

# First Record of Introduced Valencia Slug, *Lehmannia valentiana* (Férussac, 1822), in Serbia

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## SUMMARY

The established indoor population of introduced Valencia slug, *Lehmania valentiana* (Férussac, 1821), has been recorded for the first time in Serbia. The first two specimens had been found in December, 2010 and cultivated in the laboratory by the end of April, 2011 when they died. In May, we collected new specimens of different ages in the same locality, indoor garden of Hyatt Regency Belgrade hotel. In the case of large population densities Valencia slug could cause severe damage to greenhouse plants in our country, yet it is unlikely that it could survive winter outdoor in Serbia, and we do not expect its permanent outdoor establishment.

**Keywords:** Ornamentals; Slug introduction; *Lehmania valentiana*

## INTRODUCTION

The spreading of invasive species of terrestrial gastropods has been intensified following the emergence of the global interconnection, even of remote or geographically separated areas, particularly by trading of plant material, and other goods. These organisms do not possess a significant ability to independently extend their ranges, and current zoogeographical state of any local malacofauna is undoubtedly the result of multiplied introductions in some extended period. Significant introductions are generally recognizable on the basis of a typical invasive-synanthropic model of the population distribution of introduced species. In addition

to invasive species, many allochthonous species are also constantly being brought into new areas, but they do not possess harmful invasive potential, and their effects often remain unnoticed and without consequence (e.g. Godan, 1999; Barker, 2002).

Invasive species of terrestrial slugs significantly threaten crop production in areas of introduction. These species have special features that facilitate the inconspicuous passive dispersal: flexible body, small eggs and juveniles protected in the substrate, ability of long dormancy and starvation in the transport, tendency to crawl into crevices, etc. Moreover, post-invasion is ensured with a wide range of potential food and hermaphroditism (Foltz et al., 1984). Unfortunately, in

European countries there are still no proper regulations to prevent dispersal of invasive slug species.

Lusitanian Slug, *Arion lusitanicus* (Mabille, 1868), is already present in Serbia (Vukša et al., 2003). This invasive species causes extensive economic damage to vegetable and horticultural crops in several plant growing areas. According to the experience of neighboring countries, we can expect the upcoming emergence of some more invasive slug species of families Agriolimacidae, Limacidae, Milacidae and Arionidae.

In this paper we present the first indoor record of allochthonous limacid slug species, found in population establishment phase in Serbia.

## MATERIAL AND METHODS

The first two juvenile specimens, cc. 30 mm long, of unknown limacid species had been collected, from the indoor ornamental garden of *Hyatt Regency Belgrade hotel* in December of 2010, and were cultivated in our laboratory by the end of April 2011, when they died. In May, we collected more specimens in the same locality, in traps with rodent baits. These slugs were of different ages, and we cultivated them until identification, by the end of June. At the same time, we have also collected several great grey slugs, *Limax maximus* Linnaeus 1758, a native species. The indoor hotel garden is an extremely isolated small area of ca. 100 m<sup>2</sup>, with artificial stream and planted with different indoor ornamentals. Slugs were collected along the stream, near the *Anthurium*, *Scindapsus* and *Poinsettia* plants.

Collected slugs were kept in transparent plastic container, lined with moist paper towel, provided with lettuce, cabbage, potatoes, carrots, and periodically with fish food. Containers were cleaned and washed, and moist paper towels replaced every two days; slugs were cultivated under controlled environmental conditions (LD=16h:8h, T=20-22°C) (Hommay et al., 2001; Örstan, 2006).

The material was subjected to fixation and dissection (Wiktor, 1989), the identification was carried out using taxonomic keys and descriptions (Altena, 1950; Quick, 1960; Wiktor, 1989; Welter-Schultes, 2009; Kozłowski, 2010).

## RESULTS AND DISCUSSION

Based on the morphological analysis we identified species *Lehmanna valentiana* (Férussac, 1822), recorded for the first time in our country. In different

countries this species is known as Valencia slug, three-band garden slug or greenhouse slug. Taking into account relatively long period of a few months, as well as different ages of collected Valencia slugs, despite the presence of aggressive autochthonous competitor/juvenile predator species, *L. maximus*, at the same locality, it can be concluded that we have found established population of allochthonous species.

