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Azevedo-Santos, V.M., V.S. Daga, L.H. Tonella, R. Ruaro, M.S. Arcifa, P.M. Fearnside & T. Giarrizzo. 2023. **Brazil's urban ecosystems threatened by law**. *Land Use Policy* (in press).

ISSN: 0264-8377

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The original publication will be available at
A publicação original estará disponível em:

http://www.journals.elsevier.com/land-use-policy

Brazil's urban ecosystems threatened by law

Valter M. Azevedo-Santos[1,2,3], Vanessa S. Daga[4], Lívia H. Tonella[5], Renata Ruaro[6], Marlene S. Arcifa[7], Philip M. Fearnside[8], Tommaso Giarrizzo[2,9]

[1]Universidade Federal do Tocantins (UFT), Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação, CEP 77500-000, Porto Nacional, Tocantins, Brazil;
[2]Grupo de Ecologia Aquática, Universidade Federal do Pará, 2651 Avenida Perimetral, Belém, Pará, Brazil;
[3]Faculdade Eduvale de Avaré, Avaré, Brazil;
[4] Researcher, Zip Code 32825, Orlando, Florida, United States;
[5] Departamento de Direito, Universidade Federal do Tocantins (UFT), Palmas, Tocantins, Brazil
[6] Universidade Tecnológica Federal do Paraná, Programa de Pós-graduação em Ciência e Tecnologia Ambiental, Rua Dep. Heitor Alencar Furtado, 500, Curitiba, Paraná, Brazil.
[7] Departamento de Biologia, Universidade de São Paulo, Av. Bandeirantes, 3900, 14040-901 Ribeirão Preto, São Paulo, Brazil
[8] Instituto Nacional de Pesquisas da Amazônia (INPA), CEP 69067-375, Manaus, Amazonas, Brazil
[9] Instituto de Ciências do Mar (LABOMAR), Universidade Federal do Ceará (UFC), Avenida da Abolição 3207, 60165-081 Fortaleza, Ceará, Brazil

* Corresponding author: Valter M. Azevedo-Santos. Universidade Federal do Tocantins (UFT), Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação, CEP 77500-000, Porto Nacional, Brazil; Grupo de Ecologia Aquática, Universidade Federal do Pará, 2651, Avenida Perimetral, Belém, Pará, Brazil; Faculdade Eduvale de Avaré, Avaré, Brazil. Email: valter.ecologia@gmail.com

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Brazil's urban ecosystems threatened by law

Abstract

Brazil's federal Law 12,651/2012 (popularly known as the "Forest Code") requires "Permanent Preservation Areas", known as "APPs," which are strips of protected vegetation along the edges of watercourses. The widths of the strips vary, depending on the width of the watercourse, and the law applies to both rural and urban aquatic ecosystems. However, a recently approved law (14,285/2021) undermines the Forest Code by giving municipalities (counties) the attribution of defining the widths of the APPs. This even opens the possibility of eliminating urban APPs altogether if doing so is in the interest of the local administration. Reduction or elimination of APPs would result in numerous negative effects in aquatic ecosystems, which is problematic because ecosystems in cities harbor biodiversity. Therefore, a main needed step is revocation of Law 14,285/2021. Greater attention should be given to the conservation of both terrestrial and aquatic ecosystems in urban areas.

Keywords: Biodiversity. Deforestation. Forest Code. Permanent Preservation Areas. Silting. Urbanization

1. Introduction

Some of the largest hydrographic systems in the world are located in Brazil (OECD 2015). These freshwater areas harbor high biodiversity (Agostinho et al., 2005) and provide fisheries resources, water and other services to the human populations (e.g., Batista and Petrere Jr., 2004; Mateus et al., 2004; Fearnside et al., 2021; Pelicice et al., 2022). This makes Brazil a key player in discussions of freshwater biodiversity conservation (Azevedo-Santos et al., 2021a).

Virtually all of the principal Brazilian rivers receive tributaries that have passed through urban areas (e.g., Martins et al., 2008; Souto et al., 2011; Pereira et al., 2021). Large rivers also pass in or near cities, as in the case of the Tietê River that crosses, the city of São Paulo. Brazilian drainage areas also contain numerous urban lacustrine ecosystems (e.g., Lopes et al., 2002; Pinese et al., 2008; Silva et al., 2019), whether connected or not to the lotic waterbodies. In addition to these freshwater environments, marine and estuarine ecosystems (e.g., mangroves and salt marshes) are often associated with urban areas (e.g., Albuquerque and Oliveira, 2020).

Urban waterbodies, both lotic and lentic, are important ecosystems (Francis, 2014) — although they are frequently degraded due to human impacts (Walsh et al., 2005). In Brazil these areas often contain considerable diversity of animals (e.g., macroinvertebrates and fishes) and plants (e.g., macrophytes) (Albertoni and Palma-Silva, 2006; Moreno and Callisto, 2006; Zawadzki et al., 2019). This implies that these areas need to be better protected by the country's authorities.

