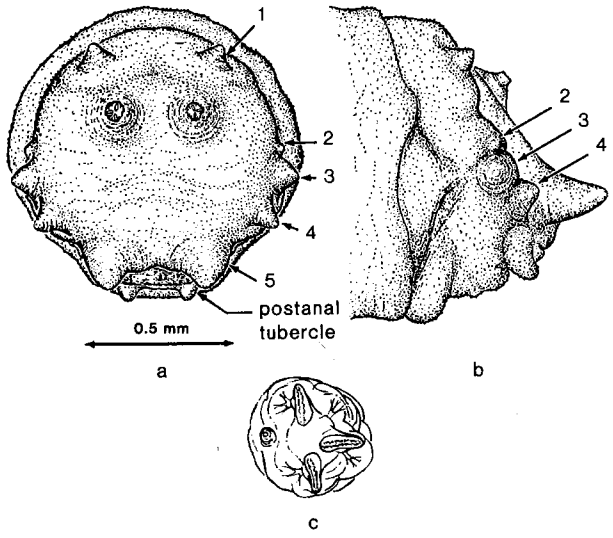

Figure 37.312

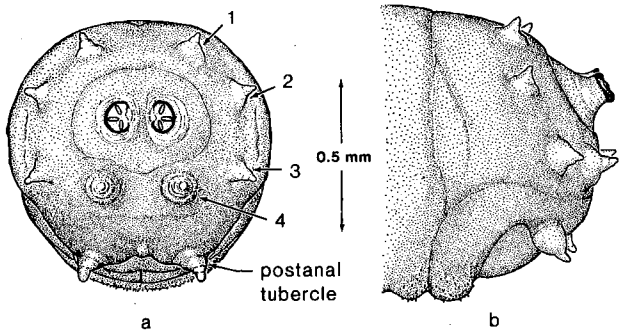

Figure 37.313

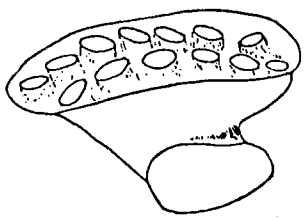

Figure 37.314

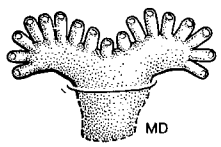

Figure 37.315

Figure 37.312a-c. Scathophagidae. *Gimnomera incisurata* Malloch. **a.** posterior of caudal segment, Nos. 1-5 are tubercles; **b.** lateral of caudal segment; **c.** posteriot spiracular plate. Larvae feed on the flower parts of beard-tongue, *Penstemon* spp. (Scrophulariaceae) (from Neff 1968).

Figure 37.313a,b. Scathophagidae. *Neochirosia atrifrons* (Coquillett). **a.** posterior of caudal segment, Nos. 1-4 are tubercles; **b.** lateral of caudal segment. Larvae form blotch mines in the leaves of *Veratrum viride* (Liliaceae) (from Neff 1970).

Figure 37.314. Scathopagidae. *Hydromyza confluens* Loew. Anterior spiracle. Larvae feed on petioles and floating leaves of yellow waterlily, *Nymphaea americana* (from Hickman 1935).

Figure 37.315. Scathophagigae. *Scathophaga stercoraria* (L.). Anterior spiracle. Larvae are frequently abundant in cattle droppings (from Manual of Nearctic Diptera, Vol. 1).

ANTHOMYIIDAE (MUSCOIDEA)

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The Anthomyiids

Figures 37.316-37.319 and Delia *Key figs. A-P*

Relationships and Diagnosis: This family is closely related to the Scathophagidae and Muscidae. Information may be found in the literature under both Anthomyiidae and Muscidae. Currently, Anthomyiidae is considered to be a separate family in the Muscoidea by McAlpine, *et al.* (1981). Huckett (1987) has recently summarized our knowledge, and Griffiths (1982–86) is revising the family.

