CONDITION OF *Hoplias* aff. *malabaricus* (BLOCH, 1794) IN TWO COASTAL STREAMS OF ITANHAÉM RIVER BASIN, BRAZIL

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ABSTRACT

The main purpose of this research was to measure the condition of the fish species *Hoplias* aff. *malabaricus* collected in Aguapeú River (black waters) and Branco River (white waters), which belong to Itanhaém River basin, a coastal watershed in São Paulo state, Brazil. Individuals of *Hoplias* aff. *malabaricus* were sampled by using gill nets, monthly from March 2001 to February 2002. The Condition Factor was obtained through the lenght-weight relationship, assuming that the higher the mass for a given length, the better the condition of the fish. The Condition Factor was compared among fishes from both rivers, resulting that Branco River individuals have significantly lower condition. Limnological aspects were studied from May 2001 to November 2002 and some show significant differences between Aguapeú River and Branco River. These were salinity, DO and total organic N, which the higher values being observed in Branco River probably due to estuarine waters influence. However, the lower condition of the Branco River fishes should also be an effect of a disturbance due to the sand mining in this river, since this activity cause important alterations to the environment, affecting the whole biota, included aquatic macrophytes, invertebrates and fishes.

Key words: *Hoplias* aff. *malabaricus*; condition factor; Aguapeú River; Branco River; Itanhaém River; aquatic macrophytes; sand mining

CONDIÇÃO DE *Hoplias* aff. *malabaricus* (BLOCH, 1794) EM DOIS RIOS COSTEIROS DA BACIA DO RIO ITANHAÉM/SP

RESUMO

O objetivo deste trabalho foi mensurar a condição de *Hoplias* aff. *malabaricus* do rio Aguapeú (águas pretas) e do rio Branco (águas brancas), ambos pertencentes à bacia hidrográfica do rio Itanhaém, na costa do litoral de São Paulo. Os peixes foram amostrados com redes de espera, mensalmente entre março/2001 e fevereiro/2002. O Fator de Condição, um indicador da condição biológica do peixe, foi obtido pela relação comprimento-peso, assumindo que os peixes com maior massa em um dado comprimento estão em melhor condição. Os resultados do Fator de Condição mostraram diferenças significativas, com os peixes do rio Branco apresentando pior condição. Algumas variáveis limnológicas foram estudadas entre março/2001 e novembro/2002. Os níveis de salinidade, OD e N orgânico total foram significativamente maiores no rio Branco devido, provavelmente, à influência de águas do estuário. A condição mais baixa dos indivíduos de *Hoplias* aff. *malabaricus* deste rio poderia ser uma resposta aos distúrbios provocados pela mineração de areia realizada no canal deste rio, uma vez que esta atividade produz alterações significativas no ambiente no qual é realizada, afetando a biota como um todo, inclusive as macrófitas aquáticas, os invertebrados e os peixes.

Palavras-chave: *Hoplias* aff. *malabaricus*; fator de condição; rio Aguapeú; rio Branco; rio Itanhaém; macrófitas aquáticas; mineração de areia

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INTRODUCTION

The Condition Factor, obtained by the length-weight relationship, is a frequently used index for fish biology study, as it furnishes important information related to fish physiological state, based on the principle that individuals of a given length, exhibiting higher weight, are in a better condition. The Condition Factor of geographically distinct fish populations permits one to evaluate the quality of the environments in which these animals live, as well as it gives information about the relationship between abiotic characteristics and the biotic components of ecosystems (BRAGA, 1986; BOLGER and CONOLLY, 1989; WILLIANS, 2000; LIMA-JUNIOR *et al.*, 2002; LIZAMA and AMBRÓSIO, 2002).

Hoplias aff. *malabaricus*, class Actinopterygii, order Characiformes and family Erythrinidae, is commonly known in Brazil as *traíra* (in other latin American countries also called trahira, tiger fish, wolf tetra, tiger tetra, mud characin or 'piranha eater'). It inhabits exclusively fresh waters, mainly in lentic and tropical warm waters. However, some individuals were observed in colder waters in southern South America. This fish lives in moderately current or still waters, in banks or in smaller depths, over mud bottom and in areas protected by aquatic macrophytes, where it uses the coloration to hide from its potential prey (PAIVA, 1974; GODOY, 1975; HENSLEY and MOODY, 1975; CARAMASCHI, 1979; HENDERSON and HAMILTON, 1995; LOWE-MCCONNELL, 1999; REID *et al.*, 2000; SAINT-PAUL *et al.*, 2000).

