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)

Juan Francisco Araya a,b

a Laboratorio de Invertebrados Acuáticos, Departamento de Ecología, Facultad de Ciencias, Universidad de Chile, Ñuñoa, Chile; b Laboratorio de Química Inorgánica, Departamento de Química, Facultad de Ciencias, Universidad de Chile, Ñuñoa, Chile

(Received 21 July 2014; accepted 8 January 2015; first published online 5 March 2015)

A new introduced species, *Otala punctata* (Müller, 1774) and new records in Chile for *Cornu aspersum* (Müller, 1774) and *Deroceras laeve* (Müller, 1774) are documented based on surveys carried out in northern and central areas of the country. The presence and distribution of these alien species are complemented with a comprehensive compilation of all 34 non-indigenous species of marine, freshwater and terrestrial Mollusca in Chile; until 1999, only 16 alien species were known in Chile. Most of these alien species are found exclusively in transformed habitats, few exist in natural environments. The mechanism of introduction for the majority of these non-indigenous species is unknown; however, horticultural development, urban and suburban transformation of original natural habitats, and the aquarium trade are the most likely pathways of introduction. The highest threat of alien species is direct competition and predation of native molluscs, especially the small native land gastropods. Education and continuous field surveys are vital to detect and prevent their propagation as well as to avoid introduction of additional alien taxa.

**Keywords:** alien species; Chile; land molluscs; *Otala lactea; Cornu aspersum*; Mollusca

**Introduction**

The introduction of non-indigenous species (NIS) of molluscs to Chile almost certainly began with the arrival of the Spanish colonists in the late fifteenth century. However, the oldest confirmed record of introduced molluscs in the country was made by Philippi (1885), who listed three introduced land snail species; *Helix aspersa* (= *Cornu aspersum*), *Helix costata* and *Helix pulchella*, the latter two with no subsequent records in the literature. The last comprehensive review on the distribution of Chilean molluscan species (Valdovinos 1999), listed 13 non-indigenous taxa, with nine terrestrial and four marine species, representing approximately 3% of all the molluscs recorded in the country. Further studies have added 20 new entries to this NIS list, most of them terrestrial gastropods (Kirch
et al. 2009; Cádiz et al. 2013), with a few marine and freshwater species most probably associated with El Niño Southern Oscillation (ENSO) events and with the aquarium trade, respectively (Letelier et al. 2007). Regarding the direct impact of those NIS; it has been established that some alien molluscs, for example species of the genus *Oxychilus* Fitzinger, 1833, can compete with or feed on local native species, especially microgastropods. Alien species can also be invasive or agricultural pests (species of the genera *Deroceras* Rafinesque, 1820; *Otala* Schumacher, 1817 and *Limax* Linnaeus, 1758), and some introduced freshwater mollusc species (species of the genera *Pomacea* Perry, 1811 and *Melanoides* Olivier, 1804) can act as hosts for the parasitic nematode *Angiostrongylus cantonensis* (Chen, 1933) or the parasitic human lung fluke *Paragonimus westermani* Kerbert, 1878. Some introduced molluscan species have indirect impacts on the ecosystem, due to the exploitation of native algae for their aquaculture (species of the genus *Haliotis* Linnaeus, 1758).

Besides documenting for the first time the presence of *Otala punctata* (Müller, 1774) in Chile, and extending the records of *Cornu aspersum* (Müller, 1774) and *Deroceras laeve* (Müller, 1774) for the country, this paper synthesizes all the available records of alien Mollusca recorded so far in the country. This list includes marine, terrestrial and freshwater species that have been introduced into natural environments, species introduced for aquaculture, species whose reports are associated with ENSO events, and species whose introduction was accidental or for which the pathway is unknown. Because little has been published on this group in Chile, information regarding the presence, distribution and possible impacts of these species is crucial for future biodiversity studies.

**Methods**

A survey of 12 localities in the regions of Iquique, Antofagasta and Atacama, northern Chile, and in the region Metropolitana, central Chile, was made in the southern summer and winter of 2012 and 2013 (Table 1). This information was complemented by an extensive bibliographic compilation on the occurrence of NIS in Chile, compiled from Boyko and Cordeiro (2001), Castilla et al. (2005), Letelier et al. (2007), Ashton et al. (2008), Kirch et al. (2009), Rumi et al. (2010), Landler and Nuñez (2012), Cádiz et al. (2013) and references therein. All the material collected in the field surveys was deposited in the collections of the Museo de Zoología de la Universidad de Concepción (MZUC) and of the Museo Paleontológico de Caldera (MPC).

The systematic affinity, geographical range, ecosystems affected, possible impacts, mode of entry and year of first record are indicated for each species included in this review. The taxonomic status of the 33 species follows the latest published systematic work on each corresponding group; however, no formal taxonomic changes are proposed here. The terminology on bioinvasion follows the definitions proposed by Occhipinti-Ambrogi and Galil (2004), Appendix C. Abbreviations by scale and impact include: EA, Established Alien; IA, Invasive Alien; NA, Noxious Alien; UA, Unestablished Alien. Abbreviations by mode of entry include: I, Introduced Alien; II, Intentional Introduction; SI, Secondary Introduction; SA, Spreading Alien; UI, Unintentional Introduction.
Table 1. New records of Otala punctata, Cornu aspersum and Deroceras laeve in Chile.

| Pulmonata |
|-----------|
| Limacoidea |
| Agriolimacidae |
| Deroceras laeve (Müller, 1774). 2 sppm collected in house gardens, under stones and plant pots, Caldera (27°41’3” S, 70°49’45” W), MZUC 39624 (1 spm); 3 sppm collected in house gardens, Tierra Amarilla (27°29’58” S, 70°16’0” W), MZUC 39625 (1 spm). |
| Helicoidea |
| Helicidae |
| Cantareus aspersus (Müller, 1774). 18° S to 43° S, EA, I. 4 sppm collected at house gardens, Iquique (20°16’26” S, 70°7’50” W), MPC 39626 (1 spm); 6 sppm collected at a public park and in house gardens, Antofagasta (23°40’16” S, 70°24’22” W), MPC 39627 (1 spm); 5 sppm collected under shrubs in a public park, Caldera Caldera (2, MZUC 39628 (1 spm), 7°4’13” S, 70°49’45” W), 1 spm collected in a public park, Copiapó (27°23’57” S, 70°18’23” W), MPC 39629 (1 spm); 3 sppm collected in house gardens, Tierra Amarilla (27°29’58” S, 70°16’0” W), MPX 39630 (1 spm), 2 sppm collected in public park, Vallenar (28°34’27” S, 70°46’11” W), MPC 39631 (1 spm). |
| Otala punctata (Müller, 1774), 33° S, UA, I. 2 sppm collected attached to fence-posts in a vineyard, Buin, Santiago (33°44’17” S, 70°45’06” W). MZUC 39632 (1 spm). |

Abbreviations: MPC, Museo Paleontológico de Caldera; MZUC, Museo de Zoología de la Universidad de Concepción; spm, specimen; sppm, specimens. Abbreviations by scale and impact: EA, Established Alien; UA, Unestablished Alien; by mode of entry: I, Introduced Alien.

Results

Systematic list

Class BIVALVIA Linnaeus, 1758
Order MYTILOIDA Férussac, 1822
Family MYTILIDAE Rafinesque, 1815
Genus Mytilus Linnaeus, 1758
Mytilus galloprovincialis Lamarck, 1819

Description

Poppe and Goto (2000).

Distribution

Native to the Mediterranean Sea, this mussel now shows a worldwide distribution (Westfall and Gardner 2010). In Chile, it was recorded for the first time in 2000 (Daguin and Borsa 2000), and it has been recorded from Dichato (36°33’ S, 72°56’ W) to Punta Arenas (53°10’ S, 70°56’ W) (Tarifeño et al. 2012).

Possible mechanism of introduction/Status

Maritime transport or unintentional introduction/established (Daguin and Borsa 2000; Tarifeño et al. 2012).
Remarks
Invasive species, may displace native mytid species (Branch and Steffani 2004). EA, SA.

Order **OSTREOIDA** Férussac, 1822
Family **OSTREIDAE** Rafinesque, 1815
Genus **Crassostrea** Sacco, 1897
**Crassostrea gigas** (Thunberg, 1793)

Description
Osorio (2002), Coan and Valentich-Scott (2012).

Distribution
Native to Japan and Korea and the North Atlantic Ocean (Coan and Valentich-Scott 2012). This species is usually introduced through aquaculture (Diederich et al. 2005). In Chile this species was introduced in 1978 and has been recorded from latitude 15° S to 40° S (Valdovinos 1999).

Possible mechanism of introduction/Status
Intentional transplantation/unestablished (Valdovinos 1999).

Remarks
Filter feeder, invasive species, species of commercial importance (Diederich et al. 2005). UA, II.

Order **PECTINOIDA** Gray, 1854
Family **PECTINIDAE** Rafinesque, 1815
Genus **Pecten** O. F. Müller, 1776
**Pecten maximus** (Linnaeus, 1758)

Description
Poppe and Goto (2000).

