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Freshwater Bryozoa in Argentina: A Novel Record in a RAMSAR Wetland

Briozoos de agua dulce en Argentina: Un Registro Novedoso en un Humedal RAMSAR

Monti Areco, Florencia[1,2], Avalos, Guillermo Luis[1], Kassor, Rodolfo Gustavo[1]

[1] Laboratorio Biología de los Invertebrados. Facultad de Ciencias Exactas, Naturales y Agrimensura. Universidad Nacional del Nordeste. Corrientes, Argentina.
[2] Centro de Ecología Aplicada del Litoral (CECOAL). Ruta Provincial N.º 5, Corrientes, Argentina.

E-mail: guillermo.avalos.94@gmail.com

ABSTRACT. This study focuses on freshwater bryozoans (Ectoprocta), particularly Phylactolaemata, which reproduce sexually and asexually, either by clonal budding or through encapsulated dormant structures called statoblasts. These structures are crucial for the taxonomic identification of bryozoans. Current knowledge about taxonomy, systematics, physiology, ecology, and biogeography of freshwater bryozoans in South America is scarce. In Argentina, the diversity and distribution of bryozoans are poorly known, with most studies focusing on marine species. The findings of *Plumatella emarginata* Allman, 1844 in northeastern Argentina represents the first record of a Phylactolaemata in a RAMSAR site in this country. The study area includes Totorá Lagoon and Iberá Lagoon in the Province of Corrientes, northeastern Argentina, both crucial to the local and regional ecosystem. Water physicochemical parameters were measured. This study highlights the need for further research on freshwater bryozoans in South America to enhance our understanding of these ecologically significant organisms.

Keywords: Corrientes province, Ectoprocta, Phylactolaemata, *Plumatella*, statoblast.

RESUMEN. Este estudio se centra en los briozoos de agua dulce (Ectoprocta), particularmente Phylactolaemata, que se reproducen sexual y asexualmente, ya sea mediante gemación clonal o a través de estructuras encapsuladas de resistencia llamadas estatoblastos. Estas estructuras son cruciales para la identificación taxonómica de los briozoos. El conocimiento actual acerca de la taxonomía, sistemática, fisiología, ecología y biogeografía de los briozoos de agua dulce en Sudamérica es escaso. En Argentina, el conocimiento sobre la diversidad y distribución de los briozoos es escaso, ya que la mayoría de los estudios se han centrado en especies marinas. El hallazgo de *Plumatella emarginata* Allman, 1844 en el noreste de Argentina representa el primer registro de un Phylactolaemata en un sitio RAMSAR de este país. El área de estudio incluye la Laguna Totorá y la Laguna Iberá, en la provincia de Corrientes, noreste de Argentina, ambas de gran importancia para el ecosistema local y regional. Se midieron parámetros fisicoquímicos del agua. Este estudio resalta la necesidad de realizar más investigaciones sobre los briozoos de agua dulce en América del Sur para mejorar nuestra comprensión de estos organismos de gran importancia ecológica.

Palabras clave: Provincia de Corrientes, Ectoprocta, estatoblastos, Phylactolaemata, *Plumatella.*

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INTRODUCTION

Bryozoa (Ectoprocta) comprise sessile, colonial animals, with colonies formed by genetically identical zooids through budding, a form of clonal asexual reproduction (Francis, 2001). These filter-feeding organisms are attached to submerged surfaces, have a ciliated array of tentacles, known as a lophophore, to capture organic particles and generate water currents (Francis, 2001). Most bryozoan species inhabit marine environments, although fewer than a hundred species are freshwater, where they represent a significant part of freshwater invertebrate communities (Francis, 2001; Massard and Geimer, 2008; Wood and Liebbe, 2020). Furthermore, bryozoan colonies play a pivotal role in freshwater ecosystems, particularly within periphyton and littoral communities, where they significantly contribute to nutrient cycling and trophic dynamics by serving as a key food source for both vertebrate and invertebrate species. Additionally, freshwater Bryozoa function as reliable bioindicators due to their high sensitivity to environmental disturbances and pollution, making them effective biosensors for ecosystem health monitoring (Francis, 2001; Elia *et al*., 2007).

