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WHAT FACTORS AFFECT THE FISHING RESOURCES OF THE MIDDLE STRETCH OF THE RIVER RIBEIRA DE IGUAPE (SP)?

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Abstract: The Ribeira Valley is in the southern region of the state of São Paulo and is home to the largest continuous and conserved extension of the Atlantic Forest in Brazil. The local economy is focused on primary activities, such as mining and bananas (*Musa sp*) and palm heart (*Arecaceae*) cultivation, which have a potential impact on the local ichthyofauna. In addition to these activities, the River Ribeira is home to an array of exotic and allochthonous fish, in addition to native fauna. Both artisanal and recreational fishing also take place in the river, which ensures the livelihood of fishers´ families, Indigenous peoples and Quilombolas in the region, either by supplying food from capture fishery or from sports activities. Between 2014 and 2018, scientific fisheries used gillnets and cast nets in places close to sand mining areas and points upstream of them. The fish were identified and their weights were taken. Based on the fishing efforts (net area multiplied by exposure time) and fish biomass values, the CPUE was calculated. The Kruskal-Wallis test showed that only the origin of the fish was significant, in which the abundance of exotic/allochthonous fish was higher than that of native fish (p=0.000). The ANCOVA showed that the average biomass of the fish grouped in this category was also higher than the average biomass of native fish (p=0.000), as well as the fishing effort (p=0.000). Despite constant pressures on the local fauna, non-native fish are a matter of more serious concern, which may compromise their abundance and distribution of native fish in the future. It is worth mentioning that the recent dredging promoted by the state government, aiming at deepening the riverbed of the River Ribeira, was not evaluated in this work and its possible impacts, as well as the constant mining operations, require constant studies.

Keywords: Sand mining, non-native fish, fisheries, impacts.

INTRODUCTION

Located in the southern region of the state of São Paulo, the Ribeira Valley has the largest continuous and conserved extension of the Atlantic Forest in Brazil. The Ribeira River has major economic importance due to the water supply to municipalities, irrigation of banana plantations and ore extraction (sand). Artisanal and recreational fishing also take place in the river, which ensures the livelihood of fishers´ families, Indigenous peoples and Quilombolas in the region. This is done by supplying food from capture fishery or from sports activities.

The work carried out in the Ribeira Valley region focused on activities developed along the coast. Ramires et al., (2012) carried out a study adopting an ethnoecological approach in coastal counties and interviewed seven artisanal fishermen from Registro, whose mainland fishery laid traps aimed at catching Anchoviella lepidentostolemanjuba, Mugil sp and Cynoscion sp.

Correa and Leonardo (2011) studied the capture of Centropomus ensiferus in the Ribeira Valley reporting on these fish occurring as far as the city of Iporanga, 260 km upstream from the sea. This species was considered one of the most important in the Ribeira River. After having identified its importance, the authors proposed to promote fish farming as a way of preserving the species, avoiding overexploitation.

Studies on the composition of the ichthyofauna from the River Ribeira de Iguape were conducted by Oyakawa and Menezes (2010) and 97 different fish species were identified in the region, including native and exotic or allochthonous species. These were reported by Castelani and Barrela (2006), who observed that fish farms in the region mainly keep non-native species captive and in 95% of the enterprises visited, the fish had escaped. The presence of invasive species has an impact on the environment, such as the displacement and extinction of native species, changes in trophic interactions, introduction and transmission of new pathogens, threats to the genetic diversity of native fish through hybridization and economic losses related to the loss of natural resources (Haubrock et al, 2022).

Extractive activities in Vale do Ribeira began in the Brazilian colonial period, mainly concentrated in the municipalities of Iporanga, Eldorado, Cananéia and Apiaí. The minings explored consisted of numerous quartz and auriferous veins embedded in metasedimentary rocks, and alluvial occurrences in the Ribeira de Iguape River and tributaries (Lopes, 2017). Phosphate, limestone, red ceramic, gold, silver, zinc, lead, gravel, sand and ornamental rock are currently exploited in the region.

The sand and clay that integrate the sediment of the Ribeira de Iguape River have been targets of aggregate mining for civil construction since the 1970s (Sevá Filho and Kalinowski, 2012). The exploration of mineral resources has been encouraged in the Ribeira Valley by the Government of the state of São Paulo through the "Vale do Futuro" Program, which promotes a mining plan to stimulate activity in the region and generate employment and income.

Rentier & Câmara (2022) highlight that sand mining causes impacts on the physical environment, such as (a) alteration in the sediment (causing an imbalance in the erosion and sedimentation dynamics); (b) an increase in the erosion rates of the riverbanks caused by the reduction in sediments for transport and, consequently, an increase in the flow; (c) interference with the depth of the water table. The biological environment can also be affected in different dimensions: (a) alteration in the benthic and microorganism communities due to alteration and/or loss of habitat; (b) increased turbidity and, consequently, blocking the sunlight and reduced respiration and photosynthesis, as well as blocking the respiratory organs of aquatic animals; (c) difficulty in moving fish due to the widening of the riverbed; (d) alteration in the food web due to benthic community reductions/ alterations; (e) favoring invasive species due to the disturbance of the ecosystem balance; (f) destruction of riparian vegetation due to bank erosion and alteration in the water table depth.

