

THE RECENT GASTROPODA OF OKLAHOMA, PART VIII. THE SLUG FAMILIES LIMACIDAE, ARIONIDAE, VERONICELLIDAE, AND PHILOMYCIDAE

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Keys to and discussions of the 14 species of slugs known from Oklahoma are presented, and distributional and ecological data are given.

INTRODUCTION

Since my last contribution (1), little work has been accomplished on the Gastropoda of Oklahoma, particularly on the four families of slugs known to occur within the state.

The taxonomy of slugs is generally confused, partially because most of them lack external shells, and because of their tendency toward considerable environmental and genetic variability. Moreover, all slugs are nocturnal animals, hiding during daylight hours in earthen burrows or beneath objects lying on the ground (2). They also hibernate when the ambient temperature falls within a few degrees of freezing and aestivate during long dry spells. All of these features tend to complicate collecting, reducing the number of specimens available for study. A sizeable segment of the Oklahoma slug fauna is of exotic origin. Some of these species have been able to achieve nearly world-wide distribution through human activities (3), particularly species such as *Limax maximus*, *L. flavus*, *L. valentianus*, and *Deroceras reticulatum*; other introduced species have more spotted distributions. Most of these species achieve initial introduction via plant materials, i. e., food and/or greenhouse plants, and some become serious agricultural pests.

Chichester and Getz (3) proposed a model for the importation and dispersal of slugs. In general form, that model is paraphrased here:

1. Importation phase: primary entrance, often on vegetation of various sorts, usually at more than one site.
2. Local establishment phase: each species must establish itself in the vicinity of initial entry points, almost invariably in urban areas. The most plastic species are able to exploit several niches.
3. Secondary transport phase: the species are moved to secondary foci by dissemination of plant materials outside the initial site.
4. Secondary establishment phase: repetition of the same type of adaptation that occurred in phase 2.
5. Active dispersal phase: occurs from both primary and secondary sites, often to roadside ditches, trash heaps, and other disturbed areas.
6. Naturalization phase: the species, through local selection, achieve a more or less continuous distribution.

All of these phases have been involved in the origin and spread of exotic slugs in the Oklahoma fauna, although some of the slugs have not yet achieved a continuous distribution. Some of them, like the veronicellids, will doubtless remain restricted to greenhouses, since they are of tropical origin.

RESULTS

The information which follows includes data for four families, 12 genera, and 14 species of slugs.

Key to Families of Oklahoma Slugs

- 1a. Mantle covering entire back or lacking entirely.....2
- b. Mantle covering only the anterior part of the back3
- 2a. Body nearly round in cross-section; invertible tentacles not annulated; breathing pore in anterior half of mantle.....Philomycidae
- b. Body lenticular in cross-section; invertible tentacles annulated; breathing pore at posterior end of body Veronicellidae

- 3a. Breathing pore in anterior half of mantle, situated directly in groove which connects it to mantle margin Arionidae
- b. Breathing pore in posterior half of mantle, situated slightly behind the groove which connects it to mantle margin Limacidae

FAMILY LIMACIDAE

Because of the ease with which slugs are transported in plant materials, the Oklahoma limacid fauna is considerably richer in exotic species than in native forms. In fact, four of the five living species known from the state are introduced ones. Most of the species are relatively easily identified. Characters of the family follow.

Small to large slugs with an oval mantle anteriorly placed on the back bearing a small oval, disk-shaped internal shell; elongated head may be withdrawn beneath the mantle; breathing pore on right side and connected to edge of mantle by a short slit; relatively narrow foot in three longitudinal bands (tripartite); horny jaws smooth and the radular teeth simple or bifid. Highly variable in coloration. Two genera and five living and one fossil species known from Oklahoma.

