



ECOSYSTEMS

Ichthyological research in the Sorocaba River basin, State of Sao Paulo, southeastern Brazil: trajectory of knowledge, advances, and future directions

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Abstract: Ichthyological knowledge of the Sorocaba River basin dates to the 19th century, with initial surveys by Johann Natterer. These were followed by expeditions at the turn of the 20th century by researchers from the University of São Paulo's (USP) Zoology Museum, which resulted in the description of five new species. After a hiatus of nearly a century, research resumed in 1992. Here, we present a comprehensive review of 64 publications to assess the current state of knowledge on the basin's ichthyofauna. The most frequently studied topics were community ecology (34.4%), followed by species inventory (14%), population ecology (12.5%), and feeding ecology (7.8%). The reviewed articles documented 109 fish species, with the majority belonging to the order Characiformes and the family Aces-trorhamphidae. This total comprises 93 native and 16 non-native species. Despite a recent increase in publications, we identify critical knowledge gaps. We conclude that the basin has a well-known ichthyofauna, meaning that future efforts should prioritize research on diet, reproduction, and invasive species, while also incorporating emerging topics such as microplastic pollution and modern techniques, such as stable isotope analysis, to effectively guide conservation and management.

Key words: fish, freshwater ecosystems, impact, upper rio Paraná basin, neotropical region.

INTRODUCTION

The Neotropical region is home to a rich ichthyofauna, with records of 4,225 fish species (Tonella et al. 2023). Within this region, the Upper Paraná River basin records 341 species (Dagosta et al. 2024). This study updates the previous species inventory for the Sorocaba River basin, compiled by Smith et al. (2007), which documented 71 species. We expect this number to have increased due to recent research compiled in this work. While early inventories were conducted by naturalists in the 18th and 19th centuries (Vanzolini 1996, Dagosta et al. 2024), ichthyological research in Brazil was

significantly consolidated throughout the 20th century, with advances in various subdisciplines of biology and ecology across nearly all river basins.

The post-war economic expansion during the second half of the twentieth century led to mounting pressures and impacts on Brazilian drainage basins (Araújo et al. 2009). The proliferation of human activities, particularly agriculture, dam construction, aquaculture, urbanization, mining, fishing, and the introduction of non-native species has profoundly transformed the structure, dynamics, and function of

inland aquatic ecosystems (Pelicice et al. 2021). By systematizing historical data and identifying knowledge gaps, the present study provides a crucial baseline for understanding these long-term changes and guiding future research.

Brazilian freshwater ecosystems have undergone profound alterations due to pollution, eutrophication, habitat destruction, dam construction, fishing, and the introduction of non-native species (Agostinho et al. 2005). These widespread impacts have significantly changed native fish communities, making historical data essential for understanding baseline conditions prior to severe degradation. However, comprehensive historical inventories and analyses of long-term change remain uncommon for many Brazilian river systems.

This study focuses on the Sorocaba River basin, part of the Water Resources Management Unit 10 in the Middle Tietê River region (CBH-SMT 2013). This river system drains 18 municipalities and is located in southeastern Brazil, near the São Paulo metropolitan region. This area is the most urbanized in the country, accounting for over 40% of the Brazilian population, and is subject to intense agricultural and livestock farming pressures common to the Upper Paraná River basin (Pelicice et al. 2021, IBGE 2023). Economically developed regions such as this are often where biodiversity is most gravely threatened, as conservation efforts frequently lag behind the pace of development. This context underscores the critical relevance of historical data systematization for this basin.

The Sorocaba River basin lies in a transition zone between the Atlantic Forest and Cerrado biomes and is situated within a highly urbanized region. Consequently, its rivers and streams are critically threatened by real estate speculation and agriculture, placing its ichthyofauna under severe pressure. Despite these threats, considerable research has been conducted since

1993, significantly advancing our understanding of the local fish communities. Conservation efforts are partially supported by a network of federal, state, and municipal protected areas, such as the Corredores da Biodiversidade Municipal Park, the Itupa-raranga Environmental Protection Area (APA), and the Ipanema National Forest. For instance, the Ipanema National Forest alone harbors 89 fish species, representing a significant proportion of the basin's total diversity (Smith et al. 2021). Notably, despite intense urbanization, streams within the basin's municipalities continue to support a significant ichthyofauna. The municipality of Sorocaba, for example, recorded 63 fish species in its most recent inventory (Smith et al. 2020). This persistence highlights the resilience of the local fauna and underscores the critical need for continued research and targeted protection efforts, even in highly modified landscapes.

We developed a comprehensive reference database of fish species recorded in the Sorocaba River basin, compiling information on their occurrence, sub-basin distribution, habitat use, and the sampling methodologies employed in previous studies. By synthesizing this dataset, we address the following key questions: 1) What are the historical trends and primary research themes in ichthyological studies within the basin, and what are the main knowledge gaps for future research? 2) What is the current taxonomic and ecological composition of the basin's ichthyofauna, including the prevalence of native versus non-native species? 3) How are fish species distributed across the basin's primary habitats, such as the main river channel, tributaries, and floodplain lakes?

MATERIALS AND METHODS

The Sorocaba River basin is located in the state of São Paulo, Southeastern Brazil, covering

an area of 5,269 km² across 18 municipalities (Figure 1). The river system consists of the main Sorocaba River, its headwaters (the Sorocamirim, Sorocabuçu, and Una rivers), and other major tributaries, including the Pirapora, Tatuí, Sarapuí, Pirajibu, and Ipanema rivers. Originating in the Serra de São Francisco, the Sorocaba River flows through the municipality of Votorantim before reaching the city of Sorocaba. In its middle reach, the river is characterized by extensive wetlands and several floodplain lakes, which are primarily marginal (Smith & Barrella 2000, Silva et al. 2020). These landscape features extend down-stream through the municipalities of Iperó, Tatuí, Boituva, Cerquilha, and Laranjal Paulista.

The main rivers of this system are the Sorocaba, Sarapuí, and Ipanema (Atlas

Socio-Ambiental 2009). Located in the Upper Sorocaba sub-basin, the Itupararanga Reservoir serves multiple purposes. It supplies water to the urban region of Sorocaba - the municipality with the highest population density in UGRHI-10 (>1,337 inhabitants/km²) - as well as to other municipalities bordering the reservoir (CBH-SMT 2013). The most prevalent economic activities are extractive, metallurgical, and food industries, while sugarcane, corn, and vegetables dominate agriculture (CETESB 2023). The climate varies across the basin, with classifications ranging from hot and humid with a dry winter to hot and humid without a dry season and temperate and humid without a dry season. Only 13.6% of the original vegetation cover remains, consisting primarily of Dense Ombrophylous Forest and Semideciduous Sea-sonal Forest. The remaining

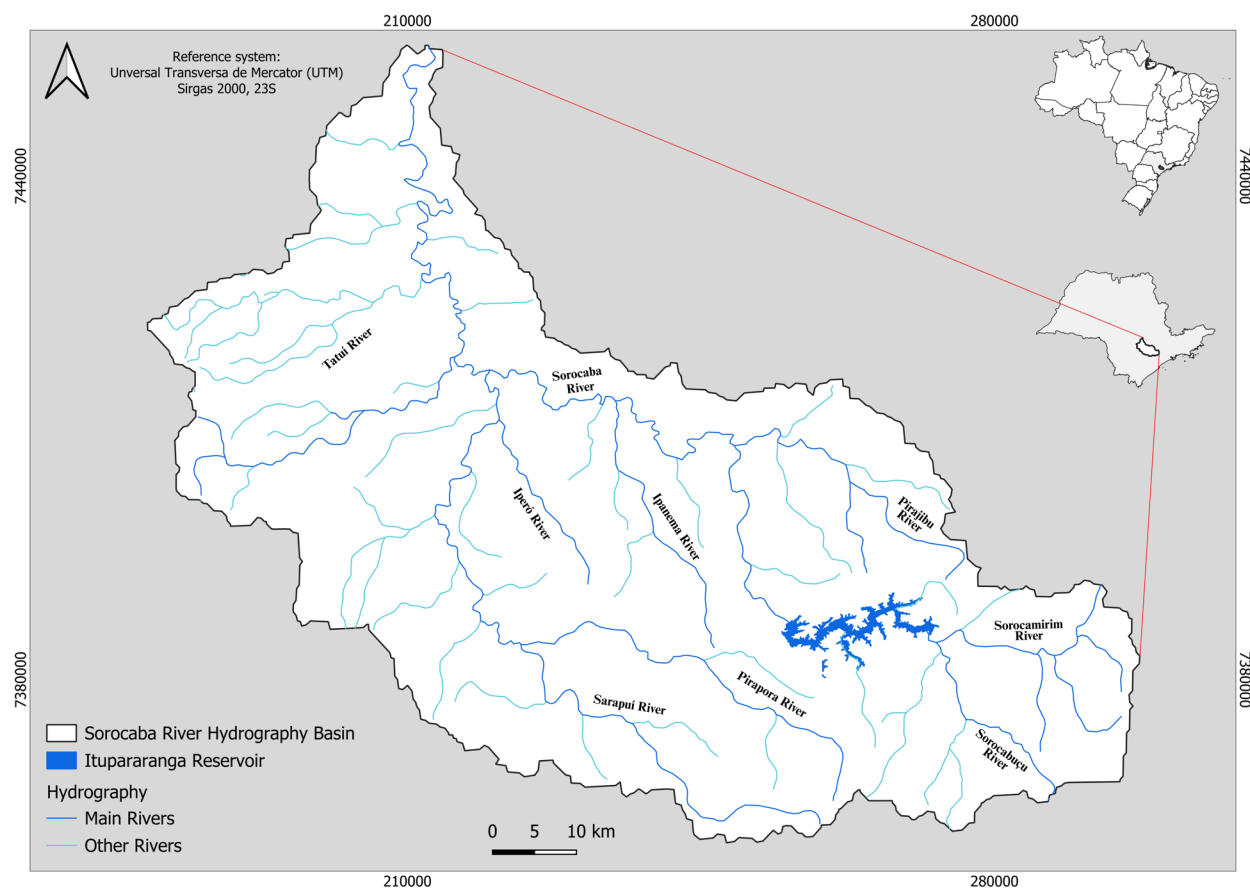


Figure 1. The geographic location of the Sorocaba River Basin and its main tributaries.

Cerrado biome is fragmented and under significant pressure from urbanization and real estate development (Atlas Socioambiental 2009).