The chemical environment is also susceptible to imbalances: (a) removal of nutrients deposited in the sediment that support planktonic aquatic vegetation, as well as riparian vegetation; (b) compromised water and air quality by fuel/oil leaks and flue gas from machinery used for excavation and transport, affecting aquatic life, plants and humans; (c) availability to fauna and flora of metals and/or other contaminants found in the sediment due to its resuspension, increasing the water turbidity. Impacts on the anthropogenic environment must also be considered, for example: (a) collapse of buildings; (b) agricultural land losses due to bank erosion and lowering of the water table; (c) reduction in fisheries and their products; (d) change in the potability of the supply water.

In addition to the impacts caused by mining, the River Ribeira may still be the target of future damming for power generation, which is a reality already seen in other rivers in the same basin, such as in the River Juquiá (Sevá Filho and Kalinowski, 2012). Freitas et al., (2022) described the impacts resulting from constructing small hydroelectric plants in the Amazon, such as changes in macroinvertebrate communities and, consequently, in the whole food web and environmental degradation associated with deforestation for dam building. The authors also emphasize the need for evaluations of the cost/benefit ratio regarding the cumulative negative impacts to install small hydroelectric plants. Large dam building to generate energy promotes the same impacts as above, but on a larger scale. In addition to these, there are changes in the biochemical processes of riparian ecosystems, riparian vegetation, human health, the water quality released by dams and the acceleration in climate change due to changes in the hydrological cycle (Li et al, 2021).

There are other primary activities that can be mentioned in the Ribeira Valley, such as banana, pine, eucalyptus and palm heart harvesting, as well as livestock (CBH-RB, 2022). Analyzing the evolution of land use and occupation in the region between 1987 and 2017, Cordeiro et al (2017) highlight the increase in areas intended for banana plantations and their predominant occupation of floodplain areas. Despite the possible increase in the local economy, banana farming brings with it the contamination of water bodies by pesticides and Marques et al (2007) observed higher concentrations of carbofuran - a compound that can remain in the environment for up to 18 months - in the water in rainy periods. When investigating the artificial eutrophication processes in rivers of the Ribeira River Basin, Calijuri et al (2008) reported that the rivers studied showed different levels of deterioration associated with banana farming areas, either due to increased levels of phosphate compounds or by increasing turbidity.

The Ribeira Valley joins 16 different Conservation Units and has the largest remnants of the Atlantic Forest. Barrela et al (2014) mention the difficulty in protecting areas interconnected by rivers as the protection of a particular component demands control over the drainage network, surrounding lands and riparian zone. In addition to the necessary preservation of the area, fishing resources also support commercial and amateur fisheries in the region, and the impacts on these resources need to be known.

Thus, given the impacts already described and the imminence of an increase in impacts on fishery resources in the region, the objective was to evaluate the anthropic impacts actions resulting from mining on the abundance of fishery resources in the middle stretch of the River Ribeira de Iguape (SP).

METHODOLOGY

STUDY AREA

The Ribeira Valley comprises 30 municipalities, of which 21 are in the state of São Paulo and the rest in the state of Paraná (Figure 1). Geographically, it occupies an extensive area represented by the Ribeira de Iguape Hydrographic Basin and the estuarine-lagoon complex of Iguape-Cananéia-Paranaguá or Lagamar with around 3,287 km, among other interconnected sub-basins (CBH-RB, 2022). The Water Resources Management Unit nº 11 – UGRHI 11, corresponding to the Ribeira de Iguape River and Litoral Sul Watershed. In the Ribeira de Iguape Basin, there are eleven integral protection conservation units, eight of which are state parks and three ecological stations, and six sustainable use units.

COLLECTION METHODOLOGY

Twenty-five scientific fishing campaigns were carried out following the methodology described by Pereira (2010). To standardize the captures, gillnets with mesh sizes of 15, 25, 35, 40, 50 and 60 and 80 mm (between adjacent nodes) were used, with a length of 10 m and an entrainment coefficient of 50%. According to the meshes, the heights of the nets varied from 1.44 to 3.60m. The nets were placed in coastal areas with little turbulence during the morning of the first day and fished every 12 hours, completing a 24-hour fishing effort. In addition to the above modality, whenever possible, fishing with a cast net was conducted, with three throws at each location.

After fishing, the period of capture (time), gear, place of capture and species were recorded. The fish were taken to the São Paulo State University (*Universidade Estadual Paulista "Júlio de Mesquita Filho"*) and data such as weight (non-eviscerated individual), total and standard length, maximum perimeter and height were taken.

CHARACTERIZATION OF SPECIES, SPATIAL DISTRIBUTION, AND COMMUNITY STRUCTURE

The CPUE (capture per effort unit) is an index proportional to the average amount of individuals presented, of size capturable to the area in a period (Petrere et 2010). Fonteles Filho (1989) refers to the available equipment representing a part of the device, that is, a part of the available devices/length of stock available to the fishing equipment. This abundant capture capacity reflects the availability of protective enclosures that influence the capacity for better production.

The effort exerted in the experimental fishing was calculated in terms of net size (area in m²) multiplied by the exposure time of the gear (hours) (Petrere, 1978). The CPUE analysis was obtained for all sampled sites (P1 and P2), for the species captured, for all mesh sizes used and for the fish species grouped according to their origin, according to the $CPUE = \frac{\sum biomass}{\sum f}$, with biomass grouped according to the above categories, as well as the fishing effort

To identify which variables could affect relative abundances, an ANOVA was applied to CPUE data as a function of sampling points and fish origin. Despite the transformation in log-log scale, the residuals of the analysis had a different distribution from the normal one and the non-parametric Kruskal-Wallis alternative was chosen

The points were chosen for their interest in exploring the possible impacts of mining activity. The grouping of fish according to their origin sought to explore the participation of non-native fauna in the composition of the captured ichthyofauna.

