Chapter 12

Insect Pests[1]

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The importance of insect damage to peanuts has not been generally recognized, even by the peanut industry and agricultural leaders. Textbooks of economic entomology barely mention peanut insects, although numerous species of insect pests attack the crop in the field and in storage. These insects feed on the foliage and underground parts of the growing plants, suck the juices of pods curing in the field, and infest peanuts and their products in storage and in transit to markets.

The control of insect pests of peanuts is a serious problem. Scores of species of pests attack peanuts throughout the world, and perhaps a dozen are of major importance in the United States. Information on the control of some of these forms is sparse and in some instances the economic status is controversial. In addition, chemicals that provide better control of some of these pests leave undesirable residues on the crop at harvest and cannot be recommended. It is the purpose of this chapter to summarize the available information on peanut insect pests and to point out the need for additional information. Typical control recommendations for each pest will be mentioned. However, since control recommendations change rapidly as new research information becomes available, and since recommendations vary from state to state because of geographic, climatic, and other differences, the reader is directed to his state Agricultural Experiment Station and Cooperative Extension Service and the USDA for specific control recommendations.

[1]In addition to the insects discussed in this chapter, numerous minor pests have been observed attacking peanuts in various parts of the world. No attempt is made to cover all of these pests, and no claim is made that the publication is in any sense complete.

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FOLIAGE FEEDING PESTS

Corn Earworm

Importance. The corn earworm, *Heliothis zea* (Boddie), attacks peanut foliage and frequently causes light to moderate damage. Occasionally, severe outbreaks of this insect occur. The caterpillars feed on the foliage of peanuts, ragging the plants and in some instances defoliating them. This insect not infrequently occurs in mixed populations with velvetbean caterpillar, fall armyworm, and other caterpillars. Heavy losses in yield from defoliation or from severe ragging of leaves may occur. Although corn earworm may be considered one of the major pests of peanuts during certain seasons, entomological literature contains almost no references to earworm infestations in peanuts. Merkl (130) lists peanuts as one of the principal crops in Alabama being damaged by this insect but based his conclusion on unpublished records of the Auburn University Agricultural Experiment station. So far as the authors are aware, serious damage has not been reported outside of the Georgia, Florida, Alabama area.

Leuck, *et al.* (120) has pointed out that damage from corn earworm was significantly higher, in both 1965 and 1966, on Spanish type peanuts in Georgia, than on runner and Virginia types.

Description of Stages. The various stages of the corn earworm have been described by several investigators. Descriptions given below are taken from the sources indicated.

The egg has been described by Phillips and Barber (148), Quaintance and Brues (157), and others. The description of Quaintance and Brues follows:

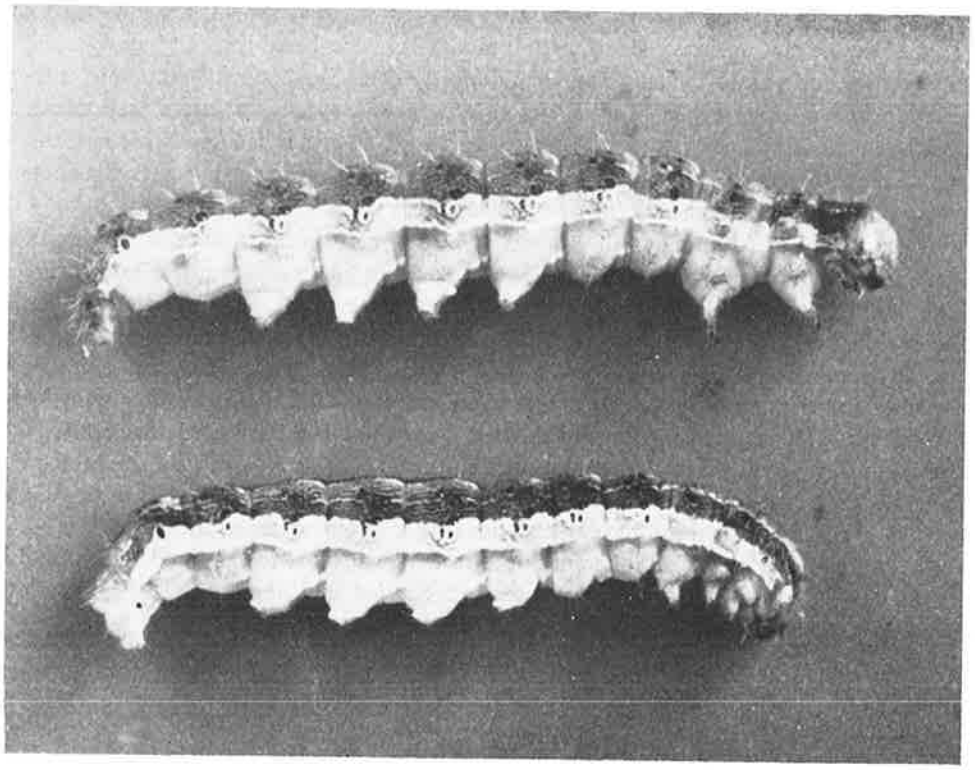

Figure 1. The corn earworm.

Egg

Width, 0.48 mm.; height, 0.50 mm. Shining, waxy white, faintly tinged with yellowish. The form is almost dome-shaped, except that it is slightly narrower at the extreme bottom and widest about the basal third. Base flat and apex obtusely rounded.

The larval and pupal descriptions of Ditman and Cory (62) follow:

Larva

First Instar. Length (soon after hatching), 1.5 mm. Head and thoracic legs, shiny black. Body newly hatched larva very pale and rather transparent; after some feeding, opaque and creamy yellow. There is a very slight tendency to darker and lighter longitudinal stripes, at least in larvae nearly ready to molt the first time. Setae of body of rather medium length, black; on head, some are black and others of a lighter color. Cervical shield and minute setigeral warts dull brownish black; also the prolegs externally, and the anal plate. Around each setigeral wart is a poorly defined circular space of whitish beyond which the generally yellow color of the body appears. The characteristic minute dermal spinules of the older larva are scattered and very indistinct in this instar.

Second Instar. Length, 3.4 mm. Appearance much the same as in first instar. Differs in that the setigeral warts are much broader and show up clearly to the naked eye. The dermal spinulation is more pronounced and general. The longitudinal stripes are but little more evident, if any, than in the previous stage. In the first two or three instars the larvae have a semi-looping gait as do the younger larvae of some of the cutworms.

Third Instar. Length, 7.0 mm. Head, olive brown with darker brown mottlings, especially on each side near vertex; bears a few fine setae. Cervical shield black or slightly brownish, with two short white lateral stripes. Body entirely covered with minute blackish spinules, appearing like a "sand-paper" surface as compared with the skin of most of the related caterpillars. Four narrow white dorsal stripes and a broad white band laterally, alternated with olive brown. Setigeral warts prominent, shiny black, and obtusely cone shaped rather than nearly flat as in previous instars. Setae moderately long and shiny black. Dorsal abdominal warts are larger, especially on first and second segments. Thoracic legs black; prolegs black on their sides both experiorly and on the mesal surface. Crochets black.

Fourth Instar. Length, 11.4 mm. Appearance much as in third instar. Differs in the fact that some of the dorsal stripes laterally now appear broken into short, irregularly disposed lengths interrupted by dark ground color. There is a broader lateral white band in or near which the spiracles lie.

Fifth Instar. Length, 17.9 mm. In general, this stage marks the change to greater contrasts in the markings and to more brilliant colors. The appearance of red hues, as on the ventral surface and in the paler portions of the body markings, is now quite general. Head, orange brown with fine pale setae. Cervical shield and setigeral warts as before, but the latter bearing pale setae. The shield may lose its dark color in many specimens, however. All legs pale; claws of thoracic legs and crochets of prolegs are brownish. Two continuous mid-dorsal white lines now enclose a darker area appearing as a blackish band, in the middle of which lies a third white line. Dorsum laterally to white spiracular band transversed by short white lines on a red and gray ground which becomes darker near the lower edges and tends to concentrate in segmental dark patches in some specimens.

Sixth Instar. Length, 24.8 mm. Appearance much as in the fifth instar, but in general more brightly colored and showing more pronounced individual variation in the nature of the markings. Cervical shield not so dark, and less distinct from the surroundings in many cases, although in some types of larvae it is very distinct.

Pupa

The pupa, just after it is rid of the larval skin, is very soft and delicate and almost larviform. It is pale green on the head and thorax; the wings are transparent with the venation showing as whitish lines; the abdomen is whitish and opaque, with shades of rosy pink dorsally, and orange-colored spiracles. A large transverse rosy spiracle anteriorly bordered with white lies on each side of the prothorax; a transverse median rosy spot between the eye; and four black dots on each eye.

In a half hour after the molt, the pupa has begun to contract and press its appendages into the places habitually taken by them. The colors are hidden by the darkening and hardening of the chitenous coat of the pupa. This change to the natural shiny brown of the pupa takes place rather slowly over a period of a day or more. The first portions of the body to darken are the head and dorsal regions of the thorax and abdomen.

Measurements of twenty-two pupae showed that there is comparatively little variation in size in this stage. The length was found to average 19.1 mm., ranging from 17.6 mm. to 20.6 mm. The breadth of the pupa at the widest point across the back or dorsum is a little greater than

the greatest depth from the dorsal to the ventral surface. The average measurement in the first cases was 5.5 mm., while the average depth was 5.4 mm.

The original description of the adult (73) was translated by Ditman and Cory (62) as follows:

Adult

A bombyx, with wings deflexed and yellowish; with a middle spot and posterior obsolete streak rather obscure. Habitat, islands of South America. Collector, Father Smith. Of medium size. The antenna simple. The body yellowish with a more obscure middle spot. Posteriorly with an obsolete streak which is spotted with very small punctures. Hind margins brownish. Hind wings yellowish, with posterior margin fuscous.

Biology. Studies on biology of the corn earworm have been conducted by numerous workers (22, 62, 107, 147). The insect overwinters in the pupal stage which may be found 2 to 6 inches below the surface of the soil. The adult emerges in the spring or early summer, and the female soon begins depositing eggs. Eggs are laid singly on the leaves and terminal buds of many plants. When corn in the silking stage is present the eggs are frequently deposited on the silks. One female may lay as many as 3,000 eggs. On peanuts, the caterpillars feed on the leaves, causing ragging of the foliage, or even complete defoliation of the plants. When the larva is mature it pupates in the soil. Time required for complete development, egg to adult, is approximately 30 days under favorable conditions. In addition to feeding on peanuts this insect is a major pest of several other crops including sweet corn, field corn, cotton, tomatoes, tobacco, and soybeans. It is commonly called corn earworm, tomato fruitworm, bollworm, or podworm, depending on the crop it infests.

The moths are most active at dusk or during warm, cloudy days. They are strong fliers and may migrate for considerable distances before depositing eggs. There appears to be a tendency for the migration to be northward.

Control. The literature available on control of the corn earworm is too extensive to review in this paper. Winburn and Painter (186) reported 46 hymenopterous and 22 dipterous insects that aid in natural control. An enormous amount of research has been conducted on the chemical and cultural control of the corn earworm on corn, cotton, tomatoes, soybeans, and several other crops. However, very little information is available on control of this insect on peanuts. Experiments at the Wiregrass Substation of the Auburn University Experiment Station after World War II proved that this insect could be successfully controlled on peanuts with cryolite, DDT, and toxaphene (10, 12, 13). More recent research in Alabama and other states indicates that monocrotophos, carbaryl, methyl parathion, EPN and malathion will control this insect under certain conditions (2, 24, 204). When ultra-low-volume (ULV) applications of several materials were compared with other application techniques for the same materials for corn earworm control, no significant differences in control resulted from the application techniques (140). Regardless of application technique or material used the insect is most readily controlled when the larvae are small. Full-grown caterpillars are somewhat resistant to most insecticides.

Some of the materials mentioned here are not presently labeled for use on peanuts and, therefore, cannot be recommended for use on this crop. The material most commonly recommended for control of this insect on peanuts is carbaryl. For specific and recent control recommendations for any given locality consult current USDA or state insect control recommendations.

Fall Armyworm

Importance. The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), is a periodic pest of peanuts across the peanut belt. Some damage occurs each season, and not infrequently the insect is present in sufficient numbers to cause complete defoliation of peanuts.

Few references to fall armyworm damage to peanuts are found in entomological literature. Hinds and Dew (94) reported peanuts as a food of this pest, and Robinson (163) reported serious damage in Barbour County, Alabama. The pest has caused severe damage throughout southeastern Alabama and southwestern Georgia on several occasions (11, 12). Control experiments have shown that fall armyworm may reduce the yield of cured peanuts as much as 500 pounds per acre (12, 197).

In addition to feeding on peanuts, the fall armyworm attacks numerous other plants including corn, sorghum, oats and other grasses; alfalfa, soybeans, velvetbeans, cowpeas, and other legumes, as well as many other types of plants.

Description of Stages. Detailed descriptions of the life-history stages were made by Luginbill (125). Briefer descriptions have been made by H. G. Dyar and published by Chittenden (44). The descriptions given of the egg and larva are from Chittenden; those of the pupa and adult are from Luginbill.

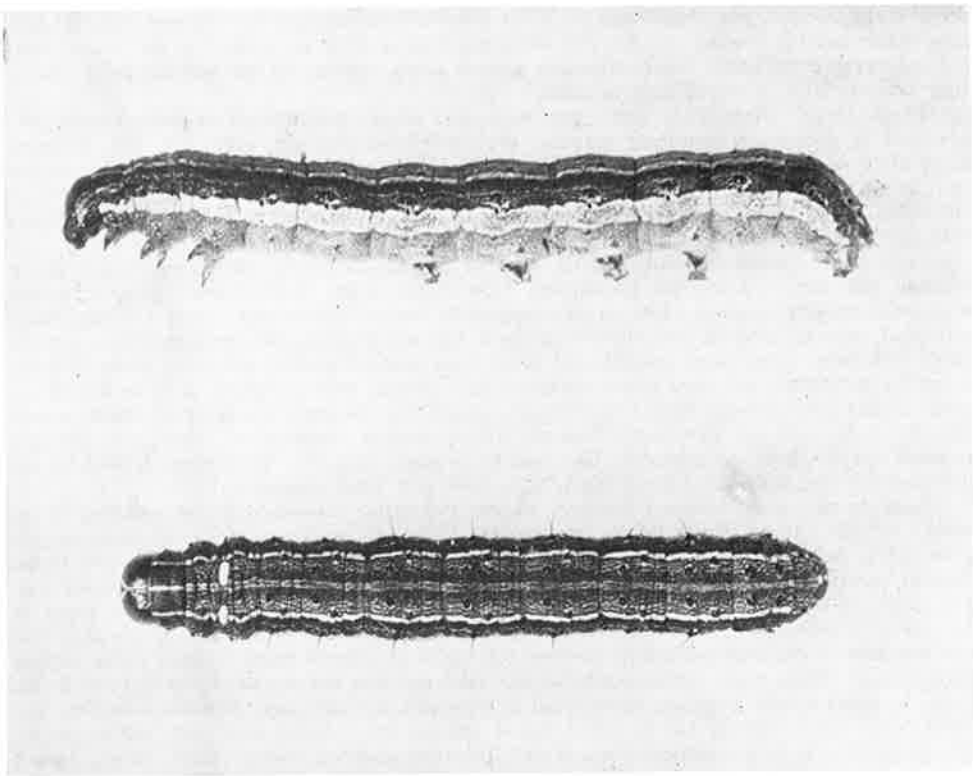

Figure 2. The fall armyworm.

Egg

Eggs (deposited) in a close double layer, one above the other, more or less covered with fine gray down from the moth; spherical, well-rounded, the base a little flatter than the apex, uniform; vertical ribs numerous, about 60, small, joined by distinct crossbars nearly as large as

the ribs themselves and forming rectangular or lightly hexagonal areas; above, the ribs do not diminish till near the vertex, where they become converted into reticulations, smaller toward the micropyle; color, pearly pink; diameter, 5 mm.

