Abstract
Specimens collected in the type locality of species, called toptypes, are of great value for taxonomic and systematics studies, mainly if the type material is much old, lost, or in bad condition to be analyzed. Additionally, toptypes may provide information through the application of modern techniques in biological studies, as those that incorporate molecular or fine anatomical data. In this report, we discuss the possibility to connect systematics, history and biodiversity conservation from the collection of freshwater fish species toptypes in the upper Paraná River basin, southeastern Brazil. This ecoregion of Neotropical fish fauna has been researched since the beginning of 19th century, when European naturalists traveled collecting specimens that served to the species descriptions. Surprisingly, after about 200 years of biological studies, there are still novel taxa (genus and species) to be described in the basin. Much of the type series of the species described from the mid-19th century to the beginning of the 20th were housed in Europeans or north American museums. Those series were frequently compounded by one or few specimens and, in many cases, are currently lost or in bad handling conditions. In this scenario, toptypes collections are welcome to develop studies about fish systematics and diversity conservation, providing also the access to historical information of biological studies in Brazil. The material collected in this project is housed in the Laboratory of Systematic Ichthyology from the Federal University of São Carlos (LISDEBE) and is available for the scientific community. We assessed the original species descriptions and data from museum archives in order to map the type localities, which enabled us to research the historical context of the naturalists' explorations. The fish collecting fieldwork provided relevant biological material to the recognition and validity of species from taxonomical research, and to collect tissues for molecular analysis. It was also possible to identify that riverine environments visited by the naturalists were highly changed by anthropogenic activities, including river impoundment for hydroelectric purposes, introduction of species, and pollution, among other impacts, highlighting the necessity of programs for fish diversity conservation. Finally, the process of assembling toptypes collections of any taxa may represent the opportunity to develop interdisciplinary knowledge in biological sciences.

Introduction
Traditionally, animal species descriptions must be accompanied by type material deposit in institutions that maintain research collections. The type series deposited may contain one or more specimens, being available for examination by researchers. Although type series represent the most important material that allows species delimitation, description and identification, its use to gather additional anatomical data for systematic studies is limited, chiefly when is necessary the application of techniques that may screw up the material.

In this way, specimens collected in the type locality of species, called toptypes, are of great value for taxonomic and systematics studies, mainly if the type material is much old, lost, or in bad condition to be analyzed. Topotypes, or part of them, may be used to the development
of studies that incorporate molecular or fine anatomical techniques, providing important information to revisionary and systematics research. Topotypes may contribute to conservation biology, since they enable the species delimitations and the confirmation or not that one species is present in the place from where it was described.

In this report, we link systematics, history and biodiversity conservation from a collection of freshwater fish species topotypes in the upper Paraná River basin, southeastern Brazil. The process of assembly a topotypes collection of the species described from mid-19th century to the beginning of the 20th, when the species descriptions were based on few specimens housed in European and North American museums, offers opportunity to gather samples for morphological and DNA-sequence studies, to compile historical information, and to identify deleterious environmental changes in these localities inserted in the most densely occupied region of Brazil.

**Historical context**

The first observations on the fauna of Brazil were done concomitantly with the arrival of the Portuguese Pedro Álvarez Cabral in the northeastern coast of the country (Teixeira and Papavero, 2006). The first great work that documented the exuberant nature of Brazil was the *Historia Naturalis Brasiliae* of Willem Piso (1611-1678) and Georg Marcgrave (1610-1644), published in 1648 (Santos et al., 2010). Marcgrave offered some fish species descriptions, almost all form marine fishes, and of course not yet in agreement with the binomial nomenclature adopted after Linnaeus's *Systema Naturae*. In the end of the eighteenth century, Alexandre Rodrigues Ferreira (1756-1815), as commandant of the Portuguese scientific expedition named *Viagem Philosophica*, collected fishes in the Amazon basin and sent to Lisboa. During the Napoleonic invasion to Portugal, the mostly freshwater fishes collected by Ferreira were sent to the Muséum National d'Histoire Naturelle, as reported by Antunes (2003).

