

First records of the invasive slug *Arion lusitanicus* auct. non Mabille (Gastropoda: Pulmonata: Arionidae) in Romania

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The invasive pest slug *Arion lusitanicus* (also known as *Arion vulgaris*) has spread throughout much of Europe within the last 60 years, becoming one of the worst agricultural and horticultural pest species. It has now been detected in Romania for the first time. There are dense populations at two sites in Brașov County (2013) and another occurrence in Mureș County (2012). We review occurrences in neighbouring countries and discuss evidence that *A. lusitanicus* might have arrived in Romania earlier. Further research on the species' spread in Romania and on its impact on the native fauna and flora is necessary.

Key words: *Arion vulgaris*, invasive species, pest, *Arion rufus*

Introduction

The terrestrial slug fauna of Romania has received some attention from malacologists (e.g. BIELZ 1851; BIELZ 1863; CSIKI 1918; GROSSU 1970, 1983; LUPU 1974), but the results are far from comprehensive. One of the remaining open questions concerns the occurrence of large *Arion* species. In his catalogue of the Romanian molluscs, GROSSU (1983) listed six species of *Arion*, including *A. ater* (Linnaeus, 1758) (meaning *A. ater* s.l., i.e. probably *A. rufus*). But he stressed that the inclusion of *A. ater* was based entirely on reports of BIELZ (1851), CSIKI (1918) and Soós (1943) as he himself had never come across any large arionids in Romania (see also LUPU 1974). However, it seems highly unlikely that all those three authors had misidentified one of the small *Arion* species as *A. empiricorum* (*A. ater* s.l.), and it would be quite possible for Grossu to have overlooked the semelparous *A. rufus* if he had not searched in late summer or autumn. Moreover, GROSSU (1993) listed *A. ater* s.l. again in his catalogue of Romanian molluscs but this time mentioned that it was found at an unspecified locality near Oradea (Bihor County), the same location as previously published by CSIKI (1918) and situated in the same county (Bihor) as two of the sites indicated by Soós (1943). No further information about the collecting details or vouchers is provided. According to GROSSU (1993) the species included in the catalogue were all preserved in his private collection, but it remains unclear whether these include vouchers for all mentioned sites within Romania. The largest and most important part of Grossu's private collection is today found at the "Grigore Antipa" Museum in Bucharest (Romania), but it does not include any Romanian specimens of large *Arion* (GROSSU 1997, POPA, pers.

comm. 2014). The absence of precise data is probably the reason why the large arionids do not appear in BANK's (2011a) checklist of the terrestrial and limnic molluscs of Romania. We think that, as with other slug groups such as *Arion subfuscus* s.l. or *Deroceras*, the current inventory of Romanian large arionids is incomplete and should be investigated further.

Here, we report the first discoveries of another large arionid in Romania, the slug known as *Arion lusitanicus* or *Arion vulgaris*, one of the most important invasive pest species in Europe (RABITSCH 2006). This pest slug is not the same as the true *Arion lusitanicus* J. Mabille, 1868 (CASTILLEJO 1998), with which it had been confused in the past. The name *Arion vulgaris* Moquin-Tandon, 1855 has been suggested as a replacement (FALKNER et al. 2002). However, as there is uncertainty whether the original description of *A. vulgaris* really applies to the invasive species, we follow BANK (2011b) and BANK et al. (2007) in retaining the name *A. lusitanicus* until further clarification.