Distribution
Native to Europe, Eastern Atlantic Ocean (Poppe and Goto 2000). The only record for Chile does not give a precise distribution (Valdovinos 1999), although attempts at its aquaculture in Chile were made in La Herradura Bay, Coquimbo (30° S).

Possible mechanism of introduction/Status
Intentional transplantation/unestablished (Valdovinos 1999).
Remarks
Filter feeder, species of commercial importance (Poppe and Goto 2000). UA, II.

Class **GASTROPODA** Cuvier, 1795
Order **CAENOGASTROPODA** Cox, 1960
Family **AMPULLARIIDAE** Gray, 1854
Genus *Pomacea* Perry, 1810
*Pomacea bridgesii* (Reeve, 1856)

Description
Reeve (1856), Coelho et al. (2012).

Distribution
Native to America, Amazon Basin (Brazil, Peru, Bolivia) (Cowie and Thiengo 2003). In Chile, this species was found for the first time in the country in 2000 (Letelier et al. 2007) and has been recorded only in Santiago (33°27’ S, 70°38’ W).

Possible mechanism of introduction/Status
Aquarium trade/established (Letelier et al. 2007).

Remarks
Polyphagous, invasive, they can compete with native freshwater species (Aditya and Raut 2001). EA, I.

*Pomacea canaliculata* (Lamarck, 1822)

Description
Estebenet and Martin (2003), Rawlings et al. (2007), Jackson and Jackson (2009).

Distribution
Native to America, Uruguay and Argentina (Jackson and Jackson 2009), invasive in the USA (Rawlings et al. 2007) and in South-East Asia (Cowie 2000). In Chile this species has been found only in the Estero Conchalí, Los Vilos (31°55’ S, 71°31’ W), Región de Coquimbo, central Chile (Jackson and Jackson 2009).

Possible mechanism of introduction/Status
Aquarium trade/established (Jackson and Jackson 2009).
Remarks
Omnivorous, invasive, may predate native species (Cazzaniga 1990; Kwong et al. 2009). This species can also act as an intermediate host of the parasitic nematode *Angiostrongylus cantonensis* (Yang et al. 2013). EA, I.

Family **THIARIDAE** Gill, 1871
Genus *Melanoides* Olivier, 1804
*Melanoides maculata* Bruguière, 1789

**Description**
Moneva et al. (2012).

**Distribution**
Native to Asia, Philippines. In Chile this species has been found only in the Lluta river (18°24' S, 70°19' W), Región de Arica y Parinacota (Letelier et al. 2007).

**Possible mechanism of introduction/Status**
Aquarium trade/established (Letelier et al. 2007).

Remarks
Detritivore, invasive (parthenogenetic species). This is a common aquarium snail. EA, I.

*Melanoides tuberculata* (Müller, 1774)

**Description**
Olivares and Gálvez (2008).

**Distribution**
Native to southern Asia (China, Taiwan and Philippines) (Letelier et al. 2007). In Chile this species has been found only in Pica (20°29' S, 69°19' W), Región de Arica y Parinacota (Olivares and Gálvez 2008).

**Possible mechanism of introduction/Status**
Aquarium trade/established.

Remarks
Herbivore, detritivore, invasive (parthenogenetic species). This is a common aquarium snail and it has been cited as an intermediate host of the human liver fluke (Dundee and Paine 1977). EA, NA, I.
Order: **LITTORINIMORPHA** Golikov and Starobogatov, 1975
Family **RANELLIDAE** Gray, 1854
Genus **Monoplex** Perry, 1810
**Monoplex keenae** (Beu, 1970)

Description
Keen (1971), Beu (2010).

Distribution
Native to America, from La Paz, Gulf of California (Mexico) to Galápagos Islands (Ecuador) (Beu 2010). In Chile this species has been found only in La Rinconada, Antofagasta Bay (23°28’ S, 70°30’ W), recorded for the first time in the country in 2007 (Ashton et al. 2008).

Possible mechanism of introduction/Status
Associated to ENSO events/established (Ashton et al. 2008).

Remarks
Carnivorous species (Beu 2010). This species is consumed by locals in northern Chile, where it is named *caracol perro* (= dog snail) (Ashton et al. 2008). EA, SA.

**Monoplex wiegmanni** (Anton, 1838)

Description
Keen (1971), Beu (2010).

Distribution
Native to America, Baja California to Southern Peru (Beu 2010). In Chile this species has been recorded only in Antofagasta Bay (23°28’ S, 70°30’ W), Región de Antofagasta (Castilla et al. 2005).

Possible mechanism of introduction/Status
Associated with ENSO events/unestablished (Castilla et al. 2005).

Remarks
Carnivore (Beu 2010). UA, SA.
Family **TATEIDAE** Thiele, 1925  
Genus **Potamopyrgus** Stimpson, 1865  
*Potamopyrgus antipodarum* (Gray, 1843)

**Description**
Collado (2014).

**Distribution**
Native to New Zealand and its adjacent islands and invasive in North America and Europe (Winterbourn 1970; Kerans et al. 2005). In Chile this species has been recorded in the city of Santiago in the Parque O’Higgins (33°28’ S, 70°39’ W), and Estero La Dehesa (33°22’ S, 70°15’ W), and in the city of Salamanca, central Chile, in the Chalinga River (31°46’ S, 70°59’ W) and in the Estero Consuelo (31°46’ S, 70°37’ W) (Collado 2014).

**Possible mechanism of introduction/Status**
Unknown/established (Collado 2014).

**Remarks**
Generalist species, feeding on aquatic plants, green algae and detritus (Haynes and Taylor 1984). Invasive, ovoviviparous species. EA, I.

**Order** **ANASPIDEA** Fischer, 1883  
**Family** **APLYSIIDAE** Lamarck, 1809  
**Genus** **Aplysia** Linnaeus, 1767  
*Aplysia juliana* Quoy and Gaimard, 1832

**Description**
Marcus (1955).

**Distribution**
Circumtropical; eastern and western Atlantic (Marcus 1955) as well as the Indian and Pacific Oceans (Kay 1964), in shallow marine habitats. In Chile this species has been recorded in Iquique (20°11’ S, 70°08’ W), Antofagasta (23°38’ S, 70°24’ W) and Taltal (25°24’ S, 70°29’ W) (Castilla et al. 2005). This species was found for the first time in Antofagasta in 1982 (Tomicic 1985), associated with ENSO events.

**Possible mechanism of introduction/Status**
Associated with ENSO events/unestablished (Castilla et al. 2005).
Remarks
This is a large herbivorous marine slug, feeding almost exclusively on the alga *Ulva lactuca* (Frings and Frings 1965). UA, SA.

Order **STYLOMMATOPHORA** Schmidt, 1855  
Family **ACHATINELLIDAE** Gulick, 1873  
Genus *Pacificella* Odhner in Skottsberg, 1922  
*Pacificella variabilis* (Odhner, 1922)

Description
Odhner (1922), Cooke and Kondo (1960).

Distribution
Native to Henderson Island (Preece 1995), widespread in the South Pacific Islands from Western Polynesia (Samoa, Tonga) throughout southeastern Polynesia to Easter Island (Kirch et al. 2009). In Chile this species has been recorded only in Easter Island (39°48’ S, 73°14’ W) (Stuardo and Vega 1985; Stuardo and Vargas-Almonacid 2000), and it was found for the first time in Chile by Odhner (1922).

Possible mechanism of introduction/Status  
Human transportation/established (Stuardo and Vargas-Almonacid 2000).

Remarks
Although this species was described as native to Easter Island (Odhner 1922), it is probably native to Henderson Island, where some fossil shells are present in sedimentary deposits pre-dating human settlement (Preece 1995). EA, UI.

Family **SUBULINIDAE** Fischer and Crosse, 1877  
Genus *Allopeas* Baker, 1935  
*Allopeas clavulinum* (Potiez and Michaud, 1838)

Description
Pilsbry (1906).

Distribution
Native to East Africa (Hayes et al. 2012). In Chile this species has been reported only from Easter Island (39°48’ S, 73°14’ W), with the first record in 1965 (Kirch et al. 2009).

Possible mechanism of introduction/Status  
Human transportation/unestablished (Kirch et al. 2009).
Remarks
Detritivore, herbivore (Brodie and Barker 2011). UA, I.

Allopeas gracile (Hutton, 1834)

Description
Pilsbry (1906).

Distribution
Native range uncertain; this species is currently widespread in the tropics (Rowson et al. 2010). In Chile this species has been reported only from Easter Island (39°48’ S, 73°14’ W) (Boyko and Cordeiro 2001).

Possible mechanism of introduction/Status
Human transportation/probably established (Boyko and Cordeiro 2001).

Remarks
Detritivore, herbivore (Brodie and Barker 2011). EA, I.

Genus Rumina Risso, 1826

Rumina decollata (Linnaeus, 1758)

Description
Paul (1982), De Francesco and Lagiglia (2007).

Distribution
Europe, Mediterranean basin/Cosmopolitan (Cowie 2001), invasive in Far East and South America (Miquel et al. 1995). The first and only record for Chile does not give precise data (Rumi et al. 2010).

