Fishes of the Taquari-Antas river basin (Patos Lagoon basin), southern Brazil

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Received November 29, 2011 – Accepted March 23, 2012 – Distributed February 28, 2013
(With 4 figures)

Abstract

The aquatic habitats of the Taquari-Antas river basin (in the Patos Lagoon basin, southern Brazil) are under marked environmental transformation because of river damming for hydropower production. In order to provide an information baseline on the fish fauna of the Taquari-Antas basin, we provide a comprehensive survey of fish species based on primary and secondary data. We found 5,299 valid records of fish species in the basin, representing 119 species and 519 sampling sites. There are 13 non-native species, six of which are native to other Neotropical river basins. About 24% of the total native species are still lacking a taxonomic description at the species level. Three native long-distance migratory species were recorded (*Leporinus obtusidens*, *Prochilodus lineatus*, *Salminus brasiliensis*), as well as two potential mid-distance migrators (*Parapimelodus nigribarbis* and *Pimelodus pintado*). Although there is only one officially endangered species in the basin (*S. brasiliensis*), restricted range species (21.7% of total species) should be considered in conservation efforts.

Keywords: ichthyofauna, biodiversity, survey, neotropical, Rio Grande do Sul.

Peixes da bacia do rio Taquari-Antas (sistema da Laguna dos Patos), sul do Brasil

Resumo

Os ambientes aquáticos da Bacia do rio Taquari-Antas (Bacia da Laguna dos Patos, sul do Brasil) vêm sofrendo considerável transformação, principalmente em razão da implantação de barragens para geração de energia elétrica. Com o objetivo de estabelecer um diagnóstico amplo da ictiofauna da Bacia do Taquari-Antas, realizou-se um inventário das espécies dessa bacia a partir de dados primários e secundários. Foram obtidos 5.299 registros válidos de espécies de peixe na bacia, representando 119 espécies e 519 localidades amostradas. Ocorrem, na bacia, 13 espécies não nativas, seis das quais são oriundas de outras bacias neotropicais. Cerca de 24% de todas as espécies carecem de descrição taxonômica no nível específico. Foram registradas três espécies nativas migradoras de longa distância (*Leporinus obtusidens*, *Prochilodus lineatus* e *Salminus brasiliensis*) e duas potenciais migradoras de média distância (*Parapimelodus nigribarbis* e *Pimelodus pintado*). O fato de uma espécie ser oficialmente reconhecida como ameaçada na bacia (*S. brasiliensis*) e a grande proporção de espécies de distribuição restrita (21,7% do total) devem ser levados em consideração nos esforços de conservação.

Palavras-chave: ictiofauna, biodiversidade, inventário, neotropical, Rio Grande do Sul.

1. Introduction

The Brazilian freshwater fish fauna is extremely diverse, with more than 2,500 valid species distributed through several habitat types and river systems, and there is a growing number of new species being described (Buckup et al., 2007). However, river basins in Brazil are becoming increasingly transformed by human activities, particularly in the southeastern and southern regions, where land use change, pollution and damming for hydroelectricity are the main factors affecting fish conservation (Agostinho et al., 2008; Barletta et al., 2010). This continuous process of environmental change threatens the existence of fish species and their habitats, therefore conservation planning and

prioritization require information on species composition and distribution in relatively large areas. In Brazil, surveys for improving the knowledge base on freshwater fishes are frequently called for (Vari and Malabarba, 1998; Agostinho et al., 2005, 2008; Buckup et al., 2007).

In this paper, we present the results of a fish species survey in the Taquari-Antas river basin (26.470 km^2), in southern Brazil. This region has been historically affected by urban, industrial and agricultural activities, although there are several relatively less affected areas of Atlantic forest and natural grasslands. In the early 2000s, river damming for hydropower generation became an additional cause of environmental transformation. By the end of 2010, there were 26 hydroelectric power plants (from <1 MW to 130 MW) in operation or under construction in the Taquari-Antas basin, with more than 80 sites under examination for potentially new dams (data from the Rio Grande do Sul State Foundation for Environment Protection – FEPAM, and from the Brazilian electric power authority database, ANEEL/SIGEL). In the lower Taquari river there is also a canal lock for navigation, which can be considered the first obstacle for upstream fish migration.

In spite of a relatively large number of recent taxonomic studies and fish sampling across the Taquari-Antas basin, a consolidated overview of the fish species composition and distribution is lacking. Studies providing a wider perspective of the Taquari-Antas fishes were only recently published (Malabarba et al., 2009; Luz-Agostinho et al., 2010), however their scope was limited to specific regions within the watershed. Malabarba et al. (2009) surveyed the fishes from the high basaltic plateau, including the headwaters of the Taquari-Antas and Caí rivers (both in the Patos Lagoon basin) and of Pelotas and Canoas rivers (upper Uruguay river basin). They found 46 species and a high degree of endemism for fishes of the Jacuí headwaters (21.7%), which include the Taquari-Antas headwaters. Luz-Agostinho et al. (2010) found 70 species in the mid-stretch of the Taquari-Antas and several tributaries, and also report baseline information on the reproduction and feeding of several species.

