

Invasive freshwater gastropods in South America: *Physa acuta* and its expansion to Austral Patagonia in Argentina

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Abstract. *Physa acuta* is a freshwater snail of North American origin that has spread to all continents. In South America it was detected for the first time in 1966 (Brazil) and is currently present in Argentina, Brazil, Peru, Chile, Colombia, Ecuador and Uruguay, occupying 13 of the 52 South American freshwater eco-regions. Its introduction would be related to the import and transportation of aquatic plants. Here we update the distribution of *P. acuta* in Argentina based on a review of scientific collections, published works and new collections. Our review expands the distribution of the species from 11/23 Argentine provinces (until 2010) to 19/23, and we report the first record for the province of Santa Cruz, this being the southernmost site of the species. This new discovery in the province of Santa Cruz (Austral Patagonia), with an established and reproducing population in an urban area, poses a potential threat to local biodiversity (where there are no records of other non-native mollusks) and to human and animal health. This is due to the finding of populations in southern Argentina that are naturally infested by *Fasciola hepatica*. The record of *P. acuta* in aquatic environments of southern Patagonia makes it necessary to generate monitoring and control plans with the objective of identifying the dispersion vectors and preventing the spread of the species in other water bodies in the region.

Keywords. Conservation; Invasive species dispersion; Santa Cruz province; Patagonia.

INTRODUCTION

Biological invasions represent an important ecological and economic problem in the globalized world, leading to noteworthy consequences such as the decrease and/or loss of biodiversity, disruption of ecosystem natural cycles, and the spread of diseases (Alonso & Castro-Díez, 2012; Diagne *et al.*, 2021; Carranza *et al.*, 2023). Globalization has played a crucial role in increasing the dispersal of these species by facilitating the movement of goods, people, and living organisms across borders. This is particularly evident in aquatic ecosystems, where the incidence of invasive species has surged in recent decades due to their close association with human activities (Hulme *et al.*, 2008; Hulme, 2009; Clusa *et al.*, 2017). Mollusks are not exempt from these dis-

persals, and in South America, 86 non-native species have been detected, including 16 freshwater species (11 gastropods and 5 bivalves) (Darrigran *et al.*, 2020). Among these species *Physa acuta* Draparnaud, 1805 [= *Physella acuta* (Draparnaud, 1805); = *Physa cubensis* Pfeiffer, 1839; = *Physella cubensis* (Pfeiffer, 1839); = *Physella venustula* (A. Gould, 1847)], snail of the family Physidae, of North American origin, has profusely invaded all continents, except Antarctic (*e.g.*, Vinarski, 2017; Ebbs *et al.*, 2018). *Physa acuta* has been called “the sewage snail” because it can live in highly polluted water (Appleton, 2003). This species has also been considered of medical importance since it can potentially act as an intermediate host of human trematodes (Kanev, 1994; Dreyfuss *et al.*, 2002). However, invasive populations have a lower number of trematodes than populations in

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their range of origin (Ebbs *et al.*, 2018). In addition, impacts on native species have been reported in at least South Africa, New Zealand and Australia (Winterbourn, 1980; Brackenbury & Appleton, 1993; Zukowski & Walker, 2009).

Physa acuta exhibits a sinistral shell (like all species in the Physidae), thin and generally opaque, allowing it to be distinguished from native species, *Stenophysa marmorata* (Guilding, 1828), in South America (Núñez, 2011). According to Núñez (2011), shell characteristics alone are insufficient for species determination, and anatomical features are required, among which the following stand out: mantle not folded over the shell; triangular projections of the mantle in varying numbers; light pigmentation without a dark line at the level of the foot; absence of papilla in the female gonopore; presence of preputial gland; penis typically slender, with a decreasing diameter towards its free end.

In South America, *Physa acuta* is currently dispersed in 7 countries (Argentina, Brazil, Chile, Colombia, Ecuador, Peru and Uruguay), occupying 13 of the 52 ecoregions of South America (Darrigran *et al.*, 2020). The first record of this species in South America was in Brazil in 1966 (Leme, 1966), being cited as *Physella cubensis*. Later it was cited in Chile (Te *et al.*, 1978, as *Physella venustula*), Argentina (Miquel, 1985, both as *P. cubensis* and *P. venustula*) and Peru (Larrea *et al.*, 1990, as *P. venustula*). The first records in Colombia, Ecuador and Uruguay are not precisely defined (Darrigran *et al.*, 2020).

