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Bois' River: contributions to the ichthyofauna in the headwaters of the Araguaia River basin, Northwest Goiás, Brazil

Rio dos Bois: contribuições para a ictiofauna nas cabeceiras da bacia do rio Araguaia, Noroeste do Goiás, Brasil

Rio de los Bois: contribuciones a la ictiofauna en las cabeceras de la cuenca del río Araguaia, Noroeste de Goiás, Brasil

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Abstract
This study presents the results of fish diversity in a stretch of the Rio dos Bois, a Cerrado source, located in northwest Goiás, Brazil. Being an important tributary of the headwaters of the Araguaia River, Araguaia-Tocantins basin, which has important attributes in the maintenance of the biota of this complex ecosystem, and part of this Cerrado mosaic. The studied region comprises the main channel of the Rio dos Bois, from its head to the mouth of the Rio Formiga. Ichthyofauna samplings were carried out over two climatic seasons in the region (dry and rainy), carried out in June/2021 and November/2021, respectively. Sampling was carried out at 5 sampling points, distributed equidistantly from upstream to downstream, in Rio dos Bois. As a result, 15,645 specimens were recorded, distributed in a richness of 46 species. In this study, the results were evaluated by ecological tests, such as frequency of occurrence, *Dominance_D, Simpson_1-D, Shannon_H', Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker* and *Chao-1*. And analyzed by normality test in *Tukey test* and ANOVA-One way. It is possible to identify the most diverse sampling sites, as well as the points that showed divergence between high capture rate and low diversity. Indicating that some sites have greater conservation importance than others, envisioning future priority actions for environmental preservation.
Keywords: Cerrado rivers; Ichthyofauna; Natural nurseries.

Resumo
Este estudo apresenta os resultados da diversidade de peixes em um trecho do Rio dos Bois, um manancial de Cerrado, localizado no noroeste do Goiás, Brasil. Sendo um importante tributário das cabeceiras do rio Araguaia, bacia Araguaia-Tocantins, que possui importantes atributos na manutenção da biota deste complexo ecossistema, e parte deste mosaico do Cerrado. A região estudada, compreende a calha principal do Rio dos Bois, da sua cabeceira até a foz do Rio Formiga. As amostragens da ictiofauna foram efetuadas ao longo de duas estações climáticas da região (seca e chuvosa), realizadas em junho/2021 e novembro/2021, respectivamente. As amostragens foram realizadas em 5 pontos amostrais, distribuídos equidistantes de montante à jusante, no Rio dos Bois. Como resultado registrou-se 15.645 espécimes distribuídos em uma riqueza de 46 espécies. Neste estudo, os resultados foram avaliados por testes ecológicos, tais como, frequência de ocorrência, *Dominance_D, Simpson_1-D, Shannon_H', Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker* e *Chao-1*. E analisados pelo teste de normalidade no *Tukey test* e ANOVA-One way. Sendo possível identificar os locais amostrais mais diversos, assim como os pontos que apresentaram divergência entre alta taxa de captura e baixa diversidade. Indicando que, alguns sítios apresentam maior importância de conservação que outros, vislumbrando futuras ações prioritárias a preservação ambiental.
Palavras-chave: Rios do cerrado; Ictiofauna; Berçários naturais.

Resumen
Este estudio presenta los resultados de la diversidad de peces en un tramo del Rio dos Bois, una fuente del Cerrado, ubicada en el noroeste de Goiás, Brasil. Siendo un importante afluente de la cabecera del río Araguaia, cuenca Araguaia-Tocantins, que tiene importantes atributos en el mantenimiento de la biota de este complejo ecosistema, y parte de este mosaico del Cerrado. La región estudiada comprende el cauce principal del Rio dos Bois, desde su cabecera hasta la desembocadura del Rio Formiga. Los muestreos de ictiofauna se realizaron en dos épocas climáticas de la región (seca y lluviosa), realizadas en junio/2021 y noviembre/2021, respectivamente. El muestreo se realizó en 5 puntos de muestreo, distribuidos equidistantemente de aguas arriba a aguas abajo, en Rio dos Bois. Como resultado se registraron 15.645 ejemplares, distribuidos en una riqueza de 46 especies. En este estudio, los resultados fueron evaluados por pruebas ecológicas, tales como frecuencia de ocurrencia, *Dominance_D*, *Simpson_1-D*, *Shannon_H'*, *Evenness_e^H/S*, *Brillouin*, *Menhinick*, *Margalef*, *Equitability_J*, *Fisher_alpha*, *Berger-Parker* y *Chao-1*. Y analizado por prueba de normalidad en *prueba de Tukey* y ANOVA-One way. Es posible identificar los sitios de muestreo más diversos, así como los puntos que mostraron divergencia entre alta tasa de captura y baja diversidad. Indicando que algunos sitios tienen mayor importancia de conservación que otros, vislumbrando futuras acciones prioritarias para la preservación ambiental.
Palabras clave: Ríos del cerrado; Ictiofauna; Viveros naturales.

1. Introduction

Ecological services are of paramount importance for the functioning of the ecosystem, as well as for maintaining the supply of resources. Being one of the primary processes in the structuring of communities, and environmental changes promote the increase of several ecological problems. These changes directly affect the organisms, the characteristics of the structure of local communities (Soares et al. 2017). In this way, mineral material extraction activities in general generate changes in the landscape, especially when linked to bodies of water. These modifications enable the transformation of the predictive environmental conditions, as well as the biota (Lima et al. 2021).

The greatest diversity for freshwater fish is recorded for South America, with great taxonomic and phylogenetic variety, and high rates of endemism. The Amazon basin and the Paraná-Paraguay complex hold the greatest diversity in the South American continent. The richness of Amazonian species is considered one of the largest in the world, with approximately 1000 species of fish (Saviato et al. 2021a).

Many basins form an intricate array of basins that drain the Amazon region of northern Brazil. In this large complex is the Araguaia-Tocantins River basin, which was once considered one of the most fishy rivers in the world (Barbosa & Rubin 2020). The drainage has numerous tributaries and sub-tributaries in the northern portion of the states of Maranhão, Tocantins, Goiás, Mato Grosso and the Federal District. With 967.000 km², it is considered the largest entirely Brazilian basin, being sub-divided into 12 hydrographic regions, forming a hydrographic complex that permeates many ecosystems (Gomes et al. 2019, Lowe-McConnell, 1999).