At the present time, there are no characters known that will separate all larvae of Anthomyiidae from the related family Scathophagidae or from several more distantly related families. The larvae show a great deal of structural variation, but, in general, they are conic-cylindrical (peg-shaped) with fan-like anterior spiracles and with marginal tubercles on the posterior spiracular disc. Rearing to adults is suggested for accurate identification, especially of non-pest species.

Biology and Ecology: Anthomyiid larvae have diverse feeding habits as a group and frequently within a single species. Larvae may be saprophagous, coprophagous, phytophagous, or predacious. Larval behavior and host associations can be very important supplementary information in their identification. Most economically important *Delia* species (the root maggots) attack a much greater diversity of plant species than the common name indicates.

Many of the important species feed on the roots of cruciferous plants and other vegetables. *Delia floralis* (Fallén) (=*crucifera*), the turnip maggot, and *D. plannipalpis* (Stein) appear to be exclusively root feeders, the former feeding on turnip, cabbage, and cauliflower while the latter also feeds on radishes (Brooks 1951). *D. radicum* (L.), the cabbage maggot, usually feeds on the roots of cabbage, turnip, radish, and cauliflower, but may also feed in the growing point of turnip and cauliflower before the head is formed, in the inflorescence of cauliflower, and in the midrib and larger leaf veins of cabbage and its relatives (K. M. Smith 1927). *D. florilega* (Zetterstedt) (=*trichodactyla*) and *D. platura* (Meigen) (=*cilicrura*), the seedcorn maggot (which is only an occasional problem on seedling corn and other large seeds), feed on the roots of such cruciferous plants as turnip, Brussels sprouts, and cabbage that have already been damaged by other Diptera larvae, but they may also attack the cotyledons and shoots of beans, peas and other vegetables (Brooks 1951; Miles 1950). *Delia antiqua* (Meigen), the onion maggot, is an important pest of onions; larvae may be found feeding in the bulbs of young onions, in maturing bulbs, and on bulbs in storage. Damaged and decomposing onions are particularly attractive. *Delia echinata* (Séguy) is a spinach midrib and stem miner (Miles 1953). *Delia brunnescens* (Zetterstedt), the carnation maggot, and *D. cardui* (Meigen) are miners in

stems and shoots of carnations (Séguy 1932). *D. coarctata* (Fallén) attacks the stems of wheat, rye, barley and other grasses (Keilin 1917a), and is now established in northeastern North America (McAlpine and Slight 1981). *Botanophila fugax* (Meigen) also feeds on roots of plants such as turnip and Brussels sprouts that have been previously damaged by other larvae (Brooks 1951).

The important genus *Pegomya* has been subdivided in recent years. Griffiths (1982, following Hennig 1973) divided *Pegomya* into two subgenera, with the subgenus *Pegomya* consisting of just leaf miners. The larvae of these can be easily distinguished by the numerous (at least 3) teeth on the mouthhooks (fig. 37.318a). The subgenus *Pegomya* was further divided into four sections: 1) the *bicolor* section which are miners on Centrospermae and Polygonaceae; 2) the *hyoscyami* section with the *hyoscyami* subsection on Caryophyllaceae, Chaenopodiaceae, Solanaceae, Polemoniaceae and *Lupinus* (Fabaceae), including the *hyoscyami* superspecies (the beet and spinach leaf miners) which form blotch mines in leaves of spinach and a wide variety of other plants (Cameron 1914; Frost 1924; Michelson 1980), and the *genupuncta* subsection on Asteraceae; 3) the *minuta* section with host data for one species only (*cognata* Stein on *Salicornia*); and 4) the *dorsimaculata* section with host data for only one species (*wygodzinskyi* Alburquerque on *Amaranthus*). The other subgenus, *Phoraea,* is also divided into four sections: 1) the *rubivora* section which are mainly stemborers on Rosaceae and *Equisetum;* 2) the *geniculata* and 3) the *flavoscutella* sections which feed on mushrooms (Wallace 1971); and 4) the *holmgreni* section for which no life-history data is available.

