

THE TERRESTRIAL SLUGS OF NORTHEASTERN NORTH AMERICA

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INTRODUCTION

The term 'slug' is applied to those gastropod mollusks in which there has been a distinct trend towards the loss of the external shell. With one exception, all the terrestrial slugs which have been recorded from, or could be expected to be found in northeastern North America have entirely lost the external shell. Some forms still retain a small, plate-like remnant of the shell under the fleshy mantle; in others only granules or spicules of calcium carbonate buried in the mantle remain. The loss of the shell reduces the need for calcium and permits the animals to move through narrow spaces.

Associated with the loss of the coiled shell has been the assumption of a partial anteroposterior, external bilateral symmetry. The foot is lengthened to accommodate the viscera which lie in an elongated body cavity. In all genera except *Testacella*, the unpaired openings of the lung, excretory, genital system, and digestive tract are on the right side near the anterior end of the body. In *Testacella* the openings of the lung, excretory system, and digestive tract are located posteriorly under the right edge of the external shell; the reproductive pore opens below the right upper tentacle.

The arrangement of the internal struc-

tures still resembles the general pattern found in the shelled relatives. Most systems still display the asymmetry resulting from the process of torsion, a characteristic feature of the class Gastropoda. Except in certain primitive groups, the digestive system extends posteriorly to fill the elongate body cavity over the foot.

As a result of the loss of the shell, the entire body of the slug is naked. The body surface contains numerous slime glands scattered over its entire surface. These exude a copious flow of slime, particularly when the slug is disturbed. The slime aids the animal in removing noxious substances from the body surface and may serve as a protective device against potential predators. The slime does not afford protection from desiccation, however. The consistency and color of the slime vary among species and are aids in their identification.

A pedal gland whose pore is located anteriorly just below the mouth produces a particularly large amount of slime. This provides the foot with a layer of slime over which the slug travels. The slime formed by the pedal gland is left as a distinct trail on the substrate. One can frequently determine prior activity of slugs by observing the slime trails on the surface over which they have traveled.

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NORTHEASTERN NORTH AMERICAN FAUNA

An outline of the classification of slugs recorded from or of possible occurrence in northeastern North America is as follows:

CLASS GASTROPODA

SUBCLASS Pulmonata (Euthyneura)

ORDER Stylommatophora

SUBORDER Sigmurethra

DIVISION Aulacopoda

Superfamily Endodontacea

Family Arionidae

Subfamily Arioninae

Arion subfuscus

Arion intermedius

Arion ater

Arion hortensis

Arion fasciatus

Arion circumscriptus

Arion silvaticus

Family Philomycidae

Philomycus carolinianus

Pallifera dorsalis

Superfamily Zonitacea

Family Limacidae

Subfamily Limacinae

Limax maximus

Limax flavus

Lehmannia valentiana

Deroceras laeve

Deroceras reticulatum

Subfamily Parmacellinae

Milax gagates

Superfamily Oleacinacea

Family Testacellidae

Testacella haliotide

Both species of Philomycids and *Deroceras laeve* (Limacidae) are native to North America and occur throughout northeastern North America. All the remaining species have been introduced into North America from Europe. Although seven genera of Arionidae are native to the western regions of North America, none of these has been reported from eastern North America.

Of the introduced species, *Deroceras reticulatum*, *Arion subfuscus*, and *A. fasciatus* have become widespread and very abundant in the northeast in general. *Limax maximus* may be locally abundant, but is more spotty in its distribution. *Arion hortensis*, *A. intermedius*, *A. silvaticus*, and *A. circumscriptus* have been reported from several localities but normally are not found in large numbers in these colonies. The remaining species are found in greenhouses or as isolated individuals; no established colony of these species has been found in northeastern North America.

BIOLOGY

Habitats.—The presence of an exposed moist integument restricts slugs to relatively damp situations. Most species are relatively intolerant of submersion in water, however. The evaporation of water from the skin as well as that lost in slime production (by the pedal gland in particular) is compensated for by water in the food and by cutaneous absorption of dew, rain, or other free water.

The most favorable places for slugs are: under leaf litter; beneath the bark of dead trees; under logs, boards, rocks, paper, or other debris; at the base of grasses and sedges; in the soil (especially in gardens and truck farms); and in cellars and damp sites under outbuildings.

The three native species are more or less solitary inhabitants; they normally are encountered as isolated individuals; Only in exceptionally favorable sites does one find more than a few individuals together. The introduced species are in general more gregarious than are the native species. They are frequently encountered in dense colonies in natural situations as well as in cultivated gardens and fields.

Activity patterns.—Since slugs are relatively intolerant of desiccation and ultraviolet radiation, most species are nocturnal in habits. A few species (*Arion subfuscus* and *Deroceras reticulatum* in particular) are found active above the surface even on relatively clear days, however.

Seasonal activity is influenced by temperature, moisture, and food availability. During the winter most species burrow into the substrate and hibernate under logs or other objects on the ground. Some species may become active in sheltered places during warm periods in the winter; most are inactive in the northeast from December to March, however. Some species may have short periods of inactivity (or aestivation) during the more extremely hot, dry periods in the summer. Such periods of inactivity may also be partially related to unavailability of succulent food. The slugs immediately become active again after a rainy period.

Life history.—Eggs are laid in clusters of up to several dozen eggs in moist places

under leaf litter, logs, or debris. The eggs may be connected by thin gelatinous threads which adhere together in compact masses or they may form loose, unconnected aggregations. The eggs are gelatinous in appearance; they vary from clear to brownish opaque in color. They range from 2 to 5 mm in size and from round to oval in shape.

Newly hatched individuals may be somewhat lighter in color than adults; in some the color pattern of the young may differ from that of the adults. Young individuals are active and begin feeding immediately after hatching.

Rate of growth varies among species and is dependent upon temperature, moisture, and food availability. Under normal conditions adult size and sexual maturity is usually attained between 3 to 9 months. Many species die soon after completing egg laying. The enlargement of the reproductive system during the breeding period results in a rather sudden increase in the size of many species during their final month or two of life.

All species of terrestrial slugs that occur in northeastern North America are hermaphroditic. Cross fertilization is normal; when two individuals mate there is usually a mutual exchange of sperm. In some matings an individual may function only as a male or a female, but not both. Self-fertilization has been reported in *Arion ater*, *A. subfuscus*, *A. intermedius*, *Milax gagates*, and *Deroceras reticulatum*. Self fertilization can occur with or without self-copulation. Parthenogenesis has not been recorded in slugs.

Most species have rather elaborate courtship displays, usually consisting of some sort of a circular 'dance' preceding copulation. In *Deroceras* a penial accessory organ, the sarcobelum, is used to stimulate the partner during the final stages of the 'dance.' *Milax* has an atrial accessory organ which functions as a stimulator. *Arion hortensis* everts the distal portion of the oviduct which also serves as a stimulatory structure. *Limax maximus* has been observed to mate while hanging from mucus threads below a ledge or tree branch.

Arion and *Milax* form a spermatophore which contains the sperm; this structure is deposited in the seminal receptacle of the mating partner. The other genera transfer the sperm as a viscous mass.

Food habits.—In the wild, slugs feed primarily on fungi, decaying organic matter, paper, fecal material, and carrion. In greenhouses and gardens a variety of fresh plant food is consumed; succulent plants, including roots, stems, and fruits as well as leaves are especially favored. *Testacella* feeds on earthworms and slugs while others display cannibalistic tendencies when in crowded conditions.

Enemies.—Slugs are preyed upon by various species of amphibians, reptiles, birds, and small mammals. Some insects are also known to feed on slugs.

METHODS OF DISPERSAL

Slugs are readily dispersed from place to place by the activities of man. Both eggs and adult slugs are transported with greenhouse plants and soil. Movement of nursery plants with associated soil and organic material from one region to another is an important method of dispersal. Other related methods of dispersal include packaged food items such as fruits and vegetables, garden settings, and floricultural cuttings. When the above items are either planted or discarded the slugs or eggs on them are liberated and the species may become established in a new region.

The method in which plants are maintained in greenhouses (in wooden flats, moist pots, in soil beds, etc.) and the requirement of warm, uniform temperatures, and frequent watering of the tables (with the resulting high humidities) afford an ideal habitat for slugs. If there is any excess debris in the greenhouse the conditions are even more suitable.

Greenhouses therefore may serve as a source of 'sporadic records' for species that do not become established in natural conditions. The removal or discarding of potted plants and cuttings may result in slugs being liberated in the wild, especially in such places as cemeteries and garbage dumps. Although these species may not be able to form established colonies because of unfavorable environmental conditions, individuals may thus be frequently collected away from greenhouses. While such a process could result in the establishment of permanent colonies, there is no evidence that this is happening in northeastern North America at the present time. Except for *Deroceras reticulatum*, the wild are not normally abundant in greenhouses.

Transportation of logs (with bark attached), sod, and any material or machinery which has been on the ground and on which soil sticks and remains moist during movement are potential dispersal means for slugs. During the early days of commerce ballast carried in ocean-going ships may have also been a ready means of transporting European species on small, isolated, uninhabited islands where ballast was dumped indicate some of the early introductions may have been via ballast. Later introductions into North America have obviously been by way of horticultural and floricultural materials. Present inspection practices by plant and animal quarantine personnel have reduced such introductions.

ECONOMIC IMPORTANCE

The native slugs are seldom abundant enough under natural conditions to be considered serious pests in the northeast. *Deroceras laeve* is often abundant in greenhouses, however and can do considerable damage.

Introduced species, especially because of their tendency to be gregarious and locally very abundant, as well as their association with man's activities, can become serious pests. In addition to greenhouse damage, they are locally problems in gardens and flower beds; damage to commercial crops is not particularly significant in the northeast. In addition to destruction, injury, or aesthetic damage to plants and fruits, they are somewhat of a nuisance when abundant in lawns or other places where they are stepped on or when encountered in one's lettuce salad.

Parasites.—Relatively little work has been done concerning the importance of slugs as intermediate hosts for parasites of significance to man or his domestic animals. Malek (1962) gives a list of Trematodes and Nematodes that have been found to use slugs as intermediate, transport, or definitive hosts. Taylor (1907) cites *Limax maximus* as a host of the fowl tapeworm, *Davainea proglottina*.

Control measures.—Numerous commercial poisons are available; only those containing metaldehyde have proven to be effective, however. Baits (1.75% metaldehyde, 5.0% tricalcium arsenate, and 93.25% inert material) are most effective in greenhouses and small garden plots. Since such baits

mold easily, they must be changed frequently. Liquid (20% metaldehyde) or dust (15% metaldehyde) are more effective in larger areas such as lawns or fields (they may also be used on greenhouse benches and in small gardens, however). Care must be taken to get the spray on the ground below the plants; if sprayed on the surface of plants, it will be ineffective.

Steam sterilization of greenhouse tables is also an effective method of slug control. Removal of debris and other hiding places for slugs will aid greatly in reducing the number of slugs in greenhouses.

PRESERVATION

The simplest method of preserving slugs is to place them directly in 70% ethyl alcohol or in 2% phenoxyethanol; isopropyl ('rubbing') alcohol will also suffice. The volume of alcohol should be approximately 3 to 4 times the volume of the slugs in the container to prevent undue dilution of the alcohol by the body fluids of the slugs. The slugs should be covered sufficiently to prevent drying out. As a safety procedure, vials can be stoppered with cotton plugs and then the individual vials placed in a large container of alcohol. This will reduce maintenance to a minimum.

When placed directly in alcohol the slugs preserve in a contracted condition. If it is desirable to have the slugs in a more relaxed state to facilitate dissection, they can be drowned before preservation. This is done by placing them in vials completely filled with water and stoppered so that no air bubble is present. The vials should be maintained at room temperature and the slugs observed at frequent intervals to determine when movement ceases (24 to 48 hours). The slugs will die in a somewhat extended position; they can then be preserved in 70% alcohol.