The reviewed literature provided the basis for dividing this study into five chronological periods. These periods were defined as follows: 1) the 19th century; 2) 1900 - 1992, the period prior to the establishment of Biological Sciences programs in the basin region; 3) 1993 - 2003, following the creation of these programs and the beginning of formal ichthyological research; 4) 2004 - 2013, corresponding to the first major species inventory; and 5) 2014 - 2025, characterized by the expansion of studies and the publication of an updated species list. A scientific literature search was conducted from November 2023 to January 2025, targeting publications released between 1990 and 2025. Using the HistCite software (Garfield 2009), the retrieved articles were classified by author, journal, institution, year, and country. Articles published before this main search period were also considered for historical context and comparison.

The information presented in this study was gathered through a systematic review. Articles were selected based on the following inclusion criteria: i) addressing the subject of ichthyology; ii) being conducted in the Sorocaba River basin

(including the main river or its tributaries); and iii) having the full text accessible. Publications from 1990 to 2025 were identified using the Scopus, Web of Science, and Google Scholar electronic databases. We conducted distinct searches for ichthyological studies focusing on each of the basin's major rivers.

The process of reading, organizing, selecting, and excluding articles was managed using the Start 3.0.3 software (State of the Art through Systematic Review). This program, developed by the Software Engineering and Research Laboratory at the Federal University of São Carlos (UFSCar), facilitates the organization of publications according to a pre-defined review protocol. Full-text articles were accessed through the CAPES Journals Portal via an institutional subscription of the Universidade Paulista (UNIP). Finally, the following data were extracted from each selected article: a) year of publication; b) species reported; c) river; d) specific location; and e) study category (Table I).

Furthermore, historical data on the basin's ichthyofauna were obtained by consulting the collections of the Zoology Museum of the University of São Paulo (MZUSP) and the Sorocaba Historical Museum. From each publication or report, we extracted information on the investigation type, sampling methods, species list, abundance (where available), and

Table I. Data extracted from the articles, description of the classification and application for each theme analyzed.

Data obtained	Classification	Application
Year	1990 to 2025	Used to determine the time trend of posts
Species	Species documented in each study	Used to distinguish the target species of study from other species investigated in the basin
River	Located in the studied river basin	Used to define the rivers where the studied species are found
Locality	Geographic coordinate	Used to identify the locations where species were sampled
Study Category	Ecology, biology, reproduction, genetics, population dynamics	Classification based on the major objectives of the studies

spa-tial distribution. Species were then classified according to their origin: Autochthonous - species native to the Sorocaba River basin; Allochthonous - species native to other Brazilian basins and introduced to the Sorocaba basin; Invasive - species originating from other continents that have established populations in the basin.

Species that could not be identified to the species level, as well as those lacking confirmed occurrence records or even species introduced but not established in the basin, were excluded from the analysis. The vouchers presented in this manuscript were obtained from the collections (SpeciesLink) and published articles. In cases where the nomenclature was outdated, it was corrected. Taxonomic classification and nomenclature follow Fricke et al. (2025). The conservation status of each species was assessed according to the official list for the State of São Paulo (State Decree 63.853/2018) and the Brazilian National List of Endangered Species (MMA Ordinance Nº 148, 7 June 2022; ICMBio, 2023). For datasets where abundance data were available, we calculated species richness, the Shannon-Wiener diversity index, and Pielou's evenness using PAST software (v. 4.06; Hammer 2021).

RESULTS

Ichthyological studies in the Sorocaba River basin prior to 1992

Many naturalists visited the Sorocaba River basin. Among them, the Austrian Johann Natterer stands out, having collected specimens in Brazil for 18 years (1818-1836). According to Straube (2000), Natterer "headed south, traveling along the Fluminense coast, passing through the Paraíba River valley to the Iron Plant at 'Ypanema', near Sorocaba." This location, situated on a tributary of the Sorocaba River,

is now the Ipanema National Forest (Vanzolini 1993). Natterer's work contributed significantly to the understanding of the ichthyofauna of the Upper Paraná River basin (Dagosta et al. 2024). As documented by Heckel (1840), his notes included the collection date, sex, and provenance of the collected fish specimens.

Scholars such as Friedrich Siebenrock, Rudolf Kner, Johann Jacob Heckel, and Leopold Fitzinger later studied the fish collected by Natterer (Heckel, 1840). Notably, species Natterer collected from the Ipanema River, a tributary of the Sorocaba, were formally described by Rudolf Kner, Franz Steindachner, and Jacob Heckel. For its time, Natterer's work constituted one of the most significant ichthyological collections from Brazil. The specimens from the Sorocaba region, particularly the Ipanema River, were deposited in the Natural History Museum of Vienna. According to Heckel (1840), Natterer's journal, which contained information on other potential discoveries, was unfortunately lost in a shipwreck.

Several species were formally described based on specimens collected in the Sorocaba River basin during this period. These include:

- *Prochilodus vimboides* Kner 1859 (Prochilodontidae): Described by Rudolf Kner from specimens that Johann Natterer collected in the Ipanema River.
- *Hisonotus depressicauda* (Miranda Ribeiro 1918) (Loricariidae): A small catfish collected in the Sorocaba River by E. Von Zeidler and described by Miranda-Ribeiro.
- *Hypostomus ancistroides* (Ihering 1911) (Loricariidae): An armoured catfish collected in the Tatuí River and described by R. von Ihering.

While studying the collections of the Paulista Museum (now the MZUSP), Miranda-Ribeiro (1918)

also described other notable species. From the Tatuí River, he described *Curimatus insculptus* Fernández-Yépez (1948) (Curimatidae), which was later reassigned to the genus *Steindachnerina* Fowler, 1906 by Fernández-Yépez (1948). From the Sorocaba River, he described *Pimelodella rudolphi* Miranda Ribeiro 1918 (Heptapteridae), a species now considered a junior synonym of *Pimelodella meeki* Eigenmann 1910. The type specimens for these species described by

Miranda-Ribeiro and Ihering are deposited at the Museu de Zoologia da Universidade de São Paulo (MZUSP). A total of eighteen fish species were recognized (Table II) considering collections from the 19th and 20th centuries (up to 1992). *Prochilodus vimboides* is not included in this table because the specimens are deposited outside of Brazil, and only specimens deposited in collections in the country are considered here.

Table II. Species collected in the 19th century and between 1900 and 1992. 1) species deposited at MZUSP; 2) species deposited at ZUEC; 3) species deposited at LIRP. *Itupararanga Reservoir.

Name at the time	Valid name	Colector	Date	Location (River)
CHARACIFORMES				
Acestrorhamphidae				
<i>Astyanax bimaculatus</i> (Linnaeus 1758) ¹	<i>Astyanax lacustris</i> (Lütken 1875)	J. Lima	1906	Tatuí
<i>Astyanax fasciatus</i> (Cuvier 1819) ²	<i>Psalidodon fasciatus</i> (Cuvier 1819)	I. Sazima	1978	Sorocaba
<i>Astyanax schubarti</i> Britski 1964 ²	<i>Psalidodon schubarti</i> (Britski 1964)	I. Sazima	1978	Sorocaba
<i>Astyanax lacustris</i> (Lütken 1875) ²	<i>Astyanax lacustris</i> (Lütken 1875)	I. Sazima	1978	Sorocaba
Acestrorhynchidae				
<i>Acestrorhynchus falcistrois</i> (Cuvier 1819) ¹	<i>Acestrorhynchus lacustris</i> (Lütken 1875)	-	1896	Ipanema
Erythrinidae				
<i>Hoplias</i> sp. ¹	<i>Hoplias malabaricus</i> (Bloch 1794)	J. Lima	1906	Tatuí
<i>Hoplias malabaricus</i> (Bloch 1794) ¹	<i>Hoplias malabaricus</i> (Bloch 1794)	Zeidler	1906	Tatuí
Serrasalminidae				
<i>Serrasalmus spilopleura</i> Kner 1858 ¹	<i>Serrasalmus maculatus</i> Kner 1858	Zeidler	1906	Sorocaba
Anostomidae				
<i>Leporinus silvestrii</i> Boulenger 1902 ¹	<i>Megaleporinus obtusidens</i> (Valenciennes 1837)	J. Lima	1906	Sorocaba
Curimatidae				
<i>Curimatus</i> sp. ³	<i>Steindachnerina insculpta</i> (Fernández-Yépez 1948)	F. Marcondes	1984	Sorocaba*
SILURIFORMES				
<i>Plecostomus ancistroides</i> Ihering 1911 ¹	<i>Hypostomus ancistroides</i> (Ihering 1911)	-	-	Tatuí
<i>Plecostomus auroguttatus</i> Kner 1854 ¹	<i>Hypostomus luetkeni</i> (Steindachner 1877)	J. Lima	1906	Tatuí
<i>Hypostomus plecostomus</i> (Linnaeus 1758) ¹	<i>Hypostomus ancistroides</i> (Ihering 1911)	J. Lima	1906	Tatuí
<i>Rhamdia quelen</i> (Quoy & Gaimard 1824) ¹	<i>Rhamdia quelen</i> (Quoy & Gaimard 1824)	J. Lima	1906	Tatuí

Table II. Continuation.

<i>Pimelodella rudolphi</i> Miranda Ribeiro 1918 ¹	<i>Pimelodella meeki</i> Eigenmaann 1910	J. Lima	1906	Tatuí
<i>Otocinclus depressicauda</i> Miranda Ribeiro 1918 ¹	<i>Hisonotus depressicauda</i> (Miranda Ribeiro 1918)	Zeidler	1906	Sorocaba
Callichthyidae				
<i>Corydoras</i> sp. ³	<i>Osteogaster aenea</i> (Gill 1858)	F. Marcondes	1984	Sorocaba*
GYMNOTIFORMES				
<i>Eigenmannia virescens</i> (Valenciennes 1836) ¹	<i>Eigenmannia virescens</i> (Valenciennes 1836)	Garbe	1896	Ipanema
CICHLIFORMES				
Cichlidae				
<i>Crenicichla jaguarensis</i> Haseman 1911 ¹	<i>Saxatilia britskii</i> (Kullander 1982)	Zeidler	1906	Ipanema
<i>Geophagus</i> sp. ³	<i>Geophagus iporangensis</i> Haseman 1911	F. Marcondes	1984	Sorocaba*
CYPRINODONTIFORMES				
Poeciliidae				
<i>Phalloceros caudimaculatus</i> (Hensel 1868) ¹	<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025	J. Lima J. Lima J. Lima Zeidler	1896 1905 1906 1906	Tatuí Tatuí Tatuí Sorocaba
<i>Phalloceros caudimaculatus</i> (Hensel 1868) ¹	<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025			
<i>Phalloceros caudimaculatus</i> (Hensel 1868) ¹	<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025			
<i>Phalloceros caudimaculatus</i> (Hensel 1868) ¹	<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025			

Studies carried out since 1993

Ichthyological research in the basin resumed in 1992 with the creation of the Biological Sciences program at the Pontifical Catholic University (PUC-SP). Research efforts expanded further with the establishment of similar programs at the Paulista University (UNIP Sorocaba) in 2005 and the Federal University of São Carlos (UFSCar) in 2008. The evolution of this research, illustrated in Figure 2, shows a sharp increase in scientific output starting around 1993, with productivity sustained over the following decades. Consequently, the number of inventoried species in the basin has steadily increased over the last 30 years. Figure 3 presents all the locations sampled to

date, revealing the most sampled regions and gaps where future sampling could be targeted. The surveys conducted have concentrated their sampling along the main channel of the Sorocaba River, its main tributaries, and the Itupararanga Reservoir, areas often corresponding to higher order and more urbanized reaches. In contrast, many areas remain unsampled or undersampled, particularly streams located in rural and less urbanized areas of the basin.