Possible mechanism of introduction/Status
Human transportation/unestablished

Remarks
Omnivorous and invasive species, minor plant pest, it may prey on other gastropods (Barker 2004). UA, I.
**Family AGRIOLIMACIDAE** Wagner, 1935  
**Genus Deroceras** Rafinesque, 1820  
**Deroceras invadens** Reise, Hutchinson, Schunack and Schlitt, 2011

**Description**  
Barker (1999), Reise et al. (2011).

**Distribution**  
Palaeartic/Cosmpolitan (Reise et al. 2011). According to Hutchinson et al. (2014) this species has records in Chile since 1962 (as *Deroceras panormitanum* Lessona and Pollonera, 1882), and it has been recorded in Limache (33°00′ S, 71°23′ W), Santiago (33°24′ S, 70°36′ W), Talagante (33°42′ S, 70°52′ W) and in the Juan Fernández Archipelago.

**Possible mechanism of introduction/Status**  
Human transportation/established.

**Remarks**  
Invasive species (Hutchinson et al. 2014). EA, IA, I.

**Deroceras laeve** (Müller, 1774)

**Description**  
Thomas et al. (2010).

**Distribution**  
Native to North America and introduced in Europe, New Zealand and South America (Faberi et al. 2006). In Chile this species has been recorded from Caldera (27° S), northern Chile (new records in this work, Table 1), to latitude 46° S, in the Región de Aysén del General Carlos Ibáñez del Campo (Letelier and Ramos 2002). The first record of this species in Chile was by Stuardo and Vega (1985).

**Possible mechanism of introduction/Status**  
Human transportation/established (Landler and Nuñez 2012)

**Remarks**  
This species has been cited as a pest of crops, feeding on seeds and seedlings (Faberi et al. 2006). EA, I.
Deroceras reticulatum (Müller, 1774)

Description
Martin et al. (2009), Thomas et al. (2010).

Distribution
Native to Europe and currently found in most of North America and many temperate and subtropical countries (Boyko and Cordeiro 2001). In Chile this species has been found from Valparaiso to Tierra del Fuego (Valdovinos 1999) and in the Juan Fernández Archipelago and Easter Island (Boyko and Cordeiro 2001). The first record of this species in Chile was by Stuardo and Vega (1985).

Possible mechanism of introduction/Status
Human transportation/established (Letelier and Ramos 2002)

Remarks
Herbivore, agricultural pest (Hausdorf 2002). This species has also been identified as an intermediate host of nematode parasites Angiostrongylus costaricensis Morera and Cespedes, 1971 and Angiostrongylus cantonensis (Chen, 1933) (Maurer et al. 2002). EA, NA, I.

Lehmannia Heynemann, 1862
Lehmannia valentiana (Férussac, 1823)

Description
Barker (1999), Thomas et al. (2010).

Distribution
Native to the Iberian Peninsula, Europe, now Cosmopolitan (Thomas et al. 2010). In Chile this species has been found from Valparaiso to Chiloé and in the Juan Fernández Archipelago and Easter Island (Stuardo and Vega 1985; Boyko and Cordeiro 2001). It was recorded for the first time in the country as Limax arborum Bouchard-Chantereaux, 1837 (Odhner 1922).

Possible mechanism of introduction/Status
Human transportation/probably established (Valdovinos 1999).

Remarks
Herbivore, detritivore, greenhouse pest (Thomas et al. 2010). EA, I.
Genus *Limacus* Lehmann, 1864

*Limacus flavus* Linnaeus, 1758

**Description**

Thomas et al. (2010).

**Distribution**

Native to Europe; introduced to Australia, New Zealand, and North and South America (Thomas et al. 2010). In Chile this species has been cited from Valdivia (39°48’ S, 73°14’ W) to northern Chile (Landler and Nuñez 2012). The first record of this species for Chile was by Stuardo and Vega (1985).

**Possible mechanism of introduction/Status**

Human transportation/established (Valdovinos 1999).

**Remarks**

Highly invasive species, pest of stored agricultural products (Thomas et al. 2010). EA, NA, I.

Genus *Limax* Linnaeus, 1758

*Limax maximus* Linnaeus, 1758

**Description**

Thomas et al. (2010).

**Distribution**

Western Palaearctic, introduced into North and South America, South Africa, Pacific Islands, Australia and New Zealand (Gaitán-Espitia et al. 2012). In Chile this species has been cited from 30° to 46° (Valdovinos 1999; Letelier and Ramos 2002).

**Possible mechanism of introduction/Status**

Human transportation/established (Landler and Nuñez 2012).

**Remarks**

Synanthropic species, potential carrier of human pathogens (Landler and Nuñez 2012). Nocturnal species, aggressive towards other slugs (Gaitán-Espitia et al. 2012). EA, I.
Family **ARIONIDAE** Gray *in* Turton, 1840

Genus **Arion** Férussac, 1819

*Arion intermedius* (Normand, 1852)

**Description**

Cádiz and Gallardo (2007).

**Distribution**

Native to the Holarctic, in Chile this species has been found from Valdivia (39°48’ S, 73°14’ W) to Lago Tarahuin (42°43’ S, 73°47’ W), with the first record in 2007 (Cádiz and Gallardo 2007; Landler and Nuñez 2012).

**Possible mechanism of introduction/Status**

Human transportation/established (Landler and Nuñez 2012).

**Remarks**

Herbivorous terrestrial gastropod (Bohan et al. 2000). According to Hausdorf (2002), there are no obvious effects on native land snail fauna after the introduction of this species. EA, I.

Family **HELICIDAE** Rafinesque, 1815

Genus **Cornu** Born, 1778

*Cornu aspersum* (Müller, 1774)

**Description**

Paul (1982), Barker (1999).

**Distribution**

Native to Western Europe and Mediterranean region, now cosmopolitan (Cowie 2000). This is the NIS with the oldest occurrence records in Chile (Philippi 1885) and the introduced species with the largest distribution in the country, found in this work (*Tables 1, 2*) from Iquique (20° S) to Chiloé Island (43° S).

**Possible mechanism of introduction/Status**

Human transportation/established (Araya and Catalán 2014).

**Remarks**

Herbivore, agricultural pest, invasive (Barker 1999). This species has a complicated, unresolved, taxonomy (Bank 2012). EA, I.
Table 2. Systematic-taxonomic classification, distribution, Scale/Impact and Mode of Entry of non-indigenous species of Mollusca in Chile.

| Class          | Order          | Family          | Species                              | Distribution       |
|----------------|----------------|-----------------|--------------------------------------|--------------------|
| **Bivalvia**   |                |                 |                                      |                    |
| Pteriomorpha   | Mytiloida      | Mytilida        | *Mytilus galloprovincialis* Lamarck, 1819. 36° S to 53° S, EA, SA. |
|                |                |                 |                                      |                    |
|                | Ostreoida      | Crassostrea gigas (Thunberg, 1793). 15° S to 40° S, UA, II. |
|                | Pectinoidea    | Pectinidae      | *Pecten maximus* (Linnaeus, 1758). Imprecise distribution, UA, II. |
| **Gastropoda** |                |                 |                                      |                    |
| Caenogastropoda| Ampullarioida  | Ampullariidae   | *Pomacea bridgesii* (Reeve, 1856). 33° S, EA, I. |
|                |                |                 | *Pomacea canaliculata* (Lamarck, 1822). 31° S, EA, I. |
| Cerithioidea   | Thiaridae      |                 | *Melanoïdes maculata* Bruguière, 1789. 18° S, EA, I. |
|                |                |                 | *Melanoïdes tuberculata* (O. F. Müller, 1774). 20° S, EA, NA, I |
| Tonnoidea      | Ranellidae     |                 | *Monoplex keenae* Beu, 1970. 23° S, EA, SA. |
|                | Tateidae       |                 | *Potamopyrgus antipodarum* (Gray, 1843). 31° S and 32° S, EA, I. |
| Truncatelloidea|               |                 |                                      |                    |
| Heterobranchia | Aplysioidea    | Aplysiidae      | *Aplysia* (*Aplysia*) juliana (Quoy & Gaimard, 1832). 23° S to 25° S, UA, SA. |
| Pulmonata      | Achatinelloidea| Achatinellidae  | *Pacificella variabilis* (Odhner, 1922). 39° S, EA, UI. |
|                | Achatinelloidea|                 |                                      |                    |
|                | Subulimidae    | *Allopeas clavulinum* (Potiez & Michaud, 1838). 39° S, UA, I. |
|                |                | *Allopeas gracile* (Hutton, 1834). 39° S, EA, I. |
|                | Helicidae      | *Cornu aspersum* (Müller, 1774). 18° S to 43° S, EA, I. |
|                |                | *Otala lactea* (Müller, 1774). Imprecise distribution, UA, I. |
|                |                | *Otala punctata* (Müller, 1774). 33° S, UA, I. |

(Continued)
Genus *Otala* Schumacher, 1817

*Otala lactea* (Müller, 1774)

**Description**
Abbott (1989).

**Distribution**
Native to countries bordering the western Mediterranean Sea (Iberian Peninsula and northwest Africa) (Herbert and Sirgel 2001). The first and only record for Chile did not give precise data (Rumi et al. 2010).

