Biol Invasions (2023) 25:673–691
https://doi.org/10.1007/s10530-022-02942-z

REVIEW

Species movements within biogeographic regions: exploring the distribution of transplanted mollusc species in South America

Gustavo Darrigran · Ignacio Agudo-Padrón · Pedro Baez · Carlos Belz · Franz Cardoso · Gonzalo A. Collado · Modesto Correoso · María Gabriela Cuezzo · Cristina Damborenea · Alejandra A. Fabres · Monica A. Fernandez · Suzete R. Gomes · Diego E. Gutiérrez Gregoric · Sergio Letelier · César Lodeiros · Sandra Ludwig · Maria Cristina Mansur · Samuel Narciso · Guido Pastorino · Pablo E. Penchaszadeh · Ana Carolina Peralta · Andrea Rebolledo · Alejandra Rumi · Rodrigo B. Salvador · Sonia Santos · Paula Spotorno · Silvana Carvalho Thiengo · Teofânia Vidigal · Alvar Carranza

Received: 9 September 2021 / Accepted: 1 October 2022 / Published online: 29 October 2022

Abstract The movement of species is among the most serious environmental threats of the new millennium, as the transplantation of species beyond their native or historical range has intensified in the last five decades. Traditionally, studies on bioinvasions have focused on species that have been introduced, deliberately or accidentally, to biogeographic regions where they did not previously occur. However, less attention has been given to species movement to novel areas within the same biogeographic region. Our research group, the South America Introduced Molluscs Specialists, analyzed potential cases of native South American mollusc species introduced deliberately or accidentally beyond their natural range within

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10530-022-02942-z.

G. Darrigran · C. Damborenea (✉) · D. E. Gutiérrez Gregoric · A. Rumi
División Zoología Invertebrados, Museo de La Plata, FCNyM, UNLP; CONICET, La Plata, Argentina
e-mail: cdambor@fcnym.unlp.edu.ar

I. Agudo-Padrón
Projeto "Avulsos Malacológicos", Florianópolis, SC, Brazil

P. Baez · G. A. Collado · A. A. Fabres · S. Letelier · A. Rebolledo
Sociedad Malacológica Chile, SMACH, Santiago, Chile

P. Baez
Centro de Investigación Marina de Quintay (CIMARQ), Facultad de Ciencias de la Vida, Universidad Andrés Bello, Quintay, Chile

C. Belz
Laboratório Ecologia Aplicada e Bioinvasões, Centro Estudos do Mar/Universidade Federal do Paraná, Pontal do Paraná, Paraná, Brazil

F. Cardoso
Laboratorio de Biología y Sistemática de Invertebrados Marinos, Departamento Académico de Zoología, Facultad de Ciencias Biológicas, Universidad Nacional Mayor de San Marcos, Lima, Peru

G. A. Collado
Departamento de Ciencias Básicas, Facultad de Ciencias, Universidad del Bío-Bío, Chillán, Chile

M. Correoso
Departamento de Ciencias de la Vida y Departamento de Ciencias de la Tierra y de la Construcción, Universidad de las Fuerzas Armadas, ESPE, Valle de los Chillos, Sangolquí, Ecuador

M. G. Cuezzo
Instituto de Biodiversidad Neotropical, CONICET/Facultad de Ciencias Naturales UNT, Tucumán, Argentina

South America. To achieve this, it is key to differentiate between anthropogenic processes and passive responses to environmental conditions. We considered the past and current spatial distribution of species, analyzed known or putative vectors, and discuss the impacts of taxonomic and nomenclatural knowledge. Based on the evidence currently available, we propose different scenarios to explain observed changes in mollusc distributions within South America. Seventeen transplanted mollusc species (TMS) were recognized, considering marine, freshwater, and terrestrial environments. Of the 189 South American ecoregions 31 were occupied by transplanted species, but this proportion varied by environment: 10 of 28 marine ecoregions, 12 of 52 freshwater ecoregions, and 9 of 109 terrestrial ecoregions. The ecoregions with TMS are generally located in the peripheral zones of the continent. Those with the highest number of TMS were the Southern Caribbean (three species) in the marine environment, the Central Andean Pacific Slopes (three species) in the freshwater environment, and the Alto Paraná Atlantic forests (two species) in the terrestrial environment. The number of unintentionally moved TMS is greater than those moved intentionally. The transplantation process is similar to the introduction and settlement process of non-native mollusc species, and so is their impact.

Keywords Transfer · Translocation · Range expansion · Bioinvasion · Ecoregions

Introduction

To develop control or eradication measures, the Convention on Biological Diversity (CBD 1992, 2010) prioritizes the identification and study of invasive non-native species, one of the most significant causes of biodiversity loss at a global scale (e.g., Blackburn et al. 2020). This framework led specialists on molluscs and bioinvasions from different regions of South America to establish an expert research group, namely

A. A. Fabres
Laboratorio de Genética y Evolución, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Santiago, Chile

M. A. Fernandez · S. R. Gomes · S. Carvalho Thiengo
Laboratório de Referencia Nacional para Esquistossomose-Malacologia, Instituto Oswaldo Cruz, Fiocruz, Rio de Janeiro, Brazil

C. Lodeiros
Grupo de Investigación en Biología y Cultivo de Moluscos, Dpto. de Acuicultura, Pesca y Recursos Naturales Renovables, Facultad de Ciencias Veterinarias, Universidad Técnica de Manabí, Portoviejo, Ecuador

C. Lodeiros
Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná, Venezuela

S. Ludwig
Pós-Graduação em Genética, Inst. Ciências Biológicas, Universidade Federal Minas Gerais, Belo Horizonte, Brazil

M. C. Mansur
Grupo Pesquisa CNPq, Biodiversidade de Moluscos Continentais, Museu de Ciências Naturais, Porto Alegre, Brazil

S. Narciso
CIAC-FUDENA, Centro de Investigación y Atención Comunitaria, Chichiriviche, Falcón, Venezuela

G. Pastorino · P. E. Penchaszadeh
Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", CONICET, Ciudad Autónoma de Buenos Aires, Argentina

A. C. Peralta
Laboratorio de Biología Marina, Departamento de Estudios Ambientales, Universidad Simón Bolívar, Caracas, Venezuela

R. B. Salvador
Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand

S. Santos
Departamento de Zoologia, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, RJ, Brazil

P. Spotorno
Programa de Pós-Graduação em Oceanologia, Instituto de Oceanografia, Universidade Federal do Rio Grande, FURG,, Rio Grande, RS, Brazil

T. Vidigal
Laboratório de Malacologia e Sistemática Molecular, Departamento de Zoologia, Instituto de Ciências Biológicas; Lelf: Laboratório de Estudos de Limnoperna fortunei, Centro de Pesquisas Hidráulicas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

A. Carranza
Área Biodiversidad y Conservación, Museo Nacional de Historia Natural, 25 de mayo 582, Montevideo, Uruguay

the "South America Introduced Molluscs Specialists Group" (eMIAS; https://alienmolluscsgroup.wixsite.com/saamgroup). Once established, an initial synthesis of the status and distribution of non-native molluscs in South America at an ecoregional scale was developed (Darrigran et al. 2020). This work targeted introduced species in South America from other continents. However, little attention has been paid to the phenomenon of species movement within the same biogeographic regions. In this context, eMIAS identified species of molluscs, native to South America, that had experienced modifications to their historical distributions within the continent that are not attributable to natural dispersal processes. Cases analyzed ranged from obscure local species, such as the sea slug *Aplysia dactylomela* Rang, 1828, to globally conspicuous species, such as the black-striped mussel, *Mytilopsis sallei* (Récluz, 1849), a brackish-water bivalve native to coastal lagoons and estuaries of Central America and the Caribbean (Fernandes et al. 2018).

In the mainstream literature, the terms 'transplantation', 'transfer', or 'translocation' have been used interchangeably to identify this process. Even though the terms are typically considered synonymous, several authors have pointed out important distinctions and alternative definitions. Currently, it has been argued that the planet is going through a new era, the Anthropocene, in which disturbances are mainly generated from the globalization of trade and climate change (Hobbs et al. 2018). These processes are advancing at unprecedented rates and scales, and have yet to reach their climax. Because of climatic changes, species can access new regions, while others are forced to reduce their ranges (or disappear) in response to altered environments. Hayward et al. (2015) even proposed redefining the IUCN guidelines on the natural range of species to include potential range shifts and subpopulations existing outside the natural range but in broadly similar habitat. In this work, we follow the definition of the IUCN (2022), in which an indigenous species (= native species) is defined based on three criteria: (1) it is intrinsically part of the ecosystem and developed there, (2) it arrived in the area long before records of such matters were kept, (3) it arrived by natural means (unaided by human action). We acknowledge that this definition is only a pragmatic and conventional rule to be used to guide our study (Holguín 2003). Herein, a species is considered non-native when it is introduced outside its natural geographical range through human action, being able to maintain a self-sustaining population (Turbelin et al. 2017). If a non-native species disperses and has an evident environmental and socio-economic impact, it is considered invasive (Darrigran et al. 2020). Furthermore, we define transplantation (transfer, translocation) as the movement of native species from one locality to another by human action, with successful establishment outside their known historical geographical range (in our case, within South America). Such species movements can be both accidental or deliberate (e.g., for conservation, trade, research). A species is considered to be established in the environment when there are populations with multi-generational reproductive success (Kočovský et al. 2018).

Knowledge of the invertebrate fauna of South America is still fragmented and incomplete (Damborenea et al. 2020; de Barros et al. 2020). Despite the high richness of native molluscs in the continent, there are major knowledge gaps, mostly because of the biased and unequal coverage by the areas studied, errors in identification, and taxonomic uncertainty, all of which can have consequences for conservation (Salvador 2019; de Barros et al. 2020). There are also differences among marine, freshwater and terrestrial environments in terms of species richness, research effort, and vulnerability. In contrast, the socio-economic and ecological impacts of some invasive species have led to a more comprehensive knowledge of these species (Darrigran et al. 2020). As a corollary, in South America, the distribution and biology of economically important invasive mollusc species are better understood than the distribution and biology of native molluscs (Dos Santos et al. 2021). Similarly, some of the knowledge of certain species native to South America has come from studies on other continents where they have become invasive (e.g., Wong et al. 2011; Joshi et al. 2017; Calazans et al. 2018, 2021; Fernandes et al. 2018).

In this context, this work aims to assess native species of molluscs from South America that have been transplanted within the continent, including marine, freshwater, and terrestrial realms. Based on the evidence currently available, we propose different scenarios to explain observed changes in molluscan distribution within the continent.

Material and methods

A collaborative effort was made by 29 expert malacologists and taxonomists from countries in South America (Argentina, Brazil, Chile, Ecuador, Peru, Uruguay, and Venezuela) and from New Zealand, belonging to the eMIAS group. Scientific and grey literature, databases on the subject were analyzed, and experiences were exchanged through a virtual forum among the group. Then, the group listed the transplanted mollusc species (TMS) and reached a consensus on the status of each species in the 189 ecoregions (marine, freshwater, and terrestrial) recognized in South America (Online Resources 1–3).

The geographic range of each species was determined based on literature records and expert experience at an ecoregional scale (see also Darrigran et al. 2020). Following Olson and Dinerstein (2002), ecoregions were defined as areas of land or water with a characteristic set of natural communities, ecological dynamics, and environment that share most of their species. Geographic Information System (GIS) layers were based on Olson et al. (2001) for terrestrial ecoregions, Spalding et al. (2007) for marine ecoregions, and Abell et al. (2008) for freshwater ecoregions. In South America, 28 ecoregions are recognized for marine environments (http://maps.tnc.org/files/metadata/MEOW.xml; Online Resource 1), 52 for freshwater environments (http://maps.tnc.org/files/metadata/FEOW.xml; Online Resource 2), and 109 for terrestrial environments (http://maps.tnc.org/files/metadata/TerrEcos.xml; Online Resource 3).