The Araguaia-Tocantins basin is a complex mosaic of lentic and lotic environments with a high diversity of habitats, which hold much of this diversity for the fish group (Saviato et al. 2021a). Considering its importance for Neotropical biodiversity, the Araguaia-Tocantins is seriously threatened, since about 80% of its basin is in the most explored biome, the Cerrado. The causes of this environmental deterioration are agricultural activities, urban expansion, deforestation, mineral exploration, and the installation of hydro-energy dams, etc. (Saviato et al. 2020). This ecotone complex is biodiverse and has both typically Amazonian species, as well as Cerrado (*stricto sensu*) species since this basin is inserted in an ecotonal region. Being inserted in the southern portion of the Amazon basin, which is an important totally Brazilian catchment area and flowing through 4 Brazilian states (Goiás, Mato Grosso, Tocantins and Pará), in central western Brazil (Gomes et al. 2019).

The fauna and flora of this region are a sample of the richness added to all the ecosystems participating in the Araguaia drainages. This abundant and unique biodiversity consists mainly of tropical organisms, which have a close relationship with the mosaic of micro and meso habitats, which configure the landscape and physiognomy of the Araguaia River basin (Silva & Andrade 2017).

The exploration of the Cerrado biome passes through several sectors, from agribusiness, livestock, urban expansion, and mineral exploration. This form, despite its large extension, the largest biome in Brazil, is super exploitative, due to its smooth geography, fertile soils and rich in minerals. Therefore, the environmental de-characterization is, in general, the greatest effective impact in the region, generating changes in the existing groups of organisms (Araújo et al. 2020). In this way, changes in environmental conditions, whether physical, chemical, or biological, can impact aquatic ecosystems. Which, because they are dynamic, respond quickly to external stimuli. Thus, mining operations can have a direct impact on the physical and chemical parameters of these locations, a fact that consequently alters the limnological and biological conditions of these areas (Nunes 2022). Aquatic organisms are the group most impacted by any disturbances in the aquatic or physical environment. This fact has reference to leached products, whether from the exploratory sectors in the region, or secondary impacts.

Since the rivers are supplied by the catchment basin as a whole and the water drained from it passes through the terrestrial environment carrying all sorts of solutes. Effective in changes in the physical-chemical quality of water from springs, affecting the homeostasis of organisms, resulting in changes in local ichthyocenosis (Saviato et al. 2021b).

In recent years, scientists and environmental managers have recognized ichthyic communities as an integrating index of a complex set of physical and biological conditions of water bodies, that is, fish are indicators of the biotic integrity of lakes, reservoirs, streams, rivers, streams, etc. Research shows that fish exert great control over populations of other organisms, including vegetation, aquatic macroinvertebrates, plankton, and even nutrient cycling and sediment resuspension (Esteves et al. 2021).

Changes in the ichthyofauna are difficult to observe, given that visual observation of fish along watercourses is impractical. Thus, patterns of alteration are recorded by capturing different species along the stretches affected by the implementation of certain projects. These records can be obtained by carrying out a diagnosis (survey) of the species that occur in the affected areas. The diagnosis of ichthyofauna aims, therefore, to provide subsidies for the implementation of guidelines for the management of ichthyofauna in the affected water bodies to make the enterprise sustainable from the biological point of view and the conservation of fish species.

Therefore, this manuscript aims to present in a preliminary way the results of Monitoring the ichthyofauna of the Area of Influence of the mining initiative, based on bibliographic information, and performing the collection of primary data, aiming to infer about the indicators of the aquatic community in the basin. of the Dos Bois River, to contribute to the increase of knowledge about the biology of this basin and to promote the construction of subsidies for the mitigation of the impacts generated in the environment.

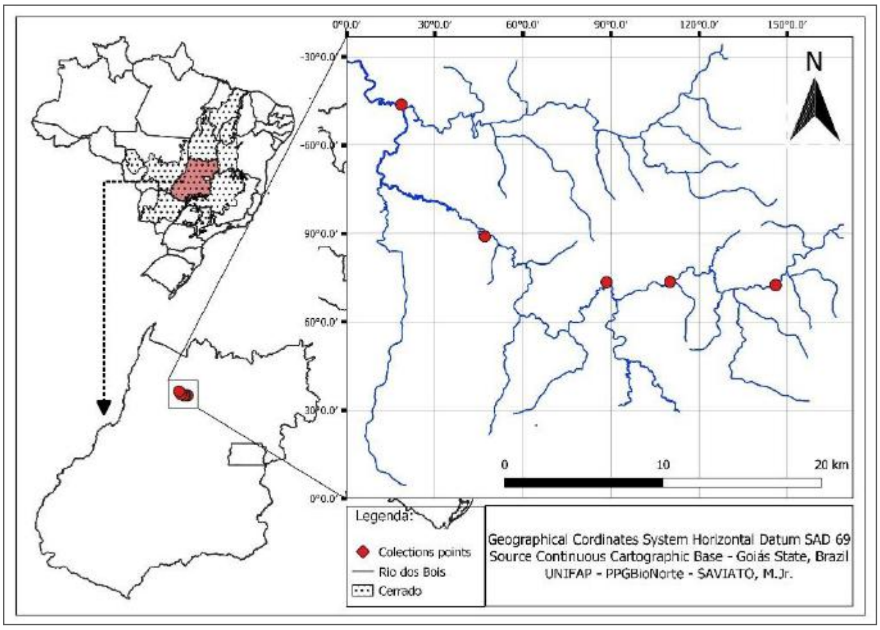
2. Methodology

2.1 Description of the study area

The Dos Bois River is located on the right bank of the Araguaia River basin, in the northeast of Goiás. With its total catchment area of approximately 35.000 km², it is important to drain this area as well as a relevant tributary for the basin as a whole. Passing through several physiognomies, most of it Cerrado and Gallery Forest, it is a typical river of the headwaters inserted in the South American Savanna (Santos et al. 2006).

The studied region is occupied by livestock and arable areas, as it has a vocation for agribusiness. However, mining exploration has been growing, as there are large mineral deposits with economic importance for the international industry (Silveira 2013). And in line with such characteristics, this basin has been going through structural and physical chemical changes, from the exemplified exploitation. The five sampling sites were identified in the field and their geographic coordinates were presented, as well as the priority locations for the encounter with the specimens were considered (Figure 1).

Figure 1 - Dos Bois River watershed, located in the northwest of the Goiás state - BR.



Source: Authors (2022).

