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Abundance and length structure of *Brycon nattereri* (Osteichthyes, Bryconidae), an endangered fish species in central Brazil

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ABSTRACT. *Brycon nattereri* is a threatened fish species restricted to small headwater rivers of the Paraná, São Francisco and Tocantins rivers. This species has been extirpated from many sites, and little is known about its ecology. In this sense, the present study investigated temporal variations in the occurrence, abundance and length structure of *B. nattereri* in the Dois Irmãos river, a small headwater river from the Tocantins river basin. Samples were taken monthly between January and November of 2009 and 2010. The studied site comprised a 4.5 km river stretch, sampled with an active fishing method (fly fishing). Individuals caught were counted, measured and returned immediately to the river. We caught 302 individuals along two years. *Brycon nattereri* was present in the studied stretch in all sampling months, with higher abundance between November and May (wet season). We registered a wide range of lengths, with predominance of adult fish; young were captured in July and August, indicating recruitment in the region. The present study, therefore, showed that populations of *B. nattereri*, an endangered fish species, still persist in small headwater rivers of the upper Tocantins river.

Keywords: fish population, seasonality, conservation, headwater, Tocantins river.

Abundância e estrutura de comprimento de *Brycon nattereri* (Osteichthyes, Bryconidae), uma espécie de peixe ameaçada do Brasil central

RESUMO. *Brycon nattereri* é uma espécie de peixe ameaçada restrita a pequenos rios de cabeceira dos rios Paraná, São Francisco e Tocantins. Esta espécie tem sido extirpada de muitos locais, e pouco se sabe sobre sua ecologia. Neste sentido, o presente estudo investigou as variações temporais na ocorrência, abundância e estrutura de comprimento de *B. nattereri* no rio Dois Irmãos, um pequeno rio de cabeceira da bacia do rio Tocantins. As amostras foram coletadas mensalmente entre janeiro e novembro de 2009 e 2010. A área de estudo compreendeu um trecho de 4,5 km do rio amostrados com um método de pesca ativa (pesca com mosca). Indivíduos capturados foram contados, medidos e imediatamente liberados para o rio. Foi capturado um total de 302 indivíduos ao longo do período dois anos. *Brycon nattereri* esteve presente no trecho estudado em todos os meses de amostragem, com maior abundância entre novembro e maio (estação chuvosa). Registramos uma ampla gama de comprimentos, com predominância de peixes adultos. Jovens foram capturados em julho e agosto, indicando que o recrutamento está ocorrendo na região. O presente estudo, portanto, mostra que as populações de B. nattereri, uma espécie de peixe ameaçada de extinção, ainda persiste em pequenos rios de cabeceira do alto rio Tocantins.

Palavras-chave: populações de peixes, sazonalidade, conservação, cabeceiras, rio Tocantins.

Introduction

The genus *Brycon* includes 42 valid species (ESCHMEYER; FONG, 2014), distributed across different river systems of South America. Most species are rheophilic and migratory, but some have specific habitat affinities, such as the pirapitinga *Brycon nattereri* Gunter, 1864. This is a medium-sized fish (maximum standard length = 27.9 cm) found in headwaters of the Paraná, São Francisco and Tocantins river basins, restricted to lotic environments with the presence of riparian vegetation (LIMA et al., 2008). Because of these specific demands, populations of *B. nattereri* have been seriously threatened by dams, land use (deforestation) and other disturbances (LIMA et al., 2008). Common in the past, it has been extirpated from many headwater systems (LIMA et al., 2008; ROSA; LIMA, 2008); as a consequence, *B. nattereri* is currently listed as 'threatened with extinction' in the Brazilian official list of threatened species (ROSA; LIMA, 2008).

