

# The green cellar slug *Limacus maculatus* (Kaleniczenko, 1851) (Gastropoda, Pulmonata, Limacidae) new for the Netherlands

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## ABSTRACT

This paper presents the first report of the green cellar slug *Limacus maculatus* (Kaleniczenko, 1851) from the Netherlands. Suspicions were raised after pictures of several specimens were put on the online data platform Waarneming.nl in November 2020 under the name of *L. flavus* (Linnaeus, 1758), a similar species already known from the Netherlands. Further investigation of external and internal components revealed that the specimens indeed belong to *L. maculatus*. This article describes this first discovery of *L. maculatus* in the Netherlands and provides a thorough discussion of the anatomical characteristics.

Key words: first record, Gastropoda, introduction, Limacidae, *Limacus maculatus*, Netherlands, range extension

## INTRODUCTION

In November 2020, the second author found seven slugs in his garden. He reported this observation with some photos on the online data platform Waarneming.nl (<https://waarneming.nl/>) under the name *Limacus flavus* (Linnaeus, 1758) (Fig. 1). Studying the photos, the first author suggested that it was a species more similar to *L. maculatus* (Kaleniczenko, 1851), a species not known from the Netherlands. On social media his suspicions were reinforced by Vollrath Wiese who recommended further investigation.

In 1851, Kaleniczenko described *Krynichillus maculatus* Kaleniczenko, 1851 from the Crimea. More than a decade later, Lehmann (1864) described a new genus for *Limacus breckworthianus* Lehmann, 1864, a species from Australia, in

which the back and tail are not keeled and a mucous gland in the tail is missing. This slug turned out to be synonymous with *L. flavus*. Later, *Limacus* was chosen as the genus for *L. flavus* because of the attachment of the bursa copulatrix to the oviduct, a unique feature within the Limacidae Rafinesque, 1815 (Giusti, 1973). Forcart (1986) and Wiktor (2001) made it clear that this character is not characteristic for all *Limacus* species, but that a combination of 1) the presence of a rectal caecum, 2) a different radula and 3) the shape of the penis is typical for this taxon.

In terrestrial pulmonates, a rectal caecum is found in some species of Limacidae (*Limacus*, *Lehmannia* Heyne- mann, 1862 and *Ambigolimax* Pollonera, 1887: with a long caecum) and Agriolimacidae Wagner, 1935 (*Deroceras* Rafinesque, 1820: with a short caecum) (Barker, 1979; Grossu, 1983; Barker, 2001; Wiktor, 2001). According to Barker (2001), this original characteristic has disappeared in the other genera of these families.

On the radula, *Limacus* has small ectocones on the aculeate marginals and can be distinguished from *Lehmannia* (and *Ambigolimax*) in which the lateral teeth are S-curved and the marginal teeth have many cusps (Barker, 1979; Wiktor, 2001; Barker, 2004).

The penis of *Lehmannia* (and *Ambigolimax*) is short, the penis of *Limacus* is curved and long (Wiktor, 2001).

This distinction in caecum, radula and penis has not prevented several authors from using *Limacus* as a subgenus. Sometimes in *Lehmannia* (Giusti, 1973; Barker, 1979; Alonso et al., 1986), sometimes in *Limax* Linnaeus, 1758 (van Regteren Altena, 1950; Likharev & Wiktor, 1980; Wiktor & Norris, 1982; Kerney et al., 1983; Wiktor, 2001).

Likharev & Wiktor (1980) have chosen *Limax* (*Limacus*) *maculatus* as a valid name for the taxon on the basis of comparable specimens from the Crimea without comparing this species with other slugs from that region. Nor have they designated a neotype (Wiktor & Norris, 1982; Evans, 1986). A complication was that the choice of *Limacus* as a genus or as a subgenus of *Limax* influenced the epithet (Wiktor, 2001;



Fig. 1. *Limacus maculatus*, 5 specimens on 12.xi.2020 in the garden in Eindhoven, the Netherlands. (Photo: Peter van de Haar).