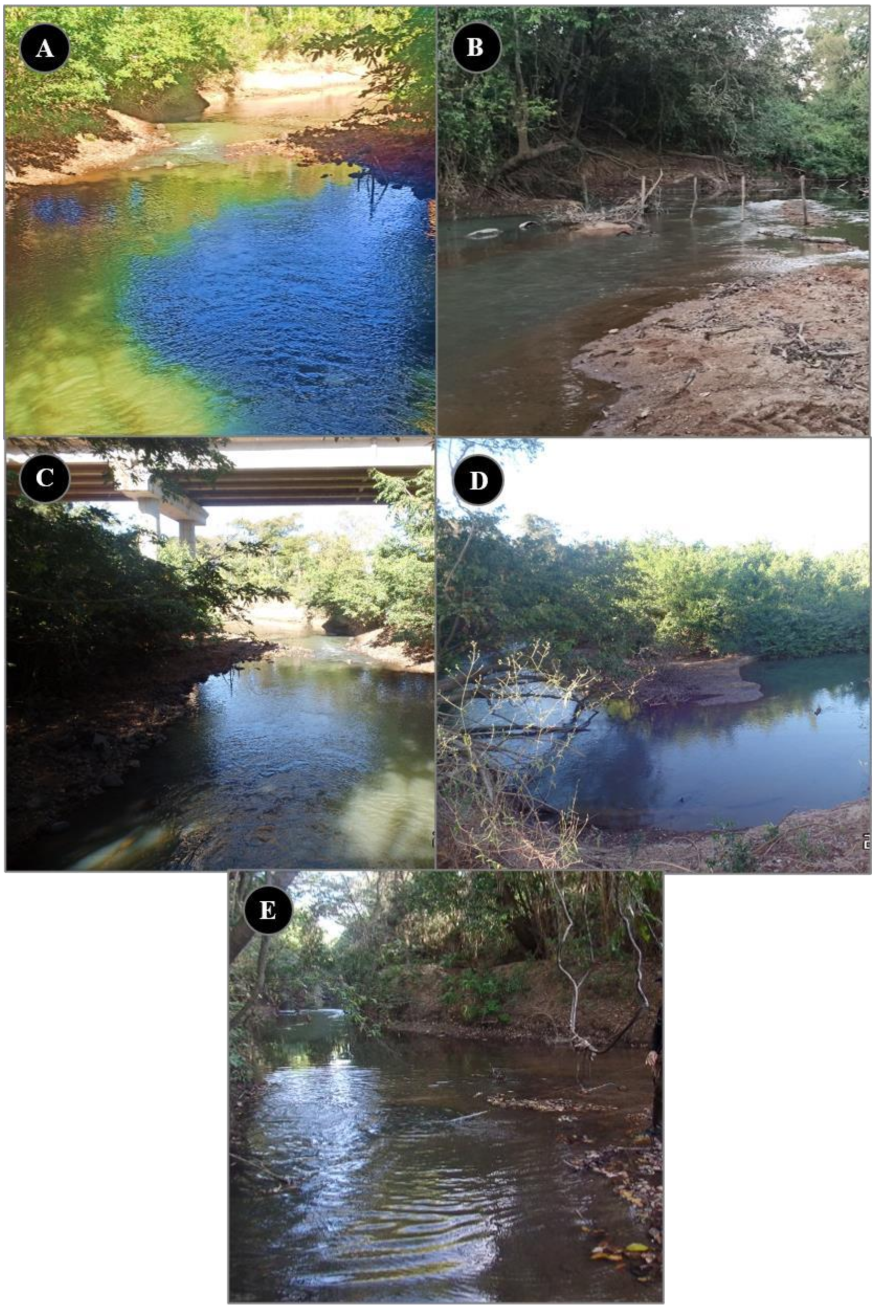
To collect the ichthyofauna specimens, these five sampling points were distributed along the main channel of a stretch of the Dos Bois River, from the headwaters near the GO-556 road, to the fifth point, near the mouth of the Formiga River (Table 1). Sampling took place in two seasons of 2021 (dry - July and rainy - November).

Table 1 - UTM geographic coordinates of collection points within the Dos Bois River watershed

Colections Points	Longitude 22M	Latitude
01	680205.00 m E	8422958.00 m S
02	673539.00 m E	8423221.00 m S
03	669530.00 m E	8423224.00 m S
04	661869.00 m E	8426228.00 m S
05	656655.00 m E	8434760.00 m S

Source: Authors (2022).

Figure 2 – Sampling points, distributed from upstream to downstream, on the main channel of Dos Bois River, Point 01 (A), Point 02 (B), Point 03 (C), Point 04 (D), Point 05 (E), in the municipality of Alto Horizonte, Goiás, Brazil.



Source: Authors (2021).

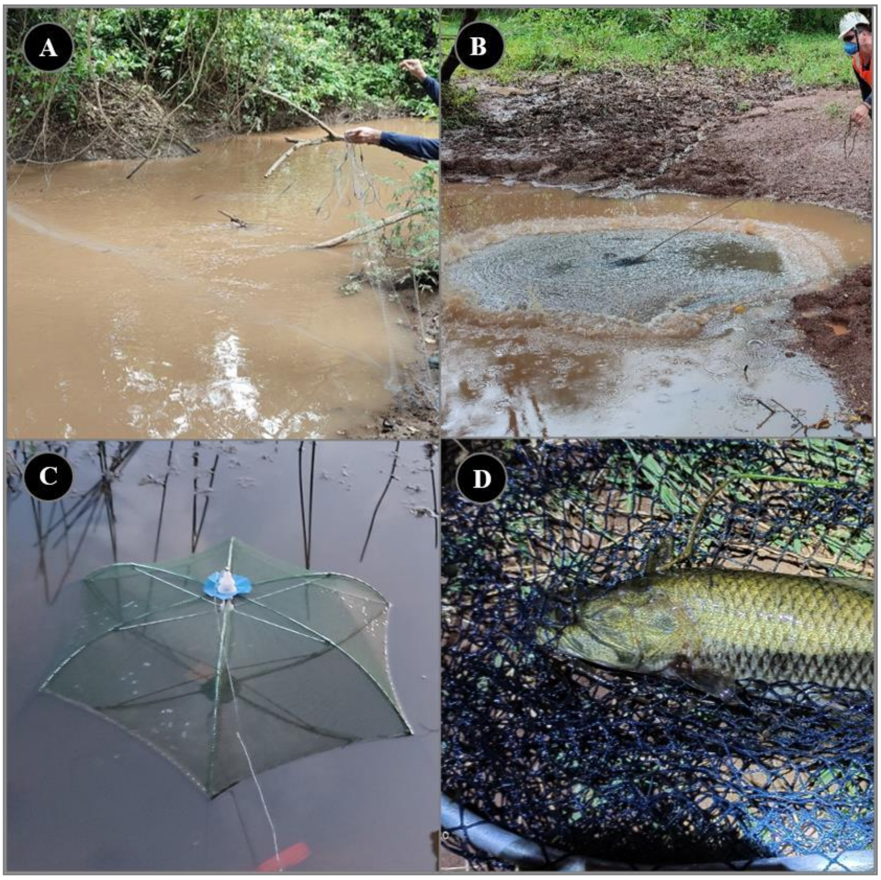
2.2 Data collect

Sampling was carried out using the following methods: gillnets, cast nets and holes for collecting fish. When using gill nets (1.5 m high by 10 m long, with meshes of 15, 30, 40 and 60 mm between nodes), they were installed for 12 hours during the day to avoid predation of the material by piranhas (Figure 3 A).

