

month and by September are second-stage larvae, causing damage to grass roots before descending to lower levels to overwinter.

Second-stage larvae migrate to near the surface early during the second spring and after feeding become third-stage larvae. Underground feeding damage is greatest during July into September as third-stage larvae feed on roots of turfgrass or cultivated crops. They overwinter the second year in this stage.

During spring of the third year third-stage larvae migrate to near the soil surface to complete their feeding, pupate during July and August, become adults in September, and without emerging, overwinter as adults to complete their 3-year life cycle.

Collection

Adults of many species are attracted to light and hence are easily collected in light traps. This is primarily true of the more agriculturally important species whose larva are injurious to underground stems and grass roots. Woodruff (1973) indicates that blacklight (actually ultraviolet light) is much more attractive to beetles than is visible light. The advent of blacklight traps has resulted in more species and specimens collected and records obtained than all other methods combined. The less effective methods he refers to include searching for food of saprophagous groups or trapping by sinking cans or jars to ground level and baiting with such materials as propionic or butyric acid, amyl acetate, and fermenting malt, molasses, and yeast. Others, including the Japanese beetle, Oriental beetle, and rose chafer, feed diurnally on their favorite host plants and can readily be picked off.

On the other hand, larvae are more difficult to collect in quantity since most are concealed in or under dung, carrion, decaying vegetable matter, wood, or in the soil and must be dug out in most cases. The phytophagous species of greatest importance as pests of grasses are rather easily collected during spring or fall when they are feeding on grass roots near the soil surface. When populations of 10–20 or more third-stage larvae per 0.1 m² are present, the sod may easily be peeled back, revealing countless numbers of larvae. Collected larvae should be held in a large volume of soil or medium of their habitat, or isolated one to a container with their habitat medium to prevent cannibalism.

Larvae of root feeding species are rather easily reared to adults by placing them in moist soil containing grass seed and holding for pupation and eclosion.

Scarabaeid larvae are best preserved by killing in near-boiling water and placing in 70% ethyl alcohol as practiced by Ritcher (1966) or 70% isopropyl alcohol as practiced by Woodruff (1973).

Identification

Taxonomic literature on Scarabaeidae is much more abundant for adults than for larvae. Therefore, larval identification may require rearing individuals to adults. Blatchley (1910) has the most complete description of adults of the family as a whole. Borror and DeLong (1970) have an adult key to subfamilies based on more recently accepted divisions. Woodruff's (1973) publication on the scarab beetles of Florida should not be overlooked in the study of six saprophagous subfamilies. His illustrations, "Stereoscan" (scanning electron microscopy) photos, and distribution maps, not only for Florida but the entire United States, adds much to his descriptions. Lugenbill and Painter's (1953) keys to May (or June) beetle adults are the most complete for this important genus.

Identification of Larvae to Subfamilies

For the most complete taxonomic work on the larvae of Scarabaeidae, one must turn to Ritcher (1966), whose work is the most comprehensive and recent. Ritcher's (1966) key to the subfamilies of Scarabaeidae based on characters of the third (ultimate) stage larvae is given with modifications. Figures 40.9–40.62 have been consolidated from Ritcher's (1966) plates. Use of his keys are recommended for larval identifications beyond the subfamily level.

