Belgian Journal of Zoology
www.belgianjournalzoology.be

ISSN 2295-0451

Research article
https://doi.org/10.26496/bjz.2024.116

The find of six species new to Belgium highlights the role of the stone trade as a pathway for non-native land snails (Gastropoda: Stylommatophora)

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Abstract. Surveys in stone yards in Wallonia (southern Belgium) led to the find of six taxa of land snails being new to Belgium and one being new to Wallonia. The new taxa can be divided into two groups: living animals of the European species *Charpentieria itala*, *Laciniaria plicata*, *Chilostoma cingulatum*, and *Theba pisana*, and shells with remains of the dead animals in the case of the Asian taxa *Cathaica fasciola*, *Acusta* sp., and *Bradybaena jourdyi*. The latter are widespread in their respective Asian native range while *Acusta* sp. and *B. jourdyi* had never been reported from Europe. We discuss the role of stone yards as hubs for the dispersion of land snails. The individuals of the newly observed taxa may have arrived in several waves (with successive arrivals of stones) and may not reproduce in the stone yard. We explore the risks of settling. In this study, we provide evidence that the doorsnails *C. itala* and *L. plicata* have already settled elsewhere in Wallonia. *Theba pisana*, *C. fasciola* and *Acusta* sp. have the potential to behave as invasive species.

Keywords. Non-native species, first record, stone yard, invasive species.

BRONNE L. & DELCOURT J. (2024). The find of six species new to Belgium highlights the role of the stone trade as a pathway for non-native land snails (Gastropoda: Stylommatophora). *Belgian Journal of Zoology* 154: 11–30. https://doi.org/10.26496/bjz.2024.116

Introduction

The human-mediated dispersal of non-native species, primarily through the transportation of goods and the expansion of transportation networks, is leading to the disruption of biogeographic barriers (CAPINHA *et al.* 2015). This phenomenon has intensified on a global scale due to the expansion of socioeconomic interactions, the growth of transportation networks, and the influence of climate change. As certain species expand or alter their geographic ranges, they also have the potential to become invasive in the newly colonized areas. A more comprehensive understanding of the pathways through which they are introduced can aid in devising measures to mitigate the risks of invasion and conserve native biodiversity.

Terrestrial gastropods, one of the most diverse groups of terrestrial animals, are commonly used as model organisms in ecology, biogeography, and conservation biology (e.g., Régnier *et al.* 2015; Gheoca *et al.* 2023). In the European species, biogeographical changes resulting from a combination of human-mediated dispersal and climate change have already been observed. Examples include *Hygromia cinctella* (Draparnaud, 1801), *Cernuella virgata* (da Costa, 1778) and *Arion vulgaris* Moquin-Tandon, 1855 (Peltanová *et al*. 2012; Proćków *et al*. 2019). The majority of alien species observed in East and Central Europe originate from Mediterranean regions (e.g., Peltanová *et al*. 2012), but some species have also been reported from outside the Western Palaearctic, such as *Zonitoides arboreus* (Say, 1817), *Lucilla scintilla* (Lowe, 1852) and *L. singleyana* (Pilsbry, 1889) from North America (Dvořák & Kupka 2007; Horsák *et al.* 2009), and *Paraloama servilis* (Shuttleworth, 1852) from New Zealand (Van den Neucker & Ronsmans 2015).

The poor active mobility aptitudes of terrestrial gastropods do not impede their dispersal over great distances, as dispersal mostly relies on the movement of natural fluids (hydrochory and anemochory) and of bigger animals (Dörge *et al.* 1999; Bartlow & Agosta 2021). Terrestrial gastropods have long been known to travel via birds, both by epizoochory and endozoochory (Delcourt 2022), but epizoochory also occurs on amphibians (Kolenda, 2017), livestock (Fischer *et al.* 1996), human clothes and footwear (Faliński 1972; pers. obs.).

Land snails and slugs also travel with goods (contaminant) and on human vehicles (stowaway). Those are the most important introduction pathways for alien terrestrial invertebrates (Hulme *et al.* 2008). Seebens *et al.* (2017) established a well-fitted correlation between the total value of commodities imported in a country and the number of known alien species of molluscs, which has not yet reached its limit. Anthropogenic pathways include transport attached to agricultural and horticultural products, to means of conveyance, and to raw materials and finished products (Dörge *et al.* 1999). Quarry products, in particular, can be an important vector of translocation for terrestrial gastropods (Fischer & Reischütz 2010; Michalak & Price 2010).

The objective of our study was to examine stone yards in the South-Eastern part of Belgium to determine whether the transportation of quarry products serves as a vector for introducing non-native land snail species to Belgium. We report here the first records for Belgium of six species of terrestrial gastropods and the first record for Wallonia (southern Belgium) of another one. The living individuals of four European species as well as shells with remains of the dead animals of three Asian species were all found in the same stone yard. We completed our study with additional surveys and database checks to determine whether any of these species have already established themselves in Belgium.

Material and methods

Field surveys

Surveys of terrestrial gastropods were conducted in four large stone yards located in the province of Liège (Belgium): in April, May and October 2022 in the yard of a natural stone importer situated next to the Liège autonomous port, in Hermalle-sous-Argenteau (50.7173° N, 5.6710° E; 3.5 ha), in June 2022 and February 2023 in the yard of a reseller of Belgian quarry products and recycler of street cobblestones from Belgium, the Netherlands and northern Germany, in Herstal (50.6976° N, 5.5886° E; 3.6 ha), in December 2022 and January 2023 in the yard of a stone producer in Sprimont and in the "Centre d'interprétation de la pierre" (CIP), located next to and historically linked to the stone yard (50.5052° N, 5.6680° E; 6.2 ha), and in February and April 2023 in the yard of a construction equipment store in Sankt-Vith (50.2884° N, 6.0965° E; 4.1 ha) (Figs 1–2). Those parts of the ground of the yards not constantly traversed by forklifts or trucks, the pallets and their feet, and the feet of stone piles were browsed with bare eyes while walking at a slow pace (ca 3 km/h). The inner and surrounding walls, and the feet of the walls were inspected more cautiously (approx. 60 m/h), with bare eyes and with the help of magnifying glasses with a factor 2×. Stones, logs and other objects lying on the ground and being light enough to be turned were also inspected.

From May 2022 to September 2023, the new species found in Hermalle-sous-Argenteau were furthermore specifically sought in the outdoor demo spaces of 20 smaller construction equipment or stone stores.