The criterion for a species to be considered as a TMS was the existence of documentation of its transplantation within South America. To avoid confusion between the type of species under study and in agreement with the definitions mentioned above, and the description of introduction pathways by Faulkner et al. (2020), we worked on the basis of three premises:

1. The way in which the species are distributed, both in geographic space and in time, responds to historical, ecological, and physiological factors throughout their range (Maciel-Mata et al. 2015).
2. The causes of transplantation of native species are human-related, including conservation, trade, research, and accidental transport.
3. Transplanted species can cause the same problems and potential dangers as introduced species, which leads us to consider the same pathway(s) as those proposed for introduced organisms by the Convention on Biological Diversity (CBD 2014) (as interpreted by IUCN, 2017). The mechanisms and pathways by which TMS may arrive, and enter a new region are detailed in Fig. 1.

Based on these premises, the list of transplanted species was compiled considering known historical distribution, new location(s), ecoregion(s) of the new location(s), pathway(s) of transplantation, and impacts. References are given for each case. Furthermore, mollusc species transported by humans and only found in captivity were mentioned, but are not

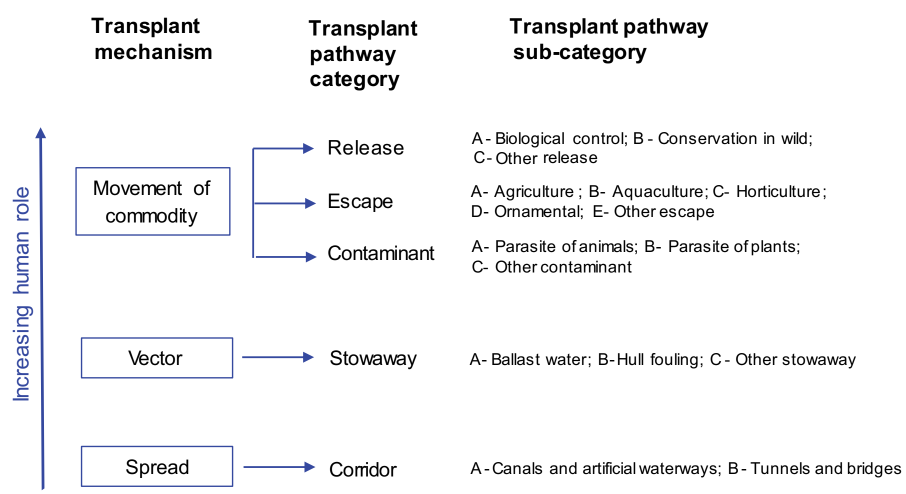


Fig. 1 Classification framework for routes of introduction / transplantation, modified from Faulkner et al. (2020). The nomenclature proposed in IUCN (2017) was partially applied. The mechanisms and pathway categories are based on Hulme et al. (2008)

counted as TMS as they had not been found in the natural environment.

Results

Seventeen transplanted mollusc species (TMS) were recognized in South America (Online Resources 4, 5): ten bivalves (only one freshwater species) belonging to six families (Fig. 2) and seven gastropods (four freshwater and three terrestrials) belonging to three families (Fig. 3).

Transplanted mollusc species were recorded in 16% (31/189) of the ecoregions, specifically in 36% (10/28) of the marine ecoregions, 23% (12/52) of the freshwater ones, and 8% (9/109) of the terrestrial ones. The ecoregions with TMS (31) are generally located in the peripheral zones of the continent, typically adjacent to other ecoregions with TMS (Figs. 2, 3).

The marine ecoregions with most transplanted species (Table 1) are Southern Caribbean (3 TMS) and Uruguay-Buenos Aires Shelf, Northeastern Brazil and Southeastern Brazil (2 TMS each). In freshwater, Central Andean Pacific Slopes ecoregion has three TMS and Western Amazon Piedmont two TMS, and in the terrestrial environment the only region with more than one TMS is Alto Paraná Atlantic Forest with two. In several localities, certain species were recognized in captivity (Figs. 2, 3). The country with the most TMS is Chile, with five in the wild and three in captivity, followed by Argentina, Brazil and Colombia with four, Ecuador with three, Peru with two, and Uruguay and Venezuela with one each (Online Resources 4 and 5).

The freshwater *Pomacea canaliculata* (Lamarck, 1822) is the transplanted gastropod recorded in the largest number of ecoregions (seven). For bivalves, it is the marine scissor date mussel *Leiosolenus aristatus* (Dillwyn, 1817), present in four ecoregions. The transplantation mechanism (Table 2) was Movement of Commodity for all gastropod species except *P. canaliculata*, while for bivalves this mechanism corresponds to only four of the cases. The remaining bivalve transplants (six) occurred by Vector, as several species are in the two subcategories 'hull fouling' and 'ballast water'.

In South America, TMS are known to cause some type of impact, both on the natural environment (e.g., modification of the environment, displacement of native fauna), and socio-economic (e.g., agriculture, aquaculture, parasite vector) (Table 3, Online Resouces 4 and 5).

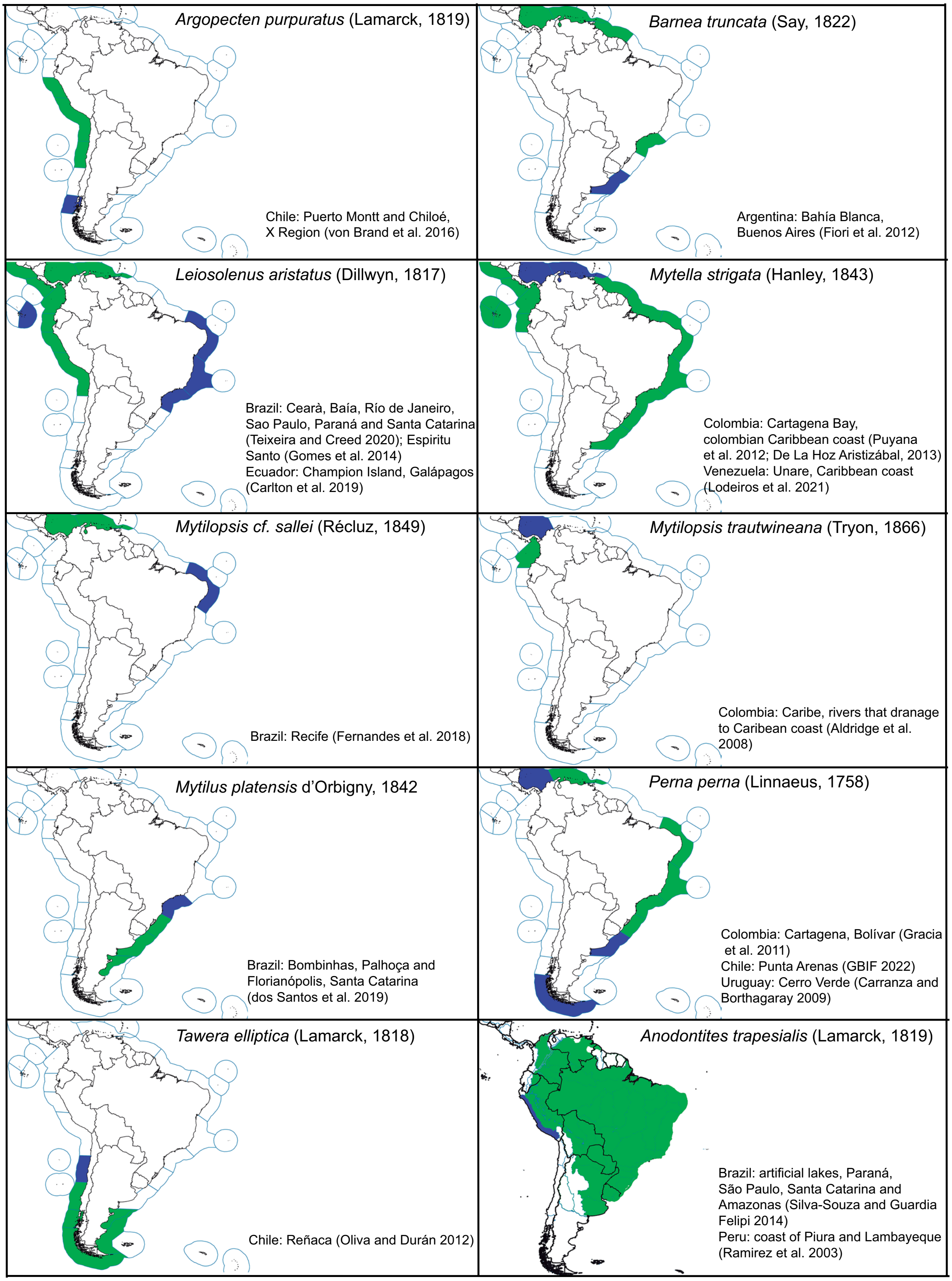
Nine species have undergone modifications in their historical distributions, but do not fit the transplantation definition (Table 4, Online Resource 6). Furthermore, species such as *Mytilus platensis* d'Orbigny, 1842 and *Perna perna* (Linnaeus, 1758) are still undergoing debate regarding their taxonomy and their status as natives (Online Resource 6).

Discussion

Given our current knowledge of climate change, it is expected that more changes in species distribution and abundance within South America will take place in the coming decades (McDowell et al. 2014; Bárcena et al. 2020). Those changes will be interacting with other stressors, such as habitat loss, change in land use, eutrophication, and impacts of invasive species. To understand the overall impacts of these factors, their interactions must be examined, and probably the first step is to precisely identify the current distributions of species in the continent.

Species are naturally dispersed by different mechanisms, but human activities have become a common means of transport, not only moving species from one geographic region to another, but also expanding their natural distributions. Studies of non-native species are many, particularly biased towards invasive species with noticeable impact on human welfare. However, the transplantation (as here defined) of species is not frequently considered, despite their potential socio-ecological impacts.

