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Short Communication

Filling gap on the distribution of the *Prochilodus lineatus* (Valenciennes, 1837) (Characiformes, Prochilodontidae) in southernmost Brazil and implications for the species' conservation

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ABSTRACT

Studies on species distribution provide crucial information for political decision-making and conservation. In this study, we present a distribution extension of the streaked prochilod *Prochilodus lineatus* (Valenciennes, 1837) to Mirim Lagoon, extreme south of Brazil. This species has high potential as a fishery resource for the region and is an important organism in the energy flow of freshwater ecosystems. Following studies aiming to monitor the species occurrence in Mirim-Patos Lagoon are highly recommended. Additionally, we highlight the importance of studies dealing with ecological aspects such as monitoring of landings, reproduction, age and growth, and trophic aspects of the species.

Keywords: Neotropical region; Rio Grande do Sul state; Mirim Lagoon.

Preenchendo lacunas na distribuição do *Prochilodus lineatus* (Valenciennes, 1837) (Characiformes, Prochilodontidae) no extremo sul do Brasil e implicações para a conservação da espécie

RESUMO

Estudos sobre a distribuição das espécies fornecem informações cruciais para a tomada de decisões políticas e para a conservação. Neste estudo, apresentamos uma ampliação de distribuição do grumatã *Prochilodus lineatus* (Valenciennes, 1837) para a Lagoa Mirim, no extremo sul do Brasil. Essa espécie tem alto potencial como recurso pesqueiro para a região e importante no fluxo de energia dos ecossistemas de água doce. Estudos futuros visando monitorar a ocorrência da espécie no sistema lagunar Patos-Mirim são altamente recomendados. Além disso, destacamos a importância de estudos que abordem aspectos ecológicos, como monitoramento de desembarques, reprodução, idade e crescimento e aspectos tróficos da espécie.

Palavras-chave: Região neotropical; Estado do Rio Grande do Sul; Lagoa Mirim.

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INTRODUCTION

The Mirim Lagoon, located on the southernmost coastal plain of Brazil, is a complex ecosystem that straddles the border between Brazil and Uruguay. This elongated body of water, which extends for 185 km, with a mean width of 20 km, has a total area of 3,749 km^2 (Kotzian & Marques, 2004; Pieve et al., 2020). The Mirim Lagoon, as part of the Mirim Lagoon-São Gonçalo hydrographic basin, is one of the most important freshwater ecosystems in the southernmost region of Brazil, playing a pivotal role as a source of water for the local population and the irrigation of agriculture (*e.g.*, rice and soy). The lagoon also has a crucial ecological function in the conservation of the local flora and fauna, hosting a notable level of species endemism (JICA & SCP-RS, 2000; Piedras et al., 2012). This ecosystem is a fishing area for artisanal fishermen from different locations (municipalities of Pelotas, Arroio Grande, Jaguarão, Rio Grande, and Santa Vitória do Palmar, in Rio Grande do Sul state, Brazil), where fishing is fundamental to the local economy and sustainability (Piedras et al., 2012).

The principal fishery resources exploited by the artisanal fishers of the Mirim Lagoon are the trahira *Hoplias* aff. *malabaricus* (Bloch, 1794), the silverside *Odontesthes* spp., and the catfishes *Pimelodus pintado* (Azpelicueta, Lundberg & Loureiro, 2008), *Rhamdia quelen* (Quoy & Gaimard, 1824), and *Loricariichthys anus* (Valencinnes, 1840) (Piedras et al., 2012). These resources are highly seasonal. For example, trahira is harvested predominantly during the austral summer, while *R. quelen* is captured more frequently in the winter (Piedras et al., 2012).

Characiformes is the most diverse order of neotropical freshwater fish, with 2,334 described species (Toledo-Piza et al., 2024). Among the 24 characiform families, Prochilodontidae comprises 21 valid species (Toledo-Piza et al., 2024). According to Soares et al. (2021), prochilodontids play an important role in the energy flow of aquatic ecosystems, by consuming basal material deposited on the bottom substrate, which constitutes one of the primary sources of energy that sustains food chains.