Personal observation and sport fishermen indicate that remnant populations of *B. nattereri* still persist in small rivers of the upper Tocantins river basin, Central

Brazil. However, this watershed has been targeted for hydropower development in the last decade: large dams were constructed in the main channel (AGOSTINHO et al., 2011; ARAÚJO et al., 2013) and several small dams have been installed in the tributaries (TOLLEFSON, 2011). Moreover, the Cerrado biome in Central Brazil has been extensively converted to agriculture and pastures (KLINK; MACHADO, 2005), especially in recent years. This scenario of extensive landscape change is causing a progressive loss of habitats that are important to *B. nattereri*. Therefore, the confirmation of remnant populations in the upper Tocantins river basin would indicate that these headwaters have high conservation value, particularly because this species has been extirpated or is now rare in other basins and localities (LIMA et al., 2008). Also, we highlight that ecological aspects of *B. nattereri* remain largely unknown.

In this sense, the present study investigated the existence of relict populations of *B. nattereri* in the upper Tocantins river basin. To this end, we analyzed temporal variations in the occurrence, abundance and size structure of *B. nattereri* in the Dois Irmãos river, a small headwater river. The existence of persistent populations in this area emphasizes the need for land use and conservation planning that explicitly take into account the presence of *B. nattereri*, particularly because this fish is now threatened with extinction. We hope these results inspire more comprehensive surveys in the headwaters of the Paraná, São Francisco and Tocantins rivers.

Material and methods

Study area

The study was conducted in the Dois Irmãos river, a second order tributary of the Almas river and headwaters of the Tocantins river basin (Goiás State, Brazil). This lotic system is characterized by variable altimetric profiles, strong water flow (Figure 1), the presence of rapids, waterfalls, and high water transparency. The rainy season, with increased river flow, occurs between November and May (Figure 2), with a clear peak between February and April (AGÊNCIA NACIONAL DE ÁGUAS, 2005). The studied site comprised a 4.5 km river stretch (between 15° 14' 43" S/49° 02' 43" W and 15° 43' 50"/49° 01' 47" W), located in the lower reach (736-748 a.s.l.), near the confluence with the Almas river. The study area is extensively covered by riparian vegetation (Figure 1), with closed canopies found in some areas.

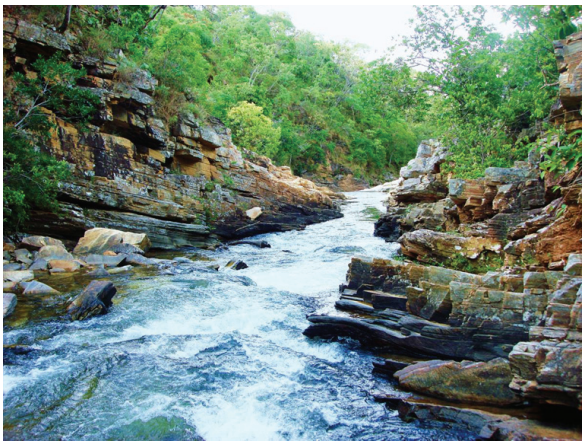

Figure 1. Dois Irmãos river, upper Tocantins river basin, natural habitat of *Brycon nattereri*.

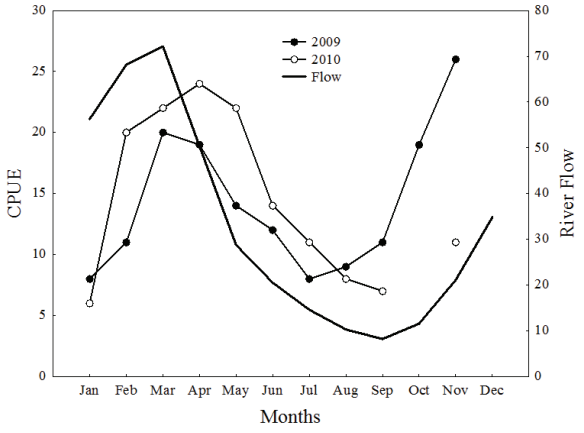

Figure 2. Monthly variation in the abundance of *Brycon nattereri* (CPUE: individuals/ 4.5 km/ 6 hour), in 2009 and 2010. The solid line is the mean river flow (m^3 s^{-1}), measured downstream from the sampling site, at the Almas river station, between 2000 and 2012 (AGÊNCIA NACIONAL DE ÁGUAS, 2005).