A stepwise Analysis of Covariance (ANCOVA) was applied to the biomass data (g) from scientific fisheries, as it constitutes an important tool to analyze fishery data, as there are many factors that determine the success of fishing operations (Petrere, 1986). This analysis allows the comparison of means through a linear relationship between the biomass variable (Wt-g) and the covariates (point of capture and origin of the fish), without dividing the capture by the effort, which is a valid decision only if the line passes through the origin, which is not always the case (Huitema, 1980).

The model initially tested was: $Wt=\mu+Pt+Orig+Pt*Orig+Inf+\varepsilon$, where: Wt = response variable – logarithmized fish weight; μ = population mean; lnf = covariate – logarithmized fishing effort; Pt = factor – fishing site with two levels (P1, downstream of the dredging site, and P2, close to the dredging region); Orig = factor – fish origin with two levels (native and non-native).

RESULTS

CAPTURED SPECIES

Between October 2014 and November 2018, 884 individuals were captured, whose total weight was 147,940.7g, belonging to four orders and 16 families (Table 1). The largest captures in number were R. kronei (135), followed by O. oglinum (125) and Hyphessobrycon sp (115). In weight, the species that had the highest captures were C. gariepinus (24065.5g), followed by P. lineatus (18069.9g) and C. parallelus (16401.8g).

Cast net fisheries resulted in the capture of a

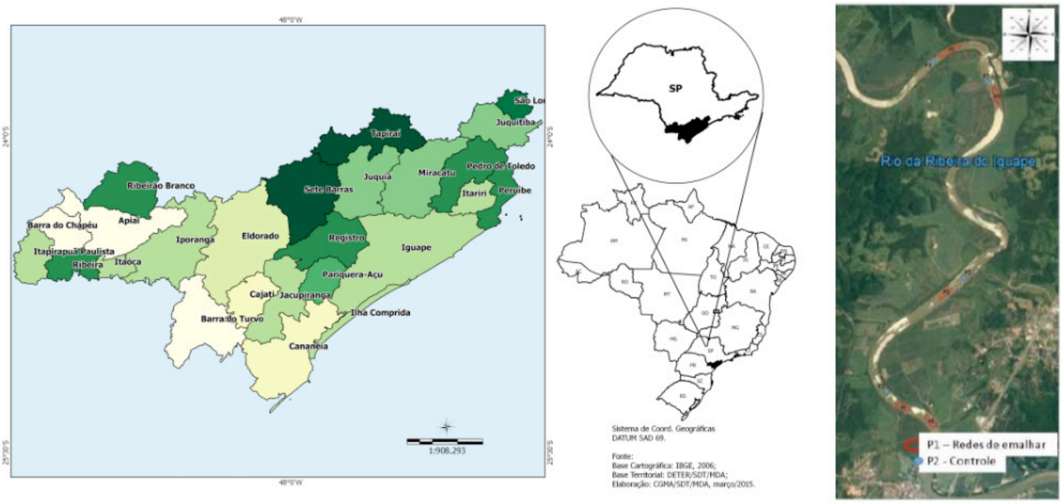

Figure 1: Study area (Sistema de Informações Geográficas, 2020)

Order	Famíly	Scientific name	N	Wt (g)	Wt-average ±SD (g)
Characiformes	Anostomidae	*Leporinus friderici* (Bloch, 1794)	1	200.00	200.00
		Leporinus piau (Fowler, 1941)	8	1,208.70	151.09±111.446
	Bryconidae	*Salminus brasiliensis* (Cuvier, 1816)	7	5,838.90	834.13±555.129
	Characidae	*Astyanax* sp (Baird & Girard, 1854)	80	1,139.60	14.25±11.191
		Hyphessobrycon sp (Durbin, 1908)	24	1,390.00	57.92±29.804
		Oligosarcus hepsetus (Cuvier, 1829)	57	4,522.90	79.35±67.054
	Curimatidae	*Cyphocharax santacatarinae* (Fernández-Yépez, 1948)	13	1,638.70	126.05 ± 93.022
	Erythrinidae	*Hoplias malabaricus* (Bloch, 1794)	26	14,096.40	542.17±275.26
		Hoplias lacerdae (Ribeiro, 1908)	1	11,890.00	11,890.00
	Prochilodontidae	*Prochilodus lineatus* (Valenciennes, 1837)	87	18,069.90	207.70±332.176
	Serrasalmidae	*Piaractus mesopotamicus* (Holmberg, 1887)	2	317.40	158.70±6.930
Clupeiformes	Clupeidae	*Opisthonema oglinum* (Lesueur, 1818)	125	6,396.80	51.17±29.223
	Engraulidade	*Anchoviella lepidentostole* (Fowler, 1911)	1	14.60	14.60
Perciformes	Centropomidae	*Centropomus parallelus* (Poey, 1860)	42	16,401.80	390.52±313.442
		Centropomus undecimalis (Bloch, 1792)	1	1,269.20	1,27.20
	Cichlidae	*Crenicichla* sp (Heckel, 1840)	9	1,086.60	120.73±108.206
		Geophagus sveni (Lucinda, Lucena & Assis, 2010)	71	9,197.10	129.54±84.294
		Oreochromis niloticus (Linnaeus, 1758)	7	3,927.00	561.00±349.835
Siluriformes	Callichthyidae	*Callichthys callichthys* (Linnaeus, 1758)	4	303.20	75.80±69.371
	Clariidae	*Clarias gariepinus* (Burchell, 1822)	34	24,065.50	707.81±580.145
	Heptapteridae	*Pimelodella transitoria* (Miranda Ribeiro, 1907)	29	619.40	21.36±4.797
	Pimelodidae	*Pimelodus maculatus* (Lacepède 1803)	108	10,258.90	94.99±78.132
		Rhamdia quelen (Quoy & Gaimard, 1824)	7	1,204.90	172.13±160.248
	Loricariidae	*Hypostomus agna* (Miranda Ribeiro, 1907)	5	1,730.30	346.06±129.179
		Rineloricaria kronei (Miranda Ribeiro, 1911)	135	11,152.90	82.61±64.330
Total			884	147,940.7	

