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Distribution, abundance and use of different environments by dominant ichthyofauna in the influence area of the Itaipu Reservoir

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ABSTRACT. The aim of this paper is to characterize the structure of dominant ichthyofauna in the Itaipu reservoir and its area of influence. 85,160 individuals were collected during the period from November 1983 to October 1989 in 11 sample sites, or rather, in the dam area (Guaíra, Santa Helena and Foz do Iguaçu), in the tributaries of its left bank (the rivers Arroio Iguaçu, Ocoí, São Francisco Falso and São Francisco Verdadeiro), in upstream and downstream Paraná River, in the tributaries of the Paraná River (Piquiri and Iguatemi). Results showed a great number of species with low frequency and few dominant species. Among the dominant species *Auchenipterus nuchalis, Hypophthalmus edentatus, Iheringichthys labrosus, Loricariichthys* sp., *Parauchenipterus galeatus, Plagioscion squamosissimus, Prochilodus lineatus, Pterodoras granulosus, Rhaphiodon vulpinus* and *Steindachnerina insculpta* are conspicuous. The places of the feeding, reproduction and initial development places to the dominant species were identified.

Key words: dominant ichthyofauna, Paraná River, Itaipu reservoir.

RESUMO. **Distribuição, abundância e uso de diferentes ambientes pela ictiofauna dominante na área de influência do reservatório de Itaipu.** Com o objetivo de caracterizar a estrutura da ictiofauna dominante do reservatório de Itaipu e de sua área de influência, foram coletados 85.160 exemplares durante o período de novembro de 1983 a outubro de 1989 em 11 estações de amostragem distribuídas no corpo principal do reservatório (Guaíra, Santa Helena e Foz); em tributários da margem esquerda deste (Arroio Guaçu, Ocoí, São Francisco Falso e São Francisco Verdadeiro); no rio Paraná (a montante e a jusante do reservatório) e em tributários do rio Paraná (Piquiri e Iguatemi). Os resultados demonstraram um grande número de espécies com baixa freqüência e poucas espécies dominantes. Entre as espécies dominantes destacaram-se: *Auchenipterus nuchalis, Hypophthalmus edentatus, Iheringichthys labrosus, Loricariichthys* sp, *Parauchenipterus galeatus, Plagioscion squamosissimus, Prochilodus lineatus, Pterodoras granulosus, Rhaphiodon vulpinus* e *Steindachnerina insculpta*. São apresentadas indicações acerca dos locais de alimentação, reprodução e desenvolvimento para as referidas espécies.

Palavras-chave: ictiofauna dominante, rio Paraná, reservatório de Itaipu.

Dams cause changes in the dynamics of river systems, independently of the way they are operated. Change degree in the river's hydrological regime is determined by its morphometry and flux regulation (Agostinho, 1992). The latter implies a new restructuring of the system involving a relationship between organism and environment.

Dams interrupt the migratory routes of fish in the rivers and impair the abundance of available stock (Carvalho and Merona, 1986). In South America the Paraná River basin has the largest number of dams along its course since it is responsible for 70% of hydroelectric power of the country (Agostinho and Júlio Jr., 1999). Changes in the hydrological regime due to the damming of the Paraná River and its main affluents, chiefly in its upper section, have certainly established new ecological conditions. However, Brazilian bigger rivers are being transformed into a series of artificial lakes faster than it is necessary to acquire biological and ecological knowledge of their aquatic fauna (Bazzoli *et al.*, 1991).

Complex interactions between individuals and their relationship with the abiotic parameters recommend a systemic approach in which the populations of impounded ecosystem will be the

ideal study units. Fish assemblage may be more generally recognized by changes among dominant species than by any other trait in the assemblage (Deshmukh, 1986).

In this context, the present research intends to understand the changes occurring in dominant fish populations in the Paraná River basin, between the mouth of the rivers Iguaçu and Piquiri after the formation of the Itaipu Reservoir. It will show the colonization and impounding process produced by the reservoir on this segment of the community. Basic informations on changes in the composition and structure of populations during this period and of the mechanisms in the utilization of these artificial environments are useful for their management, whose aim is to diminish the effects of impacts or even foresee the behavior of assemblages in future ones.