Sampling

The strong water flow and the canyon-like structure of the Dois Irmãos river (Figure 1) impeded the use of conventional fishing gears, such as gill nets or cast nets. Therefore, we used fly fishing to sample individuals (hook 1/8), on a catch-and-release basis. This sampling method allows the easy handling of captured specimens and the immediate return to the environment, with minimal injuries. The bait used was the winged female of the ant *Atta* spp., which is widely used by local fishermen and seems to present high effectiveness irrespective of season and fish size (VITORINO JR., personal observation). Sampling was standardized by time effort (about 6 hours to cover 4.5 km) and number of fishermen (one angler, with experience in the use of fly fishing). Overall, fishing effort was about 750 m $hour^{-1}$, employed in the downstream-upstream direction, where the bait was continuously cast into rapids and runs.

Samples were taken monthly between January and November of 2009 and 2010, totaling 22 samples. In each month, we recorded the number of individuals caught in the stretch. Between May and November 2010 we measured total length of each fish (TL, cm). All individuals were returned alive to the river, except one specimen, deposited in the fish collection of the Laboratory of Ichthyology Systematics of the Federal University of Tocantins, Porto Nacional, Brazil (UNT 11550).

Data analysis

To investigate the variation in fish abundance over months and years, we calculated the catch per unit effort (CPUE: fish/4.5 km/ 6 hours). To investigate the seasonal variation in fish abundance, we plotted total CPUE against months, for each year. Differences in mean CPUE between years were tested with a t-test for independent samples, considering months as replicates. The length structure in 2010 was assessed by calculating the number of individuals within different size classes (2 cm intervals). The percentage of young and adults was also calculated. Lima et al. (2008) provide data about standard length (SL, cm) at first maturity in the upper Tocantins river basin: 11.4 cm SL for females and 9.8 cm for males. Once we did not investigate gonadal development and sex, we considered immature those fish < 12 cm SL. To obtain SL values, we converted TL values into SL with the equation SL = 0.9291 + 0.8173 * TL (linear regression: R^2 = 0.99; n = 4). We then considered immature those fish < 13 cm TL.

Results

A total of 302 individuals were caught during 2009 and 2010. *Brycon nattereri* was present in the river stretch during all sampling months (Figure 2), except in October 2010, when the stretch was disturbed by fire and sampling was not performed. Total CPUE ranged between 6 and 26 individuals/ 4.5 km/ 6 hours, with higher values between November and May in both years (Figure 2), and lower values between June and September. Mean CPUE was 14.27 ± 1.78 SE in 2009 and 14.5 ± 2.18 SE in 2010, and with no significant difference in mean CPUE between years (t = -0.08; p = 0.936).

The total length ranged from 10.4 to 36.1 cm (fish caught between May and November 2010), with predominance of adult fish (86% with TL > 13 cm), particularly within classes between 18 and 22 cm (Figure 3). We observed a variation in length structure over the months (Figure 4); immature fish (10.4 – 12.9 cm) were caught only in July and August.

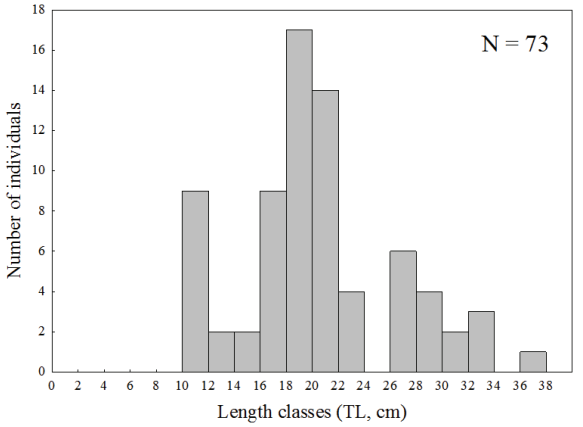

Figure 3. Length structure of *Brycon nattereri* in the Dois Irmãos river (May to November 2010). The figure shows the number of fish within size classes (2 cm intervals).

