

A Field Guide to the Slugs of Kentucky



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Contents

Introduction.....	7
Identification Key to Family, Genus and Species	11
Species Descriptions	14
Glossary of Terms.....	30
References.....	31
Acknowledgments.....	34

Introduction

Slug biology, ecology and pest status

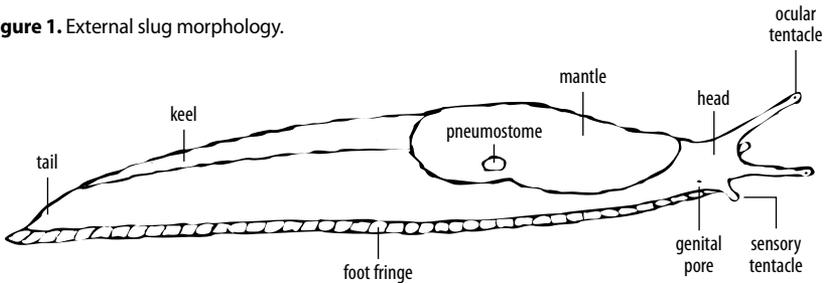
Slugs are soft bodied gastropods (Mollusca) with rasping mouthparts and two pairs of tentacles (Figure 1). The animal's eyes are located on the uppermost, longer pair, called ocular tentacles; the lower pair, called peduncular tentacles, have a sensory function. A slug breathes through a small hole called a pneumostome that is located on its mantle, the flap of tissue behind the head.¹ All species are capable of producing mucus that aids in moisture retention as well as movement, defense, and reproduction.² Slugs are hermaphroditic; when environmental conditions are adverse to sexual reproduction (e.g. when food is limited or during periods of adverse weather such as high temperature or low rainfall), a slug can self-fertilize and produce viable offspring.³ Slugs prefer cool, dark and moist habitats, and activity patterns tend to be highly variable throughout the day but greatest immediately after sunset and during the hours proceeding dawn.⁴ When temperatures increase or conditions become too dry, slugs coat themselves with mucus to prevent desiccation and undergo aestivation (a period of summer dormancy). During this time they remain contracted and immobile. Typ-

ically, aestivation will occur in the soil; however, some slugs can aestivate while being attached to stationary objects such as rocks and stones.

Terrestrial slugs usually lay their eggs in holes or underneath debris, and the number of eggs per batch, and the number of batches laid, varies between individuals and species.⁵ For example, according to Carrick,⁶ *Deroceras reticulatum* can lay up to 500 eggs per year: Davies⁷ states that *Arion hortensis* lays from ten to thirty eggs per batch in captivity. Hatchling slugs appear very similar to adult slugs, with only size and differences in color pattern distinguishing them from their mature counterparts. The time necessary to reach sexual maturity and the natural life span of slugs varies between species with some, such as *Deroceras reticulatum*, having an annual life cycle, and others, such as *Limax maximus*, having a biennial or plurennial life cycle.

- 1 South, 1992
- 2 South, 1992; Gordon, 1994
- 3 South, 1992
- 4 South, 1992
- 5 South, 1992
- 6 Carrick, 1938
- 7 Davies, 1977

Figure 1. External slug morphology.



Slugs occur throughout temperate and tropical regions and are present in a variety of habitats including forests, grasslands, river edges and areas characterized by high levels of anthropogenic disturbance (e.g. urban gardens, plant nurseries, garden centers and agroecosystems). Generally, invasive species are found in disturbed habitats such as urban and agricultural areas; native species dominate the malacofauna in more remote locations such as old growth forests.¹

Slugs are well-known agricultural pests throughout the world and attack a wide range of agricultural and horticultural crops.² For example, *Deroceras reticulatum* can be responsible for up to one third of winter wheat seed and seedling losses in the United Kingdom and other temperate regions.³ In North America, evidence for the agronomic impact of slugs is less widely reported, but invasive mollusks are responsible for significant losses to soybean,⁴ legumes,⁵ corn,⁶ alfalfa,⁷ tobacco,⁸ and strawberries.⁹ Such losses are likely to increase in significance as production systems diversify and agricultural practices increasingly adopt organic, low-input and minimum tillage approaches. In 1985, losses equivalent to \$14 million to potato crops and \$5 million to winter wheat were recorded in Great Britain alone.¹⁰ Slugs are also widely regarded as important pests of leeks, potatoes, onions, artichoke, brassicas, carrots, celery, cucumbers, chicory and beans.¹¹ Moreover, slugs are also important pests in the horticultural and floricultural industries with primulas, campanulas, saxifrage and Michaelmas daisy often sustaining significant levels of aesthetic damage.¹² Although they sometimes consume mature foliage and flowers,¹³ damage typically occurs during the seedling stage.¹⁴ On flowering plants and ornamentals, slugs will also often feed on bulbs, corms and tubers.

In addition to direct yield losses resulting from feeding activities, slugs vector several plant diseases. Wester et al.¹⁵ reported that slugs are capable of transporting downy mildew to lima beans, and Hering¹⁶ reported that *Deroceras reticulatum* and *Arion hortensis* spread the fungus *Botrytis* along grapevines, a trait also common among other slug species. They also transmit brassica dark leaf spot,¹⁷ carrot licorice rot,¹⁸ and bacterial soft rot.¹⁹ Slugs can pose potential health risks to humans by vectoring certain pathogens. Sproston et al.²⁰ demonstrated the ability of *Deroceras reticulatum* to vector *Escherichia coli* 0157. The slugs came into contact with the pathogen on sheep feces and then transferred it to vegetables where the bacteria remained viable for several days. This ability to vector disease and bacteria further highlights the potential adverse impacts of invasive slugs in the U.S. Finally, important commodities grown throughout Kentucky have been reported as food resources for many invasive species known to occur within the state. Therefore, economic losses are likely to increase in future years because of changing agricultural production practices and more favorable climatic conditions.