A more satisfactory method of relaxation is by the use of nembutal (pentobarbital sodium) or menthol crystals. A maximum of 10 to 15 slugs should be placed in approximately 100 cc of water in a dish provided with a cover. Ten cc of a 10% solution of nembutal or 2 or 3 small crystals of menthol are then added to the water. The slugs should be observed at periodic intervals to insure that they remain in the water and to determine when they are completely relaxed. Additional relaxing

agent may be added as needed. When using nembutal apin prick may be used to determine when the animals are unable to contract; when menthol is used, the slugs should not be disturbed as once they contract, they may not completely extend again. Once thoroughly relaxed, the slugs can be preserved in 70% alcohol.

Since the color of slugs soon fades in alcohol, detailed descriptions of the color of the live animals (including the slime produced when handled) should be recorded in the collection notes. When preserved, the mucus of most species forms an opaque layer over the body. This slime should be carefully rubbed off to permit examination and identification of the animals.

Labels should be written in pencil or permanent ink (not ballpoint!) on good quality paper and placed in the vial with the animals from each collection site. Information on the label should include date, exact location of the collection site, collector, general habitat, and color of the animals and slime. It is also desirable to include a collection number and repeat the above information with a more detailed description of the habitat in a collection log book.

Preserved specimens can either be shipped in vials packed in shipping containers or the slugs can be tightly tied in plastic freezer bags with a small piece of cotton saturated with alcohol; the bag can be sealed in an envelope. Specimens should not be maintained more than a few days in plastic bags, however, as the alcohol will eventually dissolve the bags.

A KEY TO THE TESTACELLID, ARIONID, PHILOMYCID AND LIMACID SLUGS OF NORTHEASTERN NORTH AMERICA

- 1. **EXTERNAL** abalone-shaped shell present on posterior end (Fig. 8d)
 .. (Testacellidae) *Testacella haliotideae*
EXTERNAL shell absent (see footnote 1 for exceptions) 2
- 2. **MANTLE** covers more than 2/3 of the back (Fig. 1b) ... (Philomycidae) 3
MANTLE covers less than 1/2 of the back (Fig. 1a) 4

¹ An external, anteriorly located shell is found in the New World *Binneya* and the Old World *Parmacella*. Neither has been reported in eastern North America.

- 3. **HEAD** covered by anterior lip of mantle; slime milky when animal is irritated; mantle covered with many dark pigmented spots, some of which may coalesce to form paired and/or unpaired longitudinal bands or streaks; adults more than 50 mm long *Philomycus carolinianus*
HEAD not covered by anterior lip of mantle; slime clear when animal is irritated; mantle either without spots or with a mid-dorsal line plus faint lateral spot rows; adults less than 35 mm long *Pallifera dorsalis*
- 4. **BREATHING PORE** in posterior half of mantle (Fig. 1e); jaw smooth (Fig. 1c) (Limacidae) 5
BREATHING PORE in anterior half of mantle (Fig. 1f); jaw ribbed (Fig. 1d)
 (Arionidae, Arioninae) *Arion* .. 10
- 5. **DORSAL KEEL** extends to posterior margin of mantle; mantle subdivided by a horseshoe shaped groove. (Fig. 1g)
 (Parmacellinae) *Milax gagates*
DORSAL KEEL does not extend forward to posterior margin of mantle; mantle not subdivided by a groove (Fig. 1h)
 (Limacinae) ... 6
- 6. **TAIL TRUNCATED** when viewed from the side (Fig. 1k); posterior margin of mantle rounded (Fig. 1i); nucleus of concentric mantle ridges lies on right side of mantle (Fig. 1i) ... (*Deroceras*) . 7
TAIL POINTED when viewed from the side (Fig. 1l); posterior margin of mantle obtusely angular (Fig. 1j); nucleus of concentric mantle ridges lies mid dorsally (Fig. 1j) 8
- 7. **BREATHING PORE** with apale border (Fig. 1m); slime milky when animal is irritated; rectal caecum present (Fig. 1o); penial appendix multifid and crenulate (Fig. 2b); ovotestis exposed
 *Deroceras reticulatum*
BREATHING PORE not pale bordered (Fig. 1n); rectal caecum absent; penial appendix simple, smooth and tubular (Fig. 2c); ovotestis hidden by digestive gland *Deroceras laeve*
- 8. **MANTLE** bears at least one pair of dark longitudinal bands; penial appendix present (Fig. 2e) .. *Lehmannia valentina*
MANTLE bears either yellow spots, black spots or blotches, or bears no markings at all; penial appendix present (Fig. 2a) ... (*Limax*) 9
- 9. **MANTLE** with black spots, blotches or no markings at all; rectal caecum absent; slime clear *Limax maximus*
MANTLE yellow spotted; rectal caecum present (Fig. 1p); slime yellow
 *Limax flavus*

10. **TUBERCLES** conically shaped with hyaline apices when animal contracts (Fig. 1q); adults less than 25 mm long *Arion intermedius*
TUBERCLES not conically shaped and without hyaline apices when animal contracts (Fig. 1r); adults more than 25 mm long 11
11. **FOOT FRINGE** wide; foot fringe bears numerous dark vertical lines at least posteriorly; lateral dark bands present or absent 12
FOOT FRINGE not conspicuously wide; foot fringe without dark vertical lines; lateral dark bands always present .. 13
12. **COARSE, ELONGATE TUBERCLES** on side and back; adult animals lack bands on mantle; slime usually clear; free oviduct of constant diameter throughout its length and very short (Fig. 2N) *Arion ater*
TUBERCLES not conspicuously coarse or elongate; adult animals may or may not have lateral bands; slime usually yellow; free oviduct slender proximally, swollen distally and long (Fig. 2g) ... *Arion subfuscus*
13. **BREATHING PORE** located below lateral mantle band; mid-dorsal, post mantle tubercles raised and enlarged to form longitudinal ridge (may be faint or lost in some adults) (Fig. 4a); sole white to gray in life; free oviduct slender through its length; seminal receptacle pear shaped (Fig. 2i) 2
..... *Arion fasciatus* complex²
BREATHING PORE located within lateral mantle band; mid-dorsal tubercles not enlarged, no ridge is discernible; sole bright yellow to orange in life (color disappears in alcohol); free oviduct swollen distally; seminal receptacle ball shaped (Fig. 2j) ... *Arion hortensis*

SUPERFAMILY ENDODONTACEA

Family Arionidae Gray, 1840

Description

Slugs with an internal shell in the form of an oval plate or a mass of granules,

² Some European workers believe that *Arion fasciatus* as previously conceived by older workers is a complex of three species. See text for discussion and key to the component species.

except in the genus *Binneya* in which the shell is external. The jaw is ribbed (Fig. 1d). The kidney surrounds the pericardium. An epiphallus is always present. The foot sole may be uniform or tripartite.

Distribution

Europe, Africa, Asia, North America. Members of the genus *Arion* have been introduced into North and South America, Polynesia, Australia, New Zealand, Tasmania, and South Africa.

Origin

The family appears to have originated from an Endodontid stock. The most primitive subfamily, Binneyinae, has an external, depressed, spiral shell, a common origin of the retractor muscles, and a solid 'tail.' See Pilsbry (1948) for further evolutionary discussion.

Subfamily Arioninae Binney, 1864

Slugs with a shell in the form of a flat plate (*Geomalacus*) or discrete granules (*Arion*). Foot fringe wide. A caudal mucus gland is present. A penis is absent. The left and right tentacular retractor muscles and the buccal retractor muscle originate separately at or beyond the posterior margin of the diaphragm.

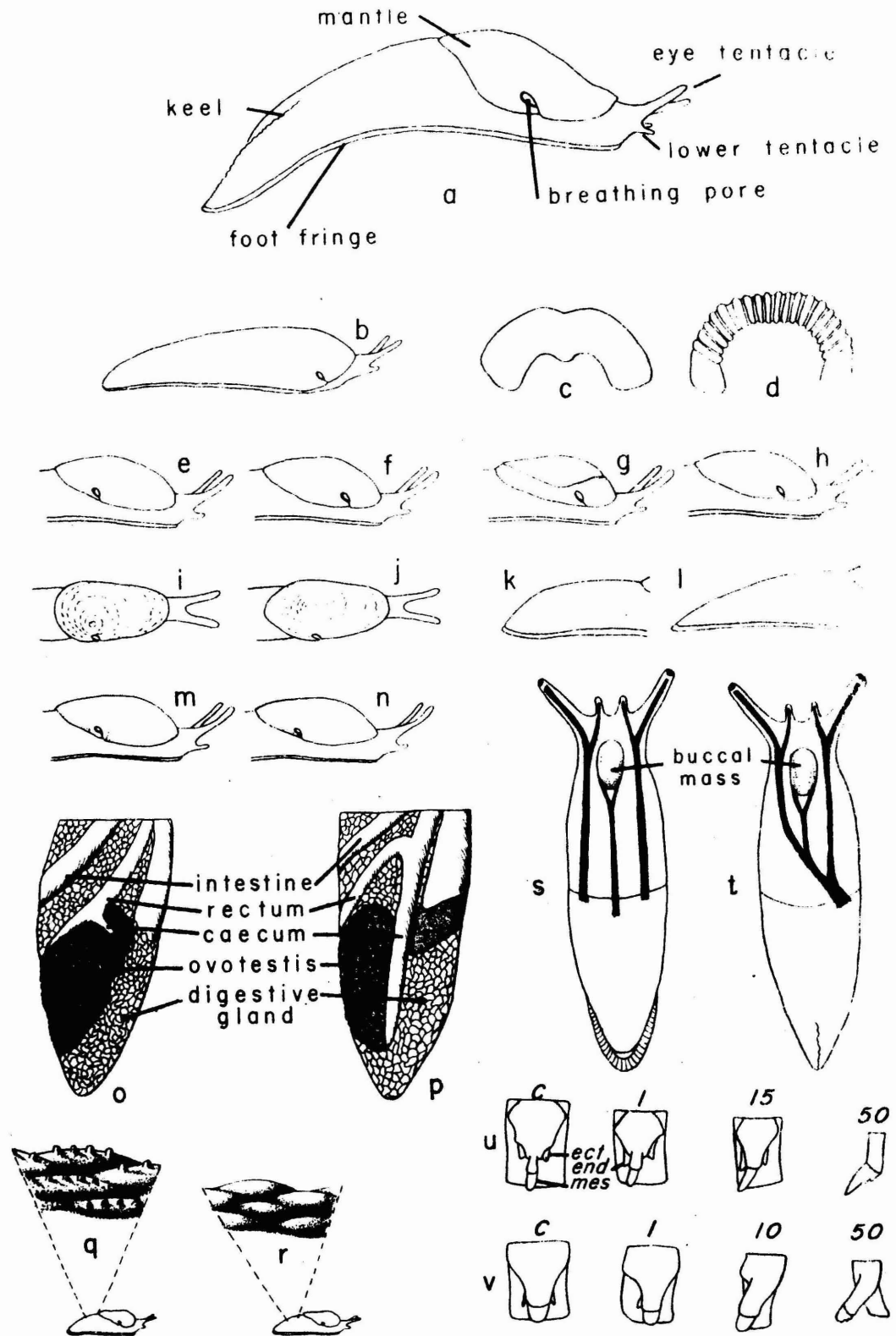
Genus *Arion* Férussac, 1819

Arion Férussac, 1819, Hist. Nat. Moll., p. 53.

Slugs with shell reduced to discrete granules. Breathing pore located in the anterior half of the mantle on the right side. Reproductive opening below lateral margin of the mantle in the vicinity of the breathing pore.

EXPLANATION OF FIGURE 1 (OPPOSITE PAGE)

FIG. 1. Diagnostic characters used in key and text. a, generalized slug; s, retractor muscles in typical Limacids; t, retractor muscles in typical Arionids; u, radular teeth of *Lehmannia valentiana* (position of teeth in transverse row is indicated by number, except median tooth which is labeled c; ect., ectocone; end, endocone, mes, mesocone); v, radular teeth of *Lehmannia marginata*.



The genus is native to the western Palearctic Region. One or more species have been introduced into North and South America, South Africa, Australia, Tasmania, New Zealand, and Polynesia.

Arion is perhaps one of the more complex slug genera; the systematics of the group are still unsolved. Color and color patterns are variable; the traditionally dependable characters such as radula and jaw are not reliable systematic characters. The most dependable characters are the distal parts of the accessory sex organs.

Arion subfuscus (Draparnaud, 1805)

Limax subfuscus Draparnaud, 1805, Hist. Nat. Moll. France, 2:125.