Abbreviations: EA, Established Alien; IA, Invasive Alien; I, Introduced Alien; II, Intentional Introduction; NA, Noxious Alien; SA, Spreading Alien; UA, Unestablished Alien; UI, Unintentional Introduction.
Possible mechanism of introduction/Status
Human transportation/unestablished.

Remarks
Generalist herbivore, possibly invasive, garden and horticultural pest (La Pierre et al. 2010). UA, I.

Otala punctata (Müller, 1774)

Description
De Mattia and Mascia (2011).

Distribution
Western Mediterranean: northwest Algeria, eastern Spain and the Balearic Islands (De Mattia and Mascia 2011). This is the first record for this species in the country: Buin, Santiago (33°43'59" S; 70°45'00" W) (Tables 1, 2).

Possible mechanism of introduction/Status
Human transportation/unestablished.

Remarks
Herbivore, invasive. This species is widely raised in heliciculture (De Mattia and Mascia 2011). UA, I.

Family MILACIDAE Ellis, 1926
Genus Milax Gray, 1855
Milax gagates (Draparnaud, 1801)

Description
Barker (1999), Thomas et al. (2010).

Distribution
Native to Europe, Mediterranean basin. Introduced in North America, Australia, New Zealand, Japan, South America, and numerous Atlantic and Pacific Islands (Thomas et al. 2010). In Chile this species has been cited from latitude 30° S to 45° S and in the Juan Fernández Archipelago and Easter Island (Valdovinos 1999). The first record of this species for Chile was by Stuardo and Vega (1985).

Possible mechanism of introduction/Status
Human transportation/established (Valdovinos 1999).
Remarks
Herbivore, invasive and common in areas associated with humans; it is predominantly a subterranean species and a pest of root crops (Barker 1999). EA, I.

Family **OXYCHILIDAE** Hesse, 1926 (1879)
Genus *Oxychilus* Fitzinger, 1833
*Oxychilus alliarius* (Miller, 1822)

Description
Cádiz et al. (2013).

Distribution
Native to Western Europe/Cosmopolitan (Horácková and Juricková 2009). In Chile this species has been recorded in Las Rojas, Coquimbo region (29°54' S, 71°10' W), in the Arboretum Park, Isla Teja, Valdivia (39°50' S, 73°14' W) and in the Juan Fernández Archipelago (Cádiz et al. 2013). The first record of this species for Chile was by Odhner (1922).

Possible mechanism of introduction/Status
Human transportation/established (Cádiz et al. 2013).

Remarks
Carnivore, facultative predator of other small snails (Meyer and Cowie 2010). This species is known as the “garlic snail” because of its ability to emit a strong smell of garlic when irritated (Hayes et al. 2012). EA, I.

*Oxychilus cellarius* Müller (1774)

Description
Rigby (1963), Barker (1999).

Distribution
Native to western and central Europe and the western Mediterranean, introduced to Scandinavia, North and South America, the Philippines, South Africa, St Helena, Australia and New Zealand (Barker 1999). In Chile this species has been recorded between 30° S and 45° S (Letelier and Ramos 2002), and in the Juan Fernandez Archipelago (Stuardo and Vega 1985). The first record of this species for Chile was by Stuardo and Vega (1985).
**Possible mechanism of introduction/Status**
Human transportation/established (Cádiz et al. 2013).

**Remarks**
Carnivorous species (Cádiz et al. 2013). EA, I.

**Family** PUNCTIDAE Morse, 1864  
**Genus** Paralaoma Iredale, 1913  
**Paralaoma servilis** (Shuttleworth, 1852)

**Description**
Christensen et al. (2012).

**Distribution**
Native to New Zealand, widespread worldwide (Christensen et al. 2012). In Chile this species has been found only on Easter Island (39°48’ S, 73°14’ W), Región de Valparaiso (Kirch et al. 2009).

**Possible mechanism of introduction/Status**
Human transportation/established (Kirch et al. 2009).

**Remarks**
Detritivore, invasive. This species has a historically complex taxonomy (Falkner et al. 2002). EA, I.

**Family** GASTROCOPTIDAE Pilsbry, 1918  
**Genus** Gastrocopta Wollaston, 1878  
**Gastrocopta pediculus** (Shuttleworth, 1852)

**Description**
Pilsbry 1916–1918.

**Distribution**
Widely distributed among tropical Pacific islands, probably native to Indonesia and the tropical western Pacific (Brook et al. 2010). In Chile, this species has been reported only from Easter Island (39°48’ S, 73°14’ W), Región de Valparaiso (Boyko and Cordeiro 2001).
**Possible mechanism of introduction/Status**
Human transportation/unestablished (Boyko and Cordeiro 2001).

**Remarks**
Detritivore (Brodie and Barker 2011). UA, I.

*Gastrocopta servilis* (Gould, 1843)

**Description**
Pilsbry 1916–1918; Whisson and Köhler (2013).

**Distribution**
Probably native to the Caribbean, Central America and Brazil (Brook et al. 2010). In Chile this species has been reported only from Easter Island (39°48′ S, 73°14′ W), Región de Valparaiso (Kirch et al. 2009).

**Possible mechanism of introduction/Status**
Human transportation/unestablished (Kirch et al. 2009).

**Remarks**
Detritivore, could compete with native species (Brodie and Barker 2011). UA, I.

Family **PHYSIDAE** Fitzinger, 1833

Genus **Haitia** Clench and Aguayo, 1932

**Haitia venustula** (Gould 1847)

**Description**
Gould (1847), Biese (1949) (as *Physa nodulosa* Biese, 1949).

**Distribution**
Native to South America, from northern Peru to central Chile (Núñez and Pelichottì 2003), introduced in Argentina (Miquel 1985). In Chile this species has been cited (as *Physa nodulosa*) for the Limari, Illapel and Elqui (29° S to 31° S) (Miquel 1985).

**Possible mechanism of introduction/Status**
Cryptogenic/record dubious (Taylor 2003).

**Remarks**
Cryptogenic freshwater gastropod species, it may represent a native species. EA, UI.
Subclass **VETIGASTROPODA**
Family **HALIOTIDAE** Rafinesque, 1815
Genus **Haliotis** Linnaeus, 1758
**Haliotis discus hannai** Ino, 1953

*Description*
Geiger and Owen (2012).

*Distribution*
Native to coastal waters of East Asia (Geiger and Owen 2012). In Chile this species is commercially harvested, with aquaculture farms in Caldera (27º S), northern Chile (Valdovinos 1999). It was first introduced to the country in 1982 (Flores-Aguilar et al. 2007).

*Possible mechanism of introduction/Status*
Imported to Chile for aquaculture (Castilla et al. 2005; Flores-Aguilar et al. 2007).

*Remarks*
Herbivorous species, this species has an indirect impact on the communities of the native rocky kelp *Lessonia nigrescens* and *Lessonia trabeculata*, which are used as abalone food in Chilean aquaculture facilities (Castilla et al. 2005; Flores-Aguilar et al. 2007). This species is also a primary introduction vector for the non-indigenous boring polychaete species *Polydora uncinata* Sato-Okoshi, 1998 (Radashevsky and Olivares 2005). UA, II.

**Haliotis rufescens** Swainson, 1822

*Description*
Geiger and Owen (2012).

*Distribution*
East coast of the Pacific Ocean from Sunset Bay, Oregon, USA, to El Rosario, Baja California, Mexico (Mardones et al. 2013). In Chile this species is found around Caldera (27º S) and in the Región de Los Lagos (41º S to 46º S), only in aquaculture farms (Valdovinos 1999), with the first introduction to the country in 1977 (Flores-Aguilar et al. 2007).

*Possible mechanism of introduction/Status*
Imported to Chile for aquaculture (Flores-Aguilar et al. 2007).
Remarks

Herbivorous species, this species has an indirect impact on the communities of the native rocky kelp *Lessonia nigrescens* and *Lessonia trabeculata*, which are used as abalone food in the local aquaculture facilities (Castilla et al. 2005; Flores-Aguilar et al. 2007). This species is also a primary and secondary introduction vector in Chile for the non-indigenous boring polychaete species *Dipolydora huelma* Sato-Okoshi and Takatsuka, 2001; *Dodecaceria cf. opulens* Gravier, 1908; *Polydora rickettsi* Woodwick, 1961 and *Terebrasabella heterouncinata* Fitzhugh and Rouse, 1999 (Moreno et al. 2006). UA, II.

Discussion

A total of 34 introduced species in 19 families are documented, including 20 terrestrial gastropods, eight marine species (gastropods and bivalves) and six freshwater gastropods (Table 2). Taxa in the families Haliotidae, Ostreidae and Pectinidae include species that are cultivated for export, with no records in natural environments in Chile (Castilla et al. 2005; Castilla and Neill 2009). *Mytilus galloprovincialis*, the only marine NIS in Bivalvia, is found in natural environments associated with banks of the native species *Mytilus edulis* in the Bay of Concepción, central Chile (Tarifeño et al. 2012). Other marine species include the gastropods *Aplysia juliana*, *Monoplex keenae* and *Monoplex wiegmanni*, all of which are associated with ENSO events (Castilla et al. 2005) and whose records may represent natural southern range extensions of their corresponding natural tropical distributions.