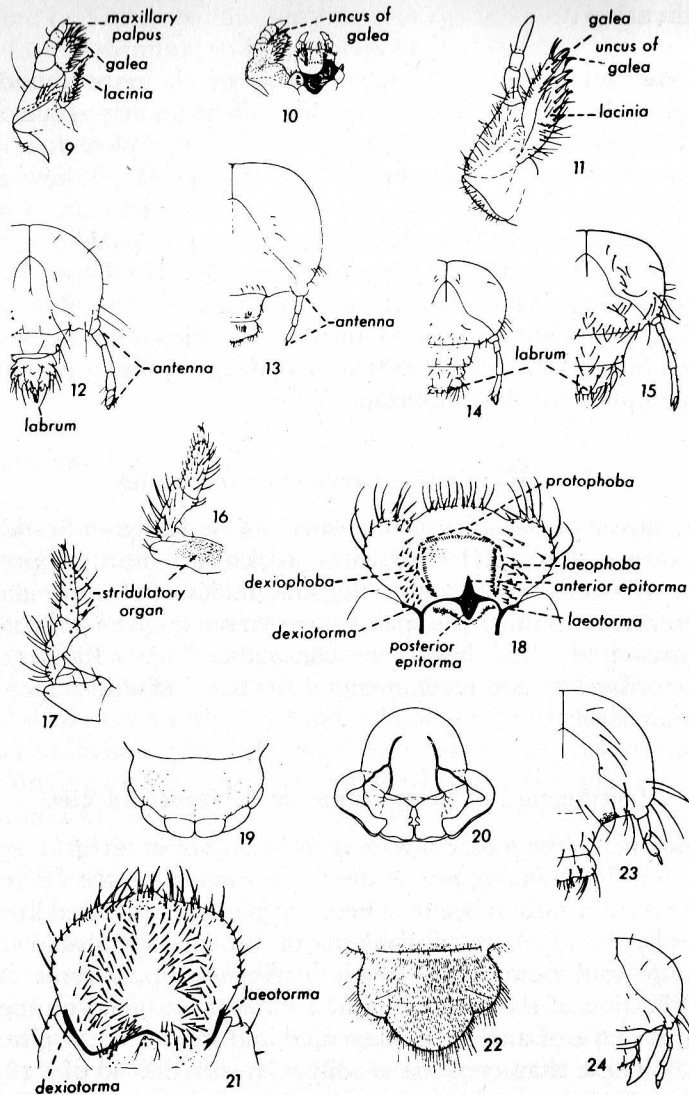
Identification of Most Common Turfgrass Species

In the northeast, the most commonly found larvae in turfgrass are introduced species: the Japanese beetle, the European chafer, the Oriental beetle, and the Asiatic garden beetle. These are generally followed in order of abundance by the northern masked chafer, a native scarabaeid with a 1-year life cycle, and various June beetle, *Phyllophaga* spp., larvae. A key to field identification of these species and a *Phyllophaga* based on the rastral patterns and shape of anal slit is presented and supported by illustrations (Fig. 40.63). These characters are readily seen with the aid of a 10× hand lens.

KEY TO THE SUBFAMILIES OF SCARABAEID LARVAE†

- 1a Maxilla with galea and lacinia distinctly separated (Fig. 40.9) 2
- 1b Maxilla with galea and lacinia entirely fused (Fig. 40.10), or fused proximally but distally free, or (rarely) not fused but fitting tightly together (Fig. 40.11) 10

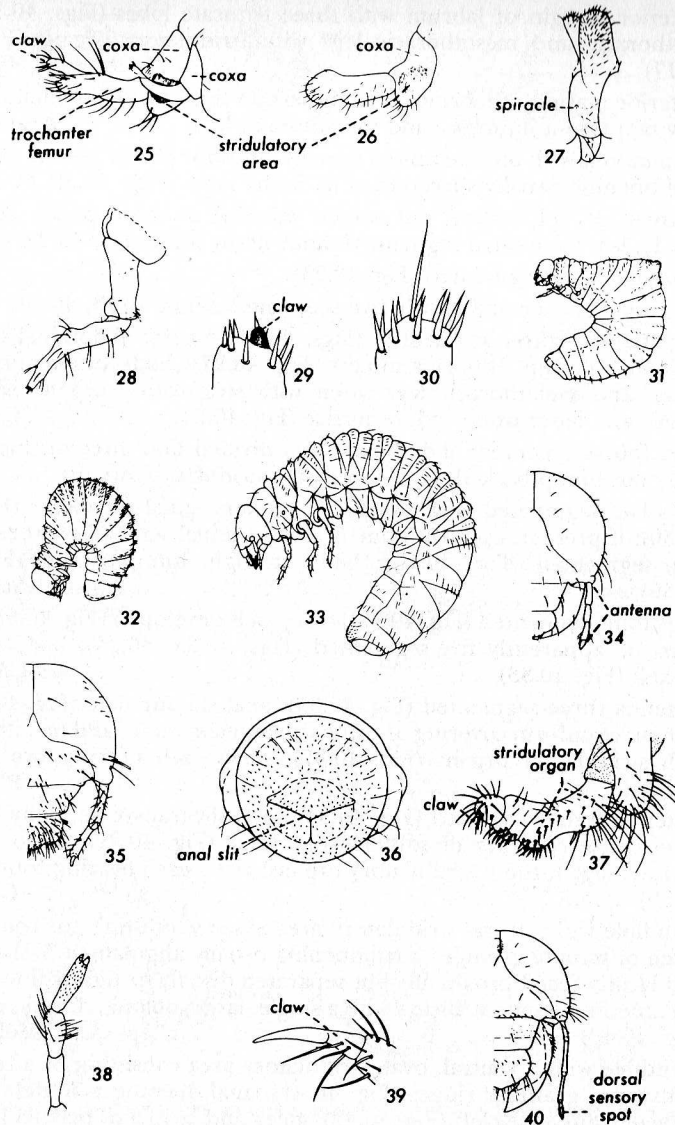
† Modified from Ritcher (1966).