Other methodologies applied, in these same places, were the performance of five casts (2.5 m diameter and 5.0 mm mesh between nodes) on each bank, per sampling site (Figure 3 B). Also, the use of netting (60cm in diameter, 60cm in depth and 5mm of mesh), in the form of 10 shots per bank (Figure 3 D).

In addition to these, the passive pit trap methodology was applied, with an attractive bait (80 cm in diameter, 2.5 mm mesh and 6 trap entrances), installed for 12 hours at each sampling point, and they were installed at dusk and collected at dawn. A pit was installed at each sampling point (Figure 3 C).

Figure 3 – Methodologies applied to the capture of specimens of the species identified for the study, gill net (A), cast net (B), covo (C) and puçá (D).



Source: Authors (2021).

2.3 Biological classification

To classify the species and species nomenclature, families and orders, relevant and current literature and determinations were followed (Froese & Pauly 2019, Fricke et al., 2022, Saviato et al. 2020, Saviato et al. 2021a), the captured fish being identified, if possible, immediately after capture and then measured and photographed; immediately released in their place of origin.

2.4 Collection and deposit in scientific collection

The captured fish were measured, weighed and photographed, and those that were able to return to the environment were immediately released into the river. All specimens collected, as determined in Resolution nº. 301 of December 8, 2012 of the Federal Council of Biology (CFBio) and CFBio Ordinance No. 148/2012 that "Regulates the procedures for capturing, containing, marking and collecting vertebrate animals provided for in Articles 4, 5, 6 and 8 of CFBio Resolution No. 301/2012", together with the regulations of the National Council for the Control of Animal Experimentation - CONCEA (Ministry of Science, Technology and Innovation - MCTI).

Euthanasia, whenever necessary, would follow the standard protocols that use immersion in an anesthetic solution, which is the method used administering high doses of anesthetics aiming at euthanasia in fish and amphibians.

After being anesthetized, the specimens would then be fixed in 10% formaldehyde for 48 h and later transferred to a 70% ethyl alcohol solution where they were preserved. They would later be deposited in the collection of the Center for Biological Study and Research (CEPB) of the Pontifical Catholic University of Goiás (PUC/GO). However, considering that all the animals were released, in their places of capture, not constituting biological material to be deposited, there was no deposit in that collection (Figure 4 and Figure 5).

Figure 4 - Animals collected and awaiting identification, before their release at the site, Dos Bois River, GO.

Source: Authors (2021).

Figure 5 - Salminus hilarii Valenciennes 1850, undergoing identification before its release, at the capture site in Dos Bois River, GO.

Source: Authors (2021).

2.5 Data analysis

The following analyzes were performed: calculation of total and relative abundance, frequency of occurrence of species, analysis of similarity, analysis of diversity, calculation of species richness and calculation of constancy by species, using the statistical program PAST 4.03 and Word Excel resources .

The frequency of occurrence of the species was calculated based on the following formula:

$$FO = \frac{ni * 100}{n}$$

Where:

FO = frequency of occurrence of a given species (in percentage)

ni = number of individuals of species i

n = total number of individuals in the sample

The similarity analysis is given by the homogeneity and/or heterogeneity of the study area and evaluated by the *Jaccard-Sji* similarity. Being obtained by the following formula:

$$\boldsymbol{Sij = a/(a + b + c)}$$

Where:

Sij = Similarity Coefficient between two areas (i and j)

a = Number of species in common recorded between two areas

b = Number of species present in the first area (i);

c = Number of species present in the second area (j).

One of the most widespread and also used for this study was the Shannon-Wiener diversity index (Pielou 1975). It is obtained by applying the following formula:

$$\boldsymbol{H' = -\sum_{i=1}^{S}(pi) \times (log_n pi)}$$

Where:

S = total number of species in the sample;

i = species 1, 2, 3 ... i in the sample;

pi = the proportion of species i, estimated as ni/N, where ni is the measure of importance of species i (number of individuals).

To identify the similarity between the sampling sites, the evenness index was used, being most commonly expressed by the Pielou Index (*J'*):

$$\boldsymbol{J' = \frac{H'}{H'max.}}$$

Where:

H' is the value obtained for the Shannon-Wiener index;

H' max is its theoretical maximum value, which is given by ln (S).

Equitability varies between 0 and 1, reaching its maximum when all species are represented by the same number of specimens.

The total number of species (S) per sampling point was used as site richness. Consequently, this species richness is very dependent on the sample size, that is, the larger the sample, the greater the number of species that can be sampled. Thus, species richness says little about community organization, increasing depending on the area, even without habitat modification. It is used to calculate equity.

Among others that can be calculated, however, unusual, such as: Dominance_D, Simpson_1-D, Shannon_H', Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker and Chao-1.

Each species was classified, according to its constancy in the sampled community, as constant, accessory, or accidental. The criterion for this classification was based on the percentage of the number of samples in which the species was recorded, in relation to the total number. Thus, the species was considered constant when this percentage exceeds 50%; accessory, when it is between 25% and 50%; and accidental, when it is less than 25%.

Sampling sufficiency is a quantitative concept used in biological studies to inform whether the sample used is “representative” of the community. The collector curve, in turn, is a technique that emerged from the species-area relationship, considered of great importance in the characterization of communities and that has been extensively used in ecology studies, particularly in Brazil to indicate sample sufficiency.

Species accumulation curves (collector curves) allow us to assess how close a study is to capturing all species in the site. When the curve stabilizes, that is, no new species are added, it means that the total richness has been obtained. From this, further sampling is not necessary.

To make the results obtained by the ecological analyses robust, the means ± SD (Standard Deviation of the means) were taken and only the difference at the 5% level of significance was considered. All results were tested for normality and homoscedasticity through Shapiro-Wilk and Bartlett. And so, the data with normal distribution were evaluated in the analysis of variance (ANOVA - *One Way*) followed by the *Tukey* test for comparison between means.

For data that did not follow this distribution pattern, Kruskal-Wallis was used followed by the Dunn test to compare medians using the GraphPad Instat program, version 3.0.

2.6 Eating habits

Environmental assessment is based on the identification of ecological functions and their maintenance. In this way, the relationships between organisms and the environment enable their interaction, permanence, and search for resources. Therefore, regarding the attacks of these organisms in relation to their foraging strategies and exploitation of food resources, in the classification used by Zavala-Camin (1996), it is possible to identify 7 distinct groups. These groups are Herbivores (food based on plants and algae); Omnivores (exploit plants or animals and/or their remains); Detritivores (feeds on the remains of animals and plants deposited in the river bed); Iliophages (they feed on the biota that develops attached to the substrate); Invertivores (feeds on invertebrates); Piscivores (they eat fish) Planktivores (exploit plankton – microcrustaceans and microscopic algae).

