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Nota

The most cosmopolitan freshwater gastropod invades the Lower São Francisco River: first record of *Physella acuta* in Sergipe

El gasterópodo dulceacuícola más cosmopolita invade el Bajo Río São Francisco: primer registro de *Physella acuta* en Sergipe

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Abstract

Biological invasion and habitat modification are major drivers of biodiversity loss. River damming, in particular, leads to hydrological, limnological, and habitat disruptions, and facilitates the introduction, establishment and spread of alien species. In Brazil, most alien freshwater mollusk species have been observed in reservoirs. This study documents the first occurrence of the highly widespread exotic freshwater gastropod *Physella acuta* (Physidae) in Sergipe, Brazil. In February 2019, individuals of *P. acuta* were observed along the margin of the Xingó reservoir. The individuals were photographed *in situ* and collected for identification in the laboratory. Results confirm the first occurrence of *P. acuta* in Sergipe, expanding its known range in Brazil and updating the list of the invasive species in both Sergipe and the Lower São Francisco River.

Keywords: aquatic macroinvertebrates, invasive species, habitat, Mollusca, Physidae, distribution.

Resumen

Las invasiones biológicas y las modificaciones de hábitat son importantes motores de pérdida de biodiversidad. El represamiento de ríos, en particular, provoca perturbaciones a nivel hidrológico, limnológico y de hábitat, y facilita la introducción, establecimiento y propagación de especies exóticas. En Brasil, la mayoría de las especies exóticas de moluscos de agua dulce se han observado en embalses. Este estudio documenta la primera ocurrencia del gasterópodo dulceacuícola exótico *Physella acuta* (Physidae) en Sergipe, Brasil. En febrero de 2019, se observaron individuos de *P. acuta* a lo largo del margen del embalse de Xingó. Los individuos fueron fotografiados *in situ* y recogidos para su identificación en el laboratorio. Los resultados confirman la primera ocurrencia de *P. acuta* en Sergipe, ampliando su rango conocido en Brasil y actualizando la lista de especies invasoras tanto en Sergipe como en el bajo Río São Francisco.

Palabras clave: macroinvertebrados acuáticos, especies invasoras, hábitat, moluscos, Physidae, distribución.

Introduction

Biological invasions and habitat modifications are two of the five major drivers of biodiversity loss (MEA, 2005). On the one hand, the introduction of alien species is widely considered to be the second leading cause of this phenomenon worldwide (Bellard et al., 2016), posing a significant threat to ecosystems and native species (IUCN, 2000; Bellard et al., 2016). On the other, the construction of river dams can generate hydrological, limnological, and habitat disturbances that threaten native biodiversity. These disturbances include alterations to natural flow regimes, sediment transport, and water quality. Furthermore, they can dismantle physical barriers, eliminate natural competitors and predators, and facilitate the spread and establishment of invasive alien species (Havel et al., 2005; Johnson et al., 2008; Thomaz et al., 2015; Miyahira et al., 2020). Nearly all alien freshwater mollusk species recorded in Brazil have been observed in reservoirs (Miyahira et al., 2020). The phylum Mollusca represents a significant portion of invasive species in the world. It comprises four of the nine aquatic invertebrates and two of the seventeen terrestrial invertebrates listed on the 100 worst invasive alien species (Lowe et al., 2000).

Commonly known as sewage snail, acute bladder snail and European physa, *Physella acuta* (Draparnaud, 1805) is a highly invasive aquatic pulmonate snail of the Physidae family. Its widespread presence makes it one of the most ubiquitous aquatic macroinvertebrates globally (Dillon et al., 2002; Appleton, 2003; Taylor, 2003; Wethington, 2004) and has earned it recognition as the “most cosmopolitan freshwater gastropod” (Dillon et al., 2002, p. 8; Latini et al., 2016). Despite its prevalence, *P. acuta*’s taxonomic history is complex and includes an extensive synonymy list (Dillon et al., 2002; Taylor, 2003; Wethington & Lydeard, 2007; Taylor, 2003; Vinarski, 2017; Paul & Aditya, 2021; GBIF, 2025). This species exhibits remarkable genetic variation, both within species and populations (Wethington, 2004), and phenotypic plasticity (Zukowski & Walker, 2009; Núñez, 2011; Paul & Aditya, 2021). The Physinae subfamily currently includes 18 delineated candidate species, with some taxa exhibiting cryptic diversity. A study based on species delimitation by Young et al. (2021) identified the *P. acuta* complex as a well-supported group nested within the *Physella* clade and highlighted its close relationship to the *Physella* genus.