Arion subfuscus Drap., Scharff, 1891, Trans. Roy. Dublin Soc., 4:542.

Description

External. A large slug, some forms exceeding 80 mm in length when fully extended. Typically with a black band on each side of the body and mantle; in some color phases the bands may be very faint or absent. The lower boundary of the right mantle band usually diffusely surrounds the breathing pore. The well-developed foot fringe normally has distinct vertical dark lines, at least posteriorly, the foot sole is whitish gray. The slime is yellow or orange, at least when the animal is disturbed. This species displays more variation in color and pattern than any other imported Arionid slug. The basic color pattern forms found in northeastern North America are:

1. (Fig. 3a). Dorsum dark reddish brown to black. Upper boundary of lateral band or entire band masked by dark ground color. Dark pigmentation may extend laterally almost to the foot fringe or the sides may be sufficiently light in color to make the lower boundary of the lateral bands visible. Vertical dark lines on the foot fringe distinct, at least posteriorly. Eye-bearing tentacles darkly pigmented. Sexually immature individuals of this color phase are reddish brown dorsally and laterally so that lateral bands are more distinct. Individuals of this color phase tend to be somewhat larger than those of other color phases; adults may exceed 80 mm when fully extended. This color phase is the most widely distributed one in Connecticut. It is especially common in the southwestern part of the state.

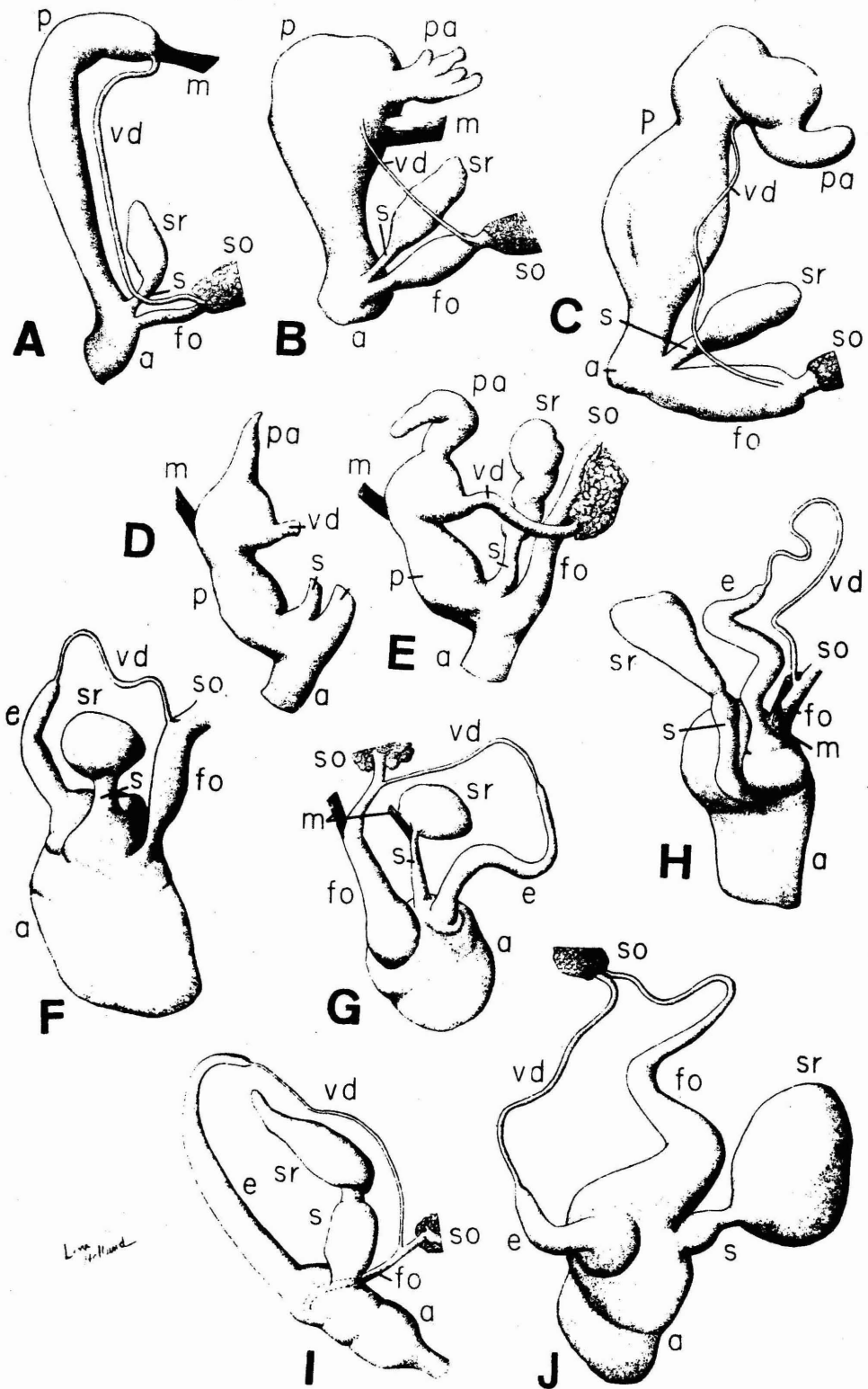
2. (Fig. 3b). Dorsum brown to brownish gray, mottled with black pigment. Area just above lateral bands lighter brown so that bands appear much darker and more distinct than in other color phases. Laterally, the valleys between the tubercles are darkly pigmented so that the overall effect is of a dark reticulum on a whitish gray background. These reticulations are most distinct in the region below the lateral margins of the mantle. Foot fringe and sole as in the first color phase. The eye-bearing tentacles are darkly pigmented. Not common in Connecticut, although fairly abundant in New York, Vermont and portions of New Hampshire and Massachusetts.

3. (Fig. 3d). Dorsum and sides yellow to orange, the only indications of dark pigment are reticulations between the lateral margins of the mantle and the foot fringe (as in color phase 2), indistinct posterior remnants of the lateral bands, and dark vertical lines on the foot fringe (these may be lacking in some individuals, however). The eye-bearing tentacles are darkly pigmented. This phase, when collected in the wild is generally yellow or occasionally orange-yellow. When reared in the laboratory on lettuce they become a vivid orange after a few weeks. The yellow or orange color is mainly in the slime. The yellow or orange color goes into solution in alcohol leaving the animal a light tan to gray color, except for the few black markings. We have only one record of this color phase in Connecticut (North Branford); it is abundant in much of northern New England. Immature individuals are colored and patterned like the sexually mature animals.

4. (Fig. 3c). Dorsum light brown to brownish yellow; lateral bands usually very

EXPLANATION OF FIGURE 2 (OPPOSITE PAGE)

FIG. 2. Distal genitalia (not drawn to same scale). A, *Limax maximus*; B, *Deroceras reticulatum*; C, *Deroceras laeve*; D, *Lehmannia marginata* (after Quick, 1960); E, *Lehmannia valentiana*; F, *Arion intermedius*; G, *Arion subfuscus*; H, *Arion ater*; I, *Arion fasciatus*; J, *Arion hortensis*; so, spermoviduct (in some figures shown partially ensheathed by prostate); fo, free oviduct; vd, vas deferens; e, epiphallus; p, penis; sr, seminal receptacle; s, stalk of seminal receptacle; a, atrium; m, genital retractor muscle; pa, penial appendix.



faint, being most distinct on the mantle. The bands are brown (or occasionally pale gray); hence, when the brown pigmentation of the dorsum extends laterally, the bands are virtually obscured. The sides usually are whitish and unreticulated. The vertical lines of the foot fringe are barely discernible or absent. The eye-bearing tentacles are usually unpigmented or only faintly so. This color phase is also not common in Connecticut. It is more common in southeastern Maine and in portions of the Atlantic Provinces of Canada.

It should be noted that the above color phases are intended to apply to whole populations or significant portions of populations. Within the limits defined for any one color phase there can be considerable variations. The color phases are defined for sexually mature individuals except where noted. Immatures are usually somewhat lighter in color and possess more distinct lateral bands.

Internal. As with other species in the genus, the distal portion of the accessory sex organs are the most reliable characters to use for identification. The free oviduct is proximally slender and distally dilated and relatively much longer than in *Arion ater*. The vas deferens is slender and approximately as long as the free oviduct. The junction of the epiphallus with the upper atrium is marked by a raised ring or annulus. The seminal receptacle is spheroidal. The stalk is slender at its receptacular end, but becomes dilated as it proceeds toward the atrium. The atrium is distinctly divided into an upper and lower portion and is relatively small when compared to *Arion ater*. (Fig. 2g).

Eggs. Opaque, white, pearl-like, almost spheroidal eggs are laid in clusters of up to several dozen. Quick (1960) gives the dimensions as 2.25 X 2.25 to 2.25 X 3.25 mm.

BIOLOGY

Life cycle and reproductive behavior.— In Connecticut *Arion subfuscus* is an annual species that overwinters as eggs or newly hatched young. The overwintering individuals and the young which hatch in the spring become sexually mature by late summer and early fall. Egg deposition, under leaf litter, decaying logs, and rocks, etc., reaches a peak in September and October. The adults usually die soon after laying eggs. Adults are rarely found in the field in late November. In most

populations it appears that at least a few individuals are out of reproductive synchronization with the majority of the population; an occasional egg mass or mature slug will be encountered in the spring or summer.

Mating behavior begins with one member of the pair following the other until body contact is established. Once body contact is achieved the slugs gradually orient themselves so that the genital openings are in opposition. To do this the slugs align their anterior ends side by side but pointing in opposite directions. Their bodies are also curved in such a way that the anterior end of each slug rests in the concavity of the partner's curved body. In this position each slug everts its atrium and brings it in contact with that of its partner's. The joined atria form a bluish, thin walled ovoidal mass between the two animals. The animals maintain this position until a mutual exchange of spermatophores has taken place; this may require an hour or more. Occasionally, during the preliminary stages, one or both slugs may be observed rasping away the upper layers of the partner's skin. Some of the wounds inflicted are deep enough to remove the entire pigment layer leaving the injured animal with whitish blotches.

In the laboratory egg laying begins within a week after mating. Each slug may produce several egg masses during the course of its reproductive life. The eggs hatch in about four weeks when maintained at 15° C. The newly hatched slugs are about 5 to 7 mm long.

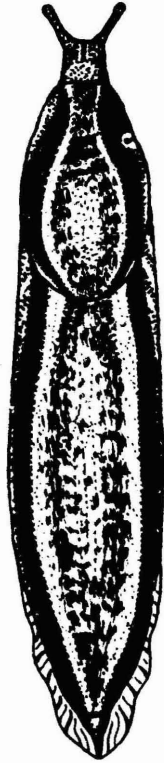
Habitat and feeding habits. *Arion subfuscus* is basically a woodland and ecotonal animal. In Connecticut it is especially abundant in maple or mixed hardwoods, but not in predominantly oak woods. It is most frequently encountered under thin layers of leaf and twig litter, loose bark and slightly decayed logs. Farther north, it is abundant in spruce-fir forests as well as in deciduous forests. It is occasionally found in dumps and cultivated areas.

EXPLANATION OF FIGURE 3 (OPPOSITE PAGE)

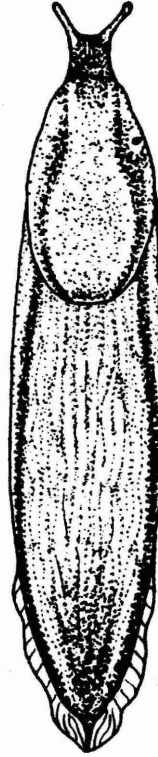
FIG. 3. Lateral and dorsal views of *Arion subfuscus*. a, color form 1 (X 1 1/3); b, color form 2 (X 1 1/2); c, color form 4 (X 1 1/3); d, color form 3 (X 1 1/2).



