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Rapid Communication

First record of Peacock bass *Cichla kelberi* Kullander & Ferreira, 2006 in the Brazilian Pantanal

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Abstract

Biological invasions impact many communities and ecosystems around the world. Thus, the detection of harmful species is particularly important. In this study, the occurrence of Peacock bass *Cichla kelberi* in the Brazilian Pantanal was registered. The main stream of the Paraguay River, the Padre Inácio stream and their connected lakes were sampled, in the Pantanal, Upper Paraguay River basin. Six specimens were sampled including three females at beginning of maturation. The high level of turbidity of the main channel of the Paraguay River is possibly restricting the dispersal of *C. kelberi* to other regions of the Pantanal. But, due to the voracious piscivory of this species and the impact had in other Neotropical regions, this record highlights that the occurrence of *C. kelberi* can be a new threat to one of the best-conserved wetlands in the world.

Key words: biological invasion, non-native fish, freshwater fish, Neotropical floodplain

Introduction

Species introductions have been considered a process of global change due to its geographical range (Ricciardi 2007), having many negative impacts in communities and ecosystems (Simberloff et al. 2013). Such impacts include the change of native biotas (e.g. Olden et al. 2004) and modifications in the trophic cascades (Zaret and Paine 1973; Cucherousset et al. 2012), among others. In the invasion, a non-native species must overcome a series of barriers that can prevent its survival during the transport, introduction event, establishment and dispersion (Blackburn et al. 2011). When non-native species overcome dispersion barriers, the population of these species can spread to sites far away from the locale of introduction (Blackburn et al. 2011).

In aquatic environments, species introduction is frequently associated with anthropogenic activities (e.g. Johnson et al. 2008; Agostinho et al. 2010; Azevedo-Santos et al. 2011). Aquaculture and sport fishing are important mechanisms of fish species introduction (Naylor et al. 2001; Rahel 2002; Britton and Orsi 2012). The peacock bass *Cichla* spp. are fish species native from the Neotropical Amazonian basin that have been introduced in many other water bodies worldwide (e.g. Zaret and Paine 1973), due to its commercial and game values (Zaret and Paine 1973; Fugi et al. 2008; Pelicice and Agostinho 2009). *Cichla* species behave as highly voracious predators and its colonization can be fast in environments with favorable conditions, especially with high water transparency, as they are highly dependent on visual cues (Fugi et al. 2008). The decrease in the richness, abundance and species diversity of native fish (Latini and Petrere Jr. 2004; Pelicice and Agostinho 2009; Menezes et al. 2012) and changes in the trophic web (Zaret and Paine 1973; Fugi et al. 2008; Pinto-Coelho et al. 2008) are some of the ecological impacts often associated with the introduction of the *Cichla* species.

Cichla piquiti Kullander and Ferreira, 2006 was first introduced in the Pantanal, a Neotropical wetland, in 1982 in the Piquiri River basin, settling in marginal lakes of clear water in this basin (Nascimento et al. 2001; Resende et al. 2008).