Arion lusitanicus is spread via the unintentional introduction of eggs and immature or adult individuals with plants (RABITSCH 2006, WEIDEMA 2006), but probably also with soil, stones, wood and other material. Within the last 60 years, it has expanded from its native range (assumed to be somewhere in SW Europe) across western and much of central and northern Europe (ENGELKE et al. 2011 and references therein, RABITSCH 2006, WEIDEMA 2006) and continues to spread further. The easternmost records are from Estonia (ANONYMOUS 2009), Latvia (RUDZĪTE et al. 2010), Lithuania (SKUJENĀ 2013) and the Ukraine (SVERLOVA & GURAL 2008, GURAL-SVERLOVA & GURAL 2011). Thus it is understandable that a recent fact sheet of terrestrial and



Fig. 1. Noteworthy occurrences of *A. lusitanicus* (with dates of confirmed discovery) in Romania and nearby countries. Not all published localities are shown (especially in Hungary and Poland). Map created in QGIS 2.0.1 (QGIS Development Team 2013) using outlines from Natural Earth.

aquatic invasive species of Romania (SKOLKA et al. 2010) already mentioned *A. lusitanicus* as a species to be expected in Romania.

Arion lusitanicus in Romania

The first discovery was by AV in the garden of the Casa Dio in the town of Regin (Mureş County, Mihai Viteazul Street 51, 46.77590° N, 24.69890° E) on 5th September 2012 (Fig. 1). Two individuals of *A. lusitanicus* were crawling on mowed grass after rain. The larger, orange slug was 5.2 cm long and mature. The other, brown slug was only 3.5 cm long and juvenile. Species identity has been confirmed anatomically. The specimens are in the

collection of the Hungarian Natural History Museum, Budapest, collection number HNHM 98913.

Another two populations were discovered on 14th September 2013, in the context of a series of collecting trips initiated by AMP and HR to survey slugs at Timișu de Sus and Predeal (Brașov County, Southern Carpathian Mountains; Fig. 1). These localities are 1.4 km apart, along a mountain road. At the site at Timișu de Sus (45.5245° N, 25.5720° E, 876 m a.s.l.), the slugs were crawling within 3 m of the paved road at the margin of the village, in the ditch and the herbaceous strip along the road and in the adjacent patch of deciduous forest. The population density (calculated by counting slugs in three squares of 1 m², 5 m



Fig. 2. *Arion lusitanicus* from Timișu de Sus (Brașov County, Romania) collected from one square metre. Photo by H. Păpușeanu.

apart) was 10–15 individuals per m² (Fig. 2). Twenty slugs were collected by AMP. Voucher specimens are in the collections of the Senckenberg Museum of Natural History Görlitz (collection number p17939) and of the Brukenthal National Museum.

In Predeal, the slugs were found at the margin of the town (45.5120° N, 25.5717° E, 1044 m a.s.l.) on rough ground along an unpaved track, between buildings. Sparse vegetation covered the ground, and there were small patches of conifers (silver fir, *Abies alba*, mixed with Norway spruce, *Picea abies*). The slugs were less abundant than at Timișu de Sus (about three per m²). Seven specimens were collected by AMP (voucher specimens at the Senckenberg Museum of Natural History Görlitz, no. p17940, and at the Brukenthal National Museum).

Living specimens from Timișu de Sus and Predeal had an average length at rest of 6.5 cm. Coloration and external appearance of the slugs agreed with published descriptions of *A. lusitanicus* (Fig. 3a, b). The foot fringes contrasted only little with the colour of the upper body, which was the same for all individuals within each population. However, even though the two sites are close together, the body coloration differed between sites: orange at Timișu de Sus (Figs 2, 3b) and brown at Predeal (Fig. 3a).

The slugs were transported alive to the Natural History Museum in Sibiu, killed in carbonated water and preserved in 75% ethanol. One specimen from each collecting site was dissected as described by REISE (2013), and its genital organs photographed (Fig. 4 a, b). The genital traits indicative of *A. lusitanicus* include the relatively small and short atrium, and the long, muscular distal part of the oviduct with the characteristic long folds (ligula) inside (RISCH & BACKELJAU 1989; GURAL-SVERLOVA & GURAL 2011).