Law 12,651/2012 (popularly known as the "Forest Code") protects Brazil's watercourses and strips of land along their edges, which are designated as "Permanent Preservation Areas" or "APPs" (Brazil, 2012). This law includes both urban and rural aquatic ecosystems (Brazil, 2012). A recently enacted Law (14,285/2021) severely undermines the Forest Code by giving local politicians in municipal (county) governments the attribution of defining the widths of the APPs (Brazil, 2021) and providing an opportunity to remove the protection of urban ecosystems. This law is controversial, from both legal and environmental perspectives (Thomaz et al., 2021; Antunes, 2022; Wacheleski and da Silva, 2022). Here we show potential problems of

this recent law and argue the need to preserve urban ecosystems, both terrestrial and aquatic.

2. An assault on Law 12,651/2012

Law 12,651/2012 defines the "Permanent Preservation Area" (known as the "APP": *Área de Preservação Permanente*) as a "(…) protected area, whether covered or not by native vegetation, with the environmental function of preserving water resources, the landscape, geological stability and biodiversity, facilitating the gene flow of fauna and flora (…)" (Brazil, 2012: Chapter 1). APPs are "the marginal strips of [land along] any perennial and intermittent natural watercourse, excluding the ephemeral ones, from the edge of the regular streambed (…)" (Brazil, 2012: Chapter 2). Law 12,651/2012 establishes that the vegetation along watercourses must be protected in a strip at least 30 m wide and can require widths greater than this depending on the width of the watercourse (Brazil, 2012). This law has various problems (see Grasel et al., 2018; Terra et al., 2021) but protects urban ecosystems at some level. An illustration of this is the plan for infrastructure to be built near the "Praça das Nascentes" (in Portuguese) square in the city of São Paulo that was stopped based on the argument that the project was within the limits of an APP (Supplementary Material 1). Other similar cases have occurred in Brazil (e.g., Supplementary Material 2). This means that, combined with good enforcement, Law 12,651/2012, if not modified by the new law, reduced impacts on urban ecosystems.

In the recently approved Law (14,285/2021) Article 4 opens the possibility of local administrations reduce or eliminating urban APPs altogether after "(…) hearing the state, municipal or district environmental councils (…)" (Brazil, 2021). The justification for this provision as given in the proposal for the law (Proposed Law 2510/2019) is that Law 12,651/2012 is wrong because it "(…) sets equal APP limits for rural and urban areas and allows intervention or suppression of native vegetation in APPs only in cases of public utility, social interest or low environmental impact" (Brazil, 2019) and because "it happens that in such hypotheses [the law] does not fit with various situations that are very common in urban areas, such as private and public buildings close to slopes and watercourses or waterbodies" (Brazil, 2019). We believe that Law 14,285/2021 was proposed to reduce or eliminate the APPs in urban areas.

Leaving it to the municipal authorities to decide the size of the APP in urban areas is likely to result in setbacks for ecosystems. Three features that guarantee this are: (i) lack of knowledge of local decision makers about the scientific evidence (e.g., Casatti, 2010; Valera et al., 2018; Pissarra et al., 2019) showing the importance of these areas, (ii) lobbies from interest groups that can profit from building in areas dismembered from APPs, and (iii) the effect of charismatic measures in attracting votes. Urban APPs are often occupied, and removing the population from these places would be unpopular and would conflict with the electoral interests of local politicians. This means that occupations close to watercourses are almost certain to be legalized by municipal decree.

3. Urban ecosystems at stake

The reduction or elimination of APPs under Law 14,285/2021 would generate even more social and ecological impacts. For example, the permission to build houses close to watercourses will result in material losses after floods (Thomaz et al., 2021). This would generate costs both for the people and for the municipal governments. The flooding in São Paulo State caused by torrential rains in 2023 illustrates the situation well (Supplementary Material 3). Negative impacts on urban aquatic ecosystems may be

numerous and include introduction of non-native species, pollution of waterbodies (Thomaz et al., 2021), and intentional destruction of wetlands and waterbodies by landfills to allow construction. In addition, interventions in APPs have high potential to generate both direct and indirect siltation (Araújo, 2002; Thomaz et al., 2021; Ottoni et al., 2023) (Figure 1).

Figure 1. A silted stream: (a) during; and (b) after intervention in its APPs.

Occupation or other activities in APPs affects biodiversity because native species inhabit urban environments (Figure 2a-c), including waterbodies that are already impacted (e.g., Moreno and Callisto, 2006; Cunico et al., 2011). For example, in a search (Methods in Supplementary Material 4) we found that that numerous studies have documented native fish assemblages in Brazil's urban aquatic ecosystems (Figure 3a-b). Urban aquatic ecosystems contain species that have only been described in the last decade (e.g., Reis et al., 2012; Costa et al., 2021), and also contain species that are threatened (Figure 2b) or considered to be endemic (Table 1). For instance, siltation caused by interventions in APPs may have highly negative impacts on fish diversity in these ecosystems (Azevedo-Santos et al., 2021b). Urban APPs also contain terrestrial fauna (e.g., Figure 2d-f), and the vegetation itself is important for conservation of these biological components.