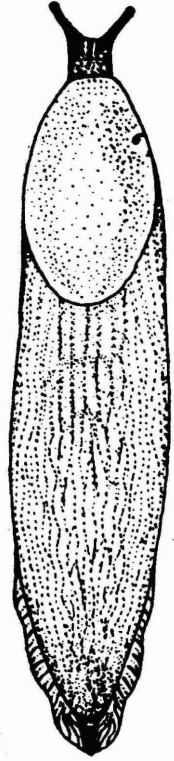
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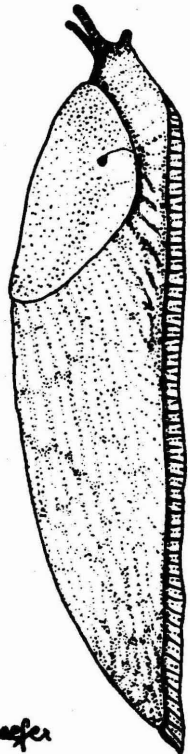
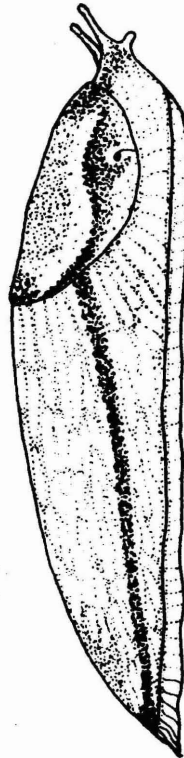
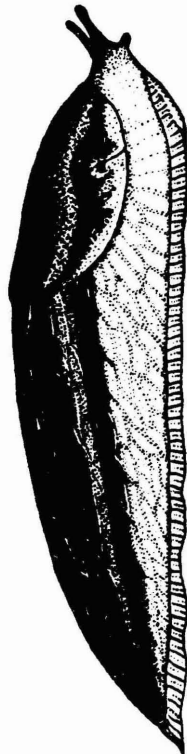
b



c



d



Schaefer

The ecological distribution in northeastern North America agrees well with its ecology in its native Europe. Økland (1922) considered that the most characteristic habitat of *Arion subfuscus* in Norway was forests, especially coniferous forests, although it also was found in refuse heaps. Taylor (1907) and Quick (1960) indicate that *Arion subfuscus* in the British Isles resides in deciduous and coniferous woods as well as damp hedge rows, waste ground and some gardens.

Although it can be reared successfully on lettuce in the laboratory, it is apparently mainly fungivorous in the wild.

Distribution

A native of Europe, it is now found throughout most of the British Isles and Europe north of a line through Orenburg, Odessa, northern Italy, Barcelona and Oporto (Quick, 1960). It has been introduced into Venezuela (Arias, 1959), Iceland and New Zealand (Quick, 1949), and much of northeastern North America, including Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, New England, New York, Connecticut, and Pennsylvania.

Arion intermedius (Normand, 1852)

Limax intermedius Normand, 1852. Descr. six limaces nouv. Valenc., p. 6.
Arion minimus Simroth, 1885, Z. Wiss. Zool., 42(2):237.
Arion intermedius Normand, Taylor, 1907, Monogr. Moll. Brit. Isles (Testacellidae, Limacidae, Arionidae), p. 240.

Description

External. The smallest member of the genus in North America, it is less than 25 mm long when fully extended. In the contracted, living animal each tubercular ridge bears one to several conical, hyaline projections. These unique projections give the animal an overall bristly appearance. The projections normally are not apparent in preserved specimens. Lateral bands, if present, are faint. The right mantle band surrounds the breathing pore. There is often a row of black dots anteriorly just above the foot fringe. The body color is gray to yellowish gray. In life the foot sole is yellow owing to the accumulation of yellow mucus. In preserved animals, the foot sole is whitish gray.

There is little of the variation in color, pattern, and size seen in *Arion subfuscus* and in the *A. fasciatus* complex. Fig. 5c.

Internal. The free oviduct is short (much shorter than the epiphallus plus the vas deferens) and of approximately constant diameter or slightly constricted distally. The epiphallus and the vas deferens are of about equal length. The seminal receptacle is spheroidal. Its stalk is short, stout, and widely dilated at its atrial end. Fig. 2f.

Eggs. Opaque white, ellipsoidal eggs are laid in clusters of one to two dozen. Quick (1960) gives the dimensions of the eggs as 2 X 1.5 to 2 X 2 mm.

Biology

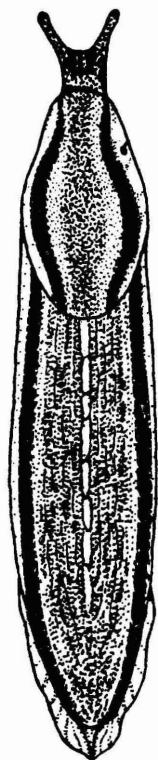
Life cycle and reproductive behavior. Because *Arion intermedius* is not abundant or widely distributed in northeastern North America, it is difficult to determine if there are any major differences between its life cycle here and in its native Europe. In the laboratory it completes the entire life cycle in three months. In the wild, individuals of adult size have been found from late June through October suggesting that reproduction may occur throughout the summer and fall. A similar pattern occurs in Europe (Quick 1960; Økland 1922). The newly hatched and immature individuals are the predominant overwintering stages.

Eggs are deposited under logs and leaf litter. The eggs hatch in about three weeks when maintained at 15° C. Newly hatched individuals are about 4 mm long.

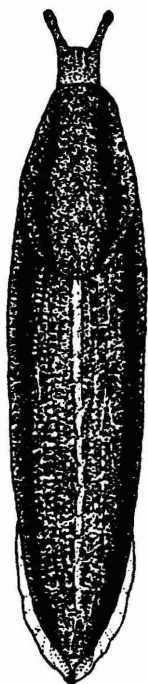
Mating behavior has not been observed. The spermatophore has not been seen (Quick, 1960). In the laboratory individuals kept isolated from the time of hatching commonly produce viable eggs (Jerry Franz, personal communication).

EXPLANATION OF FIGURE 4 (OPPOSITE PAGE)

FIG. 4. Lateral and dorsal views of a, *Arion fasciatus* (X2); b, *Arion circumscriptus* (X 2 1/3); c, *Arion silvaticus* (X 2 1/3), d, *Arion hortensis* (X2).



a



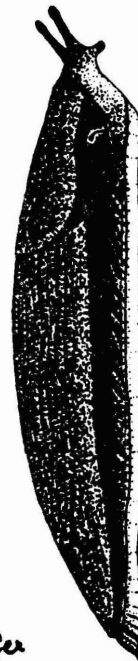
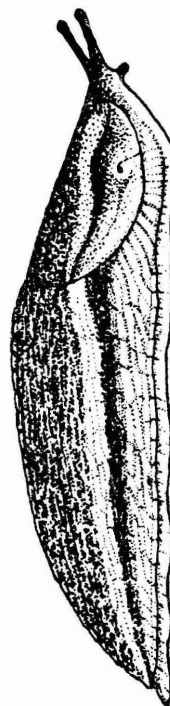
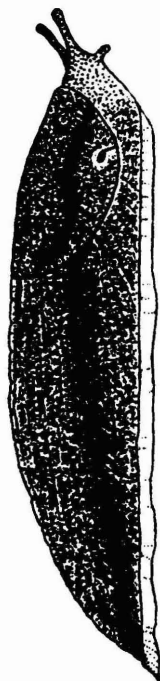
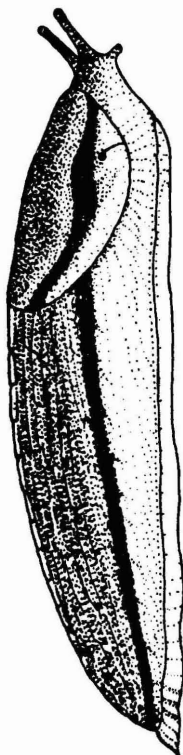
b



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Schaefer

Habitat and feeding habits. *Arion intermedius* is basically a woodland and ecotonal animal. In the relatively few instances where this slug has been collected in northeastern North America it has generally been associated with deciduous woods (other than oak), shrub thickets or hedgerows. In the British Isles it is common in the moist ground litter of woods, thickets, and at the roots of grass in open fields (Quick, 1960). Taylor (1907) indicates that in Germany the slug is associated with 'pine covered, heathy land.'

The animal is chiefly fungivorous although it does well in the laboratory on a lettuce diet.

Distribution

A native of Europe; it is now found throughout the British Isles and most of Europe. Introduced into New Zealand, Polynesia, South Africa, and North America. It has been reported in California (Pilsbry, 1948). In northeastern North America it has been collected in Quebec, New Hampshire, Maine, Massachusetts, Rhode Island, Connecticut, and New York. In these areas its distribution is very spotty; it may be locally abundant however.

Arion ater (Linnaeus, 1758)

Limax ater, Linnaeus, 1758, Syst. Nat. (10), 1:652.

Limax rufus Linnaeus, 1758, Syst. Nat. (10) 1: 652; Quick, 1960, Bull. Brit. Mus. (N.H.), 6(3): 103-226.

Arion empiricorum Férussac 1819, Hist. Nat. Moll., 2.

Arion ater (Linnaeus), Taylor, 1907, Mon. Moll. Brit. Isles (Testacellidae, Limacidae, Arionidae), p. 167.

Arion ater has at various times in the past been considered a complex of two species, *Arion ater* and *A. rufus*. Quick, (1947, 1949) treats *A. rufus* as a separate species. However, Quick (1960) again grouped *A. rufus* with *A. ater* and now considers *A. rufus* as a subspecies of *A. ater*.

Description

External. The largest slug in the genus, its extended length may exceed 150 mm. Adults lack lateral bands. When present

in the young, the mantle bands are located much closer to the dorsal mid-line than in other species of *Arion*. The right mantle band lies wholly above the breathing pore. The tubercles are elongate and prominent. The foot fringe is wide and bears prominent vertical dark lines. The adult coloration ranges from yellow through reddish brown to black. The foot fringe may be dark or brightly colored. The sole is gray. The slime is usually clear, although occasionally it may be yellow or orange. Specimens seen at Sherbrooke, Quebec were dark olive brown with a reddish foot fringe. A specimen from Cape Bon Ami (near Cap des Rosiers), Quebec was black with a reddish foot fringe. Pilsbry (1948) reported specimens from Maine as being black and specimens from Cap des Rosiers, Gaspé, Quebec as being 'russet with orange foot.' Fig. 5a, b.

Internal. The free oviduct is very short and of uniform diameter. It is ensheathed by the genital retractor muscle. The bulbous seminal receptacle is attached to the upper atrium by a long slender stalk of uniform diameter. The stalk is longer than the free oviduct. The base of the epiphallus bears an annulus. According to Quick (1960) the lower atrium of *A. a. ater* is longer and larger than the upper portion while in *A. a. rufus* the upper atrium is longer and larger. In both cases the atrium is very large. Figure 2h, drawn from a Cape Bon Ami specimen, probably represents *A. ater rufus*.

Eggs. Opaque, initially white, oval eggs are laid in clusters of several dozen (as many as 250 per cluster). They turn yellow to brown as development proceeds. Quick (1960) gives the dimensions of the eggs as 5 X 4 mm.

Biology

Life cycle and reproductive behavior. Because *Arion ater* is not abundant in northeastern North America, we must depend

EXPLANATION OF FIGURE 5 (OPPOSITE PAGE)

FIG. 5. Lateral and dorsal views of a, *Arion ater*, adult (X1); b, *Arion ater*, immature (X 1 1/8), c, *Arion intermedius* (X 2 1/2); d, *Philomycus carolinianus* (X 1 1/2); e, *Pallifera dorsalis* (2 1/3).



a



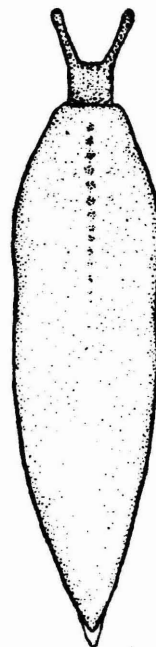
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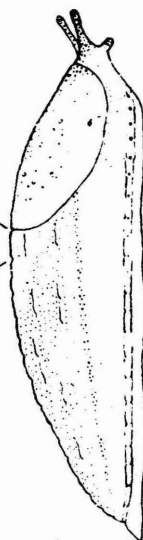
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e



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upon European authors, especially Taylor (1907), Økland (1922) and Quick (1949, 1960) for information pertaining to its life cycle.

