Composition and Seasonal Variation of the Ichthyofauna from Upper Rio Paraguaçu (Chapada Diamantina, Bahia, Brazil)

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ABSTRACT

The aim of this work was to characterize the composition of the ichthyofauna of the upper course of the Rio Paraguaçu. Two excursions were carried out, one in the dry season, and the other in the rainy season, with 36 localities sampled. A total of 63 species were collected. Multivariate analyses indicated that abiotic variables such as the channel order and altitude were the main influences on the number of species present. The number of species in each excursion was equivalent in the two seasons, suggesting that seasonal changes have little influence on the ichthyofauna of this area.

Key words: Rio Paraguaçu, Chapada Diamantina, fish community, abiotic parameters, seasonality

INTRODUCTION

The Chapada Diamantina forms a watershed between the São Francisco basin and the rivers of the East basin that discharge directly in the Atlantic Ocean. The Rio Paraguaçu has its origin in the Chapada covering about 500km up to its estuary in the west portion of the Todos os Santos Bay. This river is one of the largest basins of northeastern Brazil, but remains almost unexplored ichthyologically (Higuchi et al. 1990). The headwaters of the Rio Paraguaçu host a rich and endemic ichthyofauna (Pinna, 1992).

The anthropic interference in the rivers of the Chapada Diamantina is represented, mainly by former diamond mining; presence of towns and cities; farming with intense activity of irrigation;

and adventure tourism in increasing expansion. These activities make it necessary to implement urgent strategies of preservation of the Chapada. However, the real condition of the aquatic biota is yet unknown. The objective of this work was to characterize the composition of the ichthyofauna of the upper Rio Paraguaçu drainage.

MATERIALS AND METHODS

Field sampling
Two excursions were carried, one in rainy period (March 1999) and one in the dry period (November 1999), totalizing 36 localities of sampling in the high course of the River Paraguaçu and its main tributaries (Fig. 01).

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Sampling equipment was used according to the microhabitat conditions: gillnets, handnets, cast seines, fish trap and bolter. Order of the canal, altitude, width, depth, stream velocity, outflow, temperature and transparency of the water were registered.

Specimens were fixed in 4% formaldehyde and later were preserved in ethanol (70º GL). Species were identified by literature (Menezes, 1969; Gosse, 1976; Gery, 1977; Garavello, 1979; Britski

et al., 1986; Burgess 1989; Vari 1991; Pinna 1992; Buckup 1993; Malabarba 1998) and by comparison with the collections at Museu Nacional do Rio de Janeiro and Museu de Zoologia da Universidade de São Paulo. Specialists on some of the groups were also consulted. In order to build the taxonomic list, in this study was adopted the classification of Reis et al. (2003).
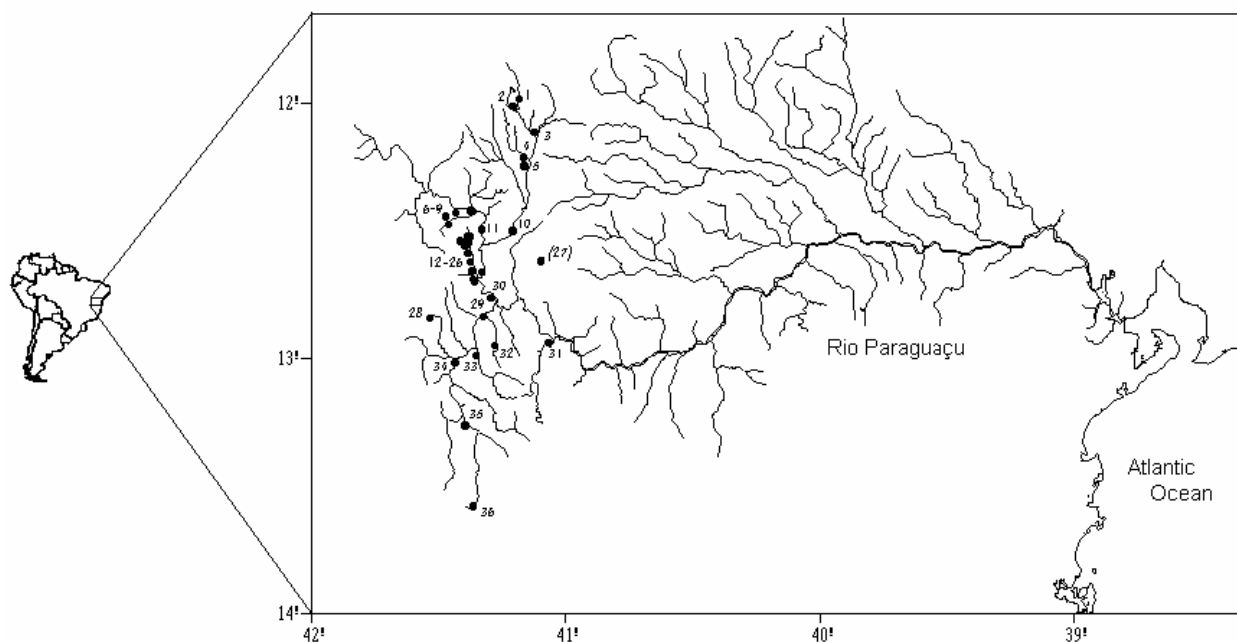