In Argentina, the first record refers to the Ciudad Autónoma de Buenos Aires and the province of Buenos Aires (as *P. cubensis*) and the province of Río Negro (as *P. venustula*) (Miquel, 1985), based on records of 1970 and 1981 respectively (Fig. 1B). Miquel & Parent (1996), cite it for the province of Santa Fe, and subsequently, Miquel & Zelaya (1999), expand its distribution to the provinces of Córdoba (with records from the 80's), Tucumán, Salta (as *P. cubensis*) and San Juan (as *P. venustula*, with records from the 80's). Núñez & Pelichotti (2003) first mention it for the provinces of Corrientes, Jujuy and San Luis, and Paraense (2005), without providing precise collection dates, cites it for Mendoza. The latest review of the Physidae family in Argentina, conducted by Núñez (2009), confirms the presence of *P. acuta* in 11 of the 23 Argentine provinces (plus the Ciudad Autónoma de Buenos Aires).

In this work, we update the distribution of this species in Argentina, since 2010, based on new collections, review of scientific collections and publications.

MATERIAL AND METHODS

As an initial foundation, we used the distribution data partially published in Rumi *et al.* (2008) and Núñez (2009), which included the latest revision of malacological collections in Argentina (Museo de La Plata: MLP, Museo Argentino de Ciencias Naturales: MACN, Fundación Miguel Lillo: FML) and works published until 2008.

The databases were updated through the revision of the mentioned collections, including the collection at the Instituto de Biodiversidad Neotropical – IBN, data published in scientific journals from 2009 onwards, and our records obtained through fieldwork in the provinces of Buenos Aires, Chubut, Entre Ríos, Mendoza, Neuquén, San Luis, and Santa Cruz, among which are the completion of two doctoral theses (de Lucía, 2022; Torres, 2022). Specimen identification followed the methodology outlined by Núñez (2011). To search for published works, we utilized several search engines: CONICET Digital, Biblioteca electrónica de Ciencia y Tecnología, Biodiversity Heritage Library, Naturalis, Google Scholar, SEDICI (Servicio de Difusión de la Creación Intelectual-UNLP), Sistema Nacional de Repositorios Digitales, and GBIF. The keywords used included Argentina, Physidae, *Physa*, *Physella*, *acuta*, *cubensis*, *venustula*, and combinations thereof.

RESULTS

The review of publications, scientific collections, and new collections shows the expansion time and space of *Physa acuta* in Argentina. Until 1990, it was found in four provinces (Buenos Aires, Córdoba, Río Negro, and San Juan) in addition to the Ciudad Autónoma de Buenos Aires (Fig. 1B). Until 2000 it had expanded northward, including the provinces of Salta, Tucumán, Jujuy and Santa Fe (Fig. 1C); while ten years later it added the provinces of Corrientes, Mendoza and San Luis (Fig. 1D). By 2020, the presence expanded in seven more provinces (Chaco, Catamarca, Chubut, La Rioja, Entre Ríos, Neuquén, and La Pampa) (Fig. 1E). Finally, in 2023, the province of Santa Cruz was added, to complete the current distribution of this species, present in 19 of the 23 provinces of Argentina, which allowed the creation of a database with 229 records of this species (see Table S1, Fig. 1F). It was observed that the provinces that presented the greatest number of records are Buenos Aires, Tucumán, Salta, and Córdoba, while four other provinces only have one record each (Chaco, La Pampa, La Rioja, and Santa Cruz) (Fig. 2).

Based on the publications by Rumi *et al.* (2008), Núñez (2009) and Núñez *et al.* (2010), the review of scientific collections yields new records for the provinces of Chaco (no collection date), Catamarca (since 2011), La Rioja (since 2012), La Pampa (since 2013) and Neuquén (since 2013). Regarding the bibliographic review, this provided new records in the province of Chubut (Esquel and surrounding areas, since 2012) (Assef *et al.*, 2014).

From the new collections carried out in the central region of the country, the species has been recorded in the provinces of Buenos Aires, Chubut, Mendoza, Neuquén and San Luis, where it was already documented (Fig. 3). Additionally, it was recorded for the first time in the province of Entre Ríos (since 2010, MLP 13507, 13863). In the south of Argentina, specifically in the province of Santa Cruz, it was found in the city of Caleta Olivia (MLP-Ma 16102), in the March of 2023 (Fig. 3).