1 Kappes, 2006

2 Barker, 2002; Godan, 1983; South, 1992

3 Port & Port, 1986; Glen, 1989; Brooks et al., 2005

4 Hammond et al., 1999

5 Byers et al., 1985

6 Hammond & Stinner, 1987

7 Barratt et al., 1989

8 Mistic & Morrison, 1979

9 Prystupa et al., 1987; Duval & Banville, 1989

10 Port & Port, 1986

11 South, 1992

12 Barnes & Weil, 1945

13 Eaton & Tomsett, 1976; Ministry of Agriculture, 1979

14 Ministry of Agriculture, 1979

15 Wester et al., 1964

16 Hering, 1969

17 Hasan and Vago, 1966

18 Dawkins et al., 1985

19 Dawkins et al., 1986

20 Sproston et al., 2005

Slug collecting

A range of sampling techniques can be utilized to collect slugs. Although the vast majority of species are nocturnal, specimens can easily be found during the day by searching under sources of cover in suitable habitats (e.g., flower pots in garden centers, decaying wood in forests and in sprinkler valve boxes in urban gardens). A number of authors¹ have successfully used soil cores to sample slug communities. This method involves removing a turf-soil core (e.g. 10 cm x 50 cm) and gently washing it in a fine-meshed sieve with water. This technique is an important tool for collecting species such as *Tandonia budapestensis* and *Tes-tacella haliotidea*, which are predominant-

ly subterranean. Baited traps, consisting of cat/dog food or organic vegetables covered with black plastic sheeting, can also be used to collect specimens.² The food provides an attractant for slugs; the plastic sheeting provides suitable shelter and maintains a high humidity. Since certain behavioral characteristics (e.g., response to a continuous disturbance) are important in identifying some species, specimens should be kept alive in containers (e.g. 15 cm x 15 cm x 15 cm) lined with damp paper towel and fed on organic vegetables, oatmeal and/or pet food. For additional information on establishing and maintaining slug colonies, see Sivik³ and Stephenson.⁴

Slug preservation and dissection

Some slug species, such as *Arion hortensis*, are difficult to identify solely on external morphological traits; dissection and examination of genitalia is necessary in some cases to make positive identifications. Before specimens are preserved, make detailed notes on collection locale, date, slug size and the color of both the general body and mucus. Such information can prove very useful at a later date, as colors tend to fade over time when a specimen is stored in alcohol. If possible, take a photograph of the dorsal, ventral and right sides of the slug.

Place specimens for preservation in a jar that has been filled to the brim with boiled water and has been allowed to cool. Seal the jar for approximately 24 hours, then remove the slug and place it in 70 percent ethanol. This method ensures that the slugs will be extended and easier to dissect than if placed directly into ethanol. If specimens are required for molecular studies, excise the tip of the tail prior to preservation

and preserve in 100 percent ethanol.⁵ The remainder of the slug should be handled as described above.

To prepare a Petri dish for the dissection, pour hot wax to a depth of approximately 5 mm and allow to solidify. Place the slug on the wax surface, straighten its body and insert pins through the head close to the tentacles, and near the tip of the tail. Add water until the specimen is covered. Use a fine scalpel to make an incision just above the genital pore (Figure 1). Continue the dissection beneath the entire mantle and upwards to a point just posterior to the end of the mantle. This flap of tissue can now be peeled back to view the internal organs. The genitalia are white (Figure 2) and can be traced back from the genital pore. For additional details on slug dissecting techniques, see Kerney and Cameron.⁶

1 South, 1964; Hunter, 1968; Rollo & Ellis, 1974

2 Mc Donnell et al., 2008

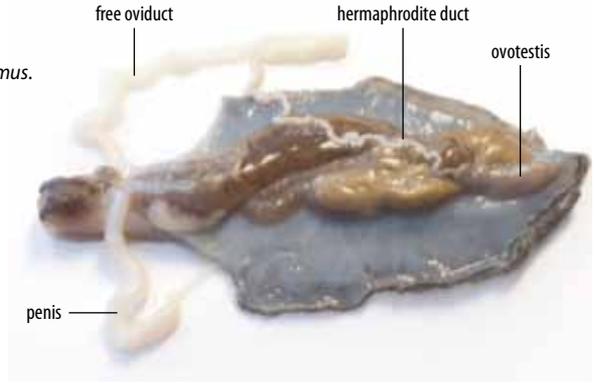
3 Sivik, 1954

4 Stephenson, 1962

5 Mc Donnell et al., 2009

6 Kerney & Cameron, 1979

Figure 2. Genitalia of *Limax maximus*.



External and internal anatomy

The external morphology of a typical slug is illustrated in Figure 1. Figure 2 shows the genital structure of *Limax maximus*. The ligula, or stimulator, which is important in identifying certain arionids and milacids, can be viewed by cutting open the atrium. The atrium also contains the epiphallus structure (at the outlet of the epiphallus), which is important in identifying the differ-

ent species of the *Arion hortensis* complex (see below for details). In addition, a finger-like projection called the flagellum is present on the penis of certain species recorded in Kentucky, such as *Lehmannia valentiana*. For additional detail on the internal anatomy of the various slug families and species, see Bäckeljau and Van Beeck,¹ Barker,² Kerney and Cameron,³ Pinceel et al.,⁴ and Quick.⁵

Status of slugs in North America

Slugs in the subfamily Ariolimacinae (*Ariolimax*) and the genera *Prophysaon*, *Anadenulus*, *Bimneya*, *Hemphillia*, *Hesperarion*, *Philomyces*, and *Pallifera* are all native to North America.⁶ In contrast, the invasive U.S. fauna consists primarily of European species such as *Arion distinctus*, *Arion fasciatus*, *Arion hortensis*, *Arion intermedius*, *Arion rufus*, *Arion subfuscus*, *Deroceras panormitanum*, *Deroceras reticulatum*, *Limax maximus*, *Milax gagates*, *Tandonia budapestensis*,⁷ and tropical species such as *Veronicella cubensis*.⁸ Robinson and Slapcinsky⁹ estimated that there are currently more than 80 established species of exotic slugs and snails established in the U.S. and Canada (excluding the Hawaiian

Islands and Puerto Rico). These invasive species include the slug *Deroceras laeve*, which is considered both native and exotic to North America as some populations have been introduced very recently and have subsequently expanded their range.¹⁰

¹ Bäckeljau & Van Beeck, 1986

² Barker, 1999

³ Kerney & Cameron, 1979

⁴ Pinceel et al., 2004

⁵ Quick, 1960

⁶ South, 1992; Mc Donnell et al., 2009

⁷ Hazay (Reise et al., 2006; Mc Donnell et al., 2009)

⁸ Pfeiffer (Mc Donnell et al., 2008)

⁹ Robinson & Slapcinsky, 2005

¹⁰ South, 1992

The following species of invasive slugs are known to occur in Kentucky,¹ although others are likely present but have not been reported in the literature. (See *Key to Genera and Species*, which includes a description of those species likely to occur.)