Table 1: Species of fish captured throughout the middle stretch of the River Ribeira de Iguape, grouped by family and order, between 2014 and 2018

single specimen of Cichla sp with Wt=273.0g. Due to this, there was no possibility of an in-depth analysis of these fisheries.

CPUE STUDY

The analysis of CPUE by fishing location showed a higher value at Point 2 (cpue=1.74g/m²/h), corresponding to the location without dredging interference, while at Point 1 the value obtained was 1.68g/m²/h (Figure 2). The total efforts amounted to 87,828.7m²*h in P1 and 83,678.4m²*h in P2.

The analysis of CPUE per season of the year had the highest value in the dry season (cpue=2.02g/m²/h), while in the rainy season, the value obtained was 1.73g/m²/h (Figure 3). The total efforts amounted to 64,478.0m²*h in the dry season and 82,127.1m²*h in the rainy season.

The CPUE values per mesh sizes were increasing as the mesh increased. The lowest CPUE value was obtained for mesh 15 (1.68g/m²/h) and the highest value for mesh 80 (1.92g/m²/h) (Figure 4). Fishing efforts declined as mesh openings increased, reaching between 86,739.8m²*h for the 15mm mesh opening and 69,599.3m²*h for the 80mm mesh opening.

The CPUE study for the native or non-native fish categories revealed that, despite the second category having had a fishing effort about 13 times lower ($f_{non\text{-}native}$=6,328.0 m²*h; f_{native}=81,565.7 m²*h), its relative abundance was almost four times higher ($CPUE_{non\text{-}native}$=5.43g/f; $CPUE_{native}$=1.39g/f), showing evidence of the strong presence of invasive fish (Figure 5).

STATISTICAL ANALYSIS

The Kruskal-Wallis test revealed that the points were not significant for the determination of CPUE values (p=0.450). However, the origin of the fish was significant (p=0.000) (Figure 6).

In the stepwise procedure, variables with p-values lower than 0.05 are successively and automatically disregarded from the model. The ***InWt=μ+Orig+Inf+ε*** model was the end that best explained the relationship between catches, fish origin and fishing effort (Table 2). The normality test applied to the residuals obtained in the final model had a different distribution from the normal one. All possibilities to normalize them through transformations were exhausted and as there is no non-parametric alternative, the model was adopted. This occurred because the design is balanced, which makes the f tests more robust, according to the current literature in the area (Huitema, 1980).

The averages calculated for invasive fish were 6.293 ±0.635 ($Wt_{non\text{-}native}$=673.506±453.205g) and for native fish, 4.112±1.164 (Wt_{native}=136.365±451.551g) (Figure 5), showing evidence of higher catches for invasive fish (Figure 7).

The analysis of logarithmized captures on the exerted efforts showed the data dispersed around the fit line of R^2=.233, explained by the model lnwt=0.868+0.744*lnf.

DISCUSSION

CAPTURED SPECIES

The Ribeira Valley joins fourteen Conservation Units with different characteristics, such as geographic isolation, which contribute to the great endemism (Miranda, 2012).

Castelani and Barrela (2006) recorded 41 different species of fish in fish farming in the Ribeira Valley, of which only six were native and 35 were exotic/allochthonous. Among these 41, there were confirmed escapes of 29 species (Table 4).

Among the species captured in this study, twelve were also found in Oyakawa & Menezes (2011). These authors mention the presence of 391 different species in the state of São Paulo and of these, 97 can be found in the River

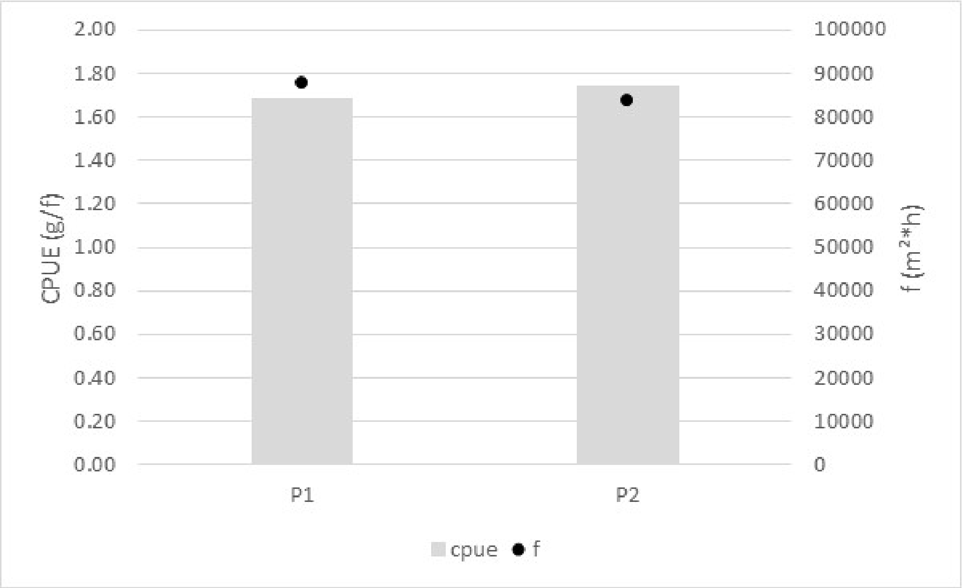

Figure 2: Total CPUE study in the middle stretch of the River Ribeira de Iguape, grouped by point, between 2014 and 2018