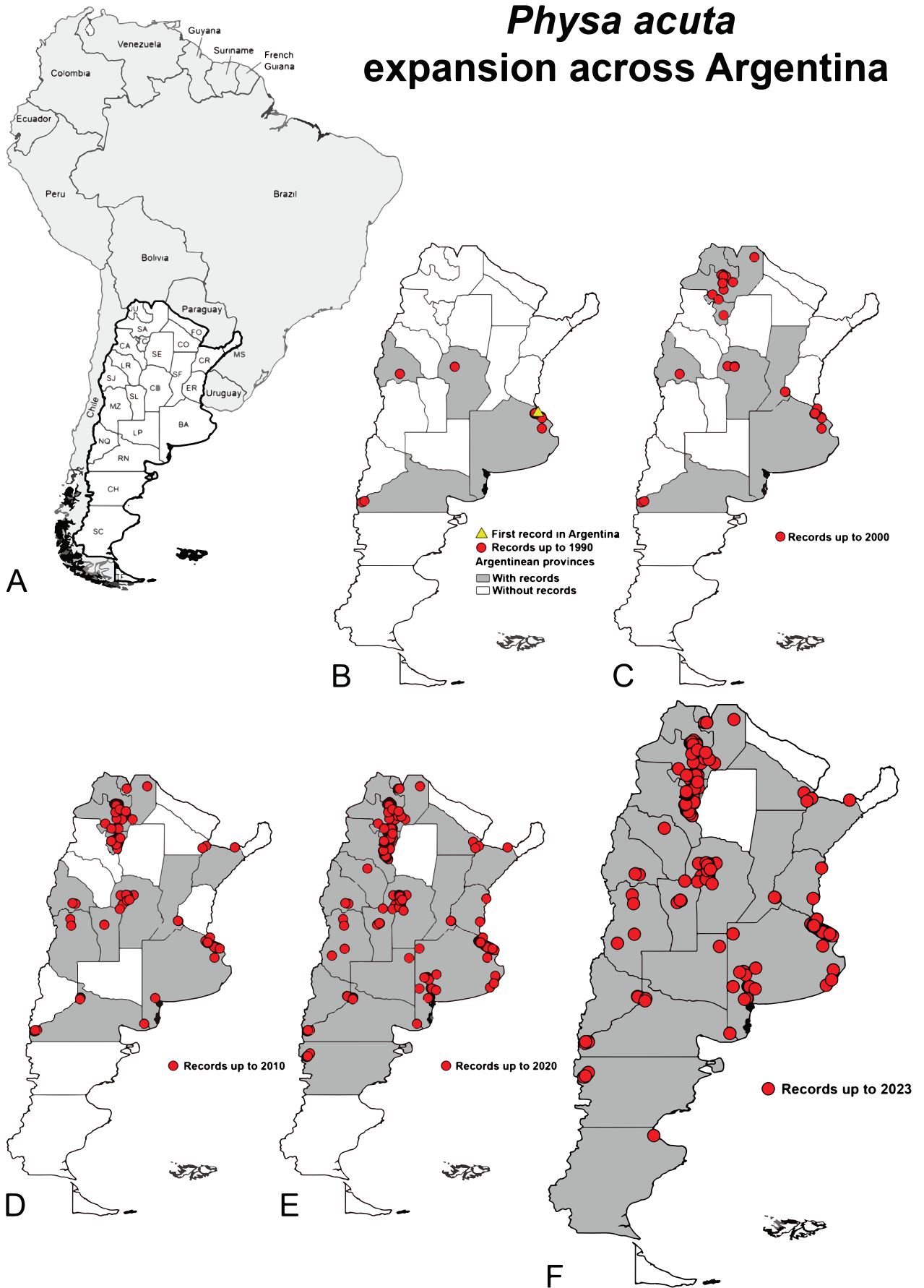


Figure 1. Dispersion of *Physa acuta* in Argentina over time: (A) Province of Argentina; (B) Records up to 1990; (C) Records up to 2000; (D) Records up to 2010; (E) Records up to 2020; (F) Records up to 2024. Provinces: BA: Buenos Aires; CA: Catamarca; CB: Córdoba; CH: Chubut; CO: Chaco; CR: Corrientes; ER: Entre Ríos; FO: Formosa; JU: Jujuy; LP: La Pampa; LR: La Rioja; MS: Misiones; MZ: Mendoza; NQ: Neuquén; RN: Río Negro; SA: Salta; SC: Santa Cruz; SE: Santiago del Estero; SF: Santa Fe; SJ: San Juan; SL: San Luis; TC: Tucumán; and TF: Tierra del Fuego.