Our main objective is to present a comprehensive survey of the fish species of the Taquari-Antas basin. We used primary data from our own field collections, but also compiled a large amount of secondary data, including samples from several different habitats. In particular, we aimed at producing a species list that is the best approximation of the actual species composition in the studied area, and where taxonomic consistence and uncertainties are objectively pointed out. We also assessed the fish fauna in terms of non-native species, conservation status, general spatial distribution patterns, species with restricted geographical distribution, and migratory species.

2. Material and Methods

2.1. Study area

The Taquari-Antas basin is situated in southern Brazil (state of Rio Grande do Sul) and is one of the main sub-basins of the Patos Lagoon basin (Figure 1), which is a large drainage flowing into the Atlantic Ocean and is one of the freshwater ecoregions recognized by Abell et al. (2008). It is a 7th order river basin (Strahler, 1957; stream network map at 1:250.000 scale) with a total area of 26.470 km^2. The Antas river, as the main river is called in the upper section of the basin, flows from a high basaltic plateau (*ca.* 800 to 1200 m a.s.l) through deeply incised valleys until the lowlands, where it is known as Taquari river.

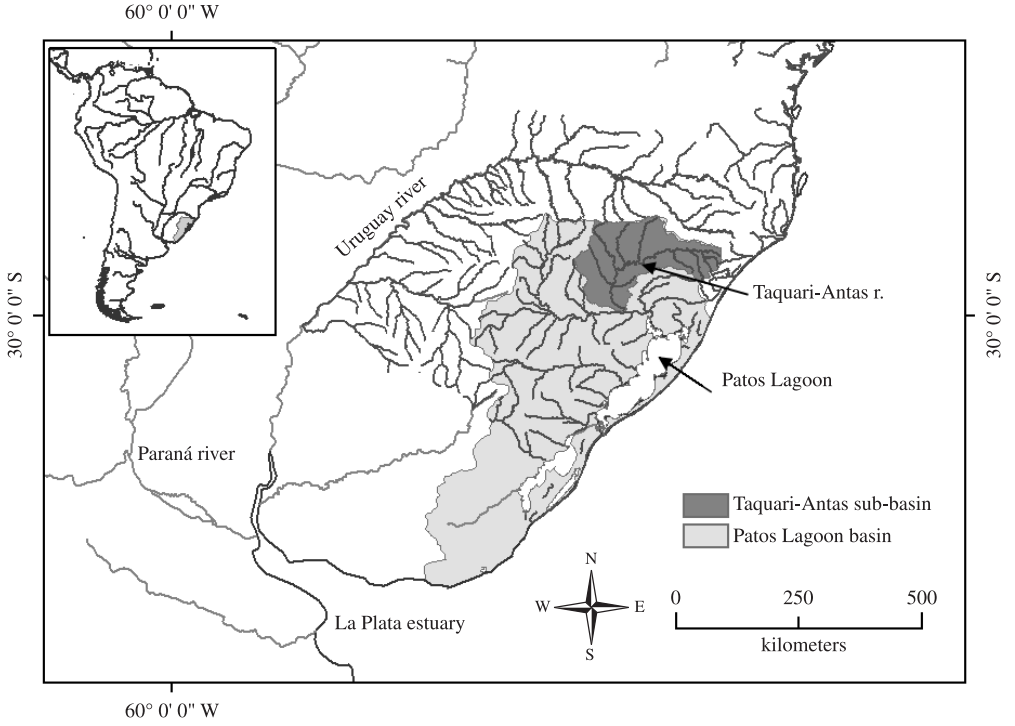

Figure 1. Geographic location of the Taquari-Antas basin within the Patos Lagoon basin.

The lowlands flow through terrains formed by alluvial deposits in elevations between 20 m to 100 m a.s.l. The main river channel, from headwaters to the confluence with Jacuí river, is *ca*. 400 km long and the mean annual flow is 606 $m^3.s^{-1}$ (Rio Grande do Sul, 2007).

2.2. Species records

We determined the fish species of the Taquari-Antas basin from primary and secondary data. Primary data were obtained by sampling fish assemblages at several localities across the study area during 2010. Secondary data were obtained by reviewing and validating records from the largest and most regionally representative fish collections (Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul, MCN; Museu de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul, MCP; Department of Zoology of Universidade Federal do Rio Grande do Sul, UFRGS). Additionally, we reviewed species records from scientific publications and technical environmental reports available at FEPAM.

The fish records compiled comprise samples obtained by several different fishing techniques (gill nets, seine nets, cast nets, dip nets and electrofishing) and encompassed several habitat types (small streams to large rivers, reservoirs and small wetlands).

2.3. Geographical coordinates of species records

After compiling the fish record database for the whole Taquari-Antas basin, we found three types of geographic location data: (a) descriptions of the sampling site geographic location without geographic coordinates (found mostly in museum records and in bibliographic sources), (b) geographic coordinates that had been obtained in the field, using GPS receivers and (c) geographic coordinates from unknown sources. In the first case, we approximated geographic coordinates on the basis of the site descriptions or site locations pictured in maps included in the bibliographic sources, using a geographic information system ArcGis (ESRI) and the digital version of the official 1:50.000 cartographic database of Rio Grande do Sul (Hasenack and Weber, 2010). This cartographic database includes the stream network, roads, cities and detailed toponymy, and is usually used by researchers for field navigation and for describing sampling site locations. Information about the *datum* associated with geographic coordinates was rare in the database, therefore we assumed WGS84 for all records.