All of the 20 recorded introduced terrestrial Gastropoda species are ground-dwellers, and they are all associated (together with freshwater species) with human-disturbed habitats (Table 2). Ten of these terrestrial species have been recorded in Easter Island alone (Boyko and Cordeiro 2001; Kirch et al. 2009) which, however, has a single species of native land mollusc: the subfossil snail species *Hotumatua anakenana* Kirch, Christensen and Steadman, 2009; now extinct (Kirch et al. 2009). The remaining invasive species are distributed in continental Chile, mostly in specific locations along the southern part of the country (Cádiz and Gallardo 2007; Rumi et al. 2010; Landler and Nuñez 2012). Among these, species of the genus *Oxychilus* have been cited as particularly dangerous to native micromolluscs, preying selectively on them (Cádiz et al. 2013). Freshwater species include six gastropods, five of them widely known as invasive molluscs (Olivares and Gálvez 2008; Jackson and Jackson 2009; Collado 2014) and a cryptogenic species of Physidae, *Haithia venustula*, recently transferred from genus *Physa* Draparnaud, 1801, and which may possibly constitute a native species (Miquel 1985; Taylor 2003). Dubious records include the species *Otala lactea* – a species easily misidentified with the congeneric *Otala punctata* – and *Rumina decollata*, both species listed from Chile but without any geographic reference or further information (Rumi et al. 2010).

The first record of *Otala punctata* is made here from two locations near agricultural land in the commune of Buin, Region Metropolitana, in central Chile (Table 1). The species is widespread worldwide and is a minor plant pest. Even when only a pair of specimens was collected, the potential proliferation of this species may approach that of *Cornu aspersum* in Chile. *Cornu aspersum* and *Deroceras laeve* were found in gardens, greenhouses, and monoculture plantations in the cities of Vallenar, Tierra
Amarilla, Copiapó, Caldera, Antofagasta and Iquique, in northern Chile (Table 2). *Cornu aspersum* was previously recorded in Chile only from Caldera (27° S) to Chiloé Island (42° S), including Easter Island and the Juan Fernández Archipelago (Araya and Catalán 2014), whereas *Deroceras laeve* had been recorded from latitudes 30° S to 40° S (Valdovinos 1999). The northern distribution in Chile for *C. aspersum* and *D. laeve* is therefore extended here by about 1084 km. Fortunately, both of these species (*C. aspersum* and *D. laeve*) have never been recorded in natural environments and it seems that they are restricted to transformed habitats in general.

Regarding impacts by NIS, apart from the obvious invasive threats, the aquaculture of *Haliotis* species in particular has an indirect negative impact on communities of indigenous algae (*Lessonia trabeculata*, *Macrocystis pyrifera* and *Gracilaria chilensis*) which are collected and processed to feed these abalone species (Flores-Aguilar et al. 2007). These haliotid species also constitute introduction vectors for non-indigenous boring polychaete species (Radashevsky and Olivares 2005; Moreno et al. 2006). Regarding freshwater NIS, the introduction of the snails *Pomacea canaliculata* and *Melanoides tuberculata* poses a risk as both of these species have been documented as potential vectors for trematode parasites (Letelier et al. 2007) and *P. canaliculata* in particular has been listed as a predator of amphibian eggs (Karraker and Dudgeon 2014). The only positive impact of non-indigenous molluscan species relies on the primary production and commercialization of *Crassostrea gigas*, *Haliotis discus* and *Haliotis rufescens* (2138 tons in 2012) (Servicio Nacional de Pesca 2012).

As a result of this revision, a new record for a molluscan NIS – *Otala punctata* – and new distribution records for the species *Cornu aspersum* and *Deroceras laeve* are given for the Chilean territory, resulting in a total at present of 34 invasive molluscan species recorded in the country. Most (61%) of the molluscan NIS constitute terrestrial taxa, and most (about 45%) of the new arrivals have a European origin. More than half (52%) of all these molluscan NIS were first recorded after the year 2000, doubling the 13 species recorded by Valdovinos (1999), indicating a large increase in the introduction (or recognition) of these species in Chile. Results indicate that the majority of the molluscan NIS in the country are associated with human-dominated/disturbed habitats, with comparatively few species found in natural environments. Among these, the gastropods *Pomacea*, *Melanoides* and *Oxychilus* have the largest potential negative impact as invasive species and could greatly affect native biota. Taking into account that this is the first comprehensive study compiling all the records of freshwater, marine and terrestrial non-indigenous molluscs in Chile – and that the results indicate a rapid increase in this group in the country – an in-depth study of the distribution, ecological characteristics and impacts of these alien species is of utmost importance. Particularly, it is necessary to study and test their direct effects on the native freshwater and terrestrial species, to eradicate alien species already established in the country, and to prevent further NIS from establishing in the Chilean territory.

**Acknowledgements**

I am grateful to Lukas Landler, Virginia Polytechnic Institute and State University (Blacksburg, VA, USA) and to Cristopher B. Boyko, Dowling College, (Long Island, NY, USA) for helping with literature, and to Alan G. Beu, GNS Science (Lower Hutt,
New Zealand) for his comments and correction of an early version of the manuscript. I am indebted also to two anonymous reviewers and to the academic editor for their commentaries, corrections and suggestions, which greatly improved the quality of the manuscript. I thank also Daniel Geiger (Santa Barbara Museum of Natural History, Santa Barbara, CA, USA) who kindly checked the language and corrected a final version of the manuscript. This work is dedicated to Professor Cecilia Osorio (Universidad de Chile, Santiago, Chile) for her long contribution to the knowledge of Chilean molluscs and for her long friendship and personal support.

ORCID
Juan Francisco Araya http://orcid.org/0000-0002-4087-9641

References
Abbott RT. 1989. Compendium of landshells. Melbourne: American Malacologists.
Aditya G, Raut SK. 2001. Food of the snail, Pomacea bridgesii, introduced in India. Curr Sci. 80:919–921.
Anton HE. 1838. Verzeichniss der Conchylien welche sich in der Sammlung von Herbert Eduard Anton Befinden. H. E. Anton, Halle, xvi + 110 pp.
Araya JF, Catalán R. 2014. A review of the non-bulimulid terrestrial Mollusca from the Region of Atacama, Northern Chile. ZooKeys. 398:33–51.
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. Helgoland Mar Res. 62:107–110.
Baker HB. 1935. Jamaican land snails. Nautilus. 48:83–88.
Bank RA. 2012. Comments on Cornu Born, 1778 (Mollusca: Gastropoda, Helicidae): request for a ruling on the availability of the generic name (Case 3518). Bull Zool Nomencl. 69:279–283.
Barker GM. 1999. Naturalised terrestrial Stylommatophora (Mollusca: Gastropoda). Canterbury: Fauna of New Zealand No. 38.
Barker GM. 2004. Natural enemies of terrestrial Molluscs. Wallingford (UK): CABI Publishing.
Beu AG. 1970. The Mollusca of the subgenus Monoplex (family Cymatiidae). T Roy Soc NZ. 11:225–237.
Beu AG. 2010. Neogene tonnoidean gastropods of Tropical and South America: contributions to the Dominican Republic and Panama Paleontology Projects and uplift of the Central American Isthmus. Bull Am Paleontol. 377–378:1–550.
Biese WA. 1949. Revisión de los moluscos terrestres y de agua dulce provistos de concha de Chile. Familia Ancylidae y Physidae. B Mus Nac Hist Nat. 24:217–239.
Bohan DA, Glen DM, Wiltshire CW, Hughes L. 2000. Parametric intensity and the spatial arrangement of the terrestrial mollusc herbivores Deroceras reticulatum and Arion intermedius. J Anim Ecol. 69:1031–1046.
Born I von. 1778. Index rerum naturalium musei caesarei Vindobonensis. Pars I. Testacea, Vindobonae, 42+458+78 pp.
Bouchard-Chantereaux NR. 1837. Catalogue des mollusques terrestres et fluviales observes jusqu’à ce jour à état vivant dans le department du Pas-de-Calais. Mémoirs de la Société Agricole de Boulogne (ser. II). I:141–230.
Boyko C, Cordeiro R. 2001. The terrestrial Mollusca of Easter Island (Gastropoda, Pulmonata). Basteria. 65:17–25.
Branch GM, Steffani NC. 2004. Can we predict the effects of alien species? A case-history of the invasion of South Africa by *Mytilus galloprovincialis* (Lamarck). J Exp Mar Biol Ecol. 300:189–215.

Brodie GD, Barker GM. 2011. Introduced land snails and slugs in the Fiji Islands: are there risks involved? In: Cr V, Mn C, Towns DR, editors. Island invasives: eradication and Management. Gland: IUCN; p. 32–36.

Brook FJ, Walter RK, Craig JA. 2010. Changes in the terrestrial molluscan fauna of Miti’aro, southern Cook Islands. Tuhinga. 21:75–98.