Bryozoa are classified into three categories: Stenolaemata, exclusively marine; Gymnolaemata, mainly marine but including a few freshwater members of the order Ctenostomata and, Phylactolaemata exclusively inhabiting freshwater environments (Francis, 2001; Wood and Liebbe, 2020).

Phylactolemate species live attached to a wide variety of submerged substrates in both lentic and lotic waters, in environments rich in suspended organic matter and phytoplankton, with temperatures ranging from 0°C to 37°C and a broad tolerance to pH levels (Okamura and Hatton-Ellis, 1995; Orellana Liebbe, 2006; Wood, 2010). Their colonies are composed of tubular, chitinous zooids, featuring an epistome and a horseshoe-shaped lophophore (Orellana Liebbe, 2006). These phylactolaemates reproduce sexually, as well as asexually through clonal budding and via encapsulated dormant structures known as statoblasts (Francis, 2001; Massard and Geimer, 2008). This adaptation serves as a mechanism for reproduction, survival, and dispersal, capable of withstanding freezing, desiccation, and other environmental stresses. Under favorable conditions, statoblasts bud and initiate a new colony (Francis, 2001). There are three primary types of statoblasts distinguished by their morphology and function: 1) sessoblasts, which remain cemented to a substrate or the colony itself; 2) floatoblasts, which are buoyant and free-floating; and 3) piptoblasts, found exclusively in *Fredericella* spp., which neither float nor attach externally, adhering to the colony walls via small projections. The type, morphology, and size of statoblasts are key elements for the systematic classification of this group (Francis, 2001; Orellana Liebbe, 2006).

Despite their wide distribution and frequent occurrence in collections, along with their potential significance in littoral community biomass, the current knowledge of freshwater bryozoans in South America is still scarce (Cordiviola de Yuan, 1977a, b; Raddum and Johnsen, 1983; Cazzaniga, 1989; Orellana Liebbe, 2006; Wood and Okamura, 2017). Their small size often leads to their oversight into freshwater invertebrate collections, highlighting a critical need for comprehensive research into their taxonomy, systematics, physiology, ecology, and biogeography.

In Argentina, the information is especially scarce, with research primarily focused on marine species (López-Gappa and Lichtschein, 1988; López-Gappa, 2000; Liuzzi *et al*., 2018). This has resulted in a significant gap in understanding the diversity and distribution of freshwater bryozoans in the region. This issue is particularly critical given that the study area comprises a wetland designated as a RAMSAR site, recognized for its ecological singularity and significance at local, regional, and global scales (RAMSAR, 2023). The Iberá Wetland, one of the largest in South America in terms of both surface area and geographical location, ranks

as the fifteenth most important wetland at the continental level (Neiff *et al*., 1994). Moreover, they play a crucial role in maintaining genetic and ecological diversity, reinforcing their status as one of the most biodiverse wetlands in the biosphere (Almirón and Casciotta, 2004; RAMSAR, 2023). The presence of *P. emarginata* in these wetlands suggests that habitats with high macrophyte diversity and specific physicochemical conditions provide an optimal environment for its colonization and development (Poi *et al*., 2017). Therefore, our objective is to document and analyze the presence and characteristics of *P. emarginata* in the RAMSAR wetlands of Corrientes Province, Argentina. Through this, we aim to improve the knowledge on its distribution range and contribute to the updated records of the species.