Knowledge of the native and non-native mollusc fauna of South America is heterogeneous. Studies on mollusc diversity are incomplete in vast regions of South America (Darrigran et al. 2020) and therefore the number of valid native species is not yet well established (e.g., Salvador 2019; Dos Santos et al. 2021). This lack of knowledge is evidenced in the present study by the number of transplanted mollusc species (TMS) recognized for all of South America. Although there is no up to date record of mollusc species present on the continent, the reported mollusc richness of the largest of the 12 countries in South America, Brazil, is close to 2,950 species considering


Argopecten purpuratus (Lamarck, 1819)
Chile: Puerto Montt and Chiloé, X Region (von Brand et al. 2016)
Barnea truncata (Say, 1822)
Argentina: Bahía Blanca, Buenos Aires (Fiori et al. 2012)
Leiosolenus aristatus (Dillwyn, 1817)
Brazil: Cearà, Baía, Río de Janeiro, Sao Paulo, Paraná and Santa Catarina (Teixeira and Creed 2020); Espiritu Santo (Gomes et al. 2014)
Ecuador: Champion Island, Galápagos (Carlton et al. 2019)
Mytella strigata (Hanley, 1843)
Colombia: Cartagena Bay, colombian Caribbean coast (Puyana et al. 2012; De La Hoz Aristizábal, 2013)
Venezuela: Unare, Caribbean coast (Lodeiros et al. 2021)
Mytilopsis cf. sallei (Récluz, 1849)
Brazil: Recife (Fernandes et al. 2018)
Mytilopsis trautwineana (Tryon, 1866)
Colombia: Caribe, rivers that dranage to Caribean coast (Aldridge et al. 2008)
Mytilus platensis d'Orbigny, 1842
Brazil: Bombinhas, Palhoça and Florianópolis, Santa Catarina (dos Santos et al. 2019)
Perna perna (Linnaeus, 1758)
Colombia: Cartagena, Bolívar (Gracia et al. 2011)
Chile: Punta Arenas (GBIF 2022)
Uruguay: Cerro Verde (Carranza and Borthagaray 2009)
Tawera elliptica (Lamarck, 1818)
Chile: Reñaca (Oliva and Durán 2012)
Anodontites trapesialis (Lamarck, 1819)
Brazil: artificial lakes, Paraná, São Paulo, Santa Catarina and Amazonas (Silva-Souza and Guardia Felipi 2014)
Peru: coast of Piura and Lambayeque (Ramirez et al. 2003)

◂**Fig. 2** Distribution of transplanted bivalves in South America by ecoregions (limits of ecoregions in light blue). Ecoregions that include the known historical geographic distribution are shown in green; those that include transplant locations are shown in blue. For each species the location and reference of transplants are mentioned. More information is available in Online Resource 4

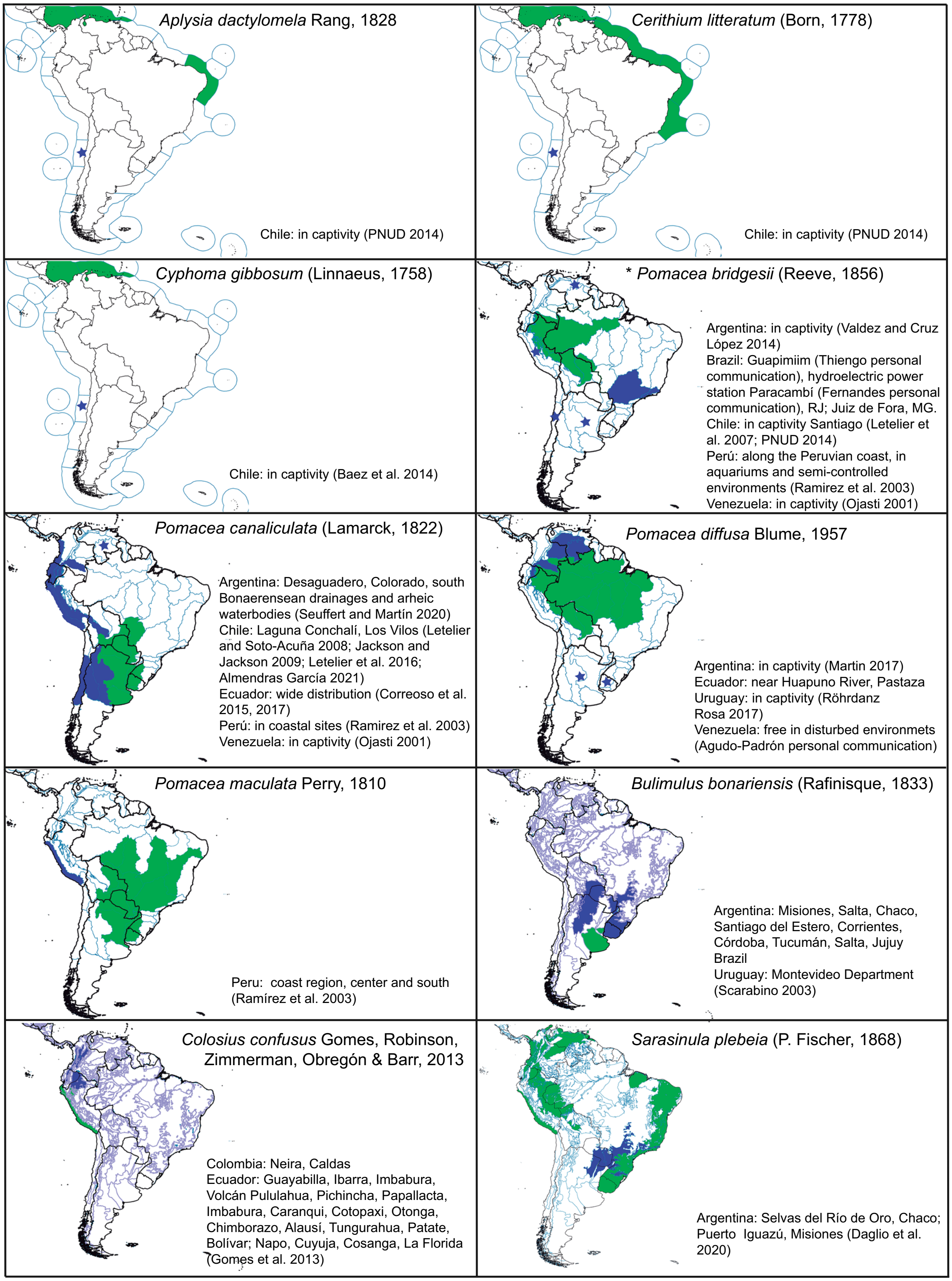
the freshwater, terrestrial, and marine environments (Amaral and Jablonski 2005; Simone 2006; Salvador 2019); 1800 species have been recorded in Chile (Aldea et al. 2019), while approximately 1300 species are reported from Argentina (Rumi et al. 2008; Bigatti and Signorelli 2018; Dos Santos et al. 2021) and the richness in tropical countries is expected to greatly exceed those numbers. This information allows us to affirm that the 17 TMS identified here for all South America constitute a very conservative estimate. It is likely that our partial knowledge of the distribution and taxonomy of many of the molluscs is masking other potential TMS. Furthermore, there are also species that are mobilized by humans for commercial use, cultivation, or research reasons, but are only found in captivity and have not established themselves in the natural environment (Darrigran et al. 2020); those species can potentially become new transplants in the future.

Darrigran et al. (2020) recognized four zones in South America based on the highest number of non-native mollusc species recorded after 1970 and the associated anthropogenic factors (e.g., urbanization and trade). These zones are predominantly peripheral mainland areas (i.e., Subtropical Atlantic, Northern Andes, Central Andes, and Southern Andes) and were recognized as non-native mollusc hot-spots and entry points of non-native mollusc species (Darrigran et al. 2020). Our results show that of the 31 ecoregions with TMS, 14 are included in these four hot-spots of non-native mollusc species. In addition, all terrestrial ecoregions in which transplanted terrestrial molluscs were recognized belong to the category of highest conservation priority at a regional scale (Dinerstein et al. 1995).

Consequently, it can be deduced that the environmental and socioeconomic characteristics that facilitate the introduction and settlement of non-native species of molluscs are also correlated with the transplantation of species within South America (Table 1). This result points to a relationship between the features of the environment (invasibility) and those of the transplanted mollusc species (invasiveness) (Hicks 2004). Strayer (2022) remarked that the impacts of transplanted species can be predicted from (a) the species traits, (b) how axial the translocation is (i.e., if an existing population is increased, or re-established at a recently occupied site, or introduced to a new site), and (c) the rigor of translocation protocols in cases where the aim is conservation or biocontrol (Novak et al. 2021).

Two highly successful mollusc species transplanted within South America (*Pomacea canaliculata* and *Leiosolenus aristatus*) exhibit behavioral and physiological characteristics that have facilitated their introduction in other continents. *Leiosolenus aristatus* is a boring species from the western Atlantic and the Pacific, which was detected off the coasts of Rio de Janeiro and São Paulo, southeast Brazil (Simone and Gonçalves 2006). It has also been introduced to the Cape Verde Islands (Lopes 2011) and to the Mediterranean coast of Catalonia (López Soriano and Quiñonero Salgado 2019). *Pomacea canaliculata* is among 100 of the worst invasive species worldwide (Lowe et al. 2000). This species causes major economic and public health problems in much of Southeast Asia (Joshi et al. 2017), Europe (López et al. 2010), and Africa (Buddie et al. 2021). Trade, maritime routes, and tourism have increased in the twentieth and twenty-first centuries (IUCN 2009; Hobbs et al. 2018), and are the most important factors in the introduction of non-native species globally. This is more pronounced for maritime transport (IUCN 2009) and, accordingly, the majority of TMS in South America have been recorded from marine ecoregions.

Among the terrestrial molluscs, Darrigran et al. (2020) considered the slug *Sarasinula plebeia* (Fischer, 1868) a cryptogenic species. However, Gomes and Thomé (2004) considered there to be a consensus that it was introduced into Australia and the several islands on the Pacific by commerce in the Indian and Pacific Oceans and that it is probably originally from tropical areas of America, as also stated by Cowie et al. (2008). Daglio et al. (2020) noted that *Vaginula behni* Semper, 1885, which is currently a synonym of *S. plebeia* according to Thomé (1993), was originally described based on material from Rio de Janeiro, Brazil, indicating that it has been present in South America for a long time, despite being originally described based on material from New Caledonia, in the Pacific region. According to Daglio et al. (2020), *S. plebeia*


Aplysia dactylomela Rang, 1828
Chile: in captivity (PNUD 2014)
Cerithium litteratum (Born, 1778)
Chile: in captivity (PNUD 2014)
Cyphoma gibbosum (Linnaeus, 1758)
Chile: in captivity (Baez et al. 2014)
* Pomacea bridgesii (Reeve, 1856)
Argentina: in captivity (Valdez and Cruz López 2014)
Brazil: Guapimiim (Thiengo personal communication), hydroelectric power station Paracambí (Fernandes personal communication), RJ; Juiz de Fora, MG.
Chile: in captivity Santiago (Letelier et al. 2007; PNUD 2014)
Perú: along the Peruvian coast, in aquariums and semi-controlled environments (Ramirez et al. 2003)
Venezuela: in captivity (Ojasti 2001)
Pomacea canaliculata (Lamarck, 1822)
Argentina: Desaguadero, Colorado, south Bonaerensean drainages and arheic waterbodies (Seuffert and Martín 2020)
Chile: Laguna Conchalí, Los Vilos (Letelier and Soto-Acuña 2008; Jackson and Jackson 2009; Letelier et al. 2016; Almendras García 2021)
Ecuador: wide distribution (Correoso et al. 2015, 2017)
Perú: in coastal sites (Ramirez et al. 2003)
Venezuela: in captivity (Ojasti 2001)
Pomacea diffusa Blume, 1957
Argentina: in captivity (Martin 2017)
Ecuador: near Huapuno River, Pastaza
Uruguay: in captivity (Röhrdanz Rosa 2017)
Venezuela: free in disturbed environmets (Agudo-Padrón personal communication)
Pomacea maculata Perry, 1810
Peru: coast region, center and south (Ramírez et al. 2003)
Bulimulus bonariensis (Rafinisque, 1833)
Argentina: Misiones, Salta, Chaco, Santiago del Estero, Corrientes, Córdoba, Tucumán, Salta, Jujuy
Brazil
Uruguay: Montevideo Department (Scarabino 2003)
Colosius confusus Gomes, Robinson, Zimmerman, Obregón & Barr, 2013
Colombia: Neira, Caldas
Ecuador: Guayabilla, Ibarra, Imbabura, Volcán Pululahua, Pichincha, Papallacta, Imbabura, Caranqui, Cotopaxi, Otonga, Chimborazo, Alausí, Tungurahua, Patate, Bolívar; Napo, Cuyuja, Cosanga, La Florida (Gomes et al. 2013)
Sarasinula plebeia (P. Fischer, 1868)
Argentina: Selvas del Río de Oro, Chaco; Puerto Iguazú, Misiones (Daglio et al. 2020)

◂**Fig. 3** Distribution of transplanted gastropods in South America by ecoregions (limits of ecoregions in light blue). Ecoregions that include the known historical geographic distribution are shown in green; those that include transplant locations are shown in blue. The blue stars indicate specimens in captivity (not considered TMS). For each species the location and reference of transplants are mentioned. *The distribution of *Pomacea bidgesii* is difficult to establish because *Pomacea diffusa* was previously considered a subspecies of *P. bridgesii* and, although they are currently recognized as separate species, misidentification of *P. diffusa* as *P. bridgesii* is frequent (Cowie and Thiengo 2003; Hayes et al. 2008, 2009; Cowie et al. 2017). More information is available in Online Resource 5

has been reported in Brazil (since 1885), Colombia (1978), Venezuela (1992), Chile (1993), Ecuador (2008), Peru (2015), and Argentina (2020); they considered its presence in Argentina as a transplanted species.