<i>Arion hortensis</i>	<i>Lehmannia valentiana</i>
<i>Arion intermedius</i>	<i>Limax flavus</i>
<i>Arion subfuscus</i>	<i>Limax maximus</i>
<i>Deroceras laeve</i>	<i>Milax gagates</i>
<i>Deroceras reticulatum</i>	

For information on the native slug fauna of Kentucky, see *Species Descriptions*.

Due to increased global trade, international trade agreements and tourism, invasions by non-native gastropod species continue to be a persistent problem throughout the United States. Robinson² listed 4,900 gastropods intercepted at points of entry into the United States from 100 countries between 1993. Gastropods can also be accidentally transported with plants. For example, one cardboard box of ash saplings shipped from California to Massachusetts in September 2005 was found to contain five species of snails, three species of slugs and several eggs.³ Such interstate transportation of slugs highlights the urgent need for more effective monitoring of shipments at state and national borders.

Identification Key: Family, Genus and Species

This guidebook provides a field identification key to the different families, genera and species of invasive slugs in Kentucky. Based on our collecting and research experience throughout the state and other parts of the U.S., the invasive fauna is most damaging in terms of agricultural and horticultural production, with native species seldom reaching pest status. However, we also provide an identification key to native genera (*Philomycus* and *Pallifera*) and include a brief description of this fauna.

The families and species denoted by an asterisk in the key below are those which have not yet been recorded in Kentucky but are likely to be collected in the future. For all species, we provide diagnostic field characters, and for problematic species (noted in the key) dissection is recommended to confirm identification.

¹ Burch 1962; Branson & Batch 1969; Mc Donnell et al. 2008; Thomas & Harwood, unpublished data

² Robinson, 1999

³ Gary Bernon, USDA-APHIS, pers. comm.



Key to Families

1	Slug with an external shell (Figure 3).	Family Testacellidae*
	Slug without an external shell.	2
2	Slug with mantle covering most of the body.	Family Philomycidae
	Slug with mantle covering no more than half of the body.	3
3	Pneumostome located anterior to the mid-point of the mantle (Figure 4).	Family Arionidae
	Pneumostome located posterior to the mid-point of the mantle (Figure 5).	4
4	Mantle with a horse-shoe shaped furrow; keel runs from end of mantle to tip of tail.	Family Milacidae
	Mantle without a horse-shoe shaped groove; keel shorter than above.	5
5	Mantle ridges/wrinkles centered to the right of the mantle over the pneumostome.	Family Agriolimacidae
	Nucleus of mantle ridges lies on the mid-dorsal line.	Family Limacidae

Key to Genera and Species

Family Agriolimacidae		
1	Gray to cream in color (Figure 5), usually with dark reticulations; a white, very sticky mucus secreted when continuously disturbed; up to 5 cm in length.	<i>Deroceras reticulatum</i>
	Dark to light brown; mucus watery and colorless.	2
2	Tip of the tail rises vertically or may curve backwards away from the sole; rim of pneumostome may be paler than rest of body; sole grayish; body appears to be thin-walled giving a translucent appearance; up to 3 cm in length (Figure 6); dissection required.	<i>Deroceras panormitanum</i> *
	Tip of the tail slopes forward; rim of pneumostome usually the same color as the rest of body; sole light brown; body not appearing translucent; up to 2.5 cm in length (Figure 7); dissection required.	<i>Deroceras laeve</i>
Family Arionidae		
1	Very large slug (up to 18 cm); often exhibits a "rocking" motion when disturbed; orange to red foot fringe with thin, dark vertical lines, contrasting with duller body (Figure 8); head and tentacles distinctly darker than rest of body; sole color usually matching upper surface; sole mucus very pale or colorless.	<i>Arion rufus</i> *
	Smaller slug; does not "rock" when disturbed.	2
2	Very small slug (< 2.5 cm) with an echinate, or spiny, appearance when contracted (use a hand lens); head and tentacles noticeably darker than rest of the body (Figure 9).	<i>Arion intermedius</i>
	Larger slug; not echinate when contracted.	3

Key to Genera and Species, continued.