Food habits represent an integration between food preferences, availability, and accessibility to food resources. The diversity in eating habits found in fish is the product of evolutionary processes that led to several structural adaptations. For a fish to specialize in a particular food resource, it must have a morphological structure capable of exploiting the resource and it must be in sufficient quantity, in terms of biomass, to meet the needs of the consumer (Schneider 2011). As a mirror of food diversity, there is, in the same proportion, the existence of a wide diversity of ecosystem services, performed by each trophic guild.

These organisms present several adaptations of the digestive system, according to the specialization required to ingest, digest and absorb different types of food (Zavala-Camin 1996). The need to adapt to environments with such different characteristics makes it possible for several species to coexist in the same environment (Corrêa & Smith 2019).

3. Results and Discussion

3.1 Wealth and species composition

According to the biological material obtained (Table 7), the recorded specimens are distributed in 7 orders, 19 families and 46 species, where the most diversified order was Characiformes (n = 26 species). Coinciding with the species presented for other studies in similar regions, but with higher richness (Ferreira et al. 2011, Saviato et al. 2021a).

During the sampling period, no species classified in any category of threat from the lists of threatened animals, national (ICMBio/MMA 2018) and international (IUCN 2022) or with restricted distribution were recorded.

However, the record of Salminus hilarii and Prochilodus nigricans, even though they are not listed as threatened, emphasizes attention to the large migrators that use this studied stretch for their reproductive movements.

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Table 2 - Taxonomic classification of the species collected in the study area, as well as their absolute abundance (∑), frequency of occurrence (FO) and constancy in collections, cumulative for the campaigns of the dry and rainy seasons.

Taxa	∑	FO	Constancy
CHARACIFORMES	**14431**	**92,24%**	**27,00%**
Anostomidae	**364**	**2,33%**	**50,00%**
Leporinus friderici (Bloch 1794)	364	2,33%	50,00%
Characidae	**11609**	**74,20%**	**25,60%**
Astyanax novae Eigenmann 1911	3108	19,87%	100,00%
Ctenobrycon spilurus (Valenciennes 1850)	4531	28,96%	58,33%
Hemigrammus cf. melanochrous Fowler 1913	306	1,96%	8,33%
Hemigrammus cf. stictus (Durbin 1909)	504	3,22%	16,67%
Hemigrammus hyanuary Durbin 1918	84	0,54%	8,33%
Hemigrammus levis Durbin 1908	168	1,07%	8,33%
Knodus heteresthes (Eigenmann 1908)	140	0,89%	16,67%
Moenkhausia chrysargyrea (Günther 1864)	896	5,73%	25,00%
Moenkhausia collettii (Steindachner 1882)	532	3,40%	25,00%
Moenkhausia oligolepis (Günther 1864)	84	0,54%	8,33%
Odontostilbe nareuda Bührnheim & Malabarba 2006	332	2,12%	25,00%
Phenacogaster microstictus Eigenmann 1909	644	4,12%	25,00%
Serrapinnus kriegi (Schindler 1937)	168	1,07%	8,33%
Tetragonopterus chalceus Spix & Agassiz 1829	112	0,72%	25,00%
Bryconidae	**70**	**0,45%**	**83,33%**
Salminus hilarii Valenciennes 1850	70	0,45%	83,33%
Crenuchidae	**784**	**5,01%**	**41,67%**
Characidium etheostoma Cope 1872	784	5,01%	41,67%
Curimatidae	**389**	**2,49%**	**50,00%**
Curimatella dorsalis (Eigenmann & Eigenmann 1889)	389	2,49%	50,00%
Erythrinidae	**196**	**1,25%**	**25,00%**
Hoplias malabaricus (Bloch 1794)	196	1,25%	25,00%
Gasteropelecidae	**364**	**2,33%**	**16,67%**
Thoracocharax securis (De Filippi 1853)	364	2,33%	16,67%
Iguanodectidae	**280**	**1,79%**	**33,33%**
Bryconops caudomaculatus (Günther 1864)	280	1,79%	33,33%
Prochilodontidae	**22**	**0,14%**	**8,33%**
Prochilodus nigricans Spix & Agassiz 1829	22	0,14%	8,33%
Serrasalmidae	**327**	**2,09%**	**11,11%**
Piaractus brachypomus (Cuvier 1818)	109	0,70%	16,67%
Pygocentrus nattereri Kner 1858	196	1,25%	8,33%
Serrasalmus gibbus Castelnau 1855	22	0,14%	8,33%
Cynodontidae	**26**	**0,17%**	**8,33%**
Rhaphiodon vulpinus Spix & Agassiz, 1829	26	0,17%	8,33%

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Taxa	∑	FO	Constancy
CICHLIFORMES	588	**3,76%**	**21,67%**
Cichlidae	588	**3,76%**	**21,67%**
Apistogramma sp.	56	0,36%	16,67%
Cichla kelberi Kullander & Ferreira 2006	28	0,18%	8,33%
Cichlasoma amazonarum Kullander 1983	140	0,89%	25,00%
Crenicichla labrina (Spix & Agassiz 1831)	252	1,61%	33,33%
Laetacara araguaiae Ottoni & Costa 2009	112	0,72%	25,00%
GYMNOTIFORMES	5	**0,03%**	**8,33%**
Gymnotidae	5	**0,03%**	**8,33%**
Electrophorus electricus (Linnaeus 1766)	5	0,03%	16,67%
Gymnotus carapo Linnaeus 1758	0	0,00%	0,00%
MYLIOBATIFORMES	27	**0,17%**	**8,33%**
Potamotrygonidae	27	**0,17%**	**8,33%**
Potamotrygon motoro (Müller & Henle 1841)	27	0,17%	8,33%
SILURIFORMES	587	**3,75%**	**13,89%**
Auchenipteridae	25	**0,16%**	**8,33%**
Ageneiosus inermis (Linnaeus 1766)	25	0,16%	8,33%
Heptapteridae	163	**1,04%**	**25,00%**
Pimelodella lateristriga (Lichtenstein 1823)	163	1,04%	25,00%
Loricariidae	258	**1,65%**	**13,89%**
Hypostomus faveolus Zawadzki, Birindelli & Lima 2008	99	0,63%	16,67%
Rineloricaria sp.	110	0,70%	16,67%
Squaliforma emarginata (Valenciennes, 1840)	49	0,31%	8,33%
Pimelodidae	141	**0,90%**	**8,33%**
Hemisorubim platyrhynchos (Valenciennes, 1840).	84	0,54%	8,33%
Pimelodus blochii Valenciennes 1840	26	0,17%	8,33%
Pseudoplatystoma cf. punctifer (Castelnau 1855)	30	0,19%	16,67%
Sorubim lima (Bloch & Schneider, 1801).	0	0,00%	0,00%
Zungaro zungaro (Humboldt 1821)	1	0,01%	8,33%
SYNBRANCHIFORMES	6	**0,04%**	**8,33%**
Synbranchidae	6	**0,04%**	**8,33%**
Synbranchus df. marmoratus Bloch 1795	6	0,04%	8,33%
Exótico (introduzida)	1	**0,01%**	**8,33%**
Oreochromis niloticus (Linnaeus 1758) *	1	0,01%	8,33%

Source: Authors (2022).