2.4. Taxonomic validation

Fish samples collected by the authors were identified or validated by taxonomy specialists. Voucher specimens of all species can be found in at least one of the reviewed museum collections (MCN, MCP, UFRGS). Species records from secondary sources (museum databases and non-taxonomic bibliographic sources) have been subject to nomenclature actualization (*e.g.*, *Astyanax alburnus* to *Cyanocharax alburnus*, *cf.* Malabarba and Weitzman, 2003; *Pimelodus maculatus* to *Pimelodus pintado*, *cf.* Azpelicueta et al., 2008). Museum specimens were examined only when the actual presence of a species in the Taquari-Antas basin depended exclusively on the valid identification of a particular sample. We did not consider as valid any record with dubious taxonomic identification and that could not be validated by examining vouchers specimens in scientific collections. We also excluded any record with a geographic location that could not be unequivocally determined to be within the Taquari-Antas basin. The taxonomic classification follows Reis et al. (2003a), except for the use of Labriformes (Wiley and Johnson, 2010).

We assessed the species conservation status according to the endangered species list of Rio Grande do Sul (Reis et al., 2003b) and the Brazilian list of endangered fish species (Instrução Normativa do Ministério do Meio Ambiente nº 05, 21 de maio de 2004). To determine species with restricted geographical ranges (<10.000 km^2 *sensu* Nogueira et al., 2010), we used data from our survey and primary literature, rather than assuming *a priori* only the species listed by Nogueira et al. (2010). We considered as migratory those species mentioned by Luz-Agostinho et al. (2010). Any species whose natural distribution does not include the Patos Lagoon basin was considered as non-native. We also described the general distribution pattern of species across the main geomorphological sections of the Taquari-Antas basin (Lowlands, Mid-slopes, and Plateau). Species were classified as typical of a section when >70% of their records were included in only one section. Species occurring in all sections and with more than 30% records in at least two sections were considered to be well distributed across the Taquari-Antas basin.

3. Results

We obtained 5,299 valid presence records of fish species in the Taquari-Antas basin, representing 119 species (including non-native species; Table 1) and 519 sampling sites (Figure 2). The total number of species (119) was determined only after a validation process on a preliminary listing of 266 nominal *taxa* obtained from the secondary data. Most sampling sites (43.3%) were located in higher elevation areas of the plateau, while the remaining were situated in the slopes between the lowlands and the plateau (32%) and in the lowlands (24.7%) (Figure 2).

There were records for 13 non-native species (10.9% of the total number of species), six of which are native to other Neotropical river basins (Table 2). About 25% of the total native species are still lacking a taxonomic description at the species level. Several of the recorded species have a relatively limited geographical distribution (Table 2), including only the Taquari-Antas basin, or the Taquari-Antas and adjacent neighboring watersheds (Upper Uruguay, Sinos, and Caí river, and the headwaters of small coastal watersheds). Only *Salminus brasiliensis* is officially listed as a threatened species (Reis et al., 2003b).

At least six migratory species were recorded in the Taquari-Antas basin: the long distance migrants *Leporinus obtusidens*, *Prochilodus lineatus*, *Salminus brasiliensis*, the mid-distance migrants *Parapimelodus nigribarbis* and *Pimelodus pintado*, and the non-native *Acestrorhynchus pantaneiro*. The migratory species were represented by few locality records (except for *Pimelodus pintado*, Figure 3), and were mostly limited to the mid- and lower sections of the rivers, downstream the Cachoeirão rapids, except for one record of *Leporinus obtusidens* at the Tainhas river (see Figure 3). *Pimelodus pintado* was the most widely distributed migratory species with several records upstream the Cachoeirão and in upper parts of the main tributaries of the Antas river (Prata, Carreiro and Guaporé rivers).

Table 1. Fish species of the Taquari-Antas river basin (Patos Lagoon basin), southern Brazil.