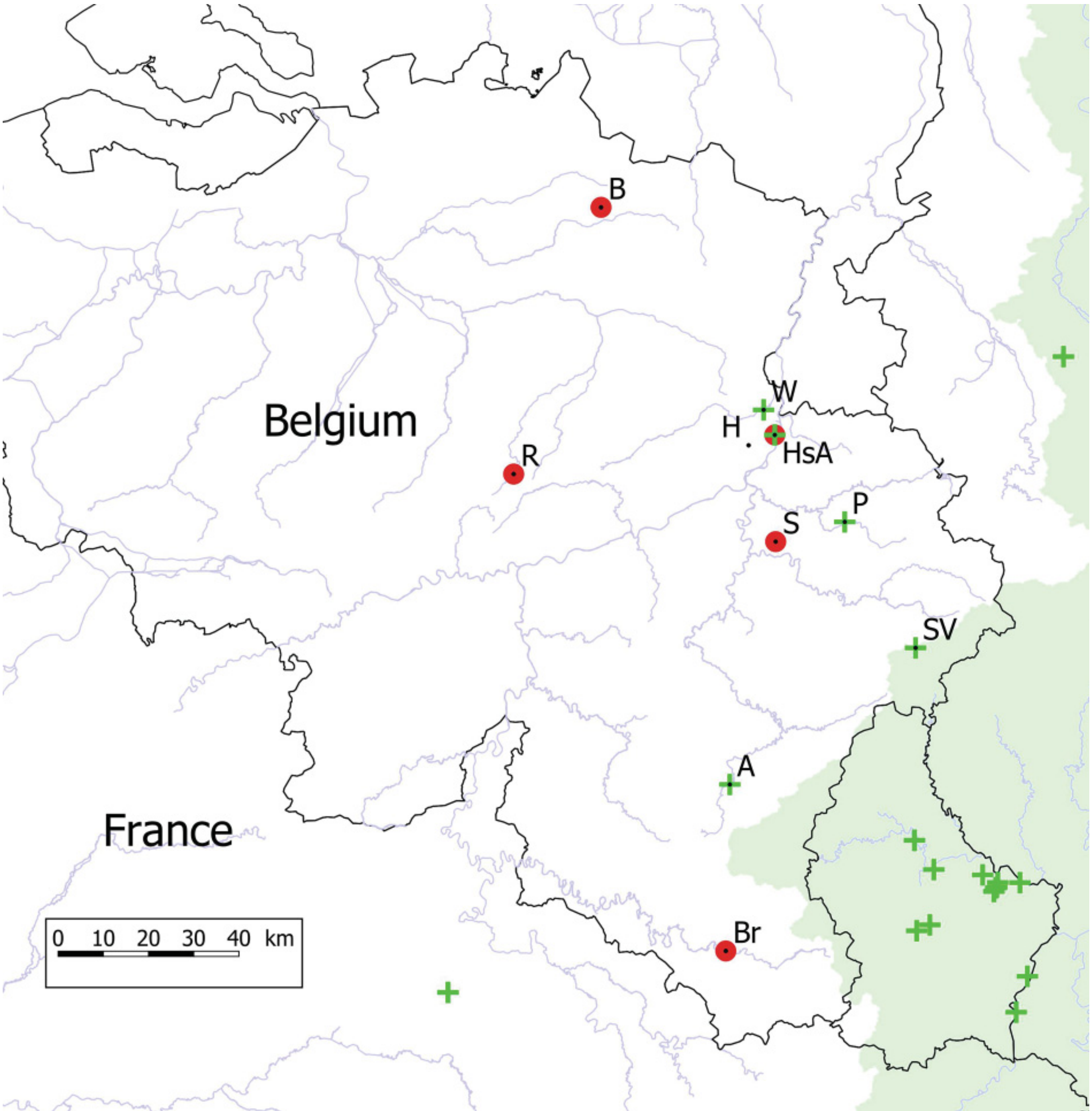

Figure 1 – Localities mentioned in the text (A = Amberloup; B = Balen; Br = Breuvanne; H = Herstal; HsA = Hermalle-sous-Argenteau; P = Polleur; R = Ramillies; S = Sprimont; SV = Sankt-Vith; W = Wonck). Green crosses = records of *Laciniaria plicata* (present study; GBIF 2023a); red dots = records of *Charpentieria itala* (present study). *Acusta* sp., *Bradybaena jourdyi*, *Cathaica fasciola*, *Chilostoma cingulatum* and *Theba pisana* were found in Hermalle-sous-Argenteau. Light green = Rhine basin.

Figure 2 – View of the stone yard in Hermalle-sous-Argenteau with, in front, the eastern wall of hollow concrete blocks in which most living individuals of the species being new to Belgium were found (see text). 2 May 2022 (Photo: J. Delcourt).

Material collected

Empty shells were collected. One living animal of each species new to Belgium was collected at each site and conserved in alcohol after euthanasia. The individuals of *Theba pisana* (Müller, 1774), a species with described invasive potential (Cowie 2022), were all collected and euthanized.

In addition, up to 1st October 2023 we reviewed documented sightings from Belgium, Luxembourg and The Netherlands for unidentified species (Gastropoda indet.) and species that resembled the species new to Belgium, using data from the citizen science portals https://observations.be / https://waarnemingen.be, https://waarneming.nl and https://iNaturalist.org, as well as our private shell collections.

Pictures were made using a Xiaomi 11T smartphone. The photos of shells were stacked with the software Helicon Focus 8 (www.heliconsoft.com). Shells and alcohol specimens were deposited in the RBINS collections (I.G. 34725).

Identification

The identification to the species level was first attempted with the help of guides to European gastropods (Welter-Schultes 2012; Rowson *et al.* 2014; Wiese 2014). Identification of exotic snail species can be impossible without, and sometimes even with, a DNA sequence-identification approach (i.e., RICHLING & VON PROSCHWITZ 2021). Nevertheless, we browsed the shells of terrestrial species in collection galleries (NMR 2022; POPPE & POPPE 2022; MNHN 2022) to discover any possible matches with the collected shells that did not correspond to European species. Subsequently, we further confirmed identifications with available literature on the matching species.

Here, we provide a brief description of the morphological characteristics of the six species previously unknown in Belgium and of the species previously unknown in Wallonia. Four of those seven species are European and three are Asian.

Charpentieria itala (Martens, 1824) (Fig. 3A) is a door snail (Clausiliidae) of variable shell height (14–23 mm), with an aperture whose height exceeds one-quarter of the total shell height, and often with

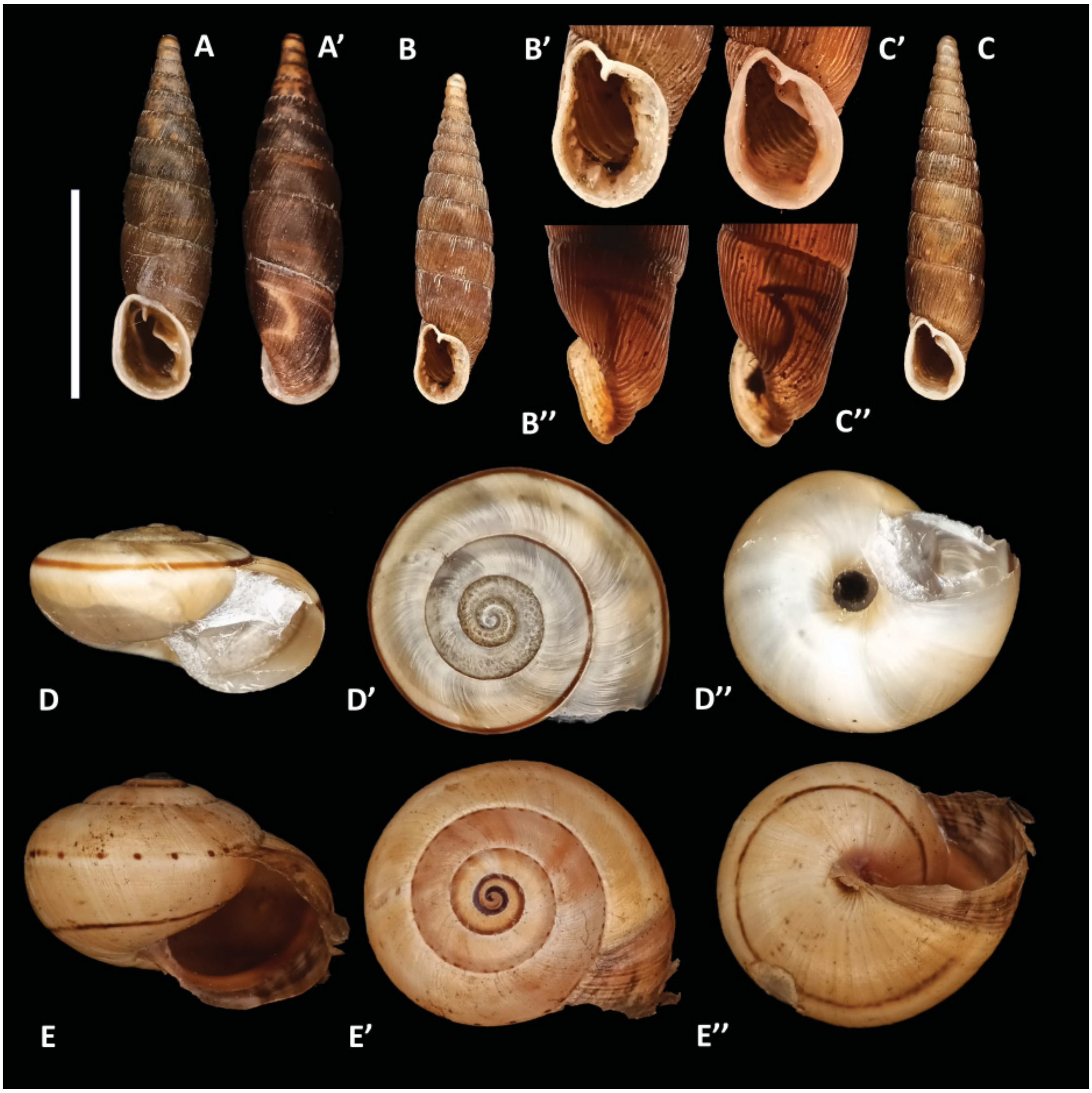

Figure 3 – Shells of the European species new to Belgium or Wallonia found in Hermalle-sous-Argenteau. **A**. *Charpentieria itala*. **B**. *Laciniaria plicata*. **C**. *Alinda biplicata*, provided for comparison with *L. plicata*. **D**. *Chilostoma cingulatum*. **E**. *Theba pisana*. The depicted shells are all adults with the exception of that of *C. cingulatum*. Scale bar: 10 mm.

a very typically papillated suture. The prominent columellaris, the rounded cervix and the frequently smooth surface, especially of the lower whorls, allow at first glance confusion with *Cochlodina laminata* (Montagu, 1803), native in Belgium. Nevertheless, *C. itala* has a lunula (absent in *C. laminata*), which shows through fresh shells (Fig. 3A'). The shape of the lunula separates *C. itala* from other species of the genus *Charpentieria* (Welter-Schultes 2012; Wiese 2014).

Laciniaria plicata (Draparnaud, 1801) (Fig. 3B) is another door snail (Clausiliidae), with a shell measuring 15–18 mm, with marked ribs, basal keel, and a groove at the lower part of the aperture. The presence of 7–10 folds on the apertural rim is the most obvious difference from *Alinda biplicata* (Montagu, 1803), native in Belgium (Fig. 3C). These folds, however, can be absent. The shape of the lunula (more rounded in *A. biplicata*) and the relative position of frontal upper palatalis and principalis (diverging in *A. biplicata* and nearly parallel in *L. plicata*) (Fig. 3B") are reliable identification criteria (Welter-Schultes 2012; Wiese 2014; Hey *et al.* 2017).