MATERIAL AND METHODS

Study Area

The study area encompasses the Province of Corrientes (Fig. 1a), located in the NE of Argentina, recognized for its landscapes that maintain a close relationship with water due to the connection of two of the main rivers of South America, the Paraná and the Uruguay (Contreras, 2016). Thus, the sampled water bodies are found in the Paraná's fluvial paleofan (Neiff, 2004; Contreras, 2016) and encompasses two regions of hydrological and biological importance in the NE region of the country. Firstly, we recognize the Sandy Hills Region of the Mega Alluvial Fan of the Paraná River (Contreras and Contreras, 2017), where the Totorá Lagoon (Fig. 1b) is located in the

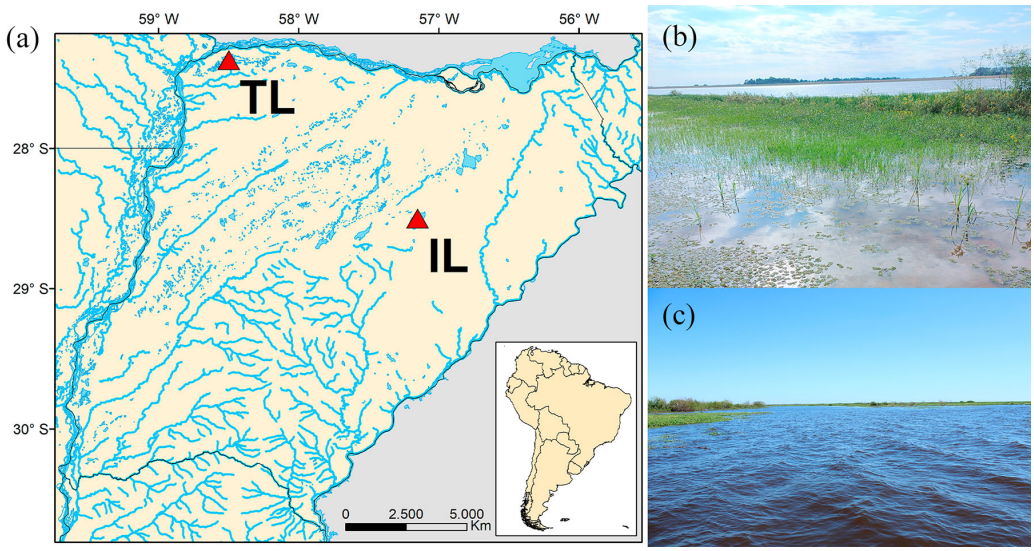

Figure 1. Sampling area within the Province of Corrientes, Argentina. (a) Geographical location of the sampling sites. (b) Totorá Lagoon. (c) Iberá Lagoon. References: TL = Totorá Lagoon; IL = Iberá Lagoon. **Figura 1.** Área de muestreos en la provincia de Corrientes, Argentina. (a) Ubicación geográfica de los sitios muestreados. (b) Laguna Totorá. (c) Laguna Iberá. Referencias: TL = Laguna Totorá; IL = Laguna Iberá.

town of San Cosme. The Totorá Lagoon is a peri-urban lagoon of circular to subcircular shape, with an approximate surface area of 95 ha. Its surroundings are marked by the presence of *Typha* vegetation and other aquatic plants. Secondly, we highlight the Iberá Ecoregion (Matteucci, 2012), which constitutes a unique wetland system in South America. It consists of estuaries, marshes, shallow lagoons, and interconnected watercourses (Neiff, 2004). Located in the north-central part of the province of Corrientes, it is surrounded by various ecoregions, such as the Humid Chaco, the Paraná Delta and islands, the Uruguay River, the Espinal, and Fields and Brushlands (Mateucci, 2012). We especially highlight the Iberá Lagoon (Colonia Carlos Pellegrini) (Fig. 1c), one of the largest and most prominent lagoons in the system. This lagoon has been designated as a RAMSAR site of international importance due to its relevance for conservation (SISR, 2024). Its shape is subrounded, and its surface area fluctuates around 24,550 hectares (SISR, 2024). These two lagoons play a critical role in the local ecosystem and are the subject of study to better understand the aquatic biodiversity and hydrological processes of the region.