This is a sedentary species, developing its entire life cycle in a relatively small geographic area. Due to these habits this fish feeds in a low frequency, but voraciously, showing great resistance to periods of starvation, even during the spawning season (an uncommon feature to the majority of fish species). The diet of adult individuals, whose average standard length is larger than 200 mm, is predominantly based on fish, followed by some kinds of crustaceans. *Hoplias* aff. *malabaricus* feeding activity is more intense during the night period, when it performs short range searches for prey (AZEVEDO and GOMES, 1943; PAIVA, 1974; CARAMASCHI, 1979; PEREIRA *et al.*, 1981; BARBIERI *et al.*, 1982; OLIVEROS and ROSSI, 1991; BISTONI *et al.*, 1995; ZAVALA-CAMIN, 1996; ALMEIDA *et al.*, 1997; REID *et al.*, 2000; BIALETZKI *et al.*, 2002; RIOS *et al*, 2002).

Few papers about *Hoplias* aff. *malabaricus* deal with feeding habits or condition, and most of them are physiology and genetics studies. Papers dealing with this species about relationship of condition and environmental variables (limnological and biological) do not exist in Brazil, in coastal hidrographic basins, as the Itanhaém River basin, studies about fresh water fishes, especially *Hoplias* aff. *malabaricus*, in coastal hydrographic basins are scarce.

The main purpose of this paper was to determine the Condition Factor of fishes *Hoplias* aff. *malabaricus* sampled from two coastal streams, Aguapeú River and Branco River, both located in the Itanhaém River basin.

Study area

The Itanhaém River basin is located on the southern coast of the State of São Paulo, southeastern Brazil (23° 50' and 24° 15' S; 46° 35' and 47° 00' W) and drains a watershed of about 950 km^2, approximately with 50 km in length and 15 km in width (SUGUIO and MARTIN, 1978; PEREIRA, 2002) (Fig. 1). The climate of the region is Af - Tropical (tropical super humid with no defined dry season, with higher rainfall during the Summer), according to Köeppen (SETZER, 1966). The meteorological conditions present little variation due to its latitude and proximity to the Atlantic Ocean. Rain is abundant (annual average of 2,183 mm), with the highest rainfall in March (279.9 mm) and the lowest in August (84.7 mm). The atmospheric temperature in the region is high, with a maximum average of 26.2 °C (February) and minimum average of 19.0 °C (July) (LAMPARELLI and MOURA, 1998).

Aguapeú River has darkened waters (black waters) and its riverhead is located in the Pre-Cambrian grounds of the Sea Range, Mongaguá town, but the larger area of its course is located on the coastal plain. This river is the principal tributary of Branco River (CAMARGO *et al.*, 2002). The river channel is 26 m wide at this sampling site and it's 14 km far from the estuary mouth (LEUNG and CAMARGO, 2005). Branco River has muddy waters (white waters) and its riverhead is on the plateau between 600 and 800 meters of altitude. It flows along the Pre-Cambrian grounds of the Sea Range and, subsequently, to the coastal plain (CAMARGO *et al.*, 2002). The channel width at this sampling site is 187 m and it's 12 km far from the estuary mouth (LEUNG and CAMARGO, 2005). In this river there is an intense sand mining activity, which consists of sand extraction from the river bed by means of suction of sediments (especially sand) at low depths. So, the water sucked by the equipment subsequently returns to the river (CHRISTOFOLETTI, 1981; CAMARGO *et al.*, 1997; ACCORSI, 2001).