Taxon	Origin	Comments
ATHERINIFORMES		
Atherinopsidae		
Odontesthes humensis	Native	
Odontesthes sp.	Native	
CHARACIFORMES		
Anostomidae		
Leporinus obtusidens	Native	
Schizodon jacuiensis	Native	
Acestrorhynchidae		
Acestrorhynchus pantaneiro	Non-native	This species is native to the Paraná-Paraguay (Menezes, 2007). It is presently found as a non-native species in the Patos Lagoon basin (see Saccol and Pereira et al., 2006).
Characidae		
Aphyocharax anisitsi	Non-native	This species is native to the Paraná-Paraguay (Souza-Lima, 2007). Presently it is found as a non-native species in the Patos Lagoon basin.
Astyanax sp. aff. *fasciatus*	Native	Nomenclature follows Melo and Buckup (2006)
Astyanax brachypterygium	Native	Restricted to headwater streams in high elevation (>1000 m). It is not exclusive from the Taquari-Antas basin (Bertaco and Malabarba, 2001)
Astyanax cremnobates	Native	Restricted to headwater streams in high elevation (>1000 m). It is not endemic to the Taquari-Antas basin (Bertaco and Malabarba, 2001)
Astyanax eigenmanniorum	Native	
Astyanax henseli	Native	
Astyanax jacuhiensis	Native	
Astyanax laticeps	Native	
Astyanax obscurus	Native	
Astyanax sp.1	Native	Undescribed species found across the Jacuí river basin (Upper Patos Lagoon basin) (V. A. Bertaco)
Astyanax sp.2	Native	Undescribed species found across found across the Jacuí, Uruguay e Tramandaí river basins (V. A. Bertaco)
Astyanax sp.3	Native	Undescribed species found only in the higher tributaries of the Taquari-Antas basin (V. A. Bertaco)
Astyanax sp.4	Native	Undescribed species found only in the Carreiro river and its tributaries (Taquari-Antas basin) (V. A. Bertaco).
Bryconamericus ecai	Native	This species is known only from its type locality and is endemic to the Taquari-Antas basin (Silva, 2004)
Bryconamericus iheringii	Native	
Bryconamericus patriciae	Native	
Charax stenopterus	Native	
Cheirodon ibicuhiensis	Native	
Cheirodon interruptus	Native	
Cyanocharax alburnus	Native	
Cyanocharax dicropotamicus	Native	
Diapoma speculiferum	Native	
Diapoma thauma	Native	Known only from the Taquari-Antas and Sinos river basins (Menezes and Ribeiro, 2010)
Heterocheirodon jacuiensis	Native	
Hyphessobrycon igneus	Native	This species was usually identified as *H. bifasciatus*, which does not occur in the Patos Lagoon basin (F. L. Barros, personal communication to C.A.S. Lucena; Carvalho, 2011)
Hyphessobrycon luetkenii	Native	
Hypobrycon sp.	Native	New species under description by L. R. Malabarba and J. Pezzi da Silva

Table 1. Continued...

Taxon	Origin	Comments
Oligosarcus jacuiensis	Native	
Oligosarcus jenynsii	Native	
Oligosarcus robustus	Native	
Oligosarcus sp.	Native	Potentially a new species (N. A. Menezes, personal communication to C. A. S. Lucena). We found one record for *O. brevioris* (MCP18700), however the data on the collection site is ambiguous and insufficient to validate the occurrence of this species in the Taquari-Antas basin
Pseudocorynopoma doriae	Native	
Salminus brasiliensis	Native	
Serrapinnus calliurus	Native	
Crenuchidae		
Characidium gr. *zebra*	Native	
Characidium orientale	Native	
Characidium pterostictum	Native	
Characidium tenue	Native	
Curimatidae		
Cyphocharax spilotus	Non-native	This species was known only for the Uruguay river and lower Paraná basin, however it has been recently found also in the Patos Lagoon basin (*e.g.*, Flores-Lopes et al., 2010; Luz-Agostinho et al., 2010)
Cyphocharax voga	Native	
Steindachnerina biornata	Native	
Erythrinidae		
Hoplias lacerdae	Non-native	Its original distribution includes the Ribeira do Iguape and Uruguay river basins (Oyakawa and Mattox, 2009). Its introduction in the Patos Lagoon basin has possibly resulted from escapement from small fishing ponds and fish culture facilities
Hoplias aff. *malabaricus*	Native	
Prochilodontidae		
Prochilodus lineatus	Native	
CLUPEIFORMES		
Clupeidae		
Platanichthys platana	Native	
Engraulididae		
Lycengraulis grossidens	Native	
CYPRINIFORMES		
Cyprinidae		
Ctenopharingodon idella	Non-native	Native from Asia, this species has been introduced for aquaculture activities
Cyprinus carpio	Non-native	Native from Asia, this species has been introduced for aquaculture activities
Hypophthalmichthys nobilis	Non-native	Native from Asia, this species has been introduced mainly for aquaculture activities
CYPRINDONTIFORMES		
Anablepidae		
Jenynsia eirmostigma	Native	Endemic to high elevation streams in the Basaltic Plateau where the headwaters of the Antas and Upper Uruguay rivers are situated (Malabarba et al., 2009)
Poecilidae		
Cnesterodon brevirostratus	Native	Restricted to small streams and wetlands in high elevation areas; it is not endemic to the Taquari-Antas basin (Malabarba et al., 2009)
Cnesterodon sp.	Native	Undescribed species. Occurs in small streams at high elevation areas; probably not endemic to the Taquari-Antas basin (Malabarba et al., 2009)
Phalloceros caudimaculatus	Native	

Table 1. Continued...

