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Astyanax lineatus (Perugia, 1891) (Characiformes: Characidae): first record in the upper Paraná river basin, Mato Grosso do Sul, Brazil

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Abstract: *Astyanax lineatus* was previously known only from the Paraguay river basin and we report the first record from the Paraná river basin near the municipality of Sidrolândia, Mato Grosso do Sul state, Brazil. The species was found in Lajeado Stream, a tributary of the Anhanduí River, which belongs to the Pardo River sub-basin of the Paraná river basin.

Key words: interface; Pardo River sub-basin; new records; fish distribution

Astyanax Baird & Girard, 1854 is a species-rich characid genus having about 140 species (Froese & Pauly 2017). It is widely distributed throughout the Neotropical Region from the southern United States of America to central Argentina (Casciotta et al. 2005). According to Javonillo et al. (2010), Mirande (2010) and Oliveira et al. (2011), the genus *Astyanax* is not monophyletic.

The upper Paraná River, which is the region upstream of Itaipu Reservoir (Graça & Pavanelli 2007), has eight *Astyanax* species: *A. biotae* Castro & Vari, 2004, *A. bockmanni* Vari & Castro, 2007, *A. fasciatus* Cuvier, 1819, *A. lacustris* (Lütken, 1875), *A. paranae* Eigenmann, 1914, *A. paranahybae* Eigenmann, 1911, *A. schubarti* Britski, 1964, and *A. trierythropterus* Godoy, 1970.

In the upper Paraguay river basin, the genus is represented by *A. abramis* (Jenyns, 1842), *A. lacustris*, *A. lineatus* Perugia, 1891, *A. marionae* Eigenmann, 1911, *A. pirapuan* Tagliacollo, Britzke, Silva & Benine, 2011 and *A. pellegrini* Eigenmann, 1907. In this paper, we report the first record of *A. lineatus* in the upper Paraná river basin.

Waterways of the basin of the Paraguay River where individuals of *A. lineatus* have been recorded were obtained from the SpeciesLink database (http://splink.cria.org.br/), and mapped to show the distribution of this species. On 18 June 2016 we sampled *A. lineatus* from the Paraná River (Mato Grosso do Sul, Brazil). This represents the first record of *A. lineatus* for the state and the upper Paraná River. Five individuals were captured from Lajeado Stream (a tributary of the Anhanduí River which is in the Pardo River sub-basin of the Paraná river basin near Eldorado farmhouse, municipality of Sidrolândia, Mato Grosso do Sul, Brazil (–20.9047° S, –054.7970° W; Figure 1).

The species was sampled using a rectangular sieve (0.8 × 1.2 m; 2 mm mesh size) and was authorized by IBAMA, 13458/2016 (SISBIO). The collected specimens were fixed in a 10% formaldehyde solution for 48 h, washed, and then preserved in 70% alcohol. The identification to species was used an identification key to the fishes of the Pantanal (Britski et al. 2007). The specimens were deposited in the zoological collections of the Universidade Federal do Mato Grosso do Sul (ZUFMS PIS4753) and the Universidade Estadual do Mato Grosso do Sul (CPUEMS 439).

Eigenmann's (1921) definition of *Astyanax* is composed of a combination of non-apomorphic nor exclusive characters: premaxillary teeth in two rows, posterior row of premaxilla bearing five denticulate teeth, complete lateral line, adipose fin present, and caudal fin naked.

According to Britski et al. (2007), *A. lineatus* has the following measurements with variation due to standard length presented: height 2.5–3.1, head length 3.4–4.2; variation due to head length: eye diameter 2.9–4.0, interorbital width 2.6–3.3; eye interorbital 1.1. Lateral line with 34–38 scales, transverse line with 6 or 7 scales above and 5 or 6 scales below. Anal rays 26–28. Premaxilla with 4 teeth in the outer series; jaw with one tooth. Humeral macula present; scales with small dark spots on top and bottom edges, together forming longitudinal lines; an elongate dark spot is present in the middle of the side starting just below the adipose fin and extending to the end of the caudal peduncle, where it continues as a dark band that stretches to the tip of the middle caudal rays. *Astyanax lin-*