Genus *Lehmanna* Heynemann, 1863 (Pulmonata: Stylommatophora: Limacidae) has European and North African distribution. Basic morphological features are: body length up to 80 mm; mantle covering less than 1/3 of the body, narrower in the anterior part, surface covered with concentric grooves; postmedial pneumostom; short keel, about 20 wrinkles between keel and pneumostom; colour variable from cream and brownish to black. At least two longitudinal stripes on the mantle (except in unicolour forms); sole is lighter in the middle; mucus colorless, watery; lateral teeth of radula S-bent, marginal teeth on the edge of radula bear numerous cusps; intestine with 3 loops, the first one being the biggest; last intestinal loop very short, with very long rectal caecum reaching posterior body end; caecum opens into last section of intestine, positioned more anteriorly than posterior bend of the last loop; prostate well developed, vas deferens short and thick; penis short, usually shorter than 2/3 of mantle length, tubular, baggy, or claviform, always crosses right ommatophore retractor; nodular or flagellate penial gland, penial flagellum on posterior part of penis; V-shaped fold inside penis; spermatheca connected with penis.

Most *Lehmanna* spp. are very active slugs, live in mountains, occur on the bark of trees or on rocks, and feed on lichens. Few species are synanthropes. There are 16 known species of *Lehmanna* in Europe (Wiktor, 2001; Welter-Schultes, 2009; Bank, 2010). Three native species are present in Serbia, *Lehmanna nyctelia* (Bourguignat, 1861), *L. marginata* (Muller, 1744) and *L. brunneri* (Wagner, 1931) (Lupu, 1971; Wiktor, 1982, 1983a, 1989). In Serbia, *L. valentiana* could be confused with *L. marginata* and *L. nyctelia*, while *L. brunneri* is confined to mountain habitats.

### Basic morphological features of *L. valentiana*

Valencia slug is a medium-sized slug, extended length cc. 60-70 mm (Figures 1 and 2). The slug body is narrow, gradually wedge tapers towards its rear end. The mantle covers about 1 / 3 of the body, pneumostom is postmedial. The mantle bears a pattern of fine, close concentric grooves. The keel is short, at end of tail only, about 20 wrinkles between keel and pneumostom.



**Figure 1.** *Lebmannia valentiana* (Férussac, 1822), Valencia slug, extended adult (length cc. 55 mm, body weight 1.52 g)



**Figure 2.** Valencia slugs adults and one juvenile (right); adult markings (left), color of the sole (center)

The ground body color is usually pale olive buff, vinaceous buff or brown in some specimens, the head is slightly darker. The color is darker on the back and mantle, becoming lighter on the sides. The general body appearance is somewhat translucent. Pigmentation of the mantle consists of a median dark longitudinal band and a pair of dark lateral bands that form a lyre-shape. There are two lateral bands on the back, rather close to the medial line, often run full length of

the body. Laterally from these, small diffuse patches of dark pigment may occur. The bands of the mantle are not continuous with those of the body. Young individuals typically have darker bands (Figures 3 and 4), but the markings of adults become obsolete and are often less conspicuous. Sometimes the bands are already poorly developed in young or half grown specimens. The sole is creamy. The mucus of *L. valentiana* is colorless and watery, not very sticky.



**Figure 3.** Cultivated Valencia slug juvenile (cc. 40 mm); juvenile markings



**Figure 4.** Valencia slug juveniles (cc. 35 mm) – typical huddling behavior at rest

The eggs of this slug are translucent, yellow, 2.25 x 1.5 mm. Newly hatched slugs are 10 mm long with blackish bands (Quick 1960; Barker 1999).

External diagnosis: In Serbia, *L. valentiana* could be confused with *L. marginata* and *L. nyctelia*, while *L. brunneri* is confined to mountain habitats. The body color of *L. valentiana* is more yellowish than *L. marginata*, and body bands are nearer middorsal band. On the other hand, *L. valentiana* is externally very similar to *L. nyctelia*, and can be distinguished only anatomically (Quick, 1960; Welter-Schultes, 2009).

The radula of *L. valentiana* bears characteristically tricuspid, acute central and lateral radular teeth (Quick, 1960). The penis is short, club-like. There is a short, blunt and rounded penial flagellum at penis end, opposite to side where vas deferens connects (Quick 1960; Wiktor, 1989; Forsyth, 2004). The oval spermatheca is equal to the length of the spermatheca duct and the penis. The alimentary canal has a long intestinal caecum (Altena, 1950; Quick, 1960).

Internal diagnosis: Tricuspid radular teeth of *L. valentiana* clearly distinguish this slug from *L. marginata*

*ta*, which has rounded monocuspid radular teeth (Altena, 1950; Quick, 1960). Within the genus *Lebmannia*, the size and shape of the penial flagellum is important for identification of species (Waldén, 1961; Kerney and Cameron, 1979). The characteristic feature that distinguishes *L. valentiana* from other *Lebmannia* spp. is broad, often layered penial flagellum, located near the attachment of the retractor muscle, while in the other species of the genus penial flagellum attaches on the opposite wall of the penis. Internally, *L. valentiana* differs from *L. marginata* in the shape of the penial flagellum (longer, rounded and blunt in *L. valentiana*, versus shorter, peaky and pointed in *L. marginata*) and the bursa copulatrix (blunt in *L. valentiana*, versus slightly peaky in *L. marginata*) (Quick, 1960). *Lebmannia valentiana* is almost identical to *L. nyctelia*, but the penis of *L. nyctelia* does not have the penial flagellum (Herbert 1997; Forsyth, 2004).