Key to Oklahoma Genera and Species of Limacidae

- 1a. Back and/or mantle bearing conspicuous bands and/or spots; intestine with six loops *Limax*..2
- b. Back and/or mantle lacking conspicuous bands and/or spots; intestine with four loops *Deroceras*..4
- 2a. Mantle and back brown or tan, bearing dorsolateral, longitudinal dark brown bands *Limax valentianus*
- b. Mantle and back gray, whitish or black, bearing black or white bands, blotches and reticulations3
- 3a. Mantle and back of dark color bearing lighter markings; slime yellowish *Limax flavus*
- b. Mantle and back of light color bearing darker markings; slime clear *Limax maximus*
- 4a. Mantle and back light to dark gray; mantle faintly concentrically striated; back granular; foot white; hindgut with branches; mucus clear, watery *Deroceras laeve*
- b. Mantle and back gray with inconspicuous spots and blotches; mantle strongly concentrically striated; back weakly granular; foot yellowish or dirty white; hindgut with a conspicuous branch; mucus milky, adhesive *Deroceras reticulatum*

Genus *Limax* Linnaeus

Large slugs, mostly western Palearctic in distribution, with spots and stripes, smooth jaw plates, and rather simple radulae. European exotics common in cities and gardens. Three introduced species in Oklahoma.

Limax maximus Linnaeus Figure 1

Records: Ottawa County (4).

Large (over 100 mm when extended) yellowish-gray slugs, spotted and blotched with black, the spots on the back behind the mantle tending to form three longitudinal bands; mantle concentrically striated; breathing pore in posterior half of mantle set at nearly right angles to the slit which extends to margin; sole, lower face, and undersides of tentacles white; internal shell very thin and flat, oblong; mucus watery, scarcely adhesive; when crawling, may extend to 115 mm or more. The tentacles, when removed, are slowly regenerated (5).

Reproduction and egg deposition were discussed by Karlin and Bacon (6), Simpson (7), and others. Preliminary courtship consists of circular crawling which culminates in mutual intertwining of the bodies. The slugs may then crawl over the edge of some object and become suspended in midair by a thick thread of slime. Mating occurs in that position, following which the slugs drop to the ground. The underground nests surround about 50 to 130 eggs that measure approximately 5.0 mm; mostly deposited during September through November.

Limax flavus Linnaeus Figures 2, 3

Records: Adair (8), Ottawa, Delaware,



FIGURE 1. *Limax maximus*. Scale = 15 mm.

Cherokee, Tulsa, Pawnee, Noble (9), McCurtain (10), and Payne (11) counties.

This large (75 to 115 mm) slug is yellowish-gray to dark gray on the upper sides and the back contains many yellow to golden spots, blotches, and vermiculations; lower sides pale yellow and granular; tentacles dark blue to blue-black; slime tenacious and yellow or golden. Another European exotic, this slug often becomes very abundant around houses and gardens. The 60 to 138 eggs (5.0 to 6.3 mm) are deposited in clutches of 12 to 32 during daylight hours (6).

Limax valentianus Férussac Figure 4

Records: Payne, Tulsa, Oklahoma, Pottawatomie, Seminole, Garvin, and Choctaw counties (9).

A medium-sized slug (50 to 75 mm), tan on the back and mantle, becoming lighter on the sides, with a darker dorsolateral band along each side. The bands of the mantle are not continuous with those of the body (12).

Many European authors assign this species to the genus *Lehmannia* (13), an epithet relegated to subgeneric level by most North American workers. Likewise, the name *L. poirieri* Mabilie and *L. marginatus* (Müller) have been applied to specimens collected in the United States (6, 14). However, *L. poirieri* is a synonym of *L. valentianus* (13), and all U.S. specimens thus far dissected have the tricuspid, acute central, and lateral radular teeth characteristic of this species, a feature which serves to distinguish this slug from *L. marginatus*, which has rounded monocuspid radular teeth (13).

Limax valentianus, a native of the Iberian Peninsula of Europe, is readily dispersed in plant materials. It is often a serious pest in greenhouses (12).

Genus *Deroceras* Rafinesque

Small limacid slugs bearing keels on the back only near the tail and breathing pores behind the middle of the right margin of the mantle; usually grayish with indistinct markings. The gut has four loops, and the penis is rather distinctly tripartite. Three species are known from Oklahoma, one fossil, one exotic and one native.

Deroceras laeve (Müller) Figure 5

Records: Kay (15, 16), Ottawa, Delaware, Adair, Payne, Creek, Pontotoc (9), and McCurtain (11) counties.