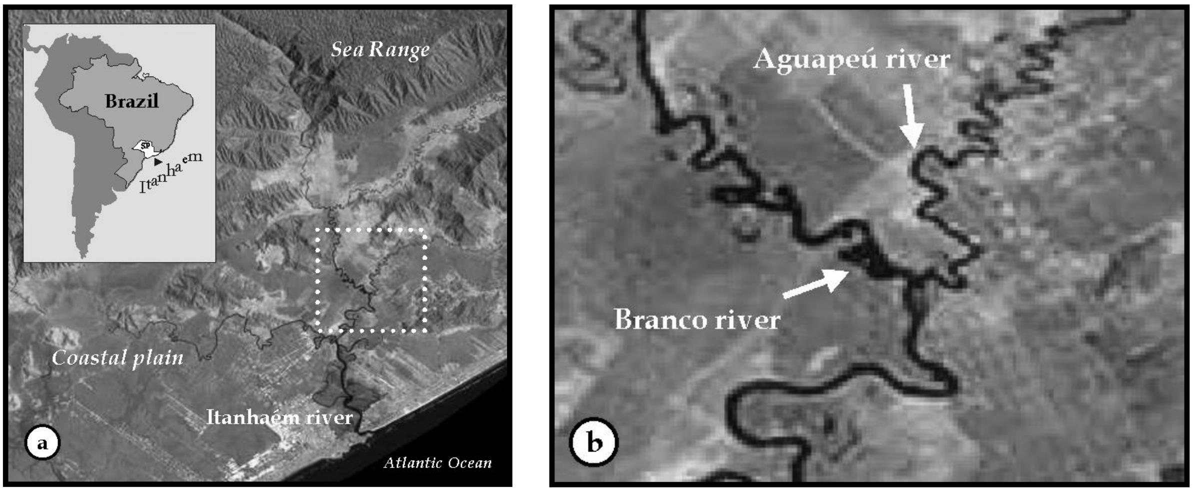

Figure 1. a. LANDSAT TM 5 satellite image of Itanhaém River basin (Scale 1:50.000). **b.** Sampling stations in the Aguapeú and Branco rivers (Scale 1:5.000). http://www.cdbrasil.cnpm.embrapa.br/. Access on: February 14 2005

MATERIAL AND METHODS

Biological sampling

Hoplias aff. *malabaricus* individuals were caught with gill nets (20 m x 1.5 m, 9 mm mesh knot to knot) fixed to aquatic macrophytes stands (*Eichhornia azurea* and *Polygonum* sp). Three gill nets were installed at the right margins of each river by the end of the evening (17 h) and taken off at the early morning (7 h) once a month, from March 2001 to February 2002. The allometric Condition Factor was calculated for each individual to quantify the "well-being" of the fish. The fish condition was calculated using the expression $K = (W / L^b)\ 100$, in which K = allometric Condition Factor; W = total weight (with gonads); L = standard length and b = weight-length expression coefficient ($W = aL^b$). The coefficient b was calculated by the least squares method applied to the data transformed to their respective natural logarithms. It was used as a constant for all samples. The Condition Factor, weight and lenght results of fishes from both rivers were compared to each other using the nonparametric test *Mann-Whitney U* (ZAR, 1999).

Environmental sampling

Limnological variables were collected in sub-surface (10 cm), under low tide conditions, at right and left margins and in the center of the river, once a quarter (season), from March 2001 to November 2002. Water temperature, salinity, electrical conductivity, pH and turbidity were measured using a Horiba® Multi-Parameter Water Quality Monitoring System (U-20 Series). Dissolved oxygen (DO) was determined by Winkler method (GOLTERMAN *et al.*, 1978). Parameters such as total suspended matter (susp. matter) (CLESCERI *et al.* 1989), ammoniacal-N (KOROLEFF, 1976), total organic N (TN) (MACKERETH *et al.*, 1978) and total P (TP) (GOLTERMAN *et al.*, 1978) were measured in laboratory. The *Levene Test (F test)* was applied to check the homogeneity of variances of the variables.

If the results were homogeneous the *t-Student* test was applied, if they were heterogeneous the *Mann-Whitney U* was used (ZAR, 1999).

The software Statistica (version 5.5) was used to perform all the statistical analysis (STATISTICA, 2000).