One genus, *Chirosia,* is specialized to feed only on ferns (Pterophyta; Aderkas and Peterson 1987). *Egle muscaria* (F.) and *E. parva* (Robineau-Desvoidy) larvae are noted as feeding on willow catkins (Gäbler 1933; Séguy 1923b). *Strobilomya anthracina* (Czerny) larvae tunnel in the rachis of the cones of spruce trees (Tripp 1954; Kangas and Leskinen 1944; Michelson 1988).

Many anthomyiids are coprophagous (*Emmesomyia, Hylemyia, Pegoplata, Calythea, Adia, Paregle*) and some specialize on fecal material in burrows or nests of rodents (*Eutrichota*) or gopher tortoises (*Eutrichota gopheri* Johnson). *Paregle audacula* (Harris) has been reared from horse dung (Hewitt 1907) as well as dog and human dung (Coffey, 1966). *Adia cinerella* (Fallén) has been reared from swine, cow, horse and sheep dung (Coffey, 1966). *Hylemya alcathoe* (Walker) and *Calythea micropteryx* (Thomas) larvae feed in cow dung (Coffey 1966; Merritt and Anderson 1977).

Among the other habitats of anthomyiid larvae, *Anthomyia pluvialis* (L.) and *A. procellaris* Rondani feed on decaying organic matter in bird nests (Keilin 1924a); *Lasiomma octoguttata* (Zetterstedt) has been reared from bird nests, skua pellets and dead snails (R. A. Beaver 1969); *Anthomyia confusana* Michelsen has been reared from dead snails (R. A. Beaver 1969). *Fucellia costalis* Stein and *F. rufitibia* Stein feed in wrack on ocean beaches (Kompfner, 1974); larvae of *Acridomyia* are parasitoids on grasshoppers (Acrididae); and larvae of *Leucophora* and *Eustalomyia* are known to live as inquilines or parasitoids in the nests of solitary bees and wasps (Huckett 1965c).

Description: Larvae of anthomyiids are usually white to off-white, occasionally yellow. Mature larvae 4–12 mm in length, most ranging from 7–9 mm. Most larvae peg-shaped, tapering anteriorly and bluntly rounded posteriorly, but some more cylindrical. Mature larvae amphipneustic.

Head: Cephalic segment retractile and bearing well-developed sensory organs anteriorly and anteroventrally. Antennae appearing 2-segmented, often with basal sclerotization.

Cephalopharyngeal skeleton usually deeply pigmented; tentoropharyngeal and hypopharyngeal sclerites separate or fused (many phytophagous species); dorsal cornua usually narrower than ventral cornua and commonly with narrow, elongate window posteriorly; connected anteriorly by fenestrated dorsal bridge; ventral cornua broader, with dorsobasal lobe and small to large window posteriorly; pharyngeal filter present in saprophagous species, reduced or absent in many phytophagous and predacious species; hypopharyngeal sclerite basically H-shaped; parastomal bars frequently absent; epipharyngeal sclerite absent; labial sclerite commonly narrow and rod-like or absent. Mandibles deeply pigmented and heavy, hook weakly decurved and with one or more accessory teeth, base subrectangular, with posteroventral projection and with or without small window; dental sclerites frequently absent, or if present, triangular in shape; apparently lacking accessory sclerites between mandibles.

Thorax and Abdomen: With or without encircling spinule bands, but usually with ventral creeping welts. Anterior spiracles arising posterolaterally on prothorax, usually fan-shaped and bearing 4–40 marginal papillae.