The primary research themes were community ecology (34.4%), followed by species inventory (14%), population ecology (12.5%), and feeding ecology (7.8%). The other themes together account for 31.3%, including biotic integrity, environmental impacts, invasive

species, reproduction, and more current topics such as microplastics, extreme events, and biomarkers. While the main collection methods have been gillnets and sieves, the use of electrofishing has increased. The most investigated habitats were rivers, reservoirs, and floodplain lakes. In recent years, the number of studies focusing on streams has grown, as these environments are important for documenting new species occurrences and applying novel methods in trophic and functional ecology.

Taxonomic Characterization of the Ichthyofauna of the Sorocaba River Basin

Our literature review identified a total of seven orders, 30 families, and 109 species cited for the basin, of which 93 are native and 16 are non-native (Table III). In total, 69.7% (76) of the species have specimens deposited in five different institutional collections. The orders

Characiformes (51 species) and Siluriformes (37 species) were the most speciose, along with the families Acestrorhamphidae (14 species) and Loricariidae (12 species). Most species were categorized as Least Concern (LC). However, several are listed under a threat category at either the national (Brazil) or state (São Paulo) level. *Characidium oiticica* Travassos 1967 (Crenuchidae) as vulnerable for Brazil, *Prochilodus vimboides* Kner 1859 (Prochilodontidae) as vulnerable for Brazil and São Paulo. According to Dagosta et al. (2024) *Prochilodus vimboides* is a very rare species in the upper Paraná river basin. Furthermore, *Bunocephalus larai* Ihering 1930 (Aspredinidae), *Piaractus mesopotamicus* (Holmberg 1887) (Serrasalminidae), *Pseudopimelodus mangurus* (Valenciennes 1835) (Pseudopimelodidae) and *Pimelodella meeki* Eigenmann 1910

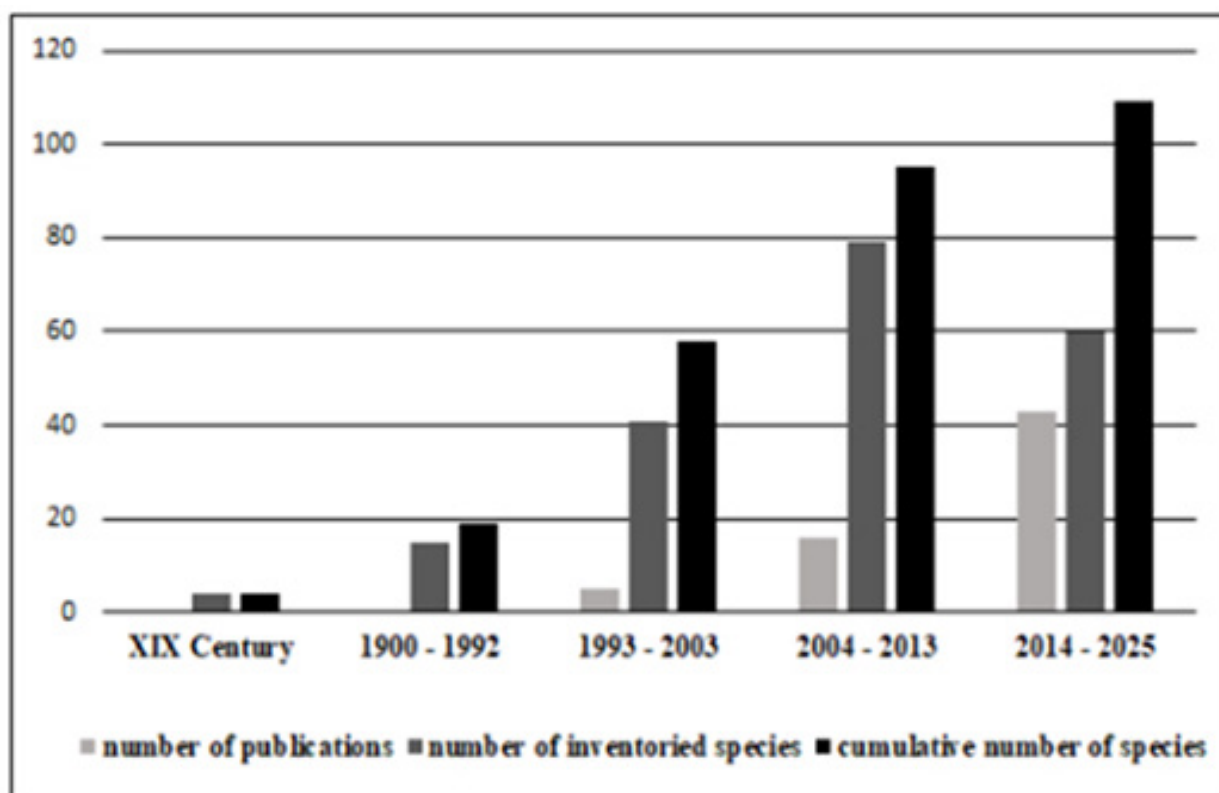


Figure 2. Evolution of the number of studies and species inventoried over time.

(Heptapteridae), respectively as Vulnerable, Endangered, Insufficient Data and Insufficient Data (Table III).

Finally, Table IV highlights the temporal increase in inventoried species. It shows that the highest abundance, richness, and diversity were recorded between 2004 and 2013, whereas ecological dominance was highest in the subsequent period (2014-2025). The most abundant species were *Poecilia reticulata* Peters 1859 (Poeciliidae) ($n = 1911$), *Psalidodon fasciatus* (Cuvier 1819) (Characidae) ($n = 1826$), *Geophagus iporangensis* Haseman 1911 (Cichlidae) ($n = 1565$), and *Phalloceros circummontanus* Souto-Santos, Mejia, Arcila & Buckup 2025 (Poeciliidae) ($n = 1114$). The highest species richness was found in the upper Sorocaba and Ipanema rivers, likely because these are the most intensively

sampled sites. In terms of total abundance, the upper Sorocaba ranked highest, followed by the associated floodplains and floodplain lakes, the main Sorocaba River channel, and the Ipanema River. The greatest diversity occurred in the Ipanema, upper Sorocaba, and Sarapuí rivers, while dominance was highest in the Pirapora River and the Ituparanga Reservoir (Table V).

DISCUSSION

Academic institutions have played a pivotal role in advancing the understanding of the ichthyofauna of the Sorocaba River basin. Since 1993, numerous studies have provided crucial data on species composition, their biological and ecological characteristics, and species-habitat relationships within critical environments such

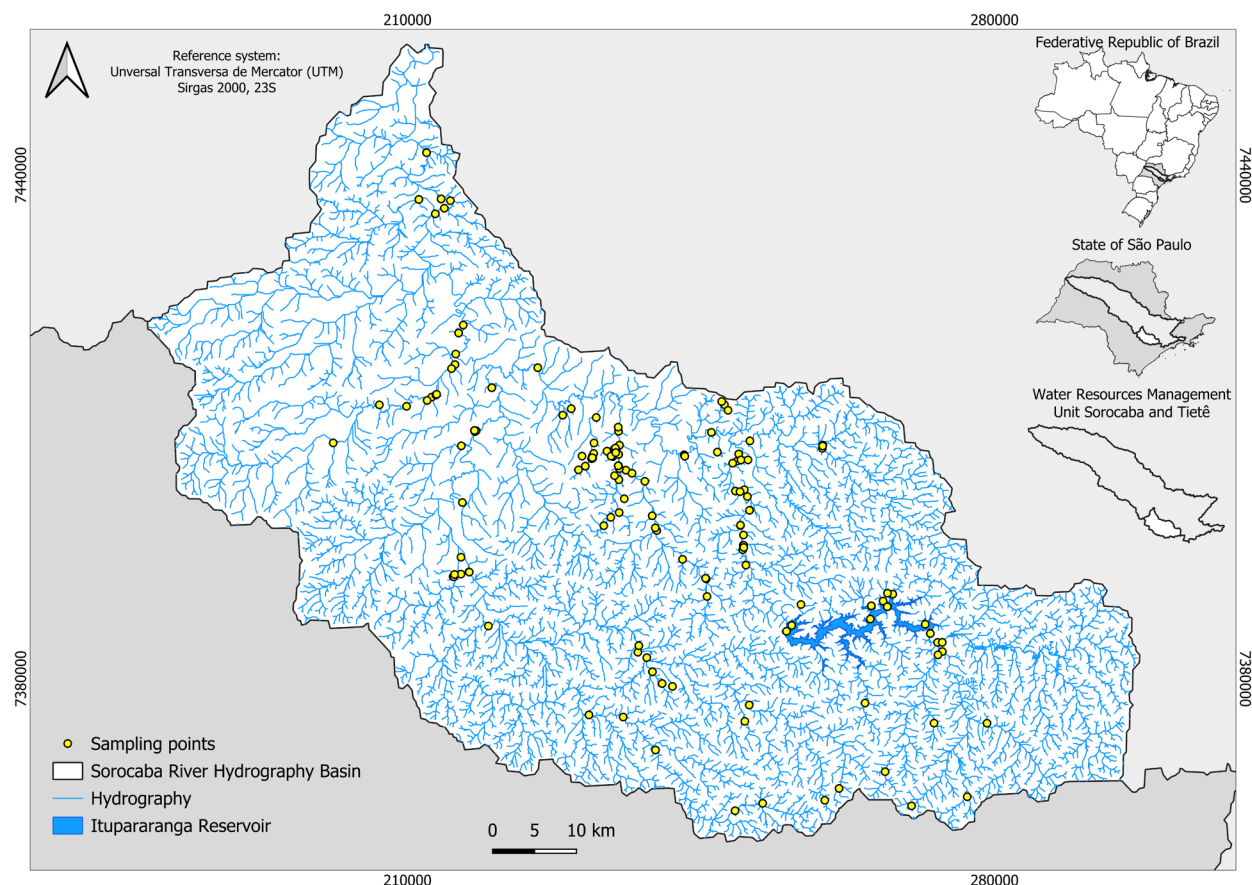


Figure 3. The geographic location of the main ichthyological studies carried out in the Sorocaba River basin.

as floodplain lakes, streams, rivers, and reservoirs. The growth in the species inventory over this period is also noteworthy, jumping from 65 species recorded in 2003 to 71 in 2007, and culminating in the 109 species documented in the present study. The basin's ichthyofauna represents 27.7% of the 393 species recorded for the state of São Paulo (Oyakawa & Menezes 2011) and 31.9% of the 341 species inventoried for the entire upper Paraná River basin (Dagosta et al. 2024). This species richness is substantial for a hydrographic basin of this size (5,269 km²).