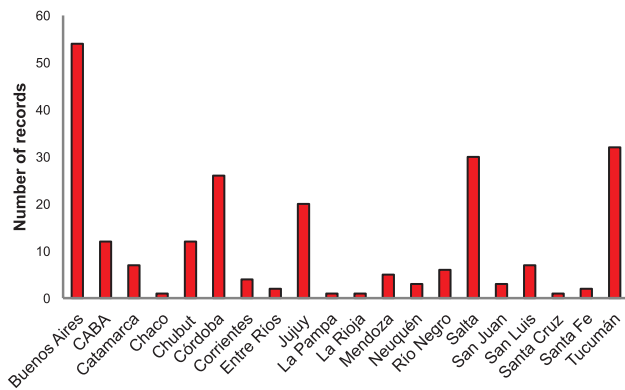


Figure 2. Number of records of *Physa acuta* per province.

DISCUSSION

Physa acuta has proven to be a successful non-native species in South America, adapting to different climates (Darrigran *et al.*, 2020). Our review results of collections, publications, and new records reaffirm this condition of invasive species since we communicate the expansion of the distribution of this species from 11 provinces in 2010 (Núñez, 2009) to 19 in almost a decade. Among these revisions, the expansion to three provinces from Argentine Patagonia stands out, Chubut (Assef *et al.*, 2014), Neuquén, and Santa Cruz. The new record for the city of Caleta Olivia, Santa Cruz, is the southernmost for the species worldwide. The environment where this species was found consists of a small, shallow stream with a sandy bed that goes through farmlands and runs along roadsides, hosting eggs, juveniles, and adults. The closest previous records are from the town of Esquel (42°S) (Assef *et al.*, 2014), Chubut province, in an area of lakes and mountain rivers surrounded by abundant vegetation. The presence of *P. acuta* in this area is

generally related to environments with a high degree of anthropogenic impact, such as agriculture, urbanization and sewage effluents (Horak *et al.*, 2023) (Fig. 4). In Chile, the nearest record is at latitude 41°S (Llanquihue Lake) (Collado *et al.*, 2020), about 5 degrees north of the one found in Caleta Olivia (46°S), the closest site to Esquel.

The review carried out by Torres (2022) shows that in the province of Santa Cruz, 13 species of freshwater mollusks are recorded, 10 belonging to gastropods and three to bivalves. All of these species are native, and here we have recorded the presence of the first invasive species of freshwater mollusks in the province. The introduction of this new entity to the province cannot be precisely determined, but it is generally attributed to the dispersion of this species through the trade of aquatic plants used in aquariums. The aquarium trade has been shown to be a source not only of introduction of non-native aquatic macrophyte species (June-Wells *et al.*, 2012), but also of fauna associated with them. These species are distributed throughout the world through a generally unregulated industry (Padilla & Williams, 2004). In Argentina, *Physa acuta* is in Category 1: Restricted and mandatory control species (EEI-1), according to MAyDS (2021). However, it continues to be sold in physical and virtual commercial aquariums. This dispersion route in general does not have exhaustive control.

Physa acuta is a species characterized by being present in disturbed environments (Miyahira *et al.*, 2023; Tchakonte *et al.*, 2023). Even recent studies (Cieplak & Spira, 2020; Collado *et al.*, 2023) demonstrate that, in this type of environment, the density of *P. acuta* is dominant, displacing native species. In the Argentine Patagonia, it has been recorded in the Esquel area (Chubut), where it has been observed in urban streams with high levels of nutrients, including phosphorus and nitrogen com-