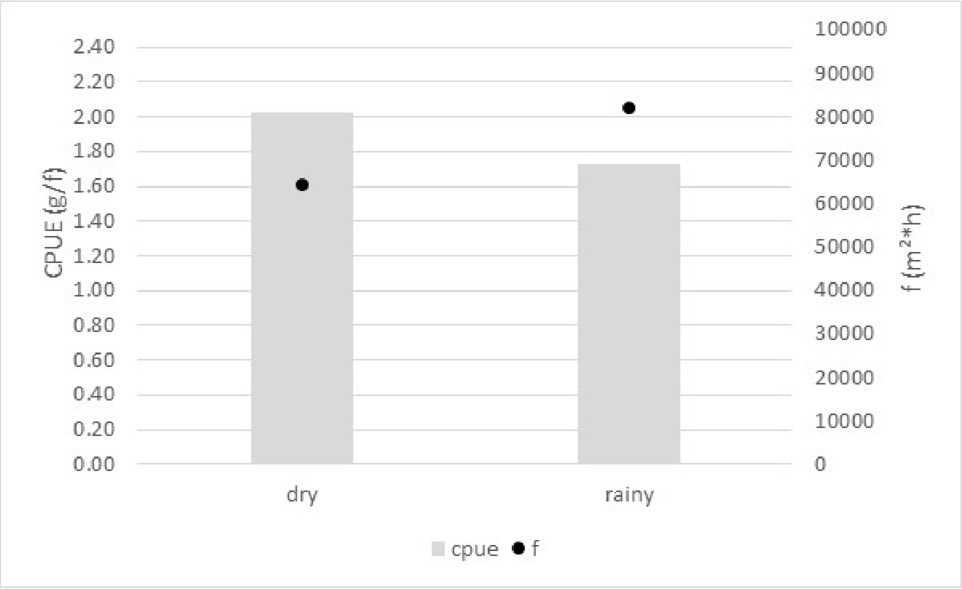

Figure 3: Total CPUE study in the middle stretch of the River Ribeira de Iguape, grouped by season, between 2014 and 2018

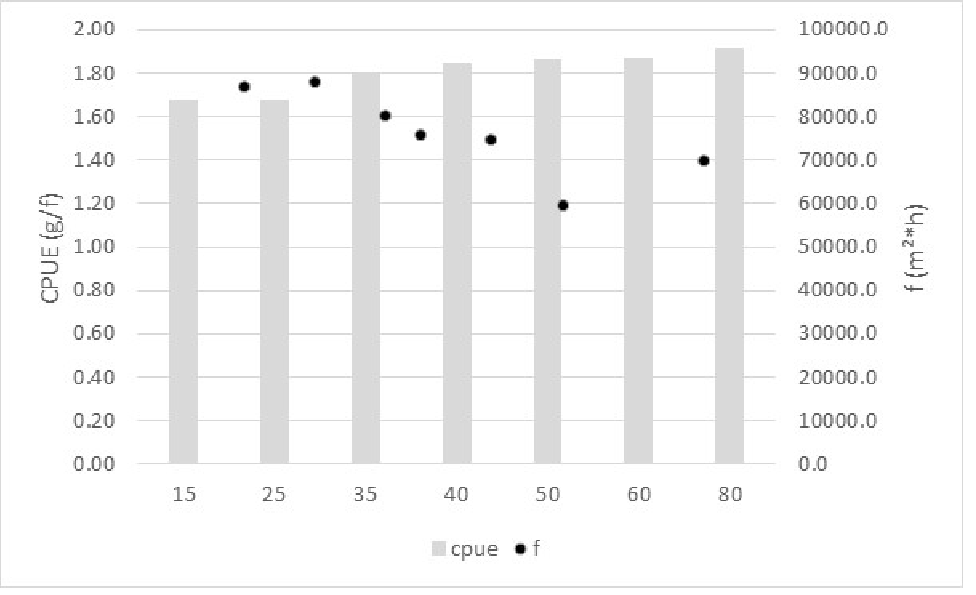

Figure 4: Total CPUE study in the middle stretch of the River Ribeira de Iguape, grouped by mesh size, between 2014 and 2018