Chilostoma cingulatum (Studer, 1820) (Fig. 3D) is a large flat helicid landsnail (Helicidae) (with a shell diameter of 20–27 mm when adult). The characteristics of the shells of the immature individuals collected (flat top, large size (10 mm at 3 whorls), opaque cream background with a single brown band above the periphery lined above and below with white, slightly eccentric umbilicus measuring about ⅙ of the diameter, smooth ribs) match many of the 28 subspecies, including the nominal one (Welter-Schultes 2012; Wiese 2014; Groenenberg *et al.* 2016; Páll-Gergely *et al.* 2020; MolluscaBase 2022).

Theba pisana (Müller, 1774) (Fig. 3E) is a middle-sized helicid snail (Helicidae) (with a shell diameter of 12–25 mm). The globular shell has a white or yellowish background with variable bands and spots. The apex is usually darker, and the lips pink. The umbilicus is narrow, and half covered. Juvenile shells are typically keeled (Welter-Schultes 2012; Wiese 2014).

Acusta Martens, 1860 (Fig. 4A) is a genus of the Camaenidae. The morphological limits between the conchologically similar species are debated (Hwang *et al.* 2021). The adult shell found in this study is large (19.6 mm wide), semi-clear globular and reminiscent of that of *Fruticicola fruticum* (Müller, 1774), the only Camaenidae native in Belgium (Van Goethem 1988). However, the shells of the genus *Acusta* can be differentiated from *F. fruticum* by the presence of a tiny umbilicus and the characteristic non-reflected lip.

Bradybaena jourdyi (Morlet, 1886) (Camaenidae) (Fig. 4B) has a unicolourous, globular shell with slightly keeled and remarkable growth lines. Adult shells are 13–21 mm wide and count 5.5 whorls (Morlet 1886; Schileyko 2011; Inkhavilay *et al.* 2019).

Cathaica fasciola (Draparnaud, 1801) (Camaenidae) (Fig. 4C) has an almost discoidal shell, depressed and coloured light cream with a reddish-brown band at the periphery, occasionally with a second band on the top of the whorls. The top of the shell is regularly ribbed whereas the lower part is nearly smooth. The aperture is elliptic with a flat bottom. The lip is not reflected, and a strong internal rib appears as a thick white band in lateral view (Philippi 1845; Zhang *et al.* 2015).

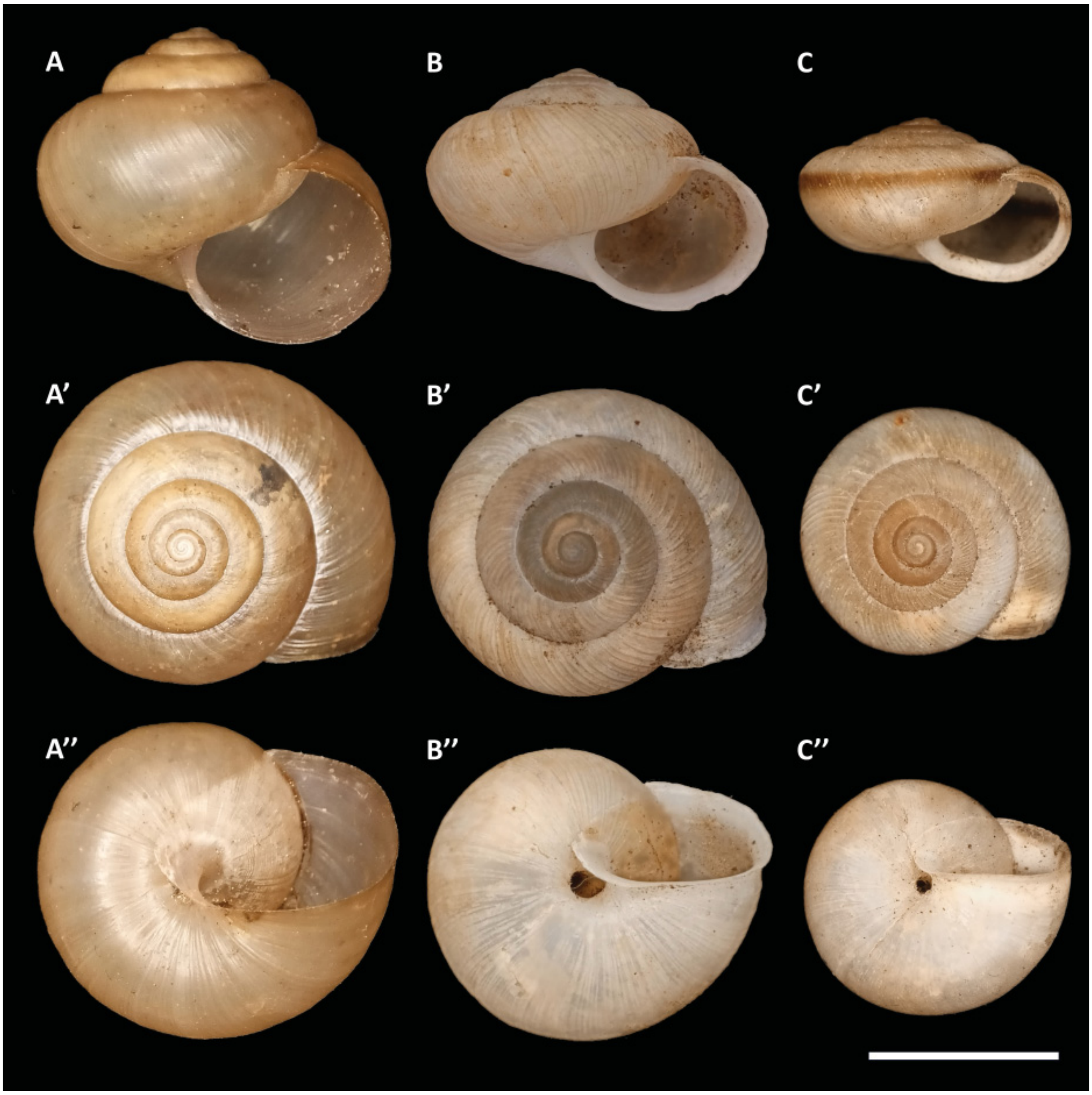

Figure 4 – Shells of the Asian species found in Hermalle-sous-Argenteau. **A**. *Acusta* sp. **B**. *Bradybaena jourdyi*. **C**. *Cathaica fasciola*. The depicted shells are adults. Scale bar: 10 mm.

Results

The surveys in the four large stone yards resulted in 63 terrestrial gastropod species; 34 of which were found in a single stone yard (Table 1).

In Hermalle-sous-Argenteau, we discovered six species previously unknown to Belgium and one previously unknown to Wallonia. Living individuals, all adult, of *Laciniaria plicata* and *Charpentieria itala* were found in April–May and in October. Living individuals, all immature, of *Chilostoma cingulatum* were only found in April-May. Empty shells with dead individuals of *Acusta* sp., *Bradybaena jourdyi* and *Cathaica fasciola* were found in April–May. Shells of *B. jourdyi* and *C. fasciola* were still found in October. Living individuals and shells of *Theba pisana* were only detected in October. All

TABLE 1

Species found in the stone yards in Hermalle-sous-Argenteau, Herstal, Sankt-Vith and Sprimont. L = living animal; S = shell (empty or with remains of the dead animal). An asterisk (*) indicates that identification was based on genitalia (on external features only otherwise). Years of the first discovery in Belgium and Wallonia (De Wilde *et al.* 1986; Van Goethem 1988; Bronne & Delcourt 2022; Hausdorf 2023; https://observations.be; T. Van den Neucker, pers. comm., January 2023).