Physella acuta has several traits that favor invasion and establishment in new environments, including its amphibious nature (Appleton, 2003), tolerance to higher salinity and temperature, fast growth rate, high fecundity, short incubation period, year-round reproduction (Brackenbury & Appleton, 1991, Appleton, 2003; Zukowski & Walker, 2009, Ng et al., 2015), and rapid locomotion against predators (Appleton, 2003). These factors allow for rapid colonization, both initially and following a stochastic event (Appleton, 2003). Notably, the species demonstrates significant tolerance and resilience to environmental disruptions (Wethington, 2004), such as recurrent floodings (Brackenbury & Appleton, 1991; Appleton 2003; Gulanicz et al., 2018) and sewage contamination (Brackenbury & Appleton, 1991; Appleton, 2003; Collado et al., 2020; Paul & Aditya, 2021). Notably, *P. acuta* exhibits high densities in eutrophic metropolitan rivers, with 4350 individuals m^{-2} reported in Brazil (França et al., 2007) and 4561 individuals m^{-2} in South Africa (Brackenbury & Appleton, 1991). Furthermore, *P. acuta* can occur with other native mollusks, such as *Glyptophysa gibbosa* (A. Gould, 1847) (Zukowski & Walker, 2009), or invasive ones, including the gastropods *Melanoides tuberculata* (Müller, 1774) and *Biomphalaria tenagophila* (d'Orbigny, 1835) (Santos et al., 2007; Miyahira et al., 2010). It is worth noting that the leech *Glossiphonia weberi* (Blanchard, 1897) and the water bug *Diplonychus rusticus* (Fabricius, 1871), species observed preying on *P. acuta* in the wild in Kolkata, India, have shown promising predatory efficacy against *P. acuta* as demonstrated by laboratory experiments conducted in the same region (Aditya & Raut, 2002a; 2002b).

Physidae snails have established themselves on every continent except Antarctica (Paraense & Pointier, 2003; Taylor 2003; Wethington, 2004; Wethington & Lydeard, 2007; Zukowski & Walker, 2009; Núñez, 2010; Vinarski, 2017). This phenomenon is commonly attributed to human activities (Taylor, 2003; Wethington & Lydeard, 2007). Despite being first described in France, *P. acuta* is native to North America (Brackenbury & Appleton, 1991; Dillon et al., 2002; Lydeard et al., 2016). In Brazil, its first record dates to 1966 in a small artificial lake at the Oswaldo Cruz Institute in Rio de Janeiro. It was initially misidentified as *Physa (Physella) cubensis* Pfeiffer, 1839 (Leme, 1966; Paraense & Pointier, 2003). Currently, the species has records in the states of Pará, Ceará, Paraíba, Pernambuco, Alagoas, Bahia, Goiás, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (Leme, 1966; Agudo-Padrón, 2008; Miyahira et al., 2010; Agudo-Padrón & Lenhard, 2011; Latini et al., 2016; Thiengo et al., 2017; Moratelli et al., 2023; Coelho et al., 2024; SDNHM, 2024; GBIF, 2025; Morris, 2025; Instituto Hórus, 2025).

This study reports the first record of *P. acuta* in the Xingó reservoir, located in the Lower São Francisco River basin, Sergipe state, northeastern Brazil. It also provides an updated distribution of the species within Brazil.

Material and methods

Inaugurated in 1994, the Xingó Hydroelectric Power Plant is the last of six hydroelectric power plants built across the São Francisco River. With an area of 60 km², a volume of 3.3 billion m³, and a run-of-river reservoir system (Santos et al., 2016), it is located in the lower third of the river's basin, 179 km from the mouth, between the states of Alagoas and Sergipe (Araújo et al., 2016; Santos et al., 2016; Holanda et al., 2021). This northeastern region has predominant Caatinga vegetation (Holanda et al., 2021) and is known as *Polígono da Seca* or "drought polygon" due to its prolonged periods of extreme drought (Santos et al., 2016). Besides electricity generation, the Xingó reservoir is used for artisanal fishing (Araújo et al., 2016), crop irrigation, and water supply for the local population (Holanda et al., 2021). Furthermore, the site has become a tourist attraction, with catamaran docks on the banks, mainly in the Canindé de São Francisco municipality (Holanda et al., 2021).