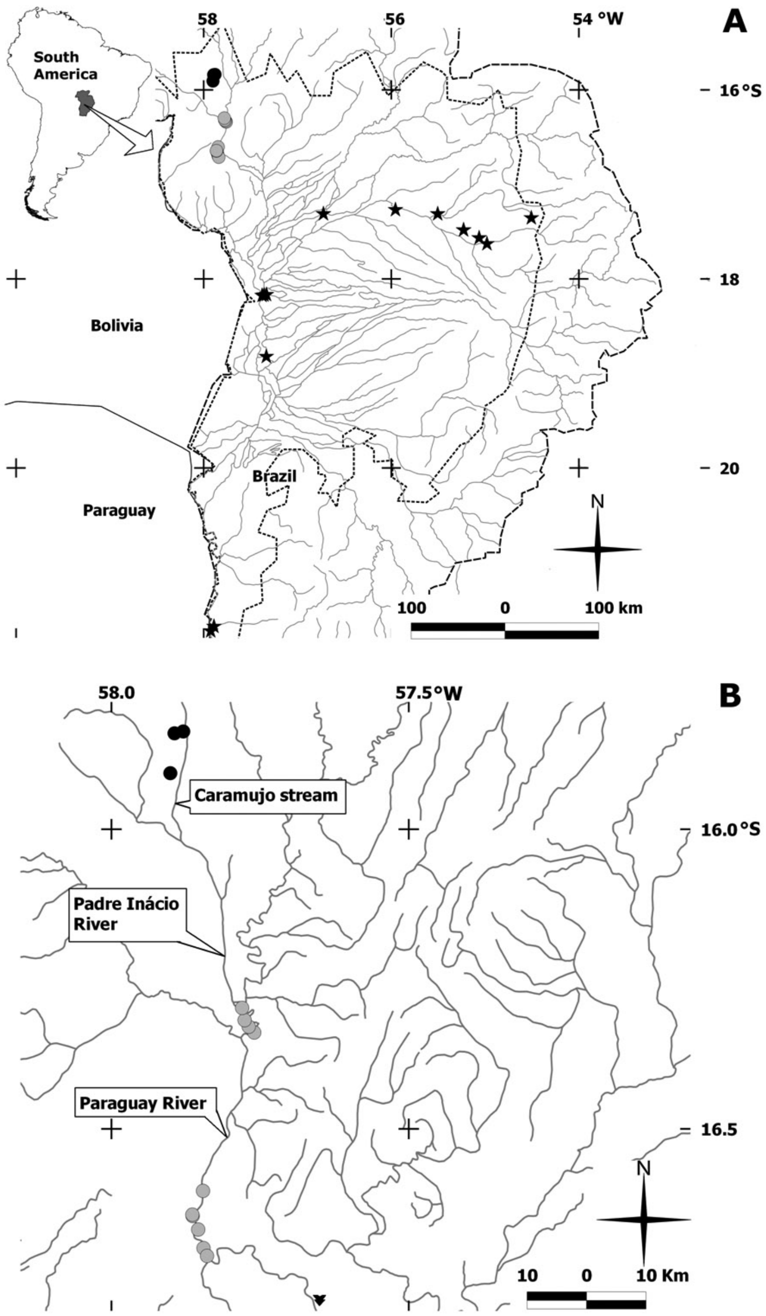

Figure 1. Occurrence of *Cichla kelberi* and *Cichla piquiti* in the Pantanal. **A**: map presenting the occurrence of *C. kelberi* and *C. piquiti* considering this study and records from the literature. .●: sites sampled in this study where *C. kelberi* was present; ●: sites sampled in this study where *Cichla* spp. was not captured; ★ : sites with presence of *C. piquiti* (following Nascimento et al. 2001, Resende et al. 2008 and Súarez et al. 2013); Dotted line: limits of the Brazilian Pantanal floodplain; Dashed line: limits of the Upper Paraguay River basin. **B**: map of the sites in the Paraguay River and Caramujo stream sampled in this study. : flow direction.

The introduction of *C. piquiti* was attributed to the rupture of fish culture ponds in farms in the region where this species was cultivated (Resende et al. 2008). Since its introduction in 1982, no individual specimen of *C. piquiti* or other *Cichla* species were recorded in the superior region of the Pantanal – but note that *C. piquiti* was introduced and is established in the lower reaches of the Pantanal (Nascimento et al. 2001; Resende et al. 2008; Súarez et al. 2013; Figure 1A). This study reports the occurrence of a second *Cichla* species in the Pantanal: *Cichla kelberi* Kullander and Ferreira, 2006. The cause of the *C. kelberi* introduction is also assessed.

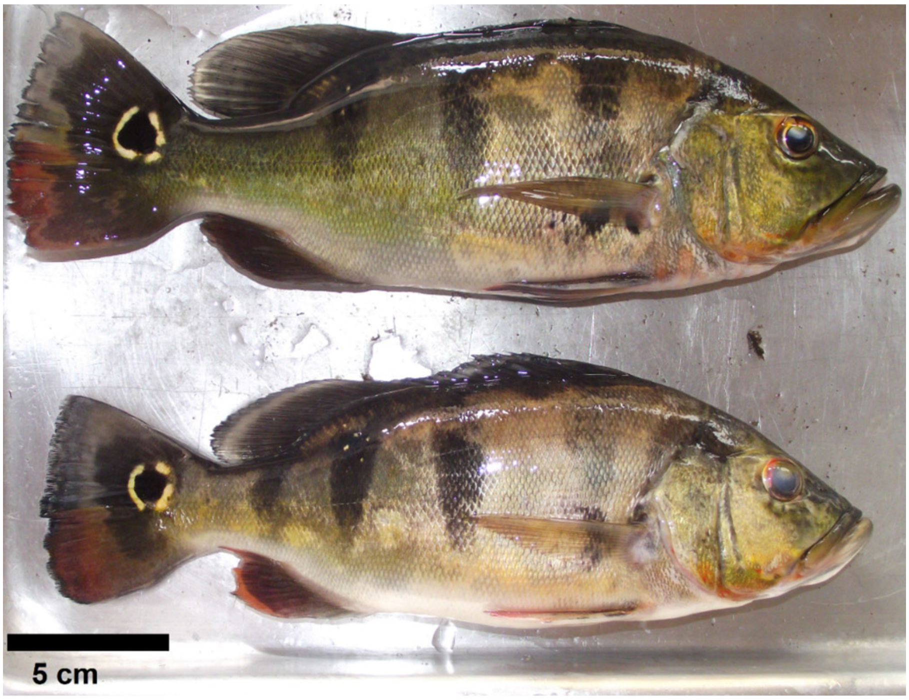

Figure 2. Specimens of *Cichla kelberi* sampled in an adjacent lake of the Caramujo stream, superior region of the upper Paraguay River basin, Pantanal (voucher ID: NUP 14756). Photographs by J.C.G. Ortega.

