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Original Article

Unexpected colonization: New records of *Sylviocarcinus australis* (Brachyura: Decapoda: Trichodactylidae) in the upper Paraná drainage, southern Brazil

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ABSTRACT

The decapod family Trichodactylidae is widely distributed in river systems of South America. However, the first record of *Sylviocarcinus australis* in the state of Paraná, Brazil, is reported herein, suggesting a possible human introduction, or lack of previous records, for a species whose known occurrences to date are in the Paraguay-middle Paraná River basins. The presence of *S. australis* in the upper Paraná River basin raises questions about its origin, extension of its occurrence and any possible ecological impacts. As this is a single record of adult males, with no females or juveniles recorded so far in the sampled area, it is not possible to conclusively trace the effective establishment of the species in this area. However, the proximity of the area to Iguaçu National Park, an important conservation area, highlights the possible presence of the species in a sensitive conservation area, with an imminent need to monitor local biodiversity. Examples of introductions of other species of freshwater crabs have shown that there are problems in coexistence with local, native species, and so understanding the potential ecological impacts of this species is crucial to ensuring the preservation of these local species.

KEYWORDS

Biological introduction, freshwater crabs, Iguaçu National Park, Neotropical region, Paraná river.

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INTRODUCTION

Trichodactylidae H. Milne Edwards, 1853 is one of seven families of primary crabs (Cumberlidge and Ng, 2009; Álvarez et al., 2020; Cumberlidge and Daniels, 2022), found in rivers, streams, lakes, and floodplains of the Neotropical region (Cumberlidge et al., 2014). It is one of the least specious families of freshwater crabs, with 15 genera and 47 species (Cumberlidge et al., 2014).

The genus *Sylviocarcinus* H. Milne Edwards, 1853 comprises five species and has a wide distribution in all the major river systems of South America (in Colombia, Venezuela, Guyana, Suriname, Brazil, Ecuador, Peru, Bolivia, Paraguay, and Argentina) (Rodríguez, 1992; Magalhães and Türkay, 1996). *Sylviocarcinus australis* Magalhães and Türkay, 1996 has been reported from Brazil (the states of Mato Grosso and Mato Grosso do Sul), Paraguay, Argentina, in the Paraguay and lower Paraná River basins (Rodríguez, 1992; Magalhães and Türkay, 1996; Collins et al., 2009). Surprisingly, during collection activities in an area almost 300 km (straight line) from the nearest occurrence, in Candelária, Argentina, and approximately 350 km (straight line) from the type locality (Paraguay, Rio Paraguay, Porto Max) (Magalhães and Türkay, 1996), the species was found for the first time in the state of Paraná, Brazil.

MATERIALS AND METHODS

Sampled area

Two adult male specimens of *Sylviocarcinus australis* were collected from an artificial, unnamed lake in a public park, in the municipality of São Miguel do Iguaçu, state of Paraná, Brazil (25°21'31.5"S 54°13'43.0"W) (Fig. 1).