Figure 1 - Study area with indication of the 36 sampling sites. The codes for the localities in Table 01.

Data Analysis

The number of species per locality in each period of sampling was compared. T test was used to determine statistical differences in the number of species between the two periods of sampling. Multivariate Principal Components Analysis (PCA) and Cluster Analysis were used to group the localities in accordance with environmental variables and the number of species, respectively. Logarithmic transformations of both environmental variables and species number data were performed. Cluster analysis was performed using Ward's method of linkage for the production of the dendrogram. For these analysis, only localities sampled in both periods were used.

RESULTS

Fish Assemblage

Fishes from 63 species representing 42 genera and 16 families were collected, representing five orders: Characiformes (37 species, 58.7%); Siluriformes (16 species, 25.4%); Cyprinodontiformes (04 species, 6.4%); Perciformes (05 species, 7.9%); e Gymnotiformes (01 specie, 1.6%). The most representative family was Characidae with 25 species. Loricariidae and Trichomycteridae with 5 species, Cichlidae and Poeciliidae with 4 species, Crenuchidae, Erythrinidae and Heptapteridae with 3 species were also well represented families (Table 1). Ten out of 63 species found (16%) were possibly new, not mentioning the species of *Astyanax*.

Spatial and temporal variation

No significant differences were shown in the species number by locality among two periods (p=0.90). The species number varied from one up to 15 species (Table 2). The river order of the canal varied from one up to 6 (sensu Strahler, 1957); the altitude varied from 285m up to1117m; the outflow from 0.12m³/s up to 6.89m³/s; the width from 1.2m, up to 33.9m and the depth from 0.1m up to 5.6m.

Cluster analysis considering the presence/absence fish data presented four groups in both excursions. In the first excursion, group 1 represented localities with more species (12-15), being composed mainly by localities in the tributaries of Rio Paraguaçu, such as the Utinga, Una and Santo Antônio rivers. Group 2 represented localities with intermediate number of species (5-8), being composed basically by minor tributaries of São José and Santo Antônio rivers. Group 3 presented low number of species (1-3) being composed by little streams of low order. Finally, group 4 represented localities in São José and Paraguaçu rivers next its headwaters, also with low number of species (Fig. 2). The codes for the localities are shown in Table 2.

In the second excursion, group 1 also represented localities with more species (9-15) being composed mainly by localities of the Utinga, and Santo Antônio rivers. Group 2 represented localities with low number of species (1-5), being composed basically by minor streams, Paraguaçu next to its headwaters and others rivers of low order. Group 3 presented high number of species (10-12), being composed by tributaries of São José. Group 4, in the second excursion represented by localities in São José and some of its tributaries, Rio Una, a tributary of the Santo Antônio and one locality of the Rio Paraguaçu in Andarai (Fig. 2). The codes for the localities are shown in Table 2.