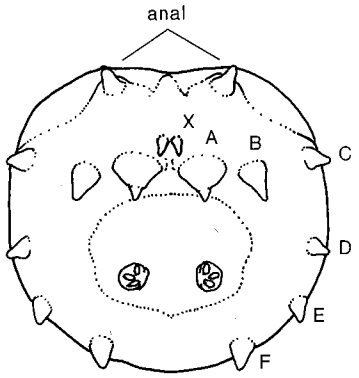
Posterior spiracular disc usually with 6–7 pairs of marginal tubercles and two postanal tubercles. Posterior spiracles very slightly to distinctly elevated on short tubes above the plane of the terminal segment. Spiracular plates with three oval to elongate spiracular slits that radiate from ecdysial scar (sometimes weak or absent). Peritremes weakly to deeply pigmented.

Comments: Twenty-three genera, with over 400 species, are recognized from America north of Mexico (Griffiths, *in litt.*). Larval descriptions are available for eight of these genera.

Several species are considered to be major agricultural pests. These include the spinach/beet leafminer, *Pegomya hyoscyami;* the onion maggot, *Delia antiqua;* the cabbage maggot, *D. radicum;* and the seedcorn maggot, *D. platura.* The common last instar *Delia* root maggots can be identified in the following key; a short synopsis of each species follows.

KEY TO THE COMMON LAST INSTAR *DELIA* ROOT MAGGOTS[1]

(Figure A is an inverted posterior view showing the tubercle relationships and names.)



Posterior View
(inverted)
Figure A

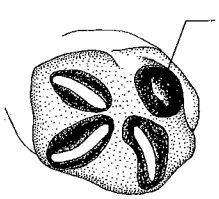
1. Assorted other maggots belonging to different families and genera may also be found, but usually not abundantly (*see* Brooks 1951 for a few of them). Drawings C, E, K, N, O redrawn from Brooks (1949 and 1951) by Peter Carrington.

1. Posterior spiracular plate with a distinct ecdysial scar (fig. B); window in dorsal cornu of tentoropharyngeal sclerite long, reaching almost to base (fig. C) 4

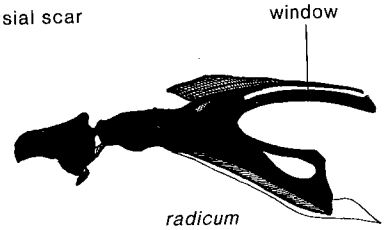
1'. Posterior spiracular plate without a distinct ecdysial scar (fig. D); window in dorsal cornu of tentoropharyngeal sclerite short, extending about to middle (fig. E) 2

2. Anterior spiracle with 6–8 papillae (fig. F) 3

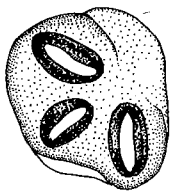
2'. Anterior spiracle with 10–14 papillae (fig. G); tubercles A and B contiguous basally, but widely separated apically (figs. H, I and J) ..... (most) (onion maggot) *antiqua*



