

SLUGS OF MARYLAND: BIODIVERSITY AND BIOLOGY

by
AYDIN ÖRSTAN
Germantown, Maryland

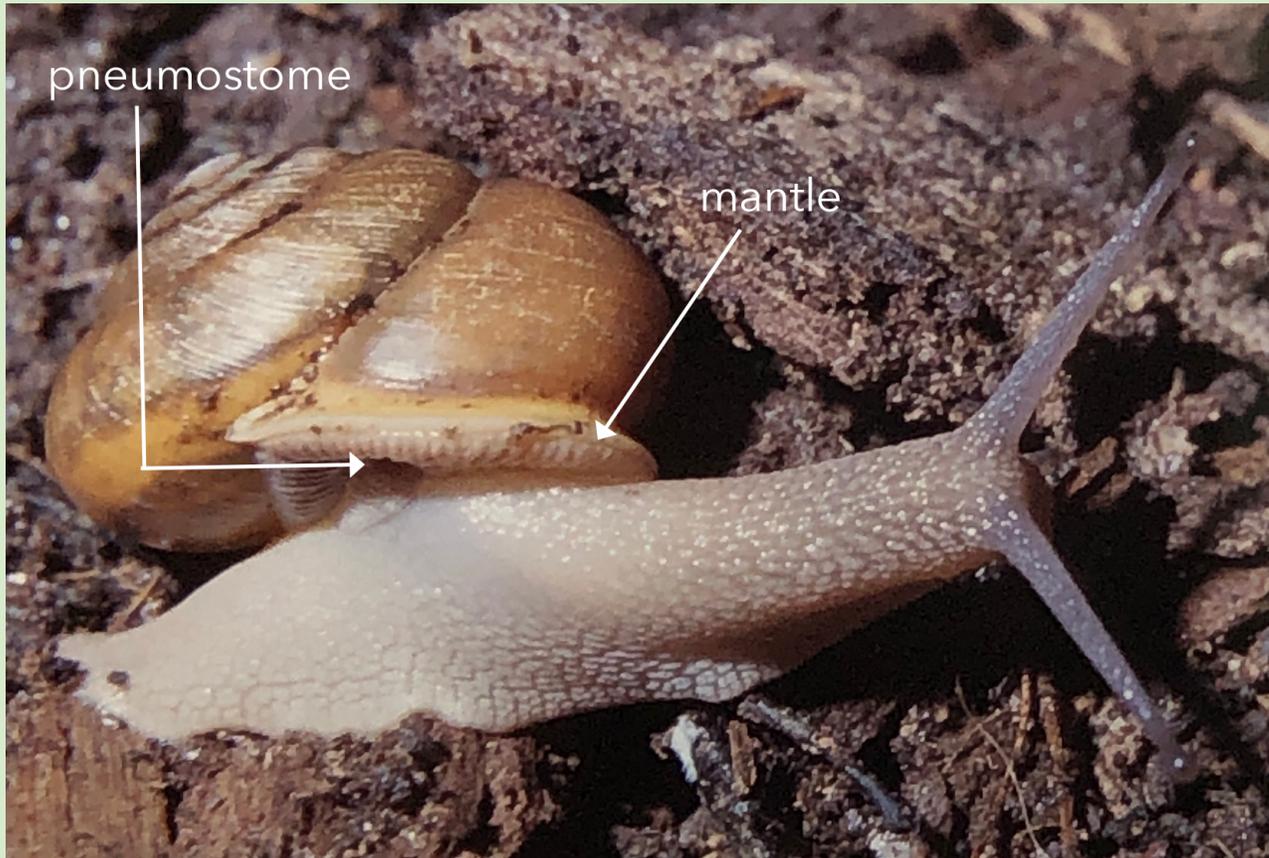
A Zoom presentation for the
Natural History Society of Maryland
14 October 2021

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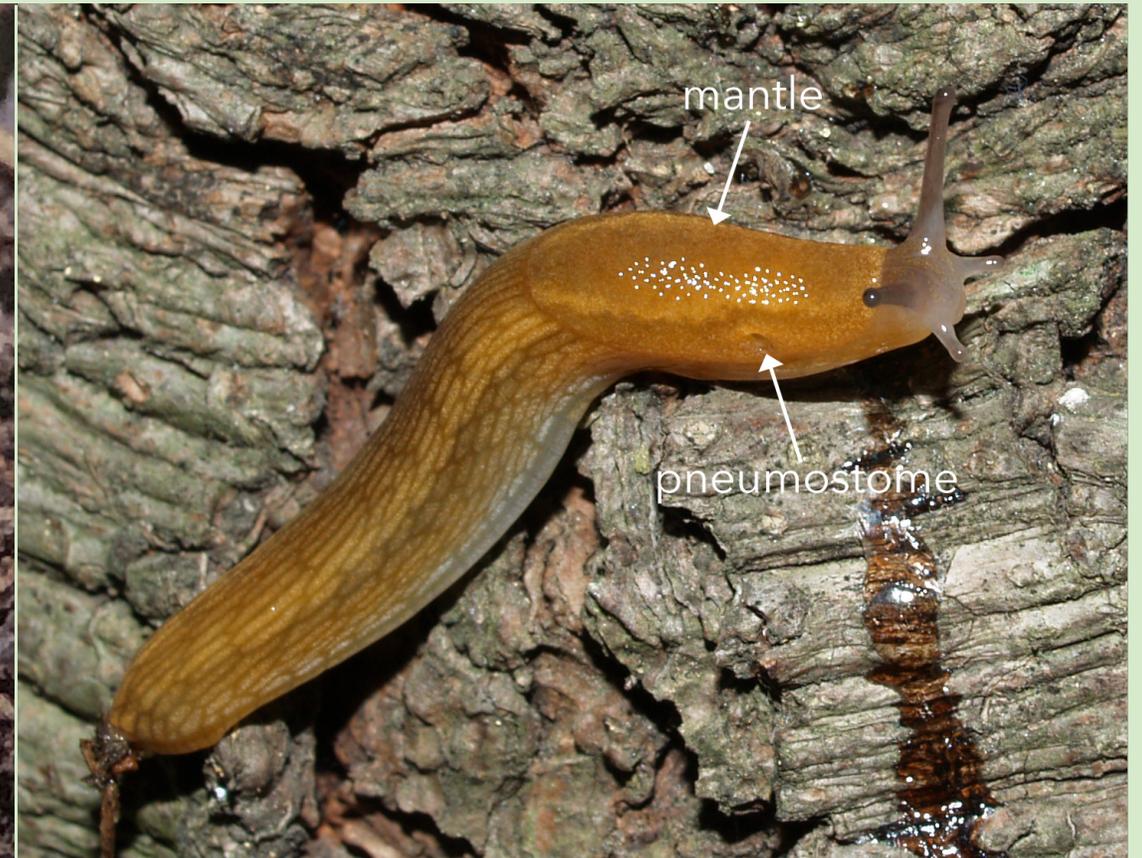
A BRIEF INTRODUCTION TO THE BIOLOGY OF SLUGS