This small slug (25 to 35 mm) is usually amber to gray without distinct markings; head and tentacles bluish to dark gray; tail with a short keel dorsally; mantle scarcely concentrically striate; back with conspicuous longitudinal furrows and tubercles; foot very narrow; mucus clear, watery and only slightly adhesive; penis ends in an appendage which is hooked but never lobed, branched, or crimped.

Deroceras laeve is most active at night although it is often seen during daylight hours. This species becomes active in spring approximately three weeks before the next (introduced) species, and it is more tolerant of low temperatures, being able to withstand sub-freezing weather whereas the introduced form is killed under these conditions (17). Egg deposition commences



FIGURE 2. *Limax flavus*, dorsal view. Scale = 18 mm.



FIGURE 3. *Limax flavus*, right lateral view, showing position of breathing pore in mantle. Scale = 18 mm.



FIGURE 4. *Limax valentianus*. Scale = 10 mm.



FIGURE 5. *Deroceras laeve*. Scale = 7.0 mm.

as soon as the slug emerges from hibernation in spring, approximately 33 eggs being laid, practically all of them hatching in 10 to 15 days.

Deroceras reticulatum (Müller) Figure 6

Records: Payne (18), Noble (11), McCurtain, Muskogee (9), Cleveland, Latimer, Marshal, Muskogee and Murray (8) counties.

This European exotic is small although larger than *D. laeve*, whitish-amber to black with flecks of gray; head and tentacles bluish-black to dark gray; foot narrow and yellowish to grayish-white; mantle strongly concentrically striated; hindgut with a well-developed branch; penis ends in a lobed or crimped gland; mucus opaque or milky and adhesive.

Deroceras reticulatum mates at night, depositing 60 to 75 eggs that average 4.0 mm each; less than five per cent of them hatch (6). The species prefers temperatures between 18 and 24 degrees C, being a more or less annual species with only a few adults surviving the winter months in North America (17). Thus, *D. laeve* has a definite selective advantage over this species under wild conditions, *D. reticulatum* building up noxious populations only in protected situations such as greenhouses.

Deroceras aenigma Leonard Figure 7

Records: Canadian and Caddo counties (19).

This Upper Pliocene to Upper Pleistocene species has been reported from Iowa, Nebraska, Kansas, Oklahoma, Texas, and Ohio loesses (20). Although the shell (internal) is somewhat similar to that of living *D. laeve*, it is much thicker and longer (19).

FAMILY ARIONIDAE

Medium-sized to large slugs (up to 250 mm) with distinct grooves along the foot that meet in a mucus pit posteriorly; margin of foot wide and distinctly dorsoventrally striate; mantle covering only the anterior portion of back; breathing pore in anterior half of mantle on the right side, lying directly in the groove which connects it to the margin; jaw ribbed; radula with tricuspid central denticles; sole tripartite. Several genera and numerous native and introduced species, but only one introduced species in Oklahoma.

Arion circumscriptus Johnston Figure 8

Records: greenhouses in Choctaw (21) and Kay (9) counties.

Back grayish to nearly black with numerous long, coarse tubercles; mantle with two lateral longitudinal lines that converge posteriorly to become continuous with similar ones on the back; tentacles smoky gray to black; sides whitish or pale yellowish; sides of foot and sole white; about 35 mm long when extended.

Arion circumscriptus is nocturnal, concentrating where there is an abundance of moisture and warmth (17). The slug lives for more than one year, often becoming a serious greenhouse pest. Egg deposition is in late summer and early fall.

FAMILY VERONICELLIDAE

A tropical family of peculiar slugs represented by a single native U. S. (14) and several introduced species (22). Body somewhat flattened or convexly round above; mantle and mantle cavity completely lacking; excretory and breathing pores located behind the foot which partially or completely covers them when retracted; foot narrow and transversely rugose; head completely covered by the back (notum); tentacles contractile and annulated. Two species from Oklahoma greenhouses.

Key to Oklahoma Genera and Species of Veronicellidae (23)



FIGURE 6. *Deroceras reticulatum*. Scale = 5.0 mm.



FIGURE 7. *Deroceras aenigma*, internal shell. Scale = 4.0 mm.