Figure 2. Photographs exemplifying animal groups that occur in Brazilian urban areas: (a) *Ucides cordatus* (Linnaeus, 1763) in a urban estuary in Belém, Pará; (b) *Leptopanchax splendens* (Myers, 1942), a fish species considered highly threatened with extinct (*sensu* Pavanelli et al. 2018) occurring in Duque de Caxias municipality, Rio de Janeiro (Costa et al. 2019); (c) Freshwater turtle (Chelidae) in a small urban watercourse in Frutal municipality, Minas Gerais; (d) *Iguana iguana* (Linnaeus, 1758) in an APP of Belém, Pará; (e) *Sicalis flaveola* (Linnaeus, 1766), in a remaining APP in Frutal municipality, Minas Gerais; (f) *Bradypus variegatus* (Schinz, 1825) in an APP of Belém, Pará.

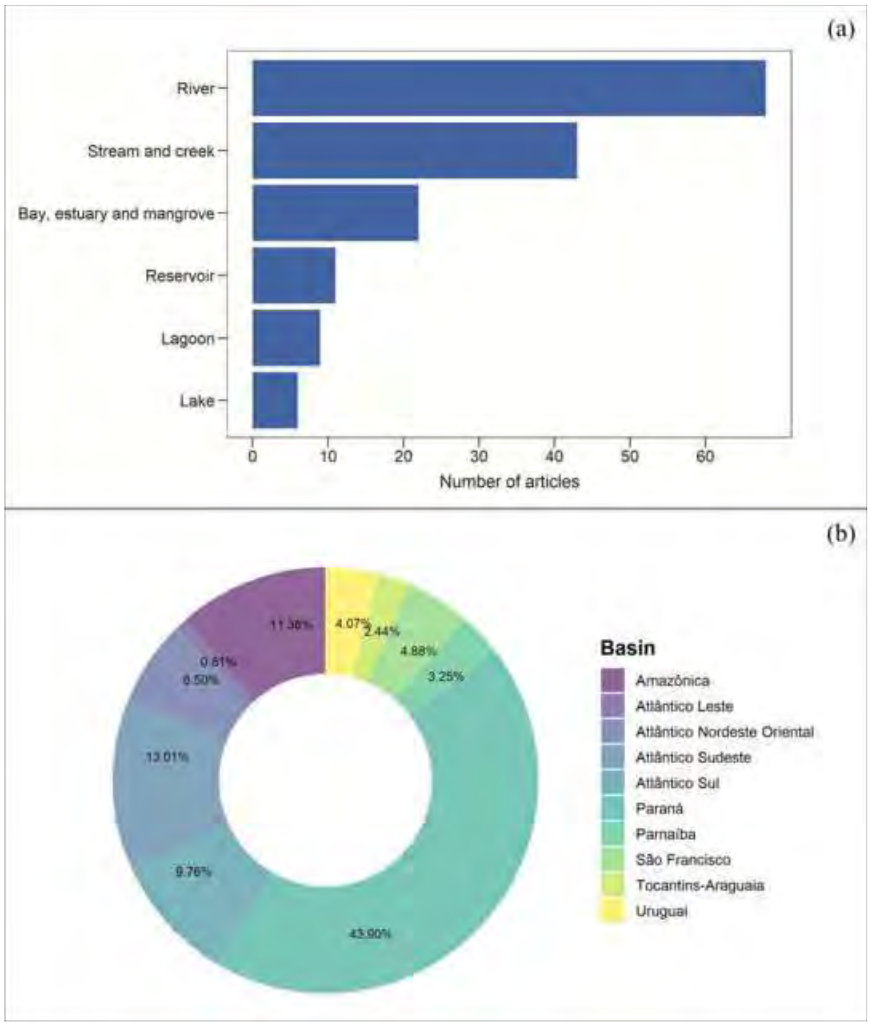

Figure 3. Number of studies on urban watercourses by (a) type of environment (b) hydrographic basin (based on Supplementary Material 4).

171
172 **Table 1.** Endemic fish species reported in the studies we analyzed (based on
173 Supplementary Material 4). Conservation status according to Akama et al. (2018),
174 Santos et al. (2018), Zanata et al. (2018), Pavanelli et al. (2018), Zawadzki et al. (2019).
175

Species	Status	Basin
Anostomidae		
Leporinus piau Fowler 1941	Least-Concern	Atlântico Nordeste Oriental
Trichomycteridae		
Cambeva barbosae Costa, Feltrin & Katz, 2021	Not evaluated	Uruguai
Cambeva botuvera Costa, Feltrin & Katz, 2021	Not evaluated	Uruguai
Characidae		
Glandulocauda caerulea Menezes & Weitzman, 2009	Least-Concern	Paraná
Crenuchidae		
Characidium bimaculatum Fowler 1941	Least-Concern	Atlântico Nordeste Oriental
Curimatidae		
Psectrogaster rhomboides Eigenmann & Eigenmann 1889	Least-Concern	Atlântico Nordeste Oriental
Steindachnerina notonota (Miranda Ribeiro 1937)	Least-Concern	Atlântico Nordeste Oriental
Hemiodontidae		
Hemiodus microlepis Kner 1858	Least-Concern	Parnaíba
Parodontidae		
Apareiodon davisi Fowler 1941	Endangered	Atlântico Nordeste Oriental
Prochilodontidae		
Prochilodus brevis Steindachner 1875	Least-Concern	Atlântico Nordeste Oriental
Serrasalmidae		
Ossubtus xinguense Jégu 1992	Vulnerable	Amazônica
Triportheidae		
Triportheus signatus (Garman 1890)	Least-Concern	Atlântico Nordeste Oriental
Cichlidae		
Cichlasoma orientale Kullander 1983	Least-Concern	Atlântico Nordeste Oriental
Aplocheilidae		
Leptopanchax splendens (Myers 1942)	Critically Endangered	Atlântico Sudeste
Rivulidae		
Atlantirivulus santensis (Köhler 1906)	Least-Concern	Paraná