What is a slug?

- A slug is basically a snail that has lost its shell incompletely or completely during evolution.
- Snails + Slugs = Gastropods
- Gastropods + Bivalves (clams, oysters) + Cephalopods (octopuses, squids) + etc. = Mollusks



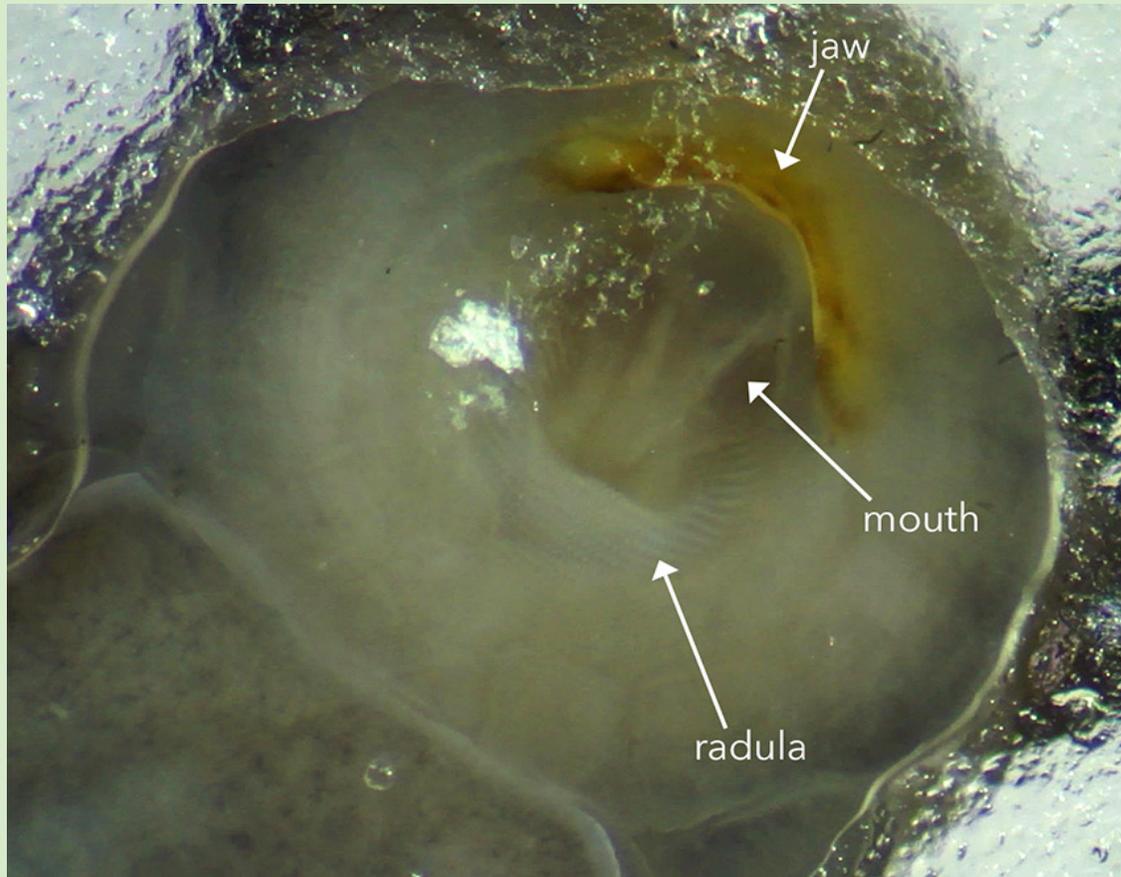
Neohelix albolabris, the largest native northeast U.S. snail.