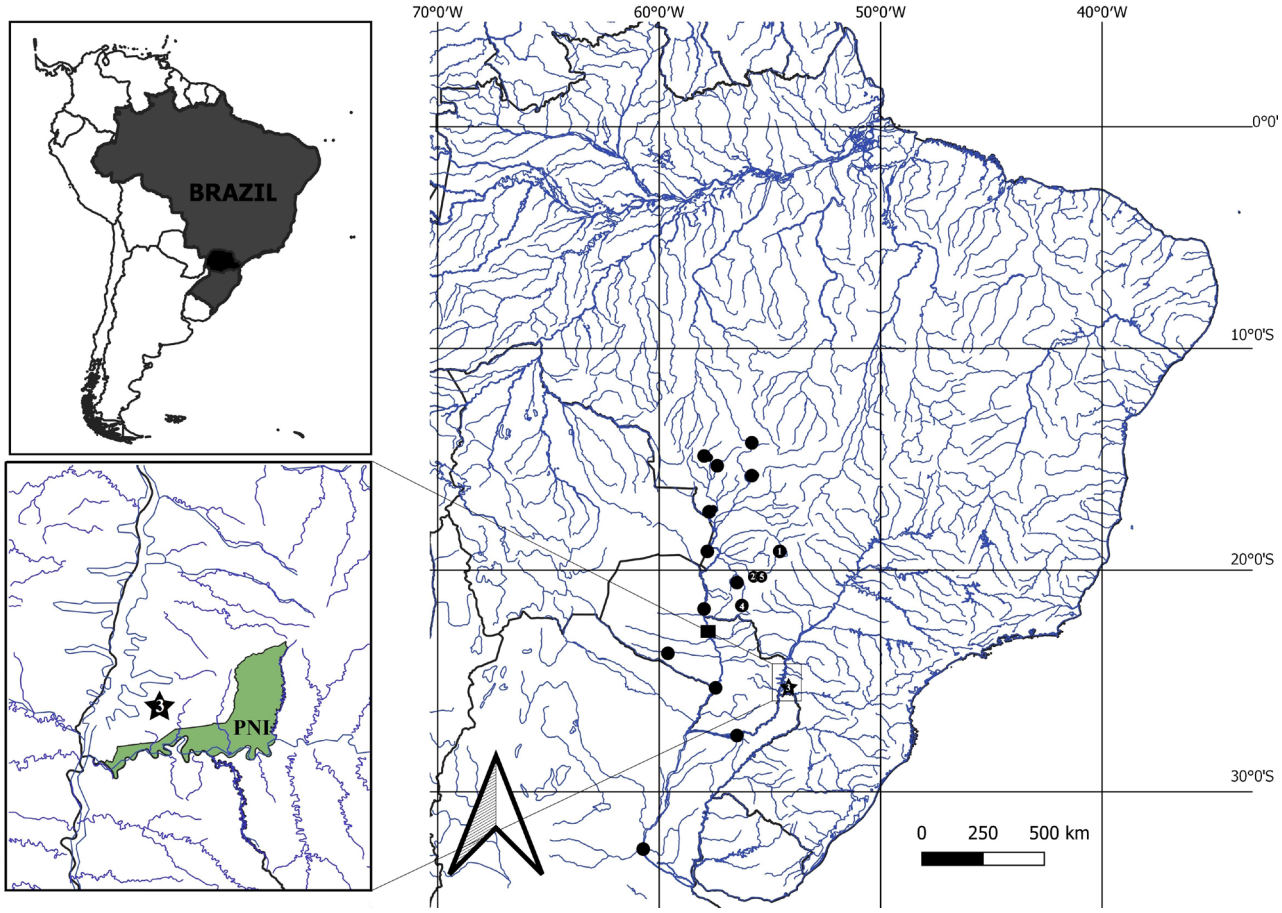

Figure 1. Distribution map of *Sylviocarcinus australis* based on records from Magalhães and Türkay (1996) and Collins et al. (2009): previous records (black circles), type locality (black square), new record (star). The numbering corresponds to the specimens in Tab. 1 and Fig. 4. PNI = Iguaçu National Park.

The animals were captured using traps, which were submerged from 8 pm until 5 am the following morning. The traps were made in the laboratory, using plastic containers measuring 25 × 15 × 8 cm (Fig. 2), built with an access ramp that allows the animals to enter and makes it difficult for them to leave (adapted from Bueno et al., 2014). Small (approx. 30 ml) perforated plastic containers were attached to the lids of the traps to hold the dog food that served as bait to attract the animals. After capture, the animals were anaesthetized on ice, then preserved in 70% alcohol for morphological and molecular analysis and deposited in the Coleção Zoológica de Crustáceos at the Universidade Estadual de Londrina (MZUEL 671).

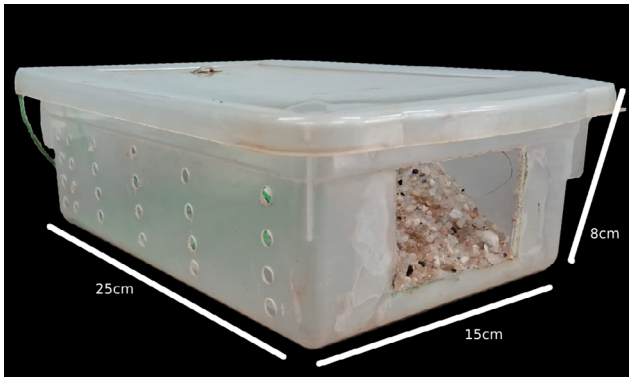

Figure 2. Image of the perforated plastic container used as crab trap.

Morphological analysis

The identity of the specimens was determined based on the description made by Magalhães and Türkay (1996), particularly of the morphology of the male first gonopods (G1). The carapace width (CW) was the widest measurement between the anterolateral spines on both sides of the carapace.