Larva

First Instar. Head rounded, bilobed, about as high as wide, clypeus triangular, half as high as the head, without perceptible paraclypeal pieces; labrum quadrate and with the mandibles projecting; shining jet black; antennae moderate, pale; setae short, pointed; width .25 mm. Cervical shield straight before, rounded behind, jet black, bearing 4 setae on each side; two more (of which one is scarcely visible) detached posteriorly, laterally, prespiracular and subventral tubercles single-haired; anal plate semicircular, dusky blackish. Body whitish, slightly translucent, tubercles large, round, black with very distinct, short, black, pointed setae. Arrangement normal, no subprimaries; on joints 3 and 4, ia and iia small ib and iib large, all well separated and equally spaced; iv and vi single-haired; on the abdomen, i, ii, and iii large, equal, i and ii on joint 12 approximately in a square, iv behind the spiracle and with v as large as the dorsal ones. Leg shields small, quadrate, black; ventral tubercles minute, also black. Feet of joints 7 and 8 slightly smaller than those of joints 9 and 10. After feeding the larva becomes green from the food.

Second Instar. Head round, slightly bilobed, shining black; width .4 mm. Body as before, a little thicker, and joint 12 more distinctly enlarged; cervical shield black; anal plate not cornified, pale like the body, shaded with gray on the sides. Color whitish, with faint traces of dorsal, subdorsal, laterial, and stigmatal lines. Tubercles large, black, and distinct as before, the subprimary ones present. Hairs short, stiff, black. Thoracic feet black, the others pale, with dark shields.

Third Instar. Head round, shining black, the sides covering the eyes and sutures of clypeus, pale luteous; width .65 mm. Shields and tubercles shining black, tubercles large, setae coarse and black. Body greenish gray, dorsal and subdorsal lines whitish, straight, narrow, and even; ground color darker laterally, ending in a blackish shade touching tubercle iv, defined on the ventral side. A broad, pale, substigmatal band; subventer grayish green, shading to the scarcely paler venter. Body uniform, joint 12 very slightly enlarged.

Fourth Instar. Head black, paraclypeal pieces and labrum pale whitish, sides no longer pale, but filled in with black mottlings; rounded, slightly bilobed, shining; width 1.1 mm. Cervical shield black, bisected, not strongly cornified; anal flap dusky; tubercles large, black. Body greenish gray, dorsal, subdorsal (at tubercle ii), and traces of narrow lateral lines pale, as before; substigmatal line broad, white, mottled with greenish and divided by a central band of this color. Feet dusky; setae distinct, black, rather long.

Fifth Instar. Head rounded, slightly bilobed; clypeus large, the paraclypeal pieces nearly attaining the vertex; mandibles prominent; brown-black, sides mottled with pale, especially posteriorly, paraclypeal pieces white, as also the verticle suture: labrum pale, width 1.8 mm. Body cylindrical, normal, joint 12 very slightly enlarged, feet nearly equal. Above dark brown, a little dotted with pale, venter more greenish, but also brown mottled. Dorsal line pale, nearly obsolete except on the thorax and anal plate; subdorsal line distinct, white, straight, a little broken on joints 12 and 13; stigmatal band broad, sharply edged, not inclosing the spiracles, white, nearly filled in with dark red mottlings. Feet all dusky; cervical shield sooty black, not strongly cornified, cut by dorsal and subdorsal lines; anal plate dusky, with two white spots, formed by the broken dorsal line; tubercles distinct, black, with short, stiff, black setae.

Sixth Instar. Head rounded, bilobed, clypeus large, the paraclypeal pieces reaching three-fourths of the distance to the vertex; brown-black, sides posteriorly mottled with pale, sutures white, all as before; width 3 mm. Body as before, joint 12 very slightly enlarged, feet equal. Blackish brown above, varying in shade, the lateral space tending to be darker, as also a space each side of the dorsal line; venter pale greenish, densely mottled. Dorsal line whitish, as broad as the subdorsal and regular, but much fainter; subdorsal line mottled with pinkish, straight. The pale mottlings of the body are heavier between tubercles i and ii and across tubercle iii, suggesting obsolete lines. Slight black streaks bordering the subdorsal line below. Substigmatal band broad, sharp, the edges a little irregular, white, filled in with pale red mottlings. Feet all dusky; cervical shield black, very narrowly cut by white dorsal and subdorsal lines; anal plate dusky, cut by pale dorsal line, with a constriction anteriorly. Tubercles cornified, distinct, dark brown, largest on joints 12 and 13; tubercle iv on joint 5 is opposite the upper corner of the spiracle, on joints 6 and 7 below the middle, on 8 at the middle, on 9 above the middle, on 10 at the upper corner, on 11 low down halfway between the spiracle and tubercle v, and on joint 12 opposite the lower corner of the spiracle. Setae short, rather stiff, dark.

Pupa

Dark reddish brown, darker on the prothorax, black immediately before emergence of the adult; labrum separated from the clypeus by distinct suture, quadrate; fronto-clypeal suture not

distinct; labial palpi visible, about one-fourth length of maxillae; mesothoracic wings reaching to caudal end of fourth abdominal segment; metathoracic wings not visible on the venter, maxillae reaching almost to tip of wings; prothoracic legs over half as long as maxillae, their femora exposed; mesothoracic legs a trifle shorter than maxillae; metathoracic legs showing caudad of maxillae not projecting from caudal margins of wings; antennae a little shorter than mesothoracic legs; sculptured eyepiece somewhat broader than the glazed eyepiece; invaginations of the tentorial arms distinct; vertex narrow on the meson, broader on the sides; mesal length of prothorax one-half that of mesothorax; mesal length of metathorax one-fourth that of mesothorax; cephalic portion of the fifth, sixth, and seventh abdominal segments and the same portion of the fourth abdominal segment on the dorsum finely and densely punctured; area around the spiracles slightly elevated, blackish; caudad of each spiracle is a shallow cavity; spiracles ellipsoidal; mesothoracic spiracle extending over half the length between the antenna and the meson, the area blackish; cremaster consisting of two short, stout, blunt spines; genital opening of female simple; slitlike, apparently situated on the eighth abdominal segment, the cephalic margins of the ninth and tenth segments curving strongly forward toward the genital opening in this sex; genital opening of male simple, slitlike, on the ninth abdominal segment on slight elevation. Length from 14.7 to 17.4 mm. Greatest width 4.5 mm.

Male. Head and thorax ochreous, suffused with reddish brown; palpi with blackish patch at side of 2nd joint; frons with blackish bar above; vertex of head suffused with fuscous; tegulae with fuscous patches; pectus whitish; fore coxae and femora suffused with fuscous, abdomen ochreous white suffused with reddish brown leaving slight pale segmental lines, the anal tuft tinged with rufous. Fore wing ochreous whitish suffused with fuscous and reddish brown, the inner area paler; subbasal line represented by double oblique dark striae from costa; a black streak below base of cell curved up to cell at extremity; a minute whitish spot defined by black on outer side in cell before the antemedial line, which is indistinctly double, oblique, waved, somewhat bent outwards in submedian fold; claviform represented by a diffused brownish streak, orbicular whitish defined by black and with pale brown centre, a whitish bar beyond it and above base of vein 2; reniform with black and white bar on inner side, its outer edge slightly defined by black and with irregular white marks at upper extremity; a slight white fork at bases of veins of 4, 3; an indistinct oblique waved line from lower angle of cell to inner margin; postmedial line indistinct, double, strongly bent outwards below costa, then minutely waved, incurved at discal fold and below vein 4, some white points beyond it on costa; an oblique diffused whitish shade from apex to vein 6, the whitish subterminal line arising from it, excurved at middle and bent outwards to tornus, some short black streaks before it in the interspaces at middle; a fine white line before termen with series of slight black streaks from it to the black terminal striae; cilia brownish with fine white line at base followed by a dark line.[3] Hind wing semihyaline white, the apex suffused with brown; a dark terminal line from apex to vein 2; the underside with the coastal area slightly irrorated with fuscous, a terminal series of black striae from apex to vein 2.

Genitalia. Uncus represented by a stout, sicle-shaped hook or spine; gnathos about as long as the uncus; harpes large and broad; the anal angles not well defined; marginal spines prominent; claspers hinged at base composed of stout hooks, one on either harpe and attached to it near the anal angle; clavus button-shaped; juxta composed of a chitinized plate in front of aedoeagus attached to articulation of harpes by two stout muscles; ampulla consists of a flap covered with numerous short spines; editum is slender, spiny at tip; peniculus oar-shaped; cornutii composed of 3 groups of several short spines each.

Female. Much more fuscous brown, the coastal area and veins irrorated with grey, the lines less distinct; the orbicular and reniform with slight whitish annuli, the former without pale bar beyond it and no white streak at lower angle of cell, the whitish fascia from apex absolete.

Biology. Adults of the fall armyworm are active during the late afternoon, night, and early morning. The female deposits eggs in masses on grasses, peanuts or other suitable host plants. The number of eggs per mass is reported (184) as varying from 9 to 349, with an average of 143 eggs per mass. One female lays an average of about 1,000 eggs.

The eggs of the fall armyworm hatch in approximately 3 days and the young larvae feed at first on the surface of the leaves, skeletonizing them. Later they devour the leaves of the plant. The caterpillars feed both in the daytime and at night. Occasionally they may be found hiding under clods at the base of plants; but this

[3] *Var. fulvosa* (Male). Fore wing somewhat more suffused with purplish, the white fascia from apex indistinct.

habit is not nearly so pronounced as in cutworms. When food becomes scarce, the caterpillars may migrate in large numbers seeking additional food plants. Most crops in the path of the march may be destroyed by this pest. At maturity the caterpillars enter the soil and pupate.

The life cycle, egg to adult, is completed in approximately 30 days. The winter may be passed in the adult stage in the southern part of the insect's range. Part of the winter may be passed also in the larval stage (184). Apparently, this species is not able to overwinter successfully except in tropical and semi-tropical areas. During the warm months the adults migrate northward and may cause damage by fall in central and northern states.

Control. Natural enemies are important in the control of fall armyworm. Tachinid flies, hymenopterous parasites, and ground beetles are important enemies of the insect. Vickery (184) lists one species of Hymenoptera ovipositing in the egg of the fall armyworm and 8 species in the larvae. Two species of Diptera and one fungus, *Beauveria globulifera,* are also listed as parasites of larvae. The fiery hunter, *Calosoma calidum* (F.), and other ground beetles are listed as important predaceous enemies of fall armyworm (44). The more important insect enemies are as follows *Chelonus texanus* Cresson, *Apanteles marginiventris* Cresson, *Meteorus laphygmae* Viereck, *Zele melleus* (Cresson), *Sagaritis dubitatus* (Cresson), *Neopristomerus appalachianus* Viereck, *Ophion bilineatus* Say, *Euplectruc platyhypenae* Howard, *Frontina archippivora* Scudder, *Arthytas piliventris* Van der Wulp. Thirteen species of birds and a large number of insects are listed (125) as enemies of the fall armyworm.

Insecticides in the form of dusts, sprays, and poison baits have been used in control of fall armyworm on various crops. References to recommended procedures are too numerous to cite. Materials which have given effective control in Alabama include cryolite, DDT, toxaphene, carbaryl, and parathion (11, 12, 23). Monocrotophos (204) and carbofuran (33) are also effective against this insect.

Recommendations for control in most states include carbaryl. For the most recent control recommendations for any given locality the reader should consult current USDA or state insect control publications.

Granulate Cutworm

Importance. The granulate cutworm, *Feltia subterranea* (F.), has been observed feeding on a wide variety of host plants. In 1964, Eden, *et al.* (69) reported that the granulate cutworm had become a serious pest on peanuts in Alabama. The cutworm damages peanuts by feeding on the foilage at night. During the day, the larvae usually stay beneath dead foliage on the ground or within the top 2 inches of the soil. If the weather is cloudy and overcast the cutworms may be found under the peanut canopy during the day. Snow and Callahan (174) conducted experiments to determine the exact amount of peanut foliage the cutworm consumes during its development. If the cutworm develops 6 instars, feeding of the first, second, and part of the third instar is confined to leaf skeletonization on the lower side of the leaf. Larvae begin eating the entire leaf during the third instar, but usually leave the main vein. The first 4 instars consume about 2.2 square inches of foliage. The fifth instar consumes 3.38 square inches and the sixth instar consumes about 18 square inches.

Cutworm damage is usually more severe during very dry seasons. The granulate cutworm is one of the few cutworms that is able to feed on dry vegetation and thus escapes drought periods (55).

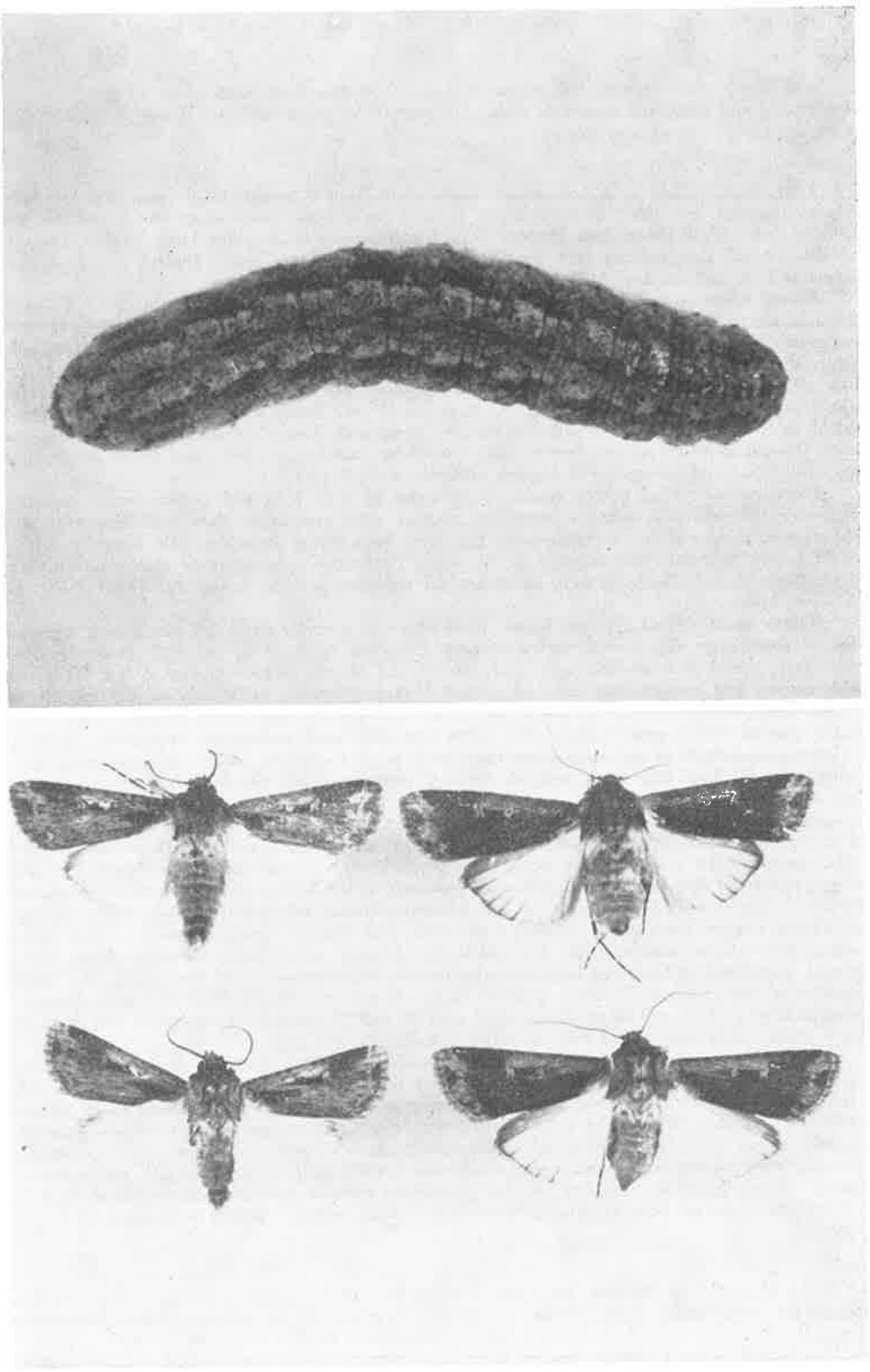

Figure 3. The granulate cutworm larva and adult.

Description of stages. Descriptions given are taken from Crumb (55).