RESULTS

The standard lengths of *Hoplias* aff. *malabaricus* sampled in Aguapeú River ranged from 146 mm to 309 mm (n = 46; median 239 mm). In Branco River they occurred between 123 mm and 298 mm (n = 27; median 239 mm). The total weight of fishes from Aguapeú River varied between 51 g and 683 g (median 282 g) and between 17 g and 623 g (median 277 g) in Branco River. Differences observed in both standard length and total weight were not significant. Values of Condition Factor (K) of the individuals sampled in Aguapeú River ranged between 3.45 and 5.14 (median 4.09) and were significantly higher than those from Branco River (p = 0,0016), which varied between 0.94 and 4.18 (median 3.83) (Fig. 2). The calculated value for b was 3.71 in fish from both rivers.

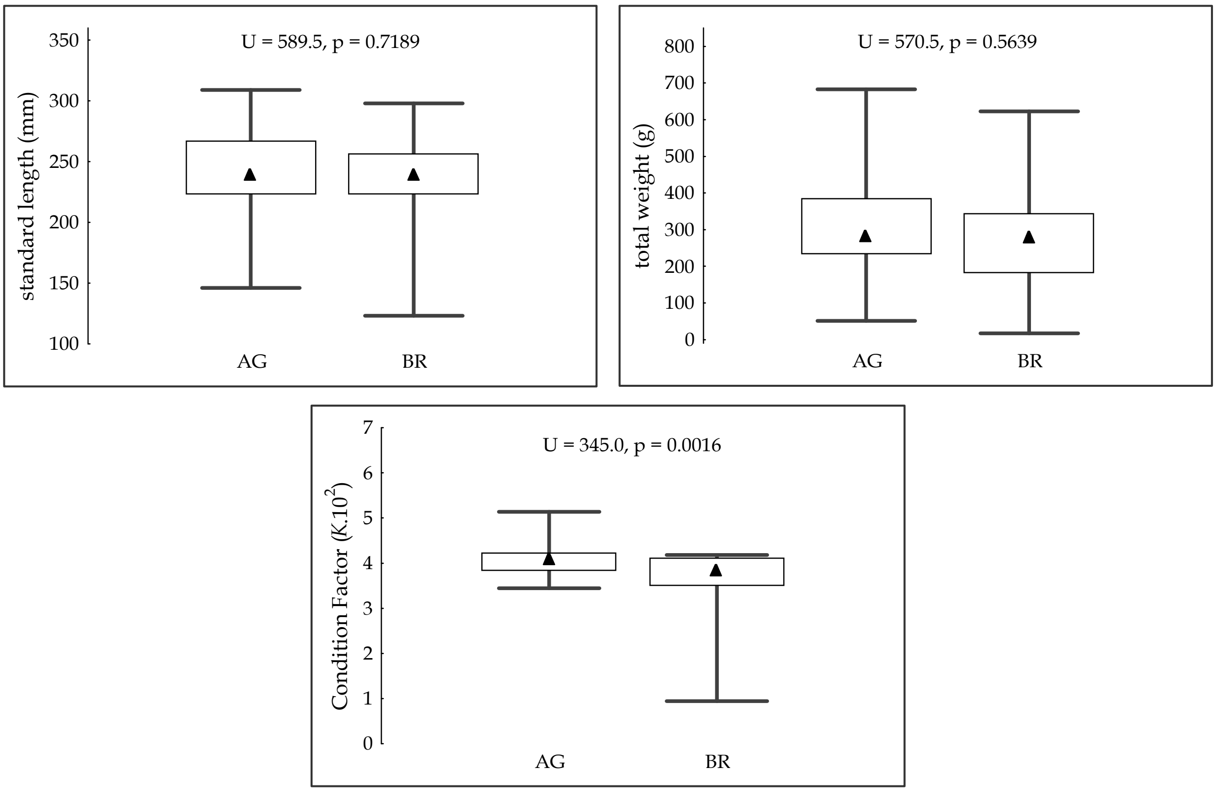

Figure 2. Median (▲), interquartile range (☐) and maximum and minimum values (I) of standard length, total weight and Condition Factor of *Hoplias* aff. *malabaricus* in the Aguapeú River (AG; n = 46) and Branco River (BR; n = 27). Significant differences at p< 0.05

The limnological variables measured on this study and the statistic tests results are shown in the Figure 3. The limnological variables that showed significantly higher results in Branco River in comparison to those from Aguapeú River were salinity (averages 0.0163 and 0.0000, respectively), DO (averages 7.63 $mg.l^{-1}$ and 6.08 $mg.l^{-1}$) and TN (averages 0.16 $mg.l^{-1}$ and 0.12 $mg.l^{-1}$).