Species	**Hermalle-sous-Argenteau**	**Sprimont**	**Herstal**	**Sankt-Vith**	**New to Belgium**	**New to Wallonia**
Acusta sp.	3 S				2022	2022
Bradybaena jourdyi (Morlet, 1886)	2 S				2022	2022
Cathaica fasciola (Draparnaud, 1801)	50 S				2022	2022
Charpentieria itala (Martens, 1824)	11 L + 13 S	11 L + 2 S			2022	2022
Chilostoma cingulatum (Studer, 1820)	11 L + 6 S				2022	2022
Laciniaria plicata (Draparnaud, 1801)	7 L + 21 S			5 L	2022	2022
Theba pisana (Müller, 1774)	5 L + 2 S				<1986	2022
Paralaoma servilis (Shuttleworth, 1852)	L				2005	2016
Morlina glabra (Rossmässler, 1835)		L			2014	2014
Ambigolimax valentianus (Férussac, 1821)	L				<1986	2012
Hygromia cinctella (Draparnaud, 1801)	S	L	S		1994	1994
Aegopinella nitidula (Draparnaud, 1850)	S	L	S		<1986	<1986
Aegopinella pura (Alder, 1830)		S			<1986	<1986
Alinda biplicata (Montagu, 1803)	L	L	L	L	<1986	<1986
Arion (*Carinarion*) sp.		L			<1986	<1986
Arion distinctus Mabille, 1868		L*			<1986	<1986
Arion hortensis Férussac, 1819	L	L*		L	<1986	<1986
Arion intermedius Normand, 1852	L				<1986	<1986
Arion subfuscus (Draparnaud, 1850)				L*	<1986	<1986
Arion vulgaris Moquin-Tandon, 1855	L*			L	<1986	<1986
Backeljaia gigaxii (Pfeiffer, 1847)			S		<1986	<1986
Candidula unifasciata (Poiret, 1801)		S			<1986	<1986
Cepaea hortensis (Müller, 1774)	L	S			<1986	<1986
Cepaea nemoralis (Linnaeus, 1758)	L	S	S	S	<1986	<1986
Chondrina avenacea (Bruguière, 1792)		L			<1986	<1986
Clausilia bidentata (Strøm, 1765)	L	L	S	S	<1986	<1986
Clausilia rugosa (Draparnaud, 1801)		L			<1986	<1986
Cochlicopa lubricella (Porro, 1838)	S	S	S	S	<1986	<1986
Cochlicopa lubrica (Müller, 1774)	S	S	S		<1986	<1986
Cochlodina laminata (Montagu, 1803)	L				<1986	<1986

Species	Hermalle-sous-Argenteau	Sprimont	Herstal	Sankt-Vith	New to Belgium	New to Wallonia
Columella edentula (Draparnaud, 1805)		L			<1986	<1986
Cornu aspersum (Müller, 1774)	L	L	S		<1986	<1986
Deroceras invadens Reise, Hutchinson, Schunack & Schlitt, 2011	L				<1986	<1986
Deroceras reticulatum (Müller, 1774)		L		L*	<1986	<1986
Discus rotundatus (Müller, 1774)	L	L	S	L	<1986	<1986
Fruticicola fruticum (Müller, 1774)		L			<1986	<1986
Helicella itala (Linnaeus, 1758)		L			<1986	<1986
Helicigona lapicida (Linnaeus, 1758)		S			<1986	<1986
Helix pomatia Linnaeus, 1758		L			<1986	<1986
Lauria cylindracea (da Costa, 1778)	L	L			<1986	<1986
Limax maximus Linnaeus, 1758	L				<1986	<1986
Macrogastra attenuata (Rossmässler, 1835)				L	<1986	<1986
Merdigera obscura (Müller, 1774)		L	S		<1986	<1986
Monacha cantiana (Montagu, 1803)	S				<1986	<1986
Monacha cartusiana (Müller, 1774)	L	S	S		<1986	<1986
Nesovitrea hammonis (Strøm, 1765)				S	<1986	<1986
Oxychilus cellarius (Müller, 1774)				L	<1986	<1986
Oxychilus draparnaudi (Beck, 1837)	L	L*	L	L	<1986	<1986
Phenacolimax major (Férussac, 1807)				L	<1986	<1986
Pupilla muscorum (Linnaeus, 1758)	S	L			<1986	<1986
Pyramidula pusilla (Vallot, 1801)		L			<1986	<1986
Succinea/Oxyloma sp.	S			S	<1986	<1986
Succinella oblonga (Draparnaud, 1801)	L	S	S		<1986	<1986
Trochulus hispidus (Linnaeus, 1758)	L	S	S	L	<1986	<1986
Vallonia costata (Müller, 1774)	L	L	S	S	<1986	<1986
Vallonia excentrica Sterki, 1893		S		S	<1986	<1986
Vertigo substriata (Jeffreys, 1933)				L	<1986	<1986
Vertigo pusilla Müller, 1774				L	<1986	<1986
Vertigo pygmaea (Draparnaud, 1801)	S			S?	<1986	<1986
Vitrea contracta (Westerlund, 1871)		L			<1986	<1986
Vitrina pellucida (Müller, 1774)		L		L	<1986	<1986
Xeroplexa intersecta (Poiret, 1801)	L	L	L	S	<1986	<1986
Zonitoides nitidus (Müller, 1774)		L		L	<1986	<1986

living specimens of *L. plicata*, *C. itala* and *C. cingulatum* were found in, on or near the eastern wall of hollow concrete blocks (on a 20 m long section, for *L. plicata*) (Fig. 2), except for one *C. itala*, which was discovered in the lawn along the southern fence, underneath a wooden board, and one *C. cingulatum* individual which was found at the foot of the western wall made of calcareous stones. The living animals and shells of *T. pisana* were collected near pallets from Spain and Portugal at the edge of the grassland north of the stone yard. The two shells of *B. jourdyi* and one of *Acusta* sp. were detected near pallets from Vietnam. The other shell of *Acusta* sp. and the shells of *C. fasciola* were found in less than 4m distance from pallets from China.

In Sprimont, living adults and immatures of *C. itala* were discovered over 250 m on the walls on both sides of the road that crosses the stone yard (Fig. 5A). In Sankt-Vith, living adults and immatures of *L. plicata* were found on a concrete wall in the demonstration garden and on concrete blocks of the eastern wall. In Herstal, only species known to occur in Belgium for a long time were found (Table 1). New locations of *L. plicata* were also discovered during the sampling of the outdoor demo spaces of smaller construction equipment or stone stores: in December 2022 in Polleur (4 adults being alive; 50.5418° N, 5.88464° E, sighting 261368769), in June 2023 in Wonck (a fresh empty shell; 50.7675° N, 5.6374° E, sighting 278075305) and in October 2023 in Amberloup (5 adults and 2 immatures being alive; 50.02405° N, 5.5133° E, sighting 289439640).

Inspection of the documented sightings of *C. laminata* on https://observations.be and https://waarneming.nl disclosed a few occurrences of the species new to Belgium outside locations associated with the stone trade: a living adult of *C. itala* in Balen (51.1745° N, 5.1341° E, April 2019, sighting 211237346; Fig. 5B), three living adults in Breuvanne (49.6931° N, 5.4931° E, May 2023, sighting 271360144) and four living immatures, two living adults and eight empty shells in Ramillies (50.6458° N, 4.8522° E, September 2023, sighting 289319186).

Figure 5 – Living individuals of *Charpentieria itala* found in Belgium. **A**. Living individual feeding on *Lecanora* gr. *albescens* found on 23 December 2022 on the wall of the stone yard in Sprimont. **B**. Specimen found in Balen close to imported tiles. Scale bar: 10 mm. (Photos: L. Bronne & E. Weetjens)

Discussion

The findings in the stone yard in Hermalle-sous-Argenteau (Wallonia, Belgium) include four European species (all found alive) and three Asian species (only found dead or as empty shells) new to Belgium or Wallonia. Two of the European species new to Belgium have also been discovered in other sites (Fig. 1). We discuss the role of the trade of stones for the arrival of these new species and the probability of their settlement.

Native range and habitats

The presumed native range of *C. itala* covers the south of the Alps, where it is often found on old walls in human settlements (WELTER-SCHULTES 2012). *Laciniaria plicata* is an Eastern and Central European species, living on rocks and frequently found on walls in human settlements (SULIKOWSKA-DROZD 2005; WELTER-SCHULTES 2012; WIESE 2014). Its known range extends west to Luxembourg (ADAM 1947; GBIF 2023a, data checked by K. Groh), North Rhine-Westphalia (KOBIALKA *et al.* 2009) and Eastern France (BICHAIN *et al.* 2023). *Chilostoma cingulatum* lives on (natural) limestone walls in the (mainly eastern) Alps as well as in areas of the northern and central Apeninnes (WELTER-SCHULTES 2012).

The worldwide distribution of *Theba pisana* is strongly facilitated by human introductions. This xerothermophilic species originates from Northwest Africa and later naturally spread to the Iberian Peninsula. The historical range covering the Mediterranean coasts and the adjacent Atlantic coasts may already have been shaped by human activities (DÄUMER *et al*. 2012). Atlantic coasts are continuously occupied northwards up to the Netherlands, including the Belgian coast.

The three other species new to Belgium come from Asia. *Bradybaena jourdyi* has been reported only from northern Vietnam and Laos (MORLET 1886; SCHILEYKO 2011; INKHAVILAY *et al.* 2019; GBIF 2023b) and is one of the most common species in Tonkin (northern Vietnam) (MORLET 1886; KHẮC *et al.* 2012; B. Páll-Gergely, pers. comm., November 2022). In particular, it lives in limestone mountains (HOÀNG NGỌC *et al.* 2021). The genus *Acusta* is widespread in East Asia and northern Indonesia (DE-NIU *et al.* 2002; HWANG *et al.* 2021). *Cathaica fasciola* (Camaenidae) is widely distributed in China, Japan, and the isle of Guam. This species is eurytopic, which explains its wide distribution (NAIQIN *et al.* 2018).