Taxon	Origin	Comments
GYMNOTIFORMES		
Gymnotidae		
Gymnotus aff. *carapo*	Native	Albert and Crampton (2003) restricted the distribution of *Gymnotus carapo* to the Amazon and Orinoco basins, coastal rivers of the Guianas and the Parnaíba and Itapicuru rivers in northeastern Brazil. There are undescribed species in the Patos Lagoon basin, including the one in the Taquari-Antas basin. It is possibly a new species in the *G. carapo* group
Gymnotus chimarrao	Native	
Sternopygidae		
Eigenmannia trilineata	Native	
LABRIFORMES		
Cichlidae		
Australoheros sp.	Native	Undescribed species (Rican and Kullander (2006)
Australoheros taura	Native	Endemic to the Taquari-Antas basin (Ottoni and Cheffe, 2009)
Crenicichla lepidota	Native	
Crenicichla punctata	Native	
Geophagus brasiliensis	Native	
Gymnogeophagus gymnogenys	Native	
Gymnogeophagus labiatus	Native	
Oreochromis niloticus	Non-native	Introduced for aquaculture, it has escaped or sometimes intentionally released in natural waters
PERCIFORMES		
Centrarchidae		
Micropterus salmoides	Non-native	Native to North America, this species was intentionally introduced in the 1980s for sport fishing in fish ponds and streams (Malabarba et al., 2009)
Sciaenidae		
Pachyurus bonariensis	Non-native	This species is native to the Paraná-Paraguay (Casatti, 2003). It is presently found as a non-native species in the Patos Lagoon basin (see Dufech and Filaho, 2007).
SALMONIFORMES		
Salmonidae		
Onchorynchus mykiss	Non-native	Native to North America, this species was intentionally introduced in the 1980s for sport fishing in high elevation streams (Malabarba et al., 2009)
SILURIFORMES		
Aspredinidae		
Bunocephalus erondinae	Native	
Pseudobunocephalus iheringii	Native	
Auchenipteridae		
Glanidium sp.	Native	Comparative studies of the lower Jacuí populations are needed to determine whether this is a new species. Geographically, the closer species is *G. catharinensis* Miranda-Ribeiro, from Tubarão river, in the state Santa Catarina, southern Brazil
Trachelyopterus lucenai	Non-native	Its original distribution includes the Uruguay river and Patos Lagoon basins. This species was not mentioned in Akama and Sarmento-Soares (2007) because it was considered a synonym of *Parauchenipterus porosus* (Eigenmann and Eigenmann, 1888) in Akama (2004).
Callichthyidae		
Corydoras paleatus	Native	
Hoplosternum littorale	Native	
Heptapteridae		
Heptapterus mustelinus	Native	
Heptapterus sp.	Native	
Pimelodella australis	Native	
Rhamdella eriarcha	Native	

Table 1. Continued...

Taxon	Origin	Comments
Rhamdia quelen	Native	We keep the use of *Rhamdia quelen* until conclusive studies about the populations of this genus are available
Ictaluridae		
Ictalurus punctatus	Non-native	This north-american catfish was introduced in fish ponds for fish production and escaped into natural waters
Loricariidae		
Ancistrus brevipinnis	Native	
Ancistrus sp.	Native	
Eurycheilichthys sp. 1	Native	Undescribed species, with distribution restricted to the Taquari-Antas basin; it is known only from the Fão river (R. E. Reis, personal communication)
Eurycheilichthys sp. 2	Native	Undescribed species, potentially endemic to the Taquari-Antas basin (see Reis and Carvalho, 2007)
Eurycheilichthys sp. 3	Native	Undescribed species, with geographical distribution restricted to the Taquari-Antas basin; it is known only from the Prata river (R. E. Reis, personal communication)
Eurycheilichthys sp. 4	Native	Undescribed species, with geographical distribution restricted to the Taquari-Antas basin; it is known only from the upper Guaporé river (R.E. Reis, personal communication)
Eurycheilichthys sp. 5	Native	Undescribed species, potentially endemic to the Taquari-Antas basin (see Reis and Carvalho, 2007)
Eurycheilichthys sp. 6	Native	Undescribed species, potentially endemic to the Taquari-Antas basin (see Reis and Carvalho, 2007)
Eurycheilichthys sp. 7	Native	Undescribed species, potentially endemic to the Taquari-Antas basin (see Reis and Carvalho, 2007)
Hemiancistrus punctulatus	Native	
Hisonotus armatus	Native	
Hisonotus carreiro	Native	Endemic to the Taquari-Antas basin (Carvalho and Reis, 2011)
Hisonotus prata	Native	Endemic to the Taquari-Antas basin (Carvalho and Reis, 2011)
Hisonotus vireo	Native	
Hypostomus aspilogaster	Native	
Hypostomus commersonii	Native	
Loricariichthys anus	Native	
Pareiorhaphis hystrix	Native	
Rineloricaria baliola	Native	
Rineloricaria cadeae	Native	
Rineloricaria malabarbai	Native	
Rineloricaria microlepidogaster	Native	
Rineloricaria strigilata	Native	
Pimelodidae		
Parapimelodus nigribarbis	Native	
Pimelodus pintado	Native	
Pseudopimelodidae		
Microglanis cottoides	Native	
Trichomycteridae		
Homodiaetus anisitsi	Native	
Ituglanis sp.	Native	First record of this genus in the Patos Lagoon basin (J. Ferrer)
Scleronema sp.	Native	*Scleronema* sp. is known only from two records in the Taquari-Antas basin; it is different from other species known in Rio Grande do Sul
Trichomycterus sp.1	Native	Undescribed species, potentially endemic to the Taquari-Antas basin; known only from the Turvo and Prata sub-basins (J. Ferrer)
Trichomycterus sp.2	Native	Undescribed species (J. Ferrer)
Trichomycterus sp.3	Native	Undescribed species (J. Ferrer)

Table 1. Continued...