FIGURE 8. *Arion circumscriptus*. Scale = 10 mm.

- 1a. Anus oval, protected ventrally by an anterior flap of skin, causing it to appear as a crescentic and traverse slit that extends beyond right margin of foot; dorsum usually with 2 longitudinal bands (sometimes broken into blotches; female opening posterior to middle of the body ... *Veronicella kraussi*
- b. Anus nearly round and nearly median, protected ventrally by a flap of skin on right side making the slit appear longitudinal and nearly completely hidden; back with indistinct spots..... *Vaginulus occidentalis*

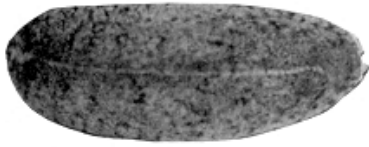


FIGURE 9. *Veronicella kraussi*, dorsal view.
Scale = 9.0 mm.

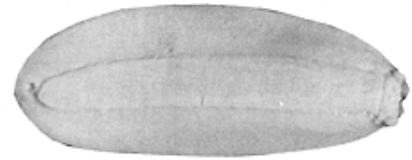


FIGURE 10. *Veronicella kraussi*, ventral view.
Scale = 9.0 mm.

Veronicella kraussi (Férussac) Figures 9, 10, 11
Records: Oklahoma City (9).

Back tan to brownish with a median longitudinal light stripe and reticulations with gray or black; dark lateral stripes vague or absent; up to 40 mm in length.



FIGURE 11. *Veronicella kraussi*, lateral view.
Scale = 9.0 mm.

Vaginulus occidentalis (Guilting) Figures 12, 13
Records: Logan County (12).

A fairly large slug (to 60 mm) with a grayish back sprinkled with black; median stripe very obscure.

FAMILY PHILOMYCIDAE

Medium-sized slugs in which the mantle covers entire rounded back; internal shell lacking; foot not tripartite; breathing pore, connected to margin by a short groove, near anterior end of mantle on right side; radular teeth with short, wide basal plates. Two genera and five species in Oklahoma.

Key to Oklahoma Genera and Species of Philomycidae

- 1a. Head and tentacles completely retractile beneath mantle; sides of foot pale without dark pigment; vagina with a curved calcareous organ (dart)...*Philomycus carolinianus*
- b. Head and tentacles not completely retractile; sides of foot brownish or grayish; no calcareous dart in vagina
Pallifera 2
- 2a. Mantle with distinct to indistinct longitudinal grayish-brown bands connected across back by diagonal chevronlike marks; basic color tan to chamois *Pallifera ragsdalei*
- b. Chevron marks present or absent; longitudinal bands lacking..... 3
- 3a. Seven to ten broad, brownish chevronlike marks across back and sides of mantle; body length 50 mm or more *Pallifera wetherbyi*



FIGURE 12. *Vaginulus occidentalis*, dorsal view. Scale = 4.0 mm.



FIGURE 13. *Vaginulus occidentalis*, ventral view. Scale = 4.0 mm.

- b. Chevron markings lacking; body lengths less than 50 mm.....4
- 4a. Mantle marked by two or three longitudinal rows of small grayish, transverse dashes or dots; head and tentacles not completely covered by mantle; small slugs, 17 to 22 mm *Pallifera fosteri*
- b. Mantle not marked by two or three longitudinal rows of dashes or dots5
- 5a. Mantle pale tan, fading to white ventrally, heavily marked by a pattern of light gray dashes or spots indistinctly arranged in about 8 longitudinal rows anteriorly, nearly black posteriorly; edges of foot white; head and tentacles not covered by mantle *Pallifera tournescalis*
- b. Mantle much reticulated with grayish-brown; edges of anterior one-fifth of foot rusty brown; head partially covered by mantle *Pallifera marmorea*

Philomycus carolinianus (Bosc) Figure 14

Records: Adair, Latimer, Muskogee, Pushmataha, and Sequoyah counties (9); Haskell and Wagoner counties (8); Choctaw, Delaware, and McCurtain counties (10); Ottawa County (14); Craig, LeFlore, and Ottawa counties (24); Cherokee County (11); Delaware and McCurtain counties (25).