The prochilodontid *Prochilodus lineatus* (Valenciennes, 1837) has a tall, silvery body with dark longitudinal lines running along the flanks, between the series of scales, a dorsal fin with tiny dark spots, bifurcated caudal fin, and a complete lateral line with 44–50 scales, with transverse lines both above (7–10 series of scales) and below, with 6–9 series of scales (Britski et al., 2007; Castro & Vari, 2004). *Prochilodus lineatus* is amply distributed in South America (Graça & Pavanelli, 2007; Nelson et al., 2016), the ecoregion of the upper and lower Uruguay basin, and the Patos Lagoon (Malabarba, 2020). Reliable information on the geographical distribution and the identification of new areas occupied by the species are fundamental to effective conservation measures (Barbosa et al., 2020). Herein we present a new area of vouchered occurrence of *P. lineatus* in Mirim Lagoon, which fills the gap about the known distribution of the species to the southernmost region of Brazil.

MATERIAL AND METHODS

Vila da Capilha beach is located at the eastern extreme of the Mirim Lagoon (Fig. 1), municipality of Rio Grande, southern Rio Grande do Sul state. This beach is located close to the BR-471 highway, which runs near the lagoon's shoreline (Kunz & Castrogiovanni, 2020).

Vila da Capilha beach is an important area for tourism, which has been attracting growing numbers of visitors in recent years, including both day-trippers and seasonal vacationers. This beach features a large stretch of sand with a gentle slope and a sandy bottom (Ceni & Vieira, 2013). The local habitat is heterogeneous, with some areas of vegetation, and others with bare sand, which permits the use of different sampling procedures. Fish sampling was conducted using gillnets with mesh sizes of 40, and 45 mm, 1.5 m in height, and a total length of 25 m (SISBIO license, number: 80579-3), with the assistance of two amateur fishermen who were fishing in the area. The nets remained in the water for 12 hours and were checked every six hours.

Once captured, the specimen was stored on ice in a styrofoam cooler and transferred to the Ichthyology Laboratory at the Universidade Federal do Rio Grande, where it was identified using a taxonomic key (Graça & Pavanelli, 2007). The total length was measured in millimeters (mm), and the total weight in grams (g), with an additional 38 morphological data, following Castro and Vari (2004) and Oliveira et al. (2010).

RESULTS AND DISCUSSION

On 18th January 2024, we collected one specimen of *P. lineatus* (ICFURG: 2954) at the mouth of the Aguirre channel (32°31'09.46" S, 52°34'55.39" W; Fig. 1), in the Vila da Capilha beach. Morphological data are shown in Table 1. This is the first vouchered record of *P. lineatus* in the Brazilian segment of Mirim Lagoon. In relation to the closest localities of previous records in a latitudinal axis, our collection site at Aguirre channel is about 60 km northwest of Jaguarão River and 55 km south of Piratini River (Fig. 1).