Material and methods

Study area

The study was conducted in the region of the Pantanal, superior region of the Upper Paraguay River basin, which is between 16º75′S and 57º70′W and 15º80′S and 57º95′W (Figure 1A). The Paraguay River basin has an area of approximately 1.095.000 km^2 (Assine and Silva 2009) and the Paraguay River is the main responsible by the drainage of the basin. The Paraguay River basin has distinct physiographic units. At the plateau exist the headwaters of the main rivers of this basin (Assine and Silva 2009; Fantin-Cruz et al. 2010). In its middle portion, the basin has a depressed region with a relatively flat relief. Finally, the Pantanal has a low and flat relief of a 15 cm/km^{-1} hydraulic gradient (Fantin-Cruz et al. 2010).

Due to their distance from the major urban areas, and with natural reserves comprising 360,000 ha, the Pantanal is relatively well-preserved (Junk et al. 2006). Although, this floodplain is threatened by different anthropogenic activities, such as the agricultural cultivation on an industrial scale at the plateau of the Upper Paraguay River basin, installation of hydropower and waterways is being planned (Harris et al. 2005; Junk et al. 2006). Furthermore, species introductions are another of the changes that threaten the biota, resulting in some socioeconomic problems to the local population (Harris et al. 2005; Junk et al. 2006). Examples of such cases include the spread of the African bee (*Apis mellifera*) and the Asian golden mussel (*Limnoperna fortunei*; see Junk et al. 2006 for more details).

Data collection

Sampling was undertaken in 13 sites of this region between May and June of 2013. These sites were sampled once in this period. A total of three lakes connected to the Paraguay River, seven sites on the main channel of the Paraguay River, two lakes that were seasonally disconnected but associated with the Caramujo stream (Padre Inácio River, a tributary of the Paraguay River) and a site in the Caramujo stream were sampled.

The specimens sampled in this study were accidentally sampled in this region by amateur anglers, so the sampling effort was not standardized or focused to capture *Cichla* species. Sampling was done with hook and line and with artificial and live baits (small characins). In the lakes and the main channel of the Paraguay River, three fishers fished for 12 hrs (from 6:00 AM. to 6:00 PM.), while in the sites associated with the Caramujo stream, two anglers fished for 10 hrs (from 8:00 AM to 6:00 PM). In all of the lake sites, either the open area near the macrophytes (submerged and floating species) in the lakes or the open area of the main channel of the river was sampled.

The specimens were fixed in 10% formaldehyde for 48 hours, and then were subsequently preserved in 70% ethanol. They were identified following Kullander and Ferreira (2006). Voucher specimens were deposited at the Ichthyological Collection of the Research Nucleous in Limnology, Ichthyology and Aquaculture (NUP 14755, NUP 14756), where a specialist confirmed the identification (Dr. W. J. da Graça, Universidade Estadual de Maringá, Paraná, Brazil). A sample of the specimens was dissected *in situ* to determine their sexes and reproductive stage. Finally, a bibliography was consulted to determine the current distribution of *Cichla* species in the Paraguay River basin.

Results

Six individual specimens of *C. kelberi* were sampled during the survey (Figure 2). Three of them were females at the beginning of gonadal maturation (the others were deposited as vouchers). The standard length varied from 19.5 to 28.5 cm (mean ± standard deviation = 23.65 ± 3.21 cm). Individual specimens of *C. kelberi* were present only in the seasonally disconnected lakes of the Caramujo stream and in the main channel of this stream. No other specimens of *C. kelberi* or *C. piquiti* were caught in the marginal lakes or in the main channel of the Paraguay River (Figure 1B). Furthermore, *C. piquiti* was not caught in the lakes of the Caramujo stream or in its main channel.

Based on the published work on the occurrence and distribution of *Cichla* species in the Pantanal floodplain, it can be inferred that the occurrence of *C. piquiti* is restricted to the lower reaches of the Pantanal. While *C. kelberi* probably only occurs in the upper reaches of the Pantanal (Figure 1A).