The PCA obtained by the analysis of the environmental variables in the first excursion explained 48.3% of the total variance. Component 1 explained 29.1% of the total variance and presented positive weight for altitude and negative for richness, order and outflow. Component II explained 19.3% of the total variance and presented positive weight for temperature and richness and negative for depth and altitude. The resulting diagram from Components I and II (Fig. 03) separated the localities along the component I, with localities of more altitude on the right side and others with more richness, width and order on the left side. Component II, in turn, separated the localities with higher temperature above and localities with more depth and outflow below. The codes for the localities are shown in Table 2.

In the second excursion PCA explained 61.7% of the total variance. Component I explained 45.2% of the total variance and presented positive weight for order, temperature, depth and richness. Component II explained 16.5% of the total variance and presented positive weight for outflow and width. The resulting diagram from Components I and II (Figure 03) separated the localities along the component I, with localities of greater altitude on the left side and others with greater richness, width and order on the right side. Component II, in turn, separated the localities with higher temperature below and localities with more depth and outflow above. The codes for the localities are shown in Table 2.

Table 01 - List of order, families, subfamilies and species of fish caught in upper Rio Paraguaçu.

Order	Family	Subfamily	Species
Characiformes	Parodontidae		*Apareiodon hasemani* Eigenmann, 1916
	Curimatidae		*Steindachnerina elegans* (Steindachner, 1875)
			Cyphocharax gilberti (Quoy and Gaimard, 1824)
	Prochilodontidae		*Prochilodus affinis* Reinhardt, 1874
	Anostomidae		*Leporinus* sp.
	Crenuchidae	Characidiinae	*Characidium* cf. *bahiensis*
			Characidium cf. *bimaculatum*
			Characidium sp. nov.
	Characidae	Incertae sedis	*Astyanax bimaculatus lacustris* (Reinhardt, 1874)

(Cont. ...)

(Cont. Table 1)

Order	Family	Subfamily	Species
			Astyanax cf. *fasciatus* (Cuvier, 1819)
			Astyanax scabripinnis (Jenyns, 1842)
			Astyanax sp.1
			Astyanax sp.2
			Astyanax sp.3
			Astyanax sp.4
			Astyanax sp.5
			Astyanax sp.6
			Astyanax sp.7
			Astyanax sp.8
			Astyanax sp.9
			Astyanax sp.10
			Hyphessobrycon negodagua Lima and Gerhard 2001
			Hemigrammus marginatus Ellis, 1911
			Moenkhausia sp. nov.
			Myxiops aphos Zanata and Akama 2004
			Phenacogaster franciscoensis Eigenmann, 1911
			Piabina argentea Reinhardt, 1866
			Triportheus guentheri (Garman, 1890)
		Serrassalminae	*Serrasalmus brandtii* Reinhardt, 1874
		Tetragonopterinae	*Tetragonopterus chalceus* Agassiz, 1829
		Cheirodontinae	*Serrapinnus heterodon* (Eigenmann, 1915)
			Serrapinnus piaba (Lütken, 1874)
		Glandulocaudinae	Glandulocaudinae sp. nov.
	Acestrorhynchidae		*Acestrorhyncus lacustris* (Reinhardt, 1849)
	Erythrinidae		*Hoplerytrinus unitaeniatus* (Schneider, 1829)
			Hoplias cf *lacerdae,* Ribeiro, 1908
			Hoplias malabaricus (Bloch, 1794)
Siluriformes	Trichomycteridae		*Copionodon orthiocarinatus* Pinna, 1992
			Copionodon pecten Pinna, 1992
			Ituglanis sp. nov.
			Trichomycterus cf *brasiliensis,* Reinhardt, 1873
			Trichomycterus sp.
	Callichthydae		*Aspidoras psammatides* (Britto, Lima and Santos, 2005)
			Corydoras cf. *garbei* (Ihering, 1910)
	Loricariidae	Hypoptopomatinae	*Parotocinclus sp.*
			Hypoptopomatinae sp.