Egg

The egg is white, flattish, 0.63 mm. broad and 0.50 mm. high, with about 36 to 40 straight slender ribs and many fine transverse lines. The second day after deposition a belt and micropylar splotch of pinkish ferruginous appear.

Larva

First instar. Head 0.34 mm. broad. Body about 2 to 3.5 mm. long; pale; skin set with minute rounded granules. Cervical shield fuscous with pale areas about the bases of the anterior setae. Head shield dark fuscous. Setigerous tubercles of abdomen large, conical, fuscous, of about equal size, bearing very long, curved, strongly capitate setae. Prolegs on abdominal segments 5, 6, and 10. Legs brownish fuscous. Anal shield entire.

Second instar. Head 0.5 mm. broad. Body about 5 to 6 mm. long and 0.8 mm. broad; broadest through about the first four abdominal segments and tapering slightly both anteriorly and posteriorly; skin set closely with minute papillae; above the spiracles grayish overlaid with brownish or sometimes with yellowish brown and ferruginous, a continuous middorsal line and pair of supraspiracular lines, white, below the spiracle pale with large white splotches. Anal shield concolorous with adjacent parts. Cervical shield pale brownish with fuscous flecks. Head shield deep fuscous. Setigerous tubercles fuscous, prominent, I to V of about equal size, bearing long, strongly capitate, curved, fuscous setae. Spiracles protuberant. Legs pale brownish, fuscous apically. Functional prolegs on abdominal segments 4, 5, 6, and 10.

Third instar. Head 1 mm. broad. Body about 12 mm. long and 2 mm. broad; tapering slightly posteriorly; skin coarsely granulose; general color grayish overlaid with brownish and ferruginous, middorsal and supraspiracular pale lines broken and indistinct, pale ventrally. Head shield brown infuscated dorsally and at the ocelli. Setigerous tubercle II of abdomen distinctly much larger than I. Prolegs present on abdominal segments 3, 4, 5, 6, and 10. Other details as in second instar.

Fourth instar. Head 1.5 mm. broad. Body about 17 mm. long and 2.5 mm. broad; tapering slightly posteriorly; skin closely, rather coarsely granulose much as in the sixth instar; general color gray; dorsal area overlaid with sandy brown and fuscous, a pale middorsal line demarked with fuscous and a segmental series of fuscous V-shaped figures, subdorsally to the spiracles a fuscous band mottled with gray, below the spiracles a band of pale flecks, beneath pale. Head shield ground color pale brown, the submedian arcs and contiguous reticulation fuscous. Setigerous tubercle II of abdomen about twice as large as I, III, IV, and V of about equal size. Spiracles black. Legs very pale brownish. Prolegs pale, functional on abdominal segments 3, 4, 5, 6, and 10.

Fifth instar. Head 2.1 to 2.5 mm. broad. Body about 22 mm. long and 3.5 mm. broad; of nearly uniform width throughout; skin set closely with conical granules much as in the sixth instar; general color grayish white, dorsal area overlaid with fuscous and sandy brown, the pale broken middorsal line demarked with fuscous especially at the juncture of the segments, V-shaped segmental figures less distinct than in the preceding instar, subdorsally to and including the spiracles a fuscous band much mottled with white and grayish especially below. Anal shield fuscous with a broad median stripe. Cervical shield brownish with fuscous markings. Head shield ground color dingy yellowish or brownish with fuscous submedian arcs and reticulation, the dorsal reticulation more or less obsolete. Spiracles black. Setigerous tubercle II of abdomen distinctly twice as large as I, II and IV of about equal size, III and V smaller, all corrugated and more or less fluscous. Legs pale, tinged with brownish apically. Prolegs pale.

Sixth instar. Head 3 mm. broad. Body about 30 to 37 mm. long and 5 to 6 mm. broad; tapering slightly posteriorly, the posterior extremity rather blunt; skin set with slightly isolated, bluntly conical, somewhat retrorse, chitinous granules interspersed irregularly among many minute secondary granules; dorsum ashy gray overlaid with sandy brown and ferruginous, sides darker, beneath heavily splotched with white. Head shield ground color pale brownish or yellowish, reticulate with fuscous and ferruginous, reticulation usually more or less obsolete, the adfrontal sutures terminating in the occipital foramen. Setigerous tubercle II of abdomen twice as large as I, IV about twice as large as III. Spiracles black. Each anterior proleg with about 8 to 12 crochets.

Pupa

Pupa about 15 to 20 mm. long and 5 to 6 mm. broad, maxillary palpi visible, labrum emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments oval, spiracles broad, directed laterally, cremaster usually with two pairs of accessory spinules, spines set on a distinct process, their bases enlarged, their outer margins nearly parallel, and their inner margins divergent from the base, the areas anterior to and below the spines obscurely rugulose.

Adult

Thorax and fore wings yellowish brown, more or less infuscated, the collar rather dark with a distinct black line, the abdomen gray, the hind wings pure white with the veins and a slight border sometimes infuscated. The orbicular spot is small, rounded, and connected with the reniform spot by a characteristic, sharply defined black dash. Expanse from slightly less than 1½ to 1¾ inches.

Biology. Eden *et al.* (69) reported 5 generations a year in southern Alabama but only 3 of these occur on peanuts. Genung (82) found that the female moth could lay as many as 1,400 eggs and averaged 500. The eggs are deposited singly or a few together on the foliage of the plants. The second day after deposition a belt and micropylar splotch of pinkish ferruginous appears. In a life cycle study at Auburn University, Lee (115) found that the duration of the egg stage varied from an average of 16.7 days at 15° C to 2.8 days at 30° C.

Jones reported that the larvae pass through 5, 6, or 7 instars in Louisiana, with 6 instars being the most common number. The duration of each instar varies with the number of instars which occur during development. Lee reported that the duration of the larval stage varied from an average of 17.5 days at 30° C to 37.2 days at 20° C (115).

The pupal stage is the overwintering stage for this cutworm. This stage is spent beneath the soil surface; the larvae bore into the soil to a level of 2 to 6 inches and form smooth-walled pupal cells (174). The duration of the pupal stage varies from about 11.3 days at 30° C to 28.2 days at 20° C. The mean number of days from egg to egg averages 89.3 at 20° C, 50.5 at 25° C and 33.6 at 30° C (115).

Control. The importance of natural enemies in the control of the granulate cutworm is imperfectly understood. Crumb (55) reported three larval parasites of this insect: *Bonnettia compta* (Fall.), *Microplitis feltia* Mues., and *Apanteles griffinii* Vier. Jones (109) had previously reported *Linnaemyia compta* Fall. and *Enicospilus purgatus* Say as larval parasites. Neither of these authors indicated that the parasites were major factors in cutworm control.

Evaluation of cutworm control is complicated by the cutworm's subterranean and nocturnal habit. Eden *et al.* (69) began the practice of counting the cutworms per foot of row between midnight and dawn. Eden demonstrated at Headland, Alabama, that cutworms could be reduced by a seasonal spray program with any of the following insecticides: cabaryl, 1 lb./a.; DDT, 1 lb./a.; or toxaphene, 2 lb./a. These were applied six times with 10- to 12-day intervals starting June 13, with the last application on August 26. For best results, Eden recommended that rates be increased as the season progressed.

In recent tests conducted by Bass and Lee (24), good control of the granulate cutworm was obtained with monocrotophos, 1 lb./a., sprayed in a 14-inch band over the row and trichlorfon, 1 lb./a., applied as a bait. However monocrotophos is presently not labelled for use on peanuts and trichlorfon baits are only labelled in certain states.

Recommendations for control in many states include TDE and diazinon. Plants treated with TDE should not be fed to poultry, dairy animals, or animals being finished for slaughter. Hay made from diazinon-treated plants should not be fed livestock for 21 days after treatment. For the most recent control recommendations for any given locality the reader should consult current USDA or state insect control publications.

Potato Leafhopper

Importance. The potato leafhopper, *Empoasca fabae* (Harr.), may attack peanuts wherever grown commercially in the continental United States. The related species *Em-*

poasca facialis Jac. is reported on peanuts in South Africa (138); *E. solana* DeLong occurs on peanuts in Hawaii (100) and *E. flavescens* (F.) on peanuts in Dutch East Indies (116). Leafhopper damage in the Georgia-Florida-Alabama area appears to be much less now than formerly. This difference may be a result of a change in the varieties grown.

In addition to injuring peanuts, *E. fabae* attacks a wide variety of plants including potato, bean, clover, alfalfa, soybean, eggplant, rhubarb, cotton, dahlia, apple, and many other plants. Several common names have been used for this insect, each referring to a host plant. It might be called peanut leafhopper, but the official common name is potato leafhopper, a name suggested by Ball (21) to indicate potato as a preferred host.

Both adults and nymphs of the insect feed upon peanuts by sucking juices principally from the lower epidermis and veins of the leaves. Some damage may result also from the deposition of eggs. As a result of leafhopper damage to peanuts, the tips of the leaflets turn yellow and as the damage becomes more acute the yellowing progresses toward the base of the leaflets and some of the tips may appear burned. Damage is more severe during dry weather. A field of infested peanuts may have a yellowish appearance rather than characteristic green. Batten and Poos (25) reported a dwarfing as well as yellowing of foliage in severe infestations in Virginia. Metcalf (132) reported a disease called "pouts" resulting in peanuts from the mass effect of toxins injected by *E. fabae;* the leaflets turned dark at the tips, and the whole leaf sometimes blackened and died. Apparently, this condition was severe "hopperburn"; it should not be confused with a dwarfed condition, also sometimes called "pouts," resulting from thrips damage.

There is considerable evidence that leafhoppers reduce the yield of peanuts (12, 25, 134, 152). In some instances, however, there has been no clear differentiation between the effect of damage from leafhopper and *Cercospora* leafspot. There is need for more exact information on losses caused by potato leafhopper to Spanish, runner, and jumbo types of peanuts. The losses should be measured in terms of yield of peanuts and yield and quality of hay.

Description of Stages. The potato leafhopper was originally described by Harris in 1841 (90) as *Tettigonia* fabae and the Genus *Empoasca* was established by Walsh in 1864. Subsequently, numerous descriptions have been published under several synonymous names. The descriptions of immature stages given are from Ackerman and Isely (1); that of the adult is from DeLong (59).

Egg

Egg elongate, subcylindrical, very delicate, slightly curved from end to end, somewhat rounded at both ends, but more so at the anterior end. When first deposited it is rather transparent, but in a few days it changes to a pale yellow while a small white cap forms at the anterior end through which the red eyes of the immature nymph are perceptible. Average length 0.82 mm., width 0.25 mm.

Nymph

First instar. Pale white, changing to a light yellowish green after feeding. Eyes dull red. Small pale spines on the dorsal side of the head, thorax, and abdomen; the latter with four spines to each segment arranged in two longitudinal rows along each side, one spine situated dorso-laterally, the other ventrolaterally. Posterior margin of metathorax blunt. First two segments of antennae pale, the remainder dusky. Avreage length 1 mm.

Second instar. General color light yellowish green. Eyes losing some of their red color. Posterior border of metathorax sharp in outline. First two segments of antennae light yellow, remainder dusky. Average length 1.30 mm.

Third instar. General color pale yellowish green. Eyes almost pearl white. Body more robust than in first two stages. Wing pads appearing as lateral buds extending to the hind

margin of the first abdominal segment. Spines darker and more prominent. Average length 1.85 mm.

Fourth instar. Head and thorax yellowish green; abdomen yellow. Eyes pearl white. Wing pads extending to hind margin of second abdominal segment. Spines prominent. Average length 2.1 mm.

Fifth instar. Head and thorax pale green; abdomen yellow. Wing pads extending to, or nearly to, the hind margin of the fourth abdominal segment. First two antennal segments green, remainder dusky. Body broader than in previous instar. Average length 2.6 mm.

Adult

Pale green, usually with a row of white spots on anterior margin of pronotum. Length 3.5 mm.

Vertex bluntly angled, a little longer on middle than next to eye and about one-third wider between eyes than length at middle.

Color. Yellowish to pale green, markings variable; vertex frequently with pale or dark-green spots; pronotum usually with a row of six or more pale spots along anterior margin, sometimes missing or indistinct; elytra greenish subhyaline.

Female genitalia. Last ventral segment moderately produced and roundedly truncated.

Male genitalia. Valve produced and rounded or bluntly angled; plates triangularly tapered to pointed apices, which are frequently upturned; lateral processes of the pygofers rounded on inner margins and broadened on apical half, then concavely rounded to narrow attenuated tips, which are slightly curved inward; spines of tenth segment broad, with tips narrowed and directed downward. This combination of characters will distinguish *Empoasca fabae* from closely related species.

Biology. Many studies have been made on the biology of potato leafhopper on potatoes, beans, and other crops, but none has been made on peanuts except in the form of general observations. Beyer (27) reported the results of life-history studies of the insect on beans in Florida and Poos (149) reported similar studies on cowpeas in Virginia. There likewise are rather comprehensive reports from other sections on the biology of the insect (74, 1, 52).

The potato leafhopper apparently overwinters only in the Gulf-Coast States where some breeding may occur throughout most of the winter. As the weather becomes warm in the early summer it spreads northward and causes damage to a variety of crops during the summer and fall. Cold weather presumably destroys all stages of the insect except in its southern range, where the winter may be passed on any green host plant such as alfalfa, clovers, castor beans, and other plants. Beyer (27) found it throughout the winter on castor beans. It is possible that hibernation may occur, either in the egg or adult stage, in part of the insect's range, but all evidence on hibernation is negative.

The time required for development from egg to adult is 18 to 24 days during warm weather (25, 59). As the weather becomes cool, this period may increase to 60 days. Approximately 5 to 10 days are required for incubation of eggs and 8 to 15 for nymphal development. Females mate and begin ovipositing in 3 to 5 days in the veins and petioles of the leaves. Approximately 60 eggs per female are deposited over a period of 30 days during warm weather. A maximum oviposition of 131 fertile eggs has been reported in Florida (27).

The average longevity of the female is 35 days, although a maximum of 123 days has been reported in Virginia (149). Longevity of males is somewhat shorter. Six generations per year have been reported in Virginia and Florida.

Additional research is needed on potato leafhopper to determine its development on peanuts, overwintering habits, and the relation of development on various wild and cultivated host plants to damage in peanuts.

Control. Natural enemies are apparently of relatively minor value in suppressing the population of potato leafhopper. Heavy rainfall reduces infestation in peanuts. A parasitic fungus, *Entomophthora sphaerosperma* Fresenius, causes a disease which is of

considerable importance. The disease has been reported from Florida (27), Arkansas (1), Iowa (74), and other localities. Eighty percent of the insects may be diseased, and as high as 37 percent of those affected may perish. Chrysopid and coccinellid larvae are important insect predators of the potato leafhopper, *Chrysopa plorebunda* Fitch and *Hippodamia 13-punctata* being species commonly observed. The predaceous bug, *Triphleps insidiosus* Say, is also a natural enemy as are certain spiders, ants, and birds. Insect parasites in potato leafhopper appear to be rare, although *Anagrus armatus* Ashm, is reported common in Iowa.

Numerous studies have been made on insecticidal control of potato leafhopper on potatoes, beans, and other crops. Some studies have been made also on peanuts. Poos and Batten (152) found that 4:4:50 Bordeaux mixture applied to peanuts in Virginia increased the yield 21 percent. In 1938 these investigators reported more extensive experiments with sulfur and copper dusts and sprays which resulted in very substantial increases in yield. Miller (134) reported similar results. In none of these reports was there a clear differentiation between increases from leafhopper and disease control, although leafspot is given as a factor. The same authority (136) has reported the potato leafhopper as the most injurious insect of peanuts in Virginia, and stated that sulfur applied for leaf-spot control repelled and controlled leafhopper, ever on undusted areas in small-plot experiments. Poos (152) found that 2% DDT reduced the infestation of the insect on peanuts and Poos, Grayson, and Batten (153) reported some increase in yield of peanuts and hay from control of leafhopper, but none of the differences was significant. Non-significant increases were also recorded (10) in yield of sound, shelled peanuts in Alabama in 1947 from the use of DDT sprays and dusts on runners. In 1948, however, the dusting of Spanish peanuts 4 times for leafhopper control in Alabama resulted in decreased infestation and in average gains in yield as follows: 2% DDT, 302 lb. dry peanuts per acre gain; 2% DDT in 90-10 sulfur-copper, 468 lb. per acre; 20% toxaphene, 470 lb. (12). Two percent gamma BHC and 5% chlordane were less effective. Four applications of dust to runner peanuts for leafspot and leafhopper control resulted in average gains in yield as follows: Sulfur-copper 90-10, 264 lb. of dry peanuts per acre; 2% DDT, 339 lb. per acre; sulfur-copper plus 2% DDT, 444 lb. Where 10 dustings were made with DDT throughout the season, no significant gains were recorded. In a nonreplicated, preliminary test, 9 dustings with 20% toxaphene for thrips and leafhopper control resulted in excellent control of both insects and a 67% increase in yield over the check.