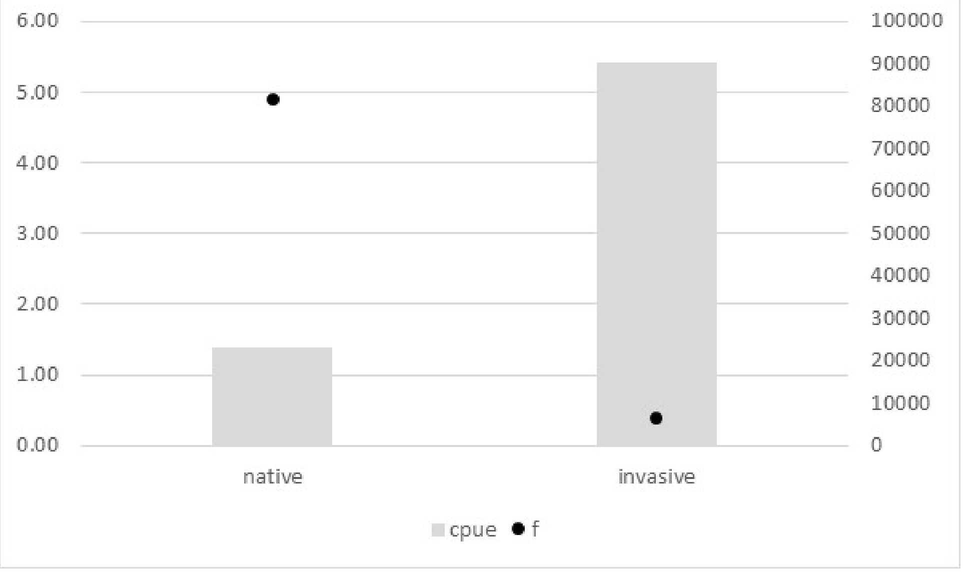

Figure 5: Total CPUE study in Middle Stretch of Ribeira de Iguape River, grouped origin of the fish, between 2014 and 2018

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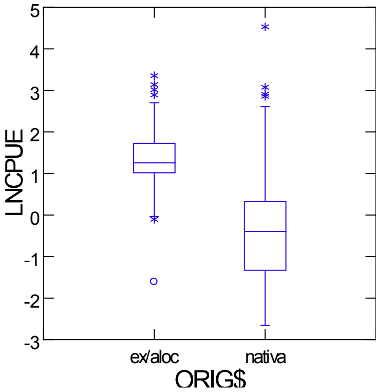

$N_{native\ fish}=833$
$Med_{LnCpue\_nativefish}=-0{,}386$
$Med_{cpuenativa}=0{,}680\ g/m^{2}*h$

$N_{invasive\ fish}=51$
$Med_{LnCpue\_invasivefish}=1{,}437$
$Med_{cpueex/aloc}=4{,}210 g/m^{2}*h$

Figure 6: Box plot of LnCPUE study in the middle stretch of the River Ribeira de Iguape, grouped origin of the fish, between 2014 and 2018

Variable	**Point**	**Origin**	**Pt*Orig interaction**	**lnf**
Levels	P1 and P2	Native and non-native	P1 and P2; Native and non-native	
p-value	0.268	0.000	0.574	0.000

Table 2: Results of ANCOVA applied to lnWt data in relation to capture locations, origin of fish, interaction between covariates and logarithmized effort in the middle stretch of the River Ribeira de Iguape, between 2014 and 2018

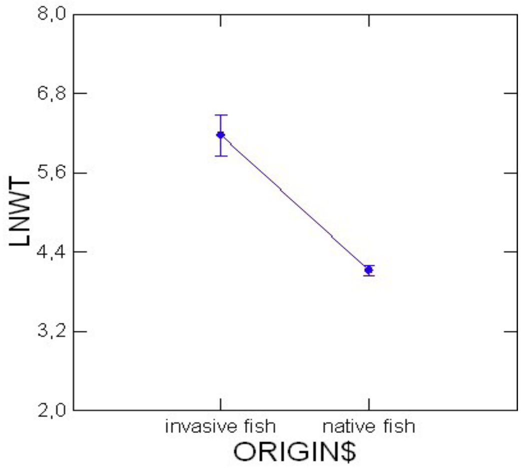

Figure 7: Average logarithmized catch distribution in relation to the fish origin in the middle stretch of the River Ribeira de Iguape, between 2014 and 2018

Ribeira de Iguape. This total may be related to the fourteen Conservation Units in the region, which make up 243,885.78 hectares (SIGAM/SIMS, 2022) and ensure good environmental conditions for biodiversity and the perpetuation of species. Reflecting on the importance of these conservation units, it is worth considering that the Ribeira de Iguape River Basin corresponds to about 6.9% of the territory of São Paulo, showing the importance of protecting the area, albeit small, on the resources in the region.

When detailing the captures of the present study, it can be observed that L. piau and L friderici were not included in the study. Fish of the genus Leporinus were analyzed by Castro (2018), and their contamination by cadmium and lead (fish caught in the municipality of Eldorado, SP) was confirmed. The L. friderici species originates from the Amazon River Basin and Suriname and its presence can reduce the diversity of ichthyofauna by competition with native species, despite being attractive for fishing activities (Latini et al, 2016). In contrast, these authors mentioned three different species of Astyanax and five of Hyphessobrycon that were not confirmed during this study.

Crenicichla sp was present in the Betari River (a tributary of the Ribeira River) during the captures of the studies by Castro (2012) and C. iguapina was present in the study by Oyakawa & Menezes (2018). Both were also included in the surveys by Henriques (2010) and Castro (2012) (Table 4).

Studies by Henriques (2010) identified the presence of G. iporangensis in the Ribera de Iguape River Basin and Geophagus sp in coastal rivers in the state of São Paulo. The first species was captured by Costa (2018) in the Juquiá River and was present in the Ribeira River in the inventory by Oyakawa1 & Menezes (2011). The G. brasiliensis species was cited in the studies by Castro (2012), having been captured to determine possible contamination. The analysis of the blood of two individuals revealed concentrations of cadmium and lead above the tolerable levels and the author attributed these contaminations to the transport of these elements to the fluvial dynamics, given that, at the time, mining activities in regions close to the collection site had ceased (Table 4).