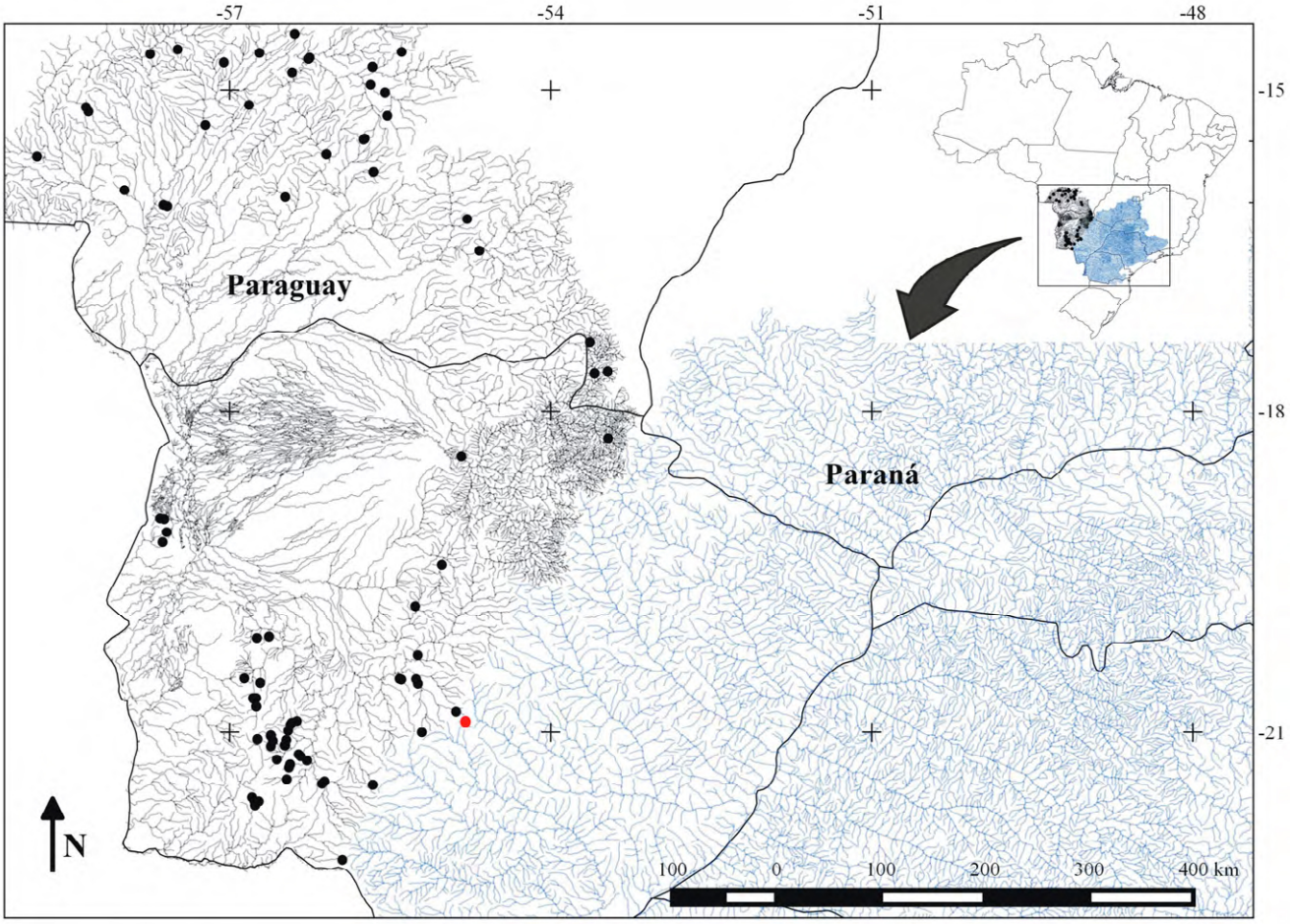

Figure 1. Location of records for *Astyanax lineatus* in the upper Paraguay river basin and upper Paraná river basin. Black dots represent records from SpeciesLink database in the upper Paraguay River basin; the red dot represents the new record in the upper Paraná river basin.

eatus differs from all congeners, except *A. kullanderi* Costa, 1995 from Araguaia River, by having dark stripes between the scale rows, forming a well-defined longitudinal striated pattern on the body (vs. dark stripes absent) (Figure 2). *Astyanax lineatus* differs from *A. kullanderi* by having 34–38 lateral line scales (vs. 31–32).