Discussion

This record reports the first occurrence of *C. kelberi* in the Pantanal. *Cichla kelberi* still has its taxonomic status under question, since molecular data suggests that it can be a subspecies of *C. ocellaris* (Willis et al. 2012). Regardless, this species differs taxonomically from those captured in rivers from other regions of the Pantanal (*sensu* Kullander and Ferreira 2006). It is noteworthy that both species are native to the Tocantins River basin (Kullander and Ferreira 2006) and possibly have their distribution restricted by similar factors. Resende et al. (2008) and Nascimento et al. (2001) note that the occurrence of *C. piquiti* is mainly in water bodies with low turbidity. In this study, *C. kelberi* was found only in the marginal lakes of the Caramujo stream and in the main channel of this stream. These environments are characterized by water transparency that reaches about two meters and presents a low or absent flow rate. As the Paraguay River has high levels of turbidity (Silva et al. 2010), this may be restricting the dispersion of *C. kelberi* in the basin (but see Súarez et al. 2013). However, other factors such as predation regime or propagule pressure (Lockwood et al. 2005) can be limiting the dispersal of this species.

Local professional anglers attribute the introduction of *C. kelberi* in the Caramujo stream to a rupture of a fish-farming pond near to the stream after a pronounced flood in 2009. The hydrography of the Pantanal keeps monomodal flood pulses that characterize floodplains (Junk et al. 2006). Pronounced flood events can cause rupture or escapes from stocking tanks or fish culture ponds, which can result in escape of ornamental/aquaculture species into the wild (Orsi and Agostinho 1999). When such structures are inappropriately close to the maximum water level, which is common in Brazil (Magalhães et al. 2011), then such events can occur frequently. Accidental escapes from aquaculture facilities are one of the main drivers of non-native introductions in freshwaters (Gozlan et al. 2010). Since 1998, laws in Brazil forbid the introduction of non-native species (Lima-Junior et al. 2012). However, the effective law enforcement of Brazilian laws is flawed (Vitule et al. 2009) and, unfortunately, violations are often encouraged by government initiatives (Lima-Junior et al. 2012). This fact, in addition to ignorance of the law and of the possible consequences of introductions on native ecosystems and biotas by the regional population, favors the increase in the distribution of non-natives (Agostinho et al. 2007).

There is evidence that *C. kelberi* can reduce the richness and abundance of small sized fish (Pelicice and Agostinho 2009). Thus, the introduction of *Cichla* species can threaten the native fish populations of the Pantanal, and in the long term, can reflect changes in all biotic communities and socioeconomic damages in this region. For instance, the Pantanal has a great diversity of small sized fish associated with macrophytes (Baginski et al. 2007; Súarez et al. 2013) that explore flooded grasslands in the floodplain (Fernandes et al. 2010). These small fish serve as food for the fauna of the piscivorous fish of greater size (Bozza and Hahn 2010) and other taxonomic groups (Gimenes and Anjos 2006). The riverine human population explores the fish of greater size in this region for subsistence and commercialization in a regional scale (Mateus et al. 2004), both for consumption and for recreation (i.e. sport fishing [Shrestha et al. 2002]). Therefore, if the process of the introduction of *Cichla* results in the consequences predicted by other authors (e.g. Zaret and Paine 1973; Latini and Petrere Jr. 2004; Pelicice and Agostinho 2009), the reduction of the abundance and richness of this fauna of small fish can restructure the trophic web within the Pantanal, thus modifying the composition and abundance of fish of greater size and economic interest. However, studies in the Pantanal region are aimed only at the occurrence of the *Cichla* species, so there is still no empirical evidence of the impact on the Pantanal native biota due to the peacock bass.

Since its introduction in 1982 until today, the spread of *C. piquiti* in the lower reaches of the Pantanal has been relatively slow (Nascimento et al. 2001; Súarez et al. 2013). It is likely that the high level of turbidity and the flood pulse of the floodplain has prevented or slowed the spread of this species to other regions of the Pantanal (Nascimento et al. 2001; Resende et al. 2008). However, there are many reservoirs in the planning stages of implementation both for the medium and long-term. These reservoirs are planned for the headwaters that flow to the Pantanal (Junk et al. 2006), which can dramatically change the abiotic conditions of the aquatic environment (especially transparency and flow; Junk et al. 2006; Agostinho et al. 2008). These changes can benefit the establishment and spread of *Cichla* species (Kullander and Ferreira 2006; Fugi et al. 2008; Pelicice and Agostinho 2009). Therefore, the introduction of *C. kelberi* can be a new threat to one of the best-preserved ecosystems (Junk et al. 2006) of the Neotropical region. To assess the magnitude of the possible impacts of this species in the Paraguay River basin, the monitoring of its establishment and possible dispersion is absolutely necessary.

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