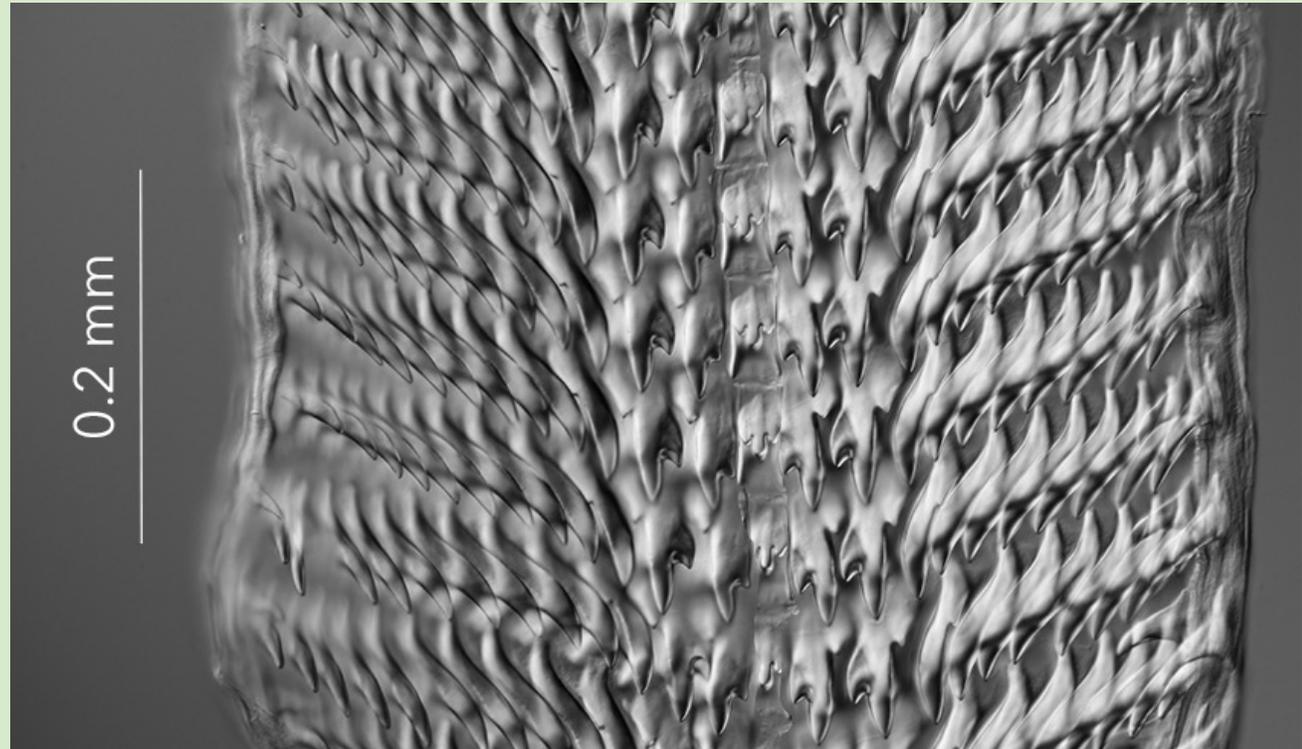
Arion subfuscus, an introduced slug common in Maryland

The radula

- An organ common to snails and slugs is the radula located inside the mouth.
- The radula is a ribbon-like organ covered with rows of hard teeth.
- In addition, the top of the mouth opening is lined with a hard plate referred to as the jaw.



The open mouth of the slug *Deroceras laeve* photographed from below.



The rows of teeth on the radula of a snail.

A video clip showing the slug *Deroceras laeve* rasping on wet corn starch coated on a glass plate. The slug was filmed from below the plate. The yellow crescent-shaped organ is its jaw, while the radula deeper inside the mouth comes into view occasionally as a white U-shaped organ. The slug was collected in College Park, Prince Georges County.



The north-facing and algae-covered siding of a house is a good place to search for radula tracks of slugs.



A slug feeding on the side of a roof gutter.



Close-up of the feeding tracks on a house siding showing the marks left by the radula of a slug.

What good is a snail's shell?



This *Mesodon thyroïdus*, a native snail common in Maryland forests, had sealed itself in a chamber of mucus against a tree trunk. It was protected against short-term water loss, insects and ground predators.

A snail's shell protects its soft body against:

- water loss
- overheating in the sun
- physical damage
- predators
- parasites



More extreme environments require more extreme measures. This *Cantareus apertus*, a native of Mediterranean countries, had closed its aperture with a thick seal of calcium carbonate to withstand the hot and dry summer. Photographed in western Turkey in June 2019.

Lacking the protection provided by a shell, slugs often perish on hot and dry sidewalks



IF IT IS GOOD TO HAVE A SHELL, WHY ARE THERE SLUGS?

Too much of a good thing can be bad

Being without a shell must have its own advantages:

- A growing snail must grow not only its body, but also its shell. They both require energy and materials. A slug, on the other hand, grows only its body. Therefore, a slug would be expected to grow faster and start reproducing sooner than a snail of a comparable body size.
- A shell on a snail's back is extra weight to balance and carry. A slug without a shell can move faster to escape danger.
- A bulky shell on a snail's back can prevent it from entering narrow spaces. A slug without a shell can enter narrow crevices to escape danger.