The O. hepsetus, C. santacatarinae, H. malabaricus, P. lineatus, R. quelen and H. agna species were also cited in the study by Castro (2018), revealing cadmium and/or plumbumd contamination in their blood samples. The P. lineatus species is native to the Paraná, Paraguai and Paraíba do Sul Basins and its presence can lead to changes in trophic conditions and nutrient cycling in the environment where it occurs (Latini, 2016). The species is used both in fish farming and fishing and its origin in the region is associated with accidental introductions caused by the region's fish farms (Castelani and Barrela, 2006) (Table 4).

It should be noted that species such as P. mesopotamicus, S. brasiliensis, O. niloticus and C. gariepinus and Chicla sp (caught in the cast net) – alien or exotic species – were accidentally or intentionally introduced into the Ribeira and Juquiá rivers due to fish escaping from fish farms in the region. These introductions may have occurred due to the breeding area flooding and the rupture of walls of ponds and monks, facilitating the escape of fish, or deliberately by fish farmers or fishers (Castelani and Barrela, 2006). The first two species originate from hydrographic basins in other regions of Brazil (Paraná, Paraguai, São Francisco, Tocantins, Alto Paraná, Alto Amazonas and Orinoco basin), while the other two originate from the African continent. They are all species used in fish farms throughout the country – and in the Ribeira Valley – whose presence may be due to escapes or intentional introductions into the region's rivers. In the second case, the release is due to the interest of commercial and amateur fishermen in catching such fish in a natural environment. Moreover, the species can cause a reduction and/or change in the diversity of native fauna, compromising water quality, and possible secondary introductions of parasites into the environment (Latini et al, 2016) (Table 4).

In addition to the presence recorded in this study, Barbieri et al., (2007) reported the presence of Clarias ssp, P. mesopotamicus and O. niloticus in coastal waters, showing their great adaptability in saline/brackish waters and a possible compromise of commercial fisheries in the region. The first one has tolerance to extreme environmental variations, is capable of absorbing atmospheric oxygen and is omnivorous, which are factors that make it easier to install in new environments. In addition, their omnivory can cause a reduction in the diversity of the native fauna of aquatic organisms (Latini, 2016). Omnivory is also a habit of P. mesopotamicus and the fluvial environment constitutes an important factor for reproductive migrations. The third species tolerates a wide temperature range, is omnivorous, has parental care and Orsi et al., (2016) highlight that O. niloticus has been quite efficient in competing for resources in the River Tibagi (PR), either for food or for space, with a broad capacity for competitive exclusion with native species (Table 4).

Despite not being identified as coming from escapes from this type of undertaking, species such as G. brasiliensis, R. quelen are among the species created in the region (Castelani and Barrela, 2006).

Latini et al., (2016) estimate that there are about 1612 occurrences of exotic species in Brazil, in which 67% (109 different species) refer to fish records (Table 4).

Introductions can produce major changes in the composition of the native community, alter its reproduction, growth and development, as well as cause hybridization, the introduction of diseases and parasites, negatively affecting the original structure of the environment in question (WELCOME, 1984).

State Decree 62,243/2016 and SAA Resolution - 73/2016 provide for exotic and alien species that can be cultivated in the state of São Paulo. In addition to the species included in this study and already described in previous studies, the "Survey of fish farming units in the state of São Paulo" (Carmo et al, 2021) discusses the creation of the exotic Asian species Pangasianodon hypophthalmus Sauvage, 1878 that has already been cultivated in the municipality of Juquiá, in the Ribeira Valley, whose homonymous river flows into the River Ribeira. Despite being legally supported, the creation of this species and its possible escape or introduction into the natural environment can incur a series of environmental impacts described for other invasive species already found in the River Ribeira, as well as the invasion of new pathogens. Despite this, a more accurate survey of the impacts of this species is necessary due to its rusticity, environmental tolerance, migratory habits, and omnivorous diet (Garcia et al, 2018).

CPUE STUDY

The CPUE analyses by site showed higher values in P2, that is, the sites exempt from the interference of the dredging activity. The lower relative abundances of fish may have been due to the absence of riparian vegetation cover and/or the suppression of aquatic vegetation, reducing the areas of refuge, feeding and reproduction of fish. In addition to these benefits, riparian vegetation also prevents erosion and silting, reducing the transport of particles to the riverbeds and compromising the activities of the ichthyofauna, such as