Arion ater is an annual slug that overwinters in the young stage. Sexual maturity is attained in the summer. Egg laying occurs in the fall. Eggs are deposited in the soil. These hatch four to six weeks later. The newly hatched slugs are 10 mm long. Mating behavior apparently is basically similar to that of *Arion subfuscus*.

Habitat and feeding habits. In Europe *Arion ater* is found along roadways, in fields, hedgerows, and woodlands, especially deciduous woods. In North America it has been found in both deciduous and coniferous woods as well as gardens.

It is omnivorous in its feeding habits.

Distribution

General. *Arion ater* is native to Europe. It is now found throughout the British Isles and most of Europe. It has been introduced into New Zealand and North America (Newfoundland, Quebec, Michigan, Washington, Maine, Oregon, and Connecticut).

Arion hortensis Férussac, 1819

Arion hortensis Férussac, 1819, Hist. Nat. Moll. 2:65.

Description

External. A small, slender slug with a fully extended length of about 40 mm. The lateral bands are very dark and are lower on the body than in the other species of *Arion*. The right mantle band surrounds the breathing pore. Dorsally the body color is blue-black to black in immature individuals and brownish black in adults; preserved adult specimens are bluish black. Just above the lateral bands the body color is lighter than elsewhere on the dorsum so that the animal appears to possess a pair of light bands just above the dark lateral bands. These light bands are especially distinct in preserved specimens. Laterally the body is gray to brown. The foot fringe is not well developed. The foot sole in life is yellow or orange owing to the accumulation of colored mucus. In preserved specimens the foot sole is white. Although in Europe this slug exists in

several color phases, all of the specimens from northeastern North America fit the typical European form described above. Fig. 4d.

Internal. The free oviduct is very long and distinctly swollen at its atrial end. The seminal receptacle is spheroidal; its stalk is very short, thick and swollen at its atrial end. The epiphallus terminates atrially in a swollen bulb. Fig. 2j.

Eggs. Transparent, oval eggs are deposited in clusters of up to three dozen eggs. The eggs gradually turn yellow and opaque. Quick (1960) gives the egg dimensions as 2.5 X 2 mm.

Biology

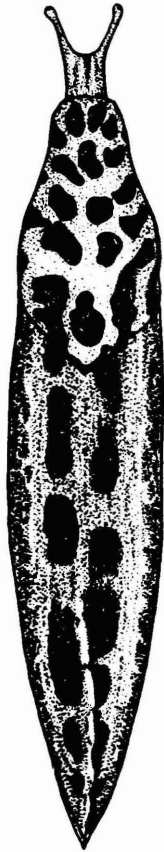
Life cycle and reproductive behavior. Based on specimens collected at various times throughout the year in Connecticut and elsewhere in northeastern North America, it appears that adults are present in both spring and fall populations in about the same proportions. Apparently there are two principal egg laying periods (spring and fall). The autumn egg laying results in newly hatched individuals which overwinter and mature by the next autumn. The individuals hatching from the spring egg laying are almost mature at the start of the next overwintering cycle. They complete maturation in the spring.

Mating behavior is basically similar to that of *Arion subfuscus*. *A. hortensis*, however, possesses a club-shaped projection which represents an everted portion of the oviduct and which is analogous to the sarcobelum (a stimulatory organ) of *Deroceras*. This projection, when fully everted, is about the same size, transparency and color as the everted atrium. During copulation each slug strokes its partner's body with the everted oviduct.

The eggs are deposited under ground litter. They hatch in about four weeks at 15°C. The young are 4 to 5 mm long.

EXPLANATION OF FIGURE 6 (OPPOSITE PAGE)

FIG. 6. Lateral and dorsal views of a, b, *Limax maximus* (X 1); c, *Limax flavus* (X 1); d, *Lehmannia valentiana* (X 1)



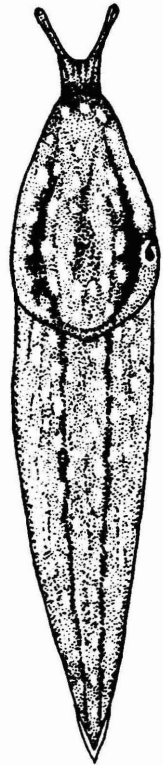
a



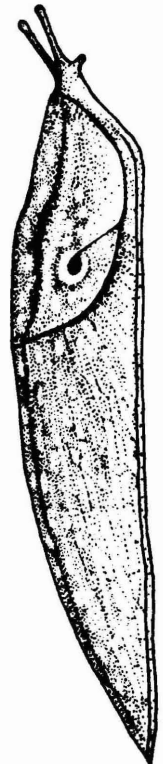
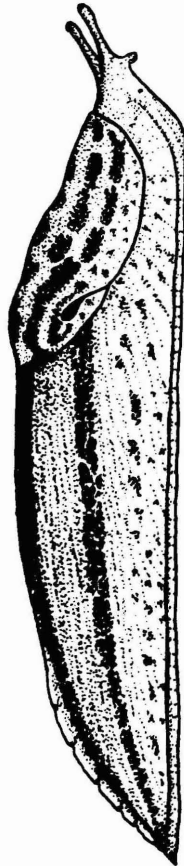
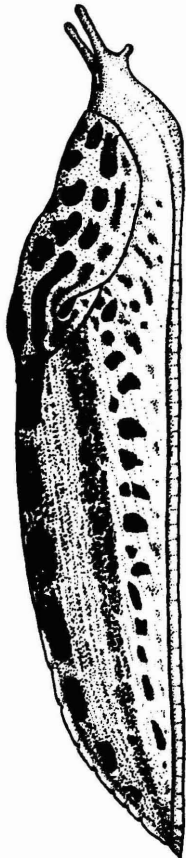
b



c



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Habitat and feeding habits. In north-eastern North America *A. hortensis* has been found in greenhouses, nurseries, parks, and other cultivated areas. It has also been found in both deciduous (other than oak) and coniferous woods (spruce-fir, in particular), in some cases not closely associated with cultivated areas. It has far too spotty a distribution in north-eastern North America to make any general statements about its preferred habitats. In Europe it is commonly found in gardens (where it is frequently a serious horticultural pest) as well as in fields and woodlands.

Judging from its reputation as a garden slug it apparently is less fungivorous than most other species of *Arion*. In the laboratory it can easily be maintained on lettuce.

Distribution

Native to Europe, *Arion hortensis* is presently found throughout all of the British Isles, most of Europe and in North Africa. It has been introduced into South Africa, Australia, Tasmania, New Zealand, Iceland, and North America. In North America it has been found in Newfoundland, Nova Scotia, Quebec, Ontario, Washington, California, Pennsylvania, Maine, and Connecticut.

Arion fasciatus complex

1. Definition

Lohmander (1937) described three forms of *Arion* which he believed were closely related, but distinct. Lohmander was not certain whether these forms constituted good species or were simple subspecies or varieties under the species *Arion fasciatus* Nilsson. Wulden (quoted by Ellis, 1966) in Sweden has extended Lohmander's research and now considers the three forms as separate and distinct species. Our own anatomical and biochemical studies using acrylamide gel disc electrophoresis to study egg and foot proteins (unpublished) convince us that there are indeed three distinct species in the complex. The three species, corresponding to Lohmander's first, second, and third forms, respectively, are: *Arion fasciatus* Nilsson, *Arion circumscriptus* Johnston, and *Arion silvaticus* Lohmander. Each species was described in detail by Lohmander. All three forms occur in northeastern North America.

A. fasciatus is by far the most widely distributed. *A. circumscriptus* and *A. silvaticus* are by comparison relatively uncommon.

In addition to Lohmander's three distinct forms a fourth form has been introduced into southern New England. This form, with reddish brown ground color and brown lateral bands is simply a color form of *A. circumscriptus*. On the basis of its internal anatomy as well as its external appearance, except for color, it agrees exactly with Lohmander's 'second' form (i.e., *A. circumscriptus*).

11. KEY TO THE SPECIES OF THE ARION FASCIATUS COMPLEX

1. **BODY BANDS** brown; dorsum and sides reddish brown
Arion circumscriptus (brown form)
BODY BANDS black; dorsum medially black and laterally brown, or dorsum entirely gray 2
2. **BODY SIDES** with a yellow or orange band just ventral to black body bands...
..... *Arion fasciatus*
BODY SIDES without yellow or orange bands 3
3. **DORSUM** uniformly dark gray flecked with black ... *Arion circumscriptus* (typical black form).
DORSUM medially black and laterally brown (there appears to be a pair of light brown bands above the black body bands) *Arion silvaticus*

Arion fasciatus (Nilsson, 1822)

- Limax fasciatus*, var. ♂, Nilsson, 1822, *Historia Molluscorum Sveciae*, p. 4.
Arion circumscriptus Johnston, 1828, *Edinb. New Phil. J.*, 5:76.
Prolepis hortensis Malm, 1868, *Goteborgs Vet. Vitt. Samh. Handl.*, 10:49.
Arion bourguignati Mabille, 1868; Simroth, 1885, *Z. Wiss. Zool.*, 42(2).

EXPLANATION OF FIGURE 7 (OPPOSITE PAGE)

FIG. 7, a-d, Lateral and dorsal views of color forms of *Deroceras reticulatum* (X 2).



a



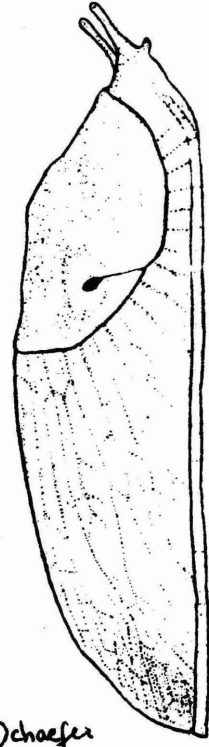
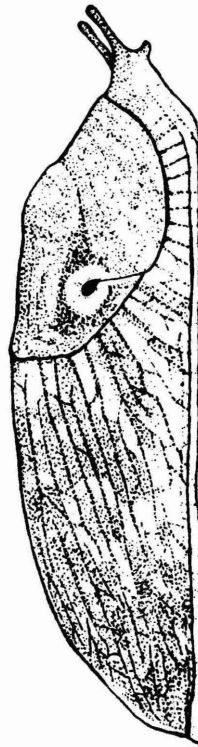
b



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d



Schaefer

- Arion nilssoni* Pollonera, 1887, Atti R. Accad. Sci. Torino, 22 $\frac{1}{2}$ 5.
Arion fasciatus, var. *flavescens* Collinge, 1893. Conchologist, 2: 26-27.
Arion circumscriptus, var. *circumscripta* Økland, 1922, Videnskap. Skrifter, I. Mat.-Nat., Kl. 1922, no. 5:32-40.
Arion fasciatus Nilsson; Lohmander, 1937, Acta Soc. Fauna Flora Fenn., 60:90-112.

Description

External. A medium sized slug, the typical extended length is between 40 to 50 mm; some laboratory reared individuals attain lengths in excess of 60 mm. The mid-dorsal ridge is usually conspicuous even in adults. The dorsal body ground color is light gray, becoming slightly lighter just dorsal to the black body bands. The mid-dorsal portion of the mantle is gray. The gray fades to pale grayish yellow just above the mantle bands. Immediately below each lateral body band there is a yellow or orange band of about the same width as the black band. This yellow or orange band is usually absent in immature individuals. The sides of the foot and the sole are white. The right mantle band lies wholly above the breathing pore (as it does in all members of the complex). The foot fringe is not as well developed as in *A. subfuscus* or *A. ater*.

Laboratory animals reared on lettuce are much more brownish orange than the wild forms. This color is acquired from a yellow colored mucus which apparently results from the high carotenoid content of the food. Wild individuals almost always have clear mucus, however. It is possible that some of the many varieties described for this species may be attributed to dietary differences as may exist between garden and woodland populations. Fig. 4a.

Internal. The free oviduct is very short (shorter than the vas deferens) and of approximately constant diameter. The seminal receptacle is typically tear-shaped with the pointed end forming the apex. The atrial end of the stalk bears a bulb-like swelling. The atrial end of the epiphallus is slightly swollen. Fig. 2i.