Sampling Site

Sampling was conducted at Totorá Lagoon (27°22'S, 58°30'W) (Fig. 1b) and Iberá Lagoon (28°31'S, 57°09'W) (Fig. 1c) in June 2022 and April 2024. For this study, samples of free-floating and rooted submerged plants were collected and placed in flask along with portions of these plants and surrounding water to ensure proper transport to the laboratory. Physicochemical variables were recorded *in situ* using multiparameter sensors (Hanna), including temperature, pH, conductivity, total dissolved solids, and dissolved oxygen.

Laboratory Analysis

The macrophytes were examined using stereoscopic and compound microscopes. Specimens of *Plumatella emarginata* were carefully isolated from the macrophytes and observed under a compound microscope to study their morphological features, with particular attention to the tentacle crown and colony structure. Additionally, the statoblasts were examined in detail to identify diagnostic characteristics. A photographic record was obtained using a Cannon EOS Rebel T3i digital camera. The images were used to measure key diagnostic characters (e.g., floatoblast diameter, capsule length), following the methodology recommended by Wood (2015), with measurements taken using Adobe Photoshop. Taxonomic identification was conducted by comparing the observed morphological traits of both the statoblasts and colonies with taxonomic keys and

Table 1. Physicochemical parameters of the sampling area in the Province of Corrientes, Argentina. **Tabla 1.** Parámetros fisicoquímicos registrados en el área de estudio en la Provincia de Corrientes, Argentina.

	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	Temperature (ºC)	Total Dissolved Solids (ppm)	pH
Totorá lagoon	7	91	27,1	46	7,61
Iberá lagoon	6,8	28,5	24,6	18	6,36

descriptions from specialized literature (Lacourt, 1968; Mundy, 1980; Mukai and Kobayashi, 1988; Cazzaniga, 1989; Wood, 2010, 2015).

RESULTS

Water bodies characterization

In the samplings carried out in both the Iberá Lagoon and the Totorá Lagoon, a significant abundance of *Salvinia biloba* was observed. In the Iberá Lagoon, this species coexists with *Egeria* and *Elodea*, while in the Totorá Lagoon, it is accompanied by *Ludwigia peploides* and *Leersia hexandra*. The physicochemical parameters of the Totorá and Iberá lagoons exhibit notable differences (Table 1). Dissolved oxygen levels were slightly higher in Totorá Lagoon (7 mg/L) compared to Iberá Lagoon (6.8 mg/L). Conductivity was significantly greater in Totorá Lagoon (91 µS/cm) than in Iberá Lagoon (28.5 µS/cm), reflecting a higher concentration of ionic compounds in the former. Water temperature in Totorá Lagoon was recorded at 27.1°C, which was 2.5°C higher than in Iberá Lagoon (24.6°C). Similarly, total dissolved solids (TDS) were more abundant in Totorá Lagoon (46 ppm) than in Iberá Lagoon (18 ppm), indicating a greater presence of dissolved inorganic and organic matter. The pH values also varied between the two environments, with Totorá Lagoon exhibiting a more neutral condition (7.61) compared to the slightly more acidic waters of Iberá Lagoon (6.36).