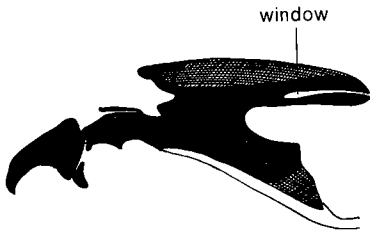
Left
radicum
Figure B



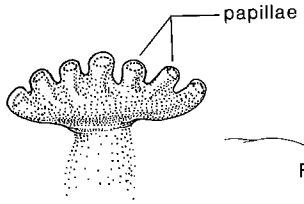
radicum
Figure C



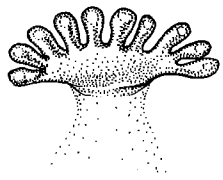
Left
antiqua
Figure D



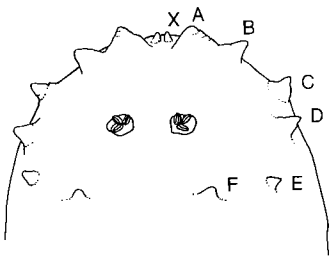
antiqua
Figure E



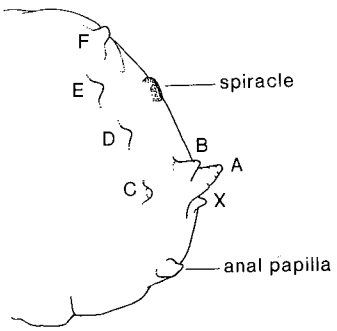
platura
Figure F



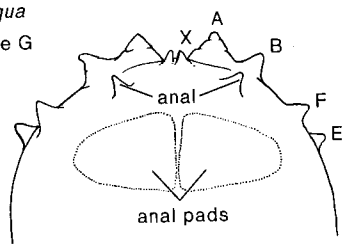
antiqua
Figure G



antiqua
Dorso-posterior view
Figure H



antiqua
lateral view
Figure I



antiqua
Ventral view
Figure J

3. Tubercles A and B long, contiguous basally, with A distinctly broader than B (fig. K) ..... *florilega*

3′. Tubercles A and B short, separate basally, subequal in breadth (fig. L) ..... (seedcorn maggot) *platura*

4. Tubercles A and B not equal, widely separated, with A notched apically (figs. M, P) *5*

4′. Tubercles A and B subequal, contiguous basally; tubercle A simple apically (not notched); tubercles X present, **the bases arising nearly in line with the bases of A and B (figs. N and O)** (*see* third choice) ..... ("turnip maggot") *floralis*

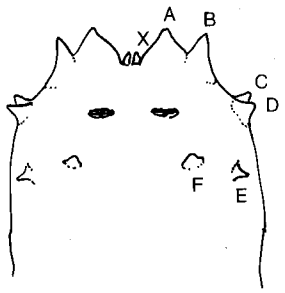
4″. Tubercles A and B subequal, contiguous basally; tubercle A simple apically (not notched); tubercles X present, **the bases clearly arising more ventrally than the bases of A and B (figs. H and J)** ..... (some onion maggot larvae with a faint ecdysial scar) *antiqua*

5. Tubercle A with a shallow apical notch (fig. P) ..... ("wheat bulb maggot") *coarctata*

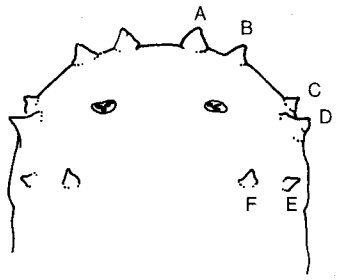
5′. Tubercle A with a deeper apical notch (fig. M) 6

6. Tubercle A distinctly separated to the base ..... ("western cabbage maggot") *planipalpis*

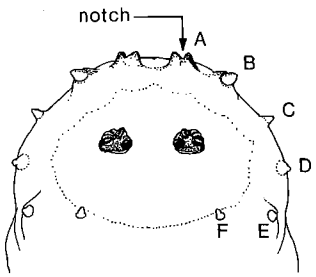
6′. Tubercle A not distinctly separated to the base (fig. M) ..... (cabbage maggot) *radicum*