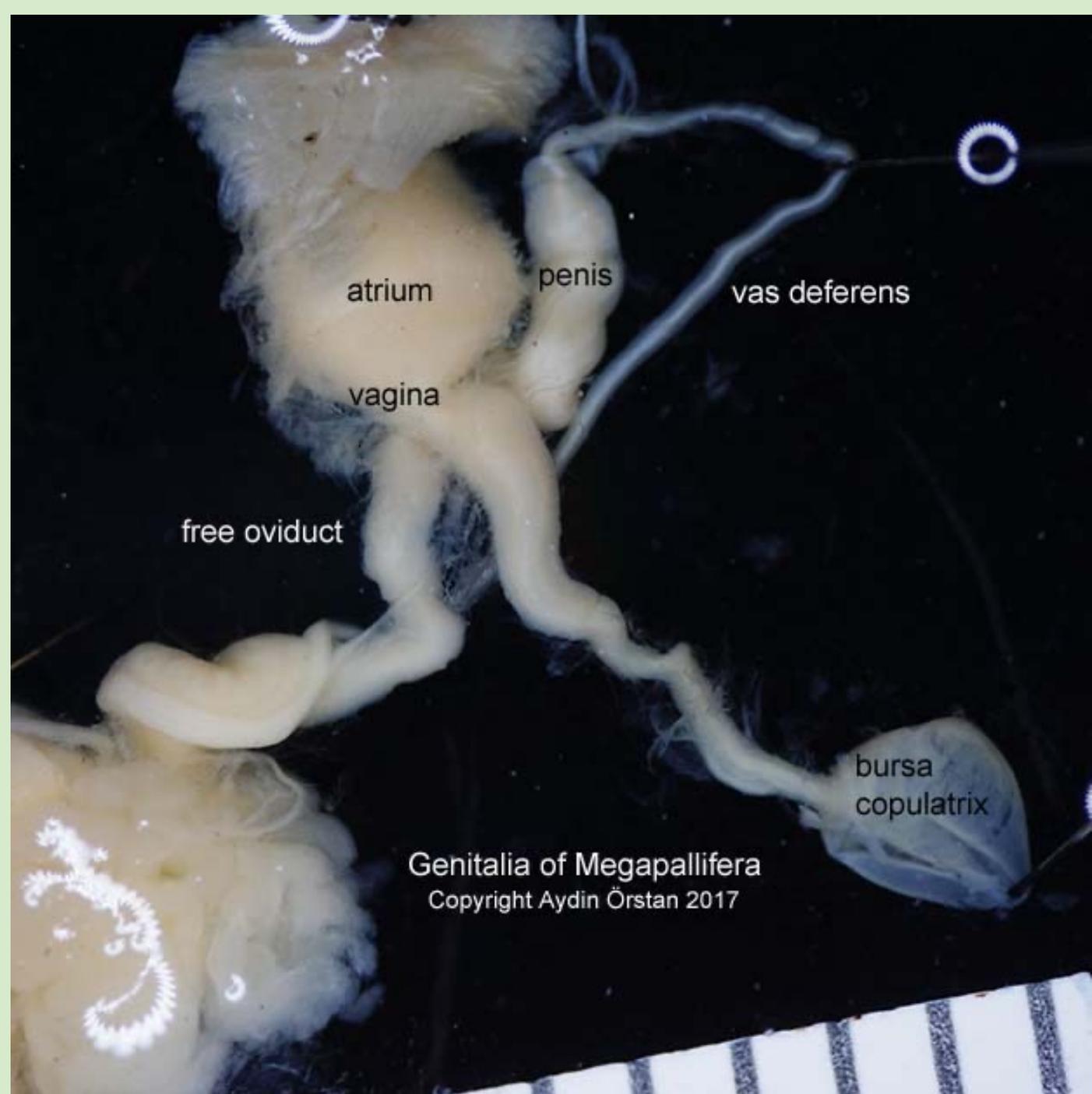
Evolution of slugs

- Several lines of evidence indicate that slugs evolved from snails.
- One clue to the evolutionary past of slugs is hidden inside their bodies: an internal vestigial shell.
- Slugs in the family Limacidae have such internal shells.
- Not every individual may have an internal shell. It is not clear if the shell has a function. In some species they may serve as calcium stores.
- The internal shell of *Limax maximus* is within its mantle cavity.



IT ALL BOILS DOWN TO SEX AND REPRODUCTION

- All slugs are hermaphrodites. Each slug has both male and female organs and produces eggs and sperm.
- In Maryland slugs, the male and female organs are united and there is a shared chamber (atrium) that opens to the outside normally on the right side of the head.
- Genitalia reside inside the body and are everted through the genital opening during mating.
- There are differences in the shapes and dimensions of the parts of the genitalia of slug species. Therefore, dissection of a slug is often necessary to confirm its identification.



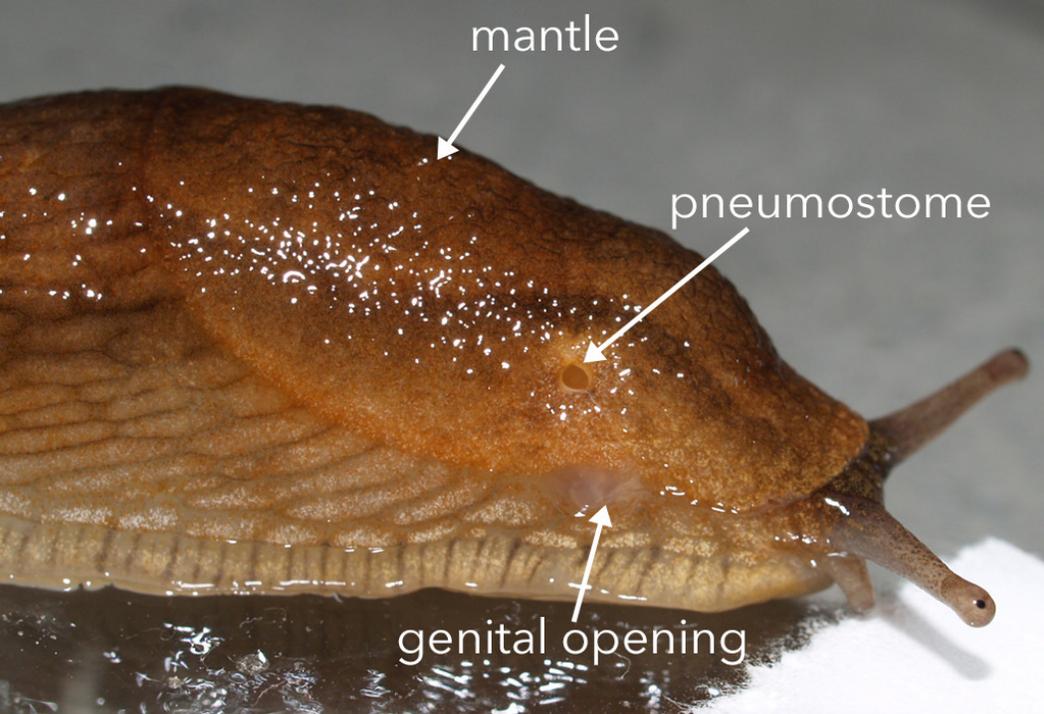
When two sexually mature individuals of the same species come together, they may mate and exchange sperm with each other.

- *Deroceras reticulatum* in pre-mating courtship
- Each slug is stroking its partner with a stimulator organ



- *Arion subfuscus* mating
- Slugs' genitalia have everted and united to exchange sperm

If no partner is available, some slugs are known to fertilize their eggs with their own sperm. This is called "selfing".