It is important to note, however, that the geographical origin of some species remains uncertain. Such is the case, as mentioned before, for the brown mussel *Perna perna*, which has been considered native to either South America (Darrigran et al. 2020) or the western coasts of Africa (Oliveira et al. 2017). Calazans et al. (2021) clarified the status of *P. perna* by analyzing the genetic structure of several populations, showing that it is native to both continents: populations in Brazil are derived from natural geographical expansion from the populations in northern Africa, which took place over 2000 years ago. In addition, taxonomic problems often prevent proper assessment of the distribution of species. For example, the geographic range of *Mytilus platensis* is not reliably defined, given its complex identification and diagnosability from other Mytilidae, such as *Mytilus chilensis* Hupé, 1854 from the southeastern Pacific (Zbawicka et al. 2018). Some studies indicate that the distribution of *M. platensis* extends from southern Brazil to southern Argentina (Dellatorre et al. 2007), with the North Patagonian gulfs probably being the southern limit of its distribution. A characteristic of this species is its ecology in the coasts of northern Argentina and southern Uruguay, where in addition to being part of the intertidal and infralittoral community, they form deep banks away from the coast, between 40 and 55 m deep (Penchaszadeh 1980). Adding to the complexity is the introduced Mediterranean *Mytilus galloprovincialis* Lamarck, 1819 in the Puerto Madryn area (42° 51′ S, 65° 15′ W), where it has hybridized with the local *M. platensis* (Zbawicka et al. 2018).

All these caveats being noted, we found that TMS occur in 18% of the ecoregions in South America, 31% of which are contiguous. Contiguous ecoregions may have similar or at least favorable environmental characteristics for the presence of TMS. Most of these scenarios correspond to contiguous freshwater ecoregions in line with the hypothesis of Bianco (1995), that river basins are the main geographic axes of introduction of non-marine aquatic species. In general, TMS transportation routes in South America are related to economic purposes, namely aquaculture, agriculture, horticulture, and trade of ornamental species. Sindermann (1993) warned about the transplantation and introduction of marine species worldwide in response to the perceived need of expanding aquaculture industries (e.g., fish, shrimp, bivalve molluscs). On the other hand, Bartley et al. (2005) stated that the use of non-native species is a proven means of increasing productivity and value of aquatic ecosystems. Likewise, FAO (2018) promoted practices for the introduction of new species and the responsible movement of live aquatic animals. According to the aforementioned, Álvarez León (2014) pointed out that it is necessary to identify the impacts of transplanting native species and introducing non-native species, in addition to regulating their use in each country. For instance, most of the transplants in Colombia have originated from aquaculture (Restrepo-Santamaría and Álvarez-León 2013) and, as the technological packages of some species were developed, they began to be used in regions different from their basins of origin ("trans-introductions" according to Bianco 1995), highlighting the importance of this type of pathway for the transplantation of species. For example, *Anodontites trapesialis* (Lamarck, 1819) was transplanted to the north coast of Peru for aquaculture purposes in integrated fish and duck cultures (Ramírez et al. 2003). Agudo-Padrón (2019, 2022) reported this species as a contaminant in fish farming tanks, farming areas, and tourist fishing facilities in rivers in southern Brazil. The life cycle of *A. trapesialis* includes an ectoparasitic larval stage that adheres to the gills and fins of host fish. The cycle is completed in the fish rearing tanks, which has a negative impact on the development of this resource. Tanks are mainly contaminated through the inadvertent introduction of infested fish. Likewise, Agudo-Padrón (2005) reported that the Federal Rural University of Pernambuco experimented with freshwater fish farming with

Table 1 Number of transplanted mollusc species (TMS) according marine, freshwater and terrestrial ecoregions of South America

Ecoregion	TMS	NNMS	Hotspots NNMS
Marine environment			
Southern Caribbean	3	1	Northern Andes
Northeastern Brazil	2	3	*
Uruguay-Buenos Aires Shelf	2	5	Subtropical Atlantic
Southeastern Brazil	2	6	Subtropical Atlantic
Central Chile	1	4	Southern Andes
Chiloense	1	4	Southern Andes
Channels and Fjords of Southern Chile	1	1	*
Eastern Brazil	1	2	*
Eastern Galapagos Islands	1	nc	nc
Southwestern Caribbean	1	1	Northern Andes
	Total marine ecoregions with TMS 10/28 = 36%		
Freshwater environment			
Central Andean Pacific Slopes	3	7	Central Andes
Western Amazon Piedmont	2	nc	*
South Andean Pacific Slopes	1	3	Southern Andes
North Andean Pacific Slopes Rio Atrato	1	3	*
Mar Chiquita – Salinas Grandes	1	4	*
Amazonas High Andes	1	2	*
Paraíba do Sul	1	5	Subtropical Atlantic
Fluminense	1	6	Subtropical Atlantic
Cuyan—Desaguadero	1	2	*
Upper Paraná	1	6	Subtropical Atlantic
Orinoco Llanos	1	3	Northern Andes
Orinoco Guiana Shield	1	1	*
	Total freshwater ecoregions with TMS 12/52 = 23%		
Terrestrial environment			
Alto Paraná Atlantic forests	2	16	Subtropical Atlantic
Southern Andean Yungas	1	16	*
Magdalena Valley montane forests	1	13	Northern Andes
Napo moist forests	1	6	*
Eastern Cordillera real montane forests	1	5	*
Northwestern Andean montane forests	1	3	*
Dry Chaco	1	12	*
Humid Chaco	1	7	*
Uruguayan savanna	1	22	Subtropical Atlantic
	Total terrestrial ecoregions with TMS 9/109 = 8%		

Following Darrigran et al. (2020): NNMS, number of non-native mollusc species (from outside South America); Hotspots of NNMS according to Darrigran et al. (2020)

*Ecoregions outside the hotspots of non-native mollusc species; nc, ecoregion not considered in Darrigran et al. (2020)

A. trapesialis for human consumption, using host fish such as carp, *Cyprinus carpio* (Linnaeus, 1758) and tilapia (*Oreochromis* sp.).

Although no further records of freshwater bivalve culturing were detected in South America, there have been instances of culturing the gastropods *Pomacea bridgesii* (Reeve, 1856) and *Pomacea lineata* (Spix

Table 2 Pathways of transplanted mollusc species in South America (seven Gastropoda and ten Bivalvia species)

Mechanism of Transplant	Pathway Category	Pathway Sub-category	
Movement of commodity	Escape	Aquaculture	
		1. *Anodontites trapesialis***	Ramírez et al. (2003)
		2. *Argopecten purpuratus***	von Brand et al. (2016)
		3. *Mytilopsis trautwineana***	Albridge et al. (2008)
		4. *Pomacea maculata**	Alcantara-Bocanegra and Nakagawa-Valverde (1996)
		5. *Tawera elliptica***	Oliva and Durán (2012)
		Ornamental	
		1. *Pomacea diffusa**	Scarabino et al. (2012) Martín (2017)
		Horticulture and Agriculture	
		1. *Bulimulus bonariensis**	Frana and Massoni (2011)
		2. *Colosius confusus**	Gomes et al. (2013)
		Live bait	
		1. *Pomacea canaliculata**	Seuffert and Martín (2020)
		Live food	
		1. *Pomacea canaliculata**	Seuffert and Martín (2020)
		Other escape	
		1. *Pomacea bridgesii*#*	Martins and Alves (2008)
		2. *Pomacea canaliculata**	Seuffert and Martín (2020)
		3. *Sarasinula plebeia**	Daglio et al. (2020)
	Contaminant	Parasite of animals	
		1. *Anodontites trapesialis***	dos Santos Silva et al. (2021)
Vector	Stowaway	Hull fouling	
		2. *Barnea truncata***	Fiori et al. (2012)
		3. *Leiosolenus aristatus***	Carlton et al. (2019)
		4. *Mytella strigata***	Lodeiros et al. (2021)
		5. *Mytilopsis* cf. *sallei***	Queiroz et al. (2020)
		6. *Mytilus platensis***	Cárdenas et al. (2020)
		7. *Perna perna***	PNUD (2014)
		8. *Pomacea canaliculata**	Seuffert and Martín (2020)
		Ballast water	
		1. *Barnea truncata***	Fiori et al. (2012)
		2. *Mytella strigata***	Lodeiros et al. (2021)
		3. *Mytilopsis* cf. *sallei***	Queiroz et al. (2020)
		4. *Mytilus platensis***	Cárdenas et al. (2020)
		5. *Perna perna***	PNUD (2014)

The mechanisms and main categories are based on Faulkner et al. (2020); *, gastropod species; **, bivalve species. More than one pathway sub-category wasrecognized for some species

#The identification of *Pomacea bridgesii* is suspect, probably mistaken for *Pomacea diffusa*; *P. diffusa* is widely distributed through much of the Amazon basin and is found around the world in the aquarium trade, while *P. bridgesii* is restricted to Bolivia and the western Amazon basin (Hayes et al. 2008, 2009; Cowie et al. 2017)

in Wagner, 1827). Souza et al. (2013) mentioned that, because of their high rates of reproduction, growth, and early sexual maturity, as well as for having been previously used as food by settlers in Trinidad, Guyana, French Guiana, and northern Brazil, they were cultivated to evaluate the viability of their use as a

Table 3 List of mollusc species transplanted in South America and their environmental impacts and positve (+) or negative (−) socioeconomic effects

	Impact on natural environment			Socioeconomic impact		
	Meaningful	Moderate	Null or unknown	Meaningful	Moderate	Null or unknown
Gastropoda						
Bulimulus bonariensis (Rafinisque, 1833)			x	A		
Colosius confusus Gomes et al., 2013			x	A		
#Pomacea bridgesii (Reeve, 1856)		D			AQ	
Pomacea canaliculata (Lamarck, 1822)	D–E				A–V	
Pomacea diffusa Blume, 1957			X		AQ	
Pomacea maculata Perry, 1810		D–E				x
Sarasinula plebeia (Fischer, 1868)			x		A-V	
Bivalvia						
Anodontites trapesialis (Lamarck, 1819)			x		F	
Argopecten purpuratus (Lamarck, 1819)			x	P		
Barnea truncata (Say, 1822)		E				x
Leiosolenus aristatus (Dillwyn, 1817)		D				x
Mytella strigata (Hanley, 1843)		D		F		
Mytilopsis cf. *sallei* (Recluz, 1849)			x			x
Mytilopsis trautwineana (Tryon, 1866)			x		F	
Mytilus platensis d'Orbigny, 1842		D				x
Perna perna (Linnaeus, 1758)			x		P	
Tawera elliptica (Lamarck, 1818)			x		P	

A (−), losses in agriculture; AQ (+), aquarium trade; D (−), species displacement; E (−), environment modification; F (−), losses in aquaculture; P (+), profits from aquaculture; V (−), parasite vector. Details in Online Resource 4 and 5

#The identification of *Pomacea bridgesii* is suspect, probably mistaken for *Pomacea diffusa* (Hayes et al. 2008, 2009; Cowie et al. 2017)

possible new food source. However, concerning the identification and geographical range of both species we highlight that *P. bridgesii* is restricted to Bolivia and the western Amazon basin, whereas *Pomacea diffusa* Blume, 1957 is widely distributed through much of the Amazon basin and it is the one in the aquarium trade that is found around the world now (Cowie et al. 2017). Regarding *P. lineata*, it occurs primarily in the Atlantic drainages of Brazil—the Brazilian Atlantic Forest biogeographic province—and is replaced by its close relative *Pomacea dolioides* (Reeve, 1856) in northern South America (Surinam, French Guiana, Guyana, and Venezuela). Thus, the reference to *P. lineata* is probably a misidentification of *P. dolioides* (Thiengo et al. 2011; Cowie et al. 2017).