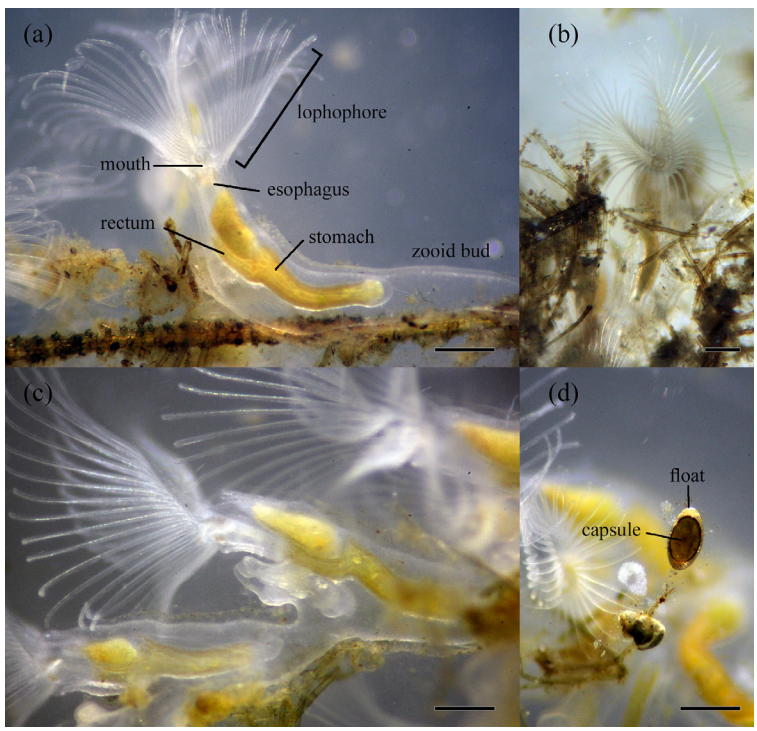

Figure 2. S. (a) Individual of *Plumatella emarginata* attached to a root. (b) Expanded lophophore. (c) Lateral view of the colony. (d) Statoblast. Scale bar: 0.5 mm.
Figura 2. (a) Individuo de *Plumatella emarginata* adherido a una raíz. (b) Lofóforo expandido. (c) Vista lateral de la colonia. (d) Estatoblasto. Escala: 0.5 mm.

Description of *Plumatella emarginata* Allman, 1844

The observed colonies were partially attached to the plant structure (Fig. 2a), branching along it. The zooids, measuring 1.65 mm, were transparent or whitish in color, and their lophophore extended in a "U" shape (Fig. 2b). Each lophophore had approximately 36 to 42 tentacles, with an estimated length of 1.21 mm (Fig. 2c). The statoblast exhibited a silver color (Lacourt, 1968; Cazzaniga, 1989) and had an oval shape (Fig. 2d). Its dimensions were 521 µm in length and 277 µm in width; the capsule measured 362 µm in length and 232 µm in width. The float measured 74 µm at its poles and 28 µm at its sides.

DISCUSSION

Freshwater bryozoans are ubiquitous and abundant organisms in lotic and lentic environments worldwide, found in both natural and artificial habitats (Wood, 2010). In South America, *Plumatella emarginata* has only been reported in Argentina. The most recent records of this species in lotic environments were documented by Cordiviola de Yuan (1977a, b) and Cazzaniga (1989). Notably, these records are over 40 years old. In the present study, we present a novel record for the extensive northeastern region of Argentina, a region of important and remarkable ecological uniqueness (Morrone, 2000; Arana *et al*., 2021) in one of the most biodiverse continents on the globe, such as South America (Neiff and Neiff, 2013). In addition, *P. emarginata* is recorded in this study in lagoons that are considered of international importance due to their biodiversity and their role in the regional ecosystem (Neiff and Neiff, 2013).

The physicochemical parameters recorded in this study are consistent with previous findings on continental bryozoan habitats (Orellana Liebbe, 2006; Wood, 2010). The water temperature in both lagoons falls within the range reported for environments where these organisms are typically found, supporting the idea that they thrive in relatively warm conditions. Regarding pH, our results align with studies indicating that bryozoans generally prefer alkaline waters (Okamura and Hatton-Ellis, 1995; Wood, 2010), as observed in Laguna Totorá (pH 7.61). In contrast, Laguna Iberá exhibited a more acidic-neutral pH (6.36), where the presence of bryozoans might be less frequent, although their occurrence in such conditions has been previously documented (Everitt, 1975). Additionally, both lagoons exhibited high levels of dissolved oxygen, a crucial factor for aquatic life sustainability, further supporting the potential for bryozoan colonization (Matteucci, 2012; Poi *et al*., 2017).