Heptapteridae			
Pimelodella enochi Fowler 1941	Least-Concern	Atlântico Oriental	Nordeste
Loricariidae			
Eurycheilichthys pantherinus (Reis & Schaefer 1992)	Least-Concern	Uruguai	
Hypostomus pusarum (Starks 1913)	Least-Concern	Atlântico Oriental	Nordeste
Hypostomus subcarinatus Castelnau, 1855	Critically Endangered	São Francisco	
Pareiorhaphis hystrix (Pereira & Reis 2002)	Least-Concern	Uruguai	
Parotocinclus jumbo Britski & Garavello 2002	Least-Concern	Atlântico Oriental	Nordeste
Parotocinclus spilosoma (Fowler 1941)	Least-Concern	Atlântico Oriental	Nordeste
Parotocinclus spilurus (Fowler 1941)	Least-Concern	Atlântico Oriental	Nordeste
Plesioptopoma curvidens Reis, Pereira & Lehmann A, 2012	Not evaluated	São Francisco	

Regional-level negative impacts may occur in addition to local impacts. For example, pollution events due to higher population density near watercourses will impact downstream areas (see Azevedo-Santos et al., 2019). For instance, over 50% of the length of the Tietê River passes through rural areas after leaving the urban area of São Paulo. This downstream portion of the river has part of its flow diverted for irrigating crops (Tundisi et al., 1991), and the river is used for fishing (e.g., Novaes and Carvalho, 2011) and for other purposes. Loss of APPs in urban areas will therefore compromise environment services in downstream rural areas.

4. More care is needed for urban ecosystems

The aquatic urban environment in Brazil needs to be better protected. A first needed step is revocation of Law 14,285/2021. In April 2022 a coalition of four political parties submitted a "Direct Suit of Unconstitutionality" (ADI) to Brazil's Federal Supreme Court (STF) requesting revocation of this law (Maimoni et al., 2022). The suit continues without a decision (STF, 2022). Legal opinions indicate that the law is, indeed, unconstitutional (Antunes, 2022; Wacheleski and da Silva, 2022), although this in no way guarantees a favorable decision on the ADI. In any case, the need for increased care of urban ecosystems goes beyond the need to revoke the recently enacted law.

We believe that the forest code (Law 12,651/2012) needs to be improved such that the legal mechanisms reflect scientific evidence related to conservation of environments and biodiversity (e.g., Casatti, 2010; Magalhães et al., 2011; Brancalion et al., 2016; Valera et al., 2018; Pissarra et al., 2019; Brito et al., 2020; Dala-Corte et al., 2020). Increasing the size of established APPs based on scientific knowledge is therefore a point to be improved in Law 12,651/2012 and applied to urban ecosystems (Thomaz et al., 2021).

Urban watercourses are already impacted by nonnative species, effluents, deforestation, canalization, and other factors (e.g., Gubiani et al., 2010; Cunico et al., 2009; Martins et al., 2017; Azevedo-Santos et al., 2018; Giarrizzo et al., 2019; Ottoni et

al., 2023). Therefore, beyond a future improvement of Law 12,651/2012 based on scientific evidence, we recommend immediate implementation of projects to restore aquatic and riparian ecosystems in urban areas. Needed initiatives include removal of public and private constructions in or near watercourses, recuperation of original riparian vegetation, installation of ecological culverts to allow the free movement of aquatic organisms (e.g., Makrakis et al., 2012), and control of pollution, including installation of surface barriers to remove at least the floating solid wastes that come from the city.

5. Conclusion

The recently approved Law 14,285/2021 is a clear assault on Brazil's Forest Code (Law 12,651/2012). The recent law's allowing municipal (county) governments to define the widths of the strips of protected vegetation (APPs) along watercourses allows local politicians to reduce or eliminate urban APPs. Reduction or elimination of APPs would result in numerous negative effects on aquatic ecosystems, including increased siltation and pollution and the loss of biodiversity, both in the watercourses and in the APPs. Therefore, a main step is revocation of Law 14,285/2021. Greater attention should be given to the conservation of urban ecosystems, including fauna and flora.

ACKNOWLEDGMENTS

We thank Axel M. Katz for providing photos of urban biodiversity. To Thomas E. Lovejoy for comments on the first draft of this manuscript. We thank the editor and reviewers for helpful comments. P.M.F. received a grant from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) [number 311103/2015-4].