Of the 15,645 specimens collected in the two campaigns, 92.24% are representatives of the order Characiformes, indicating that this order is quite numerous and diversified in this water system studied. In these two campaigns, there were intense field incursions, with approximately 40 days invested per campaign, totaling more than 80 sampling days.

The exotic species *Oreochromis niloticus* (tilapia) is originally native to the Nile River basins, coastal rivers of Israel (Trewavas & Teugels 1991), Awash River, in the Omo River, Suguta River and Lakes Malawi, Tanganyika, Albert, Edward, Tana, Jebel Marra, Kivu, Turkana, Baringo, as well as in several Ethiopian lakes (Trewavas 1983). Also found in West Africa, with a natural distribution in the Senegal, Gambia, Volta, Niger, Benue and Chad basins (Teugels & Van Den Audenaerdes 2003). However, it is widespread throughout the world through fish farming and accidental introductions into numerous watersheds (Agostinho et al. 2018).

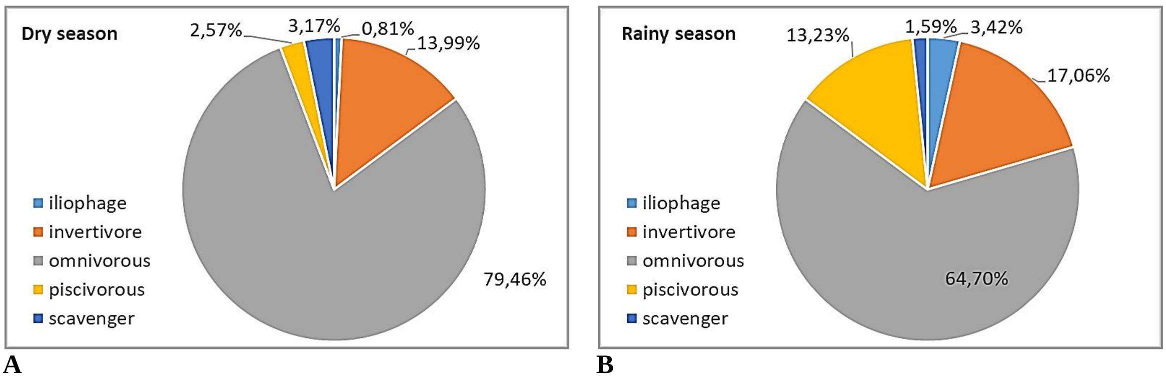
Thus, in view of the record of *O. niloticus* in the studied region, it indicates its accidental introduction into the Araguaia-Tocantins drainage system, with a potential negative impact on native Cichlids species (Portinho et al. 2021). Which can suffer competitive exclusion, as well as the other groups can have their juveniles preyed upon. Because, despite not being a predatory species, tilapia is opportunistic and reaches considerable size, exceeding 60 cm and 4.5 kg, being larger than most species of the same family present in Brazilian water systems (Agostinho et al. 2018).

It can cause relevant disturbances to the ichthyofauna, causing local extinctions of native Cichlids species. Thus, the disappearance of smaller species of orders such as Characiformes, Cyprinodontiformes, among others, which, despite being prolific, are still sensitive to the voracity of this species (Sotomayor et al. 2022).

3.2 Eating habits

Based on the data obtained, it was possible to divide the sampled species into the trophic guilds proposed by Zavala-Camin (1996), and thus also subdivided these groups by climatic season. Identifying that there were subtle differences in distribution by trophic guild, by climatic season (Figure 6).

Figure 6 - Distribution of relative abundance for each trophic guild, for the two seasons, dry (A) and rainy (B).



Source: Authors (2022).

The existence of dominance in number of individuals for a given trophic guild is clear, even if we compare the data for the different seasons. And it is possible to identify the relationship between the quantities of individuals and species collected for each Guild and the most prominent group are the omnivores, an implicit fact in the quality of the water that makes possible a dystrophic environment, with the presence of abundant organisms, food base of this guild, as well as allochthonous material carried.

In this sense, the group of invertivores was also highlighted, since the mentioned environmental quality allows a considerable increase in the richness and abundance of benthic and nektonic macroinvertebrates (Queiroz et al. 2018). Abundant organisms, as the number of resources available in the region is also abundant (Rocha 2018) because it is a depositional area for most of the period and having added to this fact, the discharges from the agroindustry (Camargo et al. 2019, Vieira et al. 2021).

During the rainy season, there is an increase in other guilds and better distribution, since this season is correlated with voluminous rains that promote the transport of materials with greater intensity, providing these organisms with a considerable increase in food resources, allowing their proliferation which consequently attracts the attention of predators (Vilela et al. 2021).

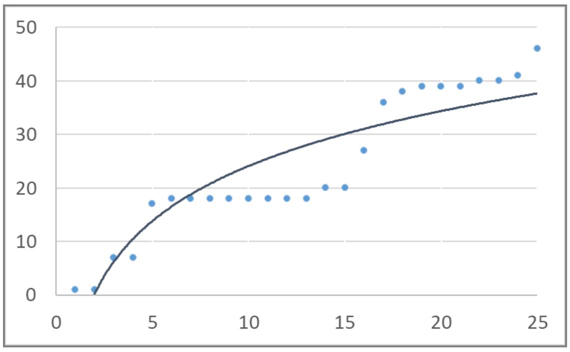
This fact is reflected in the pertinent observation about the considerable increase in the group of piscivores in the rainy season, a fact inherent to the availability of resources, already mentioned. Considering that, in that season, the reproductive processes of a large number of fish species occur, the main food of the piscivorous guild (Figeiredo et al. 2022).

In the same way that this increase in the detritivores and piscivores guilds is due to the increase of migratory species, passing through the studied place, such as: Salminus and Prochilodus, which promote reproductive displacement, during short periods during the year. Salminus is also attracted to these areas in its juvenile stages due to the availability of food resources, such as schools of juveniles of other species (Cajado et al. 2019, 2020, Montenegro et al. 2020, Sevignani et al. 2020).