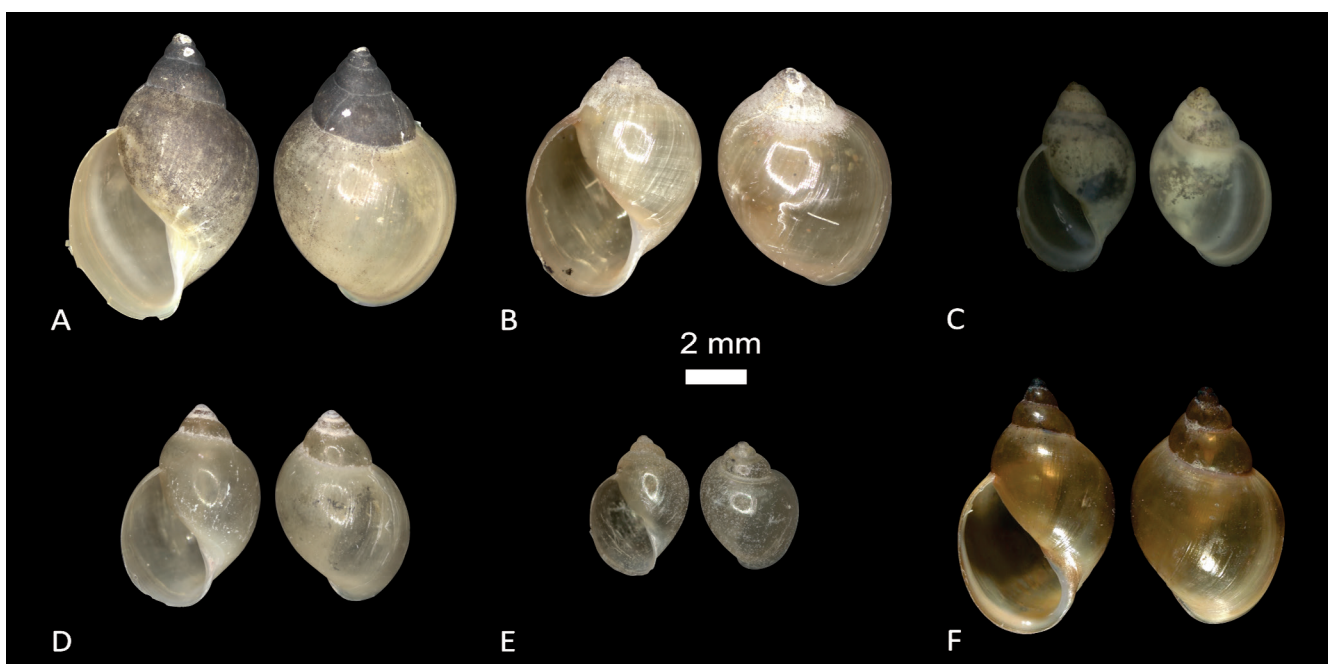


Figure 3. Specimens of *Physa acuta* collected for this study. (A) MLP 16147, Buenos Aires province; (B) MLP 16300, Chubut province; (C) MLP 14768, Mendoza province; (D) MLP 14141, Neuquén province; (E) MLP 16137, San Luis province; (F) MLP 16102, Santa Cruz province.

pounds (Assef *et al.*, 2014). Horak *et al.* (2023) evaluated the activity of the multi-xenobiotic defense mechanism in *P. acuta* specimens in highly impacted environments in Patagonia (Chubut). The authors determined that *P. acuta* specimens from environments impacted by agriculture and urbanization showed more detoxifying activity than organisms from reference sites with low impact of anthropic origin, indicating a higher degree of tolerance than native species. Laboratory studies carried out in Argentina by Núñez (2010) revealed that the growth of this species was not affected by reproduction, exhibiting a more extended reproductive period and deposit-

ing a greater quantity of eggs compared to *Stenophysa marmorata* (Guilding, 1828), a native species of the same family. In the southern part of the Buenos Aires province, in natural environments, it was determined that *P. acuta* (identified as *P. venustula*) has a semelparous and subannual life cycle, with two or three loosely defined cohorts per year, featuring almost continuous oviposition and recruitment (Martín, 2001). Both in the laboratory (Núñez, 2010) and in natural environments (Martín, 2001), they conclude that this species has a high juvenile mortality of up to 3.5 mm in length and decreases in subadults and adults.



Figure 4. Environments where *Physa acuta* was found: (A) Bagliardi Beach, Buenos Aires; (B) Reserva Natural Punta Lara, Buenos Aires; (C-D) Caleta Olivia, Santa Cruz.

In addition to this, in the Esquel area (Chubut), Sane-ro *et al.* (2018) conducted a parasitological study using different species of native and non-native gastropods, recording specimens identified as *Physa* spp. (found in the same sites as *Physa acuta* by Assef *et al.* (2014) infested with cercariae from the family Notocotylidae and *Fasciola hepatica* (Fasciolidae). According to Merlo *et al.* (2022), *P. acuta* records cercariae from the families Echinostomatidae and Plagiorchioidae in Salta, and Gorgoderioidea and Schistosomatidae in Buenos Aires. If the specimens in Chubut belong to *P. acuta* (as there are no other Physidae registered in the area), these are the first records of infection in the Argentine Patagonia in anthropized environments, representing a new vector for fascioliasis that could potentially spread throughout southern Patagonia.