(Cont. Table 1)

Order	Family	Subfamily	Species
		Hypostominae	*Hemipsilichthys* sp. nov.
			Hypostomus sp.
			Pterygoplichthys sp.
	Heptapteridae		*Pimelodella* cf. *laurenti* (Fowler, 1941)
			Rhamdia quelen (Quoy and Gaimard, 1824)
			Rhamdiopsis sp. nov.
	Auchenipteridae		*Parauchenipterus galeatus* Linnaeus, 1766
Gymnotiformes	Gymnotidae		*Gymnotus carapo* Linnaeus, 1758
Cyprinodontiformes	Poeciliidae		*Pamphorichthys hollandi* (Henn, 1916)
			Pamphorichthys sp. nov.
			Poecilia reticulata Peters, 1860
			Poecilia vivipara (Scheneider,1801)
Perciformes	Cichlidae		*Astronotus ocellatus* (Cuvier, 1829)
			Cichlasoma facetum (Jenyns, 1842)
			Cichla cf. *temensis* Humboldt, 1833
			Geophagus brasiliensis (Quoy and Gaimard, 1824)
			Geophagus sp. nov.

Table 02- Number of species by localities.

Site number	Locality	Código	Period Rainy	dry
1	Rio do Riachão	RIAC	4	5
3	Rio Utinga (1)	UTI1	15	13
4	Rio Cachoeirinha	CACH	14	9
5	Rio Utinga (2)	UTI2	14	9
6	Afluente do Santo Antônio	COSA	2	5
7	Rio Toalhas	FOTO	7	7
8	Rio Santo Antônio (Palmeiras)	SAPA	12	15
9	Rio Mosquito	RIMI	8	6
11	Rio Santo Antônio (Camelo)	SACA	12	10
12	Rio Mandassai	RIMA	2	3
13	Poço Mandassai	POMA	3	8
15	Rio São José (Nascente)	SJL2	6	7
16	Rio Mucugezinho	RIMU	2	2
17	Córrego do Lapão	COLA	2	1
18	Rio Lapão	RILA	3	6
19	Rio Lençóis	RILE	7	4
21	Rio Ribeirão	RIRI	6	5

(Cont. Table 1)

Site number	Locality	Código	Period Rainy	dry
22	Rio Capivara	CAPI	13	13
23	Rio São José (Lençóis)	SJL1	8	6
24	Rio Caldeirão	RICA	8	10
25	Córrego Roncador/Caldeirão	CORC	3	4
26	Rio Roncador	RIRO	7	12
27	Rio Santo Antônio (Remanso)	SARE	5	3
28	Rio Santo Antônio (Andarai)	SAAN	13	12
30	Rio Paraguaçu (Andarai)	PAR1	2	5
31	Rio Una	RUNA	12	8
32	Rio Piabas	PIAB	3	3
33	Rio Cumbuca.	RICU	1	0
35	Rio Paraguaçu (Cascavel)	PAR3	5	5
36	Rio Paraguaçu (Barra da Estiva)	PAR2	6	5
	Mean		6.8	6.7
	Standard Deviation		4.4	3.8