Between 1993 and 2009, research in the basin primarily focused on ecology, with an emphasis on fish assemblage composition and structure (Smith 2003). A key study on biotic integrity was also conducted during this period (Marciano et al. 2004). Despite the predominance of these community level studies, research into species-specific biology began to emerge (Takahashi 2006, Villares et al. 2008). In the subsequent period, while studies on fish assemblages continued (e.g., Stefani & Smith 2014, Nascimento & Smith 2016, Smith et al. 2021), there was a marked increase in research focused on the biology of individual species (e.g., Ribeiro et al. 2014, Villares Junior et al. 2015, Costa & Smith, 2019, Lima & Smith 2024, Santos et al. 2024, Miranda et al. 2024, Lima et al. 2025). More recently, research has expanded into new areas, including a focus on stream ecology (e.g., Vaz et al. 2017, Cetra et al. 2017), emerging threats like microplastic pollution (Oliveira et al. 2020, De Paiva et al. 2024), biomarkers (Ludgero et al. 2025), extreme events (Rodrigues et al. 2024, Smith et al. 2024), assessment of the effects of land use and cover and dam failure in a stream on the fish community of a neotropical stream (Nicomedes et al. 2025), and continued assessments of biotic integrity (Viana & Cetra 2018, Silva & Cetra 2021).

Our results show a high concentration of research on fish communities, with a primary focus on the main channel of the Sorocaba River and its tributaries. Studies on community structure are typically common in regional ichthyology, as they are comprehensive and provide a foundational understanding of the local fish fauna and its organization. Fish assemblages in river systems reflect the prevailing biotic and abiotic conditions, including the availability of food resources, shelter, and breeding sites (Bennemann et al. 2000). Therefore, the study of community structure can offer valuable insights into the overall health of an ecosystem. Consequently, fish are widely used as bioindicators of environmental quality and serve as crucial tools for ecosystem assessment (Karr 1981, Araújo 1998, Viana & Cetra 2018).

Given this extensive body of work, the Sorocaba River basin is now one of the most well studied in the state of São Paulo. The knowledge generated, which confirms that the basin supports a rich ichthyofauna (e.g., Rodrigues et al. 2008), provides a solid foundation to support future conservation policies and management initiatives. Following community-level inventories, research typically progresses to studies on population dynamics and trophic ecology, which address the functional components of the ecosystem. Our literature review reveals that these functional research areas, along with others, remain underexplored in the Sorocaba River basin and represent important knowledge gaps. Despite the extensive research in the main river channels, many smaller sub-basins and headwater streams remain largely unknown. New surveys in these areas are needed, integrating taxonomic inventories with ecological and biological investigations. Understanding the trophic structure and functional traits of the ichthyofauna is crucial for comprehending how the aquatic ecosystem functions as a whole.

Table III. Inventory of fish species in the Sorocaba River basin, according to published studies. † non-natives species.

Order/Family/Species	Voucher
CHARACIFORMES	
Characidae	
<i>Aphyocharax dentatus</i> Eigenmann & Kennedy 1903	DZSJRP23177
<i>Cheirodon stenodon</i> Eigenmann 1915	DZSJRP20612, DZSJRP25250, ZUEC18333, ZUEC18341
<i>Galeocharax gulo</i> (Cope 1870)	
<i>Odontostilbe avanhandava</i> Chuctaya, Bührnheim & Malabarba 2018	
<i>Serrapinnus heterodon</i> (Eigenmann 1915)	DZSJRP21323, DZSJRP21325, DZSJRP21418, DZS-JRP23157, ZUEC18290
<i>Serrapinnus notomelas</i> (Eigenmann 1915)	MZUSP115241, DZSJRP23168
Acestrorhamphidae	
<i>Astyanax lacustris</i> (Lütken 1875)	ZUEC4600, DZSJRP21321, DZSJRP22632, DZSJRP23165, MZUSP84632, MZUSP84658
<i>Bario sanctaefilomenae</i> (Steindachner 1907)	
<i>Hemigrammus</i> aff. <i>marginatus</i> Ellis 1911	MZUSP84647
<i>Hyphessobrycon bifasciatus</i> Ellis 1911	MZUSP127791, MZUSP127796, DZSJRP23159
<i>Hyphessobrycon flammeus</i> Myers 1924†	
<i>Megalampodus eques</i> (Steindachner 1882)†	DZSJRP23174, DZSJRP21322,
<i>Oligosarcus paranensis</i> Menezes & Géry 1983	MZUSP84635, LIRP592, DZSJRP23163
<i>Oligosarcus pinto</i> Amaral Campos 1945	LIRP579
<i>Psalidodon anisitsi</i> (Eigenmann 1907)	DZSJRP20613
<i>Psalidodon biotae</i> (Castro & Vari 2004)	
<i>Psalidodon bockmanni</i> (Vari & Castro 2007)	DZSJRP13646, DZSJRP20610, DZSJRP23170, DZS-JRP25251, MZUSP84641, MZUSP84630
<i>Psalidodon fasciatus</i> (Cuvier 1819)	MZUSP84650, ZUEC-PIS4601, DZSJRP13673, DZS-JRP20611, DZSJRP21319, DZSJRP21324, DZSJRP22631, DZSJRP23164, DZSJRP23173
<i>Psalidodon paranae</i> (Eigenmann 1914)	DZSJRP23167, MZUSP127792
<i>Psalidodon schubarti</i> (Britski 1964)	ZUEC3564, DZSJRP20616
Stevardiidae	
<i>Bryconamericus iheringii</i> (Boulenger 1887)	MZUSP84633, MZUSP84659, DZSJRP15345, DZS-JRP20607, DZSJRP25248, ZUEC18292
<i>Bryconamericus microcephalus</i> (Miranda Ribeiro 1908)	DZSJRP13649
<i>Piabarchus stramineus</i> (Eigenmann 1908)	MZUSP84639, DZSJRP23154, DZSJRP23161
<i>Piabina argentea</i> Reinhardt 1867	MZUSP84636, MZUSP 84645, MZUSP127795 MBML7767, DZSJRP20602, DZSJRP21326, DZSJRP23156
<i>Planaltina britskii</i> Menezes, Weitzman & Burns 2003	DZSJRP20619
Triportheidae	
<i>Triportheus nematurus</i> (Kner, 1858)†	
Bryconidae	
<i>Salminus hilarii</i> Valenciennes 1850	MZUSP84760, DZSJRP20620, DZSJRP21339

Table lii. Continuation.

Acestrorhynchidae	
<i>Acestrorhynchus lacustris</i> (Lütken 1875)	MZUSP84660, MZUSP115236, DZSJRP21347
Crenuchidae	
<i>Characidium gomesi</i> Travassos 1956	DZSJRP13643, DZSJRP25253
<i>Characidium oiticicae</i> Travassos 1967	
<i>Characidium zebra</i> Eigenmann 1909	MZUSP84637, MZUSP84642, DZSJRP13645, DZS-JRP20614, DZSJRP21336
Erythrinidae	
<i>Hoplias malabaricus</i> (Bloch 1794	MZUSP 84629, MZUSP 84756, MZUSP 115230, LIRP9030, LIRP9031, DZSJRP21330
Prochilodontidae	
<i>Prochilodus lineatus</i> (Valenciennes 1837)	MZUSP84763, MZUSP115270, DZSJRP21318, DZS-JRP21331
<i>Prochilodus vimboides</i> Kner 1859	MZUSP127803
Curimatidae	
<i>Cyphocharax gillii</i> (Eigenmann & Kennedy 1903)†	
<i>Cyphocharax modestus</i> (Fernández-Yépez 1948)	MZUSP84649, MZUSP115235, DZSJRP15347, DZS-JRP21348, DZSJRP22633
<i>Cyphocharax naegeli</i> (Steindachner 1881)	
<i>Steindachnerina insculpta</i> (Fernández-Yépez 1948)	MZUSP84651, MZUSP115238, DZSJRP15343, DZS-JRP21350, DZSJRP23152
Anostomidae	
<i>Brevidens striatus</i> Kner 1858	MZUSP127797, DZSJRP23191
<i>Leporinus friderici</i> (Bloch 1794)	DZSJRP20621, DZSJRP2134, ZUEC18336
<i>Leporinus lacustris</i> Amaral Campos 1945	
<i>Leporinus octofasciatus</i> Steindachner 1915	DZSJRP20622
<i>Megaleporinus obtusidens</i> (Valenciennes 1837)	MZUSP84758
<i>Schizodon nasutus</i> Kner 1858	MZUSP84646, MZUSP84762, DZSJRP20623, DZS-JRP21340
Parodontidae	
<i>Apareiodon affinis</i> (Steindachner 1879)	
<i>Apareiodon ibitiensis</i> Amaral Campos 1944	DZSJRP13644
<i>Apareiodon piracicabae</i> (Eigenmann 1907)	MZUSP84656
<i>Parodon nasus</i> Kner 1859	DZSJRP13642, MZUSP84654
Serrasalminae	
<i>Metynnis lippincottianus</i> (Cope 1870)†	
<i>Serrasalmus maculatus</i> Kner 1858	MZUSP84757, DZSJRP21320, DZSJRP21422, ZUEC18332, ZUEC18334,
<i>Piaractus mesopotamicus</i> (Holmberg 1887)	
CYPRINIFORMES	
Cyprinidae	
<i>Cyprinus carpio</i> Linnaeus 1758†	
Xenocyprididae	
<i>Ctenopharyngodon idella</i> (Valenciennes 1844)†	

Table lii. Continuation.