The presence of a new potential intermediate host of *Fasciola hepatica* could complicate the situation of fascioliasis in the province of Santa Cruz, which directly impacts livestock in the center and north of the province (Aguilar & Olaechea, 2014). Recently, Larroza *et al.* (2023) have detected, in the northwest of Santa Cruz, resistance of *F. hepatica* to Triclabendazole (TCBZ), one of the few anthelmintics available to treat fasciolosis for ruminants. This could significantly increase livestock mortality in establishments that do not have adequate sanitary controls, or indirectly through metabolic disorders that affect milk production and quality or with effects on the reproductive capacity of cattle and sheep.

The expansion of the distribution range of *Physa acuta* in water bodies in southern Patagonia represents not only a risk to biodiversity but also a health concern. The presence of this invasive species in Santa Cruz constitutes the first record of an invasive exotic mollusk for the province, making it necessary to develop monitoring and control plans. The objective is to identify vectors of dispersion and prevent the species from spreading to other water bodies in the region. These understandings serve as tools for the prevention of the introduction and establishment of invasive species, according to NISC (2001) and ELI (2002). They include risk assessment, early detection, rapid response, and public education. Public education, along with the dissemination of high-quality scientific information, is fundamentally important for making the management of biological invasions sustainable. Society must be aware of specific cases, their environmental impacts, and social effects to encourage governments to implement the necessary mechanisms for the prevention of bioinvasions (Darrigran *et al.*, 2012).

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SUPPLEMENTARY MATERIAL

Table S1. Localities where *Physa acuta* was recorded in Argentina, with information on the year of collection and reference to scientific collection or publication. In red, lots deposited as a result of our sampling efforts.

LOCALITY	YEAR OF COLLECT	MUSEUM; REFERENCES
Buenos Aires province		
Arroyo Carnaval, Villa Elisa	2018	MLP: 15429
Arroyo del Azul, Azul	—	Nuñez <i>et al.</i> , 2010
Arroyo Doña Flora, Ensenada	1984	Miquel & Zelaya (1999)
Arroyo Guaminí, Guaminí	2016	Maldonado (2020)
Arroyo Napostá Grande, Bahía Blanca	2000; 2016	Martín (2001); Maldonado & Martín (2019)
Arroyo Napostá, Bahía Blanca	2013; 2016	IBN: 408; Maldonado (2020)
Arroyo Napostá, Gamero	2011	IBN: 423
Arroyo Rodríguez, La Plata	1985	Miquel & Zelaya (1999)
Arroyo Sauce Corto, Sierra de la Ventana	2016	Maldonado (2020)
Arroyo Sauce Grande, Sierra de la Ventana	2017	MLP: 16144
Arroyo Vado Corto, Coronel Suarez	2016	Maldonado (2020)
Atalaya, Magdalena	2001	Nuñez (2009)
Bahía Blanca	2011	IBN: 386
Balneario Bagliardi, Berisso	2018	MLP: 16147
Balneario La Balandra, Berisso	2001	Nuñez (2009)
Barrio Santa Barbara, Tigre	2005	Martín <i>et al.</i> (2019)
Canal Pigué-Venado	2016	Maldonado (2020)
Establecimiento San José, Carmen de Patagones	2001	Nuñez (2009)
Ezeiza	—	MACN: 29370
Isla Martín García	1995	Nuñez (2009); MACN: 21054
La Plata, Lago del Bosque	1985	MACN: 32605
La Plata, Parque Saavedra	2007	MLP: 13159
Laguna de los Padres, Mar del Plata	2012-2014	Parietti <i>et al.</i> (2018)
Laguna del Burro, Chascomús	1988	Miquel & Zelaya (1999)
Laguna Los Carpinchos, General Madariaga	2012	Tietze & De Francesco (2017)
Laguna Nahuel Ruca, Mar Chiquita	2012, 2014	Tietze & De Francesco (2017); De Francesco <i>et al.</i> (2019)
Parque de Mayo, Bahía Blanca	2011	IBN: 421
Parque Pereya Iraola, Berasategui	—	Nuñez <i>et al.</i> (2010)
Punta Lara, Ensenada	1980, 1982	MACN: 32605, 37073
Reserva Natural Municipal de Vicente López	2015	Virgillito <i>et al.</i> (2016)
Reserva Natural Punta Lara, Ensenada	2013-2019	MLP: 15254, 15280, 15289, 15294, 15328, 15345, 15348-49, 15361, 15380
Reserva Privada El Destino, Magdalena	2018-2019	MLP: 16145, 16146
Ruta 3 km 271, Azul	—	Nuñez <i>et al.</i> (2010)
Selva Marginal Quilmeña, Quilmes	2014	MLP: 14462
Ciudad Autónoma de Buenos Aires		
Agronomía	2000	MLP: 13625
Chacarita	1998	MACN: 34476
Ciudad Autónoma de Buenos Aires	1998	MLP: 13623
Ciudad Universitaria	1988, 1998	Miquel & Zelaya (1999); MACN: 37074
Jardín Botánico	1997, 2000	Miquel & Zelaya (1999); MLP: 13621
Laguna del Golf	2000	MLP: 13626, 13628
Parque Centenario	1987	Miquel & Zelaya (1999)
Parque Norte	1988	Miquel & Zelaya (1999)
Piletas del MACN	1970	MACN: 30202
Catamarca province		
Alijilan	2017	IBN: 486, 487
Dique Sumampa	2017	IBN: 481, 488
El Alto	2017	IBN: 479
Estancias Las Beatas, San Antonio	2017	IBN: 484
Río La Viña, La Viña	2011	IBN: 391
Chaco province		
Las Palmas	—	MACN: 9957-2
Chubut province		
Arroyo Enna, Futaleufú	2015-2021	Horak <i>et al.</i> (2023)
Arroyo Esquel, Futaleufú	2012-2021	Assef <i>et al.</i> (2014); Sanero <i>et al.</i> (2018); Horak <i>et al.</i> (2023)