Materials and methods

Eleven sampling sites were chosen during the period from November 1983 to October 1989: 3 sites in the principal segment of the Itaipu reservoir (municipalities of Guaira - GUAI; Santa Helena - SHEL and Foz do Iguaçu - FOZ); 4 sites in the Itaipu reservoir's eastern tributaries (rivers Ocoí - OCOI; São Francisco Falso - SFFA; São Francisco Verdadeiro - SFVE and Arroio Guaçu - GUAC); 2 sites in the Paraná River (upstream - MONT, and downstream - JUSA the Itaipu Reservoir); 2 sites in the tributaries of the Paraná River (rivers Iguatemi - IGUA and Piquiri - PIQU)(24°18' a 25° 06'S e 53° 23'a 54° 12'W) (Figure 1). The sites in the principal segment of the Itaipu reservoir are lentic while the others sites are lotic (rivers). The samples were taken monthly and only bimonthly during autumn-winter of the 1986-1988 period.

Fishing gears were laid for 24 hours and consisted of gill nets and trammel nets with 3-16 cm-knot gill nets. When the nets were installed and revisited, the data were taken on the transparence of the water column by Secchi disc, water temperature by thermometer, and other environmental characteristics of each site (type of bank and water bottom). The velocity of water is described in crescent order (Figure 2).

Data of standard length (Ls), in centimeters with approximation in millimeters, and total weight (Wt) in grams with approximation in centigrams, were measured for each sample.

The ten greatest weight indexes of dominance (ID %) were the criteria for the choice of chief species. It involved number of individuals (Ni) and weight (Wi)(Beaumord, 1991): ID% = (Ni x Wi)*100/ Σ (Ni x Wi). The abundance of each dominant species was determined by capture per unit of effort (CPUE = number of individuals captured per one thousand square meters of net in 24 hours). In the analysis of the space and temporal variation of abundance of the chief species, CPUE values were analyzed per collection site and season of the year in each sampling period (spring - September, October and November; summer - December, January and February; autumn - March, April and May; winter - June, July, August).

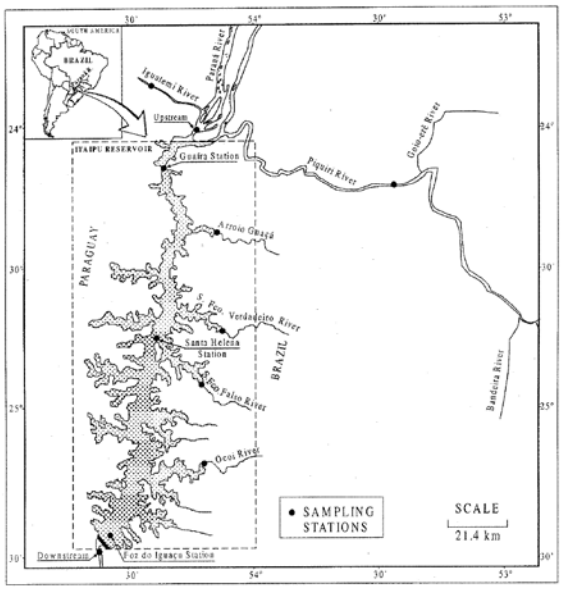

Figure 1. Sites of sampling

Identification of population strata according to the phases of development was established on CPUE basis in the number of young and adult individuals and undertaken for each period and site. Individuals over C_{100} (Vazzoler *et al.*, 1991) were considered adult, or individuals in the reproduction phase; and young, or individuals that were preparing for or did not yet participated in the reproduction cycle.

Degree of gastric repletion (GR), showing the state of stomach filling, was established according to the following scale: 0 = empty stomach; 1 = partially empty stomach; 2 = partially filled stomach; 3 = filled stomach. The above criteria did not apply to *Loricariichthys* spp and *Prochilodus lineatus* since they are water bottom feeders (Fugi *et al.*, 1996). Identification of sex and stage of gonadal maturity was undertaken by macroscopic inspection of gonads (Vazzoler, 1981).

Constancy of main species in samples in each site was determined by Dajoz (1983). The above data

and the spatial distribution of abundance of specimens with filled stomachs and of gonads in reproduction activity (mature and spent) or not (rest and maturation) were used so that indications of the use that main species make in each environment (food and/or reproduction) might be given.