Molecular analysis

The molecular procedures (extraction, amplification, purification and sequencing) followed the protocols described by Mantelatto et al. (2018). DNA was extracted from the muscle tissue of the sample (extraction site region) for molecular identification using the Chelating Ion Exchange Resin method (Chelex VR 100) (Estoup et al., 1996). The base pair region of the mitochondrial genes 16S rRNA (Schubart et al., 2000) and cytochrome c oxidase subunit 1 (COI) (Schubart and Huber, 2006) of the extracted DNA was amplified using polymerase chain reaction (PCR) (Sambrook et al., 1989). Both markers proved to be efficient for diagnosing freshwater crabs including members of the family Trichodactylidae (Souza-Carvalho et al., 2017; Mantelatto et al., 2022, 2024; França et al., 2024).

The sequences were compared with the GenBank genomic database using the Basic Local Alignment Search Tool (BLAST) implemented on the website of the National Center for Biotechnology Information. To verify the identification, we entered each sequence using the BLAST nucleotide (BLASTn) and searched for the most similar sequences in the general sequence database. After finishing the search, we confirmed that the results were organized by the closest identity.

The Maximum Likelihood (ML) phylogenetic analysis was carried out on IQ-TREE (Nguyen et al., 2015), and the consistency of the topologies was checked using 1000 bootstrap replicates, using the Ultrafast bootstrap (Hoang et al., 2018), available on this server. Values lower than 75% confidence were not considered (Souza-Carvalho et al., 2017). To complement the sampling of molecular data, additional sequences were obtained from GenBank for another species of the genus as an outgroup (Tab. 1).

Table 1. Sequences of *Sylviocarcinus australis* and *S. pictus* used in the molecular analysis. Abbreviations: CCDB = Coleção de Crustáceos do Departamento de Biologia da Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo; INPA = Instituto Nacional de Pesquisa da Amazônia; MZUEL = Museu de Zoologia da Universidade Estadual de Londrina. The numbers in front of *S. australis* are correlated with the numbering of their respective locality indicated on the map in fig. 1 and with the Maximum likelihood tree in fig. 4.

Species	Locality	Collection	GenBank	
			16S	COI
Sylviocarcinus australis	Rio Negro, MS	INPA 2560	PQ276856	PQ278269
Sylviocarcinus australis	Aquidauana, MS	INPA 2568	PQ276857	–
Sylviocarcinus australis	São Miguel do Iguaçu, PR	MZUEL 671	PQ276858	PQ278270
Sylviocarcinus australis	Jardim, MS	CCDB 6502	–	PQ278271
Sylviocarcinus australis	Aquidauana, MS	CCDB 8039	–	PQ278272
Sylviocarcinus pictus	Senador José Porfírio, PA	CCDB 5136	PP808655	PP808635

SYSTEMATICS

Infraorder Brachyura Latreille, 1802
Family Trichodactylidae
H. Milne Edwards, 1853
Genus *Sylviocarcinus*
H. Milne Edwards, 1853
Sylviocarcinus australis
Magalhães and Türkay, 1996
(Fig. 3)

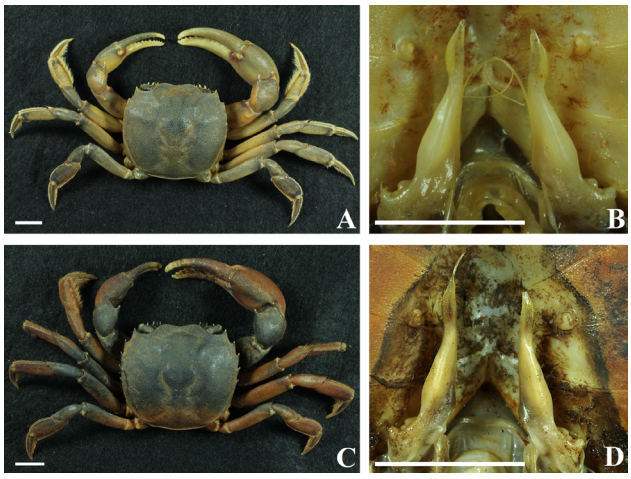

Figure 3. Male specimens of *Sylviocarcinus austalis*, MZUEL 671. **A**, Habitus, dorsal view, CW 33.38 mm; **B**, gonopod 1 in situ (from male CW 33.38 mm); **C**, habitus, dorsal view, CW 35.45 mm; **D**, gonopod 1, in situ (from male CW 35.45 mm). Scale bars= 10.0 mm.

Material examined. Two males (CW 33.38 and 35.45 mm), Brazil, state of Paraná, São Miguel do Iguaçu, municipal lake, 25°21'31.5"S 54°13'43.0"W, 27 Jan 2024; T. Arantes coll., MZUEL 671.

