

# Land slugs in plant nurseries, a potential cause of dispersal in Argentina

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## Abstract

*Land slugs in plant nurseries, a potential cause of dispersal in Argentina.* Commercial plant nurseries may serve as causes of dispersal of land snails and slugs (native and non-native) through the trade of plants and the related transport of eggs and small individuals that may pass unnoticed. Studies on the possible role of plant nurseries as a potential cause of dispersal of slugs in South America are lacking. To explore the role of garden centers, we collected and identified slugs in 12 commercial nurseries in two cities in the province of Buenos Aires, Argentina. Eight species of slugs were found. Based on our findings we validate the existence of *Deroceras laeve* and *Belocaulus angustipes* for Argentina and confirm the existence of *Ambigolimax valentianus*, which was recently cited for Argentina. We recommend that plant nurseries be regularly monitored given that snail and slug species are accidentally spread through trade in plants.

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Key words: Mollusks, Non-native, Horticultural trade, Potential pests

## Resumen

*Babosas terrestres en viveros, una posible causa de dispersión en Argentina.* Los viveros comerciales pueden causar la dispersión de caracoles y babosas terrestres (nativas y no nativas) a través del comercio de plantas y el consiguiente transporte de huevos y pequeños individuos que pueden pasar desapercibidos. No existen estudios sobre el posible papel de los viveros como causa potencial de dispersión de babosas en América del Sur. En revisiones sobre introducción accidental de especies no nativas en Argentina en los últimos años, se constató que varias de ellas se produjeron a través del comercio de plantas. Para explorar el papel de los viveros comerciales recolectamos e identificamos babosas en 12 viveros comerciales de dos ciudades de la provincia de Buenos Aires (Argentina), registrando ocho especies de babosas. Validamos a *Deroceras laeve* y *Belocaulus angustipes* para Argentina y confirmamos la presencia de *Ambigolimax valentianus*, que fue citada recientemente en Argentina. Recomendamos que los viveros sean monitorizados regularmente dado que las especies de caracoles y babosas se registran accidentalmente junto con la tierra y las plantas comercializadas.

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Palabras clave: Moluscos, No nativos, Comercio hortícola, Plaga potencial

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### Resum

*Llimacs terrestres en viviers, una possible causa de dispersió a l'Argentina.* Els viviers comercials poden causar la dispersió de cargols i llimacs terrestres (nadius i no natius) a través del comerç de plantes i el consegüent transport d'ous i petits individus que poden passar desapercebuts. No hi ha estudis sobre el possible paper dels viviers com a causa potencial de dispersió de llimacs a l'Amèrica del Sud. En revisions sobre introducció accidental d'espècies no natives a l'Argentina durant els últims anys, es va constatar que diverses introduccions es van produir a través del comerç de plantes. Per explorar el paper dels viviers comercials vam recol·lectar i identificar llimacs en 12 viviers comercials de dues ciutats de la província de Buenos Aires (Argentina) i vam registrar vuit espècies de llimacs. Vam validar *Deroceras laeve* i *Belocaulus angustipes* per a l'Argentina i vam confirmar la presència d'*Ambigolimax valentianus*, que va ser citat recentment a l'Argentina. Recomanem que els viviers siguin monitorats regularment atès que les espècies de cargols i llimacs es registren accidentalment juntament amb la terra i les plantes comercialitzades.

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Paraules clau: Mol·luscs, No natiu, Comerç hortícola, Plaga potencial

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## Introduction

Many gastropods have spread and naturalized in areas outside their native range due to human activities (Cowie and Robinson, 2003). The most important inadvertent pathway responsible for the introduction of small animals such as snails and slugs is perhaps horticultural trade (Robinson, 1999; Cowie and Robinson, 2003; Hayes et al., 2007; Cowie et al., 2008; Pergl et al., 2017; Darrigran et al., 2020; Shivambu et al., 2020). If there are no controls in place, these species may become pests in their new environments, causing damage to crops and decreasing production. They can also transmit parasites to humans and domestic animals and may have negative effects on native flora and fauna (Barker, 1999). Although both snails and slugs are potential pests, snails are more likely to be detected because of their shells. Because slugs have no protective shell they have greater plasticity and are able to find more shelter than snails. The dispersal ability of slugs is poor, however, both on a small and a large scale and is correlated primarily with anthropogenic activity.