Eggs. Ellipsoidal, semi-translucent eggs are laid in clusters of one to three dozen or more. Økland (1922) describes the egg color as white, although all egg masses of the species seen by the authors have been yellow or amber. Quick (1960) also describes the egg color as 'yellow or

sometimes dark amber' and gives the dimensions as 3 X 2 mm.

Biology

Life cycle and reproductive behavior. All size classes are present through the year. Reproduction continues from spring through the fall. Apparently all stages can successfully overwinter in our region. The situation in Europe is apparently the same (Økland, 1922).

Eggs are deposited on the soil under ground litter. Eggs maintained at 15° C hatch in about four weeks. The newly hatched slugs are about 5 mm long.

Mating in *Arion fasciatus* is different from the typical pattern displayed by its congeners. According to Quick (1960) coitus lasts only about 20 minutes. During coitus there is little or no eversion of the genital organs.

Habitat and feeding habits. *Arion fasciatus* is the most ubiquitous species of the genus. It can be found in deciduous woodlots of maple, ash, and elm, especially where the ground litter includes an abundance of twigs and small branches, but not many leaves. It can be found in hedgerows and shrub thickets. It does well in grass fields and in the grassy margins along highways. It occurs in gardens and occasionally in greenhouses. In fact, it appears to do well almost everywhere except in coniferous and oak forests. Lohmander's (1937) discussion of the ecological distribution of *Arion fasciatus* in Sweden and Norway agrees with that for north-eastern North America.

In the laboratory *Arion fasciatus* can easily be maintained on lettuce. In the wild it is probably at least partly fungivorous.

Distribution

Because the specific components of the complex have for so long been treated collectively as a single species, it is not presently possible to decide which records apply to each species of the complex. The complex is native to Europe. It is presently distributed throughout the British Isles and most of Europe. It has been introduced into Iceland and North America.

In North America it has been introduced

into most of Canada and the United States. It is undoubtedly the most widely distributed of the introduced Arionids. In northeastern North America *Arion fasciatus* is by far the most widely distributed species in the complex. Both *A. circumscriptus* and *A. silvaticus* are relatively uncommon, although there are scattered populations throughout the region.

Arion circumscriptus Johnston, 1828

- Arion fasciatus*, var. ? Nilsson, 1822, *Historia Molluscorum Sveciae*, p. 4.
Arion circumscriptus Johnston, 1828, *Edinb. New Phil. J.*, 5: 76.
Arion bourguignati Mabilie, 1868; Pollonera, 1887, *Atti R. Accad. Sci. Torino*, 22: 5.
Arion ambiguus var. *armoricana* Pollonera, 1889, *Atti R. Accad. Sci. Torino*, 24: 13.
Arion fasciatus var. *grisea* Collinge, 1892, *Conchologist*, 2(3).
Arion circumscriptus var. *nigra* Økland, 1922, *Videnskap. Skrifter, I. Math.-Nat. Kl.* 1922, no. 5: 32-40.
Arion circumscriptus Johnston; Lohmander, 1937, *Acta Soc. Fauna Flora Fenn.*, 60: 90-112.

Description

External. Typical black form. A small slug, the extended length usually does not exceed 40 mm. The dorsal and lateral ground color is gray (ranging from light steel gray through a bluish gray to a blackish gray). The dorsum and mantle are distinctly flecked with black spots of various shapes and sizes. Because of these black spots fully contracted animals appear almost black. Lateral black body bands are present. In Lohmander's (1937) description the lower boundary of each band is said to be less distinct because the sides are a darker gray than that portion of the dorsum immediately adjacent to the bands. This is not the case, however, in the relatively few populations that we have been able to sample in our region. The sides are not darker than the area immediately above the bands. The weakly developed foot fringe is faintly peppered with black spots. The foot sole is bluish-white. The slime is clear. Fig. 4b.

Brown form. The dorsal and lateral ground color is reddish brown. The dorsum and mantle are distinctly flecked with brown spots of various shapes and sizes.

The lateral bands are brown. No black pigment is present. In all other respects it is like the typical form described above.

Internal. Because the differences between this form and the other species in the complex are quite subtle and not entirely consistent, interested readers are referred to Lohmander's original paper (1937).

Eggs. Differences from *A. fasciatus*, if any, are not known.

Life cycle and reproductive behavior. Differences from *A. fasciatus*, if any, are not known.

Habitat and feeding habits. In Connecticut, all records are for mixed hardwoods adjacent to or very near cultivated lands. Lohmander (1937) stated that *A. circumscriptus* shares many sites in common with both other forms. He also indicated that it occurs in more moist and shady habitats than does *A. fasciatus*.

Differences in feeding habits from *A. fasciatus* are not known.

Distribution

See discussion under *Arion fasciatus*.

Arion silvaticus Lohmander, 1937

- Arion fasciatus* var. ? Nilsson, 1822, *Historia Moll. Sveciae*, p. 4.
Arion circumscriptus Johnston, 1828, *Edinb. New Phil. J.*, 5: 76.
 ? *Arion neustriacus* Mabilie, 1868, *ev. Mag. Zool.*, (2) 20: 138.
Arion fasciatus var. *neustriaca* Mabilie; Collinge 1892, *Conchologist*, 2(3).
Arion circumscriptus var. *sylvatica* Lohmander, 1937, *Acta Soc. Fauna Flora Fenn.* 60: 90-112.
Arion silvaticus Lohmander; Walden, 1966 (Quoted by A. Ellis in *Conchologists' Newsletter*, No. 17).

Description

External. In size, it is comparable to *A. circumscriptus*; its extended length is less than 40 mm. The lateral bands are broad and darkly pigmented. The mid-dor-

sal portions of the body and mantle are also darkly pigmented. Because the area just above the lateral bands is lightest in color there appears to be a pair of light bands present between the dark mid-dorsum and the dark lateral bands. The dorsum has a distinctly chocolate brown tinge that is not lost in preservation. There is apparently no brown pigment present, however. The brownish color results from a combination of orange and black pigments in a gray, semi-translucent matrix. The body sides are slightly paler than the dorsum. The valleys between the lateral tubercles are darkly pigmented producing a distinctly reticulated appearance. The two ventralmost rows of tubercles contain an abundance of white pigment flecks which greatly contributes to the overall paler appearance of the sides. The foot fringe is dark spotted almost to the extent of being lineolate. The foot sole is a pale yellowish white. The slime is clear. Fig. 4c.

Internal. See Lohmander, 1937.

Eggs. Differences from *A. fasciatus*, if any, are not known.

Biology

Life cycle and reproductive behavior. Differences from *A. fasciatus*, if any, are not known.

Habitat and feeding habits. In Connecticut, all records are for mixed hardwood woodlots adjacent to or very near cultivated lands. Lohmander (1937) stated that *A. silvaticus* shares many sites in common with both other forms. He also indicated that it tends to occur in even more moist habitats than *A. circumscriptus*; for example, he found it in bogs.

Distribution

See discussion under *Arion fasciatus*.

Family Philomycidae Keferstein, 1866

Description

Slugs in which the mantle covers almost the entire body. A shell is absent. The jaw is ribbed or striated. The foot sole is undivided. The tentacular and buccal muscles have separate origins. The breathing pore lies near the right anterior margin of the mantle.

Distribution

Native to Asia, North America, and Central America south to Colombia. It has been introduced into Hawaii.

Origin

Apparently arose from an Endodontid stock which also gave rise to the Arionidae.

Genus *Philomycus* Rafinesque, 1820

Philomycus Rafinesque, 1820, Annals of Nature, 1:1-16.

Description

A vaginal, calcareous stimulator is present. The jaw is striated (rather than ribbed). The mantle covers most of the head.

Distribution

Eastern North America from Canada to Florida and Texas.

Philomycus carolinianus (Bosc, 1802)

Limax carolinianus Bosc, 1802, Hist. Nat. Vers, 1:80.

Philomycus flexuolaris Rafinesque, 1820, Annals of Nature, 1:10.

Tebennophorus caroliniensis Binney, 1842, Boston Jour. Nat. Hist. 4:171.

Description

A large slug, the extended length is usually about 70 to 80 mm; occasionally it may reach 100 mm. The mantle covers the entire body, including most of the head. The mantle ground color is tan. Except for the lateral margins, however, the tan color is usually almost obliterated by a wide dark (black or brown) mid-dorsal band with diffuse margins, two narrower lateral bands that are so irregular they may appear as discontinuous blotches, and by numerous spots between these bands. Irritated individuals produce a milky slime. Fig. 5d.

Biology

P. carolinianus is a relatively inactive slug. It is widespread but rarely locally

abundant. Although native to our region, its biology is not well known. It inhabits both deciduous and coniferous woods where it is usually found in decaying logs. It is more common in deciduous forests, especially beech and basswood.

It is fungivorous in the wild.

Distribution

Eastern half of North America from Canada south to Florida and Texas.

Genus *Pallifera* Morse, 1864

Pallifera Morse, 1864, Jour. Portland Soc. Nat. Hist., 1:1-63.

Description

Slugs in which the mantle covers all of the body except the head. The genus includes several species; except for one species in Arizona, all are confined to eastern North America. Only one species occurs in Connecticut.

Pallifera dorsalis (Binney, 1842)

Philomycus dorsalis Binney, 1842, Boston Jour. Nat. Hist. 4:174.

Tebennophorus dorsalis Binney, 1851, Terr. Moll., 2:24.

Description

A small slug about 25 mm long when fully extended. Externally similar to *Philomycus* except that the head is not covered by the mantle and the tail is more tapered. The slime is more watery than that of *Philomycus*. The mantle ground color is light to bluish gray. There is usually a faint row of dots, or a broken line, extending mid-dorsally down the mantle. Occasionally a fainter, paired, lateral set of bands may also be present. The foot fringe and sole, especially toward the anterior end, may be rust red. Fig. 5e.

Biology

The life history and reproductive habits of this species are not well known. It is widespread and more abundant than is *Philomycus carolinianus*. It is a woodland form which typically is found beneath the bark of decaying logs and under the leaf litter. It is more likely to be in ecological and semi-cultivated areas than is *Philomycus*.

Distribution

It has been recorded from eastern Canada, New England, New York, Pennsylvania, Virginia, and the northern midwestern United States.

SUPERFAMILY ZONITACEA

Family Limacidae Gray, 1824

Description

Slugs in which the shell is almost always a flat plate enclosed wholly within the mantle. The jaw is smooth. The foot sole is tripartite. The breathing pore is located behind the mantle cleft in the right, rear quadrant of the mantle. The tentacular and buccal retractor muscles all arise from a common origin just behind the posterior margin of the mantle (Fig. 1t). Usually there is a dorsal keel present, at least posteriorly.

Distribution

The family is primarily a native of Europe and adjacent portions of North Africa and Asia. Only the genus *Deroceras* has a world-wide distribution. Other members of the family have been introduced into South Africa, Australia, Tasmania, New Zealand, Polynesia, Japan, Iceland, and South and North America.

Origin

The family is believed to have arisen from a Zonitid stock, probably in Europe.

Subfamily Limacinae

The mantle is concentrically ridged but lacks a subdividing horseshoe-shaped groove. The dorsal keel terminates before reaching the posterior margin of the mantle. There is no caudal gland. An epiphallus and spermatophore are absent. The stimulator, if present, is associated with the penis.

Genus *Limax* Linnaeus, 1758

Limax Linnaeus, 1758, Syst. Nat. (10), 1: 652.

Description

The concentric ridges of the mantle have their nucleus on the dorsal midline (Fig.

lj). The posterior end is pointed rather than truncated as in *Deroceras* (Fig. 11). A penial appendix and a rectal caecum may be present or absent (no penial appendix is present in any *Limax* species known to be introduced into North America). The right tentacular retractor muscle passes forward between the penis and the oviduct.

Distribution

Native to Europe and adjacent parts of Africa and Asia. Some species have been spread by commerce throughout much of the world, including Africa, North and South America, and Australia.

Limax maximus Linnaeus, 1758

Limax maximus Linnaeus, 1758, Syst. Nat. (10) 1:652.