Remarks. The identity of the two individuals of *S. australis* was confirmed by both morphological and molecular analyses (Fig. 4). The morphological characters of both specimens correspond well to those described for the species by Magalhães and Türkay (1996). The carapace has small spots evenly distributed on its dorsal surface and bears four distinct acute teeth on each side of the anterolateral margin. The pleonal somites III–VI are fused. The G1 is slender, its distal portion is straight and bears a weakly developed subdistal lobe and two longitudinal patches of small spines, the mesial one being greatly reduced and nearly indistinct.

DISCUSSION

Sylviocarcinus australis is primarily found in the Paraguay River basin, with Paraguay as its type locality, and has a restricted distribution in three Brazilian states — Mato Grosso, Mato Grosso do Sul, and Rondônia (the latter with a single record in the

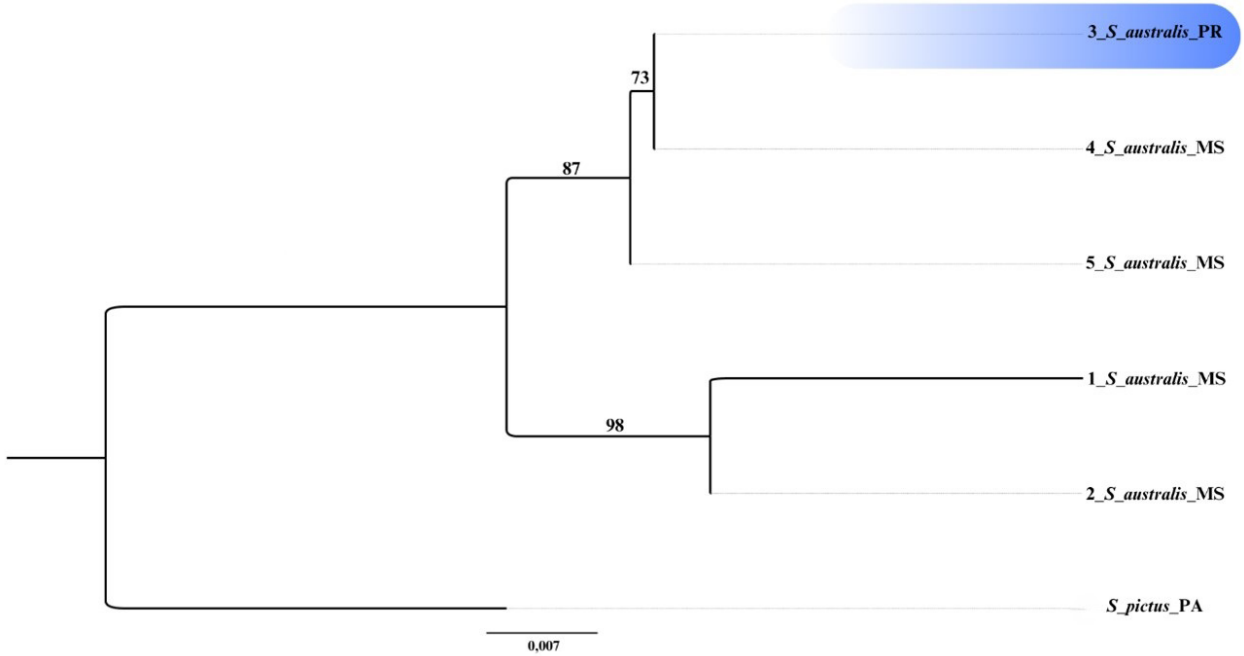

Figure 4. Maximum likelihood tree, using the 16S gene and COI, and *Sylviocarcinus pictus* as outgroup. The numbers in front of *Sylviocarcinus australis* are correlated with the numbering of their respective locality indicated on the map in Fig. 1. The branch numbers are the Bootstrap confidence values. The acronyms PR, MS and PA are the abbreviations for the Brazilian states of Paraná, Mato Grosso do Sul, and Pará, respectively.

southern portion of the Amazon basin) — as well as in Paraguay and Argentina (Magalhães and Turkay, 1996), including the lower Paraná River into which the Paraguay River flows. Our most likely hypothesis is that the specimens found in the upper Paraná River basin are not native to this region but were introduced, either deliberately or accidentally.

Although there are records of *S. australis* in the Paraná River, its occurrence has so far been restricted to the middle and lower sections, near the confluence with the Paraguay River. This region is characterized by lowland terrain with fewer rapids (Fujita, 2014), which corresponds to the typical habitat of these crabs, associated with lowland rivers (Rodríguez, 1981). In contrast, the upper Paraná is marked by a plateau relief with many rapids with high damming potential (Fujita, 2014). Furthermore, the confluence of the Iguaçu River with the Paraná River may act as a significant abiotic barrier due to intense physiographic changes in this junction, such as alterations in flow, sediment transport, and bed morphology (Roy, 2008; Lewis and Rhoads, 2015). The combination of these factors likely hinders the colonization of *S. australis* into the upper Paraná region.