Falkner et al., 2002). As a subgenus of *Limax*, *L. (Limacus) maculatus* would be the correct name. However, this name was preoccupied by *Limax maculatus* Nunnely, 1837, which turned out to be the same species as *Limax maximus* Linnaeus, 1758. In that case, *Limax (Limacus) ecarinatus* Boettger, 1881 was the correct name, which was used by Wiktor (2001) and Welter-Schultes (2012). Nevertheless, Sysoev & Schileyko (2009) and Kantor et al. (2010) used the name *Limax maculatus*. But if *Limacus* was used for the genus, *L. maculatus* was different from *Limax maculatus* and a correct name (Forcart, 1986; Falkner et al., 2002). At the request of Balashov (2013), in Opinion 2375 (Case 3639), the International Commission on Zoological Nomenclature (2016) decided to reject the name *maculatus* in both *Limax maculatus* Nunnely, 1837 and *Limax cinereus* var. *maculatus* Picard, 1840, so that *Limacus* could be retained as a genus and subgenus as well without losing the epithet *maculatus*. In recent years, *Limacus* has been used as a genus name, a choice that we also follow.

In the Netherlands, *Limacus flavus* was the only known slug from the genus *Limacus*. This species is said to be rare and is therefore included on the Red List as Vulnerable (de Bruyne et al., 2003). After several observations, however, the assumption arose, that the species is more common, but that they are often overlooked because of their hidden and nocturnal way of life (Margry, 2011).

The green cellar slug (or Irish yellow slug) *L. maculatus* originates from the Caucasus and countries around

the Black Sea. In this area it is found in Russia, Ukraine, Azerbaijan, Armenia, Georgia, Romania, Bulgaria and Turkey (Likharev & Wiktor, 1980; Wiktor & Norris, 1982; Grossu, 1983; Evans, 1986; Forcart, 1986; Wiktor, 2001; Sysoev & Schileyko, 2009; Welter-Schultes, 2012; Kobialka & Siedenschnur, 2017; Neiber, 2017; Eta & Hausdorf, 2019). A record from Greece is based on the description of the colour of a young specimen whose anatomy provides insufficient certainty (Wiktor, 2001).

Apart from this East-European distribution, it is known from the United Kingdom and Ireland (Evans, 1986; Welter-Schultes, 2012; Rowson et al., 2014a, b). Forcart (1986) mentioned *L. maculatus* for the Canary Island of Tenerife. Before that time and in recent literature, however, only *L. flavus* is mentioned for the Canary Islands (van Regteren Altena, 1950; Alonso et al., 1986; Bank et al., 2002; Núñez Brito & Núñez Fraga, 2010; Helixebas, 2020). The occurrence of *L. maculatus* in France is based on figures in Moquin-Tandon (1855: 25–26, pl. III figs 3–6) (Wiktor & Norris, 1982; Evans, 1986; Falkner et al., 2002; Neiber, 2017; Kobialka & Siedenschnur, 2017; Eta & Hausdorf, 2019). The description and these figures of *Limax variegatus* Draparnaud, 1801 have a lot in common with a *Limacus*. A figure of the genitalia indicates *L. maculatus*, but the figure of the whole slug on the other hand resembles more *L. flavus*. The figure of the intestinal tract, however, lacks the caecum and cannot be regarded as a *Limacus*. The caecum may have been overlooked



**Figs 2–4.** *Limacus maculatus*, collected on 18.xii.2020 in Eindhoven, the Netherlands. 2. Lateral view. 3. Dorsal view. 4. Ventral view. Scale bars = 2 cm. (Photos: Ingrid Margry-Moonen).

during preparation and/or drawing. Unfortunately, Moquin-Tandon (1855) does not indicate where the slug comes from. Moreover, it is not certain that all images are made from the same animal. There are no further reports from France. Since 2014, this species also has been found in Germany (Bremen: Kobiálka & Siedenschnur, 2017; Hamburg: Eta & Hausdorf, 2019) and the Czech Republic (Čejka et al., 2020). In this paper, we describe the first confirmed record of *Limacus maculatus* in the Netherlands.