Man-aided dispersion tendency

Charpentieria itala, *C. cingulatum*, *C. fasciola*, *Acusta* sp., *Bradybaena* sp. and, most of all, *T. pisana* have all been intercepted at US maritime ports between 1997 and 2007 (COWIE & ROBINSON 2003; MEISSNER *et al.* 2009). Nevertheless, only *T. pisana* is reported to have become established in the USA, where the species is ranked as third mollusc in terms of pest potential (COWIE *et al.* 2009). *Theba pisana* was introduced by humans and is widespread in California, the southern UK, Macaronesia, Australia, southern African countries and countries around the Red Sea (DÄUMER *et al.* 2012; VENDETTI *et al.* 2021; EPPO 2023). *Theba pisana* has also been sporadically found in Helgoland (Germany), Finland, the Democratic Republic of Congo, and, for Belgium, in inland Flanders and in Brussels (WIESE 2014; https://www.inaturalist.org/observations/92097501; KAYEYE *et al.* 2014; http://observations.be). Recently, *C. fasciola* has also been intercepted in Germany, the Greater Caribbean Region and in Australia, and *Acusta despecta* (Sowerby, 1839) in Australia (MEISSNER *et al.* 2009; BAUFELD *et al.* 2018; DAFF 2022). *Laciniaria plicata* has never been reported outside of Europe (GBIF 2023a) and the present occurrence of *B. jourdyi* in Belgium is the first report outside of eastern Asia (GBIF 2023b).

The role of stone yards

Quarry products can be an important vector of translocation for terrestrial gastropods (Michalak & Price 2010; Fischer & Reischütz 2010; Rosenbauer 2011). For instance, between 1985 and 2009, in the USA, 45% of the land snail and slug interceptions from temperate countries occurred with tiles, and an additional 5% on other quarry products. In the same study, 13% of the interceptions took place on containers (Michalak & Price 2010). When examining published data from other countries, such as Canada or New Zealand, or earlier periods in the USA, it is consistently observed that interceptions of snails and slugs mainly occurred with agricultural and horticultural products. In many cases, quarry products did not feature in the results. However, the results are biased, because they were derived from efforts to prevent introduction of pest, relying on known potential pathways (Cowie & Robinson 2003).

In our study, four of the species new to Belgium and the species new to Wallonia were exclusively found in the yard of an importer of natural stones in Hermalle-sous-Argenteau. The two other species new to Belgium, *L. plicata* and *C. itala*, were also discovered on stones in a few other man-made sites, separated from Hermalle-sous-Argenteau and among each other by at least 6.4 km (Fig. 1). The concentration of new species strongly suggests that at least some of those species have been imported to Hermalle-sous-Argenteau with the stones or the containers and pallets. In Central European stone yards, *C. itala* and *C. cingulatum* are the most frequent species reported as introduced by stone transportation (present in respectively 16 and 12 sites out of 43 in Rosenbauer (2011) and Fischer (2020)). The affinity of *L. plicata* for human settlements (Sulikowska-Drozd 2005; Wiese 2014) makes it a good candidate for translocation with quarry products, although in the scientific literature there is only one report of its translocation (with gardening products) (Dvořák 2016). The only interception of living individuals of *C. fasciola* in Europe also occurred on stone products (Baufeld *et al.* 2018). The documented pathways for *T. pisana* include the transport of goods; the species is frequently found on containers, as is *C. fasciola* (Meissner 2009; Vendetti *et al.* 2021). Translocation most certainly also concerns other alien species long established in Belgium, but it is impossible to assess without molecular research to what extent they contribute to the genetic diversity of the populations of land snails in the different stone yards.

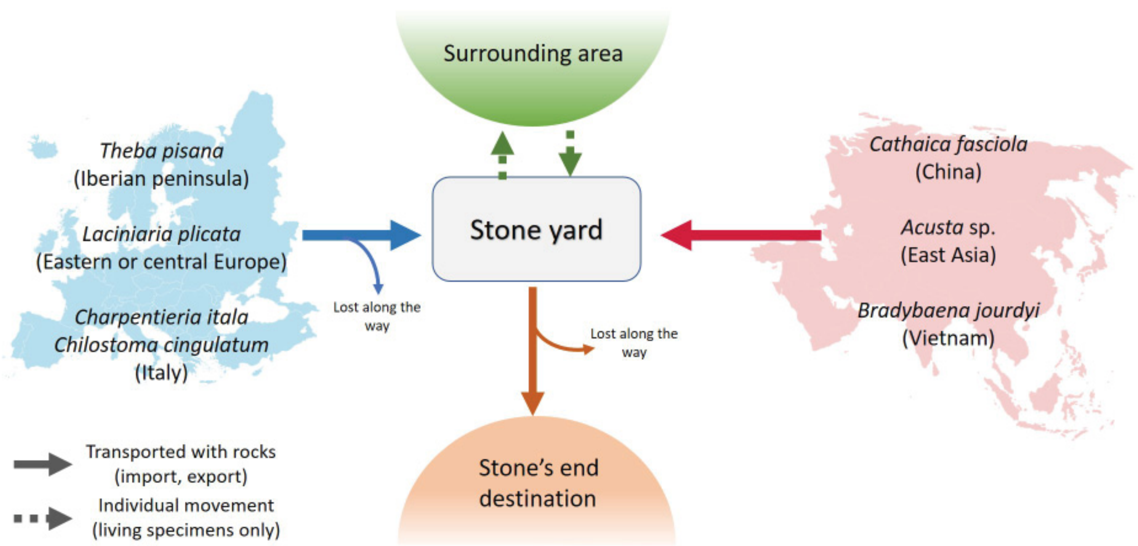

Figure 6 – Gastropod movements from their presumed origin (based on the origin of the rocks found in proximity) to the stone yard in Hermalle-sous-Argenteau and beyond. Although European species can frequently be transported and arrive alive, this does not seem to be the case with the Asian species. Sometimes individuals can be lost along the way, and do not arrive at the destination of the stones.

Stone yards could also serve as hubs for snails, just as they do for quarry products (Fig. 6). The company Bauma Stones, who established the stone yard in Hermalle-sous-Argenteau in 2014, provides resellers from Dortmund (Germany) to Nantes (France) (J.-P. Haesen, pers. comm., June 2022), including the construction equipment stores in Polleur and Sankt-Vith, where populations of *L. plicata* were found, and in Wonck, where an empty shell of *L. plicata* was found. Interestingly, the population of *L. plicata* in Hermalle-sous-Argenteau has been found less than 5 m from where paving stone displays are stored. The shell of *L. plicata* in Wonck and the population in Amberloup have been discovered at the foot of paving stone displays, although belonging to other companies than Bauma Stones. The living individual of *C. itala* found in Balen (Belgium) in 2019 was discovered shortly after the renovation of a terrace with new tiles bought from a local retailer of Italian and Spanish tiles (E. Weetjens, pers. comm., May 2022; mertensvloeren.be, accessed on 2 June 2022).

The other Belgian populations of *C. itala* could be older. The species has been living on the Heidelberg castle since 1923 (SCHMID 2002), at 232, 246, and 308 km from Breuvanne, Sprimont, and Ramillies, respectively. However, the climate in Heidelberg is slightly more continental (https://weather-and-climate.com/) and we have not estimated the theoretical distribution range of *C. itala*. In the stone yard in Sprimont, where *C. itala* was also found, no stones are currently imported from outside of the local quarry, but stones have been imported in the late 1980s and early 1990s from a quarry in Sudan. One empty shell was found stuck in calcareous deposits on the wall in Sprimont, suggesting *C. itala* being present for a long time (tufa precipitation takes several months). Nevertheless, non-local stones regularly appear in the container for broken stones and provide a likely pathway (C. Moureau, pers. comm., February 2023). Similarly, in Ramillies, the illegal dumping of construction waste next to the catholic monument where the population of *C. itala* has been found seems the most likely pathway (S. Moureau, pers. comm., September 2023) as this monument was likely built with Belgian stones (F. Tourneur, pers. comm., October 2023) and has remained unaltered since its construction in the 1940s (A. Verhaegen, pers. comm., September 2023). In Breuvanne, stones have been regularly added to the garden in which *C. itala* was found until 2021. Although most stones had been collected within a radius of 10 km, including quarries, additional building was done in 2012 with stones of unknown origin (R. Dujardin, pers. comm., May 2023).

Probability of settling

In areas surrounding a stone yard with little human activities, snail populations can settle if the environmental conditions are favourable to them. The continuous flow, and its magnitude, of snail importation into a stone yard could also impact the settling and the survival of a population. A single introduced gastropod individual can be the source of a new population if it carries allosperm or if it is hermaphroditic and capable of self-fertilization. Self-fertilization is widespread in stylommatophoran gastropods (BAUR & BAUR 2017) and has been observed in species of the families Clausiliidae, Helicidae and Camaenidae (ALMEIDA & BESSA 2001; CHEN 2009; MALTZ & SULIKOWSKA-DROZD 2014; SULIKOWSKA-DROZD *et al.* 2018). The simultaneous transport of several individuals allows cross-fertilization (allogamy) and can therefore contribute to a higher possibility of successfully founding a new population. If the reproductive longevity of the individuals is sufficient to allow mating with new arrivals, the population might benefit from increased genetic variability, which might in turn increase the probability of population survival. Finally, if the rate of new arrivals is very high, particularly if individuals survive a long time, the population size can increase by accumulation of living individuals, increasing the chance of population settlement. In Hermalle-sous-Argenteau, we have found several individuals of each land snail species found alive. However, we neither know if these individuals arrived during several occasions (with successive arrival of stones), nor if individuals being alive were the result of established populations.