On February 3, 2019, a field study was conducted along the Sergipe margin of the Xingó reservoir, approximately 1700 m from the Xingó Hydroelectric Power Plant dam (9°32'15.0"S 37°58'28.0"W) (see Figure 1). Several freshwater gastropods and egg masses were observed around the tourist terminal, which features a swimming/bathing area isolated from the catamaran docks by PVC pipes (Figure 2), and dense mats of *Egeria densa* Planch. (a macrophyte) (Figure 3). Individuals were photographed *in situ* using a digital camera (Figure 2), then manually collected, stored in aerated plastic containers and transported to the Benthic Ecology

Laboratory (DEPAq/Federal University of Sergipe) for further analysis. Each individual was identified in accordance with Paraense & Pointier (2003), Wethington (2004), Nuñez (2011), Latini et al. (2016), Collado (2017), Ng et al. (2018), Collado et al. (2020) and NIWA (2020). The shell length was determined using a digital pachymeter with a precision of 0.01 mm. After identification, the collected specimens were deposited in the biological collection of the Benthic Ecology Laboratory (DEPAq/UFS).

Results and discussion

The 17 collected specimens display shell features consistent with those of *Physella acuta*: a sinistral thin shell with longitudinal striations, oval shape, moderately lustrous, short-pointed spire, and a large ear-shaped aperture. The shells of live organisms had an external coloration ranging from dark brown to beige (Figure 2 and Figure 3). In the laboratory, the empty shells are opaque with coloration ranging from beige to cream on both outer and inner surfaces (Figure 4). The shell height ranged from 2.6 to 6.3 mm, mean = 5.14±0.23 mm (Figure 4). This interval (4-6 mm) was the most frequently encountered by Paul & Aditya (2021) and Miyahira et al. (2023), and it allows to estimate that the specimens were approximately 30 weeks old (Nuñez, 2010).

These specimens confirm the first record of *Physella acuta* in Sergipe, in the Lower São Francisco River, thus filling a gap in the understanding of its distribution in Brazil (Table 1; Figure 5). The record represents a new addition to the growing list of invasive freshwater mollusks in the São Francisco River basin, such as *Melanoides tuberculata* (Souto et al., 2011), *Corbicula fluminea* (O. F. Müller, 1774) (Santana et al., 2013), *Limnoperna fortunei* (Dunker, 1857) (Barbosa et al., 2016), and *C. largillierti* (Philippi, 1844) (Rosa, 2023). The unintentional introductions of *P. acuta* individuals and eggs are attributed to aquarium-related activities, especially through the transport of aquatic plants (Dillon et al., 2002; Miyahira et al., 2010; Latini et al., 2016; Vinarski, 2017; Ng et al., 2018; NIWA, 2020; Miyahira et al., 2023). *P. acuta* exhibits exceptional tolerance to water pollution (Brackenbury & Appleton, 1991; Appleton, 2003; Collado et al., 2020; Paul & Aditya, 2021), facilitating its proliferation within disturbed habitats. This tolerance potentially fosters a link between the species distribution and anthropogenic activities associated with pollution (Appleton, 2003; Wethington, 2004; Paul & Aditya, 2021).