Only during the nineteenth century the freshwater fish diversity of Brazil began to be deeply revealed, with the intensification of explorations aiming to collect, describe and study the fish richness and distribution in the Brazilian river basins. Holland (1911) reported that during the nineteenth century there were performed notably expeditions that resulted in great South America freshwater fish collections.

Initially, Johann Baptist Ritter von Spix (1781-1826), Carl Friedrich Philipp von Martius (1794-1868) and Johann Natterer (1787-1843) went to Brazil in 1817, in the occasion of the marriage of Dom Pedro de Alcântara (Dom Pedro I, regent prince of Portugal) and the Archduquess Karolina Josepha Leopoldina from Austria. Spix and Martius traveled around the country between 1817 and 1820 as representative of the Bavaria Kingdom. Natterer, representing Austria, stayed for more than 18 years in Brazil, collecting specimens of the fauna in different regions of the country. Fish specimens collected during the travels performed by Spix, Martius and Natterer were sent to European Museums, deposited in the ZSM, Zoologische Staatssammlung, Munich, and in the NMW, Naturistorisches Museum, Vienna, serving as material for some species descriptions. Posteriorly, Francis de Castelnau (1810-1880), in 1843, traveled in a Natterer’s similar route to Mato Grosso, Midwest Brazil, and extended his voyage to the west of the continent, collecting in Peruvian waters. The ichthyological material was deposited in the MNHN, Muséum National d'Histoire Naturelle, Paris. The Thayer Expedition, in 1865, beyond the guidance of Louis Agassiz (1807-1873), collected specimens in different regions of the South America and much of the material is housed in the MCZ, Museum of Comparative Zoology, Harvard University.

In 1907 John Diederich Haseman (1890-1969) traveled through Brazil with the Carnegie Museum Expedition and most of the material formerly deposited in Indiana University are actually housed in the FMNH, Field Museum of Natural History and in the California Academy of Sciences collections. Still in the beginning of the twentieth century, Hermann von Ilhering (1850-1930), director of the Museu Paulista, headed the collection of fish in rivers of
São Paulo State. In addition to the material housed in the Museu Paulista, actually Zoological Museum of the São Paulo University (MZUSP), specimens were also sent to the Carnegie Museum and to British Museum. At this point is important to allusion the traveler naturalist Ernst Wilhelm Garbe (1853-1925), who was the principal collector of the Museu Paulista in the period.

Here, we focused on the type localities of the species described from the material collected by Johann Natterer, John Haseman, Hermann von Ihering and Ernst Garbe in the upper Paraná River basin, southeastern Brazil. Detailed itinerary of the Natterer and Haseman expeditions may be accessed in Vanzolini (1993) and Eigenmann (1911), respectively.

**Mapped localities in the upper Paraná River basin and target species**

The upper Paraná River basin drains portions of central and southeastern Brazil. Gery (1969) recognized this part of the Rio de la Plata basin as an ichthyological province among the South American drainages. More recently, Abell et al. (2008), based on species richness and endemism, figured the basin as an ecoregion. Although some rivers of the basin may be considered well studied, there are some areas that were just recently explored and recent taxonomical works show that there are still novel genus and species to be described.