* Only localities samples in both periods are listed.
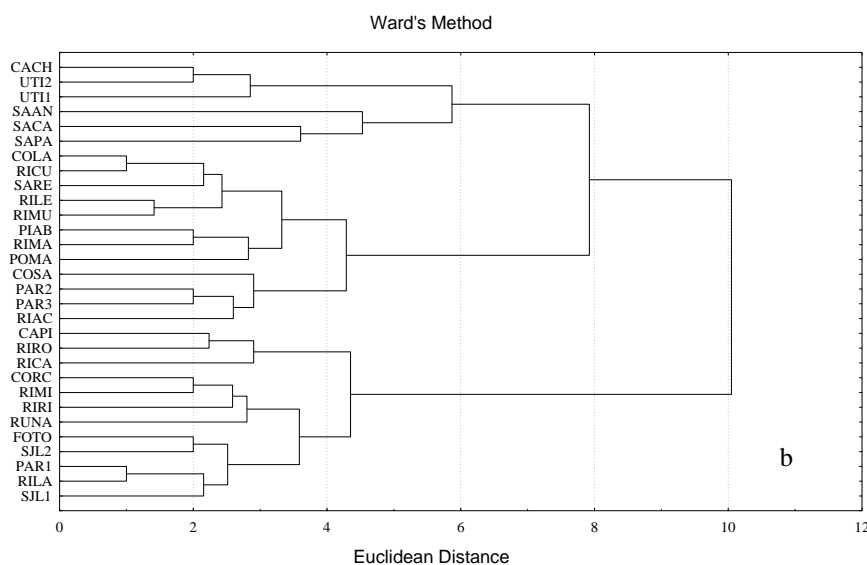

Ward's Method

Ward's Method
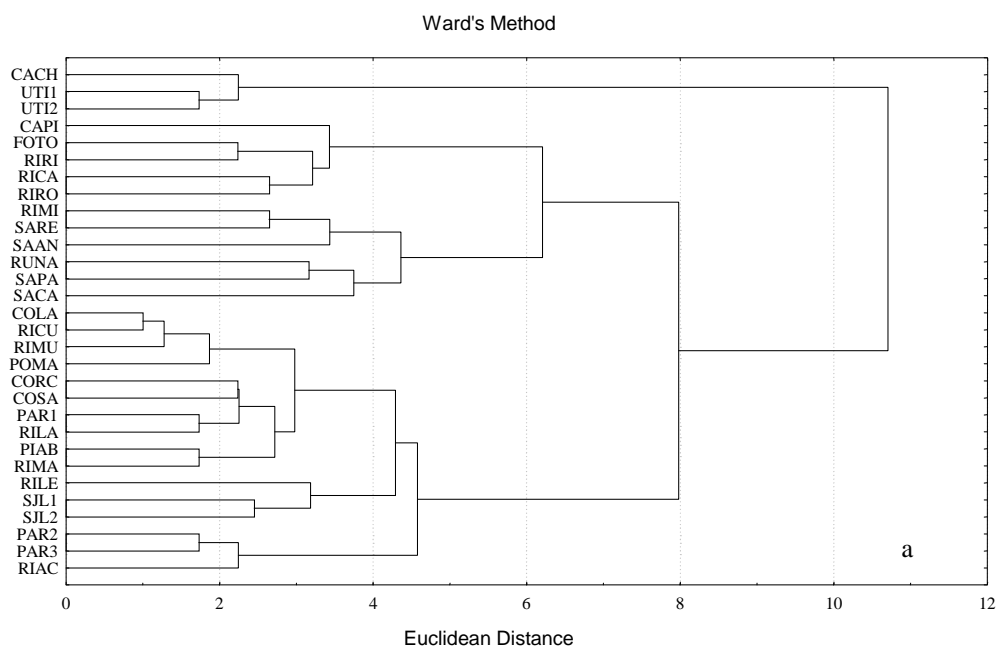
Figure 02 - Cluster analysis of the data of presence or absence in the first (a) and second (b) excursion, coded by 30 sampling sites in both excursions. The codes for the sampling sites in Table 2.