In short, the growing circulation of people, the increase in trade, and changes both to the environment and in production practices, give rise to new threats to production systems and to the natural environment (FAO 2015). In general, non-native species can have negative impacts on recipient environments and so do transplanted species (third premise of Material and Methods). According to Simberloff et al. (2012), when non-native species invade, they can modify community structure and ecosystem function, becoming ecosystem engineers (Jones et al. 1994), increasing the risk of extinction for native species (Collado 2016; Collado et al. 2019), causing negative effects on human health, and becoming a serious socio-economic threat (Pejchar and Mooney 2009). For example, *Colosius confusus* Gomes et al. 2013 occurs in the Andean region, in regions for production of cut flowers and coffee in Colombia and Ecuador (Gomes et al. 2013). In northern Peru it was found attacking coffee in Canchaque. It is also found in two other Departments in Peru (Amazonas and Cajamarca), where it is sympatric with native species in urban areas. Although not causing

Table 4 Mollusc species with alterations in their known historical distribution, but which are not considered transplantations

	Species	References	Cause of alterations
GASTROPODA			
Terrestrial	*Bulimulus apodemetes* (d'Orbigny, 1835)	Miquel (1991), Dos Santos et al. (2021)	1
	Gastrocopta servilis (Gould, 1852)	Doering (1874), Pilsbry (1916–1918), Parodiz (1957), Fernández (1973)	1
	Orthalicus pulchellus (Spix, 1827)	Cruz (1995), Simone (1999)	1
	Aplysia juliana Quoy & Gaimard, 1832	Soto (1985), Tomicic (1985), Castilla et al. (2005), Uribe et al. (2013)	2*
Marine	*Monoplex keenae* (Beu, 1970)	Beu and Cernohorsky (1986), Ashton et al. (2008), Araya (2015)	2*
	Monoplex wiegmanni (Anton, 1838)	Castilla et al. (2005), Ashton et al. (2008)	2*
BIVALVIA			
Marine	*Modiolus carvalhoi* Klappenbach, 1966	Zaffaroni (2000); Scarabino et al. (2006), Silveira et al. (2006), Borthagaray and Carranza (2007), Huber (2010)	2
	Semimytilus patagonicus (Hanley, 1843) [= *S. algosus* (Gould, 1850)]	Alamo and Valdivieso (1987, 1997), Coan and Valentich-Scott (2012), Bigatti et al. (2014), Signorelli and Pastorino (2021a, b)	3
Freshwater	*Diplodon chilensis* (Gray 1928)	Parada and Peredo (2005), Peredo et al. (2005), Valdovinos and Pedreros (2007), Fuentealba et al. (2010)	4

The causes of the alterations were classified as: *1*, Nomenclatural and/or taxonomic issues; *2*, natural dispersal, without direct human intervention; *3*, species intercepted in trade traffic; *4*, species mobilized by humans for repopulation in their known historical geographic distribution. Details of the distribution of these species in Online Resource 6

*Dispersal due to El Niño Southern Oscillation

agricultural damage as in Colombia and Ecuador, and exhibiting a different external coloration in relation to the forms found attacking coffee, no genetic variation was found between them. *Colosius confusus* was first collected in Peru in 1970 and in Ecuador in 1985 (Gomes et al. 2013). In Ecuador, it is the second most commonly found Andean species of Veronicellidae after *Colosius pulcher* (Colosi, 1921). Also, even after Colosi (1921, 1922) examined many specimens from Ecuador, he did not describe *C. confusus*, which lends support to it being a recent transplant. The lack of variation observed in *C. confusus* specimens from Ecuador, Colombia, and Peru using mitochondrial DNA sequences is consistent with recent transplantation between countries. Gomes et al. (2013) indicated thus that the species is probably originally from Peru. In Ecuador, the production of cut flowers began in the late 1970s with exports in the early 1980s (Acción Ecológica 2000), indicating that the spread of *C. confusus* could be related to expanding commercial flower production.

The terrestrial snail *Bulimulus bonariensis* (Rafinesque, 1833) was originally described based on material from Buenos Aires but spread to northeastern Argentina (Cuezzo et al. 2013), where it is reported as a pest of soybeans (Frana and Massoni 2011). It is also reported from Uruguay (Scarabino 2003) and Brazil, to both of which it was probably transplanted considering its pest status. The case of *Bulimulus* species is remarkable and a good example of how necessary it is to expand taxonomic work based not only on molecular studies but also on morphology. Maintaining taxonomic collections in public institutions is important for understanding historical distribution changes as well as the spread of certain species because of the changes produced by people. *Bulimulus apodemetes* (d'Orbigny, 1835) has an unusually wide distribution for a terrestrial gastropod and the marked intraspecific variability of its shells suggests a complex of species. The advance of agricultural frontiers in some areas of the Yungas (Bolivia, Peru and Argentina) and Dry Chaco (Bolivia, Paraguay and Argentina) ecoregions has produced the appearance of specimens similar to *B. apodemetes* in areas where they did not occur before. However, these abundant specimens in soybean crops and other grains have not yet been correctly identified. New studies are needed that focus on this malacofauna associated with human environments.

The movement of species is among the most serious environmental threats of the new millennium, as the relocation of species beyond their native or historical geographical range has intensified in the last five decades; however, its general effects on the environment are not yet sufficiently understood (Anton et al. 2019). Since the impacts of TMS may be high, both for natural environments and for socioeconomic systems, we emphasize the need for further studies of transplantations in South America and elsewhere.

Acknowledgements The authors are grateful for the suggestions and help provided by Robert Cowie and the comments of the two anonymous reviewers. GD, DEGG, and CD were partially supported by Project PICT2019-01417, Agencia Nacional de Promoción Científica; GD, CD by Universidad Nacional de La Plata (11/N927), GD, PEP and DEGG (PIP1966) and MGC (PIP0050) by Consejo Nacional de Investigaciones Científícas y Técnicas

Funding Agencia Nacional de Promoción Científica (PICT2019-01417); Universidad Nacional de La Plata (11/N927); Consejo Nacional de Investigaciones Científicas y Técnicas (PIP1966; PIP0050).

Availability of data and materials All data analyzed during this study are included in this published article and its supplementary information files.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no conflicts of interest to declare.

Ethics approval Not applicable.

Consent to participate All authors declare consent.

Consent for publication All authors declare consent.

References

Abell R, Thieme ML, Revenga C, Bryer M, Kottelat M, Bogutskaya N, Coad B, Mandrak N, Contreras Balderas S, Bussing W, Stiassny MLJ, Skelton P, Allen GR, Unmack P, Naseka A, Rebecca NG, Sindorf N, Robertson J, Armijo E, Higgins JV, Heibel TJ, Wikramanayake E, Olson D, López HL, Reis RE, Lundberg JG, Sabaj Pérez MH, Petry P (2008) Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. Bioscience 58:403–414. https://doi.org/10.1641/B580507

Acción Ecológica (2000) Las flores del mal: las floricultoras y su crecimiento acelerado. Alerta n. 88. EduAlter, Ecuador

Agudo-Padrón AI (2005) Praga de bivalves límnicos em açudes. São Paulo/ SP: Conquiliologistas do Brasil – CdB, Outubro de 2005. http://www.conchasbrasil.org.br/materias/pragas/limnicos.asp. Accessed 29 Apr 2022

Agudo-Padrón AI (2019) The Giant Native Freshwater Mussel/ Naiad Mycetopodidae *Anodontites trapesialis* (Lamarck, 1819), an Emerging Invasive Plague in Fish Culture Farms of Santa Catarina State/SC and other localities in Southern Brazil: new geographical records and brief revision. Ellipsaria 21(2):36–38

Agudo-Padrón AI (2022) The neotropical giant freshwater mussel/ bivalve naiad Mycetopodidae *Anodontites trapesialis* (Lamarck, 1819), a species considered threatened with extinction that is becoming an emerging invasive synanthropic pest: new geographical records in the Southern Brazil region. Braz J An Environm Res 5:1112–1122. https://doi.org/10.34188/bjaerv5n1-084

Alamo V, Valdivieso V (1987) Lista sistemática de moluscos marinos del Perú. Bol. Inst. Mar. Perú-Callao. Volumen Extraordinario, p 205

Alamo V, Valdivieso V (1997) Lista sistemática de moluscos marinos del Perú (segunda edición, revisada y actualizada). Instituto del Mar Perú-Callao. Publicación especial

Alcantara-Bocanegra F, Nakagawa-Valverde N (1996) Cultivo preliminar del churo *Pomacea maculata* (Ampullariidae, Gastropoda, Perry, 1810). Folia Amaz 8:29–34

Aldea C, Novoa L, Rosenfeld S, Guzmán G (2019) Lista sistemática actualizada de los Moluscos de Chile, v1.4. Universidad de Magallanes. http://gbif-chile.mma.gob.cl/ipt/resource?r=moluscos-chile. Accessed 10 May 2022

Aldridge DC, Salazar M, Serna A, Cock J (2008) Density-dependent effects of a new invasive false mussel, *Mytilopsis trautwineana* (Tryon 1866), on shrimp, *Litopenaeus vannamei* (Boone 1931), aquaculture in Colombia. Aquaculture 281:34–42. https://doi.org/10.1016/j.aquaculture.2008.05.022

Almendra García D (2021) New record of the invasive channeled apple snail *Pomacea canaliculata* (Lamarck, 1829) in central Chile. Bol Mus Nac Hist Nat Santiago de Chile 70(2):15–19. https://doi.org/10.54830/bmnhn.v70.n2.2021.207

Álvarez León R (2014) Los peces de Colombia: 20 años de esfuerzos para su conservación y protección. Bol Cient CIOH 32:85–104

Amaral ACZ, Jablonski S (2005) Conservation of marine and coastal biodiversity in Brazil. Conserv Biol 19:625–631. https://doi.org/10.1111/j.1523-1739.2005.00692.x

Anton AN, Geraldi R, Lovelock CE, Apostolaki ET, Bennett S, Cebrian J, Krause-Jensen D, Marbà N, Martinetto P, Pandolfi JM, Santana-Garcon J, Duarte CM (2019) Global ecological impacts of marine exotic species. Nat Ecol Evol 3:787–800. https://doi.org/10.1038/s41559-019-0851-0