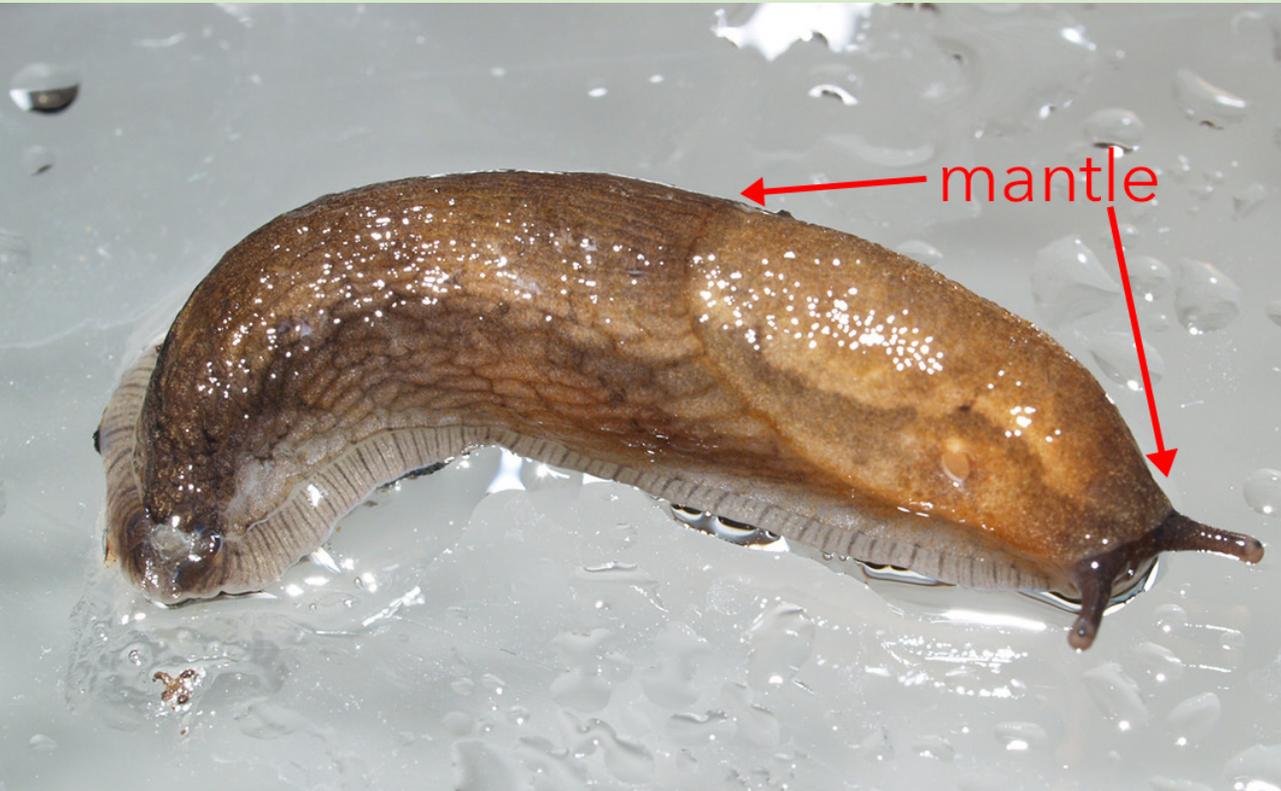
- Slugs that have mated or selfed subsequently produce eggs.
- A single slug can deposit many eggs at one time.
- These photos show an *Arion subfuscus* depositing eggs.



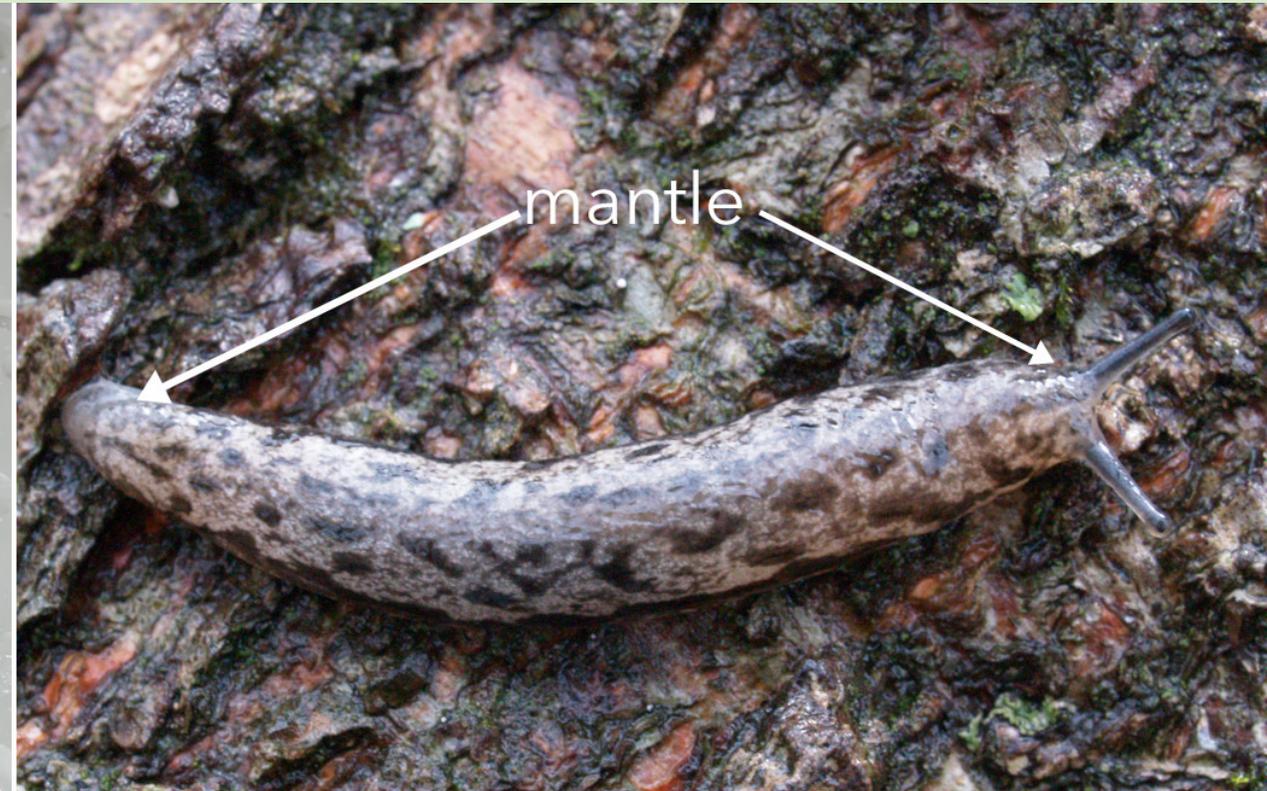
MOST COMMON SLUG SPECIES OF MARYLAND

All native slug species that have been recorded or are likely to be found in Maryland are in the family Philomycidae.