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SUPPLEMENTARY MATERIAL

Brazil's urban ecosystems threatened by law

Valter M. Azevedo-Santos[1,2,3], Vanessa S. Daga[4], Lívia H. Tonella[5], Renata Ruaro[6], Marlene S. Arcifa[7], Philip M. Fearnside[8], Tommaso Giarrizzo[2,9]

[1]Universidade Federal do Tocantins (UFT), Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação, CEP 77500-000, Porto Nacional, Tocantins, Brazil;
[2]Grupo de Ecologia Aquática, Universidade Federal do Pará, 2651 Avenida Perimetral, Belém, Pará, Brazil;
[3]Faculdade Eduvale de Avaré, Avaré, Brazil;
[4] Researcher, Zip Code 32825, Orlando, Florida, United States;
[5] Departamento de Direito, Universidade Federal do Tocantins (UFT), Palmas, Tocantins, Brazil
[6] Universidade Tecnológica Federal do Paraná, Programa de Pós-graduação em Ciência e Tecnologia Ambiental, Rua Dep. Heitor Alencar Furtado, 500, Curitiba, Paraná, Brazil.
[7] Departamento de Biologia, Universidade de São Paulo, Av. Bandeirantes, 3900, 14040-901 Ribeirão Preto, São Paulo, Brazil
[8] Instituto Nacional de Pesquisas da Amazônia (INPA), CEP 69067-375, Manaus, Amazonas, Brazil
[9] Instituto de Ciências do Mar (LABOMAR), Universidade Federal do Ceará (UFC), Avenida da Abolição 3207, 60165-081 Fortaleza, Ceará, Brazil

* Corresponding author: Valter M. Azevedo-Santos. Universidade Federal do Tocantins (UFT), Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação, CEP 77500-000, Porto Nacional, Brazil; Grupo de Ecologia Aquática, Universidade Federal do Pará, 2651, Avenida Perimetral, Belém, Pará, Brazil; Faculdade Eduvale de Avaré, Avaré, Brazil. Email: valter.ecologia@gmail.com

SUPPLEMENTARY MATERIAL 1

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SUPPLEMENTARY MATERIAL 2

Case A. https://g1.globo.com/mg/minas-gerais/noticia/2021/07/26/construcao-ilegal-na-varzea-das-flores-e-demolida-em-operacao-da-prefeitura-de-contagem.ghtml

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SUPPLEMENTARY MATERIAL 3

Case A. https://g1.globo.com/sp/sao-paulo/noticia/2023/02/18/forte-chuva-causa-alagamento-e-afeta-circulacao-de-trens-na-grande-sao-paulo.ghtml

Case B. https://g1.globo.com/sp/ribeirao-preto-franca/noticia/2023/01/31/corregos-transbordam-e-agua-invade-vias-durante-forte-chuva-em-franca-sp.ghtml

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SUPPLEMENTARY MATERIAL 4

METHODS

We performed a systematic search to find fish-based articles that have been applied in urban areas in Brazil. Thus, on September 2, 2021, we conducted a topic search in Clarivate Analytics Web of Science (http://www.webofknowledge.com) to retrieve articles published up to 2021, in all of the databases. The following terms and Boolean operators were used in our search: Topic: (Urban* OR Metropolitan OR city OR municipal* OR cities) AND Topic: (Fish*) AND Topic: (Freshwater* OR stream* OR river* OR creek* OR aquatic* OR estuar* OR Mangrove*) AND Topic: (Brazil). This search resulted in an initial pool of 507 articles. After, we refined the search by study type (article) and this step resulted in 493 articles. We included only articles that were performed with fish in urban areas in Brazil, and 148 articles were selected for further analysis. We did not include review articles. As we had a special interest in obtaining information on the occurrence of urban area endemic fish species in Brazil, we added four articles to review based on the knowledge of the authors of this study. Thus, we systematically evaluated the 152 publications using qualitative and quantitative topics to summarize the information on fish-based studies in Brazilian urban areas as following: i) the location (city, state and basin); ii) type of habitat (e.g., river/stream/creek, lake, estuary, lagoon, etc.); and iii) occurrence of endemic species. For each hydrographic basin, we used the data obtained in the articles (e.g., coordinates of a river) and considered the delimitation provided by IBGE (2021).

RESULTS

Table S1 – List of articles included in the review.