SILURIFORMES	
Aspredinidae	
<i>Bunocephalus larai</i> Ihering 1930	
Auchenipteridae	
<i>Tatia neivai</i> (Ihering 1930)	
Callichthyidae	
<i>Callichthys callichthys</i> (Linnaeus 1758)	DZSJRP13675, DZSJRP23175
<i>Hoplisoma flaveolum</i> Ihering 1911	MZUSP115227
<i>Hoplosternum littorale</i> (Hancock 1828)	MZUSP84657, DZSJRP19760, DZSJRP20608, DZS-JRP20627, DZSJRP21334,
<i>Lepthoplosternum pectorale</i> (Boulenger 1895)†	
<i>Osteogaster aenea</i> (Gill 1858)	ZUEC18289, DZSJRP13703
Cetopsidae	
<i>Cetopsis gobioides</i> Kner 1858	
Clariidae	
<i>Clarias gariepinus</i> (Burchell 1822)†	
Heptapteridae	
<i>Cetopsorhamdia iheringi</i> Schubart & Gomes 1959	DZSJRP13648
<i>Heptapterus longicauda</i> (Borodin 1927)	
<i>Imparfinis mirini</i> Haseman 1911	ZUEC18285, MZUSP115244
<i>Imparfinis schubarti</i> (Gomes 1956)	MZUSP84655, ZUEC18294, DZSJRP15346
<i>Pimelodella avanhandavae</i> Eigenmann 1917	DZSJRP21346
<i>Pimelodella gracilis</i> (Valenciennes 1835)	DZSJRP15348
<i>Pimelodella meeki</i> Eigenmann 1910	DZSJRP20605, DZSJRP23172
<i>Rhamdia quelen</i> (Quoy & Gaimard 1824)	MZUSP84761, LIRP9028, LIRP9029, DZSJRP21343, DZS-JRP21349, DZSJRP23169
Pimelodidae	
<i>Iheringichthys syi</i> Azpelicueta & Britski 2012	DZSJRP21345
<i>Pimelodus maculatus</i> Lacepède 1803	DZSJRP21344
Pseudopimelodidae	
<i>Microglanis garavelloi</i> Shibatta & Benine 2005	
<i>Pseudopimelodus mangurus</i> (Valenciennes 1835)	
Loricariidae	
<i>Hisonotus depressicauda</i> (Miranda Ribeiro 1918)	MZUSP62765, DZSJRP20603
<i>Hypostomus ancistroides</i> (Ihering 1911)	MZUSP84640, MZUSP84652, MZUSP127802, DZS-JRP13701, DZSJRP21335, DZSJRP23171, DZSJRP25249, NUP4012
<i>Hypostomus hermanni</i> (Ihering 1905)	NUP4014, ZUEC18338
<i>Hypostomus iheringii</i> (Regan 1908)	NUP 4015
<i>Hypostomus margaritifer</i> (Regan 1908)	ZUEC18337, DZSJRP21351, DZSJRP25252
<i>Hypostomus regani</i> (Ihering 1905)	
<i>Hypostomus strigaticeps</i> (Regan 1908)	NUP4017

Table lii. Continuation.

<i>Hypostomus variipictus</i> (Ihering 1911)	DZSJRP13641
<i>Neoplecostomus paranensis</i> Langeani 1990	
<i>Pterygoplichthys ambrosettii</i> (Holmberg 1893)†	DZSJRP21327, DZSJRP21352, DZSJRP21419, DZS-JRP21421
<i>Rineloricaria latirostris</i> (Boulenger 1900)	DZSJRP20615, DZSJRP23153
<i>Rineloricaria pentamaculata</i> Langeani & de Araujo 1994	
Trichomycteridae	
<i>Cambeva iheringi</i> (Eigenmann 1917)	DZSJRP13647
<i>Paravandellia oxyptera</i> Miranda Ribeiro 1912	MZUSP83702.0, DZSJRP20618
<i>Pseudostegophilus paulensis</i> Miranda Ribeiro 1918	ZUEC17923
<i>Trichomycterus brasiliensis</i> Lütken 1874	ZUEC17852, MZUSP127794
GYMNOTIFORMES	
Gymnotidae	
<i>Gymnotus carapo</i> Linnaeus 1758	MZUSP84653, DZSJRP15342, DZSJRP23176
<i>Gymnotus sylvius</i> Albert & Fernandes-Matioli 1999	DZSJRP21333
Sternopygidae	
<i>Eigenmannia virescens</i> (Valenciennes 1836)	MZUSP84644
<i>Sternopygus macrurus</i> (Bloch & Schneider 1801)	
CICHLIFORMES	
Cichlidae	
<i>Australoheros oblongus</i> (Castelnau 1855)	MZUSP84634
<i>Cichlasoma paranaense</i> Kullander 1983	
<i>Coptodon rendalli</i> (Boulenger 1897)†	MZUSP84643, MZUSP115233
<i>Crenicichla lacustris</i> (Castelnau 1855)	DZSJRP21423
<i>Geophagus iporangensis</i> Haseman 1911	MZUSP84631, MZUSP84648, MZUSP127800, LIRP18162, LIRP 18197, DZS-JRP13674, DZSJRP21337, DZSJRP21424
<i>Heterotilapia buettikoferi</i> (Hubrecht 1881)†	
<i>Oreochromis niloticus</i> (Linnaeus 1758)†	LIRP18166, LIRP18188, LIRP18194
<i>Satanoperca setepele</i> Ota, Deprá, Kullander, Graça & Pavanelli 2022†	
<i>Saxatilia britskii</i> (Kullander 1982)	DZSJRP21332, DZSJRP23155, MZUSP127801
CYPRINODONTIFORMES	
Poeciliidae	
<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025	DZSJRP20609, DZSJRP25254, ZUEC17926, LIRP18208, MZUSP127789, MZUSP127798
<i>Phalloceros reisi</i> Lucinda 2008	ZUEC17924, ZUEC17925, ZUEC17927, ZUEC18340
<i>Poecilia reticulata</i> Peters 1859†	DZSJRP20617, DZSJRP21420, DZSJRP22630, DZS-JRP22634, DZSJRP23166, LIRP18204, MZUSP127790
<i>Poecilia vivipara</i> Bloch & Schneider 1801†	ZUEC18291, DZSJRP20601
<i>Xiphophorus maculatus</i> (Günther, 1866)†	DZSJRP25256
SYNBRANCHIFORMES	
Synbranchidae	
<i>Synbranchus marmoratus</i> Bloch 1795	DZSJRP23158, ZUEC18339, MZUSP127793

For instance, studies on invasive species are particularly important, as they offer critical insights into ecosystem integrity by examining the competitive interactions for food and habitat between non-native and native species (Agostinho et al. 2006). Similarly, studies on reproductive biology are essential, as they provide crucial data on species recruitment and identify critical habitat requirements for spawning and larval development (Nascimento & Nakatani 2006). Given these gaps, we recommend that future research in the basin prioritize these underexplored functional topics and geographic areas.

The 16 non-native species identified in this study reveal a complex scenario, with many species yet to be inventoried. This could significantly increase the total number of

species that have spread throughout the basin. This issue is complex, especially when it comes to species whose evidence of introduction is controversial or incipient. Furthermore, attention should be given to the species *Cyphocharax gillii* (Eigenmann & Kennedy 1903), not considered non-native in the inventoried articles for the Sorocaba River basin, but reported by Langeani et al. (2007) as non-native to the Upper Paraná basin and maintained by Dagosta et al. (2024), and *Leptoplosternum pectorale* (Boulenger 1895), considered autochthonous by Langeani et al. (2007) for the Upper Paraná but considered non-native by Otta et al. (2018), these being likely to be considered non-native species for the Sorocaba River basin. Future studies are needed to expand knowledge about these species.

Table IV. Occurrence and/or abundance of fish species in the Sorocaba River basin according to chronological period, species status (N - native or NN - Non-Native species) and threat status according to MMA Ordinance No. 148, of June 7, 2022 (Brazil) and Decree 63.853/2018 of the State of São Paulo (SP). Threat status: Endangered (EN), Vulnerable (VU), Least Concern (LC), Data Deficient (DD) and Near Threat-ened (NT).

Order/Family/Species	1993-2003	2004-2013	2014-2025	Total	Status (na-tive or intro-duced)	Status (threat) Brazil/ SP
CHARACIFORMES						
Characidae						
<i>Aphyocharax dentatus</i> Eigenmann & Kennedy 1903	-	-	2	2	N	LC/LC
<i>Cheirodon stenodon</i> Eigenmann 1915	-	226	-	226	N	LC/LC
<i>Galeocharax gulo</i> (Cope 1870)	1	*	1	2	N	LC/LC
<i>Odontostilbe avanhandava</i> Chuctaya, Bührnheim & Malabarba 2018	-	6	-	6	N	LC/LC
<i>Serrapinnus heterodon</i> (Eigenmann 1915)	-	2	127	129	N	LC/LC
<i>Serrapinnus notomelas</i> (Eigenmann 1915)	97	94	20	211	N	LC/LC
Acestrorhamphidae						
<i>Astyanax lacustris</i> (Lütken 1875)	374	189	454	1017	N	LC/LC
<i>Bario sanctaefilomenae</i> (Steindachner 1907)	-	-	24	24	N	LC/LC
<i>Hemigrammus</i> aff. <i>marginatus</i> Ellis 1911	48	147	-	195	N	LC/LC
<i>Hyphessobrycon bifasciatus</i> Ellis 1911	-	4	1	5	N	LC/LC
<i>Hyphessobrycon flammeus</i> Myers 1924	-	-	5	5	NN	EN/LC
<i>Megalampodus eques</i> (Steindachner 1882)	-	1	16	17	NN	LC/LC
<i>Oligosarcus paranensis</i> Menezes & Géry 1983	13	116	3	132	N	LC/LC

Table IV. Continuation.