#### RECORDS AND HABITAT

The records were done in a garden of the Fregatstraat in Eindhoven, province of Noord-Brabant, the Netherlands (51.4387°N, 5.4576°E). On 12.xi.2020, the second author put photos of these slugs as *Limacus flavus* on the online platform Waarneming.nl (<https://waarneming.nl/>). In the evening of 18.xii.2020, four specimens were collected for further investigation. Since then, further slugs of this species have been observed in the garden a few more times until it started to get much colder. The garden has a paved middle part surrounded by borders with *Corylus avellana*, *Rhododendron*, *Jasminum*, *Pieris japonica* and *Ilex aquifolium*. The litter layer consists of the fallen leaves that have never been removed for the last 30 years. This extensive garden management also appears to be beneficial for other

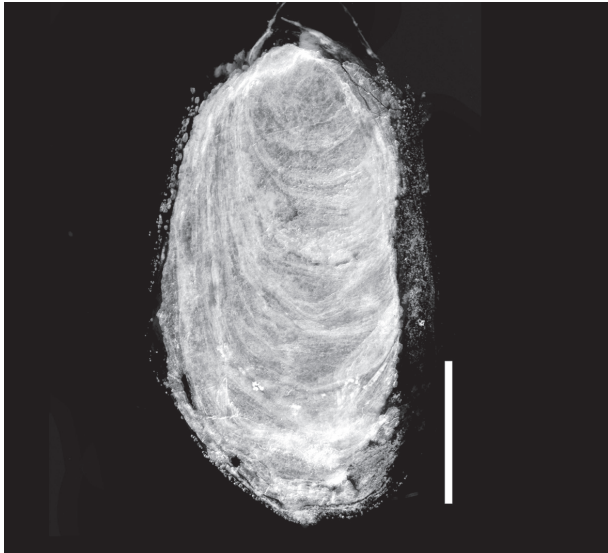
animal groups such as woodlice (Isopoda). Besides *L. maculatus*, *Limax maximus*, *Lehmannia valentiana* (A. Férussac, 1822) and *Vitrina pellucida* (O.F. Müller, 1774) were found. Specimens of *L. maculatus* were also seen in the public space behind the garden.

The photo archive of the second author showed that the species was probably already present in December 2015. A slime trail led from the front door to the pantry, where a slug was found that had all external characters of *L. maculatus*. On 22.x.2020, the second author already posted a photo of one specimen on Waarneming.nl, but it was not noticed as a different *Limacus* species.

#### IDENTIFICATION

All four collected specimens from 18.xii.2020, were used for investigating external characters.

**Body and colour:** The slugs have a short keel. The body colour of the largest slug is yellow-green and towards the front of the mantle more yellow. On the body it has dark-brown spots, which on the mantle converge into a reticulate pattern. The yellow colour and dark spots are not limited to full tubercles but faintly transcend them. The dark spots are mainly present on the upper side. The yellow-green colour predominates more towards the sole. The tentacles are grey-blue. The sole is pale. On this largest specimen, from the tail



**Fig. 5.** Shell of *Limacus maculatus*. Scale bar = 2 mm. (Photo: Ingrid Margry-Moonen).

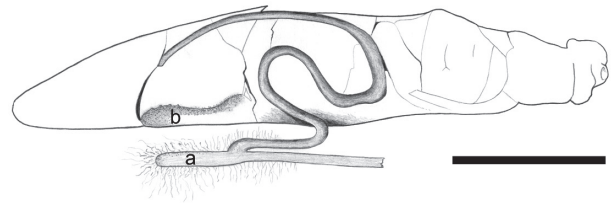
towards the mantle, a few yellow coloured tubercles are only partly situated in a line. There is no complete yellow stripe from the keel to the mantle (Figs 2–4). The second slug has the same colour as the largest one. On the third slug, towards the front side of the mantle and along the foot fringe, the yellow-green colour turns to yellow-orange. The only juvenile specimen from about 20 mm, looks darker and has a yellow stripe of 3 mm from the end of the tail towards the mantle. The mucus is colourless.