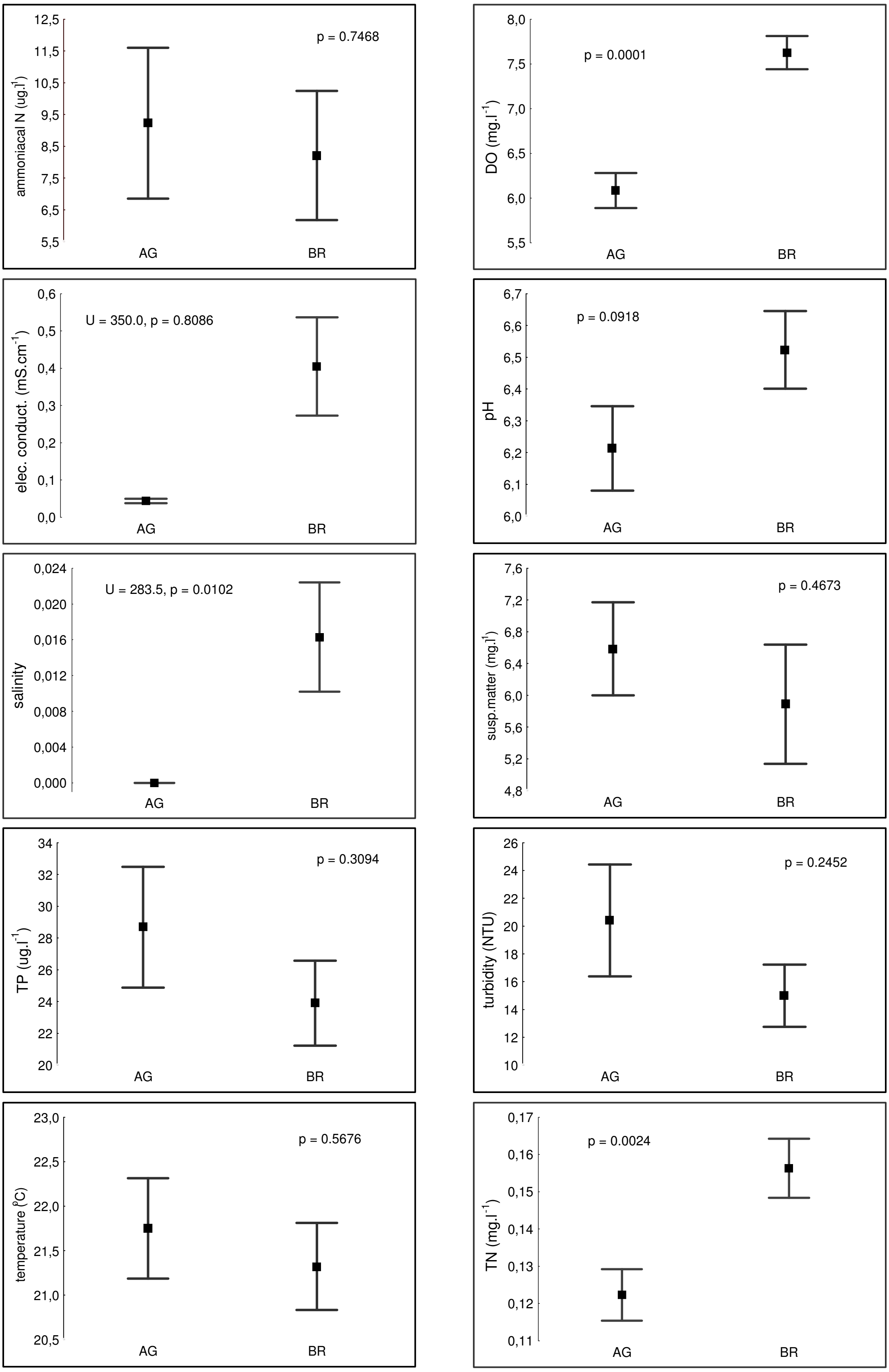

Figure 3. Average (■) and standard error (I) of the Aguapeú River (AG) and Branco River (BR) limnological variables (n = 27 for each parameter in both sampling station). Significant differences at $p<0.05$

DISCUSSION

The coefficient *b* was used as a constant for all samples because different values of *b* for each sample might produce distorted results and influence to divergent concepts from the Condition Factor definition (LIMA-JUNIOR *et al.* 2002). The Condition Factor (K) and weight (W) should be directly proportional, and consequently, the higher the weight of individuals with the same length, the higher the Condition Factor (BOLGER and CONOLLY, 1989; LIMA-JUNIOR *et al.* 2002).

Significant differences were not observed between the standard length averages of *H.* aff. *malabaricus* specimens from Aguapeú River (average 239 mm) and those from Branco River (average 239 mm). The fishes from Branco River show statiscally lower values of Condition Factor than those from Aguapeú River.

So, the limnological characteristics were analyzed and the Branco River showed statiscally higher values of salinity, DO and total organic N. Water usually provides habitat for every fish, so its chemical and physical properties (DO, salinity, temperature, pH) have strong effects on individuals (MATTHEWS, 1998).

Intense salinity gradients, besides other environmental variables, are considered primary stressors for freshwater fish (MATTHEWS, 1998). *Hoplias* aff. *malabaricus* inhabits fresh waters and belongs to the so called primary division that includes the families or other fish groups from fresh waters, which commonly do not enter marine waters. However, this can exceptionally occur (PAIVA, 1974; HENSLEY and MOODY, 1975; FERNANDEZ-BADILLO and LUGO-SOTO, 1994). Although significant influence of brackish waters from the estuarine region of the basin were detected in Branco River (Aguapeú River had no perceptible influence of marine waters during the sampling period), the salinity