<i>Oligosarcus pinto</i> Amaral Campos 1945	-	*	1	1	N	LC/LC
<i>Psalidodon anisitsi</i> (Eigenmann 1907)	-	3	-	3	N	LC/LC
<i>Psalidodon biotae</i> (Castro & Vari 2004)	-	-	1	1	N	LC/LC
<i>Psalidodon bockmanni</i> (Vari & Castro 2007)	19	150	54	223	N	LC/LC
<i>Psalidodon fasciatus</i> (Cuvier 1819)	779	874	328	1981	N	LC/LC
<i>Psalidodon paranae</i> (Eigenmann 1914)	46	283	2	331	N	LC/LC
<i>Psalidodon schubarti</i> (Britski 1964)	-	-	3	3	N	LC/LC
Stevardiidae						
<i>Bryconamericus iheringii</i> (Boulenger 1887)	-	320	44	364	N	LC/LC
<i>Bryconamericus microcephalus</i> (Miranda Ribeiro 1908)	-	2	-	2	N	LC/LC
<i>Piabarchus stramineus</i> (Eigenmann 1908)	-	9	24	33	N	LC/LC
<i>Piabina argentea</i> Reinhardt 1867	-	511	2	513	N	LC/LC
<i>Planaltina britskii</i> Menezes, Weitzman & Burns 2003	-	67	-	67	N	LC/LC
Triporthidae						
<i>Triporthus signatus</i> (Garman 1890)	-	1	-	1	NN	-
Bryconidae						
<i>Salminus hilarii</i> Valenciennes 1850	18	275	37	330	N	LC/LC
Acestrorhynchidae						
<i>Acestrorhynchus lacustris</i> (Lütken 1875)	200	57	15	267	N	LC/LC
Crenuchidae						
<i>Characidium gomesi</i> Travassos 1956	-	60	-	60	N	LC/LC
<i>Characidium oiticica</i> Travassos 1967	-	8	-	8	N	VU/NT
<i>Characidium zebra</i> Eigenmann 1909	61	81	-	142	N	LC/LC
Erythrinidae						
<i>Hoplias malabaricus</i> (Bloch 1794)	464	37	86	587	N	LC/LC
Prochilodontidae						
<i>Prochilodus lineatus</i> (Valenciennes 1837)	47	10	163	173	N	LC/LC
<i>Prochilodus vimbooides</i> Kner 1859	-	-	1	1	N	VU/VU
Curimatidae						
<i>Cyphocharax gillii</i> (Eigenmann & Kennedy 1903)	-	-	*	*	NN	LC/LC
<i>Cyphocharax modestus</i> (Fernández-Yépez 1948)	429	231	58	718	N	LC/LC
<i>Cyphocharax naegeli</i> (Steindachner 1881)	10	-	-	10	N	LC/LC
<i>Steindachnerina insculpta</i> (Fernández-Yépez 1948)	96	182	55	333	N	LC/LC
Anostomidae						
<i>Brevidens striatus</i> Kner 1858	-	36	-	36	N	LC/LC
<i>Leporinus friderici</i> (Bloch 1794)	-	3	-	3	N	LC/LC
<i>Leporinus lacustris</i> Amaral Campos 1945	-	*	-	*	N	LC/LC
<i>Leporinus octofasciatus</i> Steindachner 1915	-	6	-	6	N	LC/LC
<i>Megaleporinus obtusidens</i> (Valenciennes 1837)	6	1	6	13	N	LC/LC
<i>Schizodon nasutus</i> Kner 1858	8	107	2	117	N	LC/LC

Table IV. Continuation.

Parodontidae						
<i>Apareiodon affinis</i> (Steindachner 1879)	-	*	-	*	N	LC/LC
<i>Apareiodon ibitiensis</i> Amaral Campos 1944	-	2	-	2	N	LC/LC
<i>Apareiodon piracicabae</i> (Eigenmann 1907)	59	3	22	84	N	LC/LC
<i>Parodon nasus</i> Kner 1859	22	48	80	150	N	LC/LC
Serrasalminae						
<i>Metynnis lippincottianus</i> (Cope 1870)	-	*	-	*	NN	LC/LC
<i>Serrasalmus maculatus</i> Kner 1858	6	110	7	123	N	LC/LC
<i>Piaractus mesopotamicus</i> (Holmberg 1887)	-	*	-	*	N	LC / EN
CYPRINIFORMES						
Cyprinidae						
<i>Cyprinus carpio</i> Linnaeus 1758	1	*	-	1	N	LC/LC
Xenocypridae						
<i>Ctenopharyngodon idella</i> (Valenciennes 1844)	-	*	-	*	NN	-
SILURIFORMES						
Aspredinidae						
<i>Bunocephalus larai</i> Ihering 1930	-	2	-	2	N	LC/VU
Auchenipteridae						
<i>Tatia neivai</i> (Ihering 1930)	-	1	-	1	N	LC/LC
Callichthyidae						
<i>Callichthys callichthys</i> (Linnaeus 1758)	5	3	9	17	N	LC/LC
<i>Hoplisoma flaveolum</i> Ihering 1911	-	78	39	117	N	LC/LC
<i>Hoplosternum littorale</i> (Hancock 1828)	643	7	91	741	N	-
<i>Leptoplosternum pectorale</i> (Boulenger 1895)	-	-	*	*	NN	LC/LC
<i>Osteogaster aenea</i> (Gill 1858)	-	67	4	71	N	LC/LC
Cetopsidae						
<i>Cetopsis gobioides</i> Kner 1858	-	*	-	*	N	LC/LC
Clariidae						
<i>Clarias gariepinus</i> (Burchell 1822)	-	*	-	*	NN	-
Heptapteridae						
<i>Cetopsorhamdia iheringi</i> Schubart & Gomes 1959	-	44	-	44	N	LC/LC
<i>Heptapterus longicauda</i> (Borodin 1927)	-	-	*	*	N	LC/LC
<i>Imparfinis mirini</i> Haseman 1911	-	5	-	5	N	LC/LC
<i>Imparfinis schubarti</i> (Gomes 1956)	-	145	-	145	N	LC/LC
<i>Pimelodella avanhandavae</i> Eigenmann 1917	8	-	16	24	N	LC/LC
<i>Pimelodella gracilis</i> (Valenciennes 1835)	-	42	1	43	N	LC/LC
<i>Pimelodella meeki</i> Eigenmann 1910	-	11	64	75	N	LC/DD
<i>Rhamdia quelen</i> (Quoy & Gaimard 1824)	40	37	24	101	N	LC/LC
Pimelodidae						
<i>Iheringichthys syi</i> Azpelicueta & Britski 2012	27	110	22	159	N	LC/LC

Table IV. Continuation.

<i>Pimelodus maculatus</i> Lacepède 1803	2	3	-	5	N	LC/LC
Pseudopimelodidae						
<i>Microglanis garavello</i> Shibatta & Benine 2005	-	4	-	4	N	LC/LC
<i>Pseudopimelodus mangurus</i> (Valenciennes 1835)	-	1	-	1	N	LC/NT
Loricariidae						
<i>Hisonotus depressicauda</i> (Miranda Ribeiro 1918)	-	48	-	48	N	LC/LC
<i>Hypostomus ancistroides</i> (Ihering 1911)	398	256	145	799	N	LC/LC
<i>Hypostomus hermanni</i> (Ihering 1905)	-	45	-	45	N	LC/LC
<i>Hypostomus iheringii</i> (Regan 1908)	-	3	-	3	N	LC/LC
<i>Hypostomus margaritifer</i> (Regan 1908)	82	-	72	154	N	LC/LC
<i>Hypostomus regani</i> (Ihering 1905)	-	22	-	22	N	LC/LC
<i>Hypostomus strigaticeps</i> (Regan 1908)	-	183	-	183	N	LC/LC
<i>Hypostomus variipictus</i> (Ihering 1911)	-	10	-	10	N	LC/LC
<i>Neoplecostomus paranensis</i> Langeani 1990	14	40	-	54	N	LC/LC
<i>Pterygoplichthys ambrosettii</i> (Holmberg 1893)	-	4	59	63	NN	-
<i>Rineloricaria latirostris</i> (Boulenger 1900)	20	38	2	60	N	LC/LC
<i>Rineloricaria pentamaculata</i> Langeani & de Araujo 1994	6	-	2	8	N	LC/LC
Trichomycteridae						
<i>Cambeva iheringi</i> (Eigenmann 1917)	-	23	-	23	N	LC/LC
<i>Paravandellia oxyptera</i> Miranda Ribeiro 1912	-	12	-	12	N	LC/LC
<i>Pseudostegophilus paulensis</i> Miranda Ribeiro 1918	-	-	6	6	N	LC/LC
<i>Trichomycterus brasiliensis</i> Lütken 1874	-	-	***	-	N	LC/LC
GYMNOTIFORMES						
Gymnotidae						
<i>Gymnotus carapo</i> Linnaeus 1758	27	15	2	44	N	LC/LC
<i>Gymnotus sylvius</i> Albert & Fernandes-Matioli 1999	-	10	2	12	N	LC/LC
Sternopygidae						
<i>Eigenmannia virescens</i> (Valenciennes 1836)	6	12	-	18	N	LC/LC
<i>Sternopygus macrurus</i> (Bloch & Schneider 1801)	2	5	-	7	N	LC/LC
CICHLIFORMES						
Cichlidae						
<i>Australoheros oblongus</i> (Castelnau 1855)	-	2	1	3	N	LC/LC
<i>Cichlasoma paranaense</i> Kullander 1983	-	-	*	*	N	LC/LC
<i>Coptodon rendalli</i> (Boulenger 1897)	286	18	4	308	NN	-
<i>Crenicichla lacustris</i> (Castelnau 1855)	-	-	47	47	N	LC/LC
<i>Geophagus iporangensis</i> Haseman 1911	958	512	100	1570	N	LC/LC
<i>Heterotilapia buettikoferi</i> (Hubrecht 1881)	-	-	***	-	NN	-
<i>Oreochromis niloticus</i> (Linnaeus 1758)	12	4	9	25	NN	-
<i>Satanoperca setepele</i> Ota, Deprá, Kullander, Graça & Pavanelli 2022	-	3	-	3	NN	-

Table IV. Continuation.

<i>Saxatilia britskii</i> (Kullander 1982)	-	*	9	9	N	LC/LC
CYPRINODONTIFORMES						
Poeciliidae						
<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025	122	767	753	1642	N	LC/LC
<i>Phalloceros reisi</i> Lucinda 2008	-	697	364	1061	N	LC/LC
<i>Poecilia reticulata</i> Peters 1859	-	1	1910	1911	NN	-
<i>Poecilia vivipara</i> Bloch & Schneider 1801	106	342	819	1267	NN	-
<i>Xiphophorus maculatus</i> (Günther, 1866)	-	-	2	2	NN	-
SYNBRANCHIFORMES						
Synbranchidae						
<i>Synbranchus marmoratus</i> Bloch 1795	-	8	5	13	N	LC/LC
Individuals collected	5568	7902	6227	19645		
Species richness	41	78(90)***	60(66)***	95(107)***		
Accumulated species richness	41	94	108	107		
Diversity (Shannon-Wiener)	2.74	3.37	2.58	3.38		
Dominance	0.09	0.05	0.14	0.05		

*species documented, but number of individuals captured not available; **species collected by ongoing research; ***species richness considering the species, without the number of individuals captured.