The prevalence of land gastropods should thus be controlled in commercial plant nurseries (including greenhouses) (Kaur and Kaur, 2004). Studies concerning horticultural trade mainly refer to a single species of mollusks and few studies have been conducted in mollusks in plant nurseries (e.g. USA: Cowie et al., 2008; Bergey et al., 2014; Europe: Meeuse and Hubert, 1949; Horsák et al., 2004). Furthermore, studies in South America are lacking. Whereas inspections at national borders, airports, and seaports intercept many incoming snails, dispersal within countries is notoriously less regulated and little documented (Bergey et al., 2014). In recent years, new, non-native, invasive, or transplanted snail and slug species have been found in Argentina, possibly following this route of trade (Rumi et al., 2010; Gutiérrez Gregoric et al., 2013; Virgillito and Miquel, 2013; Daglio et al., 2020).

Apart from acting as pests from an economic point of view, land slugs may also be intermediate hosts to parasites (Nematoda, Digenea) that have man and other animals as definitive or accidental hosts (Grewal et al., 2003; Barger and Hnida, 2008). Furthermore, non-native species can act as invasive species, causing faunal homogenization associated with human-aided dispersion of species across natural biogeographical boundaries, especially in urban areas (Hodges and McKinney, 2018; Bergey and Whipkey, 2020).

The aim of this study was to perform a survey of slugs in commercial nurseries in the province of Buenos Aires in order to evaluate the role of plant nurseries as a potential cause of dispersal of native and non-native slugs.

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## Material and methods

This study was carried out in 2016 and 2017 in plant nurseries located in two cities in the province of Buenos Aires: La Plata (eight nurseries, 2016) and San Pedro (four nurseries, 2017) (fig. 1; dataset published through [Zenodo](https://zenodo.org/doi/10.5281/zenodo.4304621): Doi: <http://doi.org/10.5281/zenodo.4304621>). These nurseries were selected because they are the largest in each region and have the highest levels of commercialization. Both cities have a temperate humid climate, with the city of San Pedro having slightly higher average temperatures and rainfall (annual average temperatures: La Plata, 16.4°C, San Pedro, 18.2°C; annual average rainfall: La Plata, 88.1 mm, San Pedro, 94.6 mm, <https://www.smn.gob.ar/estadisticas>). The year-round rainfall means that the dry season (winter) does not affect the slug populations in the nurseries.

Of the eight nurseries in La Plata city, two are situated in built-up urban areas and the others are in peripheral zones with more open areas. The nurseries in the city of San Pedro are larger and more open, and they are mainly related to citrus plantations.

We used direct observation as a sampling methodology, with manual collection both regarding the pots and in the environment. The collection time in each nursery depended on the size of the center and is stated in minutes/person. The specimens found were photographed in situ and also in the laboratory where external characters were analyzed.