### Basic biological features of *L. valentiana*

In terms of trophic strategies, *L. valentiana* is omnivorous species. It feeds on algae growing on rocks and trees (Chichester and Getz, 1973), on fresh leaves of various plants, fruits and tubers (Kurozumi, 2002), but some field observations show that this species also feeds on animal matter and fallen leaves (Udaka et al., 2007). The species is known as a pest of fruits, vegetables and flowers in greenhouses and gardens (South, 1992). In gardens it can damage particularly beans and peas (leaves, pods), lettuce (older plants). In greenhouses, seed growing houses and pots the damage occurs on *Chrysanthemum* (leaves), *Narcissus* (leaves and flowers), *Nicotiana tabacum* (leaves), orchids (roots, young shoots, leaf stalks, flowers), *Tradescantia* and *Tulipa* plants (germinating bulbs, flowers, leaves). Grass plants in grass seed production and lawns can also be damaged (Godan, 1983).

Feeding activity of Valencia slug is nocturnal, begins about 40 minutes after the start of locomotor activity and shows a maximum level in the beginning of the night (Hommay et al., 1998). The peak of feeding appeared at 21.00 h. The slug had two to five meals each night, each meal lasting 13 minutes, and intervals between meals lasting 112 minutes. The mean daily individual locomotor activity time of 238 minutes consisted of 191 minutes of crawling and 47 minutes of local movements. Movements began to increase half an hour before nightfall and reached a maximum one hour later. Then they decreased slowly until 4.30 h and continued at lower intensity until 10.00 h. From 4.30 h on-

wards, activity was mostly limited to local movements. Slug activity increased slightly during the hours following sunrise (*ibid.*).

The growth of *L. valentiana* occurred in three distinct phases (Hommay et al., 2001): infantile phase, up to age of about 60-80 days, juvenile phase, up to age of about 130-160 days and adult phase, onward. The adult phase is followed by senescence (time elapsed between last egg laying and death). Adult slugs can die 20 days after last oviposition, or after 110 days. The mean longevity is cc. 250-350 days, sometimes more than 500 days. Long days and cool nights (summer – autumn) are favorable for reproduction. The age at first laying is 150-180 days, with mean age at laying 230-290 days. The average number of eggs produced per slug is 35-239. The maximum number for one individual was 1510 laid eggs, of which 1355 hatched (*ibid.*). The eggs are laid in clutches, 40-50 eggs per clutch. Incubation period is 21-24 days at 16-18°C, and clutch hatching is elapsed 5-7 days.

Although outcrossing has been noted in *L. valentiana* (McCracken and Selander, 1980), no copulation was observed by Hommay et al. (2001). Isolated individuals produced fertile eggs, showing that *L. valentiana* could reproduce by self-fertilization.

Whereas *L. marginata* is arboreal, climbing trees and plants, *L. valentiana* is confined to the ground (Quick, 1960; Kerney and Cameron, 1979), even the cultivated experimental populations are always at rest on the bottom of the arena, never on the walls (Hommay et al., 1998). These slugs often huddle together in groups when at rest. On the *contrary*, the overcrowding of the Valencia slugs induced acts of aggression during meals and associated with the occupation of resting sites (*ibid.*).

### Range, habitat and dispersion mode of *L. valentiana*

Valencia slug is originally Western Mediterranean species, from Iberian peninsula and Northwest Africa (Wiktor et al., 2000). It is not known when it began to spread, but it is now widely introduced in most parts of Europe (Kerney et al., 1983; South, 1992; Bank, 2011) and worldwide (Likharev and Wiktor 1980; Herbert 1997; Barker 1999; Wiktor et al., 2000). This slug is present in the following European countries: Andorra, Austria (Reischütz 1986), Azores (Barker, 1999), Balearic Is. (Quintana Cardona, 2006; Beckmann, 2007), Belgium, Britain Is. (Quick, 1949, 1960; Kerney, 1999), Canary Is. (Altena, 1950), Channel Is.,