Mediterranean Helicidae, Hygromiidae and Clausiliidae were found in Central European stone yards (Rosenbauer 2011; Fischer 2020). In many cases, persistent populations were observed. A long-lasting population of *C. cingulatum* in Germany (found in 1962 on a wall in Bad Liebenstein; 50.89° N; 9.00° E; Schmid 2000; Eta & Hausdorf 2019) seems to indicate the possibility of a long-term settlement in Belgium. *Chilostoma cingulatum* is, however, strictly restricted to open limestone areas, so it is not expected to spread widely (Eta & Hausdorf 2019) through Belgium as the also montane snail *Morlina glabra* (Rossmässler, 1835) has recently done (Bronne & Delcourt 2022).

Although the settlement of *C. itala* cannot be established with certainty in Hermalle-sous-Argenteau, the persistence of a population without regular reinforcement seems highly probable in Ramillies and in Sprimont, where no regular importation of material occurs from outside of the quarry. Currently, the present observations of *C. itala* in Belgium are the northernmost published records of the species. Belgian winter temperatures are not a limiting factor as *C. itala* lives up to 1700 m altitude in Switzerland (Welter-Schultes 2012). Past introductions in Baden-Württemberg (Germany) have remained localized (Schmid 2002). Introduced populations of *C. itala* seem, however, able to spread in a favourable rocky habitat. In Sprimont, the large walls around the quarry and the neighbouring "Centre d'interprétation de la pierre" provide such circumstances. The living individuals were found over a stretch of 250 m. The spread of an introduced population over an area of the same magnitude is also described in Salzburg (Austria) where Kwitt & Patzner (2019) reported the presence of *C. itala* in a graveyard and in the display area of a neighbouring stonemasonry. *Charpentieria itala* feeds on algae and lichens (Welter-Schultes 2012; Fig. 5A) and is therefore not likely to present risks for human economy.

As for *C. itala*, the persistence of a population of *L. plicata* cannot be established in Hermalle-sous-Argenteau but seems very probable within the yard of a building material store in Sankt-Vith, where adults and immatures were found at two different spots, and in Amberloup, where we found living adults and both immature and adult shells. The presence of *L. plicata* in the yard in Sankt-Vith may not necessarily result from a human-aided translocation. Indeed, the known distribution of *L. plicata* is so close to the Belgian Eastern border that Van Goethem (1988) suggested that the species could occur in Belgium. Sankt-Vith is situated in the Rhine basin and quite close (40 km) to its native range (Fig. 1). The putative old presence of the species in the French Ardennes (Fig. 1; Bourguignat 1877; Gargominy 2022) even suggests a (past?) range including a larger part of Wallonia. If true, the species either could have disappeared or simply was overlooked. The similarity with *A. biplicata*, the most reported door snail in Belgium (https://observations.be; https://inaturalist.org), and the absence of *L. plicata* in the field guides covering Belgium and/or the Netherlands (Devriese *et al.* 1997; Vilvens *et al.* 2008; Jansen 2015), could explain that the species had not been reported before. Nevertheless, we only found *L. plicata* five times in Belgium whereas we recorded *A. biplicata* 465 times in various environments (236 times after the first find of *L. plicata*) during non-random sampling of terrestrial gastropods that we conducted from 2017 to September 2023, especially in the province of Liège (data available on https://observations.be).

Theba pisana is already established in the Belgian coast area, but is here observed for the first time in Wallonia. The first reported Belgian observations of *T. pisana* date back to the 1860s, to the west of Oostende, where acclimatization experiments of individuals from Algeria were carried out, but no living individuals were observed in 1869 (Adam 1947). In 1934, the species was rediscovered nearby, in Mariakerke (Hostie 1935). However, Langeraert (2021) showed that the present populations are genetically closer to those of Iberia, southern France, and northern France. In the stone yard in Hermalle-sous-Argenteau, the presence of pallets from Spain and Portugal near the found specimens suggests an Iberian origin. In xerothermophilous conditions, *T. pisana* can rapidly develop high population densities which make the species a potentially serious, and difficult to control pest (Cowie 2022). In southern Australia, for instance, *T. pisana* has a significant impact on agronomic grain crops (Baker 2002). In

Belgium, *T. pisana* could also colonize sandy habitats, industrial sites, gardens, and agricultural lands and therefore become an agricultural pest aided by global warming (Beck *et al.* 2018).

The cases of Asian species

In their native range, *Acusta* species and *Cathaica fasciola* are considered agricultural pests in China, where they belong to the dominant snail taxa (De-niu 2002; Zhang *et al.* 2015; Baufeld *et al.* 2018; Hwang *et al.* 2021). Furthermore, *C. fasciola* is an intermediate host for the pancreas fluke *Eurytrema pancreaticum* Janson, 1889, which mainly infects ruminants globally and human beings accidentally (Baufeld *et al.* 2018). The invasive potential and the main transportation paths of *C. fasciola* have been long known: in 1909, the species was noted as recently introduced and rapidly spreading in a residential portion of British Weihaiwei, a territory in constant naval communication with mainland China (Jones & Preston 1910). A risk analysis carried out after the interception of living individuals of *C. fasciola* in Germany suggested putting the species on the European Quarantine list (Baufeld *et al.* 2018; G. Schrader, pers. comm., May 2022). Among the genus *Acusta*, *A. ravida* (Benson, 1842) could also present a risk for European agriculture, as in China, within its native range, it behaves as an agricultural pest under climatic and land-use conditions similar to Western Europe. Indeed, in the field, the species can survive temperatures from -29 to 44°C and is active between 10–35°C (mainly 16–22°C) and at relative humidity above 67% (De-niu 2002; https://weather-and-climate.com/). *Bradybaena jourdyi* has only been found in monsoon-influenced humid subtropical climate (“Cwa” in Köppen climate classification) and therefore seems less prone to present risks in Western Europe (Beck 2018).

Acknowledgements

We first thank the staff of Bauma Stones AG, especially Jean-Paul Haesen, Sprimont Blue, Van Dijck s.a. and ASB-Gedimat for making us feel at home in their stone yards. We also thank Eef Weetjens, Rudi Dujardin, Pascale Hindricq, Sophie Moureau, Arthur Verhaegen, Francis Tourneur and Gritta Schrader for providing us with additional information, Ward Langeraert and Tom Van den Neucker for sharing knowledge about *T. pisana*, Emmanuël Sérusiaux for lichen identification and Caroline Orban for advice and proofreading. We are also very grateful to Céline Moureau for the care she put in finding all the possible origins of Italian material at Sprimont. Two anonymous reviewers, the desk editor and the editor in chief greatly helped improving the manuscript.

References

Adam W. (1947). *Révision des mollusques de la Belgique I. Mollusques terrestres et dulcicoles.* Musée royal d’histoire naturelle de Belgique, Bruxelles.

Almeida M.N. & Bessa E.C. de A. (2001). Estudo do crescimento e da reprodução de *Bradybaena similaris* (Férussac) (Mollusca, Xanthonychidae) em laboratório. *Revista brasileira de zoologia* 18: 1115–1122.

Baker G.H. (2002). Helicidae and Hygromiidae as pests in cereal crops and pastures in South Australia. *In:* Barker G.M. (ed.) *Molluscs as Crop Pests*: 193–215. CAB International, Wallingford. https://doi.org/10.1079/9780851993201.0193

Bartlow A. & Agosta S. (2021). Phoresy in animals: review and synthesis of a common but understudied mode of dispersal. *Biological Reviews* 96: 223–246. https://doi.org/10.1111/brv.12654

Baufeld P., Schrader G. & Steinmöller S. (2018). Express-Risikoanalyse zu *Cathaica fasciola*. *Journal für Kulturpflanzen* 70: 163–165.

Baur B. & Baur A. (2017). Reproductive strategies in stylommatophoran gastropods. *In*: Saleuddin S. & Mukai S. (eds) *Physiology of Molluscs: a Collection of Selected Reviews, Volume 2*: 311–377. Apple Academic Press, Waretown, New Jersey.

Beck H., Zimmermann N., McVicar T., Vergopolan N., Berg A. & Wood E. (2018). Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data* 5: 180214. https://doi.org/10.1038/sdata.2018.214

Bichain J.-M., Hommay G. & Lamand F. (2023). Liste de référence annotée et actualisée des mollusques continentaux du Grand Est (France). *Bulletin de la Société d'Histoire naturelle et d'Ethnographie de Colmar* 79: 13–41.

Bourguignat J.R. (1877). Histoire des Clausilies de France, vivantes et fossiles. *Annales des Sciences Naturelles (Zoologie)* 5: 1–50.

Bronne L. & Delcourt J. (2022). The snail *Morlina glabra* (Gastropoda: Oxychilidae), although previously unreported, is widespread throughout Belgium and at least present in the Netherlands and Luxembourg. *Journal of Conchology* 44: 267–275.