The specimens from Lajeado Stream have taxonomic characteristics consistent with *A. lineatus*, in relation to standard length presented: height 3.0–3.1, head length 3.4–3.9; to head length: eye diameter 3.0–3.1, interorbital width 3.0–3.1, eye interorbital 1.0. The lateral line is with 37–38 scales and 26–28 anal rays.

The river basins of South America, including the upper Paraná, are the result of tectonic movements. More recent tectonic activities, from the Paleogene to the present, promoted rearrangements that are the main causes of headwa-

Figure 2. *Astyanax lineatus* (LS: 59.98 mm / CPUEMS 439) sampled in Lajeado Stream, a tributary of the Anhanduí River which is a sub-basin of the Pardo River in the upper Paraná River basin, Mato Grosso do Sul, Brazil.

ter capture events between nearby basins (Lima & Ribeiro 2011). The occurrence of the dynamic process of headwater capture has been widely demonstrated by studies in the upper Paraná basin, mainly on its eastern border, and have shown that geomorphological processes can influence the dispersal of fish species within the system itself (Shibatta & Benine 2005; Takako et al. 2005).

Headwater capture can occur by tectonic movement or by erosion (Tarbuck & Lutgens 2002). Evidence suggests that during the Cretaceous the western border of the upper Paraná basin extended westward over current longitudes of the Pantanal wetland (Assine 2004). Rearrangements between these two borders (ca. 2.5 MY) (Assine 2004) suggest that during the formation of the Pantanal, the upper Paraguay headwaters captured portions of the western tributaries of the upper Paraná, which explains the occurrence of some species of fish in both basins (Menezes et al. 2008).

Although there are no known tectonic movements that would have allowed the capture of some of the eastern border of the upper Paraguay by the upper Paraná, it is likely that erosion facilitated some connection between their headwaters. The headwaters of the Aquidauana River, an eastern tributary of the upper Paraguay near the municipality of Sidrolândia, are at a higher altitude (582 m) than the borders of the Anhanduí River headwaters (520 m), a western tributary of the upper Paraná. Considering the short distance of 1,450 m between these two headwaters, it is conceivable that a flood event could have caused the overflow of the Aquidauana River, causing it to connect with Anhanduí River, thereby permitting the dispersal of fish species to the lower headwaters of the Anhanduí River.

Additionally, Valério et al. (2007) analyzed fish assemblages of headwater streams of the Paraná–Paraguay basins, and recorded the occurrence of five species described for the Paraná basin in the Paraguay basin (e.g., *Astyanax fasciatus*, *Oligosarcus pintoi* Amaral Campos, 1945, *Piabina argentea* Reinhardt, 1867, *Phenacorhamdia tenebrosa* (Schubart, 1964), and *Parodon nasus* Kner, 1859), suggesting that these species dispersed during the formation of the Pantanal. Therefore, there is evidence of a connection between the headwaters of the Paraná and Paraguay river basins, suggesting that some species, including *A. lineatus*, may have dispersed from one basin to another. This finding illustrates the greater importance of expanding sampling in interface regions of basins and reviewing the material deposited in biological collections.

Thus, we believe the occurrence *A. lineatus* in the basin of the upper Paraná River is likely the result of activities associated with complex system failures in the area and events of headwater capture due to the proximity between the borders of these two basins, and that this phenomenon may be responsible for the relatively broad distribution of this species. In addition to those identified by Menezes et al. (2008), other connections may have occurred in other regions of the upper Paraná and upper Paraguay rivers, but only further research, particularly regarding phylogenetic and biogeographic relationships of the fish groups in these basins, combined with geological evidence of events of headwater capture, can help to understand the species composition of the fish communities in these basins (Langeani et al. 2007).

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