Although less likely, we cannot rule out the possibility that this species had previously gone undetected; however, this is improbable given that streams in the area have been intensively sampled previously, and no specimens of *S. australis* were observed (T.A., unpublished data).

A plausible explanation for anthropogenic introduction into the environment is that they were unintentionally, or even intentionally, translocated by an aquarium hobbyist (less likely but not exclusive) or by recreational fishermen, who frequent the Pantanal in Mato Grosso and Mato Grosso do Sul for sport fishing. It is common for fishermen to use crabs as live bait, a practice previously observed with *Dilocarcinus pagei* (see Moraes and Espinoza, 2001). After fishing, it is typical for them to release the animals still alive into the environment. Thus, these crabs could have been brought and discarded near the area where they were found, extending their distribution (Magalhães et al., 2005; Magalhães, 2016).

Close to the artificial lake where the specimens were collected, there is a spring that could serve as a colonization point for these animals. However, no females or juveniles were found, which prevents us from confirming the presence of an established population in the area. Little is known about the general biology and interspecies interactions of *S. australis*, particularly in relation to local fauna. Recently, Covich et al. (2024) evaluated the role of decapods in the food web interacting with plants in a region of Mato Grosso do Sul, where *S. australis* played a significant role as an "opportunivore".

Although the biology and desiccation resistance of *S. australis* remain unknown, the related species *Sylviocarcinus pictus* can survive up to 17 hours out of water (da Silva and Sant'Anna, 2019). This suggests that these animals may have the ability to endure prolonged periods out of water, potentially enabling them to travel significant distances between environments (such as from an artificial to a natural habitat) via dry routes.

Even though these animals were found in an artificial environment, such as a lake, there is a potential risk of dispersal into nearby natural habitats, which could lead to the invasion of native ecosystems and affect local populations of various groups. Although it is still too early to predict long-term consequences, the impacts of such invasions can be significant, especially for freshwater crabs, which often have limited distributions (Magalhães, 2003; Cumberlidge and Ng, 2009).

Additionally, the specimens were found just 14 km northwest from Iguaçu National Park, the largest forest remnant in southern Brazil dedicated to the protection of biodiversity in the Atlantic Forest, one of the most biodiverse and threatened biomes in the world (Marchese, 2015; Santos et al., 2020). This region also contains several tributaries that drain into the Iguaçu National Park, highlighting our limited knowledge of the species occurring in this conservation area. For example, other crab species, such as *Trichodactylus kensleyi* Rodríguez, 1992 (T.A., unpublished data) and anomuran crabs of the genus *Aegla* Leach, 1821 (Santos et al., 2020; T.A., personal observation), have been reported there.

Furthermore, the Itaipu hydroelectric reservoir is located merely 10 km southwest of the new record site, connecting to drainages where endemic species such as *T. kensleyi* (T.A., unpublished data) and *Aegla urussanga* Arantes, Souza-Shibatta and Teixeira, 2024 occur.

Even important conservation areas are vulnerable to biological invasions, as already documented for snail and fish in this same region (Gutierrez et al., 2007; Mezzaroba et al., 2021), jeopardizing our knowledge of the little-known native fauna of these regions. Protected areas that cover only segments of a river cannot secure the integrity, heterogeneity, and dynamism of fluvial networks, which potentially threaten most freshwater organisms. We therefore recommend that future monitoring efforts be carried out to assess the occurrence of this species in other surrounding areas, as well as to check for the presence of females, ovigerous females, or juveniles. This will help us understand this introduction and develop appropriate management strategies to protect local ecosystems and their native species.

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ADDITIONAL INFORMATION AND DECLARATIONS

Author Contributions

Conceptualization and Design: TA. Performed research: TA, FLM, GLB. Acquisition of data: TA, HG. Analysis and interpretation of data: TA, HG, FLM. Preparation of figures/tables/maps: TA, HG. Writing – original draft: TA, GLB, HG. Writing – critical review and editing: GMT, FLM. Resources, funding acquisition, and collections permits: FLM.

Consent for publication

All authors declare that they have reviewed the content of the manuscript and gave their consent to submit the document.

Competing interests

The authors declare no competing interest.

Data availability

All study data are included in the article.

Study permits

Brazilian specimens were obtained under collection permits (permanent license to FLM for collection of Zoological Material No. 11777-4 MMA/IBAMA/SISBIO and SISGEN A496BF8 and CEA7CD5).

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