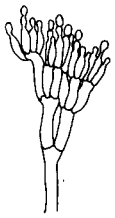
Soil Biology Guide



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Insecta: Coleoptera Scarabaeidae Larvae

HARUO TASHIRO

The family Scarabaeidae, referred to as scarab or scarabaeid beetles, contain about 1280 North American species and vary greatly in size, color, and habits. The most distinguishing common feature in adults is the antennae, terminating in an oval or elongate club composed of three (rarely more) leaves or lamellae that can be folded closely together or spread apart to show the individual lamellae (Borror and DeLong 1970). This feature has given rise to the name lamellicorn beetles, and depending on their food habits, are divided into lamellicorn scavengers and lamellicorn leaf chafers (Comstock 1977). Another common feature is their fossorial front tibia adapted for digging in soil (Blatchley 1910).

The most distinguishing characteristic of scarabaeid larvae is their stout, wrinkled C-shaped configuration when at rest, with the tip of the abdomen touching the legs or nearly so. With exceptions in one subfamily there are three larval stages. Most descriptions refer to the third stage larvae but usually apply to the second stage as well (Ritcher 1966).

The superfamily Scarabaeoidea contains two other families that might be confused with Scarabaeidae since members of all three families occupy similar habitats and have similar appearances. Lucanidae have C-shaped larvae, but the adult antennae terminate in pectinate or comblike segments incapable of being folded into a compact club. Larvae of Passalidae are not C-shaped. Also, their metathoracic larval legs are rudimentary, whereas in most Scarabaeidae they are well developed.

Morphology

External Larval Morphology

Scarabaeid adults are mostly heavy-bodied, oval to elongate, usually convex beetles with 8- to 11-segmented lamellate antennae, the most useful character for distinguishing this family.

"White grub" is the common name that Peterson (1951) applies to all scarabaeid larvae. Blatchley (1910) reserves this name only to those larvae that live in the ground and damage roots, while Ritcher (1966) applies this term in particular to grubs of economic importance to agricultural crops. Larvae of the subfamily Melolonthinae containing many of the most injurious species of Scarabaeidae are known universally as "white grubs."

Figure 40.1, a third-stage larva of a June beetle, *Phyllophaga* spp., typifies a generalized family member. Some of the larvae that feed on decaying wood and other organic matter have noticeably distended caudal segments. The head is generally brown or black and the general body color is white or yellowish except for the caudal end, which may be dark due to the accumulated feces in the rectal sac and visible through the semi transparent cuticle (Peterson 1951).

Mouthparts are well developed for chewing with strongly sclerotized mandibles which are often asymetrical. Maxillae are well developed with three- to four-segmented maxillary palpi. Antennae are three- to four-segmented. The epipharynx, the inner surface of the labrum and clypeus,

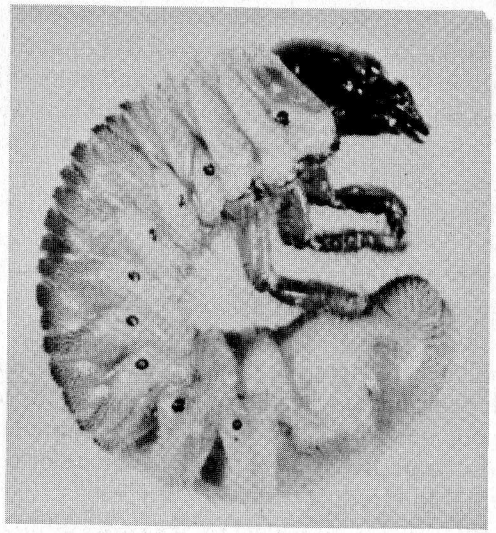

Fig. 40.1. Third-stage larva of a June beetle, *Phyllophaga* spp. typical of a root-feeding species highly destructive to turfgrass and other crops.

has numerous setae, spines, pits, and sclerotized processes useful in identification (Peterson 1951).

The three-segmented thorax generally bears four segmented legs, which usually terminate in pointed structures resembling claws. The abdomen consists of 9 or 10 segments, with each segment generally with three annulets in each of the first six or seven segments. Spiracles are present on the prothorax and the first eight abdominal segments. Ventrally, the caudal segment may bear groups of spines, scales, or stiff hairs, referred to collectively as the raster. Anal slit is either transverse, Y- or V-shaped. Both are useful in identification. Excellent treatises were published by Böving (1942) and Butt (1944) on the external larval morphology of the European chafer, *Rhizotrogus majalis* (Razoumowsky), recently changed from *Amphimallon* (Sutherland 1978).