<p>3 Dark, grayish brown to bluish black (Figures 10 & 11); mucus on sole bright yellow to orange.</p>	4
<p>Lighter, grayish to yellowish brown (Figures 4 and 12); foot sole pale yellow or grayish white with colorless mucus.</p>	5
<p>4 Tentacles bluish-black; body gray to brown in color (Figure 10) but with varying amounts of yellow granules, which may cause a slightly yellowish coloration; back color <i>not</i> contrasting with lower sides; right mantle band <i>always</i> with a break above the pneumostome; up to 4 cm in length; dissection required.</p>	<p><i>Arion distinctus*</i></p>
<p>Tentacles faintly reddish; body gray to black in color (Figure 11); sides below the lateral bands contrasting pale; <i>never</i> a break in right mantle band above pneumostome; up to 5 cm in length; dissection required.</p>	<p><i>Arion hortensis</i></p>
<p>5 Slug contracts into a hemispherical shape when disturbed and is bell shaped in transverse section when at rest; body mucus colorless; sole grayish white; up to 5 cm in length (Figure 12).</p>	<p><i>Arion fasciatus*</i></p>
<p>Slug unable to contract into a hemispherical shape when disturbed and is not bell shaped in transverse section when at rest; body mucus orange-yellow; foot sole pale yellow and sometimes translucent in appearance (Figure 4); up to 7 cm in length.</p>	<p><i>Arion subfuscus</i></p>
<p>Family Limacidae</p>	
<p>1 Body yellowish with distinct green mottling (Figure 13); tentacles contrasting oily blue; mucus slippery and plentiful; keel often marked by a pale yellow line (sometimes only obvious near the tip of the tail); mucus yellow; up to 12 cm in length.</p>	<p><i>Limacus flavus</i></p>
<p>Body without green mottling; tentacles light to dark brown; mucus colorless.</p>	2
<p>2 Mantle spotted or marbled black; mucus sticky and sparse; keel obvious; lateral bands may be present on the tail but are always absent from the mantle (Figure 14); up to 20 cm in length.</p>	<p><i>Limax maximus</i></p>
<p>Mantle with two obvious lateral bands present and a less distinct median band; mucus watery; keel poorly marked; lateral bands often run full length of the body (Figure 15); up to 7.5 cm in length.</p>	<p><i>Lehmannia valentiana</i></p>
<p>Family Milacidae</p>	
<p>Only <i>M. gagates</i> (Figure 16) has been recorded in Kentucky. See below for a full description of this and related species.</p>	
<p>Family Philomycidae</p>	
<p>1 Mantle covering the entire length of the body including the head; less than 4 cm in length.</p>	<p>Genus <i>Pallifera</i></p>
<p>Mantle covering the body but not the head; greater than 4 cm in length.</p>	<p>Genus <i>Philomycus</i></p>
<p>Family Testacellidae</p>	
<p>Testacellid slugs have not yet been recorded from Kentucky but <i>Testacella halioidea</i> Draparnaud (Figure 17) has been reported from other parts of the U.S.</p>	



Species Descriptions

Native Species

The native slug fauna of Kentucky has received relatively little research attention, and the total number of native species present in the state remains uncertain due to the lack of systematic surveys and unstable taxonomy. However, *Megapallifera mutabilis*, *Megapallifera ragsdalei*, *Megapallifera wetherbyi*, *Philomycus carolinianus*, *Philomycus flexuolaris*, *Philomycus togatus*, *Philomycus venustus*, *Philomycus virginicus*, *Pallifera dorsalis*, *Pallifera fosteri*, *Pallifera marmorea*, and *Pallifera secreta* have been reported from throughout the state.¹

Detailed ecological information on these slugs is also scarce. *Philomycus carolinianus* and *Philomycus flexuolaris* are thought to have a preference for moist upland wooded situations.² The former species is commonly collected under the bark of hardwood logs on the floodplains of forests, and the latter tends to shelter under rocks.³ Branson and Batch⁴ cited leaf litter in moist forests as a preferred microhabitat of *Pallifera dorsalis*; *Megapallifera ragsdalei* was found most often in moist, wooded ravines and streamside buffs. All of these native species most likely feed on fungi and lichens in their woodland habitats.⁵

Invasive Species

The color of specimens described in the following biographies represents typical color forms of each of the species. Any variation in Kentucky specimens will be highlighted.

¹ Burch, 1962; Hubricht, 1968; Branson & Batch, 1970; Branson, 1973; Branson & Batch, 1988; Dourson & Feeman, 2006

² Branson & Batch, 1988

³ Branson & Batch, 1970

⁴ Branson & Batch, 1988

⁵ Runham & Hunter, 1970



Agrilimacidae

Deroceras laeve

MÜLLER, 1774

Common names: Marsh slug; meadow slug.

Global distribution: *Deroceras laeve* is native to the Holarctic¹ but has been introduced to most areas of the world.²

Ecology: This partially amphibious species³ is found across a large range of habitats including marshes, wet woodlands, fields, and river banks⁴ from sea level to altitudes of greater than 3 miles.⁵ It is a pest of agricultural and horticulture habitats, feeding on both living and dead plant material.⁶ In its native range, *Deroceras laeve* takes refuge under leaf litter and woody debris.⁷

Description: *Deroceras laeve* can reach a length of 2.5 cm and has colorless mucus. Mantle covers approximately half the length of the body.⁸ Coloration is dark brown with distinctive black flecking, but specimens can be gray, light brown or black. Sole tends to be light brown. The penis of *Deroceras laeve* is variable, but it is usually long and slender with a simple appendage. However, some individuals may be solely female with vestigial male reproductive organs.⁹

Similar Species: In other parts of the U.S., *Deroceras laeve* can easily be confused with *Deroceras panormitanum*, but the lat-

ter has not yet been recorded in Kentucky. The structure of the penis is the most reliable way of distinguishing both species (see page 12 for details). A pneumostome with a distinctly paler rim has often been cited¹⁰ as a reliable characteristic for distinguishing *Deroceras laeve* (absent) from *Deroceras panormitanum* (present), but Mc Donnell et al.¹¹ have found specimens of *Deroceras panormitanum* in California lacking this trait and specimens of *Deroceras laeve* with a pale rim. As a result, this characteristic should be used with caution when identifying these species. De Winter¹² cited the shape of the tip of the tail as a considerably more reliable characteristic. In *Deroceras panormitanum* the tail tip rises vertically from the foot and may curve backwards; in *Deroceras laeve* the tail tip slopes forward.

1 South, 1992

2 Barker, 1999

3 Chichester and Getz, 1969

4 Cameron et al., 1986; South, 1992

5 Barker, 1999

6 Alicata, 1950

7 Perez et al., 2008

8 Barker, 1999

9 Kerney and Cameron, 1979

10 Barker, 1999

11 Mc Donnell et al., 2009

12 De Winter, 1988



Agriolimacidae

Deroceras panormitanum

LESSONA AND POLLONERA, 1882

Common names: Brown field slug; long-neck field slug.

Remarks: Not yet recorded in Kentucky.