The inventory of the fish species described during the covered historical period, grounded on collected material by Natterer, Haseman, Ihering and Garbe, referred as target species, and their respective type localities, were based on CLOFFSCA (Reis et al., 2003), on the Catalog of Freshwater Fishes of Brazil (Buckup et al., 2007) and on Eschmeyer et al. (2017). We mapped the type localities from the original species descriptions and data from museum archives. The localities of the species collected by Natterer are: "Ipanema" (Ipanema River, affluent of the Tietê River, near Sorocaba Municipality) and "Irisanga" (=Orissanga, actual Estiva Gerbi Municipality, in the Mogi Guaçu River basin). The localities of Haseman include: "Piracicaba" (Piracicaba Mirim River, affluent of the Tietê River basin in the Piracicaba Municipality); "Lake 4 miles from Miguel Calmon train station, Tietê River basin" (actual Avanhandava Municipality); "Tietê River, above the Salto do Avanhandava, Brazil" (José Bonfácio Municipality); "Grande River, affluent of the Paraná River, at Jaguara, Minas Gerais, Brazil". Localities of fish collection performed by Ihering and Garbe include Piracicaba and Mogi Guaçu rivers basins.

From these information, we defined four areas of the upper Paraná River, in São Paulo State, to collect specimens: two areas in the Tietê River basin (near Piracicaba and Avanhandava), one in the Mogi Guaçu River and another in the Grande River. The collected specimens and tissue samples are housed in the Laboratory of Systematics Ichthyology (LISDEBE) of the Federal University of São Carlos.

The list below presents the target species of which topotypes were collected, by order and family; including: original name; current name; type locality; LISDEBE topotypes voucher number, number of specimens, localities (decimal degrees coordinate in parenthesis), and collection dates.

Characiformes, Characidae: *Bryconamericus stramineus* Eigenmann, 1908; *Piabarchus stramineus* (Eigenmann 1908); type locality: Piracicaba; Rio Uruguay; Brazil; toptypes: LISDEBE 5036; 3, Turvo Stream, affluent of Piracicaba River (-22,53441; -48,31113), 16 October 2013, LISDEBE 5611, 1, Alambari River, affluent of Barra Bonita Reservoir, of the Tietê River, near Piracicaba (-22,76266; -48,26119), 19 September 2014. *Cheirodon notomelas* Eigenmann, 1915; *Serrapinnus notomelas* (Eigenmann, 1915); Type locality: Lake 4 miles from Miguel Calmone, Rio Tietê basin, Brazil; topotypes: LISDEBE 6410, 34, Lake near the road from Avanhandava and Barbosa, about 6.5 km of the old Miguel Calmone train station (-21,39967, -49,95738), 25 October 2014, LISDEBE 6429, 43, Flooded area in the
sources of Quaresma Creek, besides the road between Avanhandava and Barbosa (-21,40512, –49,96243), 25 October 2015.

Characiformes, Parodontidae: *Parodon tortuusus* Eigenmann & Norris, 1900; synonym of *Parodon nasus* Kner, 1858; Type locality: Rio Tietê, upper Paraná basin, São Paulo, Brazil; topotypes: LISDEBE 5026, 3, Bonito Stream, affluent of the Piracicaba River (-22,52546, -48,16746), 16 October 2013.

Characiformes, Anostomidae: *Leporinus pictus* Kner, 1858; *Leoporellus pictus* (Kner, 1858); Type locality: Irisanga, São Paulo State, Brazil; topotypes: LISDEBE 5055, 5, Mogi Guaçu River, at the Cachoeira de Emas (-21,92661, -47,36746), 05 February 2014. *Schizodon nasutus* Kner, 1858; *Schizodon nasutus* Kner, 1858; Type locality: Irisanga, São Paulo, Brazil; topotypes: LISDEBE 5060, 3, Mogi Guaçu River, at the Cachoeira de Emas (-21,92661, -47,36746), 05 February 2014.


Siluriformes, Pimelodidae: *Pimelodus microstoma* Steindachner, 1877; *Pimelodus microstoma* Steindachner, 1877; Type locality: Irisanga (Orissanga), Mogi Guaçu River drainage, upper Paraná River, São Paulo State, Brazil; topotypes: LISDEBE 5064, 34, Mogi Guaçu River, at the Cachoeira de Emas (-21,92661, -47,36746), 05 February 2014.