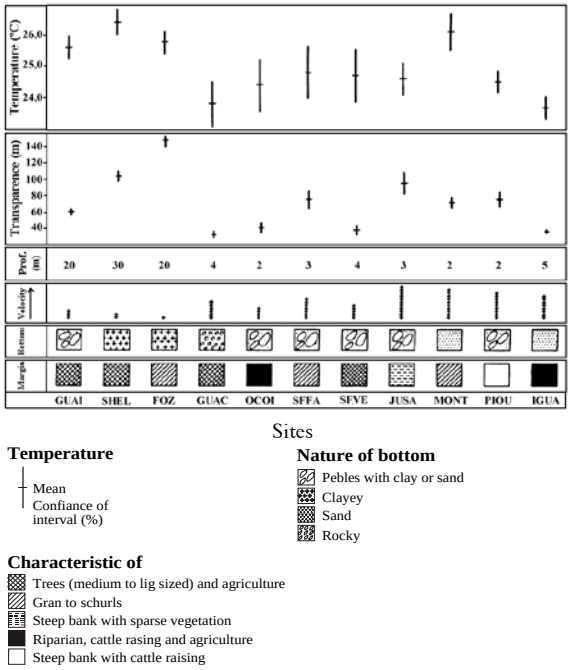

Figure 2. Environmental characteristics of each sampled site

Results

85,160 specimens of 111 species were captured from November 1983 to October 1989. It should be emphasized that not all the species of the genera *Hypostomus, Apteronotus, Pimelodella, Pimelodus, Loricaria, Loricariichthys* and *Rhamdia* were identified. At least some 15 other species should be added to the above total. Siluriform and Characiform were the most represented orders with approximately 44% of each species. They were followed by Perciforms with 8% and by Clupeiforms, Cypriniforms, Pleuronectiforms and Rajiforms with 1% of species captured (Figure 3).

Value analysis of ID showed an ichthyofauna with few dominant species (ID ≥ 1%), many species with low dominance (0.01 > ID < 1) and rare species (ID ≤ 0.01%). Among these, only species of dominant fish were chosen for the study of population structure. They will be introduced in order of dominance since they constitute approximately 90% of total ID (Figure 4).

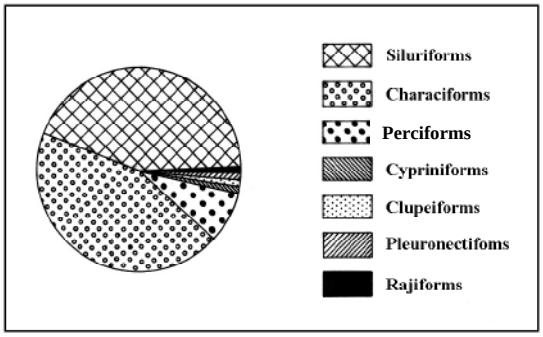

Figure 3. Relative participation of groups of fish in total number of species collected

***Hypophthalmus edentatus* Spix, 1829 (mapará).** Widely distributed in the sampled area (absent only in PIQU), the mapará was abundant in captures undertaken in the reservoir sites (highest number occurred close to the dam, 65 ind/1000m^2 of net/24h, decreasing rapidly towards GUAI with 5 ind/1000m^2 of net/24h). Its abundance was slight outside the reservoir (OCOI and SFVE with 8 and 5 ind/1000m^2 of net/24h respectively). This species was more abundant in samples taken in spring, summer and autumn. In these seasons highest CPUE values were recorded in FOZ (244 ind/1000m^2 of net/24h). In the first years of the reservoir high densities of species were recorded but decreased gradually in the following years. Capture of young specimens followed this trend, which was recorded only in the reservoir area and its tributaries. In environments in which the mapará occurred (RES, ICOI, SFVE), stomachs of specimens were filled or partially filled with food; gonads were in the reproduction phase. Environments may be characterized by calm water, clayey bottom or bottom with pebbles or clay. Average conditions of transparency, temperature, riparian vegetation and average depth are heterogeneous.