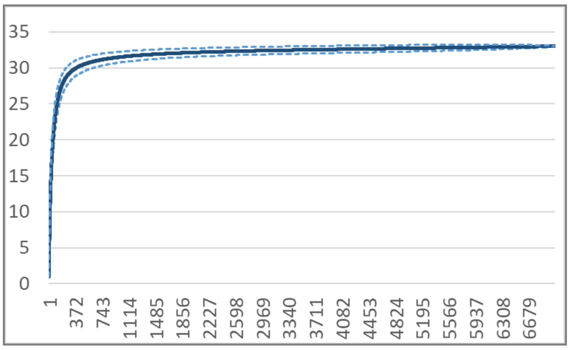
3.3 Ecological analyzes

The Species Accumulation Curve identifies an initial increase in species, which was high, but did not reach the asymptote, that is, more species may occur in this stretch of the Dos Bois River. The species rarefaction curve with 95% reliability also indicates that at the sampled site, more species are expected, indicating that there is greater species richness at the site (Figure 7).

Figure 7 - Sampling sufficiency represented by the species accumulation curve, A) Collector curve and B) Species rarefaction curve (B).



A



B

Source: Authors (2022).

The smoothing of the curve for both graphs indicates that the effort employed in the present study has sample sufficiency, given the few possible encounters with species that will add to the local richness (Beltrão & Soares 2019).

Even being a natural environment, with anthropic pressures along the studied stretch, it still allows the existence of a prominent ichthyofauna (Júnior & Lorenzi 2022). Indicative of the resilience of the environment in the face of impacts, resulting from multiple land uses in the region (Beltrão et al. 2018, Camargo et al. 2019). If these results reach most of the species existing in the place, emphasizing the considerable sampling amplitude applied for the present study (Júnior et al. 2020). For the environmental assessment as a whole or for each sampling site, the following results were obtained (Table 3).

Table 3 - Ecological indices calculated for the ichthyofauna in the area of influence of the present study, Rio Bois, using the PAST 4.03 program.

Indexes	Sample Points				
	01	**02**	**03**	**04**	**05**
Taxa_S	4	33	15	10	17
Individuals	4631	7042	1836	1215	921
Dominance_D	0,4968	0,06861	0,1817	0,1557	0,1208
Simpson_1-D	0,5032	0,9314	0,8183	0,8443	0,8792
Shannon_H	0,813	2,991	2,079	2,006	2,439
Evenness_e^H/S	0,5636	0,6033	0,533	0,7432	0,6742
Brillouin	0,8108	2,977	2,057	1,984	2,394
Menhinick	0,05878	0,3932	0,3501	0,2869	0,5602
Margalef	0,3554	3,612	1,863	1,267	2,344
Equitability_J	0,5864	0,8555	0,7676	0,8711	0,8609
Fisher_alpha	0,4309	4,484	2,235	1,492	2,96
Berger-Parker	0,6167	0,1544	0,3355	0,2305	0,2432
Chao-1	4	33	15	10	17

Source: Authors (2022).

The discrepancy pointed out by the *Shannon_H* index (diversity) is directly related to the Individuals and *Taxa_S* index, since they portray the abundance by species and the number of species for each location. However, it is possible to identify that most indices indicate similarity of results for all collection points. Because these presented diversity indices reflect the complexity of an ecosystem and/or estimate its climax (Saviato et al. 2021a).

In this way, the results indicate what is expected for an area with typical ritral characteristics for headwaters that form the drainages of the Araguaia River headwaters basin complex, as pointed out by Melo (2011) in studies close to the region, and also by Costa et al. (2019) in Rio das Almas and by Lima et al. (2021) in Rio das Mortes, In addition to corroborating the data obtained by Silva et al. (2021) who investigated the ichthyofauna of the Jiquiriçá River/BA, with characteristics similar to those found in the study area.

Since the convergence of environmental physiognomy provides similar pressures allowing the existence of an ichthyofauna with similar abundance and distribution (Souza et al. 2020, Teixeira et al. 2019)

This is an indication that there is consistency in the occurrence of these species, which are distributed in such a way as to present quite discrepant equity (0.5864 – 0.8711), with very distant values between the sampling sites.

Considering environments where the low capture and one of the seasons, there was soon a decrease in sampling, contrasting with very fishy places that abounded in captures for the two climatic periods.

This indicates that there is a difference in the composition of the fish assemblage in the explored sites. This fact is supported by the different numbers of individuals and amounts of species sampled for each point (see Table 3).

However, comparisons with the results for the other indices known as: *Evenness_e^H/S; Brilloin, Menhinick; Fisher_alpha; Berger-Parker; and Chao-1* – will present similar numerical interferences between the sampling points.

In short, it is understood that the ecological indices of all points exhibited similar implications, this may indicate that there is a similar relationship in the supply of resources, which may harbor the same species. The results showed that the diversity is similar in the four sampling points.

The *Jaccard* similarity for the ichthyofauna compares the groups formed at the sample points (Table 4, Table 5, Figure 8 and Figure 9)

They indicate that there is a similarity of approximately 20% between the sampling sites, mostly (low similarity). Indicating that the sampling sites with the greatest similarity are points 02 and 04 (25%). Emphasizing that the similarity of Jaccard-S considers the values of individuals by species.

Table 4 - Distribution of Jaccard - Sij similarities between the points, using the PAST 4.03 program.

Similarity	**Point_01**	**Point_02**	**Point_03**	**Point_04**	**Point_05**
Ponto_01	1	0,088235	0,1875	0,27273	0,10526
Ponto_02	0,088235	1	0,2973	0,30303	0,25
Ponto_03	0,1875	0,2973	1	0,31579	0,23077
Ponto_04	0,27273	0,30303	0,31579	1	0,17391
Ponto_05	0,10526	0,25	0,23077	0,17391	1