DISCUSSION

The discovery of 10 species which were new in the Chapada Diamantina ratifie the little knowledge on ichthyofauna of the northeast region. One of these new species, *Myxiophs aphos* recently described, represented a new characid genus and species. Another important fact was the presence of species of subfamily Copionodontinae, endemic and recently described for the Chapada Diamantina (Pinna, 1992). The number of species per locality was equivalent in the dry and rainy periods, suggesting little seasonal influence in the composition of fish assemblages in this area. The multivariate analyses indicated constant abiotic parameters as the order of the canal and the altitude, as main influences in the characterization of the localities and consequently in the number of species of each one of them. Changes in parameters such as the temperature and the outflow, were determinant in the organization of the community of fish. In accordance with Lowe-Mcconnel (1999), in rivers of tropical regions the seasonality is induced mainly for changes in the water level. In larger rivers of greater order, which are subjected to floods an increase in the number of species associated with migratory species is expected. Melo (2000) considers the size of the basin as a determinant factor in the variation of the number of species between dry and rain seasons, as observed in streams in central Brazil.

In larger basins, the migration processes are more frequent, determining lesser similarity between dry and rainy season, and this difference in the environment tends to increase the substitution of species of one habitat for the other, increasing, therefore, the beta diversity (Magurran, 1998; Ricklefs and Schluter, 1993). In this study, the majority of the localities present order channel between 1 and 3 and reduced width, consequently less influenced by migratory processes.

The PCA revealed the importance of factors as the order of the channel and the altitude in the ichthyofaunistic composition of the region. Several authors (Martin-Smith, 1998; Oberdorff et al. 1998; Marsh-Mattheus and Matthews, 2000) have used this analysis to determine the existence of a physical gradient responsible for the organization of the fish communities. Because of their complementary nature, PCA and cluster analyses together provide a powerful tool when identifying patterns in the structure of community data (Gauch, 1982). Caramaschi (1986) emphasized the importance of characteristics related to the river size (order of the channel, width and depth) in the distribution of stream

ichthyofauna. Marsh-Matthews and Matthews (2000) affirmed that the relation between stream velocity and depth can be reflected in the increase

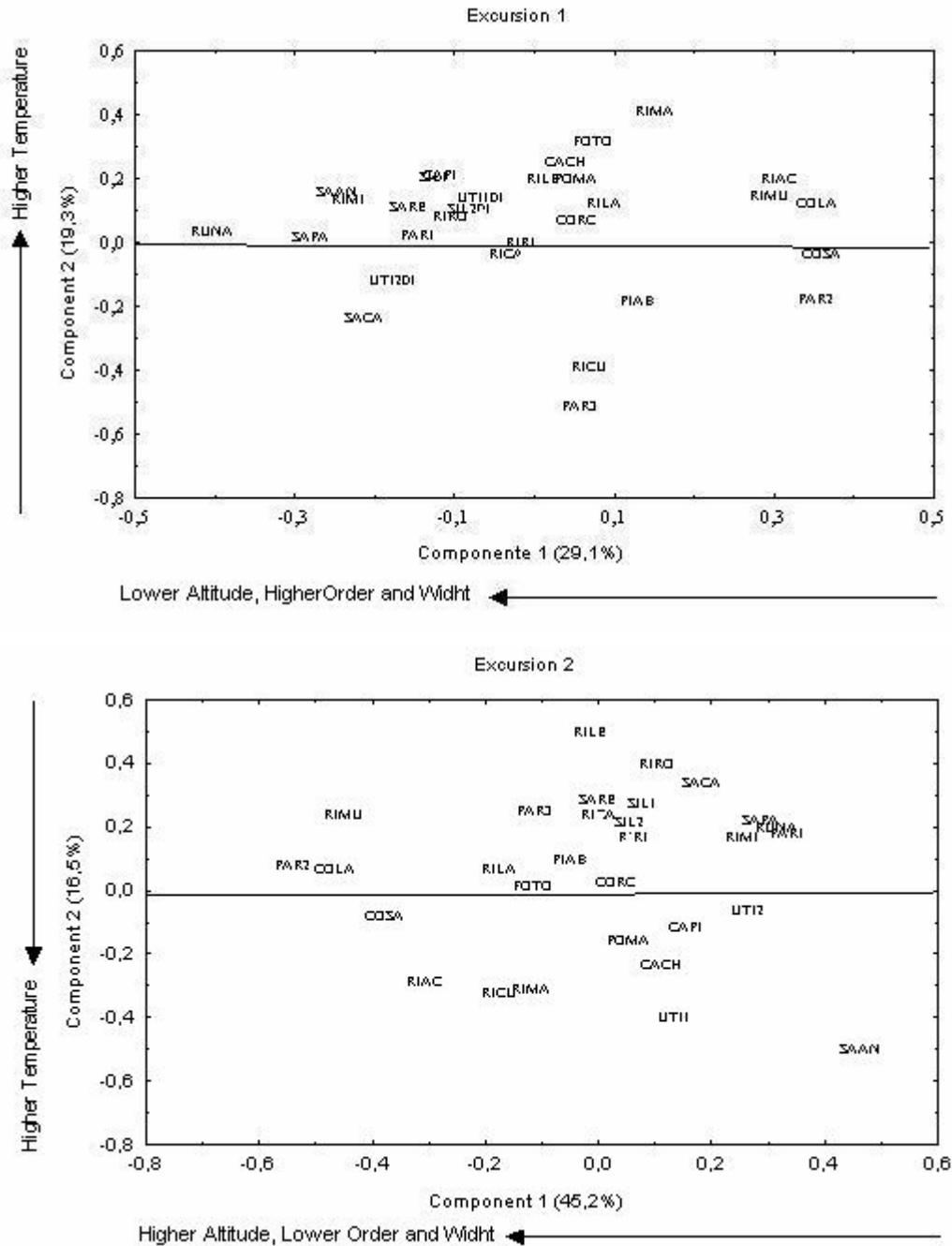of the species richness as consequence of an increase in the habitat complexity.