- There are 3 genera: *Megapallifera*, *Pallifera* and *Philomycus*.
- A common trait of the family is a mantle that covers the entire back of the slug.



Arion subfuscus, introduced, family Arionidae.



Megapallifera mutabilis, native, family Philomycidae.

Philomycus carolinianus

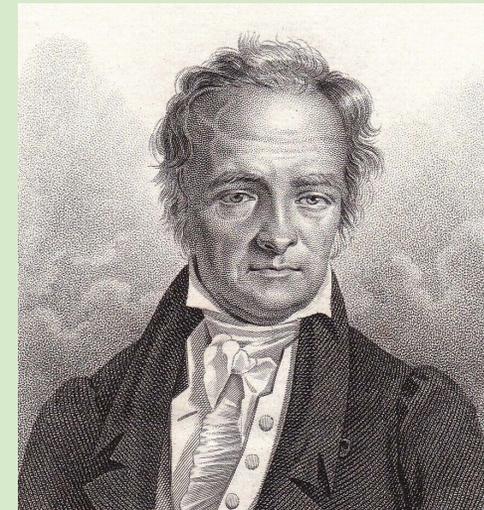


This species is easily recognized by the 2 parallel rows of elongated black spots on its back. This specimen was from Belt Woods in Prince Georges County.

There are additional *Philomycus* species, for example *P. togatus* and *P. flexuolaris*, present in Maryland. It is not easy to distinguish visually among these species; dissection or molecular methods may be necessary.

Philomycus carolinianus has the distinction of being the first endemic terrestrial gastropod species to have been described from North America.

It was described by the French naturalist Louis A. G. Bosc in 1802. Bosc spent 2 years in Charleston, South Carolina in the late 1790s. While waiting for a diplomatic assignment that never came, he collected natural history specimens several of which he later described as new species, including this slug that carries the name of the area where Bosc had found it.



Drawing of Bosc from Wikipedia

Smallest native slugs of Maryland

- *Pallifera dorsalis* and *Pallifera fosteri*.
- They can be distinguished from small species or juveniles of introduced slugs by their mantle that covers the entire back of the animal.
- They inhabit forest litter. Because of their small sizes and cryptic coloration, they are difficult to notice.
- There may be other species and even undescribed ones. The genus has not been revised since the late 1940s.
- This particular specimen was from Frederick County, May 2005. It was ~30 mm long. It has not been identified to species.
- It was fed carrot in captivity. Hence the orange color visible through its skin.



Non-native slug species that have been recorded or are likely to be found in Maryland

- They were all introduced from Europe.
- They are in different families (Agriolimacidae, Arionidae, Limacidae).
- They differ from each other and native species in dimensions and external appearances.
- However, some species pairs are difficult to separate and require dissection or DNA analysis.

Location of the pneumostome on the right side of the mantle helps to separate the families into 2 groups:

in the anterior half

in the posterior half



Arionidae



Agriolimacidae, Limacidae

Limax maximus

- The patterns on its mantle inspire its common name: leopard slug.
- True to its scientific name, it is indeed quite long, but not much wider than shorter slugs.
- It is the largest slug in eastern North America.
- It is believed to be native to southern Europe. Human activities have introduced it to various parts of the world, including North America.
- In Maryland, it may be found in gardens, empty lots, meadows, forest edges.
- This individual was photographed in Germantown, Montgomery County in August 2021.



Arion subfuscus



- In Maryland, it may be found in gardens, meadows, forests.
- Thanks to its often conspicuous orange color, it may be easily spotted on trees, especially beech trees, sometimes quite high above the ground.
- Slug's color may vary from orange to brown.
- A similar species, *Arion fuscus*, has also been introduced to North America and may be present in Maryland. The 2 species can be separated reliably only by dissection or molecular methods.



Arion intermedius

- One of the smallest non-native slugs in North America. When fully grown it is only about 20 mm in length.
- It is easily recognized by its grayish-white body and contrasting black head and tentacles.
- When contracted, its skin displays characteristic tubercles.
- In Maryland, it may be found in gardens, forests and meadows.



Most common *Deroceras* species in Maryland

- *Deroceras* is another genus of introduced slugs present in Maryland. Two *Deroceras* species are common in gardens as well as forests.
- *Deroceras reticulatum* is the larger of the two. The skin covering its posterior body has a reticulated pattern giving the slug its specific name. It can grow up to about 50 mm.
- *Deroceras laeve* is a smaller slug not exceeding about 25 mm in length. It is usually dark colored, often appearing black under low light. Distribution extends from Europe all the way across northern Asia possibly to North America. Colonies in North America may be both native and introduced.



Deroceras reticulatum



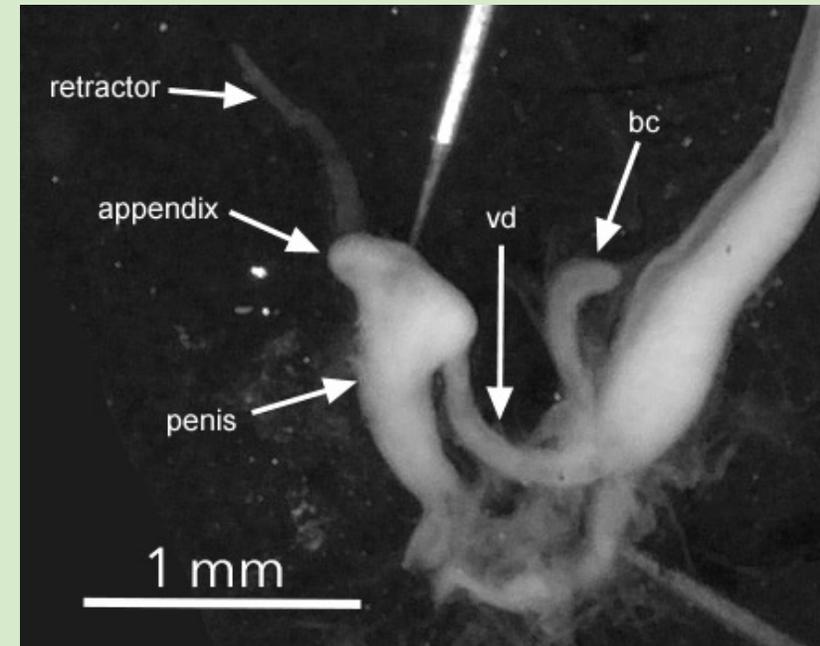
Deroceras laeve

Ambigolimax valentianus

- This species has been called *Lehmannia valentianus* until recently.
- In the older U.S. literature it was identified mistakenly as *Limax marginatus*, which is a different species now called *Lehmannia marginata*.
- Dissection is necessary for a definite identification. *Ambigolimax valentianus* is separated from similar looking species by the presence of a short appendix on its penis.
- It is believed to be native to Spain. In North America it was first recorded in California in 1930. A record from Maryland (as *Limax marginatus*) without further information was published in 1960.