Only the two largest specimens were selected for anatomical study. All figures and descriptions are based on the largest animal which reaches 9.5 cm fully stretched. After preservation it had contracted to 5 cm. Only Figure 9 is taken from the second slug (see further).

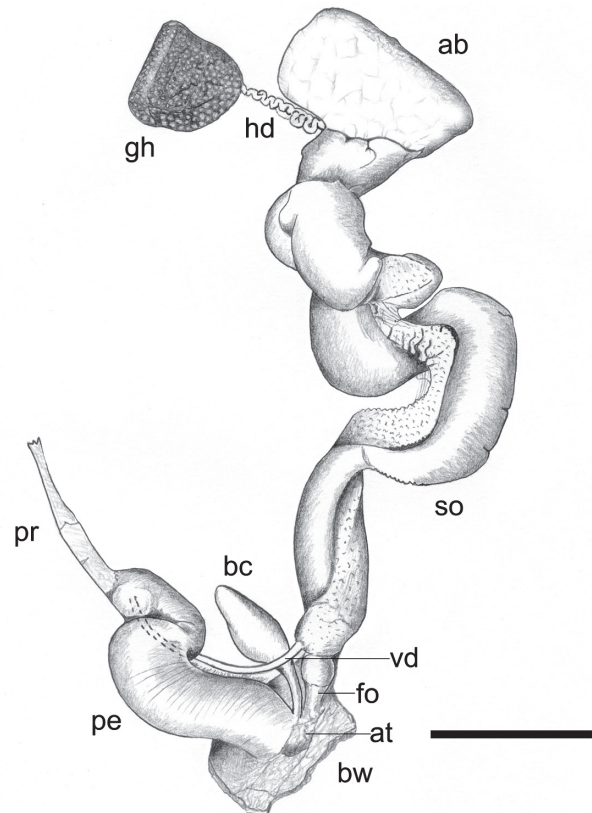
**The shell:** The asymmetric shell of the largest animal measures 6.8 × 3.9 mm, ends in a triangular point and is partly calcified and somewhat transparent (Fig. 5). It is a little narrower than figured in Rowson et al. (2014b: 125), but the shell of the second specimen has about the same width as in the well-illustrated work of Rowson and his colleagues.

**Caecum:** In our specimens, the caecum does not reach the posterior body end. In Figure 6, the impression in the underlying tissue of the digestive gland of the largest slug shows that the caecum has not contracted after it has been dissected from the integument.

**Genitalia:** The genitalia were compared to the published descriptions and figures by Wiktor & Norris (1982), Grossu (1983), Evans (1986), Wiktor (2001), Rowson et al. (2014b: 113, 117), Neiber (2017) and Eta & Hausdorf (2019). In this paper we refer to the proximal part as towards the glandula hermaphroditica and the distal part as closer towards the genital orifice. The pedunculus of the bursa copulatrix attaches to the penis, close to the atrium. The penis makes



**Fig. 6.** Final part of the intestinal tract of *Limacus maculatus*. **a.** The rectal caecum. **b.** The original impression in the soft tissue of the digestive gland. Scale bar = 10 mm. (Drawing: Kees Margry).



**Fig. 7.** Dorsal view of the genital system of *Limacus maculatus*. ab = albumen gland, at = atrium, bc = bursa copulatrix, bw = body wall, fo = free oviduct, gh = hermaphroditic gland, hd = hermaphrodite duct (only half visible, see Fig. 8), pe = penis, pr = penial retractor, so = spermooviduct, vd = vas deferens. Scale bar = 5 mm. (Drawing: Kees Margry).

an s-turn and is longer than the bursa copulatrix. The vas deferens attaches at the proximal end of the penis, close to the penial retractor (Figs 7–8). The interior of the penis from the distal side towards the proximal direction has two longitudinal ridges that half-way pass into transverse foliate creases as figured in Evans (1986: fig. 3D). In the largest slug the penis could not be stretched because of the rather short vas deferens. For this reason, a picture is presented from the interior of the penis of the second slug (Fig. 9). In this penis, one of the longitudinal ridges was cut along its length when opening. Only the second ridge is still visible.