Discussion

This study registered the presence of *B. nattereri* in the Dois Irmãos river, a headwater tributary of the Tocantins river. The population apparently lives in the area, considering that individuals were consistently caught for two consecutive years. In addition, the presence of immature fish suggests recruitment, indicating that populations of *B. nattereri* persist in these headwaters. The existence of this remnant populations confirms the high conservation value of the upper Tocantins river headwaters, especially because *B. nattereri* is now considered threatened with extinction (ROSA; LIMA, 2008).

We caught specimens of *B. nattereri* throughout the study period, with a clear seasonal variation in fish abundance within the 4.5 km stretch. This pattern suggests that the population lives in the region, performing short migrations between river stretches. This seasonal pattern indicates the use of different habitats (or river stretches) to complete its life cycle, as known for other *Brycon* species (GONÇALVES et al., 2006; LIMA; RUFFINO, 2003). In the present study, higher abundances coincided with the wet season (February to May), when the species probably use the studied site for feeding. During the dry season, fish abundance declined in the area, probably because the population moved downstream, where more suitable habitats (i.e. refuges) remain available during the low water period. *Brycon nattereri* is omnivorous (AGOSTINHO et al., 2006; LIMA et al., 2008), consuming mainly allochthonous resources from the surrounding riparian vegetation (LIMA et al., 2008) – in our study we used an allochthonous resource (*Atta* spp.) to capture the species. It is worth noting that the Dois Irmãos river is surrounded by riparian vegetation, a basic condition to maintain viable populations of *B. nattereri* (LIMA et al., 2008; ROSA; LIMA, 2008).