Figs. 40.9–40.24. Supportive illustrations for key to mainly subfamilies Hybosorinae and Acanthocerinae of Scarabaeidae larvae. [After Ritcher (1966); courtesy of Oregon State University Press.]

- 2a Distal segment of antenna little, if any, reduced in diameter compared to the other antennal segments (Fig. 40.12) 3
- 2b Distal segment of antenna much reduced in size, often appearing as an appendage of the penultimate segment (Fig. 40.13) 5
- 3a Anterior margin of labrum trilobed or broadly rounded; without serrations or truncate lobes a few **Aphodiinae**
- 3b Anterior margin of labrum serrate or with truncate lobes (Figs. 40.12, 40.14)

- 4a Anterior margin of labrum with three truncate lobes (Figs. 40.14, 40.15); prothoracic and mesothoracic legs with stridulatory organs (Figs. 40.16, 40.17) **Hybosorinae**
- 4b Anterior margin of labrum strongly serrate (Fig. 40.12); stridulatory organs may be present on meso- and metathoracic legs **Acanthocerinae**
- 5a Epipharynx with tormae united mesally, anterior phoba present (Fig. 40.18); anal opening usually surrounded by fleshy lobes (Figs. 40.19, 40.20) . . . 6
- 5b Tormae of epipharynx not united mesally, anterior phoba absent (Fig. 40.21); last abdominal segment without fleshy lobes (Fig. 40.22) 9
- 6a Antenna three-segmented (Fig. 40.23) 7
- 6b Antenna four- or apparently five-segmented (Figs. 40.13, 40.24) 8
- 7a Legs two- or three-segmented (Figs. 40.25, 40.26); abdominal terga often divided into two distinct annulets (Fig. 40.27); body often hump-backed; meso- and metathoracic legs often with stridulatory organs (Figs. 40.25, 40.26) and latter often reduce in size (Fig. 40.25) **Geotrupinae**
- 7b Legs four-segmented; abdominal terga divided into three distinct annulets; body not hump-backed; legs never with stridulatory organs. **Troginae**
- 8a Legs two-segmented (Fig. 40.28); claws very small or absent (Figs. 40.29, 40.30); if present, each with one or two terminal setae (Fig. 40.29); antenna four-segmented (Fig. 40.13); body strongly hump-backed (Figs. 40.31, 40.32); **Scarabaeinae**
- 8b Legs four-segmented (Fig. 40.33); claws well-developed (Fig. 40.33); antenna four- or apparently five-segmented (Figs. 40.34, 40.24); body not hump-backed (Fig. 40.33) most **Aphodiinae**
- 9a Antenna three-segmented (Fig. 40.35); anal slit angulate (Fig. 40.36); body without a uniform covering of soft hairlike setae; meso- and metathoracic legs with stridulatory organs (Fig. 40.37); claws each bearing two setae (Fig. 40.37) **Pleocominae**
- 9b Antenna four-segmented (Fig. 40.38); anal slit transverse; body with a uniform dense covering of soft, hairlike setae (Fig. 40.22); meso- and metathoracic legs without stridulatory organs; claws each bearing four setae (Fig. 40.39) **Glaphyrinae**
- 10a Mandible with ventral stridulatory area absent, indistinct, or consisting of a patch of minute granules; anal opening usually angulate or Y-shaped; galea and lacinia fused proximally but separated distally or tightly fitted together; last antennal segment always with a single, large, oblong, dorsal, sensory spot (Fig. 40.40) **Melolonthinae**
- 10b Mandible with a ventral, oval, stridulatory area consisting of a few to many transverse, granular ridges (Fig. 40.41); anal opening a straight or slightly curved, transverse cleft (Fig. 40.42); galea and lacinia of maxilla fused forming a mala (Fig. 40.43); last antennal segment with one or more dorsal sensory spots (Figs. 40.44, 40.45) 11
- 11a Lacinia of maxilla with one or two well-developed terminal unci (Fig. 40.46) or uncus almost absent (Fig. 40.47); maxillary stridulatory teeth always with anteriorly projecting points, never truncate (Figs. 40.48, 40.49) 12
- 11b Lacinia of maxilla with three well-developed terminal unci (Fig. 40.50); maxillary stridulatory teeth truncate (Fig. 40.51) or with anteriorly projecting points (Fig. 40.52) 13
- 12a Labrum symmetrical, either entire (Fig. 40.53), bilobed (Fig. 40.54), or trilobed (Fig. 40.55); epizygon absent (Fig. 40.56); epipharynx always with a single nesium (sclerotized plate absent), plegmata absent (Fig. 40.56); hapto-