Authors	*Article Title*	*Source Title*	*Publicat*
Jia, J; Gomes-Silva, G; Plath, M; *et al.*	Shifts in bacterial communities and antibiotic resistance genes in surface water and gut microbiota of guppies (*Poecilia reticulata*) in the upper Rio Uberabinha, Brazil	Ecotoxicology And Environmental Safety	2021
Lehun, AL; Mendes, AB; Takemoto, RM; *et al.*	Genotoxic effects of urban pollution in the Iguaçu River on two fish populations	Journal of Environmental Science and Health Part A-Toxic/Hazardous Substances & Environmental Engineering	2021
Silva, JS; Alves, RN; de Paulo, DV; *et al.*	Biliary polycyclic aromatic hydrocarbons and enzymatic biomarkers in *Eugerres brasilianus* along four tropical estuaries	Marine Pollution Bulletin	2021
Camargo, MP; Forneck, SC; Dutra, FM; *et al.*	Fish fauna in low-order streams of the Piquiri River, Upper Paraná River basin, Brazil	Biota Neotropica	2021
Pereira, LM; Dunck, B; Benedito, E	Human impacts alter the distribution of fish functional diversity in Neotropical stream system	Biotropica	2021
Costa, W. J. E. M., Feltrin, C.R. M., Katz, A.M.	Filling distribution gaps: Two new species of the catfish genus *Cambeva* from southern Brazilian Atlantic Forest (Siluriformes, Trichomycteridae)	Zoosystematics and Evolution	2021
Barreto, LS; Souza, ATD; Martins, CC; *et al.*	Urban effluents affect the early development stages of Brazilian fish species with implications for their population dynamics	Ecotoxicology and Environmental Safety	2020
Andrades, R; Guabiroba, HC; Hora, MSC; *et al.*	Early evidences of niche shifts in estuarine fishes following one of the world's largest mining dam disasters	Marine Pollution Bulletin	2020
Cruz, LC; Pompeu, PS	Drivers of fish assemblage structures in a Neotropical urban watershed	Urban Ecosystems	2020
Garcia, TD; Cardozo, ALP; Quirino, BA; *et al.*	Ingestion of Microplastic by Fish of Different Feeding Habits in Urbanized and Non-urbanized Streams in Southern Brazil	Water Air and Soil Pollution	2020
Ghisi, ND; Larentis, C; de Oliveira, EC; *et al.*	Environmental assessment of Neotropical streams using fish as bioindicators: a multibiomarker and integrated approach	Hydrobiologia	2020
Barbosa, AS; Pires, MM; Schulz, UH	Influence of Land-Use Classes on the Functional Structure of Fish Communities in Southern Brazilian Headwater Streams	Environmental Management	2020
Zawadzki CH, Penido IdS, de Oliveira JC, Pessali TC	Rediscovery and redescription of the endangered *Hypostomus subcarinatus* Castelnau, 1855 (Siluriformes: Loricariidae) from the Rio São Francisco basin in Brazil	PLoS ONE	2019
Costa, WJEM, Mattos, JLO, Amorim, PF.	Rediscovery of *Leptopanchax splendens* (Cyprinodontiformes: Aplocheilidae): a seasonal killifish from the Atlantic Forest of south-eastern Brazil that was recently considered extinct.	Journal of Fish Biology	2019

Gomes, LC; Chippari-Gomes, AR; Miranda, TO; *et al.*	Genotoxicity effects on *Geophagus brasiliensis* fish exposed to Doce River water after the environmental disaster in the city of Mariana, MG, Brazil	Brazilian Journal of Biology	2019
Salgado, LD; Marques, AEML; Kramer, RD; *et al.*	Integrated assessment of sediment contaminant levels and biological responses in sentinel fish species *Atherinella brasiliensis* from a sub-tropical estuary in south Atlantic	Chemosphere	2019
Collier, CA; Neto, MSD; de Almeida, GMA *et al.*	Effects of anthropic actions and forest areas on a neotropical aquatic ecosystem	Science of the Total Environment	2019
Pizzochero, AC; de la Torre, A; Sanz, P; *et al.*	Occurrence of legacy and emerging organic pollutants in whitemouth croakers from Southeastern Brazil	Science of the Total Environment	2019
Favero, FDT; Araujo, IMD; Severi, W	Structure of the fish assemblage and functional guilds in the estuary of Maracaipe, northeast coast of Brazil	Boletim do Instituto de Pesca	2019
Peressin, A; *et al.*	Ichthyofauna diet changes in response to urbanization: the case of upper Paranapanema River basin (Brazil)	Urban Ecosystems	2018
Viana, LF; Suarez, YR; Cardoso, CAL; *et al.*	The Response of Neotropical Fish Species (Brazil) on the Water Pollution: Metal Bioaccumulation and Genotoxicity	Archives of Environmental Contamination and Toxicology	2018
Lacerda, ACF; Roumbedakis, K; Bereta, JGS; *et al.*	Fish parasites as indicators of organic pollution in southern Brazil	Journal of Helminthology	2018
Barros, IT; Ceccon, JP; Glinski, A; *et al.*	Environmental risk assessment in five rivers of Parana River basin, Southern Brazil, through biomarkers in *Astyanax spp*.	Environmental Science and Pollution Research	2017
Sindeaux-Neto, JL; Velasco, M; Santos, P; *et al.*	Infection of the muscle tissue of the filter-feeding cichlid, *Chaetobranchopsis orbicularis* Steindachner, 1875, by *Kudoa orbicularis* (Myxozoa: Multivalvulidae) on Marajó Island in the Brazilian Amazon region	Arquivo Brasileiro de Medicina Veterinária e Zootecnia	2017
Costa, SYL; Barbosa, JEDL; Viana, LG; *et al.*	Composition of the ichthyofauna in Brazilian semiarid reservoirs	Biota Neotropica	2017
Dias, KGA; Alves, CA; Da Silva, RJ; *et al.*	Parasitic communities of *Hoplosternum littorale* (Hancock, 1828) as indicators of environmental impact	Anais da Academia Brasileira de Ciências	2017
Vieira-Menezes, FG; Costa, DPC; Brasil-Sato, MC	Nematodes of *Astyanax fasciatus* (Actinopterygii: Characidae) and their parasitic indices in the São Francisco river, Brazil	Revista Brasileira de Parasitologia Veterinária	2017
Ghisi, NC; Oliveira, EC; Guiloski, IC; *et al.*	Multivariate and integrative approach to analyze multiple biomarkers in ecotoxicology: A field study in Neotropical region	Science of the Total Environment	2017
Pinheiro, RHD; Santana, RLS; Melo, FTV; *et al.*	*Gnathostomatidae nematode* parasite of *Colomesus psittacus* (Osteichthyes, Tetraodontiformes) in the Ilha de Marajó, Brazilian Amazon	Revista Brasileira de Parasitologia Veterinária	2017
Santos, AC; Goncalves, CC; Carvalho, FR	Ichthyofauna of the Cachoeira de São Roberto and fishes of lower Preto River, upper Paraná River basin, Brazil	Biota Neotropica	2017
Furlan, VJM; de Campos, IP; Centenaro, GS	Characterization of fishing and fishing commercialization in the city of Itaqui-RS, Brazil	Vigilância Sanitária em Debate-Sociedade Ciência & Tecnologia	2016