Discussion

These are the first records known to us of *A. lusitanicus* in Romania. However, one may wonder whether the species has really arrived recently or rather had been overlooked for some time: since Grossu's work, faunistic data about terrestrial slugs in Romania have been scarce. The almost simultaneous discoveries of three occurrences, at least two of them well-established populations, suggest that the spe-

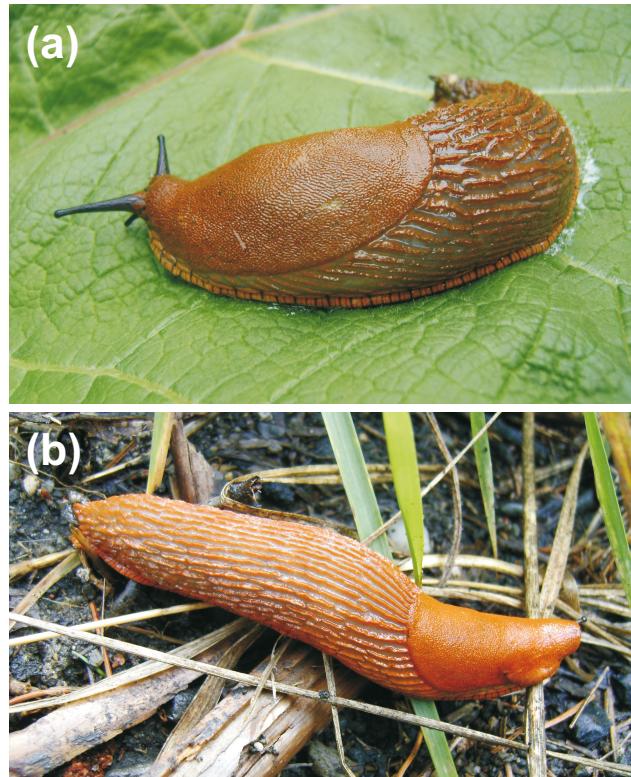


Fig. 3. Colour variation of *A. lusitanicus* from (a) Predeal and (b) Timișu de Sus. Photos by A.-M. Păpușeanu.

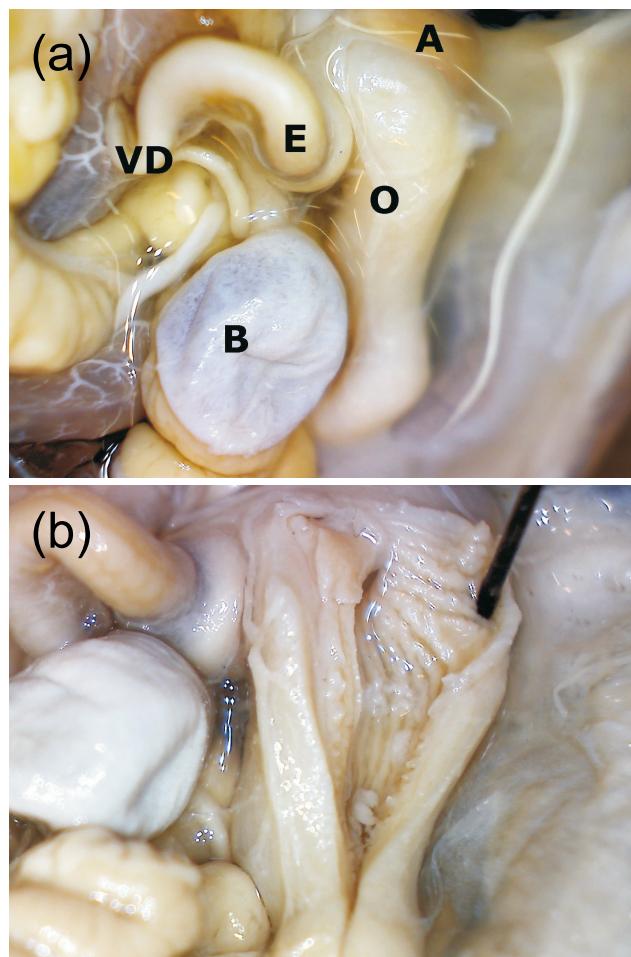


Fig. 4. (a) The genital organs of a specimen of *A. lusitanicus* from Timișu de Sus. A – atrium; B – bursa copulatrix or spermatheca; E – epiphallus; O – oviduct; VD – vas deferens or sperm duct. (b) Ligula of the same individual. Photos by A.-M. Păpușeanu.