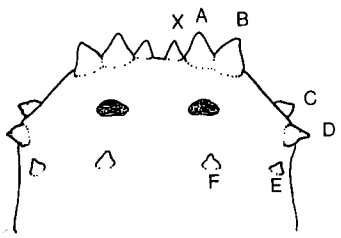
florilega
Dorso-posterior view
Figure K



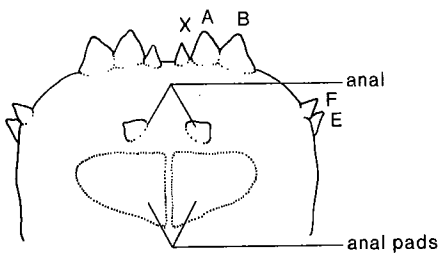
platura
Dorso-posterior view
Figure L



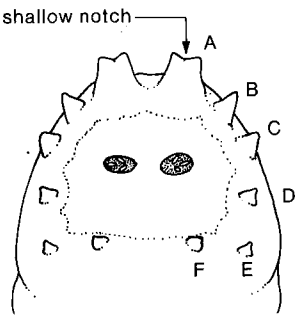
radicum
Dorso-posterior view
Figure M



floralis
Dorso-posterior view
Figure N



floralis
Ventral view
Figure O



coarctata
Dorso-posterior view
Figure P

***Delia antiqua* (Meigen), the onion maggot:** (figs. D, E, G–J). Believed to be native to northern Eurasia, the onion maggot ranges throughout the northern United States and southern Canada, where it is a major pest of onions in much of this area. It attacks the roots and bulbs of onions, occasionally infests leeks and shallots, but populations are not sustained on garlic. There are commonly three generations per year, with the first one being the most damaging because of reduction or loss of stand. Numerous natural enemies are known, but they are uncommon in commercial fields where insecticide treatments prevail.

***Delia platura* (Meigen), the seedcorn maggot** (figs. F, L). Believed to be native to the Holarctic region, the seedcorn maggot is nearly cosmopolitan, and occurs throughout much of the United States and southern Canada. It commonly attacks germinating seeds and feeds on other organic matter in soils, being most commonly a problem in high organic content soils (including those containing manure and plowed down cover crops). It attacks a wide variety of larger seeds, especially beans, peas, corn, cucumbers and other cucurbits. It is especially attracted to microbially-colonized seeds and can attack young seedlings, resulting in stand loss and reduced seedling vigor. The number of generations varies from two to many overlapping generations per year.

***Delia florilega* (Zetterstedt)** (fig. K). Holarctic in distribution like *D. platura*, and possibly of Eurasian origin, this species is similar to the seedcorn maggot in being a secondary invader that is primarily attracted by high organic matter or microbial growth. It is found from Alaska to eastern Canada,

south to New Mexico in the West and New York in the East. The maggots attack a variety of larger seeds of the same crops as *D. platura.*

***Delia radicum* (L.), the cabbage maggot** (figs. B, C, M, 37.319a–d). Also believed to be native to northern Eurasia, the cabbage maggot has a distribution similar to that of the onion maggot across the northern United States and southern Canada, where it can cause significant injury to crucifers. This includes damage to the edible roots of radish, horseradish, turnip, and rutabaga, and reduced vigor, yield or stand loss to crops such as cabbage, broccoli, Brussels sprouts, cauliflower, Chinese cabbage and kale. Numerous wild mustards and relatives are also believed to be hosts, possibly providing the reservoir of non-resistant flies, since resistance to insecticides is not known in this species to date. There are commonly three generations per year, and an array of natural enemies similar to those of the onion maggot is known from insecticide-free areas.

***Delia planipalpis* (Stein), the "western cabbage maggot".** Native to western North America, this Holarctic species currently is found from the northern Great Plains westward in America and in mountainous regions as far south as California and Colorado. It attacks radish and all of the *Brassica* varieties (cabbage, cauliflower, etc.) but is of minor importance compared with the cabbage maggot, *D. radicum* (L.). It has one generation in the north and two or more farther south.

***Delia floralis* (Fallén), the turnip maggot** (figs. N, O). Native to Eurasia, the turnip maggot has a more northern distribution than the cabbage maggot, *D. radicum,* and the "western cabbage maggot," *D. planipalpis,* and has not been recorded from the lower 48 states, although its hosts are similar. It is the most important pest of these crops from Alaska across the Canadian Prairie Provinces. There is a single generation per year in North America, but more than one generation is known from parts of Europe.

***Delia coarctata* (Fallén), the "wheat bulb maggot"** (fig. P). Native to northern Eurasia, where it is a serious pest of winter wheat, the wheat bulb fly is known from Quebec, the Maritime Provinces, and Maine (McAlpine and Slight 1981). The chief wild host in North America is couch grass, *Agropyron repens* (L.), but to date it has not been reported as attacking commercial grains here. In Europe the maggots attack the roots of fall-sown grains in the spring, notably winter wheat, barley and rye, after hatching from the overwintering eggs. In contrast to our other agriculturally important species of *Delia,* there is only a single generation per year.