Phorate and disulfoton afford excellent protection to young plants from leafhopper attacks (99). These materials are systemics and are usually applied at or before planting. Another systemic, dimethoate, is reported to give 14-day control of leafhoppers when applied as a foliar spray (144, 160). Other effective foliar sprays include endosulfan (99), naled, phosphamidon, ethion (160), dioxathion, carbaryl, endosulfan, azinphosmethyl, carbophenothion (98), methoxychlor, and malathion (35).

Present recommendations for control of this insect on peanuts in most states include carbaryl and malathion. For specific and recent control recommendations consult current USDA or state control publications.

It appears that control of potato leafhopper on peanuts is profitable. It also appears feasible to control leafspot, leafhopper, and certain other insects in one operation with a combination insecticide-fungicide. Little is known, however, regarding the relative value of controlling the insect on Spanish, runner, and jumbo peanuts. Little is known regarding the value of control on different soils, although observations indicate that

damage is more severe on poor than on more fertile soils; presumably more profit might be derived from control on the less fertile soils.

Tobacco Thrips

Importance. Thrips damage to young peanuts is widespread over most of the peanut-producing areas. The tabacco thrips, *Frankliniella fusca* (Hinds), is the principal species involved, although the flower thrips, *F. tritici* (Fitch), also infests peanuts, living mainly in the flowers (153). *Heliothrips indicus* occurs on peanuts in Sudan (49). *Taeniothrips distalis* Ky. and *T. longistylus* Ky. are reported damaging peanuts in India (159).

Apparently, the first thrips injury to peanuts in the United States was observed by Watson (188) when he collected *F. fusca* from this crop. In 1922 he reported widespread damage in Florida during the spring of 1919. Since that time the insect has been observed throughout most of the peanut-growing section of the country. In addition to peanuts, *F. fusca* attacks tobacco, cotton, beans, peas, Irish potato, oats, cocklebur, dewberry, evening primrose, crabgrass, tomato, vetch and many other plants (67, 101).

Thrips attack peanut plants most severely while they are small. The upper surface of the developing leaflets are rasped by the insects and as the leaflets unfold they have a scarred and even deformed appearance. Farmers often refer to damaged peanuts as "possum-eared," a term quite suggestive of the appearance of the leaflets. The plants fail to grow properly. Where infestations are severe, stunting occurs and the damaged peanuts recover slowly and perhaps incompletely. Thrips damage usually disappears or becomes less acute concurrently with increased rate of growth of the plants; the more rapid growth probably resulting from the nitrogen fixation and favorable climatic conditions.

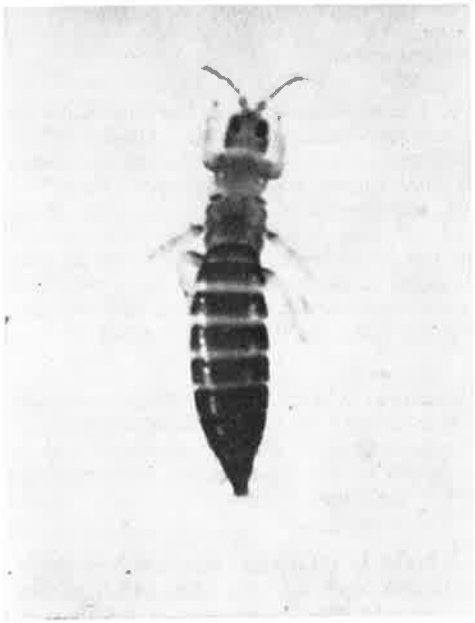

Figure 4. A wingless adult tobacco thrips.

Figure 5. Thrips damage to peanuts. Leaflets at bottom left were protected from thrips.

Thrips injury has been referred to as "pouts." The peanuts, in farmer language, were said to pout until blooming time when growth become more rapid (150). Another condition caused by potato leafhopper has also been called "pouts." It is apparent that the term "pouts" is not specific, and should not be used to designate thrips injury (168).

Recent studies have yielded contradictory evidence concerning the economic damage resulting from thrips infestation on peanuts. As a result of tests conducted at Beltsville, Maryland, it was concluded that (151) thrips reduced the yield of peanuts as much as 37%. Substantial increases in yields were reported, in some instances, from control of thrips in Maryland and Virginia (153). In Alabama, Eden and Brogden (68) found that thrips control significantly increased peanut yields for three of the five years in their study. The authors found that control of thrips on runner peanuts resulted in the setting of fruit earlier than on untreated plants, although no differences in yields were realized. Arant (14) also found that no increase in yield was realized from two early season insecticidal applications on peanuts for thrips control. However, when a fungicide was applied with the insecticide, the yields were significantly increased. In a later test (reported in this same article) several systemic insecticides significantly reduced thrips populations but this did not result in increased yields. Other workers (104, 63) have also reported thrips control with no resulting yield increases. Opinion is obviously divided on this matter. It would appear that under certain conditions of soil and climate, thrips may damage peanuts to such an extent as to reduce yields. Under other conditions of soil and climate peanuts may grow out of the stunted condition resulting from thrips damage and suffer no permanent injury.

Description of stages. Two forms of *F. fusca* adults occur (67), one with shorter wings than the other. The relative length of wings varies also with the distention of the abdomen at the time of measuring. It is not clear from the literature whether the original description of the insect (92) was the short- or long-winged type. In 1905, however, the insect was described (93) under the name *Euthrips nicotiannae* from long-winged females. These descriptions are given below:

Egg

The eggs are deposited in the tissues of the stem and leaves.

Larva, first stage

Length about 0.23 mm.; width of mesothorax 0.11 mm. General shape fusiform. Color of posterior part of thorax and entire abdomen pale yellow; elsewhere pearly white. Head quadrate; eyes reddish. Antennae 0.15 mm. in length; distinctly four-segmented; basal segment cylindrical, short; second ovate, slightly shorter than the third; third slightly conical, the apex joining the second; fourth fusiform, widest near the basal fourth, about equal in length to the other three. The fourth segment is distinctly annulated, the second and third indistinctly so; setae are present on all segments, most numerous on the fourth. Legs translucent white, stout. Abdomen tapering posteriorly; with ten segments, the first eight nearly equal in length, the ninth twice and tenth three times the length of the preceding. Each abdominal segment with longitudinal rows of setae, the ninth with two and tenth with four spines that are four times the length of the setae.

Larva, second stage

Length from 0.6 to 1.17 mm.; width of mesothorax from 0.14 to 0.2 mm.; shape same as in first stage. Color of thorax and abdomen yellowish, with exception of the last abdominal segment. Head quadrate; antennae with four segments, the fourth being more distinctly annulated than in the first stage. Abdomen with the setae increasing in length posteriorly; ninth and tenth segments about equal in length, each less than twice the length of the others.

The young nymph or prepupa

Length, 0.52 to 0.62 mm.; width of mesothorax, 0.10 to 0.12 mm. Antennae translucent, extending forward, much shortened and composed of five segments, first two cylindrical and very short, third and fourth globose, fifth tapering to the apex. The last segment of the abdomen is set with four spines by use of which the young nymph seems to protect itself, when approached by another the abdomen being turned upon it. The wing sheaths are very noticeably separated, the

upper one extending to the middle of the second segment, the lower one to the middle of the third segment. The legs are translucent white, stout.

The full-grown nymph or pupa

Length, 0.68 to 1.22 mm.; width of mesothorax, 0.15 to 0.20 mm. Shape similar to the adult. Color yellowish; head, antennae, wing pads, legs, and caudal segments of the abdomen varying to pearly white. Antennae extending to the middle of the prothorax. Three yellowish ocelli between the eyes, the latter dark red. Wing pads so closely applied as to appear single, extending to the middle of the fifth abdominal segment; length from head to tip of wing pads 0.39 mm. The abdomen is noticeably contracted longitudinally; greatest width, 0.24 mm.; longest setae, 0.078 mm.

Adult

Average length, 1.05 mm. (0.95 to 1.13 mm.); average breadth at middle of abdomen, 0.27 mm. (0.225 to 0.285 mm.). General color of head and thorax light brown or tawny yellowish-brown; abdomen dark brown.

Head about one and one-half times as wide as long, frequently slightly retracted under anterior margin of prothorax; occiput transversely wrinkled, posterior margin strongly thickened and darker in color; anterior margin slightly bisinuate, cheeks approximately straight and parallel. Eyes dark red in color, not protruding, occupying together fully one-half the width of the front of the head and being one half as long as the head; margins around eyes pale yellow in color; surface of eyes finely faceted and slightly pilose; three ocelli present, well separated, posterior ones contiguous with yellow borders to eyes, pale yellow in color and margined inwardly with pale-orange crescents; one moderately stout dark spine in front of each posterior ocellus; postocular spines weak and inconspicuous. Mouth cone reaching nearly to posterior edge of the prosternum, tapering abruptly; maxillary palpi slender, three-segmented. Antennae inserted slightly below front margin, approximate at base, about two and one-half times as long as the head and approximately equal to breadth of mesothorax.

Segment 1 is rounded, three-fourths as long as broad; 2 is broad as 1; following segments about three-fourths as thick; segments 3 to 6 are constricted at bases, becoming more stout successively. Color of segments 1 and 2 uniform light brown; 3 to 5 pale yellow at bases, shading to brown at outer ends, each succeeding segment from 3 to 6 becoming darker in color; 6 to 8 are dark brown. Spines upon segments 2 to 5 are of medium size, but not very conspicuous. Color of head varying from gray-brown to yellow-brown.

Prothorax about five-ninths as long as broad and slightly longer than the head; sides rounded, slightly wider at hind than at fore angles; one stout spine at each anterior, and two stouter spines of equal size at each posterior angle; anterior marginal pair of spines about one-half as long as those at front angles; usual row of five spines on each side of hind margin, of which number 4 is equal in strength to those on the front margin. Mesothorax nearly one and one-third times as wide as the prothorax, broadest posteriorly, sides curving outward; mesonotum without conspicuous spines, posterior margin forming an obtuse angle in middle. Metathorax slightly narrower than mesothorax, sides nearly parallel, broader than prothorax at posterior edge; metanotum bears two pairs of spines at front edge, the inner pair as strong as those at front angles of prothorax. Wings present (probably reduced at some season of year), average length about 0.68 mm., not reaching to the tip of the abdomen, breadth equal to about one-thirteenth of their length; fore wing has two longitudinal veins, each bearing stout spines set at regular intervals; fore wings shaded ash gray, hind wings gray only along basal three-fourths of midvein; spines on wing veins dark brown and conspicuous; costa bears 19 to 24 spines; fore vein, 13 to 18; hind vein, 10 to 12; scale, 5; interior of scale, 1; fringe of hairs on costa of fore wing quite heavy, in length exceeding the breadth of the wing. Legs of medium length, lighter than body in color, pale yellow, shaded more or less with brown on upper side of middle of femora and tibiae; a pair of stout brown spines at inside of tip of each tibia, small brown spines scattered along femora and tibiae; spines standing in two rows on inner side of hind tibiae are weak and only about four in each row.

Abdomen nearly cylindrical to eighth segment, then tapering abruptly to an acute tip; color uniformly dark brown; a still darker-colored narrow chitinous thickening extends across dorsal side of segments 2 to 8 near anterior edge. Three or four quite stout and rather conspicuous dark-brown spines stand at each side of dorsal plates on 2 to 8; six rather prominent spines stand in a row on posterior edge of ventral plates 2 to 7; terminal spines stout and prominent; tenth segment split open along dorsal median line.

Biology. Development of the tobacco thrips is gradual, but approaches complete metamorphosis (75). Eggs deposited in tissues of the foliage hatch in about 7 days in South Carolina (192). The immature form passes through two larval stages, during

which feeding occurs, the two stages requiring 5 to 6 days. According to Hooker (101), the mature larva "crawls to some obscure nook," becomes inactive and pupates.[4] This stage is quiescent and does not feed. At the end of 3 to 4 days the adult emerges and shortly begins feeding. The time for development from egg to adult is approximately 16 days, the period being shorter in warm weather and longer when the temperatures are relatively low.

Breeding of the tobacco thrips is continuous throughout the warmer months. Five overlapping generations have been reported (67) in South Carolina from April 10 to October 18. The female lives for an average of 30 days and deposits 50 to 60 eggs (192). Nonfertile eggs produce males and fertile eggs apparently produce only females (67, 170, 193). Males live for a shorter period than females and are usually less numerous in the field.

The tobacco thrips presumably hibernates under grass or in other protected places. It is possible that intermittent breeding takes place on wild and cultivated host plants during the warmer periods of the winter in the southern range of the insect, but specific evidence on this point is lacking. So far as is known, only the adult females overwinter (67).

Volunteer peanuts are a factor in breeding destructive populations of thrips. Many peanuts lost at harvest remain in the ground overwinter and germinate the following spring. Usually these volunteer plants emerge a few weeks earlier than the regular crop. The thrips multiply on the volunteers and then migrate to the younger plants, where peanuts follow peanuts in rotation. Doubtless other early host plants are also of importance in this respect.

Control. Heavy rainfall is one of the most effective natural controls of tobacco thrips. This fact was noted as early as 1907 (101). Predaceous insects are also of value in reducing the population. A true bug, *Triphleps insidiosus* Say, was reported as feeding upon *F. fusca* (101). The ladybird, *Hippodamia convergens* Guerin, and a lacewing, *Chrysops* sp. have been reported as predators of *F. tritici* (193) and these forms probably prey on *F. fusca* also.

Chemical control of tobacco thrips is not difficult. The first insecticidal control treatments consisted of nicotine-soap sprays (67, 101) and rotenone (112). Arant (14) found that 2% DDT, 20% toxaphene, and 2% Gamma BHC were highly effective in reducing the population of thrips but did not increase the yield. He found that when an insecticide-fungicide dust was applied the yields were significantly greater. In a later test (15) he reported that the systemic demeton gave better control of thrips for a longer period than did DDT or toxaphene; however, when demeton was applied to the foliage it retarded the growth. Effective control of thrips with DDT and toxaphene has also been reported by other workers (3, 10, 12, 66, 143, 145, 146, 150, 154, 195, 196). Arthur and Hyche (17) found that phorate and disulfoton applied to the soil gave good control of thrips but did not increase yields significantly. Eden and Brogden (68) found that phorate, applied at planting, gave good thrips control and significantly increased yields of peanuts for 3 of the 5 years reported in the study. Several experiments have indicated that phorate and disulfoton give good control of thrips on cotton when applied with the seed at planting (137, 142, 145, 158). Recommendations for thrips control on peanuts in most states include disulfoton and phorate.

Data on gains in yield of peanuts resulting from control of tobacco thrips are contradictory. It appears that gains in yield from control depend upon the severity of

[4]The closely related species *F. tritici* usually pupates in the ground (193). It is possible pupation of *F. fusca* may occur in the soil as well as on the host plant.

the thrips infestation, the efficiency of the control, the type of peanut concerned, fertility of the soil, weather conditions, and other factors. Additional research is needed on these points.

For the most recent control recommendations for any given locality the reader should consult current USDA or state insect control publications.

Velvetbean Caterpillar

Importance. The velvetbean caterpillar, *Anticarsia gemmatalis* (Hbn.), is a pest of peanuts in Alabama, Florida, and Georgia. During the past 20 years some damage from this insect has occurred locally each year, and severe outbreaks over the peanut-growing sections of these states were recorded several times (11, 12, 72, 87). Prior to this time the insect had been considered of little or no importance on peanuts, although it had received some attention on other crops.