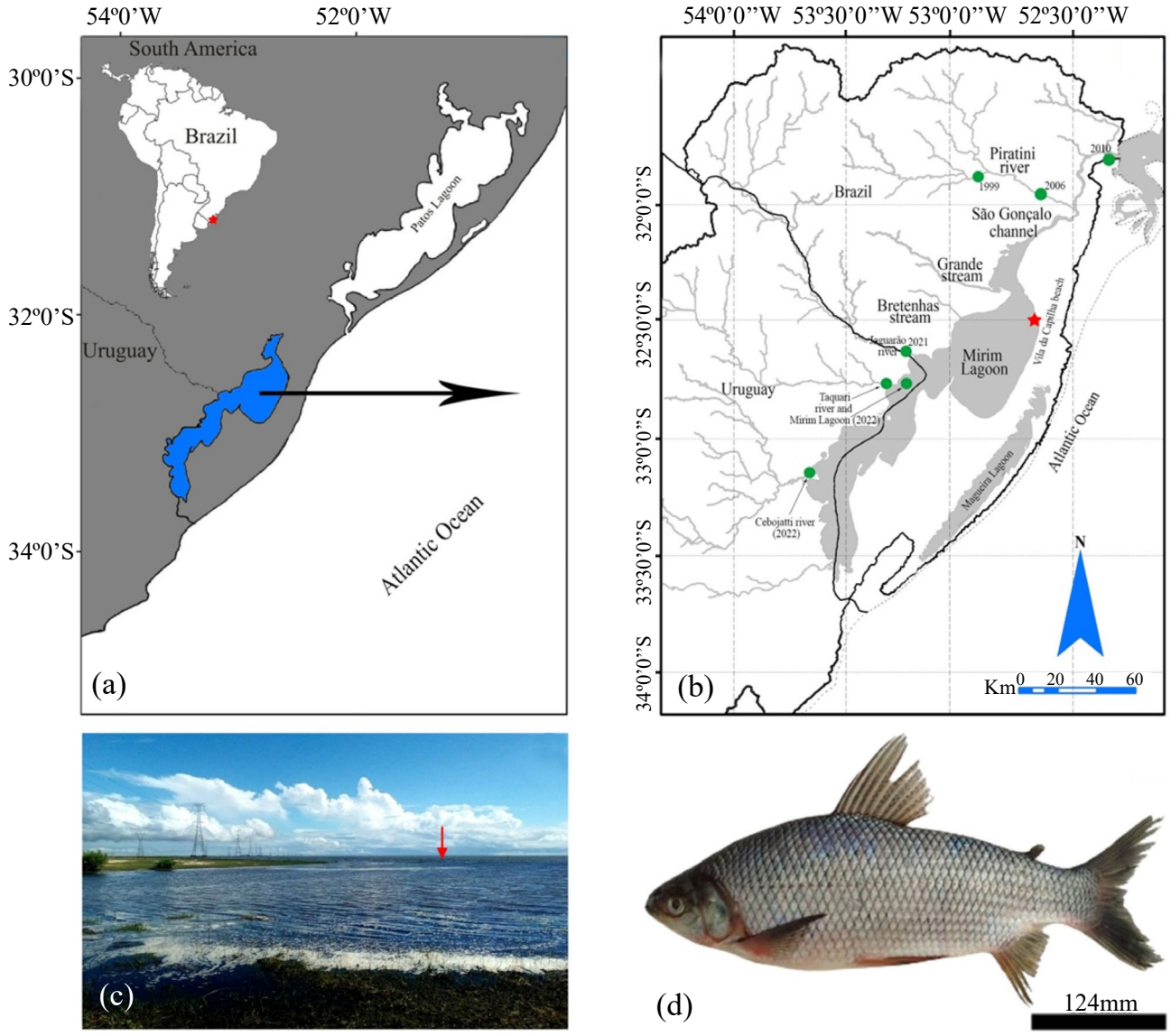

Figure 1. (a) Location of the Mirim Lagoon (in blue) in Brazil/South America. (b) Locations of the existing records of the occurrence of *Prochilodus lineatus* in the around region of the Mirim Lagoon (green dots), and the new occurrence (red star) at Vila da Capilha beach. (c) The point at which the specimen presented here was collected (red arrow). (d) The *Prochilodus lineatus* specimen from Vila da Capilha beach, total length = 372 millimeters. Photograph by Yan Gonçalves Gowert.