Internal Larval Morphology

Internal morphology of scarabaeid larvae can also be represented by the European chafer (Fig. 40.2.) (Splittstoesser et al. 1973). The alimentary canal is distinctly divided into the stomodaeum (foregut), ventricles (midgut), and the proctodaeum (hindgut), with the latter consisting of the anterior intestine, rectal sac, and the rectum. The darkened accumulated feces and soil in the rectal sac generally has the color of the soil of the larval habitat in the case of subterranean forms. Cecal diverticula occur at the anterior and posterior areas of the ventriculus. There are 10 present at the junction of the stomodaeum and ventriculus and four just anterior to the junction of the ventriculus and proctodaeum. There are four Malpighian

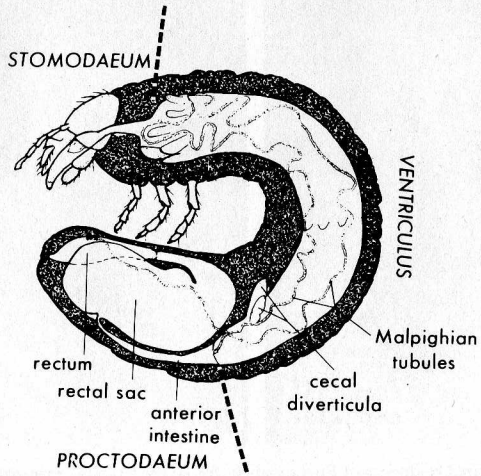

Fig. 40.2. Alimentary tract of the European chafer as a typical root feeding scarabaeid larvae. [After Splittstoesser et al. (1973); courtesy of Academic Press.

tubules, which extend forward the entire length of the midgut, then loop backward, and finally terminate on the ventral surface of the rectal sac (Menees 1958).

Larval sex can be distinguished in a number of scarabaeids by the appearance of a kidney-shaped terminal ampullae in the ventral median region of the ninth abdominal segment (Fig. 40.3*A*) in males (Tashiro et al. 1969). Ampullae are also present in females, in the posterior ventral portion of the eighth abdominal segment, but adipose tissue obscures their view through the cuticle (Fig. 40.3*B*). Vas deferens or lateral oviducts connect anteriorly to the ampullae and end in testes or ovaries in the seventh abdominal segments (Menees 1957).

Ecology

There are 14 recognized subfamilies of scarabaeids; food habits of 12 are given in Table 40.1 as modified from Ritcher (1958). Adult and larval food habits of subfamilies are so diverse that only generalizations hold true.

The subfamilies fall into two main groups, the lamellicorn scavengers, consisting mainly of the first four subfamilies, and the lamellicorn leaf chafers, consisting mainly of the last four subfamilies listed in Table 40.1. I have taken the liberty of placing the middle four subfamilies into a minor group since they consist of relatively few species whose biology is little

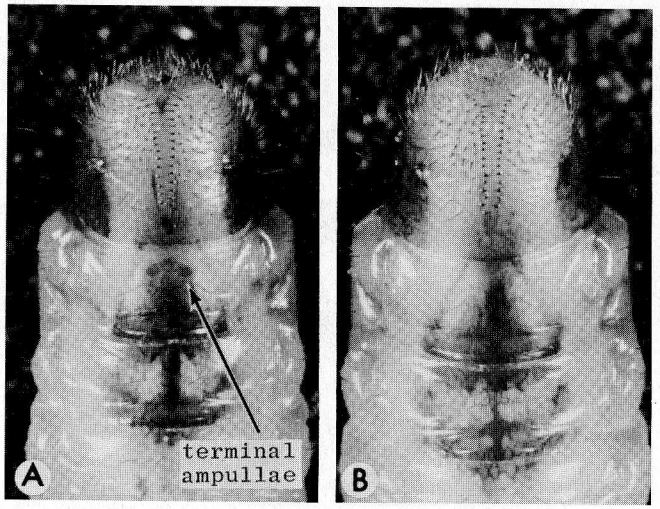

Fig. 40.3. Ventral abdominal segments of European chafer larvae to show terminal ampullae visible in the male (*A*) and invisible in the female (*B*). [After Tashiro et al. (1969); courtesy of Cornell University, New York State Agricultural Experiment Station.]