***Plagioscion squamosissimus* (Heckel, 1840) (curvina).** The species is abundant in the Itaipu reservoir with captures higher than 18 ind/1000m^2 of net/24h during the period under analysis. Highest number occurred in FOZ (CPUE = 22), OCOI and SFVE. The curvina was constant in captures at most sites. PIQU was the only exception and in GUAC and SFFA it was accessory. These sites are enviroments of faster waters. Captures were highest in summer and autumn. Young specimens, with higher abundance than adults, were distributed at all sites, except GUAC. Smallest abundance occurred in the latter. Feeding activity was greatest in FOZ, OCOI and SHEL. Individuals in the reproduction phase were captured largely in OCOI.

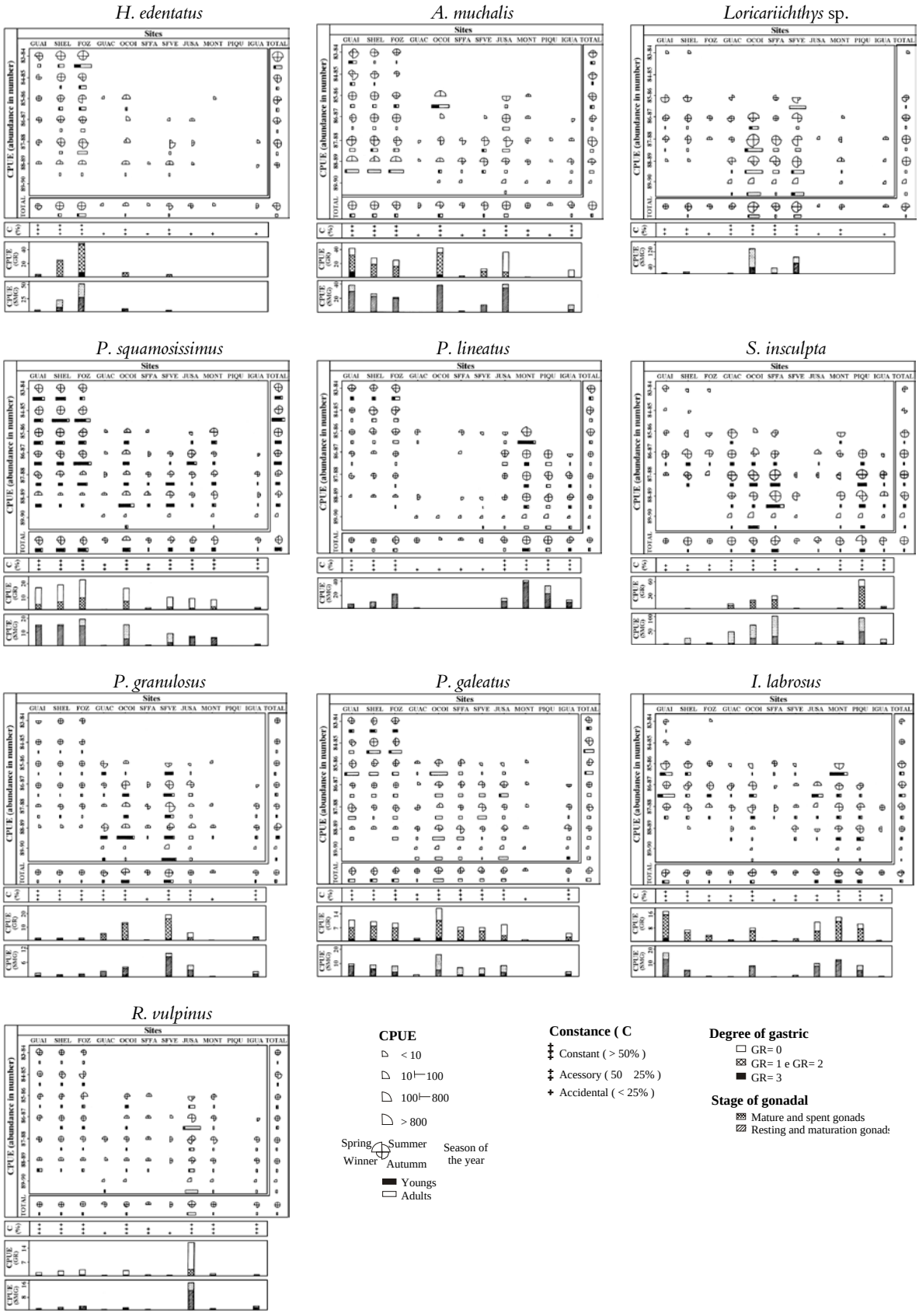

Figure 4. CPUE values in number, proportion of young and adult specimens, constancy, degree of stomach repletion and stages of gonadal maturity of dominant species for each period of the study