It's crucial to distinguish between introduced species with established populations and those that originate from occasional escapes from fish farms or deliberate releases that fail to establish breeding populations. Records of certain non-native species cited in the literature, such as *Colossoma macropomum* (Cuvier 1816) (Serrasalminae), *Megaleporinus macrocephalus* (Garavello & Britski 1988) (Anostomidae), and *Brycon amazonicus* (Agassiz 1829) (Bryconidae), likely fall into this latter category and were not included in the inventory for this article. It should be noted that the species *Piaractus mesopotamicus* (Holmberg 1887), although native to the Upper Paraná and recorded for the basin, has no collections attributed to experimental collections over the years. This may be associated with fish stocking or escapes, a fact that could also be attributed to other native species of the Upper Paraná that are not recorded in the studies carried out, but are reported by fishermen. Species cited in the

literature but without proven establishment, like *Triportheus signatus* (Garman 1890) (Triportheidae), *Metynnis lippincottianus* (Cope 1870) Serrasalminae, *Clarias gariepinus* (Burchell 1822) (Clariidae), and *Satanoperca setepele* Ota, Deprá, Kullander, da Graça & Pavanelli 2022 (Cichlidae) should be treated with caution. These specimens have not been deposited in collections, and their captures are likely occasional, indicating they may not be established.

Other species, such as tilapia (*Coptodon rendalli* and *Oreochromis niloticus*), the common guppy (*Poecilia reticulata* and *Poecilia vivipara*), the common armored catfish (*Pterygoplichthys ambrosettii*), and carp (*Cyprinus carpio* and *Ctenopharyngodon idella*), are all established in the basin. The species *Xiphophorus maculatus* (Günther 1866) (Poeciliidae) has been documented in the Sorocaba River (Stefani et al. 2023) and more recently in urban streams within the municipality of Sorocaba. The observation

of individuals at different life stages, including fry, suggests this species is in the process of becoming established (unpublished data). The species *Heterotilapia buettikoferi* (Hubrecht 1881) (Cichlidae) was recently captured in the Ipanema River basin (unpublished data), though information about its origin is limited. Furthermore, we report the presence of *Hyphessobrycon flammeus* Myers, 1924 (Acestrorhamphidae), an introduced species in the upper Paraná River basin (Dagosta et al. 2024), likely through the aquarium trade. We also report *Megalampodus eques* (Steindachner 1882) (Acestrorhamphidae), which, according to Ota et al. (2015), should be provisionally considered in-vasive, pending further studies to clarify its status.

Another factor affecting the accuracy of literature based species lists is the presence of unresolved taxonomic issues. The lack of modern taxonomic reviews for certain groups may lead to an underestimation of true species richness by masking cryptic diversity. For example, the genus *Pimelodella* (Heptapteridae) is known to require a comprehensive taxonomic revision, making species-level identification challenging (F.C.T. Lima, pers. comm. 2023). Some species of tetras (Acestrorhamphidae) from the upper Paraná River basin, especially smaller ones with a color pattern of few spots/markings, are difficult to identify specifically due to their subtle diagnostic characteristics. *Hemigrammus marginatus* Ellis 1911 (Acestrorhamphidae) is an example. The species was described for the São Francisco River basin but was also identified throughout the entire upper Paraná River basin. However, recent studies (e.g., Ota et al. 2015 and Dagosta et al. 2024) have shown that some morphotypes similar to *Hemigrammus marginatus*, e.g., *Moenkhausia cf. gracilima* Eigenmann 1908 (Acestrorhamphidae) and *M. bonita* Benine, Castro & Sabino 2004 (Acestrorhamphidae)

- two non-native species, were being mistakenly identified as *Hemigrammus marginatus*, especially in areas close to the Paraná River channel. In fact, Mota et al. (2018) recognized *Hemigrammus marginatus* lineages only for the São Francisco River basin; the similar morphotype in the upper Paraná River basin is a probable new species. Therefore, the more appropriate identification for this native species in the upper Paraná River basin is *Hemigrammus* aff. *marginatus* Ellis 1911 (Acestrorhamphidae).

Synthesizing decades of research data, as done in this study, is crucial for revealing knowledge gaps. Therefore, the present work contributes significantly to the understanding of the ichthyofauna of the Sorocaba River basin an important tributary of the Tietê and upper Paraná systems by identifying under-researched themes to guide future scientific efforts. Notably, official biodiversity maps for São Paulo do not classify the Sorocaba River basin as a high priority for conservation and restoration initiatives (Rodrigues et al. 2008). This low-priority designation is questionable, given that the basin is densely populated and its aquatic habitats are significantly degraded. Furthermore, the basin contains numerous under-explored habitats, such as floodplains and headwater streams, which likely harbor undocumented biodiversity.

The aquatic ecosystems of the Sorocaba River basin including its rivers, floodplains, and streams, are environmentally fragile due to intense urbanization and real estate speculation. Consequently, current land use patterns pose a significant threat to the conservation of these environments. This fragility is exacerbated by the weakening of regulations requiring the maintenance of native riparian buffers around water bodies, as well as by the increasing anthropization of formerly protected areas (Silva et al. 2020, 2021). Specifically, recent changes in

Table V. Occurrence and abundance of fish species in the Sorocaba River, main tributaries, marginal lagoons and Itupararanga reservoir. *Species documented but number of individuals captured not available. **Species richness considering the species without the number of individuals captured.

Order/Family/Species	Sorocaba river	Marginal flood-plains/ponds of the Sorocaba River	Tatui River	Sarapuí river	Ipanema river	Pirajibu river	Pirapora river	Itupararanga reservoir	Upper Sorocaba river
CHARACIFORMES									
Characidae									
<i>Aphyocharax dentatus</i> Eigenmann & Kennedy 1903	-	-	2	-	-	-	-	-	-
<i>Cheirodon stenodon</i> Eigenmann 1915	-	-	-	-	226	-	-	-	-
<i>Galeocharax gulo</i> (Cope 1870)	-	-	-	1	1	-	-	*	-
<i>Odontostilbe avanhandava</i> Chuctaya, Bührnheim & Malabarba 2018	-	-	*	-	*	-	-	-	6
<i>Serrapinnus heterodon</i> (Eigenmann 1915)	-	127	-	-	2	-	-	-	-
<i>Serrapinnus notomelas</i> (Eigenmann 1915)	7	110	*	-	68	25	-	1	-
Acestrorhamphidae									
<i>Astyanax lacustris</i> (Lütken 1875)	118	458	5	59	43	159	5	4	171
<i>Bario sanctaefilomenae</i> (Steindachner 1907)	-	-	-	24	-	-	-	-	-
<i>Hemigrammus</i> aff. <i>marginatus</i> Ellis 1911	-	14	-	2	-	-	-	1	-
<i>Hyphessobrycon bifasciatus</i> Ellis 1911	-	1	-	-	*	-	-	-	4
<i>Hyphessobrycon flammeus</i> Myers 1924†	-	-	-	-	-	-	5	-	5
<i>Megalampodus eques</i> (Steindachner 1882)†	-	14	-	2	-	-	-	1	-
<i>Oligosarcus paranensis</i> Menezes & Géry 1983	-	-	*	-	-	-	-	115	17
<i>Oligosarcus pinto</i> Amaral Campos 1945	-	-	1	-	*	-	-	-	-
<i>Psalidodon anisitsi</i> (Eigenmann 1907)	-	-	-	-	3	-	-	-	-
<i>Psalidodon biotae</i> (Castro & Vari 2004)	-	-	-	-	-	-	-	-	1
<i>Psalidodon bockmanni</i> (Vari & Castro 2007)	-	-	-	1	3	-	-	1	126
<i>Psalidodon fasciatus</i> (Cuvier 1819)	297	72	6	9	316	156	1	631	589
<i>Psalidodon paranae</i> (Eigenmann 1914)	1	46	-	1	144	34	-	-	105
<i>Psalidodon schubarti</i> (Britski 1964)	-	-	-	3	*	-	-	-	-
Stevardiidae									
<i>Bryconamericus iheringii</i> (Boulenger 1887)	-	-	-	-	218	39	-	-	107
<i>Bryconamericus microcephalus</i> (Miranda Ribeiro 1908)	-	-	-	-	-	-	-	-	2
<i>Piabarchus stramineus</i> (Eigenmann 1908)	-	1	*	23	*	-	-	9	-
<i>Piabina argentea</i> Reinhardt 1867	-	1	-	1	486	-	-	21	4
<i>Planaltina britskii</i> Menezes, Weitzman & Burns 2003	-	-	-	-	67	-	-	-	-
Triportheidae									
<i>Triportheus signatus</i> (Garman 1890)†	1	-	-	-	*	-	-	-	-
Bryconidae									
<i>Salminus hilarii</i> Valenciennes 1850	300	-	1	1	17	-	-	-	11

Table V. Continuation.

Acestrorhynchidae									
<i>Acestrorhynchus lacustris</i> (Lütken 1875)	-	39	*	14	92	-	-	11	111
Crenuchidae									
<i>Characidium gomesi</i> Travassos 1956	-	-	-	-	-	-	-	-	60
<i>Characidium oiticica</i> Travassos 1967	-	-	-	-	-	-	-	-	8
<i>Characidium zebra</i> Eigenmann 1909	-	61	-	-	10	-	-	-	71
Erythrinidae									
<i>Hoplias malabaricus</i> (Bloch 1794	385	24	10	11	17	1	4	31	104
Prochilodontidae									
<i>Prochilodus lineatus</i> (Valenciennes 1837)	132	12	22	7	11	-	-	*	36
<i>Prochilodus vimboides</i> Kner 1859	-	-	-	-	1	-	-	-	-
Curimatidae									
<i>Cyphocharax gillii</i> (Eigenmann & Kennedy 1903)†	-	-	-	-	*	-	-	-	-
<i>Cyphocharax modestus</i> (Fernández-Yépez 1948)	4	301	*	-	106	13	-	169	125
<i>Cyphocharax naegellii</i> (Steindachner 1881)	-	-	-	-	-	-	-	-	10
<i>Steindachnerina insculpta</i> (Fernández-Yépez 1948)	5	4	21	25	172	45	-	*	61
Anostomidae									
<i>Brevidens striatus</i> Kner 1858	-	-	*	-	36	-	-	-	-
<i>Leporinus friderici</i> (Bloch 1794)	-	-	*	-	3	-	-	-	-
<i>Leporinus lacustris</i> Amaral Campos 1945	-	-	*	-	-	-	-	-	-
<i>Leporinus octofasciatus</i> Steindachner 1915	-	-	*	-	6	-	-	-	-
<i>Megaleporinus obtusidens</i> (Valenciennes 1837)	5	-	1	-	*	-	-	-	6
<i>Schizodon nasutus</i> Kner 1858	103	-	2	-	4	-	-	-	8
Parodontidae									
<i>Apareiodon affinis</i> (Steindachner 1879)	-	-	-	-	*	-	-	-	-
<i>Apareiodon ibitiensis</i> Amaral Campos 1944	-	-	-	-	-	-	-	-	2
<i>Apareiodon piracicabae</i> (Eigenmann 1907)	-	-	-	22	3	-	9	-	50
<i>Parodon nasus</i> Kner 1859	78	-	2	-	32	-	2	-	36
Serrasalminae									
<i>Metynnis lippincottianus</i> (Cope 1870)†	-	-	*	-	-	-	-	-	-
<i>Serrasalmus maculatus</i> Kner 1858	109	5	*	1	1	-	-	-	6
<i>Piaractus mesopotamicus</i> (Holmberg 1887)	-	-	*	-	-	-	-	-	*
CYPRINIFORMES									
Cyprinidae									
<i>Cyprinus carpio</i> Linnaeus 1758†	-	-	*	-	*	-	-	*	1
Xenocyprididae									
<i>Ctenopharyngodon idella</i> (Valenciennes 1844)†	-	-	*	-	-	-	-	-	-

Table V. Continuation.