**Fig. 8.** Ventral side of the albumen gland and the hermaphroditic gland of *Limacus maculatus*, with the complete hermaphrodite duct. Scale bar = 1 mm. (Photo: Ingrid Margry-Moonen).

**Jaw:** The oxygnath jaw is 2.3 mm in length (Fig. 10). Growth lines are present over the full length. In the middle protrusion there are fine vertical lines that end in the edge as tiny little serrations. It corresponds to the figure of the jaw from *Limacus* in Barker (1979: fig. 13F).

**Radula:** The radula has about 50 teeth on either side of the central tooth. The central tooth has a mesocone which is slightly smaller than the laterals and without ectocones. About 10 lateral teeth have a large mesocone and hardly developed endo- and/or ectocones (Fig. 11a–b). Next in the row are about 30 elongated marginals without any endo- or ectocones (Fig. 11c). Last in the row are about 10 marginals decreasing towards the edge with a more or less developed ectocone (Fig. 11d).

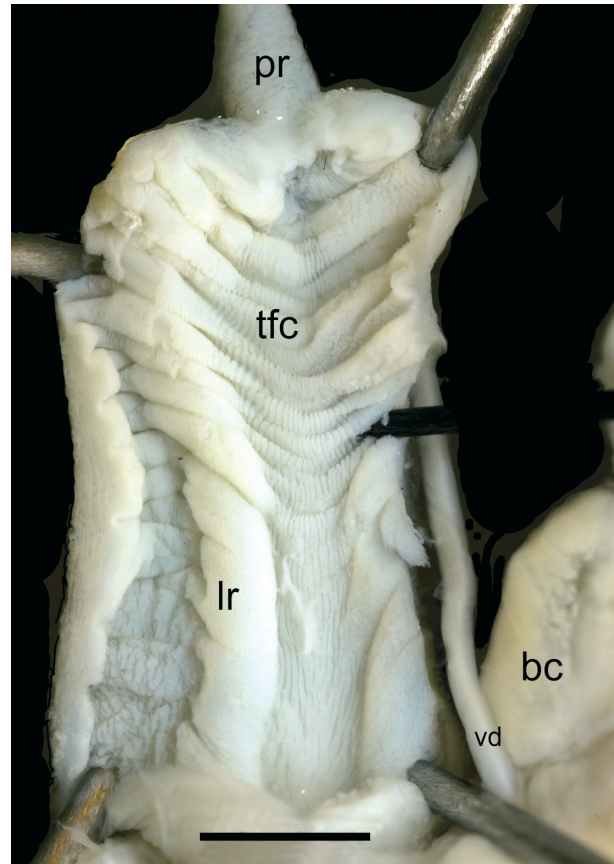
The four specimens will be deposited in the collection of Naturalis Biodiversity Center, Leiden, the Netherlands.

## DISCUSSION

The external and anatomical characters confirm the identification as *Limacus maculatus*. The insertion of the pedunculus excludes *L. flavus*.

In 1982, Wiktor & Norris determined that *L. grossii* Lupu, 1970 and *L. pseudoflavus* Evans, 1978 were synonymous with *L. maculatus* and that *L. flavus* was a different species. Evans (1986) disputes this view and maintains it as four separate species. Since the specimens of the first record in the Netherlands point to *L. maculatus* in both views, this discussion makes no difference for our findings.