A. valentianus (~50 mm long) from a garden in Germantown, June 2007. Its genitalia are on the right.



A cold black slug with an orange sole

The lowest near-ground air temperature at which this slug was observed active was 3°C (37°F). Photographed in Germantown, Montgomery County, December 2018.

Tentatively identified as *Arion hortensis* or *A. distinctus*. Awaiting dissection for a more definite identification.



SNIPPETS OF NATURAL HISTORY OBSERVATIONS OF MARYLAND SLUGS

WHAT DO SLUGS EAT?

- Most slugs are herbivores and feed on live and dead plant material.



- This *Deroceras reticulatum* was sharing a half-eaten apple with ants.

It is not unusual to encounter normally herbivore slugs feeding on animal remains.

Dead or injured and dying earthworms appear to be a favorite food.



Deroceras reticulatum (left) and *Arion subfuscus* feeding on injured earthworms

These pictures, taken 2 minutes apart, demonstrate the ability of slugs (*Deroceras reticulatum*) to detect the presence of food, in this case a dead earthworm.



Other unusual foods include remains of cat food and even dung!



Even cannibalism is not a taboo! 🤢



Deroceras reticulatum feeding on the remains of another member of its species that had accidentally been stepped on.



Megapallifera mutabilis also climbs trees to feed on the algae growing on the bark

This captive *Megapallifera* was offered a piece of beech bark with a layer of green algae on it. The photo shows its mouth applied to the bark.



The same slug on the beech bark feeding.



The bark after the slug had left. All the green layer on it had been removed by the slug.



Huddling of *Megapallifera mutabilis*

- Resting of slugs in contact with each other is called huddling.
- Huddling takes place in protected places, such as under large objects on the ground.
- Huddling is believed to slow down water loss.
- This behavior has been reported in some species in the family Limacidae.
- We have discovered that *Megapallifera mutabilis* in Maryland forests huddle in water-filled tree holes.



Tail dipping of *Megapallifera mutabilis*

- *Megapallifera mutabilis* resting in water-filled tree holes often immerse their tails in water.
- Tail dipping is believed to help these slugs rehydrate their bodies.
- This behaviour has not been reported in the literature.
- It was observed for the first time in Maryland forests.



Aerial Mating of *Limax maximus*

- Takes place while a pair of slugs is suspended by a mucus string from an elevated point.
- These photographs were taken in August 2007 in a garden in Germantown, Montgomery County.
- The entire process took about 45 min.
- There are distinct stages in the process that a mating pair always seems to go through.