Physella acuta has a high degree of habitat plasticity, including artificial ones, such as sewage drains (Appleton, 2003; Paul & Aditya, 2021), controlled aquatic environments (Alexandre, 2017), areas around major urban centers (particularly ports) (Appleton, 2003; Miyahira et al., 2010), reservoirs (Coelho et al., 2024; Miyahira et al., 2020), dams (Kock & Wolmarans, 2007; Latini et al., 2016; Miyahira et al., 2020), artificial lakes (Leme, 1966; Paraense & Pointier, 2003), channels and ditches (Kock & Wolmarans, 2007; Moratelli et al., 2023), small tanks (Latini et al., 2016), concrete pots and ponds with ornamental aquatic plants (Kock & Wolmarans, 2007), ornamental ponds (Appleton 2003; Ng et al. 2018), irrigation furrows (Kock & Wolmarans, 2007), paddy fields (Ng et al. 2018), pans (Kock & Wolmarans, 2007), quarries (Kock & Wolmarans, 2007), and as hitchhikers on aquatic plants being sold in ornamental pet trade shops (Ng et al. 2018). In natural environments, the species occurs in springs (Kock & Wolmarans, 2007), estuaries (Ng et al., 2018), wetlands (NIWA, 2020), swamps (Kock & Wolmarans, 2007), bogs (Paul & Aditya, 2021), rivers (Appleton, 2003; Taylor, 2003; Lydeard et al., 2016; Kock & Wolmarans, 2007; Lydeard et al., 2016; Thiengo et al., 2017; Ng et al., 2018; Collado et al., 2020), streams (Appleton, 2003; Latini et al., 2016; Lydeard et al., 2016) (including insular ones) (Miyahira et al. 2010; Miyahira et al., 2023), Vlei (shallow, usually seasonal or intermittent bodies of water, typically found in South Africa) (Kock & Wolmarans, 2007), lakes (Latini et al., 2016; Collado et al., 2020; NIWA, 2020), ponds (Appleton, 2003; Kock & Wolmarans, 2007; Lydeard et al., 2016; Paul & Aditya, 2021; NIWA, 2020), waterholes (Kock & Wolmarans, 2007), on rocks and sandy substratum (Appleton, 2003), roots of floating water hyacinths (Kock & Wolmarans, 2007), on macrophytes (Dillon

Junior, 2000; Miyahira et al., 2023), and attached to other marginal aquatic vegetation, stones, and leaf litter (Miyahira et al., 2023).

The success of *Physella acuta* as an invasive species might be attributed partially to its adaptability to diverse environmental conditions. This species exhibits high tolerance and resilience to fluctuations in rainfall, water body levels (Brackenbury & Appleton, 1991; Gulanicz et al., 2018; Miyahira et al., 2023), varying current velocities (Appleton, 2003), and salinity (Dunlop et al., 2008; Zukowski & Walker, 2009). Interestingly, despite its tolerance to fluctuations, *P. acuta* populations appear negatively impacted by increased rainfall volume, especially in anthropic water bodies lacking marginal vegetation (Miyahira et al., 2023). Its tolerance for strong current speeds and apparent indifference to marginal vegetation allow *P. acuta* access to a wider range of suitable substrata compared to native snail species (Appleton, 2003). For *P. acuta* adults, experiments on instantaneous salinity tolerance (72 h and lethal dose for 50% of the sample) demonstrate a high tolerance, with a > 5.2-11.8 gL^{-1} limit (Dunlop et al., 2008; Zukowski & Walker, 2009).

Previous studies have documented the detrimental effects of *Physella acuta* on native communities across diverse ecosystems (Brackenbury & Appleton, 1991; Zukowski & Walker, 2009; Nuñez, 2010). Compared to many native snails, *P. acuta* exhibits high fecundity and shorter egg hatching times, features that grant it a competitive advantage for establishing populations (Zukowski & Walker, 2009; Núñez, 2011). As a microphagous feeder, it competes with native grazers like other snails and insects for shared food sources such as detritus and algae. Moreover, its ability to reach high densities in new habitats (Zukowski & Walker, 2009; Núñez, 2010; Vinarski, 2017) raises concerns about potential food resource depletion for native competitors (Appleton, 2003). Potential physical interactions between *P. acuta* and native invertebrates in high-density situations could further magnify its negative impacts (Appleton, 2003; Zukowski & Walker, 2009; Nuñez, 2010). Finally, the species has medical significance, as it serves as an intermediate host for human trematodes such as *Fasciola hepatica* L., 1758 (Barros et al., 2002) and *Echinostoma* Rudolphi, 1809 (Zimmerman et al., 2014).

The record of *Physella acuta* in the Lower São Francisco River expands our knowledge of its distribution and emphasizes the importance of continuous monitoring programs to ensure early detection and prompt management interventions to mitigate potential ecological and health risks. Controlling the aquarium trade and associated goods remains critical to prevent freshwater snail invasions. These vectors are well-established pathways for the introduction of invasive species into ecosystems. Despite uncertainty around its full ecological impact, addressing key questions about its distribution, abundance, potential health risks, and effects on native species is crucial. Future research involving additional sampling is necessary to map the distribution pattern of *P. acuta* throughout the Lower São Francisco River. This information will help understand interactions with both native and invasive species and determine their impacts on local environments.