***Auchenipterus nuchalis* (Spix, 1829) (surumanha).** This species was recorded in all sampling sites, with abundance higher than 11 ind/1000m^2 of net/24h in the reservoir sites, JUSA, OCOI, SFVE and IGUA. Values in the reservoir were higher than 26 ind/1000m^2 of net/24h and highest towards the river zone (GUAI). Largest captures per CPUE (over 375) occurred in the reservoir tributaries (OCOI and SFVE) and downstream (JUSA) in the spring of 1986 and autumn of 1988. These sites are characterized by highest mean temperatures, nature of bottom pebles with clay or sand, margin, profundity and velocity varied. However, the 1986-87 period was marked by smaller abundance of the species in all the sampled area. Abundance of young reached approximately one third of adults, proportionally higher in OCOI and SFVE (between 1/2 and 2/3). Abundance of young in GUAI was higher in the first year of the studies, decreased till 1986-87 and was slightly higher in 1988-89. Capture of young specimens was higher than that of adults only in FOZ between the spring of 1985 and the winter of 1986. Constancy of species in sampling was over 50% in the reservoir and at OCOI, JUSA and IGUA. Highest frequency of stomachs with food occurred in the reservoir area, OCOI and SFVE. Some individuals of *A. nuchalis* with mature to spent gonads were captured at IGUA, JUSA and those of the reservoir. In the latter, however, frequency of individuals in the reproduction phase increased from the lake (FOZ) towards the river zone (GUAI).

***Prochilodus lineatus* (Valenciennes, 1847) (curimba).** The curimba is constant in all the sampled environments and accidental in the tributaries of the eastern side of the reservoir. Its relative highest density in ind/1000m^2 of net/24h occurred at site MONT (23). It was extremely abundant in the first years of the reservoir, although capture greatly decreased since 1986. Young *P. lineatus* had their highest participation in captures during the first year of the Itaipu reservoir, especially at GUAI and SHEL. Since 1988 captures in the tributaries of the reservoir were greatly reduced and composed exclusively of younger specimens. Neither pattern was verified for this species by season of the year. The highest CPUE of individuals with spent gonads or with gonads in reproduction occurred at site PIQU. They were also sampled upstream and downstream the reservoir and at IGUA. Individuals in reproduction were more abundant in lotic environments.

***Loricariichthys* sp. (Bleiker, 1862) (cascudo-chinelo).** It occurred at all sampling sites, except at PIQU. The cascudo-chinelo was recorded in more than 60% of the samples obtained in the tributaries of the eastern side of the reservoir, although more abundant in OCOI and SFVE (160 and 108 ind/1000m^2 of net/24h, respectively). These sites are small shallow watercourses, with reduced transparency, average low temperatures, pebble bottom and well-established riparian vegetation. In these environments the abundance of the cascudo-chinelo was greater in spring and winter of each year, reaching 825 ind/1000m^2 of net/24h in the winter of 1988 at OCOI. Captures were effective since the autumn of 1986, with SHEL as the site of greatest abundance (13 ind/1000m^2 of net/24h). Number of young specimens and of individuals in reproduction phase was higher at sampling sites in which the species was most abundant.

***Steindachnerina insculpta* (Fernandez-Yépez, 1948) (saguiru).** The capture of the species at the reservoir sites was restricted to GUAI in the first years of research. Since 1986 it reached SHEL as the site of greatest capture. Capture of saguiru was greater in spring and at most sites. In the summer its participation was greatest at the tributaries; in the autumn upstream the reservoir. In SFVE and JUSA collections it was considered accidental, accessory at the reservoir sites and constant in the others. Abundance of young specimens was greater than that of adults at all sampled sites. Its CPUE was higher than ind/1000m^2 of net/24h at SFFA, PIQU, OCOI and GUAC where greatest abundance of individuals in reproduction activities and with partially filled stomachs occurred. Besides lotic characteristics, environments were characterized by shallowness and type of bottom (pebbles and clay).