The availability of submerged substrates is a key factor in the colonization of bryozoans. Although these organisms can thrive on a variety of substrates, they show a preference for solid surfaces over soft and muddy ones (Okamura and Hatton-Ellis, 1995). Specifically, the environments where *P. emarginata* is recorded in this study are internationally recognized for harboring one of the most diverse aquatics vegetations of the wetlands of the Neotropical regions (Poi *et al*., 2017). Bryozoans tend to colonize and grow better in association with certain plant species (Okamura and Hatton-Ellis, 1995). Therefore, the presence of *P. emarginata* in the Totorá and Iberá lagoons suggests a close relationship with the diversity of this particular aquatic vegetation in these wetlands, as the distinctive characteristics of the macrophytes can significantly influence the colonization and growth of the bryozoans. This highlights the need to increase sampling efforts across aquatic environments in the northeast region, ensuring broader spatial coverage to improve our understanding of freshawater bryozoan´s distribution. The study will not only expand biogeographic data on the Plumatellidae family but also improve our understanding of how aquatic vegetation (a critical source of

essential resources) influences the presence, colonization, and distribution of bryozoans in these unique South American aquatic ecosystems. Consequently, the importance of environmental conditions and the availability of substrates in the distribution and growth of bryozoans is highlighted.

Bryozoan colonies play a fundamental role in the aquatic ecosystems where they develop, providing habitats for a diversity of associated organisms. Their impact on the trophic webs of freshwater communities has been widely recognized (Okamura and Hatton-Ellis, 1995; Šatkauskienė *et al*., 2018). In addition, bryozoans are considered bioindicators of environmental disturbances and pollution (Elia *et al*., 2007). In the context of the Iberá lagoons, the presence of biocides and heavy metals has been identified, although at concentrations below dangerous levels (Neiff, 2004). However, the Iberá ecoregion has experienced the advance of the agricultural-livestock frontier, especially due to rice cultivation, which involves the use of pesticides. These chemicals could affect the water quality in the Iberá lagoons (Neiff, 2004; Kurtz and Ligier, 2008). Previous studies have demonstrated the accumulation of pollutants in bryozoan colonies and their relationship with water quality and sediments in the region (Elia *et al*., 2007). Given their strategic position in the trophic webs, the pollutants present in the bryozoans can be transferred to other aquatic organisms, including fish, birds, and other invertebrates, which could affect the health of the ecosystem and the associated biodiversity (Elia *et al*., 2007). The diversity of bryozoans could also be considered in other numerous urban and peri-urban lagoons in the northeast region of Argentina (Contreras, 2016), such as the Totorá Lagoon, which can be affected by various anthropic activities due to its geographical location. Therefore, understanding bryozoan diversity is critical to effectively monitor, manage, and conserve these populations in response to the increasing anthropogenic pressures affecting the studied aquatic ecosystems. This aspect represents a line of research still unexplored in our country, highlighting the need to generate knowledge about the diversity of freshwater bryozoans to understand their role in aquatic ecosystem health. The realization of baseline studies like this one is fundamental to guide future applied research that allows for more effective and sustainable management of aquatic resources.

CONCLUSIONS

In conclusion, this study provides a detailed observation of bryozoans in the northeast region of Argentina. We have identified the presence of Phylactolaemata, marking the first record of this group in a RAMSAR site of the Northeast Argentina. This finding underscores the biological richness of the region and the importance of its conservation.

We emphasize the need to carry out more sampling to update the species record of this group for South America. This will allow us to update the data on biogeography, taxonomy, ecology, and biology of a group as important to aquatic ecosystems as bryozoans. The information generated through this study and future research efforts will contribute to a better understanding of the biodiversity of bryozoans and their role in aquatic ecosystems. In addition, this study highlights the importance of bryozoans as indicators of water quality, which can have significant implications for the management and conservation of aquatic resources. Therefore, it is essential to continue with research and monitoring efforts to protect these vital aquatic ecosystems and the biodiversity they harbor.

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CRediT Contributor Roles Taxonomy

F.M.A. Conceptualization, Data Curation, Formal Analysis, Research, Methodology, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - revision and editing. **G.L.A.** Conceptualization, Data Curation, Formal Analysis, Research, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - revision and editing. **R.G.K.** Conceptualization, Research, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - revision and editing.

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