It should be noted, especially in the economically important species, that the species names and genera used by authors have not been very stable. For this reason, it is suggested that literature searches on these species be conducted with many combinations of species names, subgenera and genera. For example, Brooks (1951) provided a key for mature larvae of Diptera attacking the roots of cruciferous plants. In this book three of the five species names of *Delia* he used are now considered synonyms. The currently valid names for six common *Delia* species covered by Brooks in 1949 and 1951 follow:

Current Valid Name	*Brooks 1949*	*Brooks 1951*
antiqua (Meigen)	*antiqua* (Meigen)	*antiqua* (Meigen)
floralis (Fallén)	*crucifera* (Huckett)	*crucifera* (Huckett)
florilega (Zetterstedt)	*floralis* (Fallén)	*trichodactyla* (Rondani)
planipalpis (Stein)	*planipalpis* (Stein)	*planipalpis* (Stein)
platura (Meigen)	*cana* (Macquart)	*cilicrura* (Rondani)
radicum (Linnaeus)	*brassicae* (Bouché)	*brassicae* (Bouché)

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MUSCIDAE (MUSCOIDEA)

Gregory A. Dahlem, *Michigan State University*

The Muscids

Figures 37.320–37.328

Relationships and Diagnosis: Muscids are closely related to the Anthomyiidae. Until the 1960s, the name "Anthomyiidae" was commonly used to encompass the entire Muscoidea, as currently delineated. The classification has changed and the name "Muscidae" has been adopted for part of this broad group of flies. Consequently, information may be found in the literature under both family names. At the present time, Muscidae is a separate family in the Muscoidea, along with Anthomyiidae and Scatophagidae (McAlpine *et al.* 1981). Huckett and Vockeroth (1987) have recently summarized our knowledge.