does not explain the lower condition of fish from this sampling station. The salinity and temperature effects in water density are important because they inflict delicate structures to aquatic environments, and the fish ecology is affected by these structures, specifically for *Hoplias* aff. *malabaricus*, whose salt tolerance is greater than most other characoids (HENSLEY and MOODY, 1975; WOOTTON, 1992). It may also be considered, according to LEUNG and CAMARGO (2005), that marine-estuarine fish may have an important influence to the freshwater food web, notwithstanding their relatively lower abundance in the riverine environment.

Branco River has shown higher values of DO. Large mats of floating aquatic plants, such as *Eichhornia crassipes* and *Salvinia molesta*, use to produce almost totally deoxygenated conditions underneath, because they prevent oxygenation of water by blocking the water-air interaction (PETR, 2000). There is, however, little probability that this would cause some injury to *Hoplias* aff. *malabaricus*, as this is a tough species known to be well adapted to low oxygen levels (PAIVA, 1974; HENSLEY and MOODY, 1975).

For instance, the comparison of total organic N and DO averages between Branco River (0.156 $mg.l^{-1}$, 7.63 $mg.l^{-1}$) and Campininha River (1.38 $mg.l^{-1}$, 3.38 $mg.l^{-1}$), nevertheless, shows that Branco River is in healthier state since its values are significantly lower for the mentioned variables. Campininha River belongs to the estuarine region of Itanhaém River basin. According to SANT'ANNA *et al.* (2007), it is polluted by domestic sewage discharges from the urban area of Itanhaém town. Is this mentioned paper, the limnological variables were analysed with the same methodology applied on the present study.

The state of *Hoplias* aff. *malabaricus* in Branco River shall be explained only when other variables are analyzed, by themselves and gathered to the other ones, which probably influence the significantly lower condition of fishes caught in this river.