Taxon	Origin	Comments
Trichomycterus sp.4	Native	Undescribed species (J. Ferrer)
Trichomycterus tropeiro	Native	Endemic to the headwaters of the Taquari-Antas basin (Ferrer and Malabarba, 2011), it occurs only in elevations > 1000 m
SYNBRANCHIFORMES		
Synbranchidae		
Synbranchus marmoratus	Native	

Table 2. Proportion of non-native species and proportion of restricted range species occurring in the Taquari-Antas basin. Restricted range species have total geographical distribution of less than 10.000 km^2 (*sensu* Nogueira et al., 2010).

Non-native species (geographic origin)	n	% total species
Neotropical (South America)	6	5.1
Other regions (Asia, North America, Africa)	7	5.9
Total	13	10.9
Restricted range species	**n**	**% (total native species)**
Distribution in the Taquari-Antas and adjacent river basins	7	6.6
Endemic or potentially endemic to the Taquari Antas basin[1]	16	15.1
Total (restricted distribution)	23	21.7

[1]Distribution status of undescribed species needs confirmation from further studies.

The fish fauna of the Taquari-Antas presents a relatively clear distribution pattern across the three geomorphological sections of the basin (Figure 4). Most species (58%) are typically distributed in lowland rivers and streams, but about half of these species had at least a few records (<30% of total specific records) in the Mid-slope valleys and in the Plateau. A typical fish fauna is also found in the Plateau (20% of total native species), including 16 species for which all records were located in this geomorphological section. In the transition between the Plateau and the Lowlands - *i.e.*, the Mid-slopes section - there is an overlap in the distribution of lowland species and headwater species, with few typical species (9.5% of total species). Only 12.4% of all native species were relatively common in the three geomorphological sections (*e.g.*, *Bryconamericus iheringii*, *Characidium pterostictum*, *Geophagus brasiliensis*, *Gymnotus* aff. *carapo*, *Hyphessobrycon luetkenii*, *Phalloceros caudimaculatus*).

4. Discussion

According to our survey, knowledge about the fishes of the Taquari-Antas basin was relatively poor until the late 1990s, and consisted of several records in museum databases (the oldest record in the examined collections dates from 1977; 62% of the collection records were sampled after 1999), and descriptions of species with geographical distributions that included the region (*e.g.*, Malabarba, 1989; Buckup, 1993; Malabarba and Mahler Junior, 1998; Cardoso and Malabarba, 1999). In the late 1990s, fish sampling was intensified as part of baseline studies for environmental impact assessments (EIA), which are demanded by the State and Federal environmental agencies (FEPAM and IBAMA) in Brazil. Vouchers of most of these samples are now kept in the fish collections of the MCN, MCP and UFRGS. From 2000 to 2011, several new species occurring in the basin were described (*e.g*, Silva, 2004; Rodriguez and Reis, 2008; Carvalho et al., 2008; Carvalho and Reis, 2009; Cognato et al., 2009; Ottoni and Cheffe, 2009; Menezes and Ribeiro, 2010; Ferrer and Malabarba, 2011; Menezes and Weitzman, 2011), but there are few studies and publications on ecology, reproductive biology or conservation (Guadagnin et al., 1998; Majolo, 2005; Alves and Fontoura, 2009; Hirschmann et al., 2008; Luz-Agostinho et al., 2010).

The number of species in the Taquari-Antas basin represents *ca.* 65% of the total number of known species for the Patos Lagoon basin (160 species, including 35 undescribed species; Malabarba et al., 2009). The number of native species in physiographically similar and geographically close river basins varies from 51 (Pardinho river, Patos Lagoon basin; Ribeiro and Köhler, 2007) to 79 (Maquiné river, in the Tramandaí river system; F. G. Becker, unpublished data) and 89 (Sinos river, Patos Lagoon basin; Leal et al., 2009). However, a proper comparison is not possible because these studies used distinct survey methods and because the studied watersheds vary in total area and ecological integrity.

The proportion of undescribed species in the Taquari-Antas is relatively large (23.6%) and similar to estimates for the whole Patos Lagoon and Uruguay river basins (21.9% and 22.2%, respectively; Malabarba et al., 2009). It is particularly important to note that part of these undescribed species are small headwater fish (*e.g. Eurycheilichthys* and *Trichomycterus*), with potentially small geographic ranges, reinforcing the previous observations of a highly underestimated diversity in the region (Malabarba et al., 2009). As noted by Ferrer and Malabarba (2011), all the highly endemic species described to the basaltic highlands (which include the Taquari-Antas mid-slope rivers and

