from 6.0 to 9.3 cm. Like *Characidium lauroi*, males of *Characidium alipioi* are slender than females. *Characidium alipioi* are bigger than *Characidium lauroi*; females of *Characidium alipioi* show a polymodal size distribution (Figura 2).

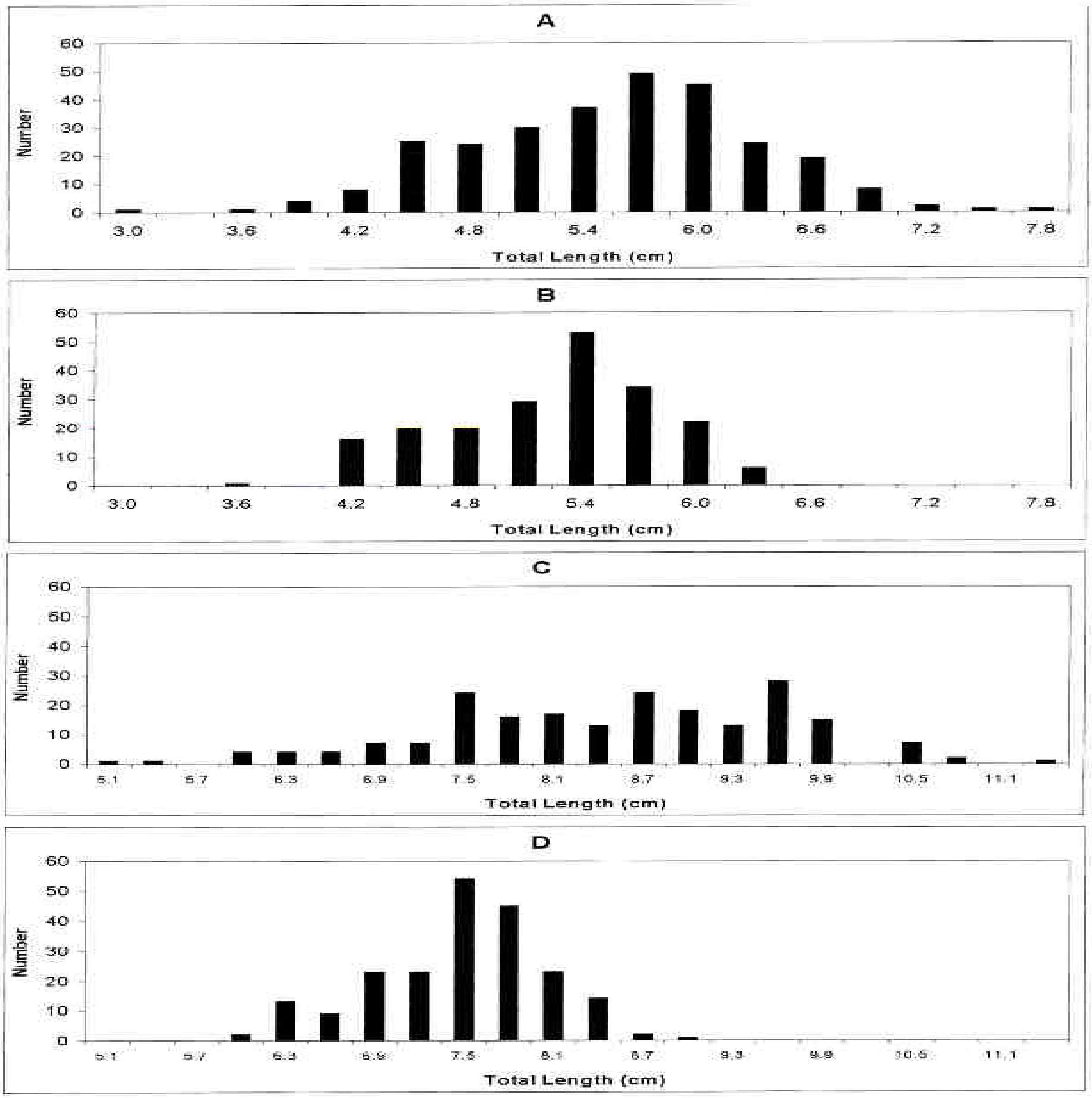

Figure 2. Length frequencies of Characidium lauroi, and Characidium alipioi from Ribeirão Grande system. **A.** Characidium lauroi females. **B.** Characidium lauroi males. **C.** Characidium alipioi females. **D.** Characidium alipioi males.