Following and tail biting while climbing



Circling

Twisting of bodies



Eversion of penises



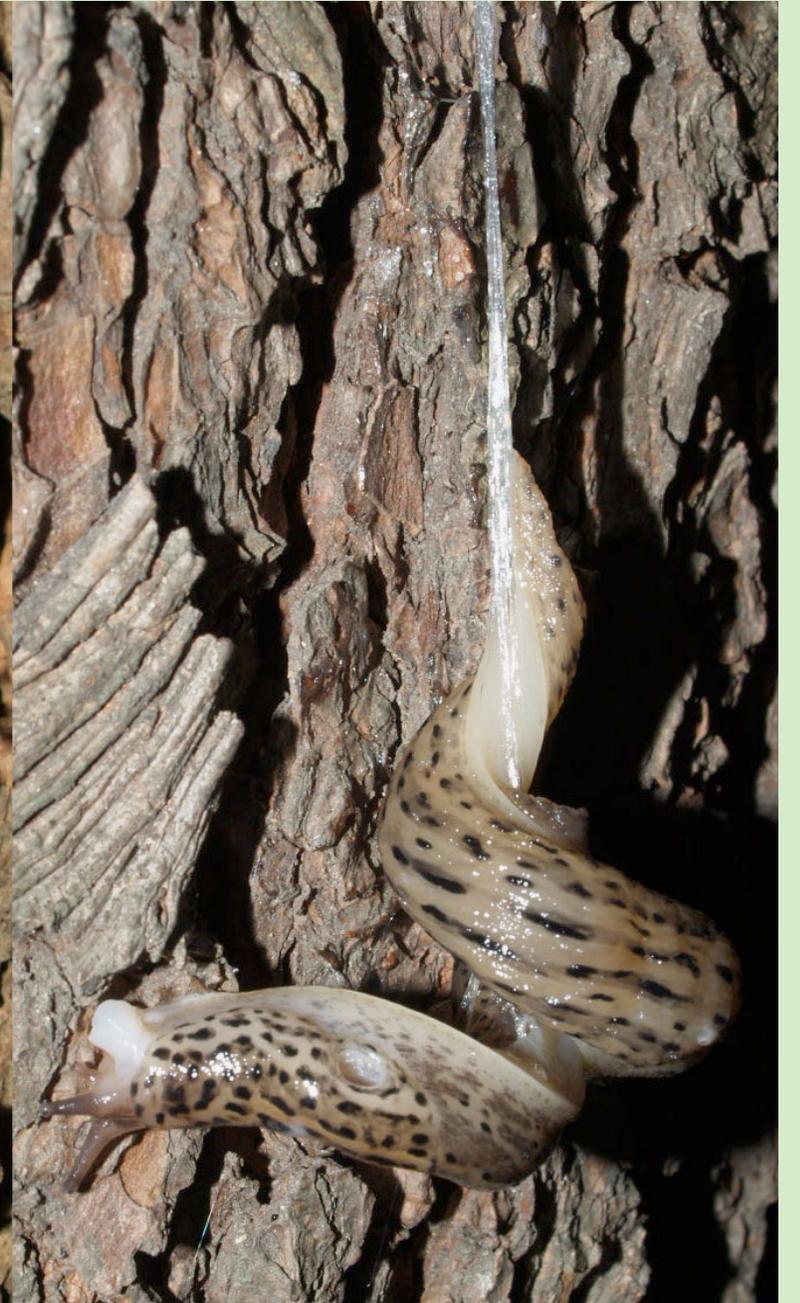
Intertwining of penises



Formation of an enlarged bulb and sperm transfer within it



Withdrawal of penises and separation



Chance favors the prepared mind – Louis Pasteur

Limax maximus mating – Germantown, 5 October 2021



The entire
process took
about 50 min.



WHEN SLUGS GO BAD

A video clip that shows 3 behaviors of slugs: aggression towards conspecifics (biting), defense (slapping with tail) and escape. The escape mechanism illustrates how relatively quickly a slug can move—an advantage of not having a shell. The slugs were *Deroceras laeve* collected in College Park, Prince Georges County.



ACKNOWLEDGMENTS

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ROBERT CAMERON, University of Sheffield, UK

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Slugs and Snails by Robert Cameron
HarperCollins Publishers. 2016.

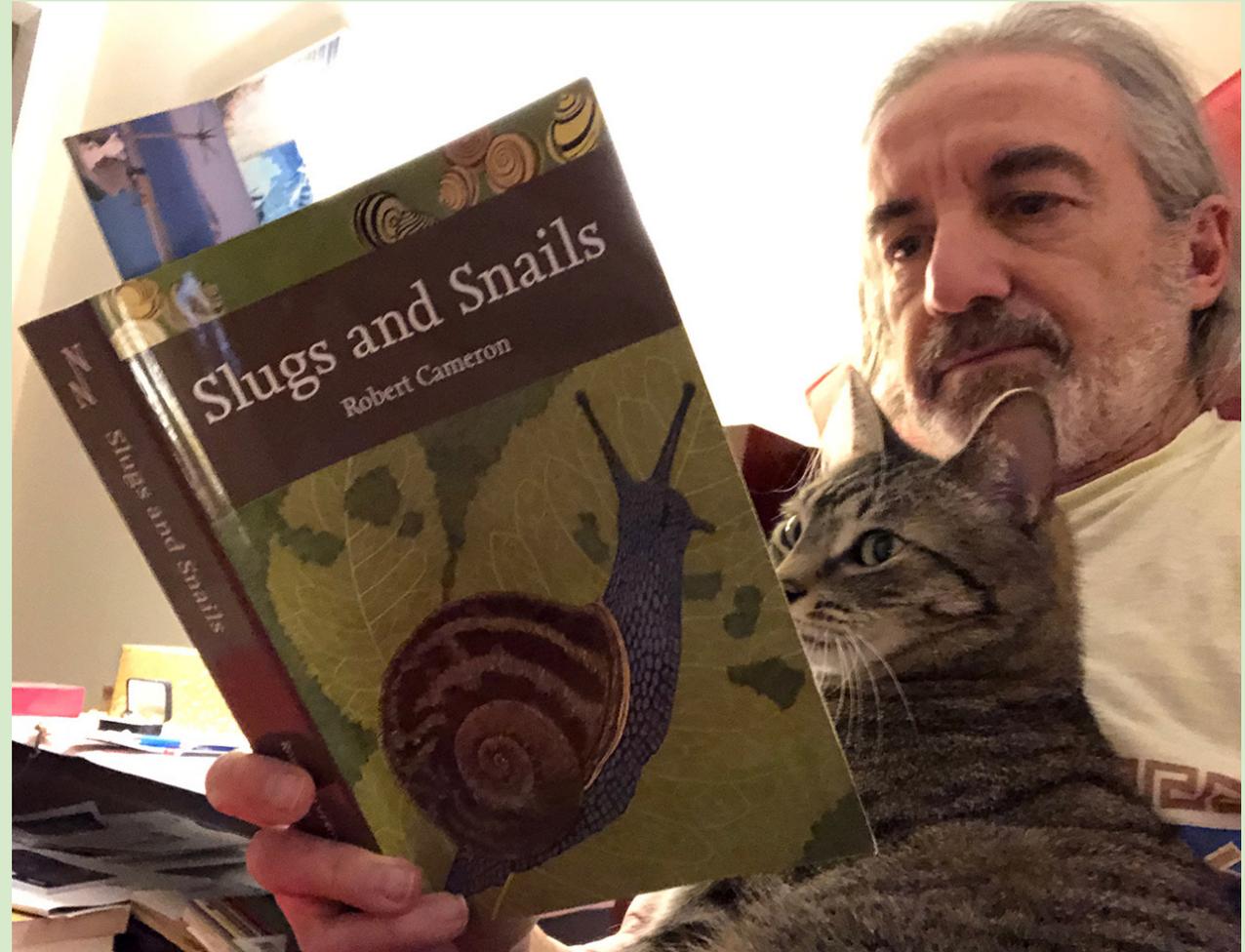
A hefty book (500+ pages) that covers almost every aspect of the biology, evolution, distribution and even cultural importance of terrestrial gastropods. Highly recommended but may be too technical for beginners.

Land Snails and Slugs of the Mid-Atlantic and Northeastern United States

<http://smasheasy.com/mollusks/index.html>

Terrestrial Mollusc Tool

<https://idtools.org/id/mollusc/index.php>



All of the videos shown here will be posted to YouTube channel:
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Slow, simple, and slimy may be the first words that come to mind when you think of slugs, but think again. These mucus covered invertebrates can crawl on a razor blade or knife edge without a cut. Slugs, which are related to the octopus, can be friend or foe. They provide valuable ecosystem services but the wrong species in

Photograph of the speaker as a young man (1975) demonstrating that snails (and slugs) can indeed crawl over a razor blade without injury. No snails were harmed during the making of this photograph!