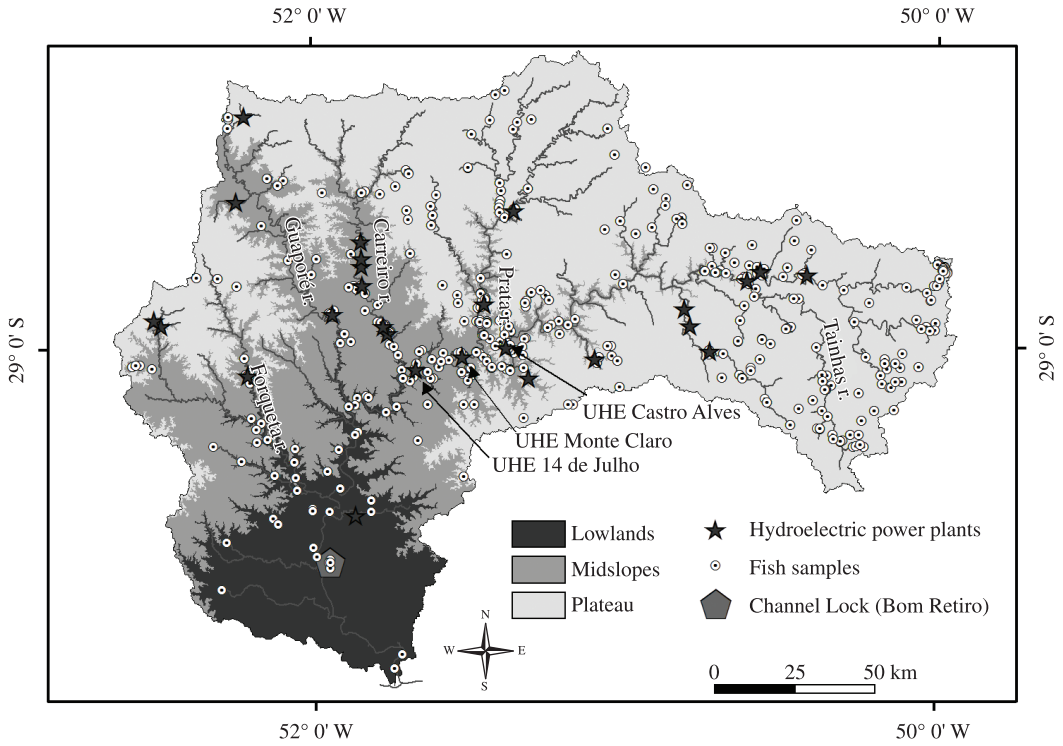

Figure 2. Locations of fish sample sites (n = 519; circles may represent more than one site) in the Taquari-Antas basin, and position of the hydroelectric power plants (>0.5 MW) in operation or in different construction stages in early 2011 (black squares). Arrows indicate the three main dams in the basin (UHE = hydroelectric power plant).

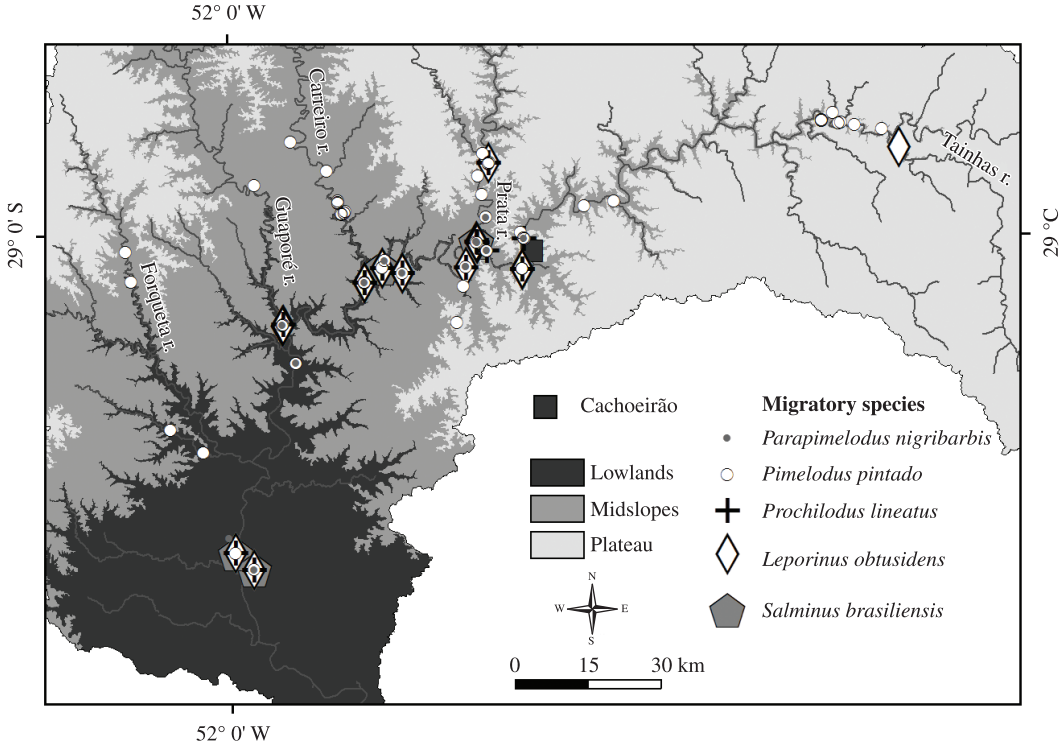

Figure 3. Records of migratory species in the Taquari-Antas basin. The Cachoeirão is a short stretch of the main channel of the Antas river with strong rapids and used to be considered a possible obstacle to several species. It is presently situated between the Castro Alves and Monte Claro dams.

headwater streams) have been discovered and described in the last 20 years. It is also interesting that some undescribed species of *Astyanax* are widely distributed across adjacent river basins, but at least two are potentially endemic to areas within the Taquari-Antas basin.