This study	**MMA (2016)**	**Castelani and Barrela (2006)**	**Oyakawa & Menezes (2011)**	**Henriques (2010)**	**Castro (2018)**
L. friderici	Allochthonous		Leporinus cf. steindachneri Eigenmann, 1097		Leporinus sp *
L. piau	Native	Native, but there are reports of captive individuals			
S. brasiliensis	Allochthonous	*S. maxilosus* scape			
Astyanax sp	Native	Native, but there are reports of captive individuals	A. cf. bimaculatus Linnaeus, 1758; A. janeiroensis Eigenmann, 1908; A. ribeirae Eigenmann, 1911	X	
Hyphessobrycon sp	Native		H. bifasciatus Ellis, 1911; H. duragenys Ellis, 1911; H. eques Steindachner, 1882; H. griemi Hoedeman, 1957; H. reticulatus Ellis, 1911	H. reticulatus	
O. hepsetus	Native		X		X
C. santacatarinae	Native		X		X
H. malabaricus	Native	X	X	X	X
H. lacerdae	Native	X	X		
P. lineatus	Native	X		X	X
P. mesopotamicus	Allochthonous	X			
O. oglinum	Native				
A. lepidentostole	Native				
C. parallelus	Native	Centropomus sp		X (Centropomus sp)*	
C. undecimalis	Native				
Crenicichla sp	Native		C. iguapina Kullander & Lucena, 2006	X	X
G. brasiliensis	Native	X	G. iporanguensis Haseman, 1911	G. iporangensis; Geophagus sp	X
O. niloticus	Exotic	X	X		
Cichla sp	Allochthonous	X			
C. callichthys	Native		X	X	
C. gariepinus	Exotic	X	X		
P. transitoria	Native		X	X	
P. maculatus	Native		X	X	
R. quelen	Native	X	X	X	
H. agna	Native	Hypostomus sp scape	X	X	X
R. kronei	Native		X	Rineloricaria sp*	X

Table 4: Comparison between catches in the present study, origin of species, presence or absence of species in other studies in the Ribeira Valley region.

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feeding, reproduction, and reducing the incidence of solar radiation (Miranda, 2012). Despite the numerical differences in relation to the relative abundances, the analysis of the captures showed no statistical difference in relation to the locations (p=0.253).

Sediment resuspension resulting from mining causes an increase in water turbidity, limiting light penetration and local primary productivity (Esteves, 1988). Concerning possible changes in water quality variables, Leonardo et al., (2008) observed that the sand extraction activity does not have a great influence on the physical and chemical variables of the River Ribeira. Despite the possible problems associated with the resuspension caused by the sand mining activity, the study showed that such areas are used for a certain time, moving to other more productive locations. The old areas remain without any intervention to contain the erosion processes of the banks, it is expected that the natural successions will establish a new balance (Mechi and Sanches, 2010).

The reduction of the river channel caused by the reduction of rainfall between April and September resulted in higher captures and higher CPUE values. This phenomenon occurs because the reduction of the flooded area causes the reduction of the area available for fish activities. The increase in concentration can be seen by the subtle difference in effort exerted in the seasons, whereby less effort is used in the dry season, with greater captures.

When evaluating the gradual increase of CPUE values in relation to mesh opening sizes, higher values corresponding to larger meshes are observed. Despite this, the effort that was used had differences, and was smaller in the smallest mesh openings ones, corroborating the fact that the highest index corresponds to the highest biomass of fish caught in larger meshes. Thus, it can be observed that the CPUE values for fish such as C. parallelus (2.81g/m^2/h), C. undecimalis (6.22g/m^2/h), C. gariepinus (4.01g/m^2/ h), H. lacerdae (92.85g/m^2/h), H. malabaricus (5.18g/m^2/h), O. niloticus (5.78g/m^2/h), P. mesopotamicus (2.13g/ m^2/h) and S. brasiliensis (6.14g/ m^2/h) were higher than the other calculated values. These fish have more evident ecomorphological characteristics when compared to the others that were captured. It is worth noting that some of these species are not native (Table 4) and their presence can lead to the disappearance of native fish, whose distribution and abundance are already impacted by the reduction of riparian forest (Miranda, 2021).

The understanding of the magnitude of the presence of invasive fish could be perceived with the CPUE analysis of the grouping of species according to their origin, when, despite the smaller fishing efforts used, a greater biomass of invasive fish was captured. Statistical analysis corroborated this perception and Manes et al., (2021) highlight that climate change may more consistently affect endemic species and, in the case of the ichthyofauna of the Ribeira River, the presence of invasive fish could contribute to this loss. Invasive species, present in Iberian rivers since the last century, have already replaced the endemic ichthyofauna and compromised the viability of native fish populations (Miqueleiz et al, 2022). Arranz et al., (2021) mention that fish sizes in the Iberian Peninsula are related to environmental conditions and biotic composition and, when relating this variable to biotic introductions and other pressure variables on stream environments, they observed that sizes are negatively correlated with nutrient concentration, and a higher relative abundance of small fish, in contrast to invasive fish assemblages, which have flat correlations.

Currently, the largest number of publications on the ichthyofauna of the

Atlantic Forest is focused on stream areas and the impacts suffered by these areas. Understanding the state of the ichthyofauna of the River Ribeira considering the impacts of mining actions can help to understand the health of the environment, as its waters are used to supply several cities, captured for fish farms in the region, agriculture irrigation and banana cultivation.

Despite the sand mining activity not directly interfering with the relative abundances of fish captured in this study, it is worth mentioning that new dredging operations were carried out in the River Ribeira de Iguape by the initiative of the São Paulo State Government to deepen the riverbed, with a view to water security (DAEE, 2022). These activities can compromise not only the abundance and diversity of fish, but also promote the resuspension of sediments and possible contamination.

CONCLUSIONS

The fish fauna of the middle stretch of the River Ribeira, in adjacent areas to the municipality of Registro, continues to be subject to profound impacts, either by sand dredging or by the intentional or unintentional introductions of non-native fish.

Although there is still no evidence of the current compromise of fish abundance related to dredging, it is believed that the presence of allochthonous and exotic fish is compromising native fish populations, given their characteristics.

In addition, it can be observed that, given the high individual biomass of non-native fish, associated with their reproductive and feeding habits, there is a concern about the impact on native fish, many with endogenous characteristics and subject to different pressures.

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