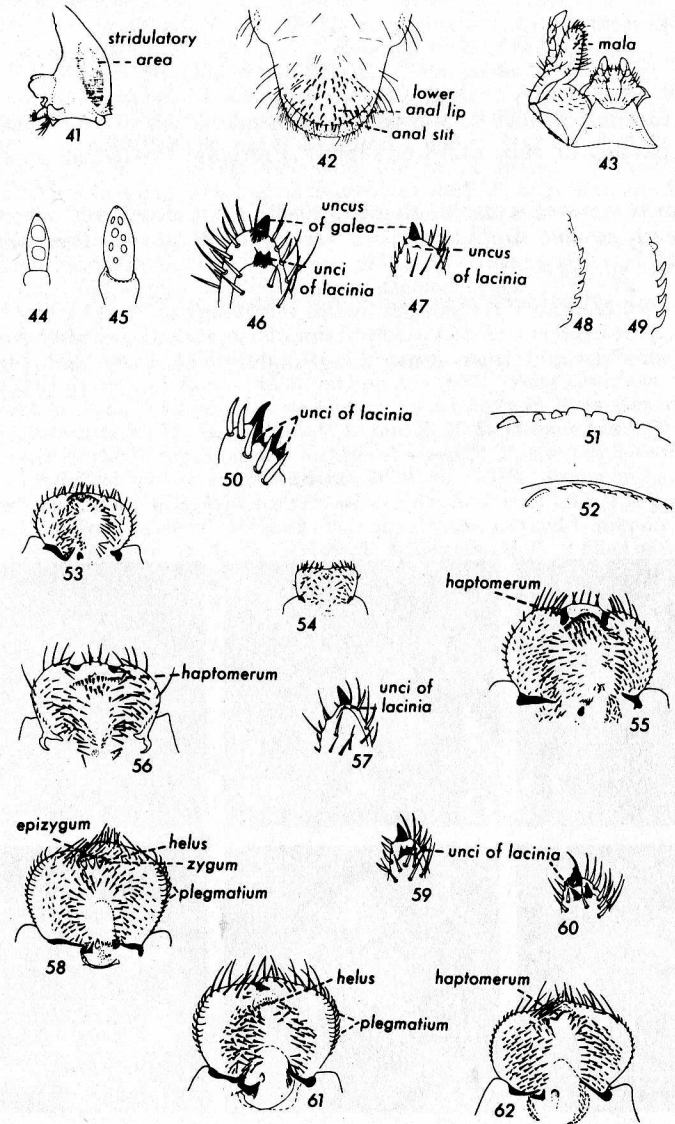
Figs. 40.25-40.40. Supportive illustrations for key to mainly subfamilies Geotrupinae, Troginae, Scarabaeinae, Aphodiinae, Pleocominae, Glaphyrinae, and Melolonthinae of Scarabaeidae larvae. [After Ritcher (1966); courtesy of Oregon State University Press.]