Some characters are variable. In *Limacus*, the caecum as depicted in Barker (1979) and Grossu (1983) is variable and hard to use for identification (Evans, 1986). The caecum does not always extend to the end of the body. The penis can have different measurements as well. According to Neiber (2017), the penis is shorter than the bursa copulatrix, according to Wiktor (2001) the penis is longer. Rowson et al. (2014b) indicate that this character is variable and has no distinctive



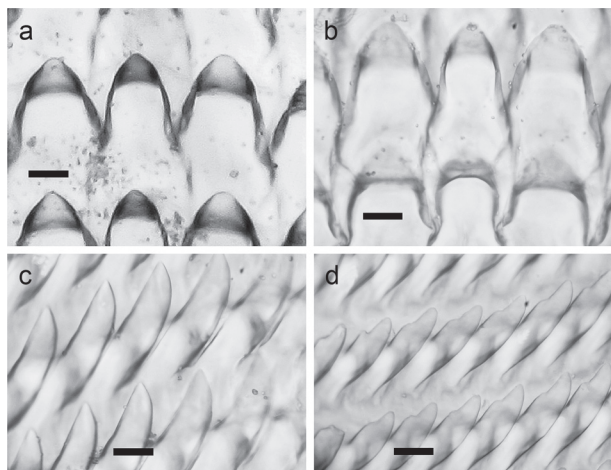
**Fig. 9.** Interior of the penis of *Limacus maculatus* (smaller specimen collected on 18.xii.2020 in Eindhoven, the Netherlands). lr = longitudinal ridge, tfc = transverse foliate creases. For other abbreviations see Fig. 7. Scale bar = 2 mm. (Photo: Ingrid Margry-Moonen).

value. Forcart (1986) explains that the difference in length of the penis in young animals is not yet clearly visible and that only the position of the attachment of the bursa copulatrix to the penis is characteristic.

Rowson et al. (2014b: 70) and Eta & Hausdorf (2019) describe an abrupt tapering of the body towards the tail tip and Wiktor & Norris (1982) and Eta & Hausdorf (2019) describe that the dark spots in *L. maculatus* extend to the



**Fig. 10.** Jaw of *Limacus maculatus*. Scale bar = 1 mm. (Photo: Ingrid Margry-Moonen).



**Fig. 11.** The radula of *Limacus maculatus*. **a–b.** The central tooth with lateral teeth on both sides. **c.** Marginal teeth without cones. **d.** Marginal teeth with simple cones. Scale bar = 20  $\mu\text{m}$ . (Photos: Kees Margry).

foot fringe. Neither of these characteristics are recognizable in our specimens (Figs 3–4).

It is possible that our three largest specimens are not fully grown yet. The maximum number of teeth in the rows of the radula has not been reached. But they can be considered as mature.

In genetic research, evidence for unequal hybridization between *L. maculatus* and *L. flavus* is found. A one-way introgression from *L. maculatus* is assumed (Rowson et al., 2014a). It would be interesting to expand genetic research to these species of *Limacus* in continental Europe.

The city of Eindhoven is part of national landscape “Het Groene Woud”. As a result of this discovery, now 111 species of molluscs from this area are known (Margry, 2021). Apparently, *L. maculatus* is spreading rapidly in Europe (pers. comm. Vollrath Wiese).

Also in view of the recent newcomer *Drusiva valenciennii* (Webb & Van Beneden, 1836) in the Netherlands (Inden et al., 2020), it is advisable to monitor the occurrence of these molluscs well in order to identify problems with invasive exotic species in time. We believe that online platforms like Waarneming.nl are a very important tool to quickly discover new, introduced species as they allow easy input of species’ records by citizen scientists and fast validation. We predict that, in the future, more observations of *L. maculatus* will be identified this way as well as other non-indigenous species new for the Dutch malacofauna. We found more pictures on Waarneming.nl, but also on the Belgian platform Waarnemingen.be (<https://waarnemingen.be/>) that could potentially be attributed to *L. maculatus* based on external characteristics. Additionally, some posts on social media and an observation on iNaturalist (<https://www.inaturalist.org/>), concerning both records from the Netherlands and Belgium, were brought to our attention by one of the reviewers. Our

discovery is the first confirmed case of *L. maculatus* via dissection for the Netherlands, but it is clear that more intensive research in the future could result in more and perhaps earlier records of this species in the Netherlands and possibly also in Belgium where it has not been recorded yet.

Following de Bruyne et al. (2015) we suggest “Groene aardslak” as the Dutch vernacular name for *Limacus maculatus*.

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