Bruguière JG. 1789. Encyclopédie Méthodique. Histoire Naturelle des Vers. Tome premier [part 1]. Panckoucke, Paris.

Cádiz FJ, Cádiz DG, Grau JH. 2013. An invasive predatory snail *Oxychilus alliarius* (Miller, 1822) (Stylommatophora: Zonitidae) threatens the native malacofauna of continental Chile: a morphological and molecular confirmation. Stud Neotrop Fauna E. 48:119–124.

Cádiz FJ, Gallardo CS. 2007. *Arion intermedius* (Gastropoda: Stylommatophora): first record of this introduced slug in Chile, with notes on its anatomy and natural history. Rev Chil Hist Nat. 80:99–108.

Castilla JC, Neill PE. 2009. Marine bioinvasions in the southeastern Pacific: status, ecology, economic impacts, conservation and management. In: Rilov G, Crooks JA, editors. Biological invasions in marine ecosystems. Berlin: Springer; p. 439–457.

Castilla JC, Uribe M, Bahamonde N, Clarke M, Desqueyroux-Faundez 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.

Cazzaniga NJ. 1990. Sexual dimorphism in *Pomacea canaliculata*. Veliger. 33:384–398.

Chen HT. 1933. A preliminary report on a survey of animal parasites of Canton China rats. Lingnan Sci J. 12:65–74.

Christensen CC, Yeung NW, Hayes KA. 2012. First records of *Paralaoma servilis* (Shuttleworth, 1852) (Gastropoda: Pulmonata: Punctidae) in the Hawaiian Islands. Occas pap Bernice P Bishop Mus. 112:3–7.

Clench WJ, Aguayo CG. 1932. New Haitian mollusks. Proc New Engl ZoClub. 13:35–38.

Coan EV, Valentich-Scott P. 2012. Bivalve seashells of tropical West America. Marine bivalve mollusks from Baja California to northern Peru. Santa Barbara Monographs: Santa Barbara Museum of Natural History.

Coelho AR, Calado GJ, Dinis MT. 2012. Freshwater snail *Pomacea bridgesii* (Gastropoda: Ampullariidae), life history traits and aquaculture potential. AACL Bioflux. 5:168–181.

Collado GA. 2014. Out of New Zealand: molecular identification of the highly invasive freshwater mollusk *Potamopyrgus antipodarum* (Gray, 1843) in South America. Zool Stud. 53:70.

Cooke CM, Kondo Y. 1960. Revision of Tornatellinidae and Achatinellidae (Gastropoda, Pulmonata). Bernice P. Bishop Mus Bull. 221:1–303.

Cowie RH. 2000. Non-indigenous land and freshwater molluscs in the islands of the Pacific: conservation impacts and threats. In: Sherley G, editor. Invasive species in the Pacific: a technical review and regional strategy. Apia: South Pacific Regional Environment Programme.

Cowie RH. 2001. Can snails ever be effective and safe biocontrol agents? Int J Pest Manage. 47:23–40.

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.

Cox LR. 1960. Thoughts on the classification of the Gastropoda. Proc Malac Soc Lond. 33:239–261.
Cuvier G. 1795. Second Mémoire sur l'organisation et les rapports des animaux à sang blanc, dans lequel on traite de la structure des Mollusques et de leur division en ordre, lu à la société d'Histoire Naturelle de Paris, le 11 prairial an troisième [30 May 1795]. Mag Enc. 1:433–449.

Daguin C, Borsa P. 2000. Genetic relationships of *Mytilus galloprovincialis* Lmk. populations worldwide: evidence from nuclear-DNA markers. In: Crame A, Harper E, Taylor J, editors. Bivalve systematics and evolution, Vol. 177. London: Geological Society of London Special Publications; p. 389–397.

De Francesco CG, Lagiglia H. 2007. A predatory land snail invades central-western Argentina. Biol Invasions. 9:795–798.

De Mattia W, Mascia F. 2011. *Otala punctata* (O. F. Müller, 1774) (Stylommatophora: Helicidae) in Italy. Iberus. 29:39–46.

Diederich S, Nehls G, Beusekom JE, Reise K. 2005. Introduced Pacific oysters (*Crassostrea gigas*) in the northern Wadden Sea: invasion accelerated by warm summers? Helgoland Mar Res. 59:97–106.

Draparnaud JPR. 1801. Tableau des mollusques terrestres et fluviatiles de la France. Montpellier et Paris, Renaud. 116 pp., 13 pls.

Dundee DS, Paine A. 1977. Ecology of the snail *Melanoides tuberculata* (Müller), intermediate host of the human liver fluke (*Opisthorchis sinensis*) in New Orleans, Louisiana. Nautilus. 91:17–20.

Ellis AE. 1926. British snails, a guide to the non-marine Gastropoda of Great Britain and Ireland, Pliocene to Recent. Oxford: Clarendon Press; 275 pp.

Estebenet AL, Martín PR. 2003. Shell interpopulation variation and its origin in *Pomacea canaliculata* (Gastropoda: Ampullariidae) from Southern Pampas, Argentina. J Mollus Stud. 69:301–310.

Faberi AJ, López AN, Manetti PL, Clemente NL, Castillo HA. 2006. Growth and reproduction of the slug *Deroceras laeve* (Müller) (Pulmonata: Stylommatophora) under controlled conditions. Span J Agric Res. 4:345–350.

Falkner G, Ripken TEJ, Falkner M. 2002. Mollusques continentaux de France. Liste de référence annotée et bibliographique. [Continental Molluscs of France. Annotated reference list and bibliography]. Paris: Muséum National d'Histoire Naturelle (Paris).

Férussac JBL d'Audebard de. 1819. Histoire naturelle générale et particulière des mollusques terrestres et fluviatiles. 1:196. Paris.

Férussac JBL d'Audebard de. 1822. Tableaux systématiques des animaux mollusques suivis d'un Prodrom general pour tous les mollusques terrestres ou fluviatiles vivants ou fossiles. Premiere partie, Tableaux systématiques généraux. Paris: Arthus-Bertrad.

Férussac JBL d'Audebard de. 1823. Histoire naturelle générale et particulière des mollusques terrestres et fluviatiles, Vol. 2. Paris: alpha-lambda; p. 96a–z.

Fischer P. 1883. Manuel de conchyliologie et de paléontologie conchyliologique. Fascicule 5-6. Paris: Savy; 1369 pp.

Fischer P, Crosse H. 1877. Etudes sur les Mollusques terrestres et fluviatiles du Mexique et du Guatemala. Mission scientifique au Mexique et dans l'Amérique Centrale. Recherches zoologiques, Partie 6. Paris: Imprimerie Nationale.

Fitzhugh K, Rouse G. 1999. A remarkable new genus and species of fan worm (*Polychaeta: Sabellidae: Sabellininae*) associated with marine gastropods. Invertebr Biol. 118:357–390.

Fitzinger LJF. 1833. Systematisches Verzeichniss der im Erzherzogthume Osterreich vorkommenden Weichtiere, als Prodrom einer Fauna derselben. Beitr Landesk Österreichs unter der Enns. 3:88–122.

Flores-Aguilar RA, Gutierrez A, Ellwanger A, Searcy-Bernal R. 2007. Development and current status of abalone aquaculture in Chile. J Shellfish Res. 26:705–711.

Frings H, Frings C. 1965. Chemosensory bases of food-finding and feeding in *Aplysia juliana* (Mollusca, Opisthobranchia). Biol Bull. 128:211–217.
Gaitán-Espitia JD, Franco M, Bartheld JL, Nespolo RF. 2012. Repeatability of energy metabolism and resistance to dehydration in the invasive slug *Limax maximus*. Invertebr Biol. 131:11–18.

Geiger DL, Owen B. 2012. Abalone: worldwide Haliotidae. Hackenheim: ConchBooks.

Gil T. 1871. Arrangement of the families of mollusks. Smithsonian Miscellaneous Collections. 227: xvi+ 49 pp.

Golikov AN, Starobogatov YAI. 1975. Systematics of prosobranch gastropods. Malacologia. 15:185–232.

Gould A. 1843. Monograph of the species of Pupa found in the United States. Boston J Nat Hist. 4:350–360.

Gould AA. 1847. Descriptions of Physa, from the collection of the exploring expedition. Proc Boston Soc Nat Hist. 2:214–215.

Gravier C. 1908. Sur les Annélides polychètes rapportées par M. le Dr. Rivet de Payta (Pêrou). Bull Mus Hist Nat Paris. 14:40–44.

Gray JE. 1821. A manual of the land and freshwater shells of the British Islands (W. Turton, ed.). London: Longman, Orme, Brown, Green and Longmans; X + 324 pp.

Gray JE. 1824. Zoological notices. On some new species of Ampullariidae. Philos Mag. 63:276–277.

Gray JE. 1843. Catalogue of the species of Mollusca and their shells, which have hitherto been recorded as found at New Zealand, with the description of some lately discovered species. In: Dieffenbach E, editor. Travels in New Zealand; with contributions to the geography, geology, botany, and natural history of that country. Vol. 2. London: John Murray; pp. 228–265; iv + 392 p.