LOCALITY	YEAR OF COLLECT	MUSEUM; REFERENCES
Arroyo Ingram, Futaleufú	2015-2021	Horak <i>et al.</i> (2023)
Esquel	2015-2021	Horak <i>et al.</i> (2023)
Río Percy, Futaleufú	2012-2021	Horak & Assef (2017); Sanero <i>et al.</i> (2018); Horak <i>et al.</i> (2023)
Río Arrayanes, Parque Nacional Los Alerces	2024	MLP: 16301
Lago Verde, Parque Nacional Los Alerces	2024	MLP: 16300
Córdoba province		
Alta Gracia	2008, 2010	IBN: 188, 330
Dique Piedras Moras	2013	Gordillo <i>et al.</i> (2013)
Dique San Roque	2000	MLP: 6929-1, 6929-2
Huerta Grande	1987	MACN: 34205
Los Hornillos	2024	MLP: 16253
Molinari	2010	IBN: 186
Piedra Pintada	1999	IBN: 334
Pinto	2002	MLP: 11843, 11846, 114848
Río Anisacate, La Bolsa	2008, 2010	IBN: 156, 314
Río Chico, Nono	2024	MLP: 16255
Río Durazno, Reserva Cerro Blanco	2008	IBN: 155
Río Grande de Punilla, La Falda	2010	IBN: 175, 178
Río Los Reartes Los Reartes	2010	IBN: 192, 195
Río San Pedro, Potrero de Garay	2008	IBN: 321
Río Suquia	2006	Zarco <i>et al.</i> (2011)
Río Suquia, La Calera	2008	Reyna <i>et al.</i> (2018)
Valle Hermoso	2010	IBN: 180, 182
Villa Giardino	1999	IBN: 326
Yacanto	2008	IBN: 157
Corrientes province		
Corrientes		Paraense (2005)
Paso de la Patria	2000	MLP: 6521
Yaciretá, Lago Embalse	2000	MLP: 6522
Entre Ríos province		
Arroyo Ayuí Grande, Concordia	2010	MLP: 13507
Río Gualaguaychú, Gualaguaychú	2014	MLP: 13863
Jujuy province		
Arroyo Los Berros, Caimancito	2013	IBN: 346
Arroyo Yuto, Yuto	2000, 2013	IBN: 375, 381
confluencia del Río Zapla y Río Grande	1994	IBN: 159
Dique La Ciénaga, La Ciénaga	2012	IBN: 343
Dique Los Alisos	1999	MLP: 6928-1, 6928-2, 12892
Parque Provincial Potrero de Yala	1999-2000	MLP: 6926, 13160
Río Burrumayo	1999	IBN: 9
Río Grande, Altos Hornos Zapla	2008	MACN: 37800
Río Perico, Perico	2011	IBN: 257
Río Zapla	2005, 2009	IBN: 112, 115, 426
Termas de Reyes	1999, 2003	MLP: 11841, 11857; IBN: 8
La Pampa province		
	2013	MACN: s/n°
La Rioja province		
Arroyo camino a Sanagasta	2012	IBN: 335
Mendoza province		
Campus UNCuyo	2004	MACN: 38189
Dique el Carrizal	—	Paraense (2005)
Dique Nihuil	2014	MLP: 15440
Mendoza	—	Paraense (2005)
Río Malargüe, el Dique	2010	MLP: 14768
Neuquén province		
Lago Mari Menuco	2013, 2015	MLP: 16140, 16141
Río Limay, San Patricio del Chañar	2015	MLP: 16139
Río Negro province		
12 km al oeste de San Carlos de Bariloche, Mallín	2008	MLP: 13026
Arroyo Nirengo, San Carlos de Bariloche	1981	MLP: 4416, MACN: 37388
Cinco Saltos	2003	Nuñez <i>et al.</i> (2010)
Lago Pellegrini, Península Ruca Có	2002	MLP: 6930-1, 6931-2