Table 40.1. Food Habits of Scarabaeidae[a]

	Saprophagous							Phytophagous	
Subfamily	Carrion	Dung	Humus	Decaying Vegetable Matter	Duff	Litter	Wood	Fungi	Seed Plants
Coprinae (Scarabaeinae)	A L	A L		A				A	
Aphodiinae	A L	A L	L	A L				A	L
Geotrupinae	A	A L	L	L	L	L		A	
Troginae	A L						L		
Acanthocerinae									
Hybosorinae		L (?)							L
Pleocominae									L
Glaphyrinae				L					L
Melolonthinae			L						A L
Rutelinae			L				L		A L
Dynastinae		L	L	L	L	L	L		A L
Cetoniinae		L	L				L		A

Source: Modified from Ritcher (1958).
[a] A, adults; L, larvae.

known. Condensations of mainly Ritcher's (1958) commentaries on primarily food habits follow.

Habits of Lamellicorn Scavengers

Dung is the major food of both adults and larvae of Coprinae (known as dung beetles and tumble bugs) and Aphodiinae (known as Aphodian dung beetles) but adults also feed on carrion, decaying vegetable matter, and fungi. Tumble bugs chew off a piece of dung, work it into a ball, roll it to a burial site, and upon burying, deposit an egg into the ball. Upon hatching the larva is assured of a food supply. The sacred scarab of ancient Egypt, *Scarabaèus sàcer* L., belongs to this group (Borror and DeLong 1970). Aphodiine larvae are primarily dung feeders, but a few feed on grass roots. The black turfgrass ataenius, *Ataenius spretulus* (Halderman), is currently a serious pest of golf course fairways (Niemczyk and Wegner 1979).

Geotrupinae (earth-boring dung beetle) adults are found beneath cow dung, horse manure, or carrion, but some occur in logs or decaying fungi. Larval food is all provisioned by their adults. Larvae of at least one species feeds on leaves, buds, and shoots, also provisioned by adults.

Troginae (or skin beetle) adults are found on old dry animal carcasses feeding on the hide, hairs, feathers, and dried tissues on the bone. Some species are found in owl pellets and beneath bark or roots (Borror and DeLong 1970). Larvae of most species feed in soil beneath carcasses of dead animals, while others are found in bird's nests and rodent burrows. Some species feed on grasshopper eggs.

Habits of Minor Subfamilies

Adults of Acanthocerinae, Hybosorinae, Pleocominae (rain beetles), and Glaphyrinae are not known to feed. Rain beetles are so named because flights usually follow rains when winged males emerged from the soil to seek burrows where wingless females reside (Ritcher 1966). Glaphyrine adults are very hairy and resemble bumblebees in flight (Ritcher 1966).

Larvae of Acanthocerinae feed on wood; pleocomine larvae feed on tree roots and some on grasses. Larvae of a glaphyrine species damage roots of cranberry.

Habits of Lamellicorn Leaf Chafers

To this group belong the subfamilies Melolonthinae (June beetles and chafers), Rutelinae (shining leaf chafers), Dynastinae (rhinoceros, hercules, and elephant beetles), and Cetoniinae (the flower beetles). Larvae of many

species are agriculturally important because they feed on roots of many crops. Also, there are many saprophagous species.

Adults of nearly all Melolonthinae are vigorous feeders on plant tissue, devouring leaves, flowers, and fruits of trees and shrubs. Many are nocturnal. Larvae of this subfamily are the most damaging to roots of grasses, legumes, field crops, trees, and shrubs. Species of May or June beetles, *Phyllophaga* spp., cause widespread damage to pastures, corn, potatoes, strawberries, and tree seedlings. The European chafer and the Asiatic garden beetle, *Maladera castanea* (Arrow), are both introduced species whose larvae are major pests of turfgrasses. Neither adult is destructive.

Of the Rutelinae, the introduced Japanese beetle, *Popillia japonica* Newman, feeds on nearly 300 species of plants, while its larva feeds on turfgrass roots. Because of the combined adult and larval feeding habits and widespread distribution east of the Mississippi River, it is considered as one of the most serious of insect pests to agriculture. The Oriental beetle, *Anomala orientalis* Waterhouse, another introduced species, is a serious turfgrass pest. The spotted pelidnota, *Pelidnota punctata,* is a common ruteline whose larvae are found in decaying stumps or rotten wood and whose adults feed on leaves of cultivated and wild grapes.