Figure 03 - Ordination diagram for the two first principal components in the first and second excursion, coded by 30 sampling sites in both excursions. The codes for the sampling sites in Table 2.

Despite the large number of studies carried out through the last years on the ichthyofauna of South

America, this was still poorly known, in particular in the Northeast region. Recently, Higuchi et al.

(1990); Pinna (1992); Lima and Gerhard (2001), Lima et al. (2001) and Zanata and Akama (2004), Britto et al. (2005), described new genera and species of Douradidae and Characidae, and a new subfamily of Trichomycteridae in the Paraguaçu basin. In this work, 10 new species were determined (including the recently described *Hyphessobrycon negodagua*, *Aspidoras psammatides* and *Myxiops aphos*). This fact showed the poor knowledge on the local ichthyofauna and the high rate of endemism, probably due to the natural characteristics of the region. Castro (1999) mentioned that smaller species made up to at least 50% of the total of species in river environments of small and average sizes and that they presented a high level of endemism. Those, however, have been poorly studied so far. The ichthyofauna of the upper Rio Paraguaçu registered in this work was composed mainly by small size fishes. Small fishes normally present minor moving capacity and are more susceptible to vicariance events, in contraposition to biggest species that generally present great geographic variation and little morphologic variation (Castro, op. cit.).

The absence of previous studies on the ichthyofauna of the Chapada did not allow to compare the current situation with that existed before the antropic interference. It could be expected that present result would represent a step to future and more complete ichthyofaunistic inventories, and for the delimitation of critical areas to the ichthyofauna.

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RESUMO

O rio Paraguaçu origina-se nas encostas úmidas da Chapada Diamantina e atravessa grande parte do estado da Bahia até desembocar na baía de Todos os Santos. Neste trabalho foi caracterizada a composição da ictiofauna do alto curso do rio Paraguaçu na região da Chapada Diamantina. Para isso, foram realizadas duas excursões de coleta, nas estações seca e chuvosa, onde 36 localidades foram amostradas. Um total de 63 espécies foi coletado e as análises multivariadas indicaram a maior influência de fatores como a ordem do canal e a altitude em relação ao número de espécies registradas. O número de espécies em cada excursão foi equivalente nas estações seca e chuvosa sugerindo pouca influência da sazonalidade na ictiofauna do alto curso do Rio Paraguaçu.

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