Figure 1. Sampling site (red dot) in the reservoir of the Xingó Hydroelectric Power Plant, Lower São Francisco River.

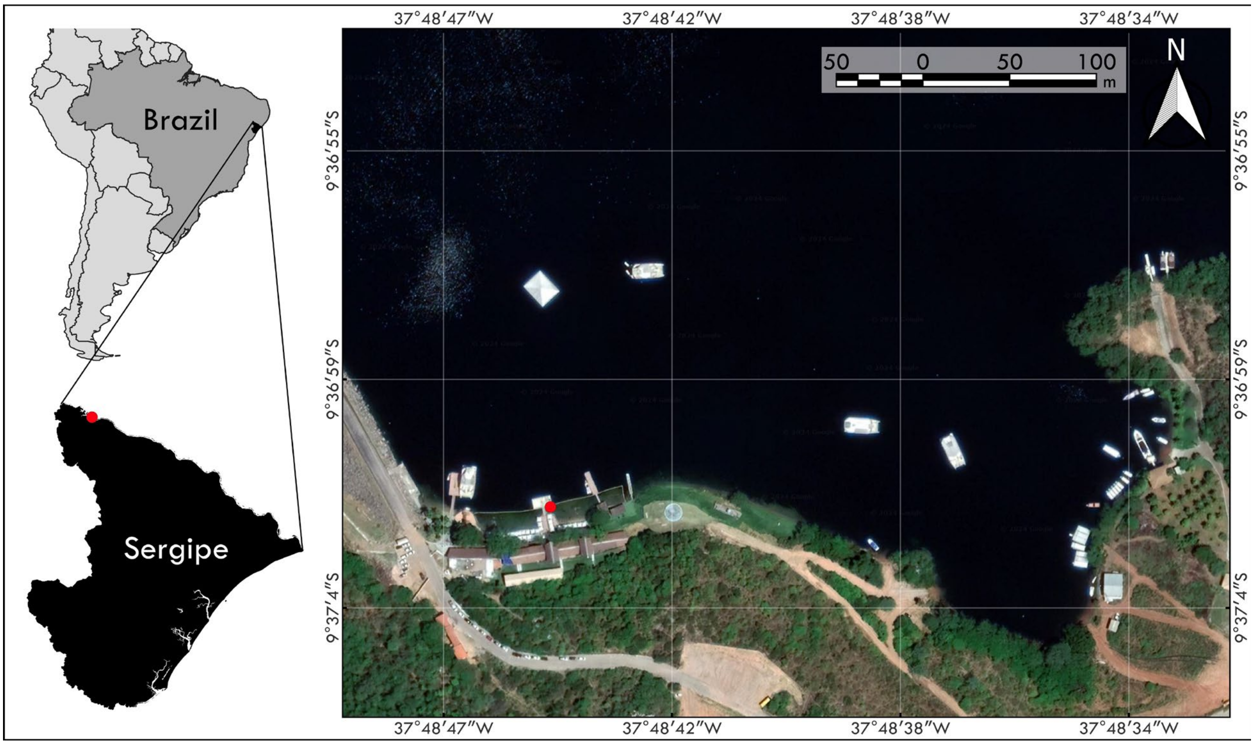
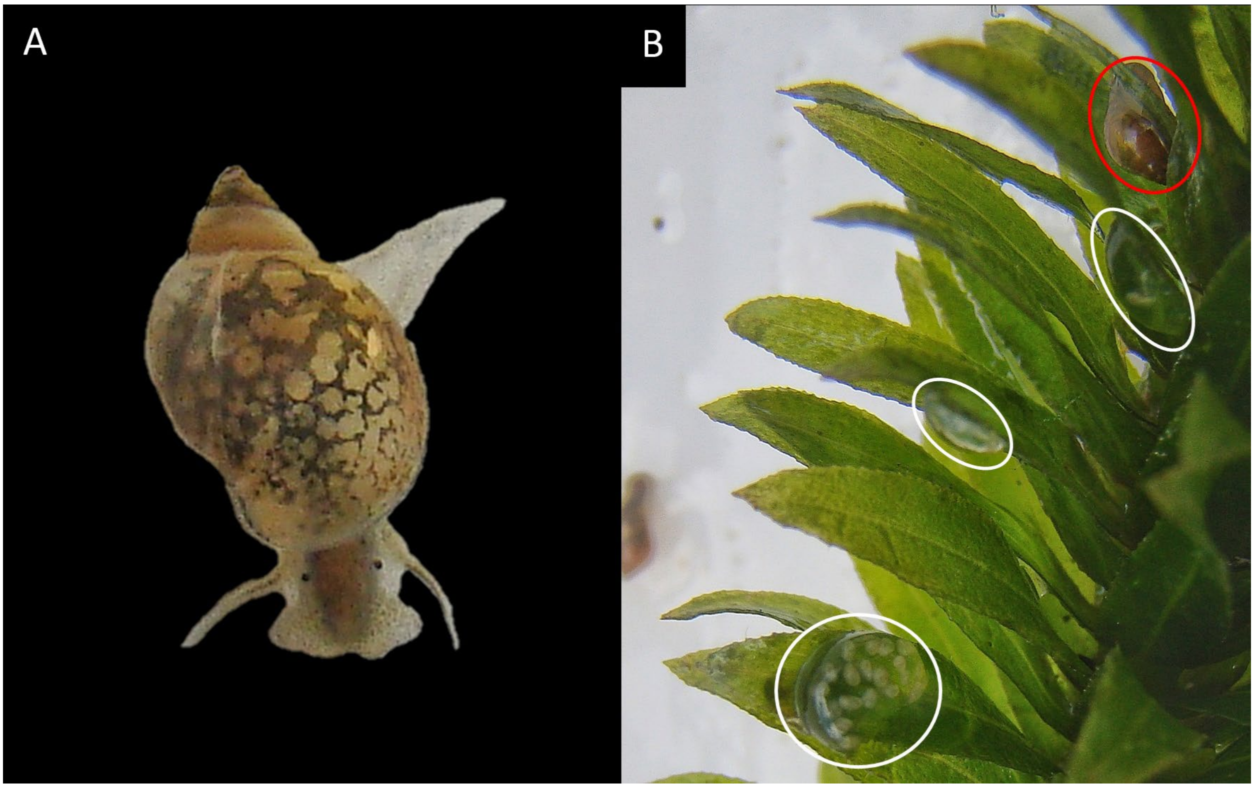