Global distribution: This slug is native to southwestern Europe¹ but has been introduced to Canada, the U.S., South America, New Zealand, Australia, South Africa and throughout Europe.²

Ecology: *Deroceras panormitanum* is found mainly in gardens, greenhouses, parks and wastelands as well as fields and hedges. The species is a serious pest of agriculture, horticulture and urban gardens.³

Description: Up to 3 cm in length with colorless mucus.⁴ Body tends to be brown but can be gray. Mantle is approximate-

ly one third the length of the body, which appears to be thin-walled giving a translucent appearance.⁵ Sole light gray. Tip of the tail rises up vertically from the sole or may curve backwards away from it.⁶ The penis of this species is bilobed and has 4 to 6 flagella between the lobes.⁷

Similar Species: See *Deroceras laeve*.

1 Kerney & Cameron, 1979

2 Chevalier, 1973; Altena & Smith, 1975; Rollo & Wellington,

1975; Barker, 1999; Forsyth, 2004

3 Barker, 1999

4 Barker, 1999

5 Forsyth, 2004

6 De Winter, 1988

7 Forsyth, 2004; Kerney & Cameron, 1979



Agriolimacidae

Deroceras reticulatum

MÜLLER, 1774

Common name: Gray field slug.

Global distribution: This species is native to the western Palearctic region but is now present in most parts of the world.¹

Ecology: *Deroceras reticulatum* is most abundant in synanthropic situations and is a common agricultural and garden pest. It feeds on most vegetable and grain crops as well as horticultural plants.² Most slugs in gardens feed at ground level or just below its surface; however, *Deroceras reticulatum* will crawl up plants to feed.³

Description: Up to 5 cm in length.⁴ Mucus is clear but becomes milky with continuous disturbance. Body color ranges from cream

to gray but specimens usually with dark reticulations. The penis is relatively large and has a bilobed appearance (due to a constriction at its midpoint). There is usually a single flagellum, which may have a number of bulbous branches.⁵

Similar Species: This species with its milky-colored mucus is unlikely to be confused with any other slug in Kentucky.

1 Quick, 1960; Barker, 1999; Forsyth, 2004

2 South, 1992; Gordon, 1994

3 Barnes & Weil, 1945

4 Barker, 1999

5 Forsyth, 2004; Barker, 1999



Arionidae

Arion distinctus

MABILLE, 1868

Common names: Darkface Arion; Mabile's orange-soled slug.

Remarks: (a) Not yet recorded in Kentucky. (b) This species is part of a species complex¹ containing *Arion hortensis* s.s., *Arion distinctus* and *Arion owenii*. Prior to taxonomic separation by Davies,² the three species were grouped together under *Arion hortensis* s.l. As such, pre-1977 records of *A. hortensis* should be treated with caution.

Global distribution: This species is native to western Europe³ but has been documented in the U.S.,⁴ Canada,⁵ New Zealand,⁶ and most of Europe including Belgium,⁷ Sweden,⁸ Norway,⁹ and the Faroe Islands.¹⁰

Ecology: This species is mainly found in areas associated with human activity¹¹ and is a serious pest of vegetable crops.¹²

Description: Up to 4 cm in length. Mucus yellow to orange and very sticky.¹³ Body color is variable and ranges from dark gray to grayish brown. Tentacles bluish-black. Back color *not* contrasting with lower sides. Right mantle band always with a break above the pneumostome.

Similar Species: In other parts of the U.S. this species can easily be confused with *A. hortensis*, but the structure of the genitals can be

used to reliably separate the species. Backeljau and Van Beeck¹⁴ cite the shape of the epiphallus structure (i.e. a structure associated with the outlet of the epiphallus in the atrium) as the most reliable diagnostic characteristic. In *Arion distinctus*, it is a relatively well-defined conical structure which extends into the atrium and covers the outlet of the epiphallus. In addition, a gutter runs from the margin of the epiphallus structure to its center.¹⁵ In the case of *Arion hortensis*, the epiphallus structure covers about half of the outlet, and the gutter is absent. The final member of the complex, *Arion owenii*, has not yet been recorded in the U.S. It has a variable epiphallus structure but, according to Backeljau and Van Beeck,¹⁶ it is usually long, thin, tongue-like and protrudes from the outlet of the epiphallus.

1 Davies, 1977; Davies, 1979

2 Davies, 1977; Davies, 1979

3 Roth & Sadeghian, 2006

4 Roth, 1986; Mc Donnell et al., 2009

5 Forsyth, 2004

6 Barker, 1999

7 Backeljau & Marquet, 1985; De Wilde 1983, 1986

8 Davies, 1979

9 Holyoak & Seddon, 1983

10 South, 1992

11 South, 1992

12 Barker, 1999

13 Barker, 1999

14 Backeljau & Van Beeck, 1986

15 Backeljau & Van Beeck, 1986

16 Backeljau & Van Beeck, 1986



Arionidae

Arion fasciatus

NILSSON, 1823

Common name: Orange-banded Arion.

Remarks: Not yet recorded in Kentucky.

Global distribution: This species is widely distributed in Europe¹ and has been introduced into North America.²

Ecology: This slug is often associated with gardens, waste ground,³ and parks.⁴

Description: Up to 5 cm in length. Grayish above but fading to paler gray on sides. Lateral bands dark but with a distinct yellow coloration below. Right lateral band passes over the pneumostome. Sole whitish gray with colorless mucus. Bell shaped in transverse section when at rest.

Similar Species: There are two additional European invasive species, *Arion silvaticus* and *Arion circumscriptus*, which are externally similar to *Arion fasciatus*, and both

have been recorded in the U.S.⁵ However, the yellowish flush below the dark lateral bands is a useful trait for identifying *Arion fasciatus* in the field. In terms of the genital morphology, the unpigmented epiphallus of *Arion fasciatus* distinguishes it from the speckled epiphallus of *Arion circumscriptus*. *Arion silvaticus* is also similar to *Arion fasciatus* but it has a wider oviduct than the latter.⁶ It is worth highlighting that Geenen et al.⁷ have cast doubt on the species status of *Arion circumscriptus*, *Arion fasciatus* and *Arion silvaticus*.