LOCALITY	YEAR OF COLLECT	MUSEUM; REFERENCES
Salta Province		
Arroyo El Tala, El Tala	2011	IBN: 241
Arroyo Guanaco, Anta	2012	IBN: 298
Arroyo La Chacra, Anta	2012	IBN: 296
Arroyo La Sala, Parque Nacional El Rey	2012	IBN: 286
Arroyo Las Cañas, camino a Popayán	2012	IBN: 288, 289, 303
Arroyo Los Naranjos, Anta	2012	IBN: 291
Camino a Parque Nacional El Rey	2009	IBN: 61
Dique Campo Alegre	—	MLP: 6534
Dique de Cabra Corral	1998	MACN: 36372
Dique la Darsena	—	MACN: 13002
El Jardín	2011	IBN: 242
Embalse El Ceybal	2009	IBN: 125
Embalse Puerta de Díaz	1995	MACN: 36371
Finca "El Carmen"	1995	MACN: 37121
Los Patitos, Parque Nacional El Rey	2009, 2012	IBN: 77, 283
Pampa Blanca	2008	MACN: 39209
Parque Nacional El Rey	1999	MLP: 11839
Río Arenales	1997	MACN: 36370
Río Camino a Parque Nacional El Rey, Finca Vieja	2009	IBN: 33, 36
Río La Candelaria, La Candelaria	2013	IBN: 392, 399
Río Negro, El Espinal	2011	IBN: 259
Río Piedras	2009	IBN: 123
Río Popayán, Parque Nacional El Rey	2012	IBN: 285
Ruta 9	—	Nuñez <i>et al.</i> (2010)
Salta	1998	MACN: 36471
San Juan province		
Nueve de Julio	2002	MLP: 6925
Pie de Palo-Caucete	—	Nuñez <i>et al.</i> (2010)
San Juan	1988	Miquel & Zelaya (1999)
San Luis Province		
Arroyo Juan Pérez, Balneario Rincón del Este	—	Nuñez <i>et al.</i> (2010)
Arroyo las Águilas, Trapiche	2018	MLP: 16137, 16138
Balneario El Muro, Quines	2012	IBN: 324
Dique La Florida, La Florida	2018	MLP: 16136
Embalse Potrero de Los Funes	2002	MLP: 6927-1, 6927-2
Santa Cruz province		
Arroyo Quinto, Caleta Olivia	2023	MLP: 16102
Santa Fe province		
Arroyo Ludeña, Rosario	1995	Miquel & Parent (1996)
Parque Urquiza, Rosario	1995	Miquel & Parent (1996)
Tucumán province		
Arroyo Los Noques, Parque San Javier	2010	IBN: 217
Dique La Angostura, El Mollar	2001, 2017	MLP: 6527; IBN: 472
El Mollar	1999	IBN: 415
Leales	1994	IBN: 158
Monteagudo	2010	IBN: 197
Planta hidroeléctrica de Escaba	2010	IBN: 214
Quebrada del Portugués, Tafi del Valle	2018	IBN: 658
Río Balderrama	2009	IBN: 154
Río Calera o La Sala, Sierra de Medina	2017	IBN: 492
Río Chico y Ruta 157	2009-2010	IBN: 146, 200
Río Los Sosa, Valle del Tafi	2005, 2011	IBN: 1, 250
Río Marapa, cerca del Dique Escaba	2010	IBN: 174
Río Noque, cerca de la unión con el R. San Javier	2012	IBN: 398
Río Salí, Granja Modelo	2008-2009	IBN: 21, 29, 74, 274, 411
Río Salí, Balneario Los Bolleritos	2008-2009	IBN: 19, 26, 70
Río San Javier	2009	IBN: 133
Río Tacanas, San Pedro de Colalao	2011	IBN: 243
San Miguel de Tucumán	2017	IBN: 475, 476
San Pedro de Colalao	2009	IBN: 372
Tafi del Valle	2011	IBN: 430

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