Araya JF (2015) Current status of the non-indigenous molluscs in Chile, with the first record of *Otala punctata* (Müller,

1774) (Gastropoda: Helicidae) in the country and new records for *Cornu aspersum* (Müller, 1774) and *Deroceras laeve* (Müller, 1774). J Nat Hist 49(29–30):1731–1761. https://doi.org/10.1080/00222933.2015.1006703

Ashton T, Riascos JM, Pacheco A (2008) First record of *Cymatium keenae* Beu, 1970 (Mollusca: Ranellidae) from Antofagasta Bay, northern Chile, in connection with El Niño events. Helgol Mar Res 62:107–110. https://doi.org/10.1007/s10152-007-0084-5

Báez P, Letelier S, Rebolledo A, Fabres A (2014) Moluscos marinos introducidos en Chile. En: PNUD (2014) Moluscos exóticos presents en Chile: Documento del Taller Moluscos Exóticos en Chile: Efectos en la Biodiversidad. Santiago, Chile, pp 37–42. http://smach.cl/wp-content/uploads/2018/05/libro_moluscos_paginas.pdf. Accessed 28 Apr 2022

Bárcena A, Samaniego J, Peres W, Alatorre JE (2020) La emergencia del cambio climático en América Latina y el Caribe. Seguimos esperando la catástrofe o pasamos a la acción? Libros de la CEPAL 160 (LC/PUB.2019/23-P), Comisión Económica para América Latina y el Caribe (CEPAL). https://repositorio.cepal.org/bitstream/handle/11362/45677/1/S1900711_es.pdf. Accessed 24 Apr 2022

Bartley DM, Bhujel RC, Funge-Smith S, Olin PG, Phillips MJ (comps./eds.) (2005) International mechanisms for the control and responsible use of alien species in aquatic ecosystems. Report of an Ad Hoc Expert Consultation. Xishuangbanna, People's Republic of China, 27–30 August 2003. Rome, FAO. 195p. http://www.fao.org/3/a0113e/a0113e00.htm. Accessed 29 Apr 2022

Beu AG, Cernohorsky WO (1986) Taxonomy of gastropods of the families Ranellidae (Cymatiidae) and Bursidae, Pt.1, Adoption of Ranellidae, and review of *Linatella* Gray, 1857. N Z J Zool 13:241–266. https://doi.org/10.1080/03014223.1986.10422666

Bianco PG (1995) Mediterranean endemic freshwater fish of Italy. Biol Conserv 72:159–170. https://doi.org/10.1016/0006-3207(94)00078-5

Bigatti G, Signorelli J (2018) Marine invertebrate biodiversity from the Argentine Sea, South Western Atlantic. ZooKeys 791:47–70. https://doi.org/10.3897/zookeys.791.22587

Bigatti G, Signorelli JH, Schwindt E (2014) Potential invasion of the Atlantic coast of South America by *Semimytilus algosus* (Gould, 1850). BioInvasions Rec 3(4):241–246. https://doi.org/10.3391/bir.2014.3.4.05

Blackburn TM, Bellard C, Ricciardi A (2020) Alien versus native species as drivers of recent extinctions. Front Ecol Environ 17:203–207. https://doi.org/10.1002/fee.2020

Borthagaray A, Carranza A (2007) Mussels as ecosystem engineers: their contribution to species richness in a rocky littoral community. Acta Oecol 31:243–250. https://doi.org/10.1016/j.actao.2006.10.008

Buddie AG, Rwomushana I, Oford LC, Kibet S, Makale F, Djeddour D, Cafa G, Vincent KK, Muvea AM, Chacha D, Day RK (2021) First report of the invasive snail *Pomacea canaliculata* in Kenya. CABI Agric Biosci 2:11. https://doi.org/10.31220/agriRxiv.2020.00027

Calazans CSH, Walters LJ, Fernandes FC, Ferreira CEL, Hoffman EA (2018) Genetic structure provides insights into the geographic origins and temporal change in the invasive charru mussel (Sururu) in the southeastern United States. PLoS ONE 13(7):e0180619. https://doi.org/10.1371/journal.pone.0180619

Calazans SH, Lourenço CR, Nicastro KR, Tagliaro CH, Zardi GI, Ferreira CEL, Fernandes FC, Silva EP, Hoffman EA (2021) Unlocking the history of a trans-Atlantic invader: did the human slave trade impact Brown mussel dispersal? J Biogeogr 48(2671–2681):1–11. https://doi.org/10.1111/jbi.14232

Cárdenas L, Leclerc J-C, Bruning P, Garrido I, Détrée C, Figueroa A, Astorga M, Navarro JM, Johnson LE, Carlton JT, Pardo L (2020) First mussel settlement observed in Antarctica reveals the potential for future invasions. Sci Rep 10:5552. https://doi.org/10.1038/s41598-020-62340-0

Carlton J, Keith I, Ruiz GM (2019) Assessing marine bioinvasions in the Galápagos Islands: implications for conservation biology and marine protected areas. Aquat Invasions 14(1):1–20. https://doi.org/10.3391/ai.2019.14.1.01

Carranza A, Borthagaray AI (2009) The brown mussel *Perna perna* in the native mussel beds of Cerro Verde (Uruguay). Mar Biodivers Rec 2:e76. https://doi.org/10.1017/S1755267209000608

Castilla JC, Uribe M, Bahamonde N, Clarke M, Desqueyroux-Faúndez R, Kong I, Moyano H, Rozbaczylo N, Santelices B, Valdovinos C, Zavala P (2005) Down under the southeastern Pacific: marine non-indigenous species in Chile. Biol Invasions 7:213–232. https://doi.org/10.1007/s10530-004-0198-5

CBD (1992) Convenios sobre la diversidad biológica. http://www.cbd.int/doc/legal/cbd-es.pdf. Accessed 24 Apr 2022

CBD (2010) Especies exóticas e invasoras. En: Decisiones adoptadas por la conferencia de las partes en el Convenio sobre la Diversidad Biológica en su décima reunion Nagoya, Japón, 18–29 de octubre de 2010, pp 325–329. https://www.cbd.int/doc/decisions/cop-10/full/cop-10-dec-es.pdf Accessed 26 Apr 2022

CBD (2014) Informe de la 12ª Reunión de la Conferencia de las partes en el Convenio sobre la Diversidad Biológica. https://www.cbd.int/doc/meetings/cop/cop-12/official/cop-12-29-es.pdf. Accessed 23 Apr 2022

Coan EV, Valentich-Scott P (2012) Bivalve Seashells of Tropical West America. Marine Bivalve Mollusks from Baja California to Peru. Santa Barbara Museum of Natural History Monographs, EUA

Collado GA (2016) Unraveling cryptic invasion of a freshwater snail in Chile based on molecular and morphological data. Biodivers Conserv 26:567–578. https://doi.org/10.1080/14772000.2016.1153526

Collado GA, Vidal MA, Aguayo KP, Méndez MA, Valladares MA, Cabrera FJ, Pastenes L, Gutiérrez Gregoric DE, Puillandre N (2019) Morphological and molecular analysis of cryptic native and invasive freshwater snails in Chile. Sci Rep 9:7846. https://doi.org/10.1038/s41598-019-41279-x

Colosi G (1921) Diagnosi di Vaginulidi (Gasteropodi terrestri). Atti Soc Ital Sci Nat Mus Civ Storia Nat Milano 60:156–160

Colosi G (1922) Contributo alla conoscenza anatomica e sistematica dei Vaginulidi Sud-Americani. An Mus Nac Hist Nat Buenos Aires 31:475–517

Correoso RM, Coello Rodríguez GM, Arrébola Burgos J, Martini LR (2015) *Pomacea canaliculata* plaga del arroz en Ecuador. Primera edición electrónica. Universidad de las Fuerzas Armadas – ESPE, Quito

Correoso RM, Espinosa E, Coello Rodriguez M (2017) *Pomacea canaliculata* in Ecuador: a recent pest with multiple implications. In: Joshi RC, Cowie RH, Sebastian LS (eds) Biology and management of invasive apple snails. Philippine Rice Research Institute (PhilRice), Nueva Ecija, pp 257–291

Cowie RH, Thiengo SC (2003) The apple snails of the Americas (Mollusca: Gastropoda: Ampullariidae: *Asolene, Felipponea, Marisa, Pomacea, Pomella*) a nomenclatural and type catalog. Malacologia 45:41–100

Cowie RH, Hayes KA, Tran CT, Meyer WM (2008) The horticultural industry as a vector of alien snails and slugs: widespread invasions in Hawaii. Int J Pest Manag 54:267–276. https://doi.org/10.1080/09670870802403986

Cowie RH, Hayes KA, Strong EE, Thiengo SC (2017) Non-native apple snails: systematics, distribution, invasion history and reasons for introduction. In: Joshi RC, Cowie RH, Sebastian LS (eds) Biology and management of invasive apple snails. Philippine Rice Research Institute (PhilRice), Nueva Ecija, pp 3–32

Cruz JO (1995) O caracol rajado *Oxystyla pulchella* (Mollusca, Bulimulidae), um organismo benéfico ao pomar cítrico: Dissertação de estrado. Universidade Federal da Bahia

Cuezzo MG, Miranda MJ, Ovando XMC (2013) Species catalogue of Orthalicoidea in Argentina (Gastropoda: Stylommatophora). Malacologia 56(1–2):135–191. https://doi.org/10.4002/040.056.0210

Daglio ED, de Lucía M, Gomes RS, Gutiérrez Gregoric DE (2020) First records of the bean-slug *Sarasinula plebeia* (Gastropoda: Veronicellidae) in Argentina. Pap Avulsos Zool 60:e20206047. https://doi.org/10.11606/1807-0205/2020.60.47

Damborenea C, Rogers DC, Thorp JH (2020) Thorp and Covich's freshwater invertebrates. Keys to neotropical and antarctic fauna, vol 5. Elsevier, Amsterdam

Darrigran G, Agudo-Padrón I, Baez P, Belz C, Cardoso F, Carranza A, Collado G, Correoso M, Cuezzo MG, Fabres A, Gutiérrez Gregoric DE, Letelier S, Ludwig S, Mansur MC, Pastorino G, Penchaszadeh P, Peralta C, Rebolledo A, Rumi A, Santos S, Thiengo S, Vidigal T, Damborenea C (2020) Non-native mollusks throughout South America: emergent patterns in an understudied continent. Biol Invasions 22:853–871. https://doi.org/10.1007/s10530-019-02178-4

de Barros G, da Silva Brito MT, Peluso LM, de Faria E, Izzo TJ, Teixido AL (2020) Biased research generates large gaps on invertebrate biota knowledge in Brazilian freshwater ecosystems. PECON 18:190–196. https://doi.org/10.1016/j.pecon.2020.06.003

De La Hoz Aristizábal MV (2013) Nuevos registros de *Mytella charruana* (Bivalvia: Mytilidae) en Colombia y algunas consideraciones sobre su ecología y estatus. Bol Centro Invest Biol 47:165–172

Dellatorre FG, Pascual MS, Barón PJ (2007) Feeding physiology of the Argentine mussel *Mytilus edulis platensis* (d'Orbigny, 1846): does it feed faster in suspended culture systems? Aquacult Int. https://doi.org/10.1007/s10499-007-9105-2