Andrade, MC; Sousa, LM; Ota, RP; *et al.*	Redescription and Geographical Distribution of the Endangered Fish *Ossubtus xinguense* Jegu 1992 (Characiformes, Serrasalmidae) with comments on conservation of the rheophilic fauna of the Xingu River	Plos One	2016
Pimentel, MF; Damasceno, EP; Jimenez, PC; *et al.*,	Endocrine disruption in *Sphoeroides testudineus* tissues and sediments highlights contamination in a northeastern Brazilian estuary	Environmental Monitoring and Assessment	2016
Fontoura, NF; Vieira, JP; Becker, FG; *et al.*	Aspects of fish conservation in the upper Patos Lagoon basin	Journal of Fish Biology	2016
Chivittz, CC; Pinto, DP; Ferreira, RS; *et al.*	Responses of the CYP1A biomarker in *Jenynsia multidentata* and *Phalloceros caudimaculatus* and evaluation of a CYP1A refractory phenotype	Chemosphere	2016
Ramos, TPA; Lehmann, AP; Barros-Neto, LF; *et al.*	Redescription of the endangered hypoptopomatine catfish *Parotocinclus spilurus* (Fowler, 1941) (Siluriformes: Loricariidae) from the upper rio Jaguaribe basin, northeastern Brazil	Neotropical Ichthyology	2016
Barrella, W; Ramires, M; Rotundo, MM; *et al.*	Biological and socio-economic aspects of recreational fisheries and their implications for the management of coastal urban areas of south-eastern Brazil	Fisheries Management and Ecology	2016
Dolbeth, M; Vendel, AL; Pessanha, A; Patricio, J	Functional diversity of fish communities in two tropical estuaries subjected to anthropogenic disturbance	Marine Pollution Bulletin	2016
Acosta, AA; Caffara, M; Fioravanti, ML; *et al.*	Morphological and Molecular Characterization *of Clinostomum detruncatum* (Trematoda: Clinostomidae) Metacercariae Infecting *Synbranchus marmoratus*	Journal of Parasitology	2016
Santos, CAB; Alves, RRN	Ethnoichthyology of the indigenous Truka people, Northeast Brazil	Journal of Ethnobiology and Ethnomedicine	2016
Silva, SVS; Dias, AHC; Dutra, ES; *et al.*	The impact of water pollution on fish species in southeast region of Goiás, Brazil	Journal of Toxicology and Environmental Health-Part A-Current Issues	2016
Lima, MAL; Freitas, CED; de Moraes, SM; *et al.*	Small-scale fishing in the municipality of Humaitá, middle Madeira River, Amazonas, Brazil	Boletim do Instituto de Pesca	2016
de Jesus, IS; Cestari, MM; Bezerra, MD; *et al.*	Genotoxicity effects in freshwater fish from a Brazilian impacted river	Bulletin of Environmental Contamination and Toxicology	2016
Ferreira, RS; Chivittz, CD; dos Santos, GS; Zanette, J	Cytochrome P450 1A mRNA in the guppy *Phalloceros caudimaculatus* and response to beta-naphthoflavone and environmental samples	Aquatic Toxicology	2016
Morais, CR; Carvalho, SM; Araujo, GR; *et al.*	Assessment of water quality and genotoxic impact by toxic metals in *Geophagus brasiliensis*	Chemosphere	2016
Ruaro, R; Gubiani, EA; Cunico, AM; *et al.*	Comparison of fish and macroinvertebrates as bioindicators of Neotropical streams	Environmental Monitoring and Assessment	2016
Batista, NJC; Cavalcante, AADM; de Oliveira, MG; *et al.*	Genotoxic and mutagenic evaluation of water samples from a river under the influence of different anthropogenic activities	Chemosphere	2016
Correa, LL; Tavares-Dias, M; Ceccarelli, PS; *et al.*	Hematological alterations in *Astyanax altiparanae* (Characidade) caused by *Lernaea cyprinacea* (Copepoda: Lernaeidae)	Diseases of Aquatic Organisms	2016