merum often with a conspicuous, transverse, curved row of stout setae (Figs. 40.55, 40.56) which may or may not be interrupted by a median process (Fig. 40.53); if the lacinia has two terminal unci, the two unequal in size (Fig. 40.57) **Cetoniinae**

12b Labrum usually asymmetrical; epizygum usually present (Fig. 40.58); epipharynx usually with two nesia and usually with plegmata (Fig. 40.58); haptomerum

never with a conspicuous, transverse, curved row of stout setae; if the lacinia has two terminal unci, the two are usually equal in size (Figs. 40.59, 40.60) (Tribes **ANOMALINI** and **RUTELINI**) **Rutelinae**

13a Plegmatia present (Fig. 40.61); haptomerum of epipharynx with a dense transverse row of six or nine heli (Fig. 40.61); maxillary stridulatory teeth never truncate (Tribe **ADORETINI**) **Rutelinae**



Figs. 40.41-40.62. Supportive illustrations for key to mainly subfamilies Cetoniinae, Rutelinae, and Dynastinae of Scarabaeidae larvae. [After Ritcher (1966); courtesy of Oregon State University Press.]

- 13b** Plegmatia absent (Fig. 40.62); haptomerum of epipharynx with a raised, bilobed or toothlike, or ridgelike process (Fig. 40.62); maxillary stridulatory teeth usually truncate (Fig. 40.51) **Dynastinae**

FIELD IDENTIFICATION OF MOST COMMON SUBTERRANEAN SCARABAEID LARVAE IN THE NORTHEAST U.S.

- 1a** Palida absent, teges scattered over lower anal lip and tenth segment
Northern masked chafer
- 1b** Palidia present **2**
- 2a** Anal slit transverse **3**
- 2b** Anal slit Y-shaped **4**
- 3a** Palidia forming distinct V; 5–8 pali on each side. *Japanese beetle*
- 3b** Palidia parallel to, subparallel or slightly diverging, 11–16 pali on each side
Oriental beetle
- 4a** Palidium transverse, crescent shaped, 20–27 stout closely set pali; maxillae with greatly swollen stipes. *Asiatic garden beetle*
- 4b** Palidia in two rows **5**
- 5a** Palidia two subparallel rows widening posteriorly; 14–22 pali each side
European chafer
- 5b** Palidia two parallel rows constricting slightly anteriorly and posteriorly
June beetle larvae

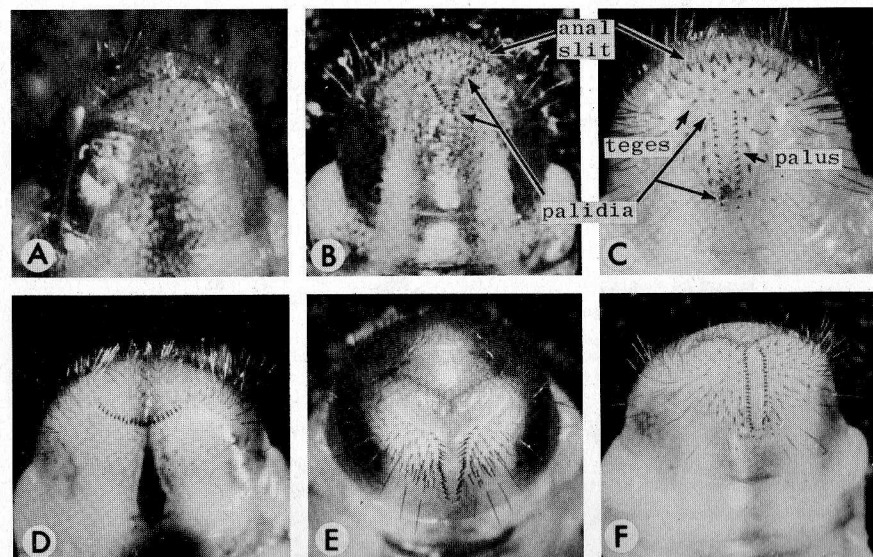


Fig. 40.63. Rastral patterns of commonly found turfgrass scarabaeid larvae in the northeast: (A) Northern masked chafer; (B) Japanese beetle; (C) Oriental beetle; (D) Asiatic garden beetle (anal slit invisible); (E) European chafer; (F) June beetle.