Adults of Dynastinae usually attack stems and roots in search of liquid nourishment. Larvae of this subfamily have the most diverse food habits, feeding on dung and all decaying vegetable matter as well as roots of living plants. Larvae of the northern masked chafer, *Cyclocephala borealis* Arrow, and the southern masked chafer, *C. immaculata* (Oliver), are both destructive to pasture grasses and lawns. The latter is also found under cattle droppings and in moist soil near straw stacks and manure (Ritcher 1966).

Adults of Cetoniinae are liquid feeders on aboveground parts of plants, preferring nectar or sap or juices of ripening fruits and vegetables. Some feed on pollen. The larvae almost never feed on roots of living plants but prefer decaying vegetable matter in the soil, dung, or dead wood. When larvae of the green June beetle, *Cotinis nitida* (L.), damage young tobacco, clover pastures, and lawns in southeastern United States, it is a result of physical disturbances of the soil and roots, not larval feeding. These larvae have a peculiar habit of crawling on their backs, making no use of their small legs (Blatchley 1910).

Life Cycles

Numbers of Molts

With the exception of some members of Pleocominae, whose larvae molt 7–11 times with a molt each year, the scarabaeids have three larval instars.

Length of Life Cycle

Life cycles of the lamillicorn scavengers and the minor subfamilies are little known compared to the lamellicorn leaf chafers. In the latter group it may be 1, 2, or 3 years, and in more northern latitudes some Melolonthinae may require 4 or 5 years. Due to the economic importance of the lamellicorn leaf chafers, some of their life cycles have been worked out in great detail.

One-Year Life Cycle. Many of the most destructive species normally complete their life cycle in 1 year, but a small percentage may require 2 years (Tashiro et al. 1969). In the more northern latitudes, the Japanese beetle may require 2 years to complete their development from eggs deposited in late August (Hawley 1944).

The detailed life cycle of the European chafer, as shown in Fig. 40.4, and all stages and stadia present, as shown in Fig. 40.5, serve to illustrate a typical 1-year life cycle.

Normally, third-stage larvae overwinter. After disappearance of all frost, larvae migrate to near the soil surface to resume feeding on grass roots. Populations exceeding 10–20 per 0.1 m^2 can cause major damage, as shown in Fig. 40.6. In the northeast, larval feeding is completed by the latter half of May; they then construct earthen cells at a depth of 5–10 cm in which they become prepupae and pupae. Adults emerge during June into early July, make nightly mating flights following warm, sunny days, and mate as beetles rest in trees. Since adults essentially do not feed, they must depend on fat stored as larvae and normally live no more than 2 weeks.

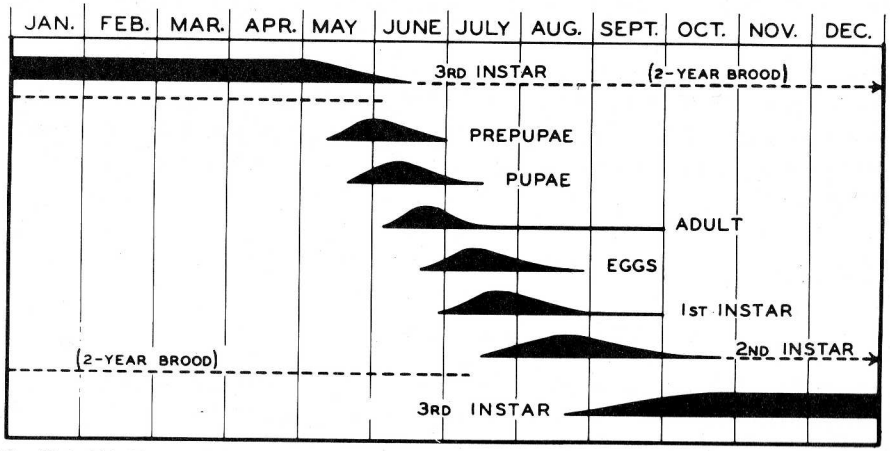

Fig. 40.4. Life history of the European chafer in western New York, an example of a 1-year cycle. [After Tashiro et al. (1969); courtesy of Cornell University, New York State Agricultural Experiment Station.]