Discussion

Characidiin fishes include species with morphological traits associated with life in torrential environments, such as small length and a large number of reductive characters (Buckup, 1993). Braga (2004) described the absence of a swim bladder and a reduction in testis and ovary for *Characidium lauroi* and *Characidium alipioi* and concluded that morphological features in stream mountain fishes were used to predict the niche adaptation for torrent-dwelling characidiins.

Shelford (apud Sheldon, 1968) explained fish distribution with the geological concept of stream bed aging. During the late Pleistocene-Holocene, the Campos do Jordão Plateau, which includes the Serra da Mantiqueira geomorphological zone, has been subject to slow, but continuous, tectonism. This fact had a strong influence upon the present drainage, being preferential sites for the stream piracy phenomena observed in headwaters along the Mantiqueira divide (Modenesi-Gauttieri *et al.*, 2002). This allowed contacts among populations of *Characidium lauroi* in Serra da Mantiqueira eastern upland parts. On the other hand, the population of *Characidium lauroi* has been separated from the population of *Characidium alipioi* according to the parapatric model. Centofante *et al.* (2003) studied the evolutionary differentiation in sex chromosomes of *Characidium lauroi* and *Characidium alipioi* in the Ribeirão Grande stream, concluding that evolutionary differentiation may be associated with a biogeographic barrier.

In small streams, fish communities can change within relatively short distances, and fish distribution and diversity can be controlled by the habitat structural features (Sheldon, 1968). The explanations of parapatric speciation along an environmental gradient and allopatric speciation with later secondary contact could cause complementary distribution, because both species are adapted to different environments (Winston, 1995). As mentioned above, a transitional zone exists between montane and piedmont (ecotone). Two populations are parapatric if they occupy contiguous territories that overlap only very narrowly (Futuyama and Mayer, 1980; Key, 1982; Taylor and Lienesch, 1996). According to Bull (1991), parapatric boundaries can occur in less extreme gradients of elevation, climate, soil, water speed and vegetation. These conditions have been found in the ecotone at the montane-piedmont zone.

In an ecotonal change, each species is better adapted to conditions on its own side. In Ribeirão Grande system, the streams exhibit a downstream decrease in gradient along their length; slopes are steep in the headwaters and become less so as one proceeds downstream. Many factors influence the physical environment of running waters, causing variations from place to place; temperature, for example, usually varies due to elevation (Allan, 1995), and an important cause of change in faunal composition is marginal vegetation loss (Karr and Schlosser, 1978). Stream chemistry also varies in stream chemical composition across a gradient from humid to arid condition; a high concentration of total dissolved salts is found in streams draining arid areas (Allan, 1995) just as observed in sites 3, 4, and 5. In the piedmont, the contact colluvium-weathered bedrock is usually marked by stone lines, as can be seen on Ferraz stream right margin (22º 47' 08'' S; 45º 28' 17'' W). These accumulations of coarse clasts from a regional paleopavement has been attributed to the widespread aridity of the last glacial maximum, ca. 13,000 - 23,000 years BP (Ab'Saber, 1977, 1979; Modenesi-Gauttieri *et al.*, 2002). During this period, the forest stayed in the slope, covering the Serra da Mantiqueira upland. Widespread aridity occurred through the piedmont up to Vale do Paraíba; soils structure confirms this hypothesis. The reasons for the complete absence of the *Characidium alipioi* in site 1, and *C. lauroi* in site 5, could be explained by a separation of an ancient characidiin during the late Pleistocene, attributed to the widespread aridity occurred in this time. Both species are closely related and appear to be involved in a genetic interaction (Centofante *et al.*, 2001, 2003).

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