Aquatic macrophytes represent an important habitat for fish, which may use them for shelter and ambushing their prey to feed, and also for reproduction; a considerable variety of invertebrates, which are used as food for fish, may also use this vegetation for shelter. The presence of vegetation will also affect the foraging mode of specific piscivorous predators. A strong correlation between *Hoplias* aff. *malabaricus* and these places for feeding exists, as well as prey and shelter availability and environmental variables are responsible for distribution and occurrence of this species (PETR, 2000; MAZZONI and IGLESIAS-RIOS, 2002, CASATTI *et al.*, 2003; PETRY *et al.*, 2003). *Hoplias* aff. *malabaricus* is a natural fish properly found in such biotopes of floating aquatic macrophyte stands in which, covered, it behaves like an ambush predator (LOWE-MCCONNELL, 1999; SÚAREZ *et al.*, 2004).

In Branco River flatboats were frequently observed, which were used for sand mining activities mainly done in the river channel. Instream sand mining may cause degradation to the aquatic and riparian habitats and to the whole biota due to large changes in the channel physionomy. Sand mining generates extra vehicle traffic, which negatively impairs the environment. Depletion of sand in the streambed and along the coastal areas causes the deepening of rivers and estuaries, and the enlargement of the river mouths and coastal inlets. It may also lead to saline-water penetration from the nearby sea. The effect of mining is compounded by the effect of sea level rise. Any volume of sand exported from streambeds and coastal areas represents a loss to the system (PONCE *et al.*, 1999).

According to CAMARGO *et al.* (1997), sand mining in Branco River occurs since at least 1962. It is intensively and illegally made at a 3 km distance from Branco River and Aguapeú River (where it does not occur) confluence. The changes in the channel morphology of Branco River can be visualized in figures 4-a and 4-b. These changes can create favorable environments to aquatic macrophytes growth, which modifies the structure of their communities, with significant impacts to the biota over a medium and long term (CHRISTOFOLETTI, 1981).

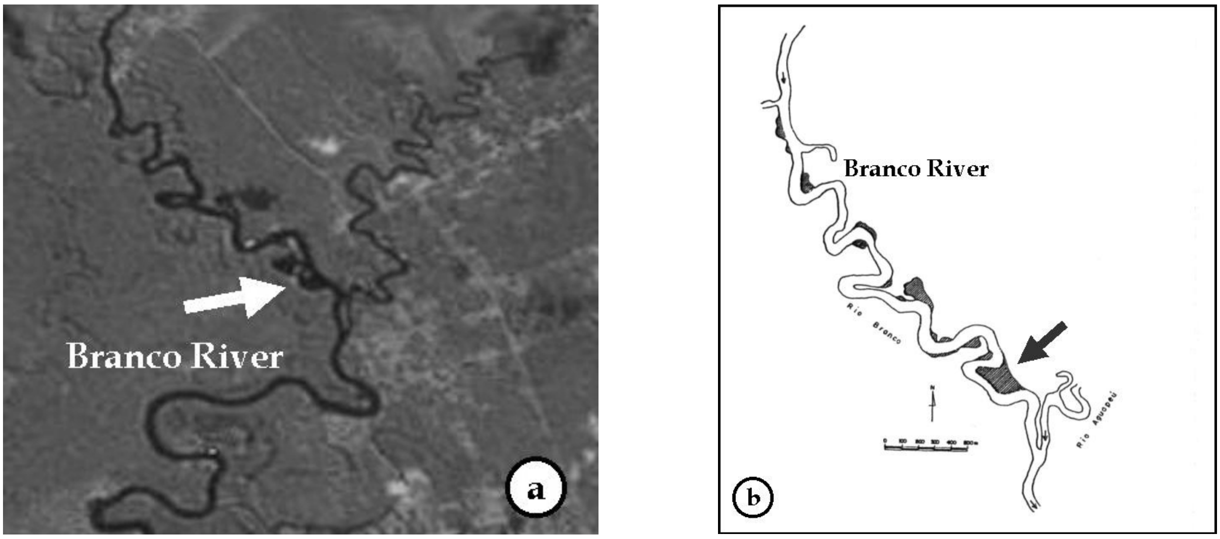

Figure 4. **a.** Satellite image (from 2003) showing the sampling station of *Hoplias* aff. *malabaricus* in Branco River (Scale 1:5.000). Accessed in Feb. 14, 2005 (http://www.googleearth.com/). **b**. Ilustration of the same part in Branco River part that shows the areas created by sand mining (in dark) (CAMARGO *et al.*, 1997)