Gray JE. 1854. A revision of the arrangement of the families of bivave shells (Conchifera). J Nat Hist. 13:408–418.

Gray JE. 1855. Catalogue of Pulmonata or air-breathing Mollusca in the collection of the British Museum. Part I. London, British Museum (Natural History). iv + 192 pp.

Gulick JT. 1873. On the classification of the Achatinellinae. Proc Zool Soc Lond. 1:89–91.

Hausdorf B. 2002. Introduced land snails and slugs in Colombia. J Mollus Stud. 68:127–131.

Hayes KA, Yeung NW, Kim JR, Cowie RH. 2012. New records of alien Gastropoda in the Hawaiian Islands. Occas pap Bernice P Bishop Mus. 112:21–28.

Heynemann FD. 1862. Einige Mitteilungen über Schneckenzungen mit besonderer Beobachtung der Gattung *Limax*. Malak Blät. 10:200–216.

Horácková J, Juricková L. 2009. A new record of *Oxychilus alliarius* (Gastropoda: Zonitidae) with the species distribution in the Czech Republic. Malacol Bohemoslov. 8:63–65.

Hesse P. 1926. Beiträge zur genauer Kenntnis des Subfamilie Helicellinae. Arch Molluskenkd. 58:113–141.

Heunemann FD. 1862. Einige Mitteilungen über Schneckenzungen mit besonderer Beobachtung der Gattung *Limax*. Malak Blät. 10:200–216.

Hutchinson JMC, Reise H, Robinson DG. 2014. A biography of an invasive terrestrial slug: the spread, distribution and habitat of *Deroceras invadens*. NeoBiota. 23:17–64.

Hutton T. 1834. On the land shells of India. J Asiat Soc Bengal. 3:81–93.

Ino T. 1953. Biological studies on the propagation of Japanese abalone (Genus *Haliotis*). Tokyo: Tokai Shobo; 108 pp.

Iredale T. 1913. The land mollusca of the Kermadec Islands. J Mollus Stud. 10:364–388.

Jackson D, Jackson D. 2009. Registro de *Pomacea canaliculata* (Lamarck, 1822) (Ampullariidae), molusco exótico para el norte de Chile. Gayana Zool. 73:40–44.
Karraker NE, Dudgeon D. 2014. Invasive apple snails (*Pomacea canaliculata*) are predators of amphibians in South China. Biol Invasions. 16:1785–1789.

Kay EA. 1964. The Aplysiidae of the Hawaiian Islands. Proc Malacological Soc London. 36:173–189.

Keen AM. 1971. Sea shells of tropical west America: marine Mollusks from Baja California to Peru. Stanford: Stanford University Press.

Kerans BL, Dybdahl MF, Gangloff MM, Jannot JE. 2005. *Potamopyrgus antipodarum*: distribution, density, and effects on native macroinvertebrate assemblages in the Greater Yellowstone Ecosystem. J N Am Benthol Soc. 24:123–138.

Kerbert C. 1878. Zur Trematoden-Kenntnis. Zool Anz. 1:271–273.

Kirch P, Christensen C, Steadman D. 2009. Subfossil land snails from Easter Island, including *Hotumattua anakenana*, new genus and species (Pulmonata: Achatinellidae). Pac Sci. 63:105–122.

Kwong K-L, Chan RKY, Qiu J-W. 2009. The potential of the invasive snail *Pomacea canaliculata* as a predator of various life-stages of five species of freshwater snails. Malacologia. 51:343–356.

Lamarck JB. 1809. Philosophie zoologique, Vol. 2. Paris: Dentu; xxv + 428 pp.

La Pierre KJ, Harpole WS, Suding KN. 2010. Strong feeding preference of an exotic generalist herbivore for an exotic forb: a case of invasional antagonism. Biol Invasions. 12:3025–3031.

Lamarck JB De. 1819. Histoire Naturelle des Animaux sans Vertèbres. Librairie Verdière, Paris; 343 pp.

Lamarck J-B De M. 1822. Histoire naturelle des Animaux sans Vertèbres 7. Verdière, Paris; 711 pp.

Landler L, Nuñez JJ. 2012. European invaders in South America: terrestrial snails and slugs in southern Chile. J Conchol. 41:263–265.

Lehmann R. 1864. Neue Nacktschnecken aus Australian. Malak Blät. 9:111–112.

Lessona M, Pollonera C. 1822. Monografia dei limacidi Italiani. Memorie della Reale Accademia delle Scienze di Torino, Classe di Scienze Fische Matematiche Naturali (Ser. II). Torino (Loescher). 82 pp.

Letelier S, Ramos AM. 2002. Moluscos terrestres y de aguas continentales de la expedición Iniciativa Darwin (1998–1999), Región de Aysén, Zona Austral de Chile. Bol Mus Nac Hist Nat Chile. 51:185–195.

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

Linnaeus C. 1758. Systema Naturae per Regna Tria Naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima reformata. 1. Holmiae, Salvius; ii + 824 pp.

Linnaeus C. 1767. Systema naturae sive regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. 12th ed. Laurentii Salvii, Holmiae. 1:533–1327.

Marcus EBR. 1955. On the Anaspidae (Gastropoda, Opisthobranchia) of the warm waters of the Western Atlantic. B Mar Sci. 22:841–874.

Mardones A, Augsburger A, Vega R, de Los Rios Escalante PDL. 2013. Tasas de crecimiento de *Haliotis rufescens* y *Haliotis discus hannai* en cultivos en estanques en el sur de Chile (41, 5° S). Lat Am J Aquat Res. 41:959–967.

Martín SM, César II, Liberto R. 2009. Distribution of *Deroceras reticulatum* (Müller, 1774) (Pulmonata Stylommatophora) in Argentina with first record of the Reserva de Usos Múltiples Isla Martin García, Rio de la Plata superior. Braz J Biol. 69:1115–1119.

Maurer RL, Graeff-Teixeira C, Thomé JW, Chiariadria LA, Sugaya H, Yoshimura K. 2002. Natural infection of *Deroceras laeve* (Mollusca: Gastropoda) with metatostrongylid larvae.
in a transmission focus of abdominal angiostrongyliasis. Rev Inst Med Trop Sao Paulo. 44:53–54.

Meyer WM, Cowie RH. 2010. Feeding preferences of two predatory snails introduced to Hawaii and their conservation implications. Malacologia. 53:135–144.

Miller JS. 1822. List of the freshwater and landshells occurring in the environs of Bristol, with observations. Annals of philosophy (ser. III). 19:376–381.

Miquel SE. 1985. Presencia de género Physella Haldeman, 1842 en la Republica Argentina (Mollusca Pulmonata Physidae). Neotrópica. 31:38–38.

Miquel SE, Parent H, Scarabino F. 1995. Achatinoidea introducidos en la Argentina y el Uruguay (Mollusca: Gastropoda: Stylommatophorida). Neotrópica. 41:26–75.

Moneva CSO, Torres MAJ, Demayo CG. 2012. Relative warp and correlation analysis based on distances of the morphological shell shape patterns among freshwater gastropods (Thiaridae: Cerithimorpha). AACL Bioflux. 5:124–135.

Moreno RA, Neill PE, Rozbaczylo N. 2006. Native and non-indigenous boring polychaetes in Chile: a threat to native and commercial mollusc species. Rev Chil Hist Nat. 79:263–278.

Morse ES. 1864. Observations on the terrestrial Pulmonifera of Maine, including a catalogue of all the species of terrestrial and fluvial mollusca known to inhabit the State. J Portland Soc Nat Hist. 1:1–63.

Müller OF. 1774. Vermium terrestrium et fluvialium, seu animalium infusoriorum, helminthi-corum, et testaceorum, non marinorum, succincta historia. Vol. II, Havnæae et Lipsiae, Heineck et Faber; xxxvi + 214 + 2 + 8 pp.

Müller CF. 1776. Zoologiae Danicae Prodromus, seu Animalium Daniae et Norvegiae indigenarum, caracteres, nomina, et synonyma. Imprimis popularium. Havnæae, xxxii + 282 pp.

Normand NAJ. 1852. Description de six limaces nouvelles observees aux environs de Valenciennes. Valenciennes. 8 pp.

Núñez V, Pelichotti PE. 2003. Sinopsis y nuevas citas para la distribución de la familia Physidae en la Argentina (Gastropoda: Basommatophora). Comun Soc Malacol Urug. 8:259–261.

Occhipinti-Ambrogi A, Galil BS. 2004. A uniform terminology on bioinvasions: a chimera or an operative tool? Marine Poll Bull. 49:688–694.

Odhner NJ. 1922. Mollusca from Juan Fernandez and Easter Island. In: Skottsberg C, editor. The natural history of Juan Fernandez and Easter Island. Vol. 3. Uppsala: Almquist and Wiksells Boktryckeri-A.-B; p. 219–254.

Olivares L, Gálvez O. 2008. Registro de la especie exótica Melanoides tuberculata (Müller, 1774) (Gastropoda, Prosobranchia, Thiaridae) en la región de Tarapacá. Bol Mus Nac Hist Nat Chile. 57:155–160.