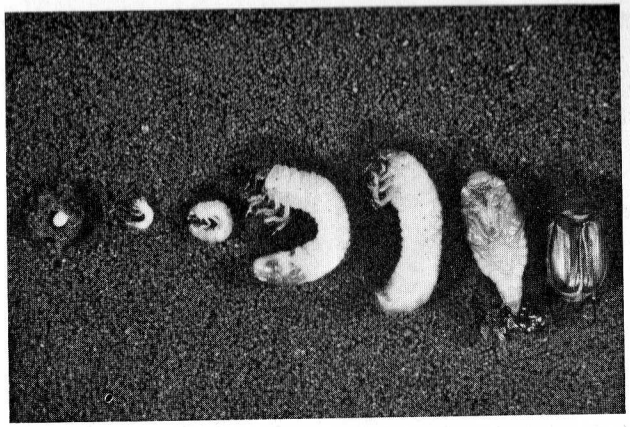

Fig. 40.5. Stages and stadia in the life cycle of the European chafer; egg, first, second, third-stage larvae, prepupa, pupa, and adult.

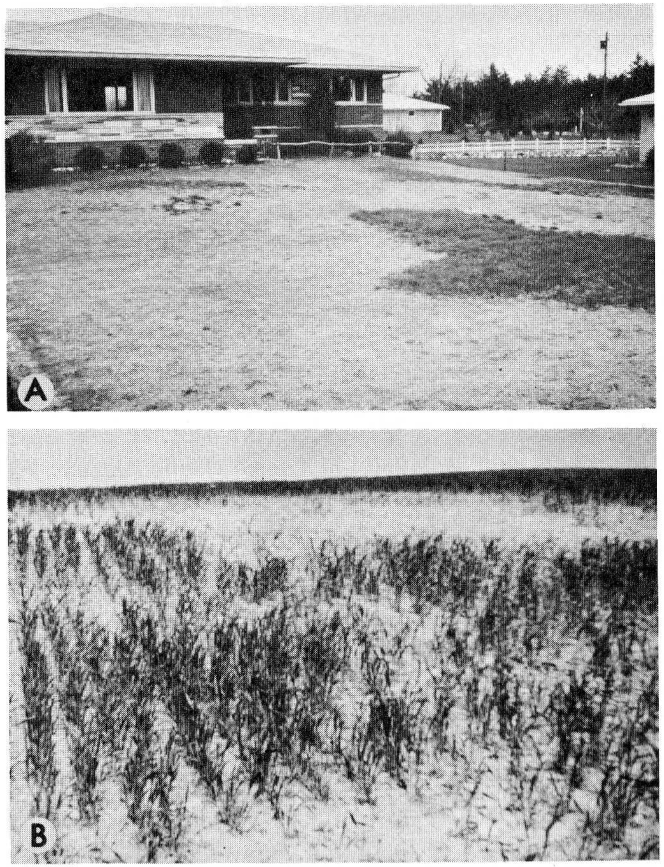

Fig. 40.6. Major damage to home lawn (*A*) and to winter wheat (*B*) caused by European chafer third-stage larvae. Equally severe damage can also develop in the fall.

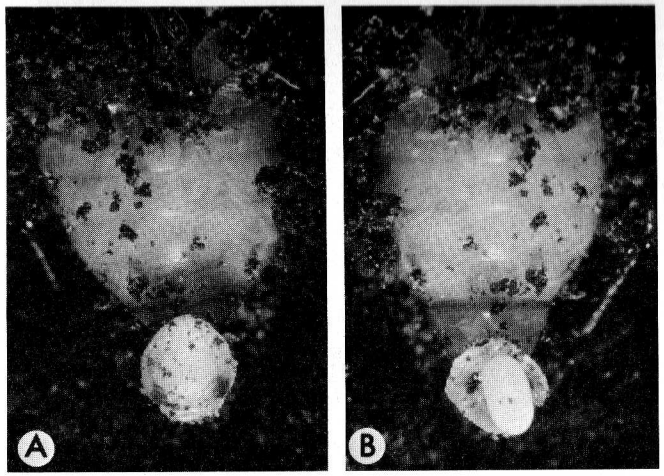

Fig. 40.7. Evagination of vaginal tract for preparing earthen cell by European chafer female (*A*). Egg is deposited simultaneously with invagination of vagina (*B*). [After Tashiro (1987)].