Description

External. A large slug, its extended length is 100 to 200 mm. The dorsal keel extends less than half the distance between the posterior margin of the mantle and the 'tail'. The keel is slightly crenate. The body color is some shade of gray or brown. There are numerous dark spots, blotches, or stripes present in a variable pattern. There may be up to 200 small irregular black spots on the mantle or there may be less than a dozen brownish, black bordered blotches; there are no regular mantle bands. On the body proper there may be several rows of black spots or blotches which may coalesce to form body bands or the body may be uniformly dark and unspotted. The tentacles are uniformly brown. The foot sole is whitish gray. The slime is clear. (Fig. 6a, b). A closely related form, *L. cinereoniger* Wolf, which has not been reported from North America, is distinguished from *L. maximus* by its dark spotted tentacles, a black body with a white keel, and its coarser tubercles (Quick, 1960).

Internal. Fig. 2a. The penis is quite large and contorted. It lacks an appendix. The free oviduct is relatively long. The distal part of the slender stalk of the seminal receptacle runs parallel and adjacent to the free oviduct; the stalk may arise from either the free oviduct or the atrium. A rectal caecum is absent.

Eggs. The transparent, colorless, oval eggs are deposited in clusters of one to several dozen. Quick (1960) gives the dimensions as 5.0 X 5.5 mm.

Biology

Life cycle and reproductive behavior. In Connecticut the eggs are deposited under rocks, logs and leaf litter, chiefly in the fall. Eggs maintained at 15° C hatch in three to four weeks. *L. maximus* lives at least three to four years (Quick, 1960); two years are required for it to reach sexual maturity in the laboratory (Simpson, 1901). It is probable that all stages overwinter in our region.

Mating behavior in *L. maximus* has been described in detail by Adams (1898). Mating usually involves the suspension of the mating pair by a thick mucus thread attached to an overhang. The pair, while suspended in mid-air intertwine their bodies and finally their penes. While in this position viscous masses of semen are exchanged.

Habitat and feeding habits. All Connecticut records for *L. maximus* are from cultivated areas such as gardens and parks or from cellars, retaining walls, etc. associated with human dwellings. In Europe *L. maximus* occurs in woods as well as in cultivated areas.

In the laboratory this species can be reared on a diet of lettuce. In the wild they are omnivorous.

Distribution

Native to Europe, it is now widely distributed throughout the British Isles, Europe and adjacent Asia and Africa. It has been introduced into South Africa, Australia, Tasmania, New Zealand, South America and throughout much of North America.

Limax flavus Linnaeus, 1758

Limax flavus Linnaeus, 1758, Syst. Nat. (10) 1:652.

Description

External. A large slug, its extended length is 70 to 100 mm. The ground color ranges from yellowish gray to green. Adults have the body irregularly blotched or spotted with yellow. Lateral bands are absent. The tentacles are blue. The foot sole is pale yellow. The slime is yellow. Fig. 6c.

Internal. The penis is quite large and contorted. It lacks an appendix. A long rectal caecum is present.

EGGS. The lemon-shaped, amber colored eggs are deposited in clusters of up to two dozen eggs. Quick (1960) gives the egg dimensions as 6 X 4 mm.

BIOLOGY

Life cycle and reproductive behavior. Because it is extremely rare in natural areas in our region we must depend upon accounts provided by European workers and upon greenhouse observations such as those provided by Karlin and Bacon (1961). In the British Isles egg laying lasts from late summer to February. The eggs hatch in three to six weeks at 20° C. Newly hatched slugs are 10 to 13 mm long.

Mating occurs on a substrate (rather than in mid-air as in *L. maximus*). Entwined penes exchange viscous seminal masses as in *L. maximus*. The actual copulation takes less than a minute.

Habitat and feeding habits. In Europe, *L. flavus* is occasionally found in woods; it is much more common in gardens and around buildings, however.

It is omnivorous.

Distribution

Native to Europe, it occurs throughout the British Isles, most of Europe and adjacent parts of Africa and Asia. It has been introduced into South Africa, Australia, South America, and in many localities in North America.

Genus *Lehmannia* Heynemann, 1861

Lehmannia Heynemann, 1861, Malakozool., 8:85-105.

Description

The penis is short; it bears a well developed appendix. There is a long rectal caecum present which extends posteriorly almost to the apex of the visceral mass (Fig. 1p). The body frequently becomes translucent and swollen owing to the absorption of water from moist surroundings (especially in *Lehmannia marginata*). The nucleus of the concentric mantle ridges is mid-dorsal (Fig. 1j). Walden (1961) suggests that *Lehmannia* be provisionally treated as a subgenus under the genus *Limax*. Since *Lehmannia* is such a well established generic name in both the North American and European literature and be-

cause its taxonomic status is still in doubt we choose to retain *Lehmannia* as a separate genus for the present.

Distribution

Native to Europe and adjacent parts of Africa and Asia, it has been introduced into South Africa, Australia, and North and South America.

Lehmannia valentiana (Férussac 1823)

Limax valentianus Férussac 1823, Hist. Nat. Moll., Suppl. Fam. Limaces, p. 96.

Limax poirieri Mabilie, 1883, Bull. Soc. Philom. Paris (7) 7:39-53; Walden, 1961, Arkiv Zoologi, (15) 3:71-95.

Lehmannia poirieri Mab., Quick, 1960, Bull. Brit. Mus. (N.H.), 6(3):197.

There has been more nomenclatural confusion about this slug than any other imported limacid. This confusion springs from two sources. First, only recently has it become clear that *L. poirieri* and *L. valentiana* are conspecific (Walden, 1961). Secondly, this slug has been referred to by many American authors as *L. marginata* in the mistaken belief that *L. valentiana* was conspecific with *L. marginata*, the forest-dwelling species of Europe. Walden (1961) discusses the problem in detail.

Description

External. A medium sized slug, the extended length is about 60 mm. The keel is very weakly developed and may occasionally be absent. The breathing pore is surrounded by a whitish area. The ground color is light brown dorsally, fading gradually to light tan laterally. The mantle bears a pair of gray to black lateral bands and usually a single, less well-defined mid-dorsal band. Only paired bands are present on the back where they are situated close together near the dorsal midline. Often the mantle bears pale yellow spots which may occasionally disrupt the dark bands. Individuals in which the spots are distinct and the bands faint may be mistaken for *Limax flavus*. The foot sole is whitish. The concentric mantle ridges are especially distinct. The slime is clear.

Internal. The penial appendix is a large, slightly contorted cylinder with a blunt to rounded terminus (Fig. 2e). The long rectal caecum is a fairly wide, flat band lying on the dorsal surface of the

visceral mass (Fig. lp). The radula is distinctly different from that of adult *L. marginata* in that the central tooth is distinctly tricuspid, as are the first dozen or more lateral teeth. (Fig. lu).

Eggs. The oval transparent eggs are deposited in loose aggregations of up to several dozen eggs. The eggs are usually colorless and 2.25 X 1.5 mm in size.

There are two other Limacid slugs which may be confused with *L. valentiana* and which have been reported from North America:

Lehmannia marginata (Müller, 1774). This woodland slug of Europe is slightly larger than *L. valentiana*. It is banded as in *L. valentiana*. Positive identification depends upon internal characters of which the most dependable are: the presence of a conical penial appendix (Fig. 2d as opposed to a cylindrical one in *L. valentiana*, and the presence of a specialized radula (in adults) in which the central tooth has a large mesocone and only vestiges of the ectocones while the inner lateral teeth have large mesocones, no ectocones, and, except for the first two rows, no endocones (Fig. lv). Apparently the only valid record for North America is from Newfoundland.

Limax nyctelius Bourguignat, 1861. Externally this North African slug looks very much like *L. valentiana*. It differs from *L. valentiana* in possessing a long penis without an appendix. This greenhouse slug has been introduced into Washington, D.C. (Quick, 1960).

Biology

Life cycle and mating behavior. In northeastern North America *L. valentiana* is essentially a greenhouse slug. Under greenhouse conditions it breeds throughout the year. The eggs are deposited on, or partially in, the soil. Eggs maintained at 15° C hatch in about four weeks. The newly hatched young are 3 to 5 mm long.

Mating behavior has not been recorded.

Habitat and feeding habits. Although it apparently occurs in a variety of habitats in California, throughout the rest of North America *L. valentiana* appears to be confined to greenhouses and their environs.

It is probably omnivorous. In the laboratory it can easily be maintained on lettuce.

Distribution

L. valentiana is a native of the Iberian Peninsula (Walden, 1961). It has spread, through commerce, to other parts of Europe and the British Isles. It has been introduced into North and South America, South Africa, Australia, and several Atlantic and Pacific Islands. In North America it has been recorded from natural areas as well as greenhouses in California and from greenhouses in many other states and provinces.

Genus *Deroceras* Rafinesque, 1820

Deroceras Rafinesque, 1820, Annals of Nature, 1:1-16.

Description

The concentric ridges of the mantle have their nucleus near the breathing pore (Fig. li). The posterior end is truncated when viewed in profile (Fig. lk). A penial appendix is present. A short rectal caecum may be present. The right tentacular retractor lies medial to both the penis and the oviduct. Lateral bands are usually absent.

The name *Agriolimax* Mörch has been used for this genus by some European workers.

The genus includes a number of species which are quite similar in external morphology but distinct in internal anatomy. Positive identification usually requires dissection.

Distribution

The genus is native to North and South America, northern Asia and Europe. Several species are restricted to western North America.

Deroceras laeve (Müller, 1774)

Limax laevis Müller, 1774, Verm. Terr. et Fluv. Hist., 2:1.

Limax gracilis Rafinesque 1820, Annals of Nature, 1:52.

Limax campestris Binney, 1842, Proc. Boston Soc. N. H., 1:52.

Description

External. A small slug, its extended length is about 25 mm. The ground color varies from light brown through light gray to black. Black, irregular spots or reticulations may be present on the body.

Extensively reticulated individuals may resemble *D. reticulatum*, especially preserved specimens where slime color is not available and where the normal dark bordered breathing pore of *D. laeve* may appear pale. When the animal is extended the mantle appears almost centrally located because of its long neck. The slime is clear and watery. Fig. 8 a, b.

Internal. Fig. 2c. The ovotestis is usually completely buried in the visceral mass. The slightly contorted and relatively large penis bears a large tubular appendix. There is no rectal caecum. Some individuals may lack penis; still others may lack both a penis and vas deferens.

Another European slug, *Deroceras caruanae* Pollonera, which has been introduced into California and eastern Canada, may be easily confused with *D. laeve*. This slug is somewhat larger than *D. laeve*. It lacks a rectal caecum. Apically, the penis bears a pair of diverging club-like processes at the junction of which arises a penial appendix consisting of several fine thread-like projections. In our region, large *D. laeve*-like slugs found in greenhouses and gardens should be examined internally to insure correct identification.

Eggs. The eggs are deposited in very loose aggregations or in small, scattered clusters. The eggs are oval and transparent. They may turn yellow several days after deposition. Quick (1960) gives the egg size as 1.8 X 1.5 to 2 X 1.3 mm.

Biology

Life cycle and reproductive behavior. Egg laying occurs throughout most of the year. Eggs are deposited on, or slightly under, the soil under logs, stones, and ground litter. They hatch in about 4 weeks at 15° C. The newly hatched slugs are 3 to 4 mm long. All stages probably overwinter in our region.

D. laeve does not engage in the preliminary 'following and circular dances' of *D. reticulatum*. Also the copulatory position is maintained for a longer period (up to an hour; Gerhardt, 1939).

Habitat and feeding habits. *D. laeve* is undoubtedly the most ecologically ubiquitous slug in northeastern North America. It can be found in greenhouses, gardens, fields, marshes, and deciduous and coniferous woods. In cultivated areas population sizes approach those of some colonial, imported slugs. In wild areas population sizes are generally small. In Connecticut

it is one of the few slugs found in oak forests.

Distribution

This species is native to North America and perhaps also Central and South America. It also occurs in Europe and northern Asia, from where it presumably spread to North America in late Pleistocene or post-glacial times (Pilsbry, 1948). In North America it is distributed throughout Canada, the United States, and Mexico. In Connecticut it is widely distributed throughout the state.

Deroceras reticulatum (Müller, 1774)

Limax reticulatus Müller, 1774, Verm. Terr. et Fluv. Hist., 2:10.

Limax agrestis Schrenck, 1848, Land und Süsw. Moll. Livlands.