The main distribution of the migratory species in the Antas river seems to be limited upstream by the strong rapids known as "Cachoeirão", as previously noted by Luz-Agostinho et al. (2010). However, these species were represented by few records in our survey (except for *P. pintado*) and were not effectively sampled before the construction of the main dams in the Antas river (14 de Julho, Monte Claro and Castro Alves, in the early 2000s; Figure 3). The "dourado", *Salminus brasiliensis*, probably used to be present in upper reaches of the basin, as suggested by occurrence data determined by Alves and Fontoura (2009) from interviews with fishermen. The migratory status of *Pimelodus pintado* is still not well established (Alves and Fontoura, 2009), but its reproductive behavior could be similar to *Pimelodus maculatus*. The latter species migrates for long-distances, but is abundant in serially impounded rivers, as the Tietê and Grande rivers (Agostinho et al., 2007), probably being able to reproduce in shorter free river stretches (Agostinho et al., 2003).

We registered a high proportion of species with small geographical ranges (*ca*. 10000 km^2 in range, following Nogueira et al., 2010), either endemic to the Taquari-Antas basin or not (Table 2). These numbers were based on recent publications (see Table 1) and on-going taxonomic investigations (J. Ferrer; V. A. Bertaco; R. E. Reis), and add another 11 species to those already listed by Nogueira et al. (2010). Most of these species occur in the upper portions of the basin (only in the Plateau or also in the Mid-slopes and valleys), as *Eurycheilichthys* spp. and *Trichomycterus* spp.. At least one species is known only from its type locality (*Bryconamericus ecai*, Silva, 2004) despite the extensive sampling in the basin. Because restricted range species are potentially more susceptible to environmental impacts and to extinction, they should be considered as targets for assessments in conservation planning and environmental licensing. This is particularly relevant in the Taquari-Antas basin, in face of the high potential for increase in the number of dams for hydroelectric power production and for land transformation (forestry and agriculture) in the upper sections of the basin.

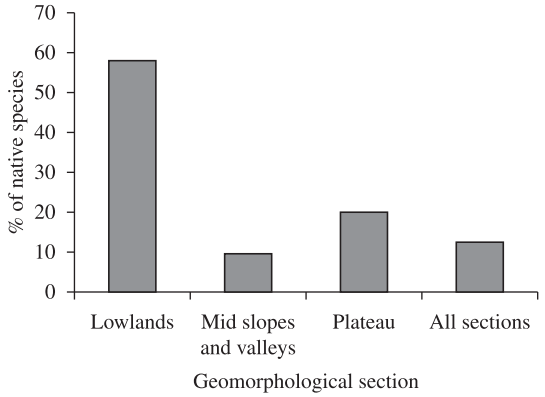

Figure 4. Percent distribution of native fish species (n = 105) in the main geomorphological sections of the Taquari-Antas basin. In *All sections*, we included species occurring in the three geomorphological sections and with more than 30% records in at least two of them.

The non-native species represented a relevant proportion (10.9%) of the total species registered in the basin, however information on their abundance, population dynamics and on their impacts on the native biota is still lacking. About half of the non-native species are original from non-Neotropical regions; some of these were introduced in fish ponds for aquaculture production and escaped into natural habitats (*e.g. Cyprinus carpio*, *Ictalurus punctatus* and *Oreochromis niloticus*), while others were released directly into streams and rivers for sport fishing (the black bass, *Micropterus salmoides*, and the rainbow trout, *Onchorynchus mykiss*, particularly in streams of the basaltic plateau). Results from a fish monitoring program with extensive sampling between 2002-2009 indicated that non-native species occur only in low abundances in the mid-lower Taquari-Antas, and evidence for reproductive populations has been indirectly suggested only for *C. carpio* (Luz-Agostinho et al., 2010). Some of the Neotropical non-natives were probably unintentionally introduced via inter-basin man-made connections resulting from land management for agriculture (rice fields), and eventually dispersed rapidly and reached high abundances in different parts of the Patos Lagoon basin (*e.g. Pachyurus bonariensi*s and *Trachelyopterus lucenai*, see Becker, 2002; Saccol-Pereira et al., 2006; Becker et al., 2007; Dufech and Fialho, 2007). We found museum records (MCP) for *Tilapia rendalli* collected in fish ponds in the late 1970s, however there was no record of this species in natural waters at the Taquari-Antas basin.

Considering the results of the present inventory, conservation in the Taquari-Antas basin should consider at least the following three components of the fish fauna. One aspect is to protect habitat for migratory fish (including the endangered *Salminus brasiliensis*), which can only be accomplished if some rivers receive no more dams. An example is the Guaporé river, which seems to function as an alternative reproductive area after the damming of the Taquari-Antas river (Luz-Agostinho et al., 2010). A second point is the protection or restoration of streams and rivers containing restricted range and endemic species, which requires an effort for formal description of these species and their geographical ranges. The third point is taking action to prevent the escapement of non-native species from fish ponds or their deliberate in natural waters, particularly where restricted range and endemic species are present.

Acknowledgements – We would like to thank Marco A. Azevedo for providing access to the the MCN collection records and to Luiz Roberto Malabarba and João Paulo Miranda for providing access to the UFRGS fish collection database. Adriano Cunha (Biolaw) kindly provided information on several fish records from the studied region. Dolores Pineda and Sílvia Pagel provided access to data from the environmental database of FEPAM. Ana Luiza Matte and Bruna Arbo Meneses helped in data management and in checking the geographical coordinates of fish records. Collections made by F. G. Becker were made under authorization of the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA; License n. 1870068).

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