***Pterodoras granulosus* (Valenciennes, 1833) (armado).** Armado wasn't captured only at PIQU. It is accidental at SFFA and MONT and constant at other sampled sites. Its abundance was greatest at SFVE (19 ind/1000m^2 of net/24h) and OCOI (12 ind/1000m^2 of net/24h). Abundance of the species was greater in autumn 1988 at SFVE (CPUE = 108) and captures in the summer were higher at many sites. Totally and partially filled stomachs were recorded in captures at SFVE and OCOI, GUAC and JUSA. It should be emphasized that at the former three sites mostly young specimens were analyzed, whilst mainly adults in the latter. The proportion of individuals with gonads in the reproduction phase was greater at JUSA, followed by SFVE, IGUA and GUAI, with faster waters and bottom with pebles with clay and sand.

***Iheringichthys labrosus* Kröeyer, 1874 (mandi).** The abundance of the mandi, captured at all sampled sites, was higher than 7 ind/1000m^2 of net/24h at SHEL, OCOI, PIQU, JUSA, MONT and GUAI, in ascending order. In these sites the species was recorded in more than one half of the samples during the period of the research. JUSA was the only exception and the species was considered accessory. In the first years of the reservoir formation captures were slight but the species became abundant between 1986 and 1988. According to the data analyzed, captures were higher in the winter. High densities of young specimens were recorded at FOZ, GUAC, JUSA, MONT and PIQU where they reached up to 38 ind/1000m^2 of net/24h. Stomachs with food were more abundant in GUAI. Gonads in an advanced reproduction process were most abundant at GUAI, followed by PIQU, JUSA and MONT. These are great lotic environments, shallow, with pebble, clay and sand bottom.

***Parauchenipterus galeatus* (Linneaus, 1766) (cangati).** The species had a wide distribution in the region. The exception was only in collections at PIQU. It was constant at all sites, accessory only in GUAC and accidental in MONT. OCOI, followed by sites in the reservoir, had the highest captures per CPUE of the species. The highest capture per CPUE occurred in the summer of 1986 (76 ind/1000m^2 of net/24h) at GUAI. Capture of young individual was higher at sites of the reservoir (approximately 2 ind/1000m^2 of net/24h). Stomachs filled with food and mature to spent gonads were found at all sites in which the species was recorded. Among the sites of the principal segment of the reservoir, FOZ contributed with most individuals in reproduction. The environments showed the most varied temperatures, profundities, nature of bottoms, velocities and margins.

***Rhaphiodon vulpinus* Agassiz, 1829 (dourado-cachorro).** The dourado-cachorro was constant in captures at almost all sites, accessory only at SFFA and accidental in GUAC and SFVE. Greatest abundance occurred in JUSA (17 ind/1000m^2 of net/24h), the most lotic environment of all. Capture of species was higher in the summer. Although with low abundance (2 ind/1000m^2 of net/24h), young specimens were recorded at all sites in which the species occurred. Proportionally, they are more abundant at sites of the reservoir and at OCOI. There are indications that feeding of species occurs outside the sampled area since many stomachs were found empty (GR = 0). Reproduction occurred more effectively in JUSA (CPUE = 4.17). This environment is characterized by pebles with clay or sand, steep bank with sparse vegetation and faster water.

Discussion

Influence area of the Itaipu reservoir presents few dominant species and a great number of occasional or even rare species. Distribution of all dominant populations occurred in all the area under analysis. However, *Parauchenipterus galeatus, Loricariichthys* sp., *Hypophthalmus edentatus, Rhaphiodon vulpinus, Plagioscion squamosissimus* and *Pterodoras granulosus* were absent in the Piquiri River. These species had not reached the upper Paraná River before the Itaipu reservoir flooded Sete Quedas. After the formation of the reservoir, dispersion upstream did not include the Piquiri River, probably because of the natural barrier of specially torrential waters in the lower segment of this river.