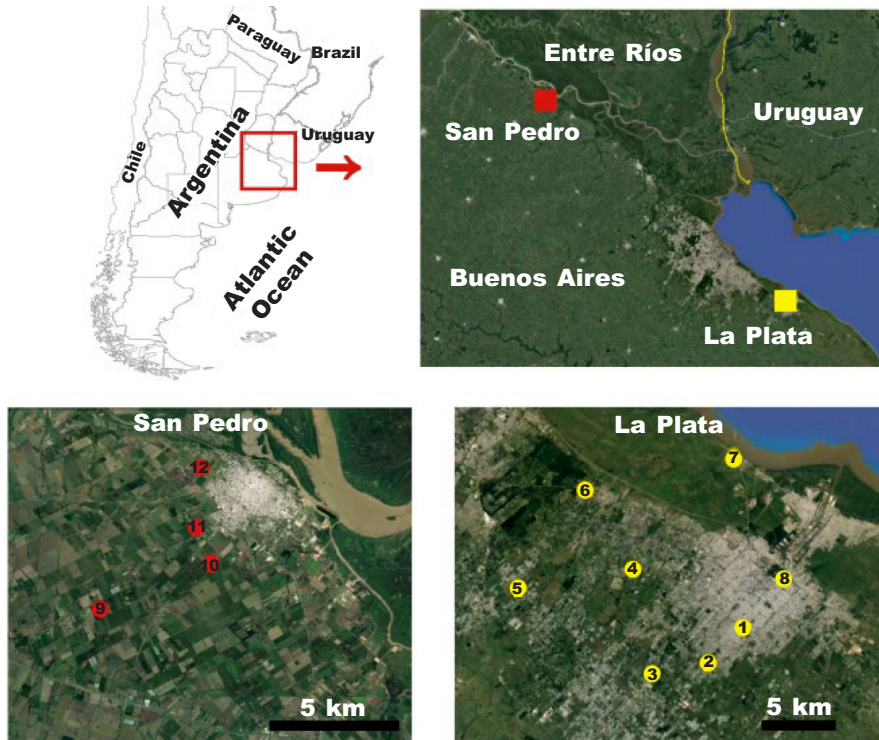


Fig. 1. Commercial plant nurseries in La Plata (yellow) and San Pedro (red) cities, Buenos Aires province. Numbers 1-12, nurseries.

Fig. 1. Viveros comerciales en las ciudades de La Plata (amarillo) y San Pedro (rojo), provincia de Buenos Aires. Números del 1 al 12, viveros.

Specimens were identified by dissection, mainly of the reproductive system (Thomé, 1976; Barker, 1999; Virgillito and Miquel, 2013; Santin and Miquel, 2015). Part of the material collected was deposited in the malacological collection of the La Plata Museum (MLP-Ma).

## Results and Discussion

Three slug species native to Argentina and five non-native slug species were recorded in the plant nurseries studied (fig. 2; table 1; dataset published through [Zenodo](https://zenodo.org/doi/10.5281/zenodo.4304621): Doi: <http://doi.org/10.5281/zenodo.4304621>). *Belocaulus angustipes* (Heynemann, 1885) was the most frequently recorded native species (10 plant nurseries), while *Deroceras laeve* (Müller, 1774) was the most widespread non-native species (11 plant nurseries, table 1). In La Plata, *D. laeve* was prevalent in most nurseries (table 1). The number of species found was highest in the two most urban nurseries (nurseries 1 and 8). Also, in these two nurseries, we recorded species that were not found in the other nurseries, such as *Limacus flavus* (Linnaeus, 1758), *Ambigolimax valentianus* (Férussac, 1821) and *Milax gagates* (Draparnaud, 1801). In San Pedro, *B. angustipes* was recorded in all the nurseries, being the most abundant species in three of them and the only species in one (table 1).

Table 1. Density (ind/30 minutes/person) of slugs per nursery: N, nursery; Lmfl, *Limacus flavus*; Drlv, *Deroceras laeve*; Drrt, *Deroceras reticulatum*; Abvl, *Ambigolimax valentianus*; Mlgg, *Milax gagates*; Phsl, *Phyllocaulis soleiformis*; Phvr, *Phyllocaulis variegatus*; Blag, *Belocaulus angustipes*; \* non-native species; T, total number of specimens by nursery (row) and by species (column).

Tabla 1. Densidad (ind/30 min/persona) de babosas por vivero: N, vivero; \* especies no nativas; T, número total de ejemplares por vivero (fila) y por especie (columna). (Para las abreviaturas de las especies, véase arriba).

N	Lmfl*	Drlv*	Drrt*	Abvl*	Mlgg*	Phsl	Phvr	Blag	T
1		8.5				7.75	1.5	3.5	85
2		0.75						1.25	8
3		18.5				0.25		3.75	90
4		18.5					0.25	0.25	76
5		13.25						1.25	58
6		8				3		3.75	59
7		10.5							42
8	2	2.75		1	0.5	0.75			28
9		9						4.75	55
10		1	0.25					4.75	24
11		0.25						1.5	7
12								2.75	11
T	8	364	1	4	2	47	6	110	543

The non-native slug species recorded are widely distributed in South America. Their natural distribution in Europe ranges from the Iberian Peninsula to Eastern Europe (Virgillito and Miquel, 2013; Darrigran et al., 2020). In this study, we validated the presence of *D. laeve* for Argentina; its presence had been questioned by Virgillito and Miquel (2013). We also confirm the presence of *A. valentianus* (recently cited for Argentina by Gutiérrez Gregoric et al., 2013). Furthermore, *D. laeve* and *M. gagates* have not been previously recorded in La Plata. For San Pedro, the two slugs recorded, *Deroceras laeve* and *D. reticulatum* (Müller, 1774), are the first records for this city. Although *D. reticulatum*, according to Virgillito and Miquel (2013), has more records from urban gardens in the province of Buenos Aires, in this study it had the least frequent occurrence, represented by only one individual, which showed abnormalities in the tentacles, perhaps because of pesticides (Daglio et al., 2019).