cies has already been in Romania for quite a while. The different body colorations (orange at Timișu de Sus and brown at Predeal) might indicate different populations of origin even though these two sites are only 1.4 km apart. It is also suggestive that *A. lusitanicus* has been known for some time in neighbouring and other nearby countries (Fig. 1).

The first record of *A. lusitanicus* from Bulgaria (Vratsa), which also is the closest to our sites in Brașov County (ca. 300 km), is as old as April 1966 (van REGTEREN ALTENA 1971, determination confirmed by DE WINTER, pers. comm. 2013). WIKTOR (1983) reported *A. lusitanicus* collected by Pintér at two sites in Bulgaria: again from Vratsa (specifically the suburb Dabnika) and from Teteven (Stara Planina). He did not mention the collecting date, but the only time Pintér collected at Teteven was on 29th June 1970, and a sample from a garden in Dabnika in the collection of the Natural History Museum of Budapest is dated 21st July 1972 (FEHÉR, pers. comm. 2013). *Arion lusitanicus* has thus been in Bulgaria for at least 48 years and, even though the records were limited to only two areas, WIKTOR (1983) assumed further, unrecognised occurrences. We do not know how much the species has spread since then, but, at least in the city of Sofia, it seems to be common nowadays (DEDOV & PENEV 2000).

Similarly old are early records from the area of the former Yugoslavia. In Slovenia, *A. lusitanicus* was found near Ljubljana in 1970 and 1973, at Postojna in 1983 and at Lenart in 1985 (WIKTOR 1996 and pers. comm. 2014; VAUPOTIČ & VELKOVRH 2002), and more records from Slovenia followed in the 1990s (FISCHER et al. 1999; VAUPOTIČ & VELKOVRH 2002). WIKTOR (1996, referring to the whole area of former Yugoslavia) stressed that the few occurrences were still very sporadic and limited to heavily disturbed sites. However, local mass occurrences existed at latest in 1993 (FISCHER et al. 1999), and the 2002 review by VAUPOTIČ & VELKOVRH indicates several concentrations of occurrences across Slovenia.

The first discovery of *A. lusitanicus* in Croatia was in the village of Delnice on 14th October 1983 (WIKTOR 1996 and pers. comm. 2014). This was followed by records from a site near Zagreb in 1998, one near Jastrebarsko and a mass occurrence in Slunj (Dalmatia), both in 1999 (FISCHER et al. 1999). The only part of former Yugoslavia directly bordering Romania is Serbia; *A. lusitanicus* was first recorded there in 2002, from several sites in Belgrade and the south west, as well as from the adjacent eastern area of Montenegro (VUKŠA et al. 2003).

In Hungary, the first specimens were collected in 1985 in Sopron, close to the Austrian border (VARGA 1986). By 2000, five sites had been reported (PINTÉR & SUARA 2004), but about 750 sites are known today, still with a higher density of records west of the river Danube than east (VARGA & FEHÉR unpubl.). Eastern records include two localities close to the Romanian border: Mánd (17 km away) in 2000 and Gyula (ca. 5 km) in 2012 (respectively 209 and 264 km to Reghin).