1 Falkner et al., 2001

2 Chichester & Getz, 1973

3 Kerney & Cameron, 1979

4 Pflieger, 1999

5 Roth & Sadeghian, 2006; Jass, 2007

6 Kerney & Cameron, 1979

7 Geenen et al., 2006



Arionidae

Arion hortensis

D'AUDEBARD DE FÉRUSSAC, 1819

Common names: Garden slug; Férussac's orange-soled slug.

Remarks: (a) Recently reported from Kentucky.¹ (b) A member of the *Arion hortensis* species complex (see *Arion distinctus* for details).

Global distribution: *Arion hortensis* has been introduced into the U.S.,² Canada,³ New Zealand,⁴ and occurs throughout Europe including Belgium,⁵ Ireland,⁶ Great Britain, France and the Netherlands.⁷ It is native to western and southern Europe.⁸

Ecology: This species is common in areas associated with human disturbance and is a well-known agricultural and horticultural pest.⁹

Description: Up to 5 cm in length. Mucus yellow to bright orange and very sticky.¹⁰ The predominant body color of this spe-

cies is black, but it can also be found in various shades of gray. The color of the sides below the lateral bands are contrasting pale, and there is never a notch in the right mantle band above the pneumostome. Tentacles faintly reddish. Internally, the epiphallus structure is an inconspicuous plate which covers about half of the epiphallus outlet, and it never has a gutter.¹¹

Similar Species: Easily confused with *Arion distinctus* (see page 18).

1 Mc Donnell et al., 2008

2 Roth, 1986; Thomas & Harwood, unpublished data

3 Forsyth, 2004

4 Barker, 1999

5 Backeljau & Marquet, 1985; De Wilde 1983, 1986

6 Anderson, 2005

7 Davies, 1979

8 Roth & Sadeghian, 2006

9 Davies, 1979; Kerney & Cameron, 1979; South, 1992; Barker, 1999

10 Barker, 1999

11 Backeljau & Van Beeck, 1986



Arionidae

Arion intermedius

NORMAND, 1852

Common names: Hedgehog Arion; Glade slug.

Remarks: Recently reported from Kentucky.¹

Global distribution: This species has been documented throughout its native range of central and western Europe.² It has been introduced into Vancouver³ and other areas in North America⁴ as well as Australia, New Zealand, South Africa,⁵ North Africa and Polynesia.⁶

Ecology: This slug is common in woodland and grassland habitats. It also occurs in gardens and agricultural land, but it is less common in these areas.⁷ Barker⁸ suggests that *Arion intermedius* is not a significant pest.

Description: Up to 2.5 cm in length. The predominant color of the body and sole is grayish-yellow, but the head has distinctly darker

tentacles. Body mucus yellow.⁹ *Arion intermedius* can be easily separated from other slug species by the presence of small spikes on the tubercles which give the slug an echinate appearance when it is contracted.¹⁰ Internally, there is no ligula within the genital atrium.¹¹

Similar Species: This arionid, with its echinate appearance, is unlikely to be confused with any other slug in Kentucky.

1 Mc Donnell et al., 2008

2 Anderson, 2005; Backeljau, 1985; Barker, 1999; Kerney &

Cameron, 1979; Solhøy, 1981

3 Rollo & Wellington, 1975

4 Chichester & Getz, 1973, Mc Donnell et al., 2009; Thomas &

Harwood, unpublished data

5 Barker, 1999

6 Forsyth, 2004

7 South, 1992

8 Barker, 1999

9 Forsyth, 2004

10 Kerney & Cameron, 1979

11 Quick, 1960



Arionidae

Arion rufus

LINNAEUS, 1758

Common names: Chocolate Arion; Red slug.

Remarks: Not yet reported from Kentucky.

Global distribution: This species can be found throughout Europe, particularly in the south, and has been introduced to the U.S.¹ and Canada.² It is native to western and southern Europe.³

Ecology: A species known from anthropogenic areas including campsites, gardens and parks.⁴ Mc Donnell et al.⁵ collected this species in coastal forests in northern California. It is omnivorous and feeds on fungi, feces, carrion and both dead and living plants.⁶

Description: Up to 18 cm in length. Body color brownish to reddish orange. The distinct foot fringe is usually orange or red (contrasting with duller body) and has obvious black vertical lines. Head and tentacles darker than the rest of the body. Body mucus is pale orange and sole mucus colorless. Specimens sometimes display a rocking behavior when disturbed.

Similar Species: *Arion rufus* is unlikely to be confused with any other slug species cur-

rently known from Kentucky, but in Europe it is very similar externally to *Arion lusitanicus* (= *vulgaris*). Although not yet reported from the U.S., this species is a very severe pest in Europe and is a likely future invasive species in Kentucky. Both species, however, can be reliably separated on the basis of genital morphology. *Arion rufus* has a large, relatively unsymmetrical atrium with a large ligula situated inside the genital atrium. The ligula of *Arion lusitanicus* on the other hand is located inside the distal part of the oviduct giving it a swollen appearance. The point of insertion of the spermathecal duct and the epiphallus is lower on the atrium in *Arion lusitanicus* than in *Arion rufus*.⁷ The latter can also be easily confused with *Arion ater* but this species has a smaller, more symmetrical atrium with a smaller ligula.⁸

1 Roth & Sadeghian, 2006

2 Forsyth, 2004

3 Roth & Sadeghian, 2006

4 Forsyth, 2004

5 Mc Donnell et al., 2005

6 Pflieger, 1999; Forsyth, 2004

7 Noble, 1992

8 Quick, 1960; Noble, 1992



Arionidae

Arion subfuscus

DRAPARNAUD, 1805

Common name: Dusky slug.

Remarks: This cryptic species is part of a complex containing two distinct species, *Arion subfuscus* and *Arion fuscus*.¹ Both have been recorded in the U.S.²

Global distribution: This species is native to northern and western Europe³ and has been documented throughout Ireland,⁴ Great Britain,⁵ Finland,⁶ Spain, Portugal,⁷ the Balkan states,⁸ and the former USSR.⁹ It has been introduced into Canada¹⁰ and other parts of North America,¹¹ New Zealand, and Venezuela.¹²

Ecology: This slug is found in many habitats, particularly forests and residential areas; however, it is scarce in agricultural fields.¹³ Mc Donnell et al.¹⁴ also collected this species in garden centers in northern California.