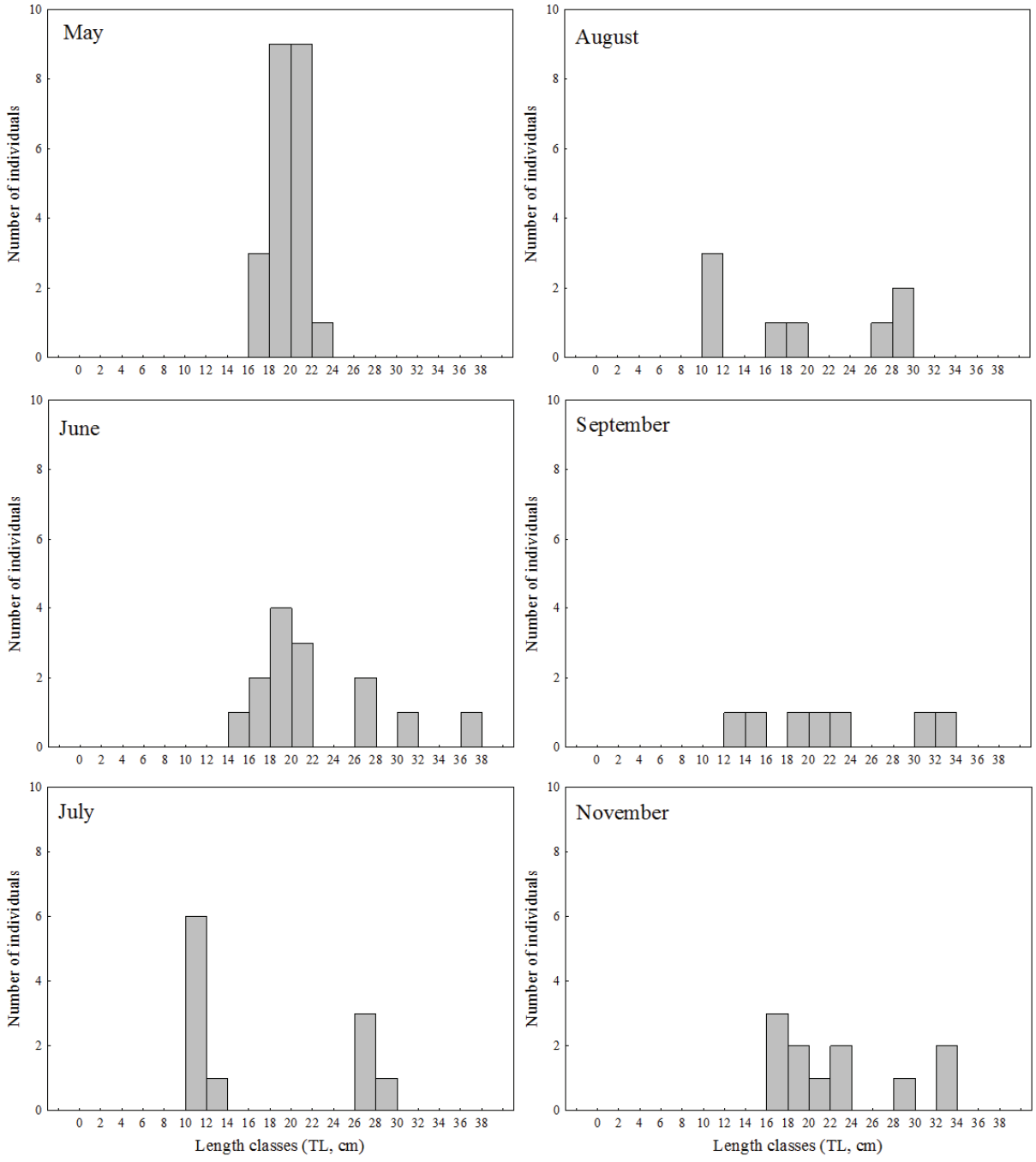

Figure 4. Variation in length structure of *Brycon nattereri* over the months (May to November 2010). The figure shows the number of fish within size classes (2 cm intervals).

A wide range of body lengths were recorded in the stretch, with prevalence of intermediate body size. An important finding was the presence of young fish, which evidences that the population is probably recruiting in the region. In addition, breeding individuals that released eggs and sperm (when handled) were consistently observed during June and November, which represent the beginning and the end of the dry season, respectively. In both years, more than half of the individuals caught in these months released gametes (VITORINO JR., unpublished data). Lima et al. (2008) also reported reproductive activity during the dry season, probably to avoid high variability in flow and strong flows during rainy periods (ABILHOA et al., 2011; WINEMILLER et al., 2008). Some studies (LIMA et al., 2008; VIEIRA et al., 2005) have suggested that this species does not perform long-distance

migration, but our results suggest short-distance seasonal movements within the basin, since abundance declined consistently in the studied stretch during drier months. Future studies should investigate spatial requirements of *B. nattereri*, such as the location of spawning, feeding and nursery habitats, and how it is related to habitat availability (e.g. low water level) and migration needs.

This type of information is necessary to set up effective plans to conserve this threatened species. At present, small hydroelectric plants (PCH) represent the most important threat, since they have been installed in many small tributaries of the basin (TOLLEFSON, 2011), affecting fluvial connectivity, local hydrology and the structure of riparian forests.

Conclusion

The present study confirmed the existence of a persistent population of *B. nattereri* in the Dois Irmãos river, a headwater tributary of the Tocantins river basin. Further research should be done in these headwaters, to map the occurrence of *B. nattereri* and to describe population structure in detail (e.g. age structure, feeding, reproduction and recruitment). Future development plans (e.g. hydropower, agriculture), therefore, must evaluate carefully the existence of remnant populations of *B. nattereri* in the target area; otherwise, this species may also go extinct in these headwaters in the near future.

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