References

Blatchley, W. S. 1910. *An Illustrated Descriptive Catalog of the Coleoptera or Beetles (Exclusive of the Rhyncophora) Known to Occur in Indiana.* Nature Publishing Co., Indianapolis, Ind. 1386 pp.

Borror, D. J. and D. M. DeLong. 1970. *An Introduction to the Study of Insects*, 3rd ed. Holt, Rinehart and Winston, New York. 812 pp.

Böving, A. G. 1942. Description of the third-stage larva of *Amphimallon majalis* (Razoumowsky). *Proc. Entomol. Soc. Wash.* 44(6):111–121.

Butt, F. H. 1944. External morphology of *Amphimallon majalis* (Razoumowsky) (Coleoptera, the European chafer). *Cornell Univ. Agric. Exp. Stn. Mem.* 266. 18 pp., 13 plates.

Comstock, J. H. 1977. *An Introduction to Entomology*, 9th ed. Cornell University Press, Ithaca, N.Y. 1064 pp.

Fleming, W. E. 1972. Biology of the Japanese beetle. *U.S. Dept. Agric. Tech. Bull.* 1449. 129 pp.

Hammond, G. H. 1940. White grubs and their control in eastern Canada. *Dom. Canada Dept. Agric. Publ.* 668. 18 pp.

Hawley, I. M. 1944. Notes on the biology of the Japanese beetle. *U.S. Bur. Entomol. Plant Quar.* E-615. 19 pp.

Lugenbill, P., Sr. and H. R. Painter. 1953. May beetles of the United States and Canada. *U.S. Dept. Agric. Tech. Bull.* 1060. 102 pp., 78 plates.

Menees, J. H. 1957. Sex identification in some larvae of Scarabaeoidea. *Bull. Brooklyn Entomol. Soc.* 52(4):97–100.

1958. The anatomy and histology of the larval alimentary canal of the European chafer, *Amphimallon majalis* Razoumowsky (Scarabaeidae). *J. N.Y. Entomol. Soc.* 66:75–86.

Niemczyk, H. D. and G. S. Wegner. 1979. *Life History and Control of the Black Turfgrass Ataenius.* Ohio Report on Research and Development, pp. 85–88.

Peterson, A. 1951. *Larvae of Insects: An Introduction to Nearctic Species. II. Coleoptera, Diptera, Neuroptera, Siphonoptera, Mecoptera, Trichoptera.* Edwards Brothers, Ann Arbor, Mich. 416 pp.

Ritcher, P. O. 1958. Biology of Scarabaeidae. In: E. A. Steinhaus (ed.) *Annual Review of Entomology*, Vol. 3. Annual Reviews, Palo Alto, Calif. 520 pp.

1966. *White Grubs and Their Allies—A Study of North American Scarabaeoid Larvae.* Oregon State University Press, Corvallis, Oreg. 219 pp.

Splittstoesser, C. M., H. Tashiro, S. L. Lin, K. H. Steinkraus and B. J. Fiori. 1973. Histopathology of the European chafer *Amphimallon majalis*, infected with *Bacillus popilliae*. *J. Invertebr. Pathol.* 22:161–167.

Sutherland, D. W. S. 1978. Common names of insects and related organisms (1978 revision). *Entomol. Soc. Am. Spec. Publ.* 78-1. 132 pp.

Tashiro, H. 1987. *Turfgrass Insects of the United States and Canada.* Cornell University Press, Ithaca, N.Y. 391 pp.

Tashiro, H., G. G. Gyrisco, F. L. Grambrell, B. J. Fiori and H. Breitfeld. 1969. Biology of the European chafer *Amphimallon majalis* (Coleoptera: Scarabaeidae) in northeastern United States. *New York State Agric. Exp. Stn. Bull.* 828. 71 pp.

Woodruff, R. E. 1973. *Arthropods of Florida and Neighboring Land Areas.* Vol. 8. *The Scarab Beetles of Florida.* Florida Dept. Agric. Consumer Serv. Contrib. 260. 220 pp.