Parauchenipterus galeatus, Prochilodus lineatus and *Pterodoras granulosus* needed different habitats for spawning and initial development. Thus, they had a greater interspecies variability in distribution and abundance. On the other hand, *H. edentatus, I. labrosus, P. squamosissimus* and *R. vulpinus* showed equivalent occurrence both for young specimens and for adults. Although they present distinct requirements in different ontogenetic phases, these phases occur in the same environment. The presence or absence of species depends not only on special conditions of the environment but also on the availability of spawning, feeding and shelter sites (Lowe-McConnell, 1991). With regard to the species analyzed, feeding sites generally coincide with places in which the greatest density of the species occurs. Biological characteristics such as age and maturity are also important and influence the choice of habitat (Morin *et al.*, 1992).

As a general rule, the first years in the formation of the Itaipu reservoir were distinguished by success in opportunistic species. After having experienced the colonization process, these species were slowly, but definitively, succeeded by others. The occurrence of certain dominant species is related to the ecology of stabilization and to the former ichthyofauna of the dammed river. These observations caused some researchers to suggest that the colonizers would be typically r-strategists (Odum, 1985; Agostinho, 1992). In proportion to the development of the community, biotic interactions increase in intensity and new conditions benefit the specialists (k-strategists) which employ

the resources in a more efficient way. Opportunistic species are small-size species, sedentary, with high reproductive potential, low longevity and wide environmental tolerance. These are characteristics that favor the invasion of other environments. Among the dominant species, *Prochilodus lineatus* is the only one that lacks these characteristics. It is a big-sized potamodrome characiform with great displacements upstream and restricted spawning period.

Besides the other two Characiforms, *Steindachnerina insculpta* and *Rhaphiodon vulpinus* and one Perciform, *Plagioscion squamosissimus*, the other species are Siluriforms. The latter have a wide diversity of forms, activity and elaborated strategies of reproduction, especially with regard to the construction of nests and egg transport. According to Ofori-Danson (1992), they are predominant in tropical reservoirs. In general the greatest contribution of the Siluriform and Characiform orders found in this research has also been recorded in other neo-tropical basins (Britski, 1992; Godinho, 1993).

Changes in limnological attributes of a watercourse by means of damming may cause populations with naturally low density to experience population booms. *Hypophthalmus edentatus*, the only planktophagous-filter species (Lansac Tôha *et al.*, 1991), slightly abundant in the area outside the Itaipu reservoir, found the best habitat for colonization. Living in the pelagic zone, the species was successful in environment occupation and favored the formation of short feeding webs. The success of the species is represented by greater density and detectable advantages at the level of population dynamics as a factor of higher condition (Benedito, 1989). In the following years, however, its abundance has been supplanted by other species, such as *Auchenipterus nuchalis* (insectivorous), *Iheringichthys labrosus* (benthophagous), *Steindachnerina insculpta* (ileophagous) and *Loricariichthys* sp. (detritivorous). These species have found more favorable environmental conditions for their life cycle.

In the last years, abundance increase of *Auchenipterus nuchalis* in the Itaipu reservoir has been associated with the process of colonization by insects (Hahn, 1991), common after the formation of this type of environment. Ferreira (1984 a; 1984b) also verified high densities of this insectivorous species in the hydroelectric powerhouse of Curuá-Una, Santarém, PA, Brazil. *A. nuchalis* is a small-sized species, of low longevity, swift growth, precocious maturation, internal fecundation (Fuem-Itaipu Binacional, 1986) and with clear sexual dimorphism in the reproduction period (Agostinho *et al.*, 1992; Goulart, 1994). Its main food consists of adult ephemeropters at the water surface. On the other hand, it is also an important feeding item for many piscivorous species (Hahn, 1991).

Plagioscion squamosissimus and *Rhaphiodon vulpinus* are the most important species among the dominant piscivorous ones. The former inhabits all environments. Such versatility is chiefly due to its feeding variability. According to Hahn (1991), the species had a diet composed of approximately 30 species of fish and *Hypophthalmus edentatus* is one of its main feeding items in the dammed area. In the above mentioned environments, the species occurs in deep places and varied water velocity, although it has been more abundant in the reservoir. This may be due to the availability of prey.