Corsica, Czech Republic (Horsák et al., 2004), Danish mainland, French mainland, Gibraltar, Hungary, Ireland (Anderson, 2005), Italian mainland (Manganelli et al., 1995), Lithuania (Skujiene, 2002), Madeira, Malta (Beckmann, 2003; Mifsud et al., 2003), Northern Ireland (Kerney, 1999), Poland (Wiktor, 2004; Stworzewicz, 2008), Portuguese mainland, Romania (Grossu, 1993), Russia (Sysoev and Schileyko, 2009), Spanish mainland, Sweden (Waldén, 1960, 1961), The Netherlands (Gittenberger and De Winter, 1980). It is also widely spread outside Europe: USA (Quick, 1960; Waldén, 1961; Getz and Chichester, 1971), Canada (Howe and Findlay, 1972; Forsyth, 2001, 2004), South Africa (Herbert, 1997), Australia and New Zealand (Barker, 1999), China (Wiktor et al., 2000), Japan (Kurozumi, 2002), Colombia (Hausdorf, 2002), Chile, Peru, Juan Fernandez Islands, and Easter Island (Barker, 1999). Finally, Valencia slug inhabits all continents except Antarctica (Stworzewicz, 2008).

The original habitats of *L. valentiana* are moist, shady locations with lots of vegetation – among the herbs along stream banks, in the bushes, under stones and fallen logs, etc. It has been found in Algeria in the mountain forests of cedar and cork oak, up to altitude of 1700 m (Wiktor, 1983b). In the area of its natural occurrence Valencia slug is also very often synanthropic species, and willingly inhabits dumps, gardens and parks (South, 1992). In the area of its introduction, *L. valentiana* is predominately synanthropic species, limited to habitats under continual human impact. It occupies urban habitats, disturbed places, gardens, greenhouses, nurseries, etc. In many Central and North European countries it has been found only indoor, mostly in greenhouses, but some outdoor populations were established in Britain (Kerney, 1999), and also in USA and Canada (Getz and Chichester, 1971; Forsyth, 2001).

In cold frames, greenhouses and nurseries, this slug takes shelter in humid compost heaps, compost bins, hides under pots, pieces of wet cardboard or wood, and in small crevices. It often occurs in abundant indoor population (Horsák et al., 2004). Consequently, Valencia slugs are dispersed mostly through plant nurseries, by the movement of plant material (Howe and Findlay, 1972; Cowie and Robinson, 2003; Cowie et al., 2008). The interceptions of invasive alien slugs, primarily European species, are regulated and well documented worldwide, but European countries do not have the appropriate regulations for slugs yet. Valencia slug has been regarded as invasive species, actionable and reportable pest in USA (Cowie et al., 2009) and has been

intercepted many times, for instance, on *Anethum graveolens* from Colombia, on *Hydrangea* spp. from Ecuador and California, on *Nemesia* sp. from France, on *Tulipa* sp. from Netherlands, etc., but also in containers, shipments of quarry product, granite, marble, tiles, machinery, metal, steel (Meissner et al., 2009).

### Relevance – risk statement

In Serbian territory, this species has been found for the first time in the indoor hotel garden, the extremely isolated and small area. It can be supposed that slugs have entered the garden in potted begonias, procured at the local flower wholesalers. Based on these findings, we could conclude that this species has already been introduced at least in few greenhouses in our country, and that it probably increases unrecorded. According to the model for the importation and dispersal of slugs (Chichester and Getz, 1969), at some places in Serbia, *L. valentiana* could already be in local establishment phase prepared for secondary transport phase – to be moved to secondary foci (greenhouses) by dissemination of plant materials. At least, the population we have found is safely isolated, cannot spread elsewhere and can be eradicated.

The potential distribution of this species in Serbia certainly deserves to be investigated in the future. In the case of large population densities this slug can cause severe damage to greenhouse plants in our country. It is unlikely that Valencia slug could survive winter outdoor in Serbia, and we do not expect its permanent outdoor establishment, any impact on ecosystems and native species.

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# Prvi nalaz introdukovanog valensijskog golaća, *Lehmania valentiana* (Ferussac, 1822), u Srbiji

## REZIME

U našoj zemlji prvi put je u zaštićenom prostoru utvrđeno prisustvo zasnovane populacije valensijskog golaća, *Lehmania valentiana* (Ferussac, 1821), alohtone vrste. Prve jedinke su nam dostavljene tokom decembra 2010, i laboratorijski su gajene do kraja aprila 2011. godine, kada su uginule. U maju su sakupljene nove jedinke različitog uzrasta na istom lokalitetu, unutrašnjem vrtu hotela Hyatt Regency, Beograd. Ukoliko valensijski golać uspostavi guste populacije u plasticima i staklenicima, mogu se očekivati velike štete na biljkama. Nasuprot tome, malo je verovatno da se ova introdukovana vrsta može održati u poljskim uslovima u našoj zemlji.

**Ključne reči:** Ukrasne biljke; introdukcija golaća; *Lehmania valentiana*