Figure 2. Collection sites of *Physella acuta* (Draparnaud, 1805) in the reservoir of the Xingó Hydroelectric Power Plant.

Notes. A) swimming/bathing area of the tourist terminal; B) PVC pipes where the specimens were photographed and collected.

Figure 3. Live specimens of *Physella acuta* (Draparnaud, 1805).



Notes. B) red ellipse = individual; white ellipse = egg masses on *Egeria densa* Planch.

Figure 4. Shells of *Physella acuta* (Draparnaud, 1805).

Notes. A) Empty shells of the 17 collected specimens; B) largest and smallest specimens collected (scale bar in millimeters).

Figure 5. Updated map of *Physella acuta* (Draparnaud, 1805) distribution in Brazil.

Table 1. Records of *Physella acuta* (Draparnaud, 1805) in Brazil.

State	Reference
Pará	SDNHM, 2024
Ceará	Morris, 2025
Paraíba	Instituto Hórus, 2025
Pernambuco	Thiengo et al.,2017
Alagoas	Morris, 2025
Sergipe	**This study**
Bahia	Latini et al., 2016; Thiengo et al., 2017; GBIF, 2025
Goiás	Latini et al., 2016
Mato Grosso do Sul	Latini et al., 2016
Minas Gerais	Coelho et al., 2024; GBIF, 2025
Rio de Janeiro	Leme, 1966; Miyahira et al., 2010; Latini et al., 2016; GBIF, 2025; Instituto Hórus, 2025
São Paulo	França et al., 2007; Latini et al., 2016; GBIF, 2025
Paraná	Latini et al., 2016; Moratelli et al., 2023
Santa Catarina	Agudo, 2008; Instituto Hórus, 2025
Rio Grande do Sul	Agudo & Lenhard, 2011

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