Prochilodus lineatus is a migratory species (Burns et al., 2024; Loureiro et al., 2023), which breeds primarily between October and December. Both Burns et al. (2024) and Loureiro et al. (2023) reported that in Uruguay, adult *P. lineatus* inhabits large rivers and streams, while juveniles are found more frequently in wetlands, channels, and marginal lagoons. The individuals so far captured in Mirim Lagoon presented a total length between 340 and 540 mm (Burns et al., 2024; present study), a size class that corresponds to sexual maturity for both females and males (Vicentin et al., 2012). Given these patterns, it would appear reasonable to assume that *P. lineatus* migrates to Mirim Lagoon possibly to reproduce, after developing in tributary rivers of the basin.

In a study of the species richness and abundance of fish at three points in the Mirim Lagoon, Moura et al. (2012) recorded a total of 30 species, but not *P. lineatus*. Ceni and Vieira (2013) used several different sampling methods to survey the fish fauna at Vila da Capilha beach and identified the total of 24 species, but lacking *P. lineatus* records. The first published record of *P. lineatus* from the southernmost region of Brazil was obtained

Table 1. Morphological data of the *Prochilodus lineatus* specimen collected from the mouth of Aguirre channel at Vila da Capilha beach, in the Mirim Lagoon, Rio Grande do Sul state, Brazil. The total weight is presented in grams (g), while the other morphological data are expressed in millimeters (mm).

Morphological data	Description of the variables	Measurement
Total weight	Weight of the individual, with the viscera intact	742.7 g
Total length	From the tip of the snout to the end of the caudal fin	372 mm
Standard length	From the tip of the snout to the insertion of the caudal fin	310
Height of the head	Measured by a vertical line at the posterior edge of the left eye	47
Height of the body	Measured by a vertical line in front of the dorsal fin	103
Height of the caudal peduncle	Smallest height of the caudal peduncle	36
Base of the anal fin	From the base of the first ray to the base of the last ray	31
Base of the dorsal fin	From the base of the first ray to the base of the last ray	49
Length of the base of the anal fin	From the anterior to the posterior edge of the anal fin	47
Length of the base of the dorsal fin	From the anterior to the posterior edge of the dorsal fin	46
Length of the head	From the tip of the snout to the extremity of the operculum in a horizontal line	72
Length of the upper mandible	From the pre-maxillary symphysis to the posterior extremity of the maxilla	20
Length of the anal fin	Distance between the origin and the extremity of the anal fin	44
Length of the dorsal fin	Distance between the origin and the extremity of the dorsal fin	64
Length of the pectoral fin	Distance between the origin and the extremity of the pectoral fin	57
Length of the pelvic fin	Distance between the origin and the extremity of the pelvic fin	58
Length of the snout	From the tip of the snout to the anterior edge of the eye	23
Length of the peduncle caudal	From the end of the anal fin to the beginning of the caudal fin	38
Diameter of the orbit	From the anterior to the posterior edge of the eye	9
Dorsal-pectoral distance (anterior)	Distance between the beginning of the dorsal fin and the anterior pectoral fin	81
Dorsal-pelvic distance (anterior)	Distance between the beginning of the dorsal fin and the anterior pelvic fin	98
Dorsal-anal distance (anterior)	Distance between the beginning of the dorsal fin and the anterior anal fin	147
Dorsal-pectoral distance (posterior)	Distance between the end of the dorsal fin and the beginning of the pectoral fin	130
Dorsal-pelvic distance (posterior)	Distance between the end of the dorsal fin and the beginning of the pelvic fin	95
Dorsal-anal distance (posterior)	Distance between the end of the dorsal fin and the beginning of the anal fin	107
Distance of the isthmus	Distance from the tip of the snout to the isthmus	52
Dorsal-peduncle distance (upper)	Distance between the end of the dorsal fin and the upper end of the peduncle	133
Dorsal-peduncle distance (lower)	Distance between the end of the dorsal fin and the lower end of the peduncle	143
Distance between the dorsal and adipose fins	Measured from the posterior base of the dorsal fin to the adipose fin	5
Interorbital distance	Shortest dorsal distance between the eyes	34
Isthmus-pelvic fin distance	Distance between the isthmus and the pelvic fin	28
Pelvic-anal distance	Distance anterior of the pelvic fin e anterior anal fin	91
Pre-anal distance	From the tip of the snout to the anal fin	246
Pre-dorsal distance	From the tip of the snout to the dorsal fin	128
Pre-nasal distance	From the tip of the snout to the nostril	18
Pre-pelvic distance	From the tip of the snout to the pelvic fin	148
Pre-ventral distance	From the tip of the snout to the ventral fin	148