A. gemmatalis damage to velvetbeans in Florida in 1903 was described by Chittenden (45). For several subsequent years, damage from the insect appears to have been observed primarily on velvetbeans. In 1918, Watson (188) reported *A. gemmatalis* attacked peanuts only when the crop was grown adjacent to velvetbeans, and stated that the adults had never been known to oviposit on peanuts under natural conditions. Later Watson (189) reported extensive velvetbean caterpillar damage to peanuts and soybeans. Additional damage to crops has been listed by others (65, 71, 87, 95, 155). Purswell (155) concluded that the insect causes economic damage to peanuts, soybeans, kudzu, alfalfa, and velvetbeans, and also attacks cowpeas, string beans, lima beans, sesbania, black locust, horse bean, and cotton. Severe damage to crops has been reported from Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas.

The velvetbean caterpillar feeds upon the leaves of peanuts. Heavy infestations cause complete defoliation of the plants, including destruction of terminal buds. The

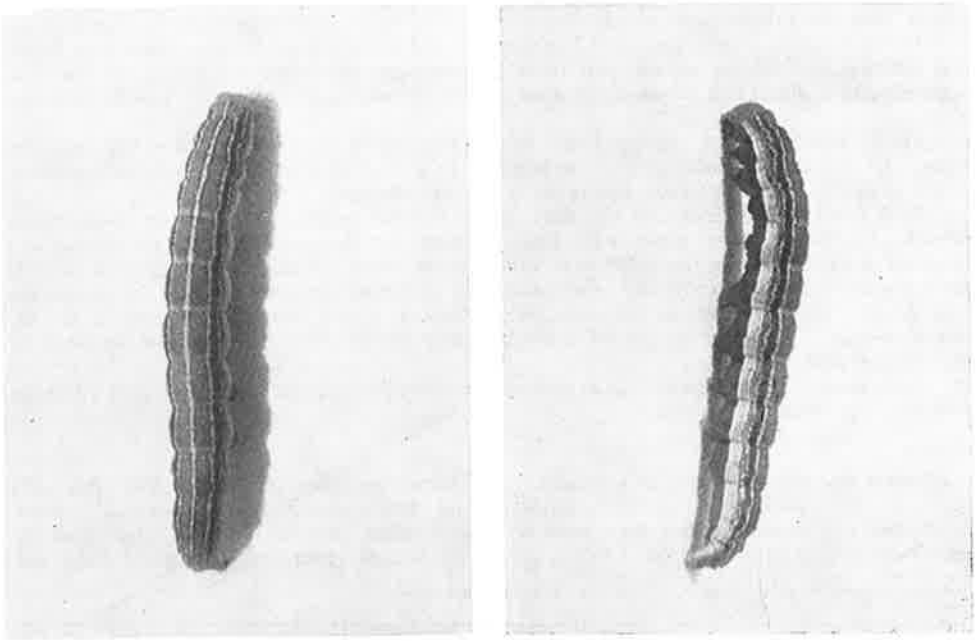

Figure 6. Velvetbean caterpillar.

yield of peanuts is reduced and additional losses result from the shedding of pods in the soil at harvest (11, 72). The yield of hay is also reduced.

Reliable data on losses from velvetbean caterpillar are difficult to obtain. In 1944, the estimated loss in Alabama was placed as high as 10 million dollars, approximately one-third the value of the crop in the State (155). In 1946, the loss in Georgia was estimated at 4 million dollars, and the saving resulting from control at nearly 10 million dollars; in Alabama the loss was estimated at 500 thousand dollars and the saving from control at over 5 million dollars.[5]

Description of Stages. Descriptions of the stages and notes on the appearance of velvetbean caterpillar have been published by several writers. The descriptions of immature stages given are by Watson (187):

Egg

The egg is nearly 2 mm. in diameter and somewhat less in height, and flattened on its lower[6] surface. It is prominently ribbed and white until about a day before hatching, when it turns a delicate pink . . . The eggs are laid singly, mostly on the underside of the leaves, although many are found on the upper surfaces and some on the petioles and stems.

Larva[7]

First instar. The newly hatched caterpillar is about 2.5 mm. long and grows to be from 6 to 7 mm. before molting. The head is light brown in color, rounded, bilobed; mouth shining; eyes black. The body is of a uniform light green color without any trace of longitudinal stripes. The tubercles are black and conspicuous; setae also black. The prolegs on abdominal segments 3 and 4 are about equal in size but are much smaller than those on segments 5 and 6 and are not used for walking. A glance at the prolegs is the most ready means of distinguishing the first and second instars. The legs are light brownish yellow.

Second instar. The markings are now very similar to those of the next instar but are somewhat less pronounced. The most conspicuous longitudinal mark is the black border to the lateral line. The papillae are black as in the first instar, but there is around the base of each a light-colored ring. The first pair of abdominal prolegs, as in the first instar, is less than a fourth as long as the third, weak, and not used in walking or clinging; but the second pair is about half as long as the third. These, too, are ordinarily not used in walking but occasionally are so used.

Third instar. Head rather square in outline, strongly bilobed, yellowish; ocelli black; mouth dark brown. Body cylindrical; all prolegs used for walking, but the first pair may be somewhat shorter than the others, light yellow; dorsal line pale white, somewhat broken, margined on each side by a darker border. Subdorsal line very pale and indistinct, bordered as dorsal line; lateral line indistinct and broken, narrow, pale white. Substigmatal line wider and continuous but of a paler color than dorsal and subdorsal. Ventral surface yellowish green. Stigmata brown. Tubercles black.

Fourth instar. Dorsal, subdorsal and sub-stigmatal lines more distinct than in the third instar. All feet used in walking, but the first and to a lesser degree the second pair noticeably shorter than the others. Otherwise this instar is very like the third.

Fifth instar. Also similar to the third instar, but the longitudinal lines are more clearly defined. Papillae are now white with brown apexes. In the area between the dorsal and subdorsal lines there are a few white dots with a brown border. One of the largest of these is situated near the anterior border and subdorsal line on abdominal segments 1-8. On the metathorax it is double. Stigmatal line is brownish yellow, broken, widely bordered with white on the ventral margin. In the lighter colored individuals this line is often a rich yellow bordered by lines of deep pink.

Sixth instar. The stigmatal line is colored like the lighter forms of the fifth instar, but the pink is usually replaced by brown.

Pupa

Brown in color, smooth and shining. Abdominal segments punctuated with fine dots which are particularly thick on the anterior half of each segment. Head somewhat pointed. At the end of the abdomen are three pairs of hooked spines, one pair is much larger than the others. Length 18-20 mm., width 4-6 mm. The pupa is light green until it is about a day old.

[5]Estimate complied by U. S. Bureau of Entomology and Plant Quarantine.
[6]Surface attached to the leaf.
[7]The description given is of the dark phase. As pointed out by Guyton (87) and others, great variation in color occurs after the first instar. The vigorous manner in which the larva wiggles upon being disturbed is an important distinguishing characteristic in the field.

Adult

No entirely adequate description of the adult has been found. A description based on reports of Chittenden (45), Watson (187), Douglas (65), and observations of the authors follow:

The moth averages approximately 37 mm. across the outstretched wings from tip to tip. The body is stout and narrowed at the apex, measuring approximately 12 mm. from head to tip of abdomen. The color varies from grayish tan to dark reddish brown. Under a hand lens the wings have a peppered appearance, black specks showing on a lighter surface. A line which may be lighter or darker than the rest of the wing extends diagonally across the outstretched wings from near the anterior distal tip of the fore wing to the mid-posterior margin of the hind wing. When the wings are at rest this line may appear as the segment of a circle. The part of the wings distal to the line is darker than the proximal part. The wings are bordered with a brown or yellowish line and are heavily fringed with gray or brown. On the under side of the wings is a row of white dots, consisting of 7 dots on each wing. This color pattern is less variable than that on the upper surface. In the field, a character of value in recognition of the moth is its rapid, spasmodic flight. When disturbed it rises quickly, flies rapidly a short distance, and settles suddenly into the foliage of the host plant.

Biology. Life-history studies of the velvetbean caterpillar have been made by numerous authorities (65, 95, 155, 187), but many facts concerning the biology of this species are still unknown. Apparently the insect does not overwinter in the United States except in southern Florida. Watson (187) recorded the presence of adults in southern Florida as early as May 1 and found the northward flight of the moth reached southern Georgia and Alabama by Septemeber 1. Subsequently, other investigators have observed the northward migration of moths during the summer months and it has been assumed that overwintering occurs only in southern Florida, Cuba and nearby islands. During recent years, the increasing damage and early appearance of the insect in southern Alabama and Georgia have led to some speculation as to whether the species is becoming acclimated to a more northern habitat. Attempts to carry immature and adult stages overwinter at the Wiregrass Substation of the Auburn University Agricultural Experiment Station in southeastern Alabama have been unsuccessful (10). Thus it appears that overwintering does not occur as far north as southern Alabama, although larvae have been collected in Houston County, Alabama, as early as June 21 (11). The northern limit of the species' overwintering range is not known.

The moth of the velvetbean caterpillar is active principally at night or during twilight. Large numbers in flight may be seen along highways at night. Oviposition also occurs mainly at night or during dark days. Eggs are deposited singly on the underside of the leaves of peanuts and other host plants. Some are also placed on the upper surface and petioles. Rank foliage is preferred for oviposition and there is a tendency to avoid peanut fields where plants are small and foliage sparse, unless the population of insects is very great.

Development from egg to adult requires approximately 4 to 5 weeks during late summer and early fall. The time has been reported as approximately 30 to 43 days on velvetbeans in Florida (187), 30 to 36 days on soybeans in Louisiana (65), and 32 to 36 days on peanuts in Alabama (155). The egg hatches in 3 to 5 days and the caterpillar feeds 16 to 26 days. Pupation usually occurs in the soil at a depth of one-eighth inch to one and one-half inches. Some larvae pupate on the surface of the ground under litter and occasionally rolled in a leaf, especially on such plants as soybeans and kudzu. The insect remains in the pupal state 7 to 15 days during warm weather.

Little is known regarding the biology of the adult of the velvetbean caterpillar. As mentioned previously, many of the moths fly northward for many miles and the females then oviposit. Information on mating habits, preoviposition period, oviposition period, total egg production, and longevity is unavailable to the authors. Exact infor-

mation on the distance traveled by moths in flight is lacking as is much other pertinent information on the biology of this pest. It is known, however, that the moth flies much further north than the insect can overwinter in any stage.

Several generations of the velvetbean caterpillar may occur during a season in Alabama, Georgia, Louisiana, and northern Florida. Three distinct generations were reported in 1929 (65) in Louisiana. Four generations were reported in Alabama in 1946 from the middle of June to the first of November (155). Larvae of the second and third generations cause serious damage to peanuts if the initial infestation occurs early and conditions are favorable for the multiplication of the insect.

Additional research is needed on the biology of the velvetbean caterpillar to determine breeding habits, flight, hibernation, host plant relationships, relation of temperature to development and survival, and factors influencing abundance, such as climatic conditions, diseases, parasites and predators.

Control. Natural enemies and climatic conditions are of value in reducing the population of the velvetbean caterpillar but cannot be depended upon for control. Douglas (65) reported seven species of birds, a predaceous wasp, a hymenopterous parasite, and a parasitic fungus attacking the caterpillar. Hinds and Osterberger (95) reported several parasites and predators, including a Tachinid, *Winthemia refopicta* Bigot, which parasitized as high as 70% of the caterpillars. They also described a parasitic fungus identified (95) as *Spicaria prasina* (Maulk.) Saw, considered synonymous with *Botrytis rileyi* observed by Watson (187). Apparently the same fungus, described by Purswell (155) and now known as *Spicaria rileyi,* has caused 30% fatality to velvetbean caterpillars in fields near Dothan, Alabama. Insect enemies of the velvetbean caterpillar includes *Sphex pictipennis* (Walsh), *Solenopsis geminata* (F.), *Calosoma sayi* (Dej.), *C. scrutator* Fabr., *Posidus maculiventris, Proxys punctulatus, Stiretrus anchorago* (Fab.), *Ephialtes aequalis* (Prov.), *Ophion bilineatum* Say, and *Brachymeria ovata* (Say). Dry weather also appears to be deterimental to the multiplication of velvetbean caterpillar.

Insecticidal control of the velvetbean caterpillar on peanuts has been found profitable. Early control practices consisted of applying arsenicals, such as Paris Green, lead arsenate, and calcium arsenate, but considerable burning of foliage resulted. Douglas (65) found sodium fluosilicate was highly effective and safe on soybeans. Ellisor and Floyd (70) found cryolite to be somewhat less toxic to velvetbean caterpillar than calcium arsenate and acid lead arsenate, but the degree of toxicity indicated the possibility of cryolite as a control for the insect. Guyton (87) reported the effective use of lead arsenate on peanuts without injury to foliage. Eddy (66) and Bissell and Alden (29) recommended cryolite on peanuts. English (72) found cryolite and 3 percent DDT dusts highly effective. Moderate gains in yield of peanuts resulted from one timely application of these dusts, and where digging was delayed 10 days fewer peanuts were lost in the soil on the dusted plots than on untreated areas. The retention of the pods by the dusted plants at harvest was especially significant and accounted for most of the benefit derived from dusting. Cryolite, DDT, and benezene hexachloride have been reported as highly effective (11). Protection from caterpillar damage by these materials resulted in gains in yields of 302 to 573 pounds of dry peanuts per acre.

Carbaryl, methyl parathion, methoxychlor, carbofuran, and monocrotophos have now been added to the list of effective materials (6, 182). Present recommendations for control in most states include methyl parathion, carbaryl, and methoxychlor. These materials should be applied as soon after eggs hatch as possible, or as soon as feeding

is noted. Methoxychlor or methyl parathion should not be applied less than 7 or 15 days before harvest, respectively.

For the most recent control recommendations for any given locality the reader should consult current USDA or state insect control publications.

Two Minor Foliage-Feeding Pests

Beet Armyworm. The beet armyworm, *Spodoptera exigua* (Hubner), has been a sporadic pest of peanuts in certain parts of the peanut belt for many years (23). This insect is smaller than the fall armyworm but resembles it. The larva is green and indistinctly striped. It reaches a maximum length of about one and one-fourth inches. In a few isolated instances it has caused serious defoliation of peanuts. Late instar larvae are very difficult to control on peanuts (23).

Red-necked Peanutworm. Larvae of the red-necked peanutworm, *Stegasta basqueella* (Chambers), have caused severe damage to peanuts in Brazil (32) and occasional minor damage in the United States (18, 28, 88). Feeding is generally confined to unopened leaflets. Published proof of economic damage to peanuts by this insect is unknown to the authors.

Some Factors in Control of Foliage-Feeding Insects

Foliage-feeding insects do not usually occur in pure populations on peanuts. Control measures are more often needed for a complex of several foliage-feeding species than for a single species. Control of leaf spot and other diseases may also be involved in a combined operation.

As reported earlier in this chapter early season control of thrips and leafhoppers is commonly obtained by the application of disulfoton or phorate at planting. Corn earworm, fall armyworm, and velvetbean caterpillar (as well as thrips and leafhoppers that occur later in the season) may be controlled with an insecticide such as carbaryl or methyl parathion applied as needed or regularly added to materials used for disease control. Other materials which will provide good control of these pests are discussed in the previous sections devoted to the specific pests. The granulate cutworm is not controlled well with materials mentioned above or any other materials now (1972) having federal labels for use on peanuts. However, promising new materials for cutworm control are discussed in the earlier section on that insect.

Precautions concerning the use of materials mentioned here and sources of original information concerning the use of these and other materials are given in the sections devoted to specific foliage-feeding pests.

State or USDA recommendations should be followed, if available, in controlling the insect-disease complex on foliage of peanuts.

SOIL INSECTS

Lesser Cornstalk Borer

Importance. During recent years, damage to peanuts by the lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller), has occurred with regularity. In addition to injuring peanuts, the borer attacks a wide variety of plants including soybeans, field peas, sorghum, and 59 other plants (176).