CAMARGO *et al*. (1997) compared the aquatic macrophytes communities from Preto and Branco rivers (two contributors to the Itanhaém River formation) and verified significant differences of the structure and biomass dynamics of these communities. A strong dominance of *Eichhornia azurea* was observed in Branco River. The lower species diversity and the *Eichhornia azurea* dominance were, probably related to anthropogenic influence in this river (changes in the channel physionomy origined by sand mining). This fact may have reduced current velocity and permitted the appearance of lower depth areas, which altered the aquatic macrophyte communities.

The architecture or spatial arrangement of plant species has an important impact on fish frequenting aquatic macrophytes stands. Therefore, fish condition and abundance, particularly for piscivorous species, are often higher in intermediate areas, possibly affecting biomass levels of structural complexity in aquatic macrophyte communities. Too dense concentrations of aquatic plants may lead to a reduction in the condition of fish because species of macrophytes capable of establishing dense stands may disturb fish movements and foraging efficiency. Piscivorous fish were commonly observed occupying small spaces devoid of plants within dense vegetation, from where they ambushed their prey. As more research is made, the interrelationships between fish and macrophyte communities seem to be more complex. Aquatic macrophytes represent one of the major links in the interrelated environment, when they do not represent the central link by themselves, which determines its stability. Fish are closely dependent on their whole environment, a balanced condition, which can be distorted by human activities (PETR, 2000).

Environmental stressors can negatively impact the aquatic biota; these stressors can be natural (salinity variations, competition, for example) or anthropogenic (physical modifications of the surroundings, as, for instance, those caused by sand mining). Stressors are incorporated by Condition Factor; although, randomic fluctuations or fish condition differences can occur due to species, gender and season facts (quantity and quality of prey, temperature, spawning period, and period of luminosity. The fish sampling method, mainly by using gill nets, which tend to be selective, can also affect the Condition Factor. By and largely, to long term environmental characteristics, food supply and level of effect from parasites can directly affect the fish condition. When distinct variables that would affect the fish Condition Factor were observed, it is not surprising that ones interpretation can often lead to mistaken results and mainly interpretations. Furthermore, the differences in the values of Condition Factor can occur under influence of more than one variable, which were not measured (LE CREN, 1951; MATTHEWS, 1998; JENKINS, 2004).

Otherwise, a disturbed river may also affect indirectly *Hoplias* aff. *malabaricus* such as the abiotic environmental conditions, as the fish species may be immune to those alterations, but, on the other hand, these conditions may cause alterations to the fish state by affecting the invertebrates and other fish, which compose its food. At the muddy water river margins (like Branco River) the floating macrophytes constitute the most important biotope, as this vegetation shows an elevated primary production and plays an important ecological role by composing the food resource, shelter for hiding and for growth of larvae and juvenile fishes of many distinct species (LOWE-MCCONNELL, 1999). Alterations of aquatic vegetation communities and habitat changes due to sand mining can reduce the habitat complexity and feeding opportunities, as well as large-sized predator quantities (SÚAREZ *et al*., 2004). The energy consumed and food-swallowing relationship, as time passes by, may be more affected in a disturbed river as the energy cost to obtain food can also be altered for *Hoplias* aff. *malabaricus* in this environment.

So, the relationships between fishes, aquatic macrophytes and environmental variables are well documented. Due to relatively low samples we assert that there are indications that the lower condition of *Hoplias* aff. *malabaricus* in Branco River is due to sand mining impacts, which could have caused important changes in the channel physionomy and some degradation to related habitats and biota - including fishes and invertebrates, as well as macrophytes. The reported alterations in the aquatic macrophyte communities in Branco River were, probably, the cause of a reduction for the fishes foraging efficiency and, consequently, affected their condition.

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