Dinerstein E, Olson DM, Graham D, Webster AL, Primm SA, Bookbinder MP, Ledec G (1995) Una evaluación del estado de conservación de las ecorregiones terrestres de América Latina y El Caribe. Banco Mundial, WWF, Washington

Doering A (1874) Apuntamiento sobre la fauna de moluscos de la República Argentina (primera parte). Bol Acad Cienc Exactas Córdoba 1:48–77

dos Santos AA, Mondardo M, da Costa Marchiori N (2019) Presença de *Mytilus* cf. *edulis platensis* em fazendas marinhas de Bombinhas, Santa Catarina, Brasil. Agropecu Catarin 32(3):53–55. https://doi.org/10.22491/RAC.2019.v32n3.6

Dos Santos DA, Domínguez E, Miranda MJ, Gutiérrez Gregoric DE, Cuezzo MG (2021) The relevance of ecoregions and mountainous environments in the diversity and endemism of land gastropods. PPG Earth Environ 45(2):228–252. https://doi.org/10.1177/0309133320948839

dos Santos Silva D, Bastos Gonçalves B, de Freitas PVDX, de Melo e Silva Neto C (2021) Bromatological study of the freshwater bivalve *Anodontites trapesialis* (Lamarck, 1819) (Unionida, Mycetopodidae). Lat Am J Aquat Res 49:465–475. https://doi.org/10.3856/vol49-issue3-fulltext-2659

FAO (2015) La FAO y la agenda de desarrollo post-2015 informe temático. http://www.fao.org/fileadmin/user_upload/mdg/doc/12._agricultura_es-1.pdf. Accessed 29 Apr 2022

FAO (2018) Biodiversidad para una Agricultura Sostenible. http://www.fao.org/3/CA2227ES/ca2227es.pdf. Accessed 29 Apr 2022

Faulkner KT, Hulme PE, Pagad S, Wilson JRU, Robertson MP (2020) Classifying the introduction pathways of alien species: are we moving in the right direction? In: Wilson JR, Bacher S, Daehler CC, Groom QJ, Kumschick S, Lockwood JL, Robinson TB, Zengeya TA, Richardson DM (eds) Frameworks used in Invasion Science. NeoBiota, vol 62, pp 143–159. https://doi.org/10.3897/neobiota.62.53543

Fernandes MR, Salgueiro F, Miyahira IC, Caetano CHS (2018) mtDNA analysis of *Mytilopsis* (Bivalvia, Dreissenidae) invasion in Brazil reveals the existence of two species. Hydrobiologia 817:97–110. https://doi.org/10.1007/s10750-018-3602-3

Fernández D (1973) Catálogo de la malacofauna terrestre Argentina, Monografías, 4. Comisión de Investigaciones Científicas, La Plata

Fiori SM, Simonetti P, Dos Santos EP (2012) First record of Atlantic mud piddock, *Barnea* (*Anchomasa*) *truncata* (Bivalvia, Pholadidae) in Argentina. Aquat Invasions 7:283–286. https://doi.org/10.3391/ai.2012.7.2.015

Frana J, Massoni F (2011) Control de caracoles (*Bulimulus bonariensis bonariensis*) en soja. INTA – Estación Experimental Agropecuaria Rafaela. Informacion

Tecnica Cultivos de Verano. Campaña 2011. Publ Misc 121:124–128

Fuentealba C, Figueroa R, González F, Palma M (2010) Variabilidad genética local del bivalvo dulceacuícola *Diplodon chilensis* (Gray 1828) proveniente de tres lagos Nahuelbutanos. Gayana 74(2):113–124

GBIF.org (2022) GBIF occurrence download https://doi.org/10.15468/dl.shs6v5. Accessed 28 Apr 2022

Gomes LEO, Correa LB, Bernardino AF (2014) New record of the non-native bivalve *Myoforceps aristatus* in SE Brazil. Strombus 21:10–14

Gomes SR, Thomé JW (2004) Diversity and distribution of the Veronicellidae (Gastropoda: Soleolifera) in the Oriental and Australian biogeographical regions. Mem Queensl Mus 49:589–601

Gomes SR, Robinson DG, Zimmerman FJ, Obregón O, Barr NB (2013) Morphological and molecular analysis of the Andean slugs *Colosius confusus*, n. sp., a newly recognized pest of cultivated flowers and coffee from Colombia, Ecuador and Peru, and *Colosius pulcher* (Colosi, 1921) (Gastropoda, Veronicellidae). Malacologia 56:1–30. https://doi.org/10.4002/040.056.0201

Gracia A, Medellín J, Gil DL (2011) *Perna perna* (Linné, 1758). En: Gracia A, Medellín-Mora J, Gil-Agudelo DL, Puentes V (eds) Guía de las especies introducidas marinas y costeras de Colombia. INVEMAR. Ministerio de Ambiente y Desarrollo Sostenible.

Hayes KA, Joshi RC, Thiengo SC, Cowie RH (2008) Out of South America: multiple origins of non-native apple snails in Asia. Divers Distrib 14:701–712. https://doi.org/10.1111/j.1472-4642.2008.00483.x

Hayes KA, Cowie RH, Thiengo SC (2009) A global phylogeny of apple snails: Gondwanan origin, generic relationships, and the influence of outgroup choice (Caenogastropoda: Ampullariidae). Biol J Lin Soc 98:61–76. https://doi.org/10.1111/j.1095-8312.2009.01246.x

Hayward MW, Child MF, Kerley GIH, Lindsey PA, Somers MJ, Burns B (2015) Ambiguity in guideline definitions introduces assessor bias and influences consistency in IUCN Red List status assessments. Front Ecol Evol 3:87. https://doi.org/10.3389/fevo.2015.00087

Hicks G (2004) Turning the tide: is aquatic bioinvaders research heading in the right direction? Aquat Invasions 15:9–20

Hobbs RJ, Valentine LE, Standish RJ, Jackson ST (2018) Movers and stayers: novel assemblages in changing environments. Trends Ecol Evol 33:116–128. https://doi.org/10.1016/j.tree.2017.11.001

Holguín M (2003) Definiciones. Preced Anu Juríd. https://doi.org/10.18046/prec.v0.1397

Huber M (2010) Compendium of bivalves. A full-color guide to 3,300 of the world's marine bivalves. A status on bivalvia after 250 years of research. ConchBooks, Hackenheim

Hulme PE, Bacher S, Kenis M, Klotz S, Kühn I, Minchin D, Nentwig W, Olenin S, Panov V, Pergl J, Pyšek P, Roques A, Sol D, Solarz W, Vilà M (2008) Grasping at the routes of biological invasions: a framework for integrating pathways into policy. J Appl Ecol 45:403–414. https://doi.org/10.1111/j.1365-2664.2007.01442.x

IUCN (2009) Amenaza marina. Especies exóticas invasoras en el entorno marino. Programa Marino Mundial de la UICN; Total Corporate Foundation. 30p. Gland. https://www.iucn.org/sites/dev/files/import/downloads/amenaza_marina___marine_menace_sp_2.pdf. Accessed 29 Apr 2022

IUCN (2017) Guidance for interpretation of CBD categories on introduction pathways. Technical note prepared by IUCN for the European Commission. https://www.cbd.int/doc/c/9d85/3bc5/d640f059d03acd717602cd76/sbstta-22-inf-09-en.pdf. Accessed 23 Apr 2022

IUCN (2022) Glossary of definitions. https://www.iucn.org/sites/dev/files/iucn-glossary-of-definitions_en_2021.05.pdf. Accessed 23 Apr 2022

Jackson D, Jackson D (2009) Registro de *Pomacea canaliculata* (Lamark, 1822) (Ampullariidae), molusco exótico para el norte de Chile. Gayana 73(1):40–44

Jones G, Lawton JH, Shachak M (1994) Organisms as ecosystem engineers. Oikos 69:373–386

Joshi RC, Cowie RH, Sebastian LS (eds) (2017) Biology and management of invasive apple snails. Philippine Rice Research Institute (PhilRice), Maligaya, Science City of Muñoz, Nueva Ecija 3119

Kočovský PM, Sturtevant R, Schardt J (2018) What is to be established: policy and management implications for non-native and invasive species. Manag Biol Invasion 9:177–185. https://doi.org/10.3391/mbi.2018.9.3.01

Letelier S, Soto-Acuña S (2008) Registro de Pomacea sp. (Gastropoda: Ampullaridae) en Chile. Amici Molluscarum 16:6–13

Letelier S, Rebolledo A, Báez P, Fabres A, Soto-Acuña S, Jackson D, Mansilla P, Collado GA (2016) The highly invasive freshwater apple snail *Pomacea canaliculata* (Gastropoda: Ampullariidae) in Northern Chile: morphological and molecular confirmation. J Zool Stud 3(5):119–128

Letelier S, Ramos AM, Huaquín LG (2007) Moluscos dulceacuícolas exóticos en Chile. Rev Mex Biodivers 78:9–13

Lodeiros C, Hernández-Reyes D, Salazar JM, Rey-Méndez M, González-Henríquez N (2021) First report of the mussel *Mytella strigata* (Hanley, 1843) in the Venezuelan Caribbean from an invasion in a shrimp farm. Lat Am J Aquat Res 49:531–537. https://doi.org/10.3856/vol49-issue3-2626

Lopes EP (2011) *Leiosolenus aristatus* (Dillwyn, 1817), new to the Cape Verde Islands (Mollusca, Bivalvia, Mytilidae). Zool Caboverdiana 2(2):71–73

López MA, Altaba CR, Andree KB, López V (2010) First invasive apple snails in Europe. Tentacle 18:26–28

López Soriano J, Quiñonero Salgado S (2019) Primera cita de *Leiosolenus aristatus* (Dillwyn, 1817) (Bivalvia: Mytilidae) para las costas catalanas. Spira 7:93–95

Lowe S, Browne M, Boudjelas S, De Poorter M (2000) 100 of the world's worst invasive alien species a selection from the global invasive species database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN)