de Campos, EO; Pereira, BB; Morelli, S	Monitoring genotoxicity potential in the Mumbuca Stream, Minas gerais, Brazil	Journal of Toxicology and Environmental Health-Part A-Current Issues	2015
Rocha, RS; Pelegrini, LS; Camargo, AD; *et al.*	*Sphincterodiplostomum musculosum* (Digenea, Diplostomidae) in *Geophagus brasiliensis* (Perciformes, Cichlidae) collected in a lake at Dois Córregos, São Paulo, Brazil	Ciência Rural	2015
Bourdineaud, JP; Durrieu, G; Sarrazin, SLF; *et al.*	Mercurial exposure of residents of Santarém and Oriximiná cities (Pará, Brazil) through fish consumption	Environmental Science and Pollution Research	2015
Bianchi, E; Goldoni, A; Trintinaglia, L; *et al.*	Evaluation of genotoxicity and cytotoxicity of water samples from the Sinos River Basin, southern Brazil	Brazilian Journal of Biology	2015
Freire, CA; Souza-Bastos, LR; Chiesse, J; *et al.*	A multibiomarker evaluation of urban, industrial, and agricultural exposure of small characins in a large freshwater basin in southern Brazil	Environmental Science and Pollution Research	2015
Mathews, PD; Silva, MRM; Maia, AAM; *et al.*	Ultrastructure and ssrRNA sequencing of *Myxidium amazonense* n. sp a myxosporean parasite of *Corydoras melini* from the Rio Negro river, Amazonas state, Brazil	Parasitology Research	2015
Campos, CP; Freitas, CED; Amadio, S	Growth of the *Cichla temensis* Humboldt, 1821 (Perciformes: Cichlidae) from the middle rio Negro, Amazonas, Brazil	Neotropical Ichthyology	2015
Pedde, V; Figueiredo, JAS; Nunes, MF; *et al.*	Environment and society: the Sinos River Basin and public policies	Brazilian Journal of Biology	2015
Santos, KPP; Soares, RR; Barros, RFM	Fishing activity and construction of craft in colony of fishermen z-18 in União/PI, Brazil	Holos	2015
Collier, CA; Neto, MSD; Aretakis, GMA; Santos, RE; *et al.*	Integrated approach to the understanding of the degradation of an urban river: local perceptions, environmental parameters and geoprocessing	Journal of Ethnobiology and Ethnomedicine	2015
Schulz, UH; Costa, PF	The effects of press and pulse disturbance by long and short-term pollution on the fish community in the Sinos River, RS, Brazil	Brazilian Journal of Biology	2015
Costa-Silva, DG; Nunes, MEM; Wallau, GL; *et al.*	Oxidative stress markers in fish (*Astyanax* sp and *Danio rerio*) exposed to urban and agricultural effluents in the Brazilian Pampa biome	Environmental Science and Pollution Research	2015
Bueno-Krawczyk, ACD; Guiloski, IC; Piancini, LDS; *et al.*	Multibiomarker in fish to evaluate a river used to water public supply	Chemosphere	2015
Oliveira, LC; Ribeiro, MO; Dutra, ES; *et al.*	Karyotype structure of *Hypostomus cf. plecostomus* (Linnaeus, 1758) from Tapajós River basin, Southern Amazon: occurrence of sex chromosomes (ZZ/ZW) and their evolutionary implications	Genetics and Molecular Research	2015
da Costa, MR; Moreti, T; Araujo, FG	Length-weight relationships of 20 fish species in the Guandu River, Rio de Janeiro State, Southeastern Brazil	Journal of Applied Ichthyology	2014
dos Santos, JAP; Esteves, KE	The fish fauna of an Atlantic Forest conservation area in the largest urban center of South America (São Paulo, SP, Brazil) and its relationship to some environmental factors	Studies on Neotropical Fauna and Environment	2014
Ribeiro, DL; Barcelos, GRM; d'Arce, LPG	Genotoxic Effects of Water from So Francisco River, Brazil, in *Astyanax paranae*	Bulletin of Environmental Contamination and Toxicology	2014

Franco, ACS; Brotto, DS; Zee, DMW; *et al.*	Reproductive biology of *Cetengraulis edentulus* (Cuvier, 1829), the major fishery resource in Guanabara Bay, Brazil	Neotropical Ichthyology	2014
Herbst, DF; Hanazaki, N	Local ecological knowledge of fishers about the life cycle and temporal patterns in the migration of mullet (*Mugil liza*) in Southern Brazil	Neotropical Ichthyology	2014
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Moreira, GSA; Adriano, EA; Silva, MRM; *et al.*	The morphological and molecular characterization of *Henneguya rotunda* n. sp., a parasite of the gill arch and fins of *Salminus brasiliensis* from the Mogi Guaçu River, Brazil	Parasitology Research	2014
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