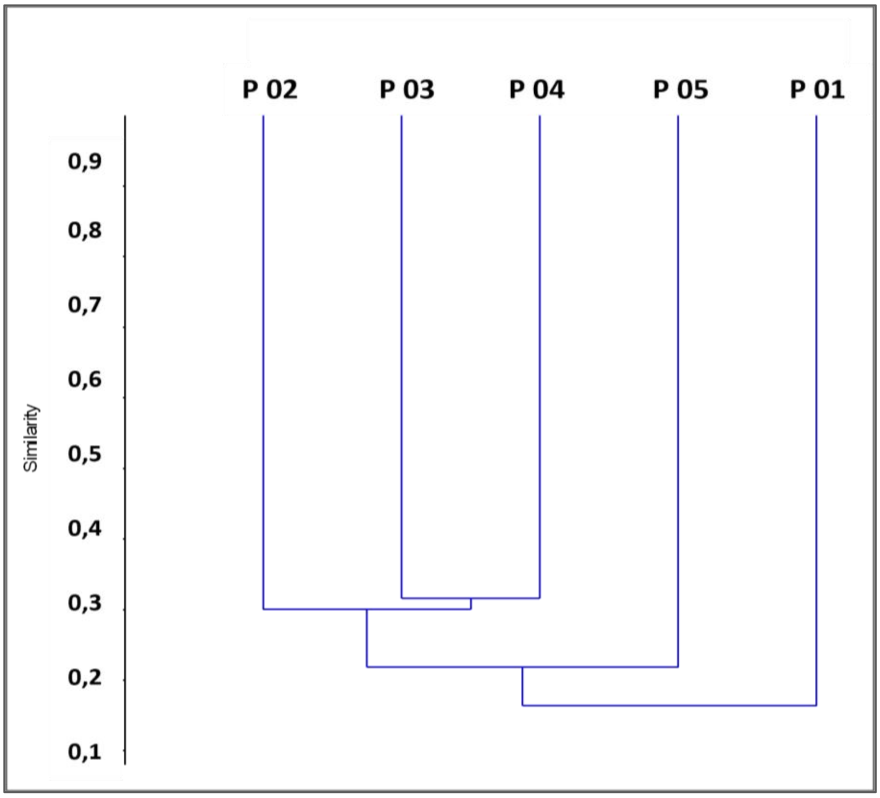
Source: Authors (2022).

Table 5 – Values for the Tukey test, relative to the similarity between the points, using the PAST 4.03 program.

***Tukey*'s test**	**Point_01**	**Point_02**	**Point_03**	**Point_04**	**Point_05**
Ponto_01		0,8968	0,9003	0,7955	0,7546
Ponto_02	1,273		0,3784	0,2556	0,2222
Ponto_03	1,26	2,534		0,9994	0,9982
Ponto_04	1,585	2,859	0,3249		1
Ponto_05	1,689	2,963	0,4288	0,104	

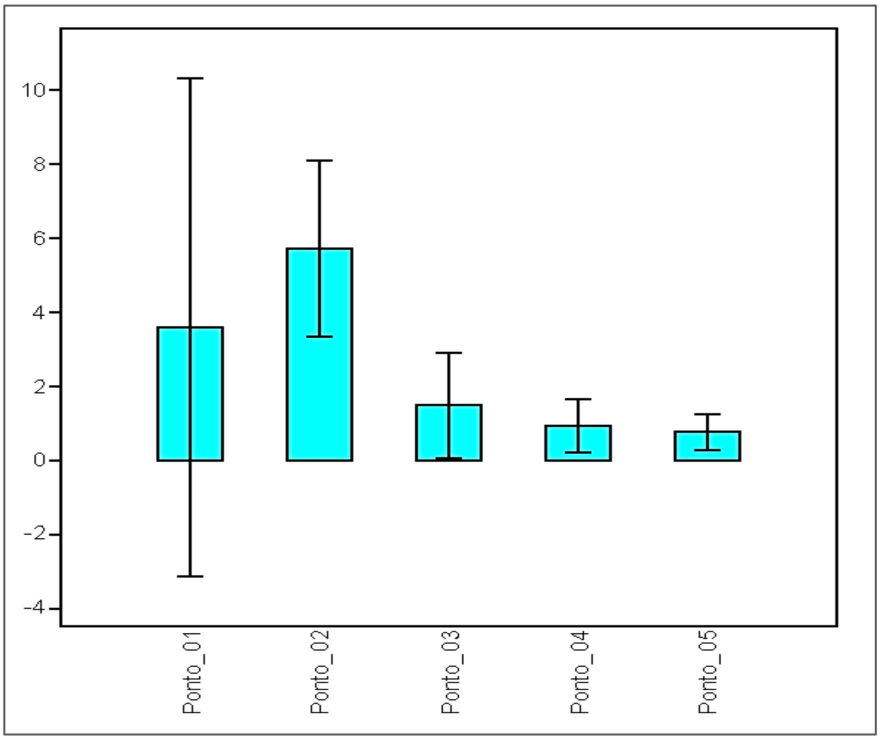
Source: Authors (2022).

Figure 8 - Grouping of similarity between the sampling sites, based on the Jaccard-S values.



Source: Authors (2022).

Figure 9 - Diversity values based on the comparison of means by the Tukey test, and their respective standard deviations.



Source: Authors (2022).

In this way, it can be inferred that each sampling point contributes specifically to the total richness of the Dos Bois River (Table 6).

Table 6 – Distribution of richness, abundance, and exclusivity values for each sampling point in the present study, PAST 4.03 program.

Sample Points	Richness	Abundance	Exclusive Species
Point 01	4	4631	1
Point 02	33	7042	14
Point 03	15	1836	3
Point 04	10	1215	0
Point 05	17	921	6

Source: Authors (2022).

It is possible to observe that there was a strong diversity deviation for Point 02, significantly influenced by the number of individuals collected, in addition to greater richness among the other sampling sites. In the same way that Point 01 presented greater variation of standard deviation between the averages of diversity, therefore, the samplings in the mentioned place, contemplated only four species. The Tukey test compares the possible pairs of means and minimum significant difference (D.M.S.) for each sample group, based on the mean residual distribution of ANOVA (One Way) and on the sample size of the groups.

However, despite being different places, they have similar physiognomy to the Cerrado riparian environments and also have similarities to the adjacent environments, lakes and streams within the pastures these complement the richness of the river as a whole, being part of the intricacy of life there.

4. Final Considerations

The ichthyofauna recorded for the sampled stretch in the Dos Bois River agrees with the fish fauna expected for the Cerrado rivers and the Araguaia headwaters region. In the same way, it exemplifies being a polyphyletic and diverse group, widespread in all points where they were sampled, except for some favorable and fishy places. The local ichthyofauna make up important organisms in the environmental assessment, due to their distribution and presence of different environments that make up the mosaic of water and wetlands in the studied region. Furthermore, there were no recorded species threatened or suffering any kind of threat to the Goiás state or to Brazil.

The present study points to data of richness and abundance that coincide with what is expected for the rivers of the Brazilian Cerrado. Where the present basin, for being totally inserted in the Cerrado area, that despite being garrisoned by the gallery forest, the studied river is also subject to the anthropic alterations. It is worth mentioning that the studied site, even with unfavorable characteristics (water pollution and changes in its physical-chemical qualities), still maintains considerable species richness and that its conservation is of paramount importance for the preservation of the aquatic environment and maintenance of fish stocks. region and the Araguaia basin.

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