Olivier GA. 1804. Voyage dans l’Empire Othoman, l’Égypte et la Perse, fait par ordre du gouvernement, pendant les six premières années de la République. Tome second. Paris. (Asgase). 466 pp.

Osorio C. 2002. Moluscos marinos en Chile: especies de importancia económica: guía para su identificación. Santiago, Chile: Facultad de Ciencias, Universidad de Chile.

Paul CRC. 1982. Pleistocene non-marine molluscs from Cala Salada, Ibiza. Geol J. 17:161–184.

Perry G. 1810. Arcana; or the museum of natural history. Stratford, London. 84 pls.

Perry G. 1811. Conchology, or the natural history of snails containing a new arrangement of the genera and species. London: Miller; 4 pp., 61 pls.

Philippi RA. 1885. Zoología. Sobre los animales introducidos en Chile desde su conquista por los españoles. An Univ Chile. 67:319–335.

Pilsbry HA. 1906. Manual of conchology, second series: Pulmonata. Vol. 18. Achatinidae: Stenogyrinae and Coelioxinae: Conchological Department, Academy of Natural Sciences of Philadelphia, Philadelphia.
Pilsbry HA. 1916–1918. Manual of conchology, second series: Pulmonata, Vol. 24, Pupillidae (Gastrocoptinae). Philadelphia: Conchological Department, Academy of Natural Sciences of Philadelphia.

Pilsbry HA. 1918. Manual of Conchology (2, Pulmonata). Philadelphia, Academy of Natural Sciences. Vol. 25. Pupillidae (Gastrocoptinae, Vertiginidae). ix + 401 pp.

Poppe GT, Goto Y. 2000. European seashells, Vol II (Scaphopoda, Bivalvia, Cephalopoda). 2nd ed. Hackenheim (Germany): ConchBooks.

Potiez VLV, Michaud ALG. 1838. Galerie des Mollusques, ou Catalogue Méthodique, Descriptif et Raisonné des Mollusques et Coquilles du Muséum de Douai. Tome Premier. J. B. Bailliere, Paris and London; xxxvi + 560 [+ 4] pp., + Atlas, 56 pp., 37 pls.

Preece RC. 1995. Systematic review of the land snails of the Pitcairn Islands. Biol J Linn Soc. 56:273–307.

Quoy JRC, Gaimard JD. 1832. Voyage de decouvertes de l’Astrolabe, executé par ordre du Roi, pendant les années 1826-1827-1828-1829, sous le commandement de M. J. Dumont d’Urville. Zoologie. Paris, Tastu; 686 pp.

Radashevsky VI, Olivares C. 2005. Polydora uncinata (Polychaeta: Spionidae) in Chile: an accidental transportation across the Pacific. Biol Invasions. 7:489–496.

Rafinesque CS. 1815. Analyse de la nature ou tableau de l’univers et des corps organisés. Palerme, 223 pp.

Rafinesque CS. 1820. Annals of nature or annual synopsis of new genera and species of animals, plants, etc. discovered in North America. First annual number, for 1820. Lexington, Smith. 16 pp.

Rawlings TA, Hayes KA, Cowie RH, Collins TM. 2007. The identity, distribution, and impacts of non-native apple snails in the continental United States. BMC Evol Biol. 7:97.

Reeve LA. 1856. Monograph of the genus Ampullaria. In: La R, editor. Conchologia iconica: or, Illustrations of the shells of Molluscous animals vol X. London: Lovell Reeve; p. 1–31.

Reise H, Hutchinson JMC, Schunack S, Schlitt B. 2011. Deroceras panormitanum and congener from Malta and Sicily, with a redescription of the widespread pest slug as Deroceras invadens n. sp Folia Malacologica. 19:201–223.

Rigby JE. 1963. Alimentary and reproductive systems of Oxychilus cellarius (Müller) (Stylommatophora). Proc Zool Soc Lond. 141:311–359.

Rowson B, Warren BH, Ngereza CF. 2010. Terrestrial molluscs of Pemba Island, Zanzibar, Tanzania, and its status as an “oceanic” island. ZooKeys. 70:1–39.

Rumi A, Sánchez J, Ferrando NS. 2010. Theba pisana (Müller, 1774) (Gastropoda, Helicidae) and other alien land molluscs species in Argentina. Biol Invasions. 12:2985–2990.

Sacco F. 1897. I Molluschi dei terreni terziari del Piemonte e della Liguria. Parte XXIV (Pectinidae). Torino: Carlo Clausen; 116 pp.

Sato-Okoshi W. 1998. Three new species of polydorids (Polychaeta, Spionidae) from Japan. Species Divers. 3:277–288.

Sato-Okoshi W, Takatsuka M. 2001. Polydora and related genera (Polychaeta, Spionidae) around Puerto Montt and Chiloe Island (Chile), with description of a new species of Dipolydora. Bull Mar Sci. 68:485–503.

Schmidt A. 1855. Der Geschlechtsapparat der Stylommatophoren in taxonomischer Hinsicht. Halle, Abh Naturwiss Ver. 1:1–52.

Schumacher CF. 1817. Essai d’un nouveau système des habitations des vers testacés. Copenhagen: Schultz; 287 pp.

Servicio Nacional de Pesca. 2012. Anuario Estadistico de Pesca. Santiago (Chile): Ministerio de Economía Fomento y Reconstrucción.

Shuttleworth RJ. 1852. Diagnosen einiger neuen Mollusken aus den Canarischen Inseln. Mitt Naturforsch Ges Bern. 241/242:137–146.

Stimpson W. 1865. Researches upon the Hydrobiinae and allied forms chiefly made upon materials in the museum of the Smithsonian Institution. Smith Misc Collect. 21:1–59.
Stuardo JR, Vargas-Almonacid P. 2000. Moluscos terrestres de Chile. Sinonimia y problemas relacionados: 1. Familias Veronicellidae, Pupillidae y Achatinellidae (Gastropoda: Pulmonata). Gayana. 64:171–188.

Stuardo JR, Vega R. 1985. Synopsis of the land Mollusca of Chile, with remarks on distribution. Stud Neotrop Fauna E. 20:125–146.

Swainson W. 1822. Description of several new shells, and remarks on others, contained in the collection of the late Mrs. Bligh. Appendix. In: A catalogue of the rare and valuable shells, which formed the celebrated collection of the late Mrs. Bligh, 58 + 20 pp. London: Dubois; pp. 1–20.

Tarifeño E, Galleguillos R, Llanos–Rivera A, Arriagada D, Ferrada S, Canales–Aguirre CB, Seguel M. 2012. ERRORNEOUS identification of the mussel, Mytilus galloprovincialis (Lamarck 1819) as the species Mytilus chilensis (Hupé, 1854) in the Bay of Concepcion, Chile. Gayana. 76:167–172.

Taylor DW. 2003. Introduction to Physidae (Gastropoda: Hygrophila); biogeography, classification, morphology. Rev Biol Trop. 51:1–287.

Thiele J. 1925. Gastropoden der deutschen Tiefsee-Expedition. In: Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition II, Vol 17 (2). Berlin: Gustav Fischer; 348 pp.

Thomas AK, Mc Donnell RJ, Paine TD, Harwood JD. 2010. A field guide to the slugs of Kentucky. Lexington (Kentucky): University of Kentucky College of Agriculture-Agriculture Experiment Station Publication SR-103.

Thunberg CP. 1793. Tekning och Beskrifning på en stor Ostronsort ifrån Japan. K Sven Vetensk Akad Handl. 14:140–142.

Tomicic J. 1985. Efectos del Fenómeno El Niño 1982–83 en las comunidades litorales de la Península de Mejillones. Invest Pesq (Chile). 32:209–213.

Valdovinos C. 1999. Biodiversidad de moluscos chilenos: base de datos taxonómica y distribucional. Gayana. 63:111–164.

Westfall KM, Gardner J. 2010. Genetic diversity of Southern hemisphere blue mussels (Bivalvia: Mytilidae) and the identification of non-indigenous taxa. Biol J Linn Soc. 101:898–909.

Whisson C, Köhler F. 2013. Gastrocopta (Mollusca, Gastropoda, Pupillidae) in the Pilbara region of Western Australia. ZooKeys. 261:15–39.

Winterbourn MJ. 1970. The New Zealand species of Potamopyrgus (Gastropoda: Hydrobiidae). Malacologia. 10:283–321.

Wollaston TV. 1878. Testacea Atlantica of the land and freshwater shells of the Acores, Madeiras, Salvages, Canaries, Capes Verdes and Saint Helena. London: Reeve and Co; xiv + 588 pp.

Woodwick KH. 1961. Polydora rickettsi, a new species of spionid polychaeten from lower California. Pac Sci. 15:78–81.

Yang TB, Wu ZD, Lun ZR. 2013. The apple snail Pomacea canaliculata, a novel vector of the rat lungworm, Angiostrongylus cantonensis: its introduction, spread, and control in China. Hawaii J Med Public Health. 72:23–25.