Peanut seedling damage may occur when peanuts are planted extremely late; however, borer damage generally occurs to pegging plants. Leuck (118) recognized two

broad types of damage. One is caused by the small larvae that feed in the vegetative buds and flower axils, on stems at the ground level, on leaves touching the soil, and on leafy debris under the plant. The second type of damage is caused by the larvae feeding on the pods and pegs. The first and second instar larvae feed only a short time in the flower axils and then move to or below the soil surface to feed. The pod damage consists of a honeycombed declevity type scarification usually extending the length of the pod. The larvae often construct tubes of silken webbing, sand particles, and excrement. These are attached to the feeding site on the plant and serve as housing for the borer. Pod penetration consists of a single small hole with typical webbing attached. The larvae usually penetrate the peg end of the pod and feed on the kernel surface sometimes consuming both kernels completely. The larvae penetrate the peg at the tip and tunnel up into the peg as far as 1½ inches (118).

Description of stages. The descriptions given are taken from Luginbill and Ainsley (125).

Egg

The egg is ovate, circular in cross section, 0.67 mm. in length and 0.46 mm. in diameter; greenish white when first laid and turns pinkish in about 24 hours.

Larva

First instar. Length 1.7 mm. Head slightly bilobed, flattened, dark brown, width 0.23 mm., clypeus triangular, 0.11 mm. high. Body pale yellow to yellowish green; posterior portion of each segment bright red to reddish brown on dorsum. These areas are joined by faint stripes, some distance apart, of the same color giving the larva a longitudinally striped as well as transversely banded appearance. Abdominal segments except terminal crossed transversely through the middle by shallow grooves on dorsum. Thoracic feet pale; abdominal prolegs whitish.

Second instar. Length 2.7 mm. Head slightly bilobed, flattened, blackish brown, width 0.29 mm., clypeus 0.14 mm. high. Body pale yellow; transverse bands and stripes adjoining as in preceding stage. Thoracic feet pale to dusky; abdominal prolegs same as venter of body, pale yellow.

Third instar. Length 5.7 mm. Head as in second instar except paler, width 0.44 mm., clypeus 0.20 mm. Body pale greenish white to pale yellowish green; transverse bands and connecting stripes

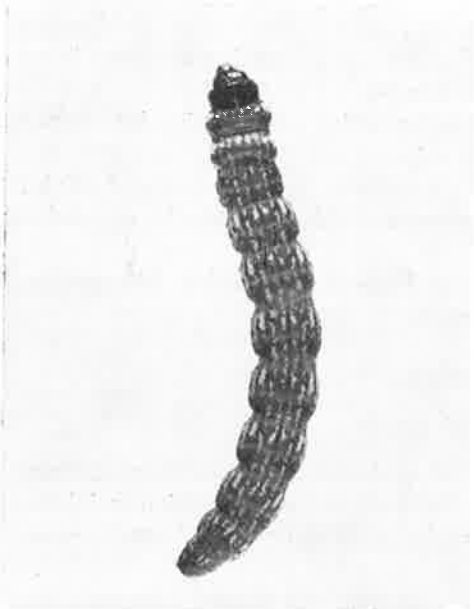

Figure 7. Lesser cornstalk borer larva.

Figure 8. White-fringed beetle.

reddish brown to brown. Thoracic legs dusky; abdominal prolegs pale yellowish green, same as venter.

Fourth instar. Length 6.9 mm. Head slightly bilobed, dark brown, 0.61 mm.; clypeus 0.25 mm. high. Body as in preceding stage except that venter is a deep green color; greenish white more conspicuous and breaking into the transverse bands; stripes joining transverse bands wider than before. Thoracic legs and abdominal prolegs as before.

Fifth instar. Length 8.8 mm. Head bilobed, very dark brown black, width 0.89 mm., clypeus 0.32 mm. high. Body as in preceding stage except that transverse bands are broken up, giving way to pale yellowish white color of the dorsum, the dark color is confined to longitudinal stripes, almost continuous over the body, venter tinged with pale reddish. Thoracic legs and abdominal prolegs as before.

Sixth instar. Length 16.2 mm. Head bilobed, dark brownish black, width 1.11 mm., clypeus 0.43 mm. high. Body green, dorsum greenish white, which breaks up the dark brown transverse bands; longitudinal stripes dark brown. Transverse grooves prominent. Thoracic legs dusky; abdominal prolegs pale.

Pupa

The pupa when first formed is pale green, yellowish on abdominal segments; later brown and preceding emergence of adult black; length 8.1 mm., width 2 mm.

Adult

Head brown to blackish. Labial palpi erect; somewhat longer in the male and more slender. Proboscis long, strong and scaled. Ocelli present. Antennae brownish being slender in the female. Fore wing very narrow, 8-9 mm. long; distal margin oblique, posterior margin waved. The male and female have the same wing markings but they are generally darker in the female. The hind wings are white, somewhat grayish or brownish along anterior and distal margins and at apex. Abdomen yellowish to fuscous, darker in female.

Biology. Most eggs are laid singly on the leaves, stems, and in the soil. These eggs require about 3 days to hatch. The larvae pass through 6 instars and mature in 13 to 24 days. The pupae are usually found in cocoons at or near the end of the larval tubes. The duration of this stage is about 10 days. Moths are most active in the field after dark when the air is still, humidity is low, and temperatures exceed 80° F. The moths lay from 100 to 200 eggs. Under optimum conditions the cycle from egg to adult can be completed in 25 to 30 days. There are 3 and a partial 4th generation during the normal crop-growing season in Georgia. The pupa seems to be the predominant overwintering stage. The pupae are found under leafy debris or just beneath the soil surface (117).

Control. Leuck and Dupree (119) found that insect parasitism is a contributing factor in lesser cornstalk borer control and often reduces infestations significantly. Observations on parasitism of the lesser cornstalk borer were made in the Piedmont and Coastal Plain regions of Georgia from 1954 until 1963. Two insects were found parasitizing the egg: *Telenomus* n. sp. and *Chelonus* n. sp. Five larval parasites were found: *Pristomerus pacificus melleus* Cushman, *Orgilus* n. sp., *Bracon mellitor* Say, *Stomatomyia floridensis* Townsend, and *Plagiohrosphenysa parvipalpis* (Wulp). In larvae collected between July 29 and September 13, 1963, parasitism ranged from 39.3 to 61.2% (119). *S. floridensis* was well represented in all collections and the dominant species in many collections.

Walton (186) found that field conditions, such as moisture, soil texture, and nearness to sorghum fields have an effect on borer damage. Walton's data indicated that the extent of damage to irrigated peanuts was about one half that to non-irrigated peanuts. Fields having loose soil described as deep sand or sand had approximately 2 to 3 times as much damage as the loam or sandy loam soils. Walton also found that as sorghum matures the borers move to peanuts.

The date of planting should be considered if the borer has been a problem. Borer populations often peak in mid-August in Georgia. If peanuts are planted near April 1, the bulk of the borer population may be avoided (118).

In tests in Texas the best control was obtained with DDT or parathion applied when mature borers appeared and at 3- to 4-week intervals thereafter as needed (186). Recent work in Georgia (79) and Alabama (24) indicates that applications of granular parathion or Dyfonate® (O-ethyl S-phenyl ethylphosphonodithioate) or spray applications of monocrotophos offer promise for control of this insect. No good chemical control recommendation for this insect on peanuts is presently available. However, monocrotophos, parathion, Dyfonate®, and other chemicals may offer future relief. More research is obviously needed on control of the lesser cornstalk borer on peanuts.

White-Fringed Beetles

Importance. White-fringed beetles, *Graphognathus* spp., are potentially one of the worst pests of peanuts in the southeastern United States. At the present time, state and federal efforts to eradicate, suppress, or contain this imported pest have prevented widespread losses to peanuts. The white-fringed beetle's first appearance in the United States was in 1936 when it was found causing damage to cotton and peanuts in northern Florida (190, 191). Shortly thereafter it was discovered in southern Alabama. In spite of rigid quarantines and intensive control work which has restricted the dispersal of the pest, it is established[8] in Texas, Louisiana, Arkansas, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Tennesee, Kentucky, Virginia, and Missouri (8).

The white-fringed beetle is native to Argentina, Chile, and Uruguay in South America. It has been introduced into the United States and also into Australia (5, 185).

Larvae of the white-fringed beetle feed upon underground parts of peanuts and damage the stand and yield. Adults feed upon the foliage. Uncontrolled, heavy infestation may cause a complete loss of the peanut crop. One report (203) showed an average of 283 larvae per square yard in peanut fields and upon emergence as high as 44 adults on one plant. In addition to peanuts, the insect feeds upon several hundred other species of plants, including cotton, velvetbean, soybean, lespedeza, lima bean, okra, sweet potato, cowpea, chufa, corn, tomato, clovers, many ornamentals, and numerous other cultivated and wild plants (203).

Description of stages. The adult white-fringed beetle was originally described in 1840 by Boheman as *Naupactus leucoloma.* Very brief descriptions of the egg and larvae have been made by several investigators.

Egg

The egg is approximately 0.9 mm. long and 0.8 mm. wide, and is oval in shape. The color when freshly deposited is milky white; the color changes to dull light yellow after 4 or 5 days.

The eggs are deposited in masses, ranging in number from a few to as high as 60 or more, but the usual number is from 15 to 25. The individual eggs and masses are covered with a gelatinous substance which makes them adhere to one another and to objects or the soil. —Young *et al.* (203).

Detailed technical descriptions of the larva are not available to the writer. A very brief description by Young *et al.* (203) follows:

Larva

The full-grown larva averages approximately one-half inch in length. The body is yellowish-white, fleshy, more or less curved, legless, and sparsely covered with hair. It consists of 12 much-folded segments, which are interrupted by two sublateral longitudinal grooves running the length of the body. The dorsal portions of the segments are bulging; the ventral portions are flat. On the sides, above the longitudinal separating grooves, small spiracles are present on all segments except the second, third, and twelfth (last).

[8] 1971.

Anderson (4) has published a key with drawings for separating *Naupactus (Graphognathus) leucoloma* from related species. This key is reproduced below:

1. With a group of several spinules dorsally on stipes at proximal end of the longitudinal row of strong setae of maxillary mala.....2
   Without spinules at proximal end of the longitudinal row of strong setae of maxillary mala. .....*Pantomorus godmani* (Cr.)

2. Eusternum of mesothorax with minute spinules[9] between and behind the two sternal setae. Scutellar setae I, II, and IV on the first four abdominal segments slender and awl-shaped (= subulate).....*Artipus texanus* Pierce
   Eusternum of mesothorax without minute spinules[9] Scutellar setae I, II, and IV on the first four abdominal segments stout and spindle-shaped (= fusiform).....3

3. Margin of posterior third of head capsule broadly arched. Paired epipharyngeal sclerome distinctly U-shaped, basal part with distinct anterior margin which forms a clear-cut angle with exterior margin of inner arm, and with inner arm about twice as long as antero-posterior extent of base.....Naupactus, n. sp.
   Margin of posterior third of head capsule ogival. Paired epipharyngeal sclerome not distinctly U-shaped, basal part with obliterated anterior margin, exterior margin of inner arm roundly connected with interior margin of outer arm, and with inner arm not longer than antero-posterior extent of base.....*Naupactus leucoloma* Boh

Adult

Buchanan's 1939 description of the *G. leucoloma* adult follows (37):

Length, 8-12 mm. Brownish gray to gray, apical declivity of elytron usually paler than disk, the latter sometimes indistinctly variegated with gray and pale brown. Scales moderately dense, setae long and conspicuous, elytral scales in general broader than those on head and pronotum; elytral setae of unequal lengths, the longer ones fine, often somewhat kinky apically in dried specimens and two or three times as long as the shorter ones, the latter brown to whitish; elytral puncture rows, at low magnifications, appearing as narrow, dark lines.

Vestiture on head and rostrum brownish in general, white above and below eye and on side of rostrum below scrobe, the scales on subapical area and on mandible very small, often somewhat coppery or greenish, the setae on front inclined, those above eye and on rostrum above suberect; nasal plate with its posterior margin elevated; median groove much widened anteriorly, the widest portion sometimes about one-fourth width of dorsum of rostrum; scape reaching hind margin of eye, funicular segment 2 considerably longer than 1, often nearly twice as long, longer than 3 and 4 together; eye distinctly elliptical. Prothorax wider than long (about 7 to 5), sides broadly and subevenly rounded; pronotum with broader white and narrower brownish scales, the white ones forming a narrow, median line toward apex and base (rarely complete), a curved, often indistinct, stripe beginning opposite elytral interval 3, and a lateral stripe which is often incomplete anteriorly, the disk sometimes with small, vague, scattered, whitish spots; pronotal setae curved, inclined on disk, more nearly erect laterally; pronotum (with scales removed) irregularly punctate and feebly rugo-granulate, median groove feeble or obsolescent. Elytral intervals faintly convex, each with about 3 or 4 confused rows of setae, the longer ones more abundant on apical declivity, the length of each longer seta equal to or greater than the width of the interval; white stripe covering interval 7 throughout, about apical two-fifths of interval 6, and basal half or more of interval 8, the stripe bordered mesad (on striae 5 and 6) by a broken, usually indistinct dark line and bordered laterad (on stria 8) by a narrow, blackish line. Body beneath scaly and setose, the setae longer and more nearly erect medially, the abdominal scales progressively finer from base to apex, abdominal vestiture sparser medially; metasternum a little longer than in *G. peregrinus*. Legs with abundant, mostly seta-like, prostrate and suberect vestiture; fore tibia with short, well separated denticulations; posterior face of hind tibia with a usually distinct ridge from base to about middle.

Biology. Only one generation of white-fringed beetles occurs annually. The eggs are deposited on the surface of the ground, usually on or next to debris (sometimes in the soil) during the summer and fall. All adults are females and each beetle deposits an average of slightly less than 800 eggs. The eggs develop parthenogenetically, hatching in about 2 weeks during warm weather. The larvae pass the winter in the soil and cause damage to crops, principally, the following spring and summer. It is at this time that the stand of peanuts may be seriously damaged. Adults emerge from

[9]The presence or absence of these spinules can be ascertained readily on specimens treated with caustic potash and on uncleared specimens when properly lighted, by studying them with a magnification of about 75 diameters.

May until November (202), the peak of emergence coming in July. Rainfall stimulates emergence. The beetles feed a few days and gradually disperse over the nearby areas. Since the elytra are fused together and the adults cannot fly, dispersal is by crawling and the distance traveled is less than 1 mile. Eggs are deposited and the adults die 2 or 3 months after emergence. Apparently few beetles over-winter in southern Alabama (202, 203) but adults have been found throughout the winter in the vicinity of New Orleans, Louisiana (122).

Control. Natural enemies are apparently of minor importance in control of white-fringed beetles. Strong (178) reported that no natural enemies of *Graphognathus leucoloma* had been found in studies through 1938-39. Glaser *et al.* (83) reported a nematode, *Neoplectana glaseri* Steiner, parasitizing *G. leucoloma* and related insects. Swain (179) reported *N. glaseri* attacking *G. perigrinus* and *G. leucoloma;* also *N. chresima* Steiner in *G. perigrinus.* Later he reported (180) *Diplogaster* sp. capable of parasitizing white-fringed beetles, but stated that this was a parasite of minor importance.

Much of the first control work on white-fringed beetles was in the nature of locating infestations, confining the insect in local areas, suppressing and, if possible, eradicating it. Federal and state quarantines have been in force and clean-up campaigns have been conducted.

Much progress has been made in the control of this insect on peanuts and other crops. Calcium arsenate and cryolite dusts, clean cultivations, herbicides for the destruction of wild host plants, and the use of soil fumigants such as methyl bromide and carbon disulfide were among the first control recommendations (142). Early work with DDT indicated that it was 69 to 74 times as effective as cryolite (201). Later, aldrin, dieldrin, and heptachlor (34) and chlordane (7) were added to recommended materials for white-fringed beetle control. At the present time chlordane is the most commonly recommended material for control of white-fringed beetle larvae in peanut fields (6). Close attention should be paid to label restrictions when using these materials.

Foliage feeding by adults of the white-fringed beetle seldom justifies control measures, but when such foliage feeding is severe the adults may be controlled by the application of almost any of the insecticides commonly used as foliar dusts or sprays on peanuts.