Perciformes, Cichlidae: *Crenicichla jaguarensis* Haseman, 1911; *Crenicichla jaguarensis* Haseman, 1911; Type locality: Grande River, affluent of the Paraná River, at Jaguara, Minas Gerais, Brazil; topotypes: LISDEBE 6325, 1, Grande River, downstream of the Jaguara Reservoir Dam (-20,01604, -47,42649), LISDEBE 6315, 1, São Pedro Stream, affluent of the Grande River at the Igarapava Reservoir (-20,05109, -47,58948), 10 July 2015.

Some formerly defined target species were not encountered by us during the fieldwork at their type localities. Some of them are common to the rivers of upper Paraná basin, such as the anostomid *Leporinus striatus* Kner, 1858, the parodontid *Apareiodon piracicaba* (Eigenmann, 1907), the characid *Serrapinnus heterodon* (Eigenmann, 1915), and the loricariid *Rineloricaria latirostris* (Boulenger, 1900). Other species are rare, as the cetopsid *Cetopsis gobioides* Kner, 1858 and *Parastegophilus paulensis* (Miranda Ribeiro, 1918); or figure in threatened species lists: the prochilodontid *Prochilodus vimboide*s Kner, 1859, the serrasalmid *Myloplus tiete* (Eigenmann & Norris, 1900), the characid *Aphyocheirodon hemigrammus* Eigenmann, 1915, and the pimelodid *Zungaro jahu* (Ihering, 1898). The characid *Brycon nattereri* Günther, 1864 is actually considered extinct at the region of its type locality.
Environmental quality and conservation of fish diversity

During field trips were possible to verify deleterious environmental changes in the covered area. In fact, São Paulo State is widely transformed by historical occupation. Riverine environments sampled by the naturalists were changed by river impoundment for hydroelectric purposes, introduction of species, and pollution, among others. Most part of the regions we collected are inserted in an agricultural landscape matrix, but some of them also present dense occupation in great urban areas, such as Piracicaba region, and the waste is easily detectable, precluding fish maintenance in some places.

In rural areas, most the small to medium rivers have the bank vegetation suppressed and commonly their river beds are silted. The great rivers Tietê and Grande are actually transformed in reservoirs cascades. Besides the inherent environmental changes caused by river impoundment, introduction fish species in the artificial reservoirs also contribute to deleterious effects in the native fish fauna diversity. Some alien species were registered by us in Jaguara and Avanhandava regions.

As stated above, upper Paraná River represents an area of endemism of the Neotropical freshwater fish fauna. It also represents the most well studied river drainage of Brazil. The environmental threatens observed in the visited regions are largely present in other areas of the basin. Even with environmental changes, rivers in São Paulo State still furnish shelter for the regional fish diversity. During fieldwork, other fish species were collected with the target species, and the registration of these species in each location may help to fulfill gaps of information about species distribution in the upper Paraná River.

Conclusion

Although topotypes appears as a term not regulated in the International Code of Zoological Nomenclature, their value for development of studies in taxonomy is unquestionable. With development of complementary approaches for the morphological data and the uselessness of the typological species concept, topotypes analysis became important framework for systematics. Anatomical and molecular data from topotypes bring security to the information about a species. There are still much to be known about phylogenetic relationships of Neotropical freshwater fish species or groups of species, and topotypes may help systematics research of the species with taxonomical problems and those that types are lost or in bad conditions.

The procedure to perform topotypes collection requires the access to the historical information about species descriptions. We focused on species described from upper Paraná River basin and we needed to access the historical context in which the naturalists traveled through Brazil in the 19th and beginning of 20th centuries. In this way, we assembled sparse information about ichthyological studies in Brazil, in a specific period, and they may be used for diffusion of scientific knowledge. Projects aiming to assembly topotypes collections of any taxa may represent the opportunity to develop interdisciplinary knowledge in biological sciences.

Acknowledgments

We thank Fernando Apone for critical reading and suggestions on the manuscript. Fapesp (process 2011/50213-5) provided financial support to fieldwork and research development.

References