Capinha C., Essl F., Seebens H., Moser D., & Pereira H.M. (2015). The dispersal of alien species redefines biogeography in the Anthropocene. *Science* 348: 1248–1251. https://doi.org/10.1126/science.aaa8913

Chen X. (2009). Self-fertilization and cross-fertilization in the land snail *Arianta arbustorum* (Mollusca, Pulmonata: Helicidae). *Journal of Zoology* 232: 465–471. https://doi.org/10.1111/j.1469-7998.1994.tb01587.x

Cowie R. (2022). *Theba pisana (White Garden Snail)*. CABI Compendium. CABI International. https://doi.org/10.1079/cabicompendium.62094

Cowie R. & Robinson D.G. (2003). Pathways of introduction of nonindigenous land and freshwater snails and slugs. *In:* Carlton J. (ed.) *Invasive Species: Vectors and Management Strategies*: 93–122. Island Press, Washington DC, USA.

Cowie R., Dillon R.T., Robinson D.G. & Smith J.W. (2009). Alien non-marine snails and slugs of priority quarantine importance in the United States: A preliminary risk assessment. *American Malacological Bulletin* 27: 113–122. https://doi.org/10.4003/006.027.0210

DAFF (2022). *National Hitchhiker (Contaminating) Plant Pest Action Plan 2022–2032*. Department of Agriculture, Fisheries and Forestry, Canberra. Available from https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/national-action-plans [accessed 15 September 2022].

Däumer C., Greve C., Hutterer R., Misof B. & Haase M. (2012). Phylogeography of an invasive land snail: natural range expansion versus anthropogenic dispersal in *Theba pisana pisana*. *Biological Invasions* 14: 1665–1682. https://doi.org/10.1007/s10530-012-0179-z

Delcourt J. (2022). L'ornithochorie des mollusques ou la dispersion des limaces et escargots par les oiseaux. *Aves* 59: 51–69.

De-Niu C., Guo-qing Z., Wenxian X., Man-sheng W., Yanhong L., Xingmin C. & Jiqing W. (2002). *Bradybaena ravida* (Benson) in cereal-cotton rotations of Jingyang County, Shaanxi Province, China. *In:* Barker G.M. (ed.) *Molluscs as Crop Pests*: 315–324. CAB International, Wallingford. https://doi.org/10.1079/9780851993201.0315

Devriese R., Warmoes T. & Vercoutere B. (1997). *Land- en zoetwatermollusken van de Benelux*. Uitgave van de Jeugdbond voor Natuurstudie en Milieubescherming, Gent. (3[e] druk), 192 p.

De Wilde J., Marquet R. & Van Goethem, J. (1986). *Voorlopige atlas van de landslakken van België/Atlas provisoire des gastéropodes terrestres de la Belgique*. Koninklijk Belgisch Instituut voor Natuurwetenschappen / Institut royal des Sciences naturelles de Belgique, Brussels.

Dörge N., Walther C., Beinlich B. & Plachter H. (1999). The significance of passive transport for dispersal in terrestrial snails (Gastropoda, Pulmonata). *Zeitschrift für Ökologie und Naturschutz* 8: 1–10.

Dvořák L. (2016). Two new records of *Laciniaria plicata* (Draparnaud, 1801) from western Bohemia (Gastropoda: Clausiliidae). *Malacologica Bohemoslovaca* 15: 1–2. https://doi.org/10.5817/MaB2016-15-1

Dvořák L.D. & Kupka J. (2007). The first outdoor find of an American snail *Zonitoides arboreus* (Say, 1816) from the Czech Republic. *Malacologica Bohemoslovaca* 6: 1–2.

EPPO (2023). *Theba pisana*. https://gd.eppo.int/taxon/THEBPI/distribution [accessed on 19 October 2023].

Eta K. & Hausdorf B. (2019). *Chilostoma cingulatum* (Studer, 1820) und *Cornu aspersum* (O.F. Müller, 1774) in Hamburg (Gastropoda: Helicidae). *Mitteilungen der Deutschen Malakozoologischen Gesellschaft* 100: 13–16.

Faliński J. (1972). Anthropochory in xerothermic grasslands in the light of experimental data. *Acta Societatis Botanicorum Poloniae* 3: 357–368. https://doi.org/10.5586/asbp.1972.028

Fischer S., Poschlod P. & Beinlich B. (1996). Experimental studies on the dispersal of plants and animals on sheep in calcareous grasslands. *Journal of Applied Ecology* 63: 1206–1221. https://doi.org/10.2307/2404699

Fischer W. (2020). Beiträge zur Kenntnis der österreichischen Molluskenfauna. LXX. Bemerkungen zu Neufunden von eingeschleppten Schnecken im Norden Wiens und dem südlichen Marchfeld. *Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft* 27: 29–32.

Fischer W. & Reischütz P. (2010). Beiträge zur Kenntnis der österreichischen Molluskenfauna XIX. Es kam nicht nur der Marmor nach Wien – Biodiversität auf dem Gelände eines ehemaligen Steinmetzbetriebes. *Nachrichtenblatt der Ersten Vorarlberger Malakologischen Gesellschaft* 17: 9–12.

Gargominy O. (2022). TAXREF. Version 4.9. UMS PatriNat (OFB-CNRS-MNHN), Paris. Checklist dataset. https://doi.org/10.15468/vqueam

GBIF (2023a). GBIF *Laciniaria plicata* Available from https://doi.org/10.15468/dl.2qm4nd [accessed on 25 February 2023].

GBIF (2023b). GBIF *Bradybaena jourdyi* Available from https://doi.org/10.15468/dl.v85ad2 [accessed on 25 February 2023].

Gheoca V., Benedek A.M. & Schneider E. (2023). Taxonomic and functional diversity of land snails reflects habitat complexity in riparian forests. *Scientific Reports* 13: 9808. https://doi.org/10.1038/s41598-023-36896-6

Groenenberg D.S.J., Subai P. & Gittenberger E. (2016). Systematics of Ariantinae (Gastropoda, Pulmonata, Helicidae), a new approach to an old problem. *Contributions to Zoology* 85: 37–65. https:/doi.org/10.1163/18759866-08501003

Hausdorf B. (2023). Distribution pattern of established alien land snail species in the Western Palaearctic Region. *NeoBiota* 81: 1–32. https://doi.org/10.3897/neobiota.81.96360

Hey P., Umbrecht K. & Bichain J.-M. (2017). Présence de la Clausilie septentrionale *Alinda biplicata biplicata* (Montagu, 1803) (Mollusca: Gastropoda, Clausiliidae) en milieu urbain (Strasbourg, Bas-Rhin). *Bulletin de la Société d'Histoire naturelle et d'Ethnographie de Colmar* 74: 35–39.

HOÀNG NGỌC K., TRẦN T. & NGUYỄN THANH B. (2021). Species composition of land snails in ban thi and Xuan Lac commune belong to Nam Xuan Lac species and landscape conservation area, Cho Don district, Bac Kan province. *Scientific Journal of Tan Trao University* 6: 111–118. https://doi.org/10.51453/2354-1431/2020/390

HORSÁK M., ŠTEFFEK J., ČEJKA T., LOŽEK V. & JUŘIČKOVÁ L. (2009). Occurrence of *Lucilla scintilla* (R.T. Lowe, 1852) and *Lucilla singleyana* (Pilsbry, 1890) in the Czech and Slovak Republics – with remarks how to distinguish these two non-native minute snails. *Malacologica Bohemoslovaca* 8: 24–27.

HOSTIE E. (1935). *Helix pisana*, Müll. en Belgique. *Les Naturalistes belges* 16: 24.

HULME P.E., 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 frame-work for integrating pathways into policy. *Journal of Applied Ecology* 45: 403–414. https://doi.org/10.1111/j.1365-2664.2007.01442.x

HWANG C.C., ZHOU W.-C., GER M.-J., GUO Y., QIAN Z.-X., WANG Y.-C., TSAI C.-L. & WU S.-P., (2021). Biogeography of land snail genus *Acusta* (Gastropoda: Camaenidae): Diversification on East Asian islands. *Molecular Phylogenetics and Evolution* 155: e106999. https://doi.org/10.1016/j.ympev.2020.106999

INKHAVILAY K., SUTCHARIT C., BANTAOWONG U., CHANABUN R., SIRIWUT W., SRISONCHAI R., PHOLYOTHA A., JIRAPATRASILP P. & PANHA S. (2019). Annotated checklist of the terrestrial molluscs from Laos (Mollusca, Gastropoda). *ZooKeys* 834: 1–166. https://doi.org/10.3897/zookeys.834.28800

JANSEN B. (2015). *Veldgids Slakken en Mossels.* KNNV Uitgeverij, Zeist.

JONES K.H. & PRESTON H.B. (1910). Notes on some species of Mollusca collected in China from 1904 to 1907, with descriptions of new species. *Journal of Molluscan Studies* 9: 9–12. https://doi.org/10.1093/oxfordjournals.mollus.a066312

KAYEYE J., KABALE B., CISHIBANJI P., MASHIMANGO J. & BAJOPE J. (2014). A preliminary survey and distribution of land snails of Katana region, southern Kivu, Democratic Republic of Congo. *International Journal of Innovation and Scientific Research* 9: 212-224.