Description: Up to 7 cm in length. The body tends to be orange-brown, often with darker lateral bands. Body mucus is orange-yellow and very sticky. Sole light yellow with colorless mucus. Foot fringe with thin lincolations. A good diagnostic feature for

this species is its inability to contract into a hemispherical shape when disturbed or at rest.¹⁵ (All other species of arionids known from Kentucky can contract into this shape when alarmed or resting.)

Similar Species: *Arion subfuscus* can be distinguished from *Arion fuscus* using the position of the genitalia relative to the digestive gland. For *Arion subfuscus*, the genitalia are large, pale and are located on the edge of the digestive gland; those of *Arion fuscus* are smaller, darker and embedded within the gland.¹⁶

1 Pinceel et al., 2004

2 Pinceel et al., 2005; Barr et al., 2008; Mc Donnell et al., 2009

3 Roth & Sadeghian, 2006

4 Anderson, 2005

5 Quick, 1960

6 Fosshagen et al., 1972

7 Alonso, 1975; Seixas, 1976

8 Osanova, 1970

9 Likharev & Rammelmeier, 1952

10 Rollo & Wellington, 1975; Forsyth, 2004

11 Roth & Sadeghian, 2006

12 Chichester & Getz, 1973; Blanchard & Getz, 1979

13 South, 1992; Thomas & Harwood, unpublished data

14 Mc Donnell et al., 2009

15 Cameron et al., 1979

16 Pinceel et al., 2004



Limacidae

Lehmannia valentiana

D'AUDEBARD DE FÉRSSAC, 1823

Common names: Valencia slug; Three-band garden slug.

Global distribution: This slug is native to the Iberian Peninsula¹ but has been introduced throughout Europe including Ireland,² Great Britain,³ the Netherlands,⁴ Sweden,⁵ and the Azores.⁶ Outside of Europe it has been recorded in the U.S.,⁷ Canada,⁸ Australia, New Zealand, South Africa, Columbia, Chile, Peru, Juan Fernandez Islands, and Easter Island.⁹

Ecology: This slug is common in greenhouses and is frequently found in residential gardens.¹⁰

Description: Up to 7.5 cm in length. The ground color is usually buff but can also be brown. This species generally has two distinct, parallel lines on its dorsal surface which often run the full length of the body. There may also be a less obvious median band. The mucus of *Lehmannia valentiana* is profuse, colorless and watery. Internally, the penis has a short, blunt flagellum.¹¹

Similar Species: In Kentucky, *Lehmannia valentiana* could be confused with *Limax maximus*, but the latter is larger, never has mantle bands and has sticky mucus (see below for additional detail). *Lehmannia nyctelia* is native to Europe and may eventually be introduced to the U.S. Externally, it is almost identical to *Lehmannia valentiana*, but the penis of *Lehmannia nyctelia* does not have a flagellum. However, Mc Donnell et al.¹² have collected specimens of *Lehmannia valentiana* in California where the flagellum has been inverted into the lumen of the penis giving the appearance of *Lehmannia nyctelia*. In cases where no flagellum is visible, collectors are welcome to send specimens to the corresponding author for confirmation.

1 Roth & Sadeghian, 2006

2 Anderson, 2005

3 Kerney, 1987

4 Gittenberger & De Winter, 1980

5 Waldén, 1960

6 Barker, 1999

7 Howe & Findlay, 1972; Chichester & Getz, 1973

8 Forsyth, 2004

9 Barker, 1999

10 South, 1992

11 Forsyth, 2004

12 Mc Donnell et al., 2009



Limacidae

Limacus flavus

LINNAEUS, 1758

Common names: Yellow cellar slug; Yellow garden slug.

Global distribution: *Limacus flavus* is native to Europe¹ and has been documented in Great Britain,² the Crimea, the Caucasus, the Near East, North Africa,³ Denmark, and Scandinavia.⁴ It has been introduced into Australia,⁵ New Zealand,⁶ North and South America,⁷ South Africa,⁸ St. Helena,⁹ China, Japan,¹⁰ Madagascar, Rarotonga, and Vanuatu.¹¹

Ecology: This highly invasive species is strongly associated with synanthropic areas. It is a pest of stored agricultural produce¹² and both residential and commercial areas.¹³ However, in Europe, it is also known to occur in woodlands¹⁴ and in Armenia, it was found in cracks in cliffs of the subalpine and steppe zones.¹⁵

Description: Up to 12 cm in length and mottled yellow and green. Body mucus yellow but sole mucus colorless. Tentacles con-

trasting blue. Keel weak, rounded and often marked by a yellow line. Internally, the penis is long with two to three kinks and the spermathecal duct joins at the apex of the oviduct.¹⁶

Similar Species: *Limacus flavus* with its yellowish-green mottling is very unlikely to be confused with any other slug species in Kentucky.

1 Roth & Sadeghian, 2006

2 Kerney, 1976

3 Likharev & Rammelmeier, 1952

4 Kerney & Cameron, 1979

5 Altena & Smith, 1975

6 Barker, 1982

7 Chichester & Getz, 1973

8 Quick, 1960

9 Gittenberger, 1980

10 Forsyth, 2004

11 Barker, 1999

12 Godan, 1983

13 Barker, 1999

14 Quick, 1960

15 Likharev & Rammelmeier, 1952

16 Kerney & Cameron, 1979

Limacidae

Limax maximus

LINNAEUS, 1758

Common names: Leopard slug; Great gray slug; Giant garden slug.