Two of three species of native veronicellids recorded, *Phyllocaulis variegatus* (Semper, 1885) and *Phyllocaulis soleiformis* (Orbigny, 1835), have their native southernmost distribution in the province of Buenos Aires: *P. soleiformis* in the city of Bahía Blanca, and *P. variegatus* in the city of La Plata (Santin and Miquel, 2015). *Belocaulus angustipes* has been cited in Argentina for Santa Fe and Tucumán provinces (Pitoni and Thomé, 1981; Thomé, 1993; Ohlweiler et al., 2009). However, in the review carried out by Santin and Miquel (2015) for the species present in Argentina, *B. angustipes* was not confirmed, suggesting that this species and *Angustipes difficilis* (Colosi, 1921) are related species. According to





Fig. 2. Slugs recorded: A, *Phyllocaulis variegatus*; B, *Phyllocaulis soleiformis*; C, *Belocaulus angustipes*; D, *Ambigolimax valentianus*; E, *Limacus flavus*; F, *Deroceras laeve*; G, *Deroceras reticulatum*; H, *Milax gagates*.

Fig. 2. Babosas registradas: A, *Phyllocaulis variegatus*; B, *Phyllocaulis soleiformis*; C, *Belocaulus angustipes*; D, *Ambigolimax valentianus*; E, *Limacus flavus*; F, *Deroceras laeve*; G, *Deroceras reticulatum*; H, *Milax gagates*.

Santin and Miquel (2015), *A. difficilis* has been recorded in the province of Buenos Aires, but not in San Pedro and La Plata cities. As the taxonomic situation of these species is not clear, we maintain the identification as *B. angustipes*, these being the first records of this species for the province of Buenos Aires (La Plata and San Pedro cities). This species has previously been cited for these latitudes in the department of Canelones, Republic of Uruguay (Scarabino, 2003).

Records of *L. flavus*, *A. valentianus*, and *M. gagates* (recorded only in one urban nursery in La Plata) may be associated with dispersal from neighboring urban areas with domestic gardens. These three species are common in domestic gardens in the city of La Plata. Residential gardens present environmental conditions that aid the dispersal of non-native mollusks (Bergey, 2019).

Regarding the impact that the recorded species can produce, in Argentina, *Deroceras laeve*, *D. reticulatum*, and *M. gagates* are considered pests of crops such as *Glycine max* (soy), *Helianthus annuus* (sunflower), *Triticum aestivum* (wheat) and *Zea mays* (corn) ([www.sinavimo.gov.ar](http://www.sinavimo.gov.ar)). Given the importance of their possible impact on public health, *P. variegatus*, *L. flavus*, *B. angustipes*, and *P. soleiformis* have been cited as intermediate hosts of *A. costaricensis*, while *P. variegatus*, *D. laeve*, and *L. flavus* are hosts of *A. cantonensis*, among other parasites (Grewal et al., 2003; Kim et al., 2014). However, in Argentina, to date, these slugs have not been reported to have these parasites.

Despite the rules and regulations in plant nursery management, these garden centers continue to be a potential cause of dispersal of slugs and snails. Good nursery hygiene, use of the appropriate pesticide/ molluscicide, and mechanical barriers may adequately reduce their spread and possible damage (Cowie et al., 2008). In this study, only two of 12 nurseries used molluscicides in pellet form (metaldehyde) for pest management. This lack of control increases the risk of dispersion of potential pests, parasitism, and homogenization of biodiversity in the country and neighboring countries. We recommend that plant nurseries be regularly monitored given that snails and slugs species are accidentally spread along with soil and trade of plants.

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