Since the major part of the research on white-fringed beetles is being conducted by the Entomology Research Division of the USDA, this agency should be consulted for latest recommendations on control.

Limited information is available on the effect of rotation and other cropping practices on control of the white-fringed beetle. Additional research is needed on these points. Additional information is also needed on the long-time effect of soil treatments with chlordane on productivity, soil organisms, fish and wildlife, and water supplies.

Other Soil Insects

Several species of soil insects attack peanuts and cause an undetermined amount of damage. In addition to the white-fringed beetle and lesser cornstalk borer, which are discussed in another section, damage to underground plant parts is caused by several species, including southern corn rootworm, lavae of the banded cucumber beetle, two species of wireworms, white grubs, and a burrowing bug.

Figure 9. Southern corn rootworm adult.

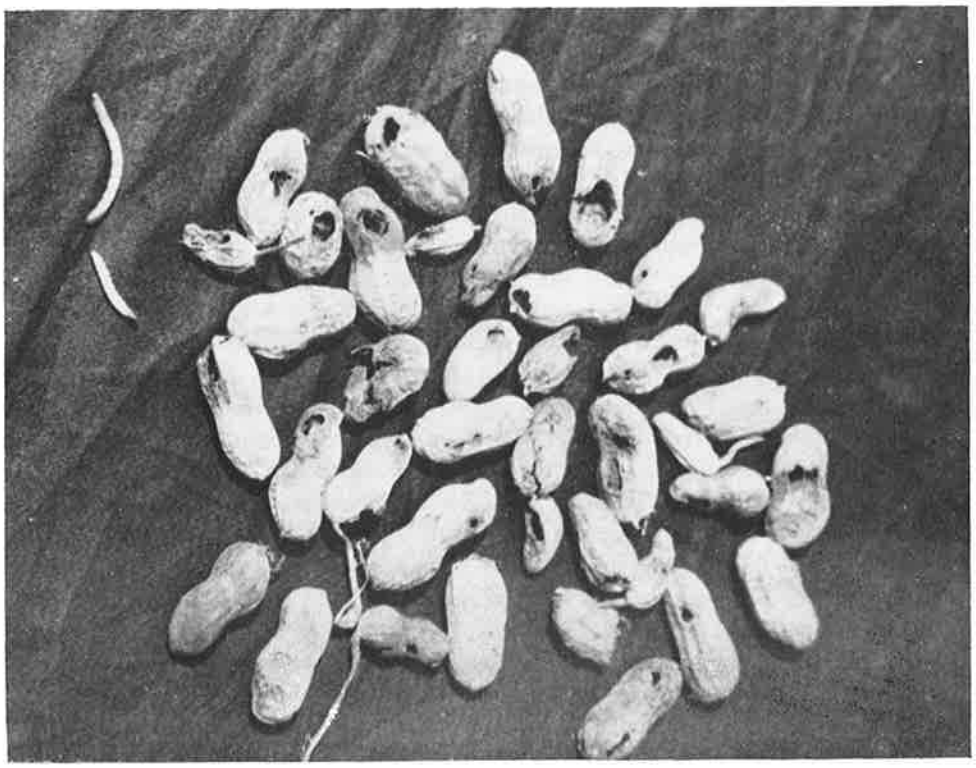

Figure 10. Peanut pods showing damage by wireworms and *Diabrotica* larvae.

Southern Corn Rootworm. This insect is the larva of a 12-spotted leaf beetle, *Diabrotica undecimpunctata howardi* Barber, commonly called the spotted cucumber beetle. The life history and habits of the insect are well known (9, 106, 172, 181). Both adults and larvae are polyphagic in their feeding habits, several hundred species of plants serving as hosts. The foliage of cucurbits and many of the legumes are among the preferred foods of adults. Eggs are deposited in the soil and the larvae develop upon underground parts of many plants including young corn and the pods of peanuts. The time for development from egg to adult is 30 to 40 days during warm weather. Adults over-winter only in the Southern States. During the summer months, many adults migrate northward and cause damage to cucurbits and other crops.

One of the first references of damage to peanuts by soil insects was made by Fink (76), who found southern corn rootworm attacking young peanut pods in Virginia; the nuts within the pods were devoured. Following this report, peanut damage from this insect received little attention until recent years. An average of 12 to 28.1% of the pods was reported as injured during 1945 and 1946 in a study made in Virginia (86). *D. undecimpunctata howardi* and larvae of the related species, *D. balteata* Lec., were found attacking peanut pods in Alabama (10). Because of the difficulty of distinguishing between the two closely related species of larvae, no attempt was made to determine relative abundance. However, the large number of recently transformed *D. balteata* adults found in pupal cells in the soil around the peanuts indicated this species was the predominant one. In 1947 Arant (10) observed as high as 35 percent of the pods injured in some fields, but in this instance a wireworm, *Heteroderes* sp., appeared to be doing much of the damage.

The extent of the damage caused by this species to peanuts has not been clearly evaluated. Apparently the insect is more destructive in Virginia and adjacent states than in the rest of the peanut belt.

Banded Cucumber Beetle. The banded cucumber beetle, *D. balteata* Lec., is a pest of peanuts, beans, vetches, cucurbits, alfalfa, tomatoes and many other vegetables, fruits, and ornamental plants. It is restricted to warm climates, occurring in the U. S. in the Gulf Coast States and California. It is distributed in Alabama from the central part of the state southward (161). The insect is found in the northern extremities of its range only in late summer and fall.

The banded cucumber beetle has been known in Mexico for many years. In 1905 it was found in Texas (46) and in 1922 in Alabama (161). Little is known regarding the habits of the larva. It will feed on underground parts of peanuts, corn, string beans, and doubtless many other plants. Using corn as food for the larvae, Robinson (162) found that approximately 30 days were required for development from egg to adult during warm weather. The number of generations, seasonal abundance, over-wintering habits, and food preferences of larvae and adults in the peanut-growing areas are largely unknown. There is a need for additional research on this insect and an evaluation of its damage to peanuts.

Wireworms. Wireworms of the genus *Heteroderes*[10] were found by the authors damaging peanut pods in Alabama in 1947. Larvae of the genus *Cebria*[10] were also collected from peanuts.

The wireworm, *Heteroderes laurentii* Guer., is widely distributed in the Southeastern States and causes economic damage to a variety of crops, including corn, snapbeans, potatoes, lespedeza, and sweetpotatoes (48). So far as the authors are aware, there is no record of damage from *Cebria* sp. in Alabama or adjoining states.

[10]Identification by Dr. W. H. Anderson, U. S. Bureau of Entomology and Plant Quarantine.

Although definite proof is lacking, it is probable that *H. laurentii* is the species which attacks peanuts. Unlike some wireworms, this species completes its development within one year. It prefers cultivated lands to sod areas. This and other species of the genus *Heteroderes* are limited to tropical and subtropical areas (113).

The major facts regarding wireworm damage to peanuts are yet to be determined.

White Grubs. The larvae of *Strigoderma arboricola* (F.), have been reported doing serious damage to peanuts in Virginia (135). The grubs attacked the peanut pods and often devoured the nuts. Soil fungi *(Rhizoctonia)* apparently invaded the pods through abrasions in the shell and caused rotting of the peanuts. The damage was more severe on soils fairly high in organic matter. The grubs caused 85 percent loss in some fields.

The adult of these grubs is a beetle (Rutelid) 10 to 12 mm. long. The head, thorax, and scutellum are blackish green in color and the elytra are dull brownish yellow (31). The beetles feed on the flowers of wild and cultivated roses and on blackberry blossoms and fruits. On collecting adults from many other plants, Grayson (85) concluded that neither the larva nor the adult was host specific for peanuts, and that grub damage to peanuts in Virginia was of a minor nature during 1944 and 1945.

A Burrowing Bug. Pangeus bilineatus (Say) caused severe damage to isolated fields of peanuts in Texas and Alabama during 1967 and 1968 (23, 88) and has been known as a pest of peanuts for at least 20 years. Other than those mentioned, literature references to *P. bilineatus* as a pest of peanuts are not known to the authors.

This insect is a roundish, shiny-black bug about ⅛ inch long. It resembles stink bugs in general shape and produces a disagreeable odor if handled. The nymphs and adults burrow into the ground under peanuts and suck the juice from the developing nuts causing the nuts to be deformed and have an undesirable flavor.

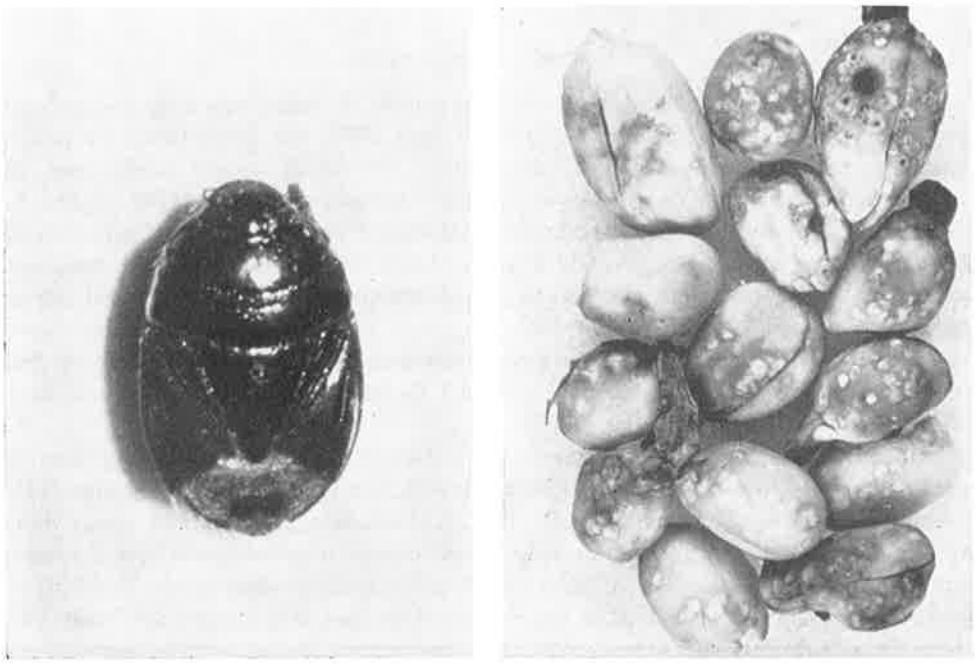

Figure 11. A burrowing bug, *Pangeus bilineatus,* and typical damage to peanuts.

This damage seems to be sporadic, but if these insects continue to occur and spread to other peanut growing regions, *Pangeus bilineatus* could become a major insect pest of peanuts.

Soil Insects of Lesser Importance

Several insects not previously discussed are recorded in the literature as attacking the pods and underground parts of peanuts. These records include the following: Japanese beetle, *Popillia japonica* Newn., attacking peanuts in Japan and a potential pest in the United States; termites in many parts of the world; a mealybug, *Pseudococcus* sp., on peanut roots causing severe damage in Puerto Rico (173); mealybug, *P. solani* Ckll., occurring on peanut roots but causing little damage in Florida (40); pineapple mealybug, *P. brevipes* (Ckll.) on peanut pods in Tanganyika (91); citrus mealybug, *P. citri* (Risso), and also *Phenacoccus hirsutus* Green on roots of peanuts in Egypt (102); larvae of the yam beetle, *Heteroligus claudius* Klug., killing as high as 72 percent of seedling peanuts in the Province of Nigeria (114); two ants, *Solenopsis fugax* Latr. and *Tetramorium coespitum* L., a mole cricket, *Gryllotalpa gryllotalpa* L., and three species of beetle larvae, *Pentodon idiota* Hbst., *Agriotes gurgistanus* Fald., and *Podonta daghestanica* Reitt in North Caucasus (167); the mole crickets, *Scapteriscus acletus* R. & H., and *S. vicinus* Scudd., on peanuts in the Southeastern United States (199); two ants, *Eciton caeca* Latr. and *Ectatomma ruidum* Roger, in Central America (38); the earwig, *Euborellia stali* Dohrn, causing as high as 20 percent damage to peanut pods in southern India (42); several species in Senegal including termites, *Termes natalensis* Hav. which attacks the nuts themselves; white grubs, *Schizoncha africana* Cast., *Anomala plebeja* Ol., *Adoretus umbrosus* F., and *Podalgus (Crator) cuniculus* attacking underground parts; the beetle, *Scydmaenus chevalieri* boring into pods and the ants, *Monomorium bicolor* Em., and *Dorylus fulvus* Westu. eating seeds of perforated pods (166).

Control of Soil Insects

Relatively few studies have been made on control of insects attacking underground parts of peanuts. Soil treatment with DDT and BHC has been found to reduce southern corn rootworm damage to corn (81). Results of control experiments on southern corn rootworm on peanuts in Virginia (86) showed that DDT applied to the soil at the rate of 50 lbs. of technical material per acre resulted in a reduction of 61 to 68% in the number of pods injured. Arant (10) found that soil treatment with DDT, BHC, chlordane, and toxaphene reduced the injury to pods by soil insects on replicated plots in Alabama. In 1949, he found that dusting peanut foliage with toxaphene or DDT reduced damage from *Diabrotica* larvae (13). Effective control of *Diabrotica* has been reported by Fronk and Dobbins (80) from soil applications of BHC, parathion, toxaphene, or DDT.

In 1956, Arthur and Arant reported on a 7-year study of soil-inhabiting pests of peanuts (16). They found several systemic insecticides to be ineffective against these pests, while soil applications of DDT, BHC, chlordane, toxaphene, and aldrin dusts applied in the drill prior to planting reduced the damage to peanut pods by soil insects. Insect damage was reduced and peanut yield was increased when aldrin, dieldrin, or toxaphene granules were applied to the surface of the soil at pegging time. Baush and Alexander (26) tested 65 formulations of 26 compounds against a cyclodiene-resistant population of southern corn rootworm in Virginia. Granular formulations were more

effective than other formulations. Nine compounds gave significant control. In unpublished data, Bass has shown that *Pangeus bilineatus* (Say) can be controlled with chlordane or diazinon granules applied at pegging time (23).

Many of the materials mentioned in this section can be used only under certain conditions and others cannot be used at all on peanuts because of labelling restrictions. For recommendations for specific soil-insect pests of peanuts for given localities consult state extension service or experiment station or USDA recommendation publications.

INSECTS ATTACKING PEANUTS AND PEANUT PRODUCTS IN STORAGE

A host of insects attack peanuts and peanut products in storage, sometimes causing severe damage. Some damage may occur in storage on farms, but the major losses are to buyers, processors, wholesalers, and retailers of peanuts and products derived from them. Insect infestations are much heavier in peanuts after they are shelled (30, 154). Salted peanuts, peanut meal, peanut butter, candies, and other confections are readily infested by insects and the peanut trade must continuously combat these pests.

Many of the forms infesting grain, milled products, dried fruits and other foods also attack peanuts. The exact number of species infesting peanuts is not known, but over 50 species infest grain and grain products (20). Among the more important stored-products pests attacking peanuts are Indian meal moth, almond moth, saw-toothed grain beetle, flour beetles, cadelle, dermestids, and others.

So far as the authors are aware, no adequate estimates are available on annual insect damage to peanuts and their products in storge. A 3-million-dollar loss in the United States was estimated in 1911 (154). In 1943 the Food and Drug Administration (78) reported that, of the 7 million pounds of imported nuts[11] examined in 1943, over 5 million pounds were denied entry because they were wormy or damaged. The major reason for the high percentage of rejections was insect infestation in large shipments of peanuts from Africa.

Different species of insects infesting stored peanuts and peanut products vary greatly in actual damage caused. However, heavy insect infestations render the products unfit for the edible trade regardless of the extent of destruction wrought.

Indian Meal Moth

The Indian meal moth, *Plodia interpunctella* (Hbn.), is a handsome moth with a wing expanse of nearly ¾ inch (20). The fore wings are reddish brown with a coppery luster on the apical two-thirds; the proximal third is whitish gray; the hind wings are dusky gray. The larva is a dirty-white caterpillar often with a pinkish or greenish tint; when full-grown, it is about ½ inch long. According to Popenoe (154) this is the most important insect pest of stored peanuts in the United States. It also causes damage to peanuts in many other parts of the world (39, 127, 133, 140, 166, 177). Larvae of the Indian meal moth feed upon shelled peanuts and spin silken threads which form a matted web. Broken kernels are preferred by this species.