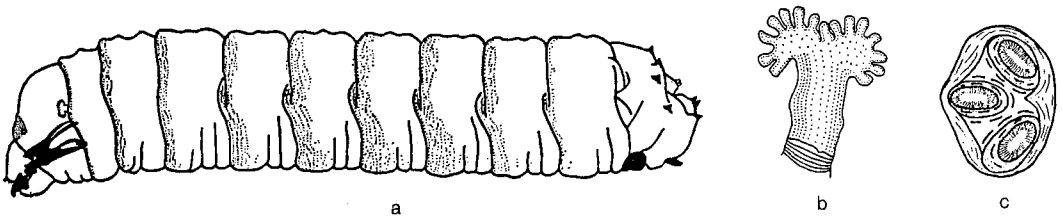

Figure 37.316

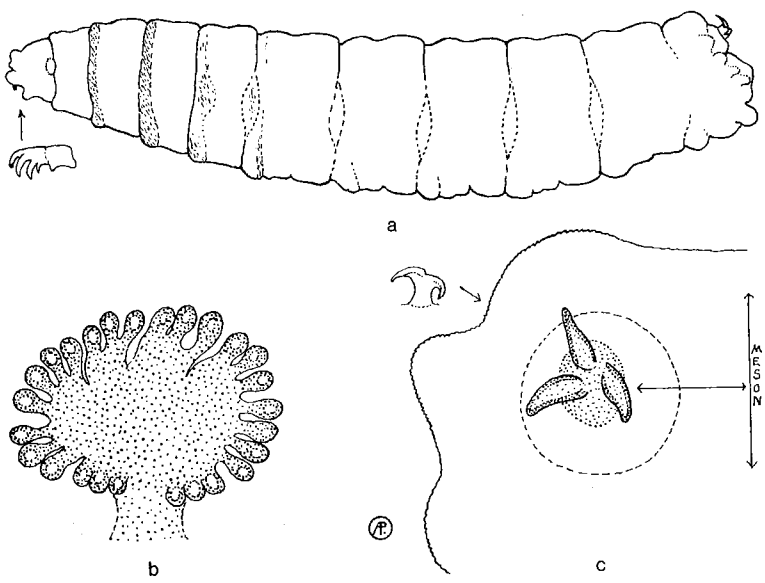

Figure 37.317

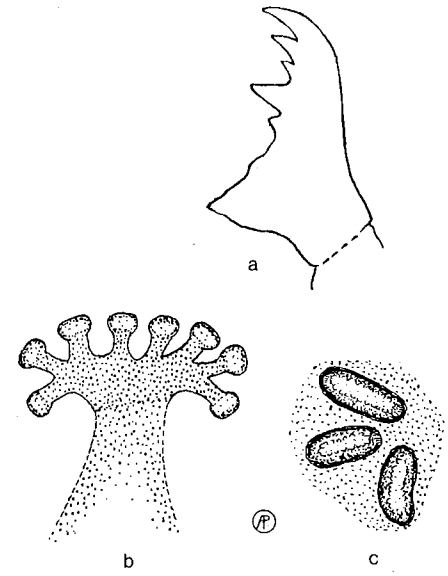

Figure 37.318

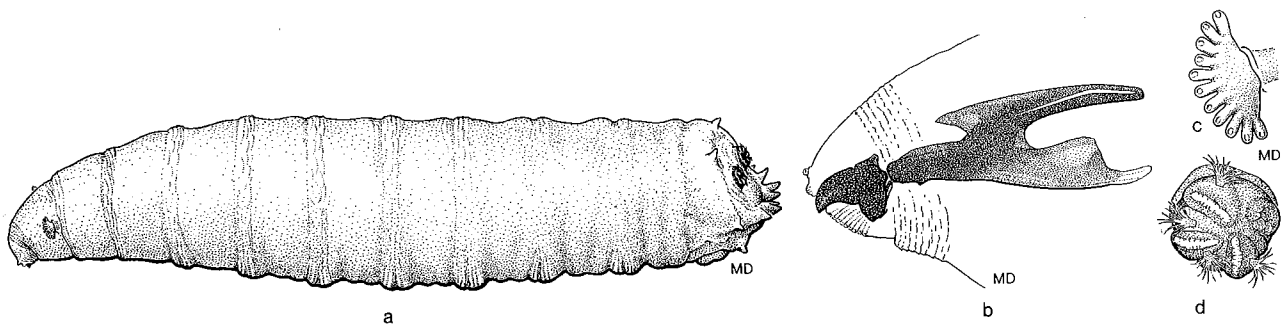

Figure 37.319

Figure 37.316a-c. Anthomyiidae. *Strobilomya anthracina* Czerny. **a.** third instar larva; **b.** anterior spiracle; **c.** posterior spiracle. Larvae tunnel in the new cones of white spruce, *Picea glauca*, in May and June, destroying the seeds (from Tripp 1954).

Figure 37.317a-c. Anthomyiidae. *Pegomya* sp. **a.** third instar larva; **b.** anterior spiracle; **c.** elevated posterior spiracle, with curved projections bearing spiracular slits. Larvae are leafminers in pale dock, *Rumex altissimus* (from Peterson 1951).

Figure 37.318a-c. Anthomyiidae. *Pegomya hyoscyami* (Panzer), the spinach/beet leafminer. **a.** mandible; **b.** anterior spiracle; **c.** posterior spiracle, which is relatively small and slightly elevated. Larvae are miners in the leaves of spinach, beets, Swiss chard, sugar beets and assorted weeds (from Peterson 1951).

Figure 37.319a-d. Anthomyiidae. *Delia radicum* (L.), the cabbage maggot. **a.** mature larva; **b.** lateral view of cephalopharyngeal skeleton; **c.** anterior spiracle; **d.** posterior spiracle. The cabbage maggot is a pest of roots of many Brassicaceae, especially cabbage and related varieties (from Manual of Nearctic Diptera, Vol. 1).