Further to the north, the species seems to have turned up only more recently. The first discoveries in Slovakia were in Liptovský Mikuláš in 1992 and at two sites in

the eastern part of the country (Košice and Porúbka N of Michalovce) in 1993 (REISCHÜTZ 1994), followed by further localities from different parts of the country between 2001 and 2003 (DVOŘÁK & ČEJKA 2003). The first anatomically confirmed occurrence in Poland was in 1993, from the southeast corner of the country (KOZŁOWSKI & KORNÓBIS 1995), but it is suspected that *A. lusitanicus* occurred in this region already by 1987 (KOZŁOWSKI & KOZŁOWSKI 2011). The slug is now widespread throughout Poland but not ubiquitous in all suitable habitats (SOROKA et al. 2009; KOZŁOWSKI & KOZŁOWSKI 2011; REISE, unpubl. obs.). In the Ukraine, *A. lusitanicus* turned up in 2007 near Lviv in the northwest of the country (SVERLOVA & GURAL 2008; GURAL-SVERLOVA & GURAL 2011). It has now spread in and around Lviv (GURAL-SVERLOVA & GURAL 2011), and there are new, though still unconfirmed, records from the more eastern district of Kiev (GURAL-SVERLOVA, pers. comm. 2013). We know of no records of *A. lusitanicus* from Moldova: the checklist by COADĂ & WELTER-SCHULTES (2011) does not mention this species.

In summary, Romania is surrounded by countries in which *A. lusitanicus* has been found (with the exception of Moldova), in some of them for more than 25 years (Fig. 1). Therefore, it seems rather surprising that the pest slug had not been recorded earlier.

In many, if not all, invaded countries of Western and Central Europe, *A. lusitanicus* has spread quickly and developed into an important agricultural and horticultural pest (e.g. SCHMID 1970, REISCHÜTZ 1984, RISCH & BACKELJAU 1989, KOZŁOWSKI 2007, PROSCHWITZ 1996, DVOŘÁK & HORSÁK 2003). It may reach amazing population densities, occasionally more than 50 individuals per square metre (GRIMM 2001, KOZŁOWSKI 2007). *Arion lusitanicus* has several traits supporting quick establishment at newly invaded sites, such as a lack of natural enemies, high fecundity and high ecological tolerance, including a broad diet (KOZŁOWSKI 2007), high survival rate under unfavourable conditions (KOZŁOWSKI 2007 and references therein, SLOTSBO et al. 2011, KNOP & REUSSER 2012), the ability to self-fertilise (HAGNELL et al. 2006) and high behavioural plasticity (GRIMM & PAUL 2001, KAPPES et al. 2012, DREIJERS et al. 2013).

Our findings demonstrate that there are at least two healthy local populations in Romania, and the occurrence at Reghin may signify a third one, perhaps at an early stage of development. Experience from elsewhere indicates that *A. lusitanicus* has the potential to develop into a pest with a high impact on Romanian agriculture and horticulture. The development of these newly discovered populations in the next few years should be kept under close observation. Further studies will also have to clarify how widely *A. lusitanicus* has spread in Romania already. Particularly in areas close to the Hungarian border (counties of Arad, Bihor and Satu Mare), further occurrences are probable. The potential impact of this slug on the native fauna and flora is another issue that needs attention. It has, for example, been shown that *A. lusitanicus* consumes more plant seeds than three other pulmonate species native to Switzerland (*Arion rufus*, *Cepaea nemoralis*, *Helix pomatia*, the last one also native to Romania) and that

fewer seeds survive passing through its gut (BLATTMAN et al. 2013). There are indications that *A. lusitanicus* might be more active or inquisitive and thus exploit novel resources better than other species (KAPPES et al. 2012). In central and northern Europe, the pest slug has been observed to displace both *A. rufus* (PROSCHWITZ 1997, KAPPES & KOBIALKA 2009, DREIJERS et al. 2013) and *A. ater* (HAGNELL et al. 2003, HATTELLAND et al. 2013) at a local scale. So, the still open question of the occurrence of other large arionids (*Arion* s.s.) in Romania should be followed up before their distribution is disturbed by the invading *A. lusitanicus*. Such surveys should not be restricted to areas where reports of mass occurrences already suggest the arrival of *A. lusitanicus*. Anatomical determination and voucher specimens are essential in this context.

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