A relatively large slug, up to 100 mm and more when fully extended. The foot and its margin are milky white; mantle heavily reticulated laterally, the reticulations becoming more concentrated on the upper sides; dorsally, mantle is usually slate gray with lighter reticulations, although Hermann and Dundee (26) reported an albino from Florida; usually two longitudinal rows of large black spots near midline. Hubricht (27) reported some upland populations in which the midline of mantle was livid brown and spotless. Head and tentacles completely retractile beneath mantle.

Philomycus prefers lowland situations in moist habitats beneath hardwood logs. It is sometimes found in trees 60 feet above the ground (28). It feeds principally upon various fungi, as the generic epithet implies.

Genus *Pallifera*

Members of this genus strongly resemble those of *Philomycus* in many particulars, but the head is not completely retractile beneath the mantle. Unlike in *Philomycus*, there is no dart apparatus and the jaw lacks a median process, being ribbed instead.

Pallifera ragsdalei Webb Figure 15.

Records: Adair County (8); Latimer and McCurtain counties (29).

Another large slug, up to 100 mm when crawling. Face and upper head white; tentacles bluish in color. Foot, except sides, which are rusty brown, nearly dead white; lower sides of mantle grayish-brown with faint mottling; a dorsolateral, indistinct grayish-brown band extends longitudinally the length of mantle, connected across back to that of opposite side by chevron-like marks of same color. The species lives in fissures on rocky bluffs and under logs.

Pilsbry (14) referred to this form as *Philomycus carolinianus flexuolaris* Rafinesque, but Hubricht (30) demonstrated that *P. flexuolaris* is a distinct eastern species. Webb (29) described the slug as a subspecies of *Pallifera wetherbyi* Binney, and Branson (12) elevated it to full species rank. *Pallifera mutabilis* Hubricht (31) is included here.

Pallifera marmorea Pilsbry

Records: Muskogee County (9); Johnston and Pushmataha counties (32); Ottawa County (12); Atoka, Cherokee,



FIGURE 14. *Philomycus carolinianus*. Scale = 7.0 mm.



FIGURE 15. *Pallifera ragsdalei*. Scale = 8.0 mm.

Latimer, LeFlore, Mayes, and Sequoyah counties (33); Adair County (8).

A small (19.0-25.0 mm when extended) slug with a dark gray mantle marbled by grayish-brown, diffuse on sides; face and upper head white, tentacles blue-black; edges and anterior one-fifth of foot rusty brown; jaw strongly arched with four main rib-striations at center. Originally described as a subspecies of *P. hemphilli* (Binney) (14), but lack of intergradation prompted its elevation to full species designation (12).

Pallifera fosteri Baker Figure 16

Records: floodplains of McCurtain County (11).

Another small (17.0-22.0 mm) species. Back strongly humped anteriorly; mantle whitish, flesh-colored or light tan with rather large black spots that tend to concentrate most heavily near center and along each ventrolateral margin of mantle, tending to coalesce into longitudinal lines (34); tentacles slate gray; foot rather broad, transversely wrinkled and yellowish-white except along anterior margins, which are rusty brown.

Pallifera tournescalis Branson Figures 17, 18

Records: Winding Stair Mountain, LeFlore County (35)

Small slugs (approximately 18 mm). Mantle slightly granular, pale tan, fading to nearly white ventrally, marked by light gray dashes and spots tending to become arranged in eight longitudinal series on the central two-thirds; tail more or less sharply pointed and black; body, head and foot off-white except for a patch of black behind tentacles; jaw with a few indistinct ribs near center. Occupies uplands at 900 to 1,200 feet mean sea level.

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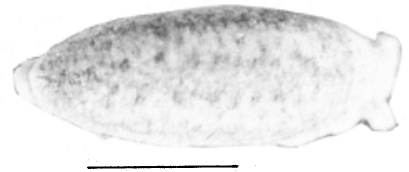


FIGURE 16. *Pallifera fosteri*. Scale = 7.0 mm.



FIGURE 17. *Pallifera tournescalis*, dorsal view. Scale = 3.0 mm.



FIGURE 18. *Pallifera tournescalis*, right lateral view. Scale = 3.0 mm.