KHẮC H.N., NHƯỢNG Đ.V., CẬY N.T. & NHẤT T.T. (2012). Landsnails (Gastropoda) in Tam Dao national park, Vinh Phuc province, Vietnam. *Vietnam Journal of Biology* 34: 317–322. https://doi.org/10.15625/0866-7160/v34n3.2462

KOBIALKA H., SCHWER H. & KAPPES H. (2009). Rote Liste der gefährdeten Schnecken und Muscheln (Mollusca: Gastropoda et Bivalvia) in Nordrhein-Westfalen. 3. Fassung 2009. *Mitteilungen der Deutschen Malakozoologischen Gesellschaft* 82: 3–30.

KOLENDA K., NAJBAR A., KUŚMIEREK N. & MALTZ T. (2017). A possible phoretic relationship between snails and amphibians. *Folia Malacologica* 25: 281-285. https://doi.org/10.12657/folmal.025.019

KWITT S. & PATZNER R. (2019). Nachweise von *Charpentieria itala* (Martens, 1824) in Salzburg (Gastropoda, Clausiliidae). *Linzer biologische Beiträge* 51: 1115–1118.

LANGERAERT W. (2021). An exploratory study on the patterns of mtDNA and phenotypic variation in the introduced land snail *Theba pisana* (O.F. Müller, 1774) in Belgium (Gastropoda: Eupulmonata: Helicidae). MSc Thesis, UGhent. Available from https://lib.ugent.be/catalog/rug01:003014802 [accessed on 10 January 2023].

MALTZ L. & SULIKOWSKA-DROZD A. (2014). Selfing and brooding in *Alinda biplicata* (Gastropoda: Pulmonata: Clausiliidae) – life history traits of a good coloniser. *Animal Biology* 64: 97–113. https://doi.org/10.1163/15707563-00002434

MEISSNER H., LEMAY A., BERTONE C., SCHWARTZBURG K., FERGUSON L. & NEWTON L. (2009). *Evaluation of Pathways for Exotic Plant Pest Movement into and within the Greater Caribbean Region*. Caribbean Invasive Species Working Group (CISWG) and United States Department of Agriculture (USDA), Center for Plant Health Science and Technology (CPHST), Plant Epidemiology and Risk Analysis Laboratory (PERAL).

MICHALAK P.S. & PRICE T. (2010). *New Pest Response Guidelines. Temperate Terrestrial Gastropods.* U.S. Department of Agriculture.

MNHN (2022). *Collections of the Musée National d'Histoire Naturelle, online galery*. Available from https://science.mnhn.fr/institution/mnhn/collection/im/item/search [accessed 19 October 2022].

MOLLUSCABASE (eds) (2022). MolluscaBase. *Chilostoma cingulatum* (S. Studer, 1820). Available from http://www.molluscabase.org/aphia.php?p=taxdetails&id=871135 [accessed 18 May 2022].

MORLET L. (1886). Diagnoses Molluscorum novorum Tonkini. *Journal de Conchyliologie.* 34: 75–78. Available from https://www.biodiversitylibrary.org/page/16070966 [accessed 19 October 2022].

NAIQIN W., FENGJIANG L. & ROUSSEAU D.-D. (2018). Terrestrial mollusk records from Chinese loess sequences and changes in the East Asian monsoonal environment. *Journal of Asian Earth Sciences* 155: 35–48.

NMR (2022). *Collections of the Natural History Museum Rotterdam, online gallery*. Available from https://nmr-pics.nl [accessed 19 October 2022].

PÁLL-GERGELY B., SÁRVÁRI F., TŐKÉSI N. & FEHÉR Z. (2020). *Chilostoma* (*Cingulifera*) *cingulatum* (S. Studer, 1820) (Gastropoda: Pulmonata: Helicidae) new to the fauna of Hungary. *Soosiana* 34: 12–17. https://doi.org/10.5281/zenodo.3701569

PELTANOVÁ A., PETRUSEK A., KMENT P. & JUŘIČKOVÁ L. (2012). A fast snail's pace: colonization of Central Europe by Mediterranean gastropods. *Biological Invasions* 14: 759–764. https://doi.org/10.1007/s10530-011-0121-9

PHILIPPI R.A. (1847). *Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien. Zweiter Band.* Fischer, Cassel.

POPPE G. & POPPE P. (2022). *Conchology.be*. Available from https://conchology.be [accessed 5 May 2022].

PROĆKÓW M., KONOWALIK K. & PROĆKÓW J. (2019). Contrasting effects of climate change on the European and global potential distributions of two Mediterranean helicoid terrestrial gastropods. *Regional Environmental Change* 19: 2637–2650. https://doi.org/10.1007/s10113-019-01573-w

RÉGNIER C., ACHAZ G., LAMBERT A., COWIE R.H., BOUCHET P. & FONTAINE B. (2015). Mass extinction in poorly known taxa. *Proceedings of the National Academy of Sciences* 112:7761-6. https://doi.org/10.1073/pnas.1502350112

RICHLING I. & VON PROSCHWITZ T. (2021). Identification problems of travelling snail species — new exotic introductions to tropical greenhouses in Gothenburg, Sweden (Gastropoda: Achatinellidae, Strobilopsidae, Helicarionidae). *PeerJ* 9: e11185. https://doi.org/10.7717/peerj.11185

ROSENBAUER A. (2011). Vorkommen südeuropäischer Schneckenarten in Steinmetzbetrieben. *Mitteilungen der Deutschen Malakozoologischen Gesellschaft* 85: 27–34.

ROWSON B., TURNER J., ANDERSON R. & SYMONDSON B. (2014). *Slugs of Britain and Ireland*. FSC, Telford.

SCHILEYKO A. (2011). Check-list of land pulmonate molluscs of Vietnam (Gastropoda: Stylommatophora). *Ruthenica* 21: 1–68.

SCHMID G. (2000). Die Große Felsenschnecke *Chilostoma cingulatum* (Studer) an Buntsandsteinmauern in Nordschwarzwald. *Carolinea* 58: 149–154.

SCHMID G. (2002). In Baden-Württemberg eingeschleppte oder ausgesetzte Mollusken. *Jahreshefte der Gesellschaft für Naturkunde in Württemberg* 158: 253–302. https://doi/org/10.26251/jhgfn.158.2002.253-302

SEEBENS H., BLACKBURN T.M., DYER E.E., GENOVESI P., HULME P.E. *et al.* (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications* 8: 14435. https://doi.org/10.1038/ncomms14435

SULIKOWSKA-DROZD A. (2005). Distribution and habitat preferences of clausiliids (Gastropoda: Pulmonata: Clausiliidae) in the eastern part of the Polish Carpathians. *Folia Malacologica* 13: 49–94. https://doi.org/10.12657/folmal.013.007

SULIKOWSKA-DROZD A., HIRANO T., WU S.-P. & PÁLL-GERGELY B. (2018). High fecundity, rapid development and selfing ability in three species of viviparous land snails Phaedusinae (Gastropoda: Stylommatophora: Clausiliidae) from East Asia. *Zoological Studies* 57: 38. https://doi.org/10.6620/ZS.2018.57-38

VAN DEN NEUCKER T. & RONSMANS J. (2015). The globally invasive *Paralaoma servilis* (Gastropoda: Punctidae) reported for the first time in Belgium. *Journal of Conchology* 421: 95-96.

VAN GOETHEM J. (1988). Nouvelle liste commentée des Mollusques récents non marins de Belgique. *Document de travail de l'Institut royal des Sciences naturelles de Belgique* 53: 1–69.

VENDETTI J., SANDIG K., SAHAKYAN A. & GRANADOS A. (2021). Multiple introductions of the pestiferous land snail *Theba pisana* (Müller, 1774) (Gastropoda: Helicidae) in Southern California. *Insects* 12: 662. https://doi.org/10.3390/insects12080662

VILVENS C., MARÉE B., MEULEMANS E., ALEXANDRE M., WAIENGNIER E. & VALTAT S. (2008). *Mollusques terrestres et dulcicoles de Belgique. Tome I : Gastéropodes terrestres à coquille (1ère partie)*. Société belge de Malacologie, Jodoigne.

WELTER-SCHULTES F. W. (2012). *European Non-Marine Molluscs, a Guide for Species Identification*. Planet Poster Editions, Göttingen.

WIESE V. (2014). *Die Landschnecken Deutschlands: Finden – Erkennen – Bestimmen.* Quelle & Meyer, Leipzig.

ZHANG M.-Z., DU Y.-L., QIN X.-C., ZHAO Y.-J., WANG J.-Z. & ZHANG Z.-Y. (2015). Study on the behaviour of dormancy breaking in *Cathaica fasciola* (Draparnaud 1801) (Gastropoda: Stylommatophora). *Molluscan Research* 35: 213–217. https://doi.org/10.1080/13235818.2015.1044886

Manuscript received: 21 March 2023
Manuscript accepted: 17 January 2024
Published on: 24 January 2024
Branch editor: Kurt Jordaens & Isa Schön