Maciel-Mata CA, Manríquez-Morán N, Octavio-Aguilar P, Sánchez-Rojas G (2015) El área de distribución de las

especies: revisión del concepto. Acta Univ 25(2):3–19. https://doi.org/10.15174/au.2015.690
Martín PR (2017) Caracoles sin Fronteras: Patrones y Procesos en Ambientes Dulceacuícolas de Argentina. Bol Asoc Argent Malacol 7(2):9–11
Martins RT, Alves RG (2008) Ocorrência de Naididae (Annelida: Oligochaeta) em três espécies de gastrópodes em campos irrigados no sudeste do Brasil. Biota Neotrop 8:255–257
McDowell WG, Benson AJ, Byers JE (2014) Climate controls the distribution of a widespread invasive species: implications for future range expansion. Freshw Biol 59:847–857. https://doi.org/10.1111/fwb.12308
Miquel S (1991) El género *Bulimulus* Leach, 1814, (Mollusca, Gastropoda, Stylommatophora) en la República Argentina. Stud Neotrop Fauna Environ 26:93–112. https://doi.org/10.1080/01650529109360839
Novak BJ, Phelan R, Weber M (2021) U.S. conservation translocations: over a century of intended consequences. Conserv Sci Pract 2021:e394. https://doi.org/10.1111/csp2.394
Ojasti J (2001) Estudio sobre el estado actual de las especies exóticas. Estudio Nacional. Secretaría General de la Comunidad Andina, Caracas, Venezuela
Oliva D, Durán LR (2012) Cultivo de almejas, una alternativa para la diversificación de la acuicultura de pequeña escala en Chile. AQUA 159:88–89
Oliveira MJS, Beasley CR, Barros NGV, Marquez NS, Simone LRL, Lima ES, Tagliaro CH (2017) Two African origins of naturalized brown mussel (*Perna perna*) in Brazil: past and present bioinvasions. Hydrobiologia 794:59–72. https://doi.org/10.1007/s10750-016-3082-2
Olson DM, Dinerstein D (2002) The Global 200: priority ecoregions for global conservation. Ann Mo Bot Gard 89:199–224. https://doi.org/10.2307/3298564
Olson DM, Dinerstein E, Wikramanayake ED, Burgess ND, Powell GVN, Underwood EC, D'amico JA, Itoua I, Strand HE, Morrison JC, Loucks CJ, Allnutt TF, Ricketts TH, Kura Y, Lamoreux JF, Wettengel WW, Hedao P, Kassem KR (2001) Terrestrial ecoregions of the world: a new map of life on earth. Bioscience 51:933–938. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2
Parada E, Peredo S (2005) Relocation as a tool for biodiversity conservation and management lessons from *Diplodon chilensis* (Gray, 1828) (Bivalvia, Hyriidae). Gayana 69(1):41–47
Parodiz JJ (1957) Catalogue of the land mollusca of Argentina. Nautilus 70:127–135
Pejchar L, Mooney HA (2009) Invasive species, ecosystem services and human well-being. Trends Ecol Evol 24:497–504. https://doi.org/10.1016/j.tree.2009.03.016
Penchaszadeh PE (1980) Ecología larvaria y reclutamiento del mejillón del Atlántico Suroccidental, *Mytllus platensis* d' Orbigny. Cah Biol Mar 21:168–179
Peredo S, Parada E, Valdebenito I, Peredo-Parada M (2005) Relocation of the freshwater mussel *Diplodon chilensis* (Hyriidae) as a strategy for its conservation and management. J Molluscan Stud 71(2):195–198. https://doi.org/10.1093/mollus/eyi024
Pilsbry HA (1916–1918) Manual of Conchology. Second series: Pulmonata, vol XXIV. Pupillidae (Gastrocoptinae). Academy of Natural Sciences Philadelphia xii + 380p., 49 pls
PNUD (2014) Moluscos exóticos presents en Chile: Documento del Taller Moluscos Exóticos en Chile: Efectos en la Biodiversidad. Santiago, Chile. http://smach.cl/wp-content/uploads/2018/05/libro_moluscos_paginas.pdf. Accessed 28 Apr 2022
Puyana M, Prato J, Díaz JM (2012) *Mytella charruana* (d'Orbigny) (Mollusca: Bivalvia: Mytilidae) en la Bahía de Cartagena, Colombia. Bol Invest Mar Cost 40:213–217
Queiroz RNM, da Silva PM, DeSouza AM, Silva LB, Dias TLP (2020) Effects of environmental factors on the distribution of the exotic species *Mytilopsis sallei* (Récluz, 1849) (Bivalvia: Dreissenidae) on the northeast coast of Brazil. J Sea Res 165:101954. https://doi.org/10.1016/j.seares.2020.101954
Ramírez R, Paredes C, Arenas J (2003) Moluscos del Perú. Rev Biol Trop 51(3):225–284
Restrepo-Santamaría D, Álvarez-León R (2013) Algunos aspectos sobre la introducción de especies, y estado del conocimiento sobre los peces introducidos en el Departamento de Caldas, Colombia. Rev Luna Azul 37:268–281
Röhrdanz Rosa AE (2017) Los caracoles manzana (Ampullariidae; Gastropoda; Mollusca) en Uruguay: revisión y actualización de su distribución. Tesina de Grado Licenciatura en Cs. Biológicas. Univ. de la República, Uruguay
Rumi A, Gutiérrez Gregoric DE, Núñez MV, Darrigran G (2008) Malacología latinoamericana. Moluscos de agua dulce de la República Argentina. Rev Biol Trop 56(1):77–111
Salvador RB (2019) Land snail diversity in Brazil. Strombus 25:10–20
Scarabino F (2003) Lista sistemática de los Gastropoda terrestres vivientes de Uruguay. Comun Soc Malacol Urug 8(79):203–214
Scarabino F, Zaffaroni JC, Clavijo C, Carranza A, Nin M (2006) Bivalvos marinos y estuarinos de la costa uruguaya: faunística, distribución, taxonomía y conservación. In: Menafra R, Rodríguez-Gallego L, Scarabino F, Conde D (eds) Bases para la conservación y el manejo de la costa uruguaya. Vida Silvestre Uruguay, Montevideo
Scarabino F, Serra WS, Laufer G, Clavijo C, Röhrdanz AE, Hayes K, Thiengo S, Cowie R, Carranza A, Meerhoff M, Burks R (2012) Llego y se puso a la venta: uso de *Pomacea diffusa* (Gastropoda: Ampullariidae) en el acuarismo uruguayo, p. 101, En: Libro de Resumenes del II Congreso de Zoología del Uruguay. 9 a 14 de diciembre de 2012. Universidad de la República Montevideo
Seuffert ME, Martín PR (2020) Exceeding its own limits: range expansion in Argentina of the globally invasive apple snail *Pomacea canaliculata*. Hydrobiologia 848:385–401. https://doi.org/10.1007/s10750-020-04447-z
Signorelli J, Pastorino G (2021a) *Semimytilus patagonicus* (d´Orbigny, 1842) (Bivalvia: Mytilidae) revealed as the valid name with priority over *Semimytilus algosus*

(Gould, 1850). Arch Molluskenkd 150:55–63. https://doi.org/10.1127/arch.moll/150/055-063
Signorelli J, Pastorino G (2021b) Correction of the authorship and date of *Semimytilus patagonicus* (Hanley, 1843). Arch Molluskenkd 150:173. https://doi.org/10.1127/arch.moll/150/173
Silva-Souza AT, Guardia-Felipi P (2014) Incubation cycle of eggs and larva of *Anodontites trapesialis* (Lamarck, 1819) (Bivalvia, Mycetopodidae) in fish farming. Panam J Aquat Sci 9(4):312–319
Silveira NG, Souza RCCL, Fernandes FC, Silva EP (2006) Occurrence of *Perna perna*, *Modiolus carvalhoi* (Mollusca, Bivalvia, Mytilidae) and *Megabalanus coccopoma* (Crustacea, Cirripedia) off Areia Branca, Rio Grande do Norte State, Brazil. Biociências 14(1):89–90
Simberloff D, Martin J-L, Genovesi P, Maris V, Wardle DA, Aronson J, Courchamp F, Galil B, García-Berthou E, Pascal M, Pysek P, Sousa R, Tabacchi E, Vila M (2012) Impacts of biological invasions: what's what and the way forward. Trends Ecol Evol 28:58–66. https://doi.org/10.1016/j.tree.2012.07.013
Simone LRL (1999) Mollusca terrestres. In: Brandão CR, Cancello EM (eds) Biodiversidade do estado de São Paulo, Brasil: síntese do conhecimento ao final do século XX. Invertebrados terrestres, vol 5. FAPESP, São Paulo, pp 3–8
Simone LRL (2006) Land and freshwater molluscs of Brazil. EGB, São Paulo, p 390
Simone LRL, Gonçalves EP (2006) Anatomical study on Myoforceps aristatus, an invasive boring bivalve in S.E. Brazilian coast (Mytilidae). Pap Avulsos Zool 46:57–65
Sindermann CJ (1993) Disease risks associated with importation of nonindigenous marine animals. Mar Fish Rev 54(3):1–10
Soto R (1985) Efectos del fenómeno El Niño 1982–83 en ecosistemas de la I Región. Investig Pesq (Chile) 32:199–206
Souza E, De Barros JCN, Paresque K, De Freitas RR (2013) The effect of stocking density on the growth of apple snails native *Pomacea bridgesii* and exotic *Pomacea lineata* (Mollusca, Gastropoda). An Acad Bras Cienc 85(2):753-760. https://doi.org/10.1590/S0001-37652013000200019
Spalding MD, Fox HE, Allen GR, Davidson N, Ferdaña ZA, Finlayson M, Halpern BS, Jorge MA, Lombana AL, Lourie SA, Martin KD, McManus E, Molnar J, Recchia CA, Robertson J (2007) Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. Bioscience 57:573–583. https://doi.org/10.1641/B570707
Strayer DL (2022) Comment: Novak et al. (2021) overestimated the successes of species translocations and minimized their risks. Conserv Sci Pract. https://doi.org/10.1111/csp2.12694
Teixeira LMP, Creed JC (2020) A decade on: an updated assessment of the status of marine non-indigenous species in Brazil. Aquat Invasions 15:30–43. https://doi.org/10.3391/ai.2020.15.1.03
Thiengo SC, Hayes KA, Mattos AC, Fernandez MLA, Cowie RH (2011) A família Ampullariidae no Brasil: aspectos morfológicos, biológicos e taxonômicos. In: Fernandez MLA, Santos SB, Pimenta AD, Thiengo SC (eds) Tópicos em Malacologia. XIX Encontro Brasileiro em Malacologia. Editora Technical Books, Rio de Janeiro, pp 95–111
Thomé JW (1993) Estado atual da sistemática dos Veronicellidae (Mollusca; Gastropoda) americanos com comentários sobre sua importância econômica, ambiental e na saúde. Biociênc Porto Alegre 1:61–75
Tomicic JJ (1985) Efectos del fenómeno El Niño 1982–83 en las comunidades litorales de la península de Mejillones. Investig Pesq (Chile) 32:209–213
Turbelin AJ, Malamud BD, Francis RA (2017) Mapping the global state of invasive alien species: patterns of invasion and policy responses. Glob Ecol Biogeogr 26:78–92. https://doi.org/10.1111/geb.12517
Uribe RA, Nakamura K, Indacochea A, Pacheco AS, Hooker Y, Schröd M (2013) A review on the diversity and distribution of opisthobranch gastropods from Peru, with the addition of three new records (Gastropoda, Heterobranchia). Spixiana 36(1):43–60
Valdez IC, Cruz López ME (2014) Biología reproductiva de *Pomacea bridgesii* (Revee, 1867) (Gastropoda, Ampullariidae). I. Histología del segmento extraductal. Acta Zool Lilloana 58:57–64
Valdovinos C, Pedreros P (2007) Geographic variations in shell growth rates of the mussel *Diplodon chilensis* from temperate lakes of Chile: implications for biodiversity conservation. Limnologica 37(1):63–75. https://doi.org/10.1016/j.limno.2006.08.007
von Brand E, Abarca A, Merino GE, Stotz W (2016) Scallop fishery and aquaculture in chile: a history of developments and declines. In: Shumway SE, Parsons GJ (eds) Scallop, biology, ecology, aquaculture and fisheires. Elsevier, Oxford, pp 1047–1072
Wong YT, Meier R, Tan KS (2011) High haplotype variability in established Asian populations of the invasive Caribbean bivalve *Mytilopsis sallei* (Dreissenidae). Biol Invasions 13:341–348. https://doi.org/10.1007/s10530-010-9825-5
Zaffaroni JC (2000) ("1998") Presencia de *Modiolus carvalhoi* (Mollusca, Pelecypoda) en aguas uruguayas. Com Soc Malacol Urug 8(74–75):101–103
Zbawicka M, Trucco MI, Wenne R (2018) Single nucleotide polymorphisms in native South American Atlantic coast populations of smooth shelled mussels: hybridization with invasive European *Mytilus galloprovincialis*. Genet Sel Evol 50:5. https://doi.org/10.1186/s12711-018-0376-z