by Burns and Cheffe (2018), from two locations on the Piratini River (Fig. 1), with specimen CIMC 58073, collected in February 1999 (31°51'43"S, 52°47'59"W), and FURG 2721, collected in November 2006 (32°0'36"S, 52°26'10"W). Burns and Cheffe (2018) subsequently recorded *P. lineatus* on the floodplain of the São Gonçalo channel (31°47'01"S, 52°14'29"W) in July 2010 (Fig. 1), showing an expansion of the species within the system. In 2021 and 2022, specimens of *P. lineatus* were collected in the Jaguarão River and at three points in Mirim Lagoon on the Uruguayan territory (Burns et al., 2024), but the authors did not record the species in Mirim Lagoon on the Brazilian territory. It should also be mentioned that Basaglia (2008) investigated artisanal fishing patterns in the Mirim Lagoon, particularly in the municipalities of Arroio Grande (Santa Isabel), Jaguarão, and Santa Vitória do Palmar (Curral Alto and Porto), and reported *Prochilodus* sp. in the catches. However, no specimen was photodocumented or deposited in a scientific collection, which impedes any confirmation of this record.

The historical character of *P. lineatus* records in Mirim Lagoon specimens from Cebollatí River in Uruguay from 1935 led Burns et al. (2024) to hypothesize that the species is native to this basin. It is also noteworthy the occurrence of *P. lineatus* specimens in the fish collection of adjacent Patos Lagoon, a system connected to Mirim Lagoon by the São Gonçalo channel, commissioned by Emperor Dom Pedro II in 1865 (Malabarba, 1989). Therefore, the very punctual records of *P. lineatus* in the densely sampled Patos-Mirim basin (Bertaco et al., 2016) indicate that the species is not well-established in this system. Indeed, the occurrence and expansion of species in an environment can directly influence local biodiversity by either promoting ecological stability or causing imbalances (Socolar et al., 2016).

We highlight that the conservation status of the species has not been assessed by the International Union for Conservation of Nature yet. However, it should be taken into consideration that potential activities such as agriculture can impact the reproductive aspects of the species. The present record of the occurrence of *P. lineatus* in Mirim Lagoon on the Brazilian territory confirms its presence in the region and highlights the importance of studies on species distribution. In the specific case of the present study, we would also emphasize the need for further research, to investigate potential breeding grounds, distribution patterns, abundance, and the feeding habitats of *P. lineatus* in the basin of the Mirim Lagoon.

CONFLICT OF INTEREST

Nothing to declare.

DATA AVAILABILITY STATEMENT

All data were generated or analyzed in this study.

AUTHORS' CONTRIBUTIONS

Conceptualization: Corrêa, F., Gowert, Y.G., Quintela, F.M., Fraga, E.C.; **Methodology:** Corrêa, F., Gowert, Y.G.; **Investigation:** Corrêa, F., Gowert, Y.G.; **Formal analysis:** Corrêa, F., Gowert, Y.G.; **Data curation:** Corrêa, F., Gowert, Y.G.; **Supervision:** Corrêa, F., Gowert, Y.G., Quintela, F.M., Fraga, E.C.; **Resources:** Corrêa, F.; **Writing – original draft:** Corrêa, F., Gowert, Y.G., Quintela, F.M.; **Writing – review & editing:** Corrêa, F., Gowert, Y.G., Quintela, F.M., Fraga, E.C.; **Final approval:** Corrêa, F.

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