Agriolimax reticulatus Müller; Luther, 1915, Acta Soc. Fauna Flora Fenn., 40 (2): 1-42.

This slug was referred to by older authors as *Agriolimax agrestis* (L.). Luther (1915) showed that *A. agrestis* as it was defined by earlier authors encompassed two species, *A. reticulatus* and the less widely distributed *A. agrestis*. *Deroceras agreste* has not been recorded from North America. However, since it closely resembles *D. reticulatum* it may have been overlooked. It is smaller than *D. reticulatum*. Internally, the ovotestis lies farther forward. The penial appendix is a short, slender unbranched tube. A short rectal caecum is present as in *D. reticulatum*.

Description

External. A larger and more robust slug than *D. laeve*, its extended length may exceed 45 to 50 mm. The dorsal keel is short but distinct. The breathing pore is surrounded by a white border. The ground color varies from almost solid black through mottled black or brown to light tan or grayish white. As its name implies the body usually appears distinctly reticulated because of the presence of black or brown pigment in the valleys between the tubercles. Occasionally dark, irregular spots will more or less completely hide the reticular pattern. The sides are normally paler than the dorsum. The foot sole is gray. The mantle is located more anteriorly in fully extended *D. reticulatum* than it is in active *D. laeve*. The slime is clear in undisturbed animals but milky white and very sticky in irritated animals (owing to the incorpora-

tion of calcareous particles in the slime). Fig. 7 a-d.

Internal. A short rectal caecum is present. The ovotestis lies near the apex of the visceral mass and is exposed dorsally (Fig. 10). The penis bears a multifid penial appendix (Fig. 2b).

Eggs. The transparent ovoidal eggs are deposited in close aggregations of up to several dozen eggs. They normally remain colorless throughout development. Quick (1960) gives the egg dimensions as 3 X 2.5 mm.

Biology

Life cycle and reproductive behavior. In northeastern North America, egg laying occurs chiefly in the late summer and fall; a few eggs may be found throughout the spring and summer, however. The adults die in the fall after egg laying. The overwintering populations consist primarily of newly hatched individuals from the fall hatching. Adult size and sexual maturity are not attained until late summer. In greenhouses and other protected habitats egg laying usually occurs throughout the year. Also, more southern localities with milder winters may have a spring egg laying peak in addition to the fall peak. In this case spring hatched individuals mature in the fall and fall hatched individuals mature in the spring.

The eggs are deposited on the soil under ground litter. The eggs hatch in three to four weeks at 15° C. The newly hatched slugs are 3 to 4 mm.

Mating involves a preliminary 'courtship dance' in which the animals follow each other in a circle. This may be performed either on a vertical or horizontal surface. Each slug moves its sarcobelum over the body of its partner as it circles. After 30 minutes or more of 'following' and circling, the animals align themselves so as to bring the reproductive openings into opposition. The atria and penes are everted. Finally, the penial appendices are also everted and the viscous seminal masses are exchanged.

Habitat and feeding habits. *D. reticulatum* is found in greenhouses, gardens, fields, pastures, in the grassy margins of highways, dumps, and occasionally in deciduous woods (especially maple or ash). It is rarely found in coniferous woods. It has the potential for being a serious pest of field crops, truck gardens, and

pasture lands because of the extremely high population densities which it can attain.

It apparently feeds on succulent vegetation to a greater extent than do most slugs. In the laboratory it can be maintained on lettuce.

Distribution

Native to all of the British Isles and most of Europe. It has been introduced into almost all parts of the world. In North America it probably occurs in every state and province. In Connecticut it is distributed throughout the state.

Subfamily Parmacellinae

The shell is either flat and completely enclosed in the mantle or spiral and partially exposed. The mantle is subdivided by a horseshoe-shaped groove. The keel extends forward to the posterior margin of the mantle. Both an epiphallus and penis are present. Copulation involves the mutual exchange of spermatophores.

Genus *Milax* Gray, 1855

Milax Gray, 1855, Cat. Pulmonata Brit. Mus., 1:174.

Description

The shell is a flat plate, completely enclosed in the mantle. A stimulator, if present, is associated with the atrium rather than the penis.

Distribution

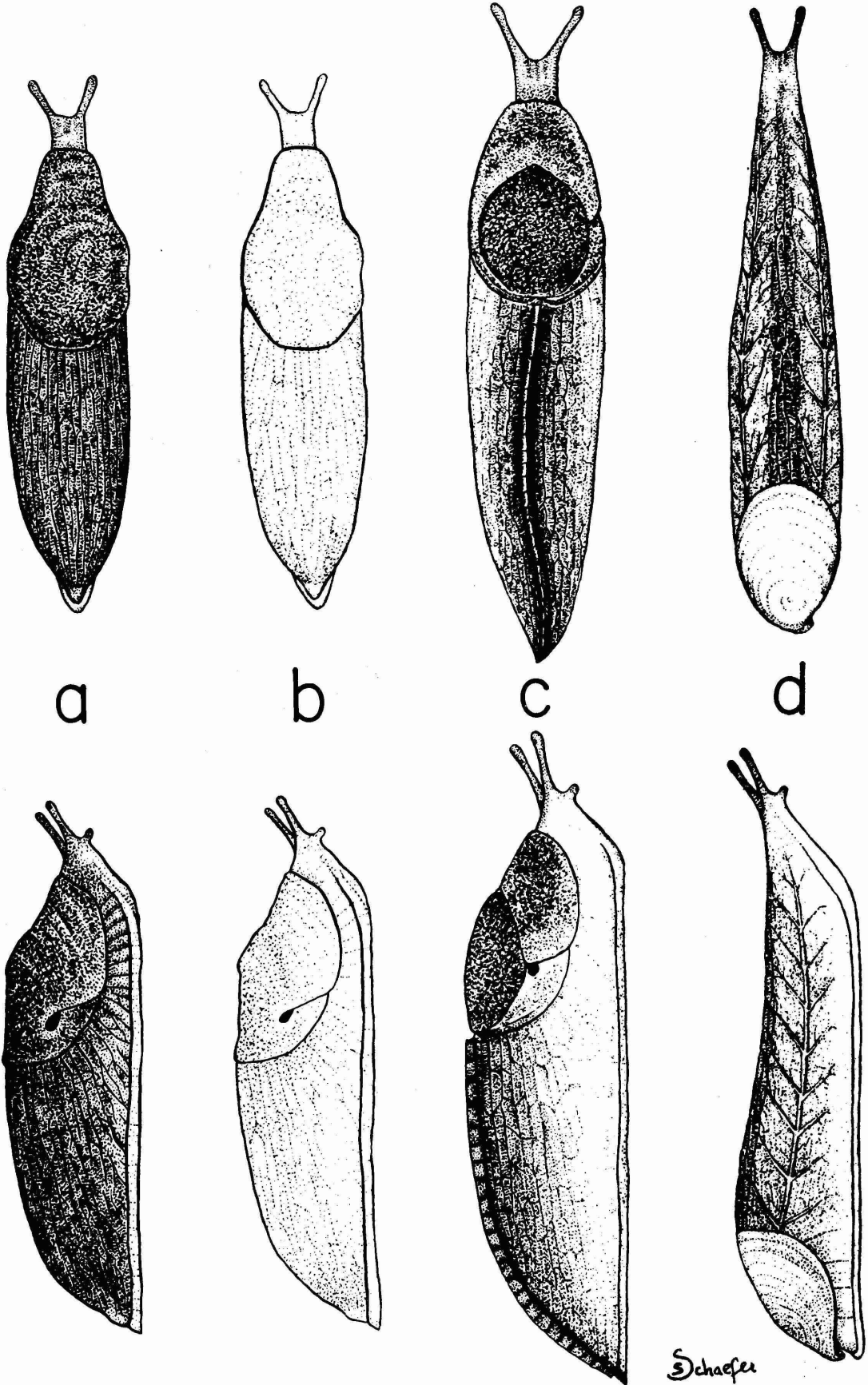
A native of Europe and North Africa, it has been introduced into Australia, North and South America, New Zealand, and South Africa.

Milax gagates (Draparnaud, 1801)

Limax gagates Draparnaud, 1801, Tabl. Moll. France, p. 100.

EXPLANATION OF FIGURE 8 (OPPOSITE PAGE)

FIG. 8. Lateral and dorsal views of a, b *Deroceras laeve* (X 2 2/3); c, *Milax gagates* (X 1 2/3); d, *Testacella haliotideae* (X 1).



Schaefer

Milax gagates Drap.; Lovell and Black, 1920, Oregon Agric. Coll. Exper. Sta. Bull. 170, p. 37.

Two separate species, *M. gagates* and *M. cf. insularis* have been confused under the name *M. gagates* (Quick, 1960). It is possible that some references to *M. gagates* in North America may be erroneous. The atrial stimulator is abundantly papillated in *M. cf. insularis* and sparsely papillated or without papillae in *M. gagates* (Quick, 1960). The description below applies to *M. gagates*.

Description

External. A medium sized slug; the extended length is about 50 mm. The dorsal keel and horseshoe-shaped mantle groove are very distinct. The body surface appears smooth because the tubercles are flat. The animal is gray to black. The dorsal keel is usually darker than the back which in turn is usually darker than the sides. The foot sole is pale gray and distinctly tripartite. The slime is clear. Fig. 8c.

Internal. The atrial stimulator bears either a few small papillae distally or none at all. (See Quick, 1960, Fig. 8, page 152).

Eggs. The eggs are transparent, oval and 2 X 1.5 mm (Taylor, 1907).

Biology

M. gagates is so rare in northeastern North America that it is not possible to say much about its biology in our region. All records for the northeast are from greenhouses, parks, or private dwellings. *M. gagates* in Europe is a slug of gardens, 'wild places,' and cliffs; it is more common along seacoasts than inland regions (Quick 1960). Because of its subterranean habits it can be a pest of root crops. It apparently breeds throughout much of the year.

During mating the animal uses its atrial stimulator to stroke the body of its partner. Apparently mating is a lengthy process (Karlin and Bacon, 1961).

Distribution

A native of Europe, it occurs throughout most of the British Isles and northwestern Europe. The closely related form *M. cf. insularis* occurs in the Mediterranean region. *M. gagates* has been introduced into Australia, New Zealand, Tas-

mania, Polynesia, South Africa and North America; it is not certain how many of these records actually refer to *M. cf. insularis*, however. In North America *M. gagates* has been recorded from the West Coast and Hawaii, Colorado, Idaho, Pennsylvania, Virginia, and Nova Scotia.

SUPERFAMILY OLEACINACEA

Family Testacellidae Gray, 1833

Description

Slug-like animals in which an abalone-shaped vestige of the shell is located externally on the posterior end. The shell covers the pallial organs. The body wall is scored by longitudinal, lateral grooves which give off upper and lower transverse branches which, in turn, ramify into finer grooves. A jaw is absent. They are subterranean forms which feed on earthworms and slugs. *Testacella* is the only genus in the family.

Distribution

Native to Europe and adjacent North Africa; the family has been introduced into South Africa and North America.

Genus *Testacella* Cuvier, 1800

Testacella Cuvier, 1800, Leçons d'anatomie comparée, 1.

Characteristics are the same as those for the family. Only one representative species in the genus will be described. Although occasionally found in greenhouses in other regions of North America, none has been recorded from Connecticut.

Testacella haliotideae Draparnaud, 1801

Testacella haliotideae Draparnaud, 1801, Tabl. Moll. France p. 99.

Description

A large slug; the extended length may reach 120 mm; the shell is 7 X 5 mm. The color is grayish yellow. The presence of a penial flagellum separates this species from *T. maugei* which is the only other species known to have been introduced into North America. Fig. 8d.

Biology

T. haliotideae spends much of its exist-

ence burrowing underground, although individuals may be found crawling on the soil surface at night. It feeds mainly upon earthworms and slugs. The species is most frequently encountered in cultivated areas. The white, ellipsoidal eggs are deposited in the soil. The egg dimensions, given by Quick (1960), are 7 X 4 mm.

Distribution

Native to the British Isles, Europe, and adjacent North Africa; it has been introduced into North America and Cuba. In North America it has been recorded from greenhouses in Tennessee, Philadelphia, Illinois, and California.

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