They return to the soil during their nightly flights, preferably to non-cultivated areas of pastures, weeds, and turfgrass, where females deposit eggs singly in earthen cells. Evagination of the vaginal tract into a balloon-like structure (Fig. 40.7*A*) compresses the moist soil and forms a cell (Tashiro 1987). An egg is deposited simultaneously with invagination of her vagina (Fig. 40.7*B*). Young eggs are ellipsoidal, but as they age become spherical. They hatch in 1 or 2 weeks.

From July into September larvae pass through the three larval stages, and by mid-September, with ample soil moisture, the third-stage larvae feed very actively within 2–3 cm of the soil surface. Summer soil moisture governs vertical distribution of larvae. As the surface soil dries, larvae migrate downward to seek moist soil at 12–15 cm or deeper. With sufficient water to moisten the soil continuously to the depths of the larvae, they will migrate to near the soil surface again within 24 hours. Feeding near the soil surface continues late into fall. As frost begins to form in surface soil, larvae will migrate downward for the winter.

Other related species whose larvae feed primarily on turfgrasses and underground stems have similar life cycles with minor deviations. Overwintering larvae of the Japanese beetle feed 3–4 weeks later during spring than those of the European chafer in the northeast; adults appear nearly a month later in late June and July. Individuals live from 4 to 6 weeks feeding and ovipositing during their entire adult life (Fleming 1972). During mid-September into October, like the European chafer, all the larvae are feeding very near the soil surface. In a mixed population, under identical environmental conditions, a much larger percentage of the Japanese beetle are second-stage larvae than the European chafer during fall. By the

time of adult emergence the following summer, this difference is compensated for by the longer larval feeding period of the Japanese beetle in the spring. Also, the Japanese beetle larvae migrate downward at the first onset of cold weather a full month before the European chafer. Other well-known species destructive to turf with similar life cycles in the northeast are the Oriental beetle, the Asiatic garden beetle, and the northern masked chafer.

Three-Year Life Cycle. May or June beetles, genus *Phyllophaga*, of which there are some 152 species in North America north of Mexico (Luginbill and Painter 1953), have life cycles that may vary from 2 to 4 years in some species, depending largely on latitude. In the northeast and Canada there are many species that have a 3-year life cycle, as illustrated in Fig. 40.8.

Overwintering adults appear in early spring and are first noticed when they fly into screens or windows as they are attracted to light on warm evenings. Adults are most abundant during May and June, when they feed on the leaves of many common shade and ornamental trees at night. Eggs are deposited in soil at a depth of about 10 cm. They hatch in about a

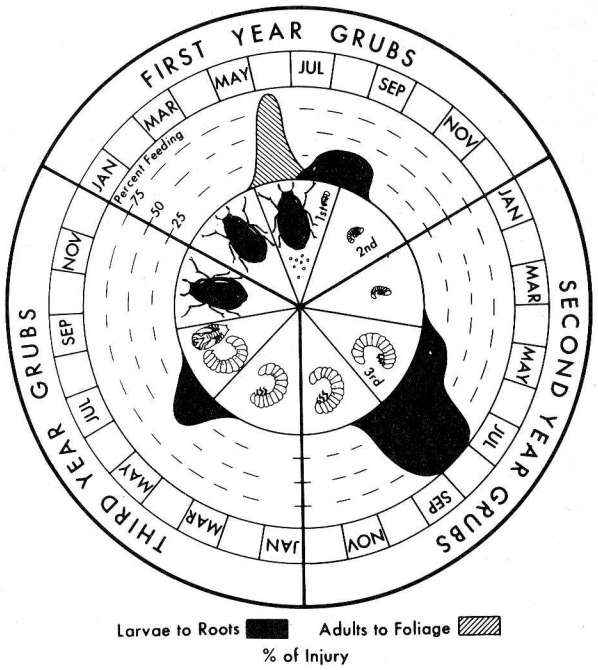

Fig. 40.8. Diagram of 3-year life cycle of a June beetle with periods of feeding damage. [After Hammond (1940). Reproduced from Agriculture Canada's Publication 668, *Farmers' Bulletin 86*, with the permission of the Minister, Supply and Services, Canada.]