SILURIFORMES									
Aspredinidae									
<i>Bunocephalus larai</i> Ihering 1930	-	-	-	-	2	-	-	-	-
Auchenipteridae									
<i>Tatia neivai</i> (Ihering 1930)	-	-	-	-	1	-	-	-	-
Callichthyidae									
<i>Callichthys callichthys</i> (Linnaeus 1758)	-	-	*	7	-	-	-	-	10
<i>Hoplisoma flaveolum</i> Ihering 1911	-	-	-	-	117	-	-	-	-
<i>Hoplosternum littorale</i> (Hancock 1828)	37	547	12	5	1	5	-	1	133
<i>Leptoplosternum pectorale</i> (Boulenger 1895)†	-	-	-	*	-	-	-	-	-
<i>Osteogaster aenea</i> (Gill 1858)	-	-	*	-	40	10	-	-	21
Cetopsidae									
<i>Cetopsis gobioides</i> Kner 1858	-	-	*	-	*	-	-	-	-
Clariidae									
<i>Clarias gariepinus</i> (Burchell 1822)†	-	-	-	-	*	-	-	-	-
Heptapteridae									
<i>Cetopsorhamdia iheringi</i> Schubart & Gomes 1959	-	-	-	-	-	-	-	-	44
<i>Heptapterus longicauda</i> (Borodin 1927)	-	-	-	-	-	-	-	-	*
<i>Imparfinis mirini</i> Haseman 1911	-	-	-	-	2	-	-	-	3
<i>Imparfinis schubarti</i> (Gomes 1956)	-	-	-	-	12	-	-	-	133
<i>Pimelodella avanhandavae</i> Eigenmann 1917	-	-	-	-	-	-	-	-	13
<i>Pimelodella gracilis</i> (Valenciennes 1835)	-	-	1	-	-	-	-	10	42
<i>Pimelodella meeki</i> Eigenmann 1910	3	-	-	-	10	1	-	-	61
<i>Rhamdia quelen</i> (Quoy & Gaimard 1824)	9	1	6	-	10	-	1	3	71
Pimelodidae									
<i>Iheringichthys syi</i> Azpelicueta & Britski 2012	-	-	1	21	3	-	-	110	24
<i>Pimelodus maculatus</i> Lacepède 1803	-	-	*	-	*	-	-	3	2
Pseudopimelodidae									
<i>Microglanis garavelloi</i> Shibatta & Benine 2005	-	-	-	-	4	-	-	-	-
<i>Pseudopimelodus mangurus</i> (Valenciennes 1835)	-	-	*	-	2	-	-	-	-
Loricariidae									
<i>Hisonotus depressicauda</i> (Miranda Ribeiro 1918)	-	-	-	-	48	-	-	-	-
<i>Hypostomus ancistroides</i> (Ihering 1911)	48	2	17	13	301	-	28	53	337
<i>Hypostomus hermanni</i> (Ihering 1905)	-	-	-	-	45	-	-	-	-
<i>Hypostomus iheringii</i> (Regan 1908)	-	-	-	-	-	3	-	-	-
<i>Hypostomus margaritifer</i> (Regan 1908)	14	-	47	11	18	-	1	-	63
<i>Hypostomus regani</i> (Ihering 1905)	-	-	*	-	22	-	-	-	-
<i>Hypostomus strigaticeps</i> (Regan 1908)	-	-	-	-	183	-	-	-	-

Table V. Continuation.

<i>Hypostomus variipictus</i> (Ihering 1911)	-	-	-	*	-	-	-	-	10
<i>Neoplecostomus paranensis</i> Langeani 1990	-	-	-	-	-	14	-	-	40
<i>Pterygoplichthys ambrosettii</i> (Holmberg 1893)	35	24	*	-	*	4	-	-	-
<i>Rineloricaria latirostris</i> (Boulenger 1900)	-	-	1	1	47	-	-	-	11
<i>Rineloricaria pentamaculata</i> Langeani & de Araujo 1994	-	-	2	-	3	-	-	-	3
Trichomycteridae									
<i>Cambeva iheringi</i> (Eigenmann 1917)	-	-	-	-	*	-	-	-	23
<i>Paravandellia oxyptera</i> Miranda Ribeiro 1912	-	-	-	-	12	-	-	-	-
<i>Pseudostegophilus paulensis</i> Miranda Ribeiro 1918	-	-	-	6	-	-	-	-	-
<i>Trichomycterus brasiliensis</i> Lütken 1874									
GYMNOTIFORMES									
Gymnotidae									
<i>Gymnotus carapo</i> Linnaeus 1758	-	8	*	-	13	-	-	4	19
<i>Gymnotus sylvius</i> Albert & Fernandes-Matioli 1999	-	-	-	-	-	-	-	-	12
Sternopygidae									
<i>Eigenmannia virescens</i> (Valenciennes 1836)	-	-	-	-	5	6	-	*	-
<i>Sternopygus macrurus</i> (Bloch & Schneider 1801)	-	-	-	-	-	-	-	5	2
CICHLIFORMES									
Cichlidae									
<i>Australoheros oblongus</i> (Castelnau 1855)	-	-	*	-	1	-	-	-	2
<i>Cichlasoma paranaense</i> Kullander 1983	-	-	-	-	*	-	-	-	-
<i>Coptodon rendalli</i> (Boulenger 1897)	1	286	*	-	1	6	-	14	-
<i>Crenicichla lacustris</i> (Castelnau 1855)	2	-	-	-	-	-	-	-	20
<i>Geophagus iporangensis</i> Haseman 1911	5	792	*	2	82	152	5	246	286
<i>Heterotilapia buettikoferi</i> (Hubrecht 1881)	-	-	-	-	*	-	-	-	-
<i>Oreochromis niloticus</i> (Linnaeus 1758)	2	7	*	-	*	4	-	-	12
<i>Satanoperca setepele</i> Ota, Deprá, Kullander, Graça & Pavanelli 2022†	-	-	-	-	-	3	-	-	-
<i>Saxatilia britskii</i> (Kullander 1982)	3	-	*	-	-	-	-	-	-
CYPRINODONTIFORMES									
Poeciliidae									
<i>Phalloceros circummontanus</i> Souto-Santos, Mejia, Arcila & Buckup 2025	737	126	*	12	52	272	-	321	-
<i>Phalloceros reisi</i> Lucinda 2008	-	-	-	-	-	-	-	-	1061
<i>Poecilia reticulata</i> Peters 1859	1419	491	*	-	1	-	-	-	-
<i>Poecilia vivipara</i> Bloch & Schneider 1801	818	107	-	-	1	-	-	-	-
<i>Xiphophorus maculatus</i> (Günther, 1866)	-	2	-	-	-	-	-	-	-
SYNBRANCHIFORMES									
Synbranchidae									

Table V. Continuation.

<i>Synbranchus marmoratus</i> Bloch 1795	1	-	*	-	3	-	-	*	9
Individuals collected	4679	3717	160	283	3277	952	61	1764	4310
Species richness	29	29	19(51)**	26(28)**	57(76)**	20	10	22(28)**	57(59)**
Diversity (Shannon-Wiener)	2.2	2.44	2.3	2.73	3.1	2.1	1.75	1.97	2.95
Dominance	0.16	0.11	0.15	0.09	0.06	0.17	0.26	0.2	0.1

environmental legislation have made wetlands smaller than one hectare particularly vulnerable by removing the legal obligation to preserve surrounding native vegetation (Grasel et al. 2018).

Furthermore, recent federal legislation governing Permanent Preservation Areas (APPs) along urban watercourses is a critical factor. This law allows municipalities to establish different regulations for riparian zones than those mandated by the national Forest Code. This can seriously threaten fish conservation in urban streams, as commercial and real estate interests may take precedence over the ecological function of APPs (Silva et al. 2020). This contributes to what Pelicice et al. (2021) describe as a pessimistic scenario, characterized by unsustainable policies and pressure for short-term development based on high-impact activities.

Potential solutions include establishing protected “free-flowing” rivers (Azevedo-Santos et al. 2019) and strictly preserving remaining riparian habitats (Dala-Corte et al. 2020). However, implementing such measures is often incompatible with current development models. The lack of effective conservation policies exacerbates the regional biodiversity crisis and jeopardizes essential ecological services that support human well being (Pelicice et al. 2021). The challenges facing the Sorocaba River basin exemplify this conflict. Concerted action is urgently needed, bringing together the basin committee, municipal environmental councils, government agencies, and other sectors of

society to address the severe degradation and mitigate the extinction risk facing several fish species. Ultimately, balancing economic development with environmental conservation remains a significant and ongoing challenge.

CONCLUSIONS

The Sorocaba River basin comprises a rich ichthyofauna that is widely distributed in several environments and, according to the numerous published works, is also recognized. Research is still required, particularly in delicate yet significant ecosystems like floodplains and streams. This work serves as a crucial guide for the ongoing research because of the information presented. While there may still be species that the scientific community is unaware of, it is hoped that new studies will be proposed with themes and in locations that have not been investigated extensively or at all. At the same time, systematic research will be developed.

The Sorocaba River basin supports a rich and widely distributed ichthyofauna, a fact now well-established by numerous scientific publications. However, further research is still needed, particularly in sensitive yet ecologically significant habitats such as floodplains and headwater streams. By synthesizing the available knowledge and identifying these key research gaps, the present study serves as a crucial guide for future investigations.

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