Global distribution: *Limax maximus* has been documented throughout Europe¹ and has been introduced into North and South America,² South Africa,³ Australia,⁴ New Zealand, and Canada.⁵

Ecology: A synanthropic species which occurs in parks, gardens, greenhouses, out-houses, cellars, greenhouses, underground tunnels and woodlands close to residential areas.⁶ It may also be a pest of agriculture and horticulture.⁷ *Limax maximus* has a unique mating ritual. Unlike most slugs, which mate on the ground or under the earth, this species mates while suspended on a thick mucus strand in the air, often under an overhanging branch or post.⁸

Description: Up to 20 cm in length. Body color pale brown with distinctly darker bands on the tail which may be fragmented into spots. Mantle *never* with dark bands, only with spotting or marbling. Antennae reddish-brown.⁹ Body and sole mucus colorless and sticky. Keel usually well-marked. Internally the penis is large and convoluted.¹⁰

Similar Species: In Kentucky, this species could be confused with the smaller *Lehm-annia valentiana*, but the latter has watery mucus and usually has distinct mantle bands (see above for extra detail).

1 South, 1992

2 Chichester & Getz, 1973

3 Quick, 1960

4 Altena & Smith, 1975

5 Barker, 1999

6 Quick, 1960; South, 1992; Pflieger, 1999; Barker, 1999

7 Barker & McGhie, 1984

8 Runham & Hunter, 1970

9 Kerney & Cameron, 1979

10 Barker, 1999





Milacidae

Milax gagates

DRAPARNAUD, 1801

Common names: Greenhouse slug; Jet slug.

Global distribution: *Milax gagates* is thought to be native to the coasts and islands of the western Mediterranean and Canary Islands¹ but has been introduced to many parts of Europe including Ireland,² Great Britain,³ and Finland.⁴ It is an introduced species in North America,⁵ Australia,⁶ New Zealand,⁷ Japan, South America and numerous Atlantic and Pacific Islands.⁸

Ecology: This species is common in areas associated with humans, such as gardens, agricultural fields⁹ and greenhouses.¹⁰ It is predominantly a subterranean species and is a pest of root crops.¹¹ *Milax gagates* is also pestiferous in greenhouses.¹²

Description: Up to 5 cm in length.¹³ Body color usually gray to black. Lateral bands absent. The keel runs from the end of the mantle to the tip of the tail and is usually of similar color to the body; however, in California Mc Donnell et al.¹⁴ collected specimens with a distinctly lighter colored keel. Body and sole mucus are colorless. Internally, the genital atrium contains a long and curved stimulator.¹⁵

Similar Species: Although this is the only milacid collected in Kentucky, there are

many similar species which are known pests in Europe. These include *Tandonia budapestensis*, which has recently been collected in the U.S.¹⁶ A dark median stripe on the sole¹⁷ can be used to distinguish this species from *Milax gagates*. *Tandonia budapestensis* also assumes a “C” shape¹⁸ when at rest or when threatened, and it has no stimulator in the genital atrium.¹⁹ *Boettgerilla pallens* is also an invasive milacid.²⁰ The latter is wormlike, bluish in color with a darker keel²¹ and hence is very unlikely to be confused with any other species.

1 Barker, 1999

2 Anderson, 2005

3 South, 1992

4 Valovirta, 1969

5 Fox, 1962; Chichester & Getz, 1973; Roth, 1986

6 Altner & Smith, 1975

7 Barker, 1999

8 Barker, 1999

9 Kerney, 1966

10 Valovirta, 1969

11 Barker, 1999

12 Gordon, 1994

13 Barker, 1999

14 Mc Donnell et al., 2009

15 Barker, 1999; Kerney and Cameron, 1979

16 Reise et al., 2006

17 Pflieger, 1999

18 Cameron et al., 1983

19 Barker, 1999

20 Kerney & Cameron, 1979

21 Forsyth, 2004



Testacellidae

Testacella haliotide

DRAPARNAUD, 1801

Common names: Shelled slug; Earshell slug.

Remarks: Not yet recorded in Kentucky.

Global distribution: *Testacella haliotide* is native to Europe and North Africa,¹ but outside of this region it has been introduced to North America and Cuba where it can be found in greenhouses.² It exists outside of greenhouses in Pennsylvania,³ and New Zealand.⁴ Roth and Sadeghian⁵ report the species from California and Barker⁶ from Australia.

Ecology: A carnivorous species feeding on invertebrates including earthworms, snails and other slugs.⁷ It spends most of its life underground, coming to the surface to hunt at night. *Testacella haliotide* is most common in gardens and compost heaps.⁸

Description: Up to 12 cm long with a small external shell located dorsally at the posterior end of the body. Body color is yel-



The externally located shell of *Testacella haliotide*.

low to grayish brown with colorless mucus. Two branched, lateral grooves originating from the anterior edge of the shell are a unique feature of testacellid slugs. In *Testacella haliotide* these grooves are separated by approximately 2 mm at their point of origin.⁹ Internally, the spermathecal duct is short and thick and the penis has an obvious flagellum.¹⁰

Similar Species: The species with its external shell is unlikely to be confused with any other slugs in Kentucky.

1 Barker, 1999

2 Chichester & Getz, 1973

3 Branson, 1976

4 Barker, 1979

5 Roth & Sadeghian, 2006

6 Barker, 1999

7 Barker, 1999

8 Cameron et al., 1986; Gordon, 1994

9 Barker, 1999

10 Quick, 1960

Glossary of Terms

Echinate. Bearing or covered with spines or bristles; prickly.

Epiphallus. A sclerite in the floor of the genital chamber.

Flagellum. Fingerlike projection on penis of certain slugs.

Foot fringe. Skin around foot of a slug.

Gastropod. Any mollusk of the class Gastropoda, comprising the snails, whelks, slugs, etc.

Genital pore. Opening from which the penis exits the body of a gastropod.

Hermaphrodite. Housing male and female sexual organs.

Keel. Raised tissue on the dorsal surface of some slugs.

Ligula. Straplike structure used for stimulation in some gastropods.

Lineolations. Very fine parallel lines.

Mantle. A fold or pair of folds of the body wall that lines the shell and secretes the substance that forms the shell in mollusks and brachiopods.

Mollusca. Phylum containing gastropods, bivalves, cephalopods, and chitons.

Ocular tentacles. Tentacles on a gastropod which contain photosensitive cells.

Peduncular tentacles. Tentacles on a slug used for sensory perception.

Pneumostome. A small opening in the mantle of a gastropod through which air passes.

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