Although with low frequency, *Rhaphiodon vulpinus* had a wide distribution in all the sampled area, except at PIQU, with greatest abundance at the site downstream the reservoir. Fish concentration at this site favors feeding conditions of the species. Fuem-Finep (1989) studies reveal sporadic occurrence of the species in the flood plain of the upper Paraná River to where it dispersed after the formation of the Itaipu reservoir, giving a greater constancy to lotic and semi-lotic environments.

According to Agostinho *et al.* (1992), increase in abundance of *Iheringichthys labrosus, Steindachnerina insculpta* and *Loricariichthys* sp. is related to changes in alloctone material that flows into the reservoir and to the development of a more stable benthic community. The first species classified as benthophagous (Fugi *et al.*, 1996) feeds on meso- and macrobenthic organisms. On the other hand, the second species is ileophagous and feeds on fine slime particle. The last species is detritivorous feeding on thicker particles. According to the author above, in tropical water bodies fish species that employ detritus somewhat form a considerable section in the biomass. Although the latter two have an insignificant role in professional fishing, they are important links in the food web, since they transform slime, detritus and benthos in energetic components available to upper trophic levels.

Prochilodus lineatus is also included in this group. It is an ileophagous species since it feeds on finely dissociated particles, algae, microorganisms and decomposed organic material (Fugi *et al.*, 1996). It is abundant throughout the sampled area and occupies second place in professional fishing in the Itaipu reservoir during 1986-87 (Agostinho *et al.*, 1989). However, in the final years of this research, a

decrease in abundance has been noted in experimental samplings in the reservoir area. The process is probably related to successive periods of drought between 1984 and 1986 that affected the biological processes in upstream flood plain where the young develop. This is also due to exceptional feeding conditions initially caused by the drowning of abundant tree vegetation. It is the place where its food (periphyton) develops at present on the decrease due to decomposition processes. In the case of *P. lineatus*, the segregation of adults in lotic environments and the occurrence of younger forms in the sites of the reservoir. Agostinho *et al.* (1993) confirm the employment of big rivers by adults of this species at the upper segment of the reservoir for reproduction. Meanwhile the young develop during the first two years in lakes and canals of the flood plain of the Paraná River.

Pterodoras granulosus is another very important commercial species. Although classified as a second class fish (Okada, 1990), it is the chief species captured in the third upper segment of the Itaipu reservoir (Agostinho, 1988). This research revealed a clear spatial segregation between young specimens and adults. Okada (1990) also noted this fact from commercial fishing data that showed that the dammed segments of the tributaries were the preferred environments of the young individuals. The author supposes that stratification may be related to food availability, since young and adult specimens have differentiated diets: the young specimens feed mainly on filamentous algae and components of the benthic community, more abundant in these transition zones. On the other hand, adults ingest vegetal remains (Fuem - Itaipu Binacional, 1989). Species reproduction is processed in lotic areas upstream the reservoir.

Parauchenipterus galeatus was benefited by changes brought about by the construction of the Itaipu dam. Although of slight commercial importance, the species has a wide food specter and is considered omnivorous (Andrian and Barbieri, 1996). Although insects are more abundant, higher vegetation, especially fruits, is extremely relevant in the species's diet. In the reservoir region the species is homogeneously distributed and mainly feeds on insects. Outside the dam area, it prefers low velocity waters where it feeds more intensively on vegetation (Andrian and Barbieri, 1996). The scarcity of small-sized individuals in the samples shows population stratification.

As a general rule, the abundance of species was greater in the spring and summer of each year, with low abundance in the winter. Specimens were not susceptible of being caught in the nets due to their low mobility during the winter. However, catches of *Iheringichthys labrosus* were similar or even higher in the cold months of each year. This fact shows that the species has a distinct strategy in the allocation of energy, especially in its maintenance during the different periods of the year.

Food availability, intensity of predation on young and adult species and toleration to physical and chemical conditions reinforce conflicting selective pressure on the employment of the environment by the individual (Angermeier and Karr, 1983). In the influence area of the Itaipu reservoir, pressures exerted in a drastic way gradually cause the evolution of reconciliatory adaptations and guarantee to fish assemblage a better acquisition and use of energy by individuals. However, since the process involves a wide span of time, further long-term studies in such environments are needed.

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