Almond Moth

The almond moth,[12] *Ephestia cautella* (Walk.), is a pest of nuts, dried fruits, and other products including peanuts. The adult has a wing expanse of about ¾ inch.

[11]Several kinds, including peanuts.
[12]Also called fig moth.

The fore wings are narrow, especially at the base, grayish to yellowish in color with dark markings which may appear as zigzag lines or suffused bands across the wings; hind wings are whitish (47). The larva is a whitish caterpillar which may be tinged with pink and green; it is cylindrical and about ½ inch long when full-grown; dark dots in four pairs of rows give the body a striated appearance. The larvae spin silken webs which may appear as masses intermingled with food and excrement. In 1911 peanuts were listed (47) as a stored product attacked by larvae of the almond moth. Since then this species has been found causing economic damage to peanuts in many sections of the world. Almond moth has been reported (30) as very destructive in Georgia. Other reports include those for Senegal (166), Spain (169), Gold Coast (50), and Britain (84).

Saw-toothed Grain Beetle

Both larvae and adults of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), attack peanuts and products derived from them. Bissel and Dupree (30), found this insect to be the most abundant species[13] in shelled peanuts in Georgia; Popenoe (154) listed it third in importance among stored peanut pests. It is recorded infesting peanuts in other parts of the world (19, 165). The adult saw-toothed grain beetle is about 1/10 inch long and brownish in color; the thorax bears 6 saw-tooth-like projections on each side. The whitish larva has a brown head, is small, slender, and slightly longer than the adult. Adults of the saw-toothed grain beetle have been kept alive over 3 years; the average life is 6 to 10 months. Two related species, *O. bicornis* (Er.) and *O. mercator* (Fauv.) occur in this country. The latter species is known to infest peanuts in Senegal (166). Both have feeding habits similar to that of *O. surinamensis.*

Flour Beetles

At least two species of flour beetles of the Genus *Tribolium* attack stored peanuts and products derived from them. The red flour beetle, *T. castaneum* (Hbst.), and confused flour beetle, *T. confusum* Duv., are fairly numerous in shelled peanuts (30). The former species has been considered (154) as second in importance among stored peanut pests in the United States. The two forms have been recorded in peanuts from other parts of the world (Roubaud, (166), *T. castaneum* and *confusum* in Senegal; Jarvis, (108), *T. castaneum* in Australia; Fletcher, (77) and Roepke, (165), *Tribolium* sp. in Pusa and Java; Okuni, (141), *T. castaneum* in Formosa). The flour beetles are elongate, reddish-brown insects about 1/7 inch long. The larvae are brownish white and somewhat flattened in appearance. Adults of the two species may be distinguished by the following differences:

As viewed from the underside of the head, the eyes of the confused flour beetle are separated by about three times the width of either eye, wereas the width of each eye as seen from below in the red flour beetle is about equal to the distance between them. The confused flour beetle has antennae gradually enlarged toward the tip, the red flour beetle suddenly enlarged at the tip; the margin of the head is notched at the eyes in the confused flour beetle and not so notched in other species (131).

Adult flour beetles may live 2 years or more, but the average life is about 1 year (20).

[13]Other than psocids.

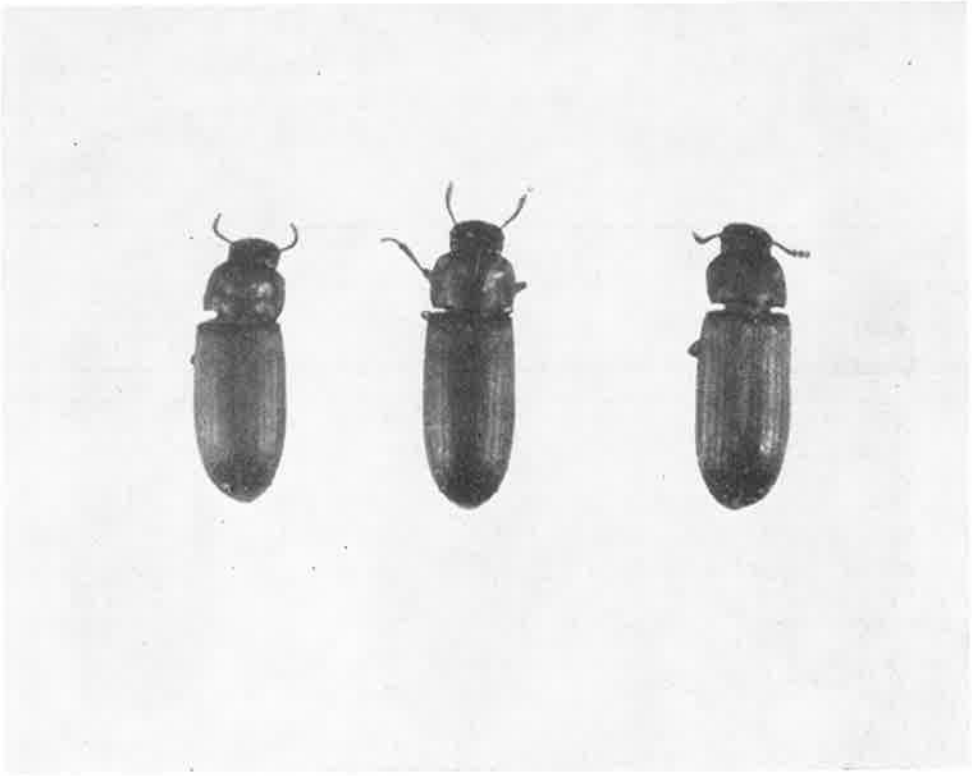

Figure 12. Red flour beetles.

Cadelle

The cadelle beetle, *Tenebroides mauritanicus* (L.), appears to be of importance in peanuts, although literature references to infestations are scarce. It has been listed (154) as fourth in importance among stored peanut pests, and has been found to be one of the more common forms in shelled peanuts stored in jute bags (30). Roubaud (166) reported it infesting stored peanuts in Senegal. The adult is an oblong, flattened beetle, black in color and measuring about 1/3 inch in length. The larva is dirty-white with the head, thoracic shield, and two horny points at the tip of the abdomen black; it is about ¾ inch long when full-grown. This insect is primarily a pest of grain and flour mills. The larvae sometimes bore into wood. Average life of the adult is 1 to 2 years. The extent of its damage to peanuts needs further investigation.

Dermestids

Several species of dermestids infest peanuts. Among the forms recorded in the literature are *Trogoderma bicolor* Arrow in peanuts imported into Holland (41); *Dermestes lardarius* L. in peanuts in Europe (206); *Attagenus gloriosae* imported into Holland (not established) in peanuts (96); unidentified species of dermestids common in shelled peanuts stored in jute bags in Georgia (30). The dermestids are small beetles that are for the most part scavengers, feeding upon animal matter. Forms that feed on plant products probably supplement the diet with dead bodies of other insects (20). Thus, it would appear that the principal damage to peanuts by these pests might be spoilage of products intended for the edible trade.

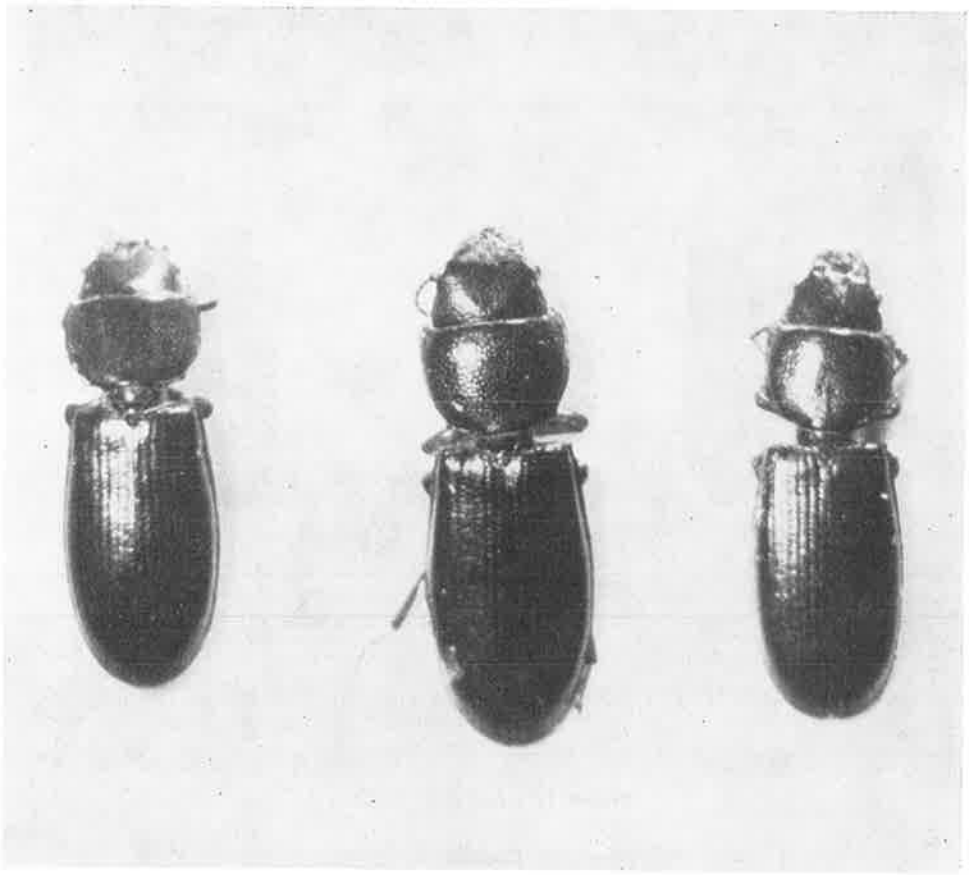

Figure 13. The cadelle beetle.

Other Pests of Stored Peanuts

The Mediterranean flour moth, *Ephestia kuehniella* Zell., may cause economic damage to peanuts. Larvae of this species were considered by Popenoe (154) as sixth in importance among stored peanut insects. However, the authors have found no additional references to this insect infesting peanuts, although it is distributed over many parts of the world.

Bruchids attack peanuts in storage, mostly in foreign countries. *Bruchus chinensis* L. attacks peanuts in Java (164). *Pachymerus acaciae* Gyll. is reported (57) as infesting peanuts and as having spread from Asia to Greece, Italy, and the north and west coasts of Africa. This species is recorded as attacking stored peanuts in Senegal (43) with 59,000 tons of peanuts being destroyed by it (183). Howard (103) referred in a general way to fumigation as a means of protecting peanuts against pea and bean weevils. However, this is the only reference found indicating bruchid injury to peanuts in the United States and it is concluded that such damage is not common.

The flat grain beetle, *Laemophloeus minutus* (Oliv.), a sap beetle, *Carpophilus* sp., the cigarette beetle, *Lasioderma serricorne* (F) and numerous psocids were found (30) in stored peanuts in Georgia and were suspected of being injurious. Other reports include a sap beetle, *Carpophilus* sp., in peanuts in Australia (108); a relative of the cigarette beetle, *Lasioderma testaceum* in peanut cake in Pusa; sap beetles, *C. ligneus*

Murr., *C. hemipterus* L., and *C. decipens,* attacking peanuts in Europe (205), and *C. obsoletus* in Japan (97). All of these insects are cosmopolitan in distribution. With the exception of the cigarette beetle, they are probably incapable of damaging sound peanut kernels but may thrive in peanuts already damaged by other insects or in certain products derived from peanuts.

Five hundred tons of peanuts, imported into California from China, were reported as destroyed by *Aphomia gularis* Zell. of the family Galleridae (60). This species closely resembles Mediterranean flour moth.

Additional reports of infestations in peanuts include the following: Tobacco (currant) moth, *Ephestia elutella* (Hbn.), injuring peanuts in Zomba (129), infesting peanut cake in Senegal (110) and in France (111), and infesting peanuts imported into California from China (61); *Sitophilus oryza* (L.) in shelled peanuts in Fiji (121) and in Georgia (30); *Alphitobius diaperinus* (Panz.), *A. piceus* Ol., and *Corcyra cephalonica* Staint. in Senegal (166); *Homoeosoma vagella* Z. in Australia; *Embia (Monotylota) vayssierei* Navas in stored peanuts in Senegal (156); *Sitotroga cerealella* (Oliv.), Angoumois grain moth, and Tenebrio sp. (meal worm) in stored peanuts in the United States (30).

CONTROL

Natural enemies are of value in controlling pests of stored peanuts, but the species of hosts and parasites involved are so numerous and varied that a detailed discussion here is not feasible. Among the more important parasitic and predaceous forms are *Microbracon hebetor* (Say), *M. judeandis* Ashm., *Idechthis canescens* (Grav.), *Omorgus frumentarius* Rond., and *Scenopinus fenestralis* (L.) (20, 171).

Sanitation and proper bagging have been found helpful in preventing insect damage to stored peanuts. Bissell and Dupree (30) found that peanuts could be protected from serious infestation by storing them immediately after shelling in cotton bags made from heavy material having 60 threads by 104 threads per inch. Jute bags counting 11 or 12 threads per inch did not give satisfactory protection. For maximum protection, properly bagged peanuts should be stored in clean, insect-free bins. To free bins, storehouses, boxcars and the like of insects, the walls, floors and ceilings may be sprayed with malathion EC at the rate of 0.45 lb./1000 sq. ft. (6). This spray should be applied not less than one week before nuts are brought in and all debris removed before storage if nuts are to be used for food or feed. In the case of farmers stock nuts stored in warehouses, malathion WP at the rate of 0.44 lb. in 2 gal. of water per 1,000 sq. ft. may be applied as a surface spray over the top of bulk stored peanuts or to the outside surface of stacked bagged peanuts. Malathion EC may also be applied to stock nuts at the rate of 1.6 lb. in 5 gal. of water per 15 tons of peanuts as a spray as the peanuts travel on conveyor to storage areas (6).

Heat and cold have been employed satisfactorily in preventing insect damage to peanuts and peanut products in storage. It was found (36) that a temperature of 125° F. for 6 hours destroyed insects in loose piles of dry peanuts without injury to the peanuts. Also it was reported (53) that a temperature of 120° to 130° F. maintained in all parts of flour mills for 10 to 12 hours destroyed all insect life. Forced circulation of air was necessary to maintain proper temperature throughout the treated area. The use of heat is limited by facilities for maintaining suitable temperatures within masses of stored products. Refrigeration is also effective in preventing insect damage. Protection against insect infestations has been reported when peanuts and

peanut products are stored at 50° F. or below (200). The keeping qualities of the products were also enhanced.

Fumigation is perhaps the most feasible method of destroying insects in stored peanuts, once they are infested. Materials which have been used for this purpose include carbon disulfide and hydrogen cyanide, a mixture consisting of three parts ethylene dichloride and one part carbon tetrachloride (105), ethylene oxide 4 ounces plus 2.8 pounds of carbon dioxide per 100 cubic feet in a vacuum tank filled with peanuts (51), and methyl bromide (128, 175). Chloropicrin has been found effective, but it is absorbed and increases the acid content of the peanuts as much as 300% (57); absorption may be reduced by using carbon dioxide with a smaller dose of chloropicrin (51).

Of the several fumigants in common usage, methyl bromide is probably the most desirable for fumigating peanuts and peanut products, provided tight masonry storehouses, vaults, or fumigation chambers are available. This gas is noninflammable, is highly toxic to insects, and penetrates well into bagged commodities or other masses of stored products. It is highly toxic to warm-blooded animals and is almost odorless. Well-trained personnel is required for fumigation with methyl bromide. The gas is usually introduced through pipes or tubes from cylinders of the liquid material, placed outside. The rate of application is 1 to 1½ pounds per 1,000 cubic feet where masses of stored products must be penetrated. After an exposure of approximately 24 hours, the chamber should be ventilated. In general, metal and wooden buildings are not suitable for fumigation with this material. For additional information on the use of methyl bromide, the reader is referred to the Supplement to USDA Circular 390 (56) and to USDA Circular 720 (53).

Stored peanuts in tightly constructed metal or wooden buildings may be fumigated with a grain fumigant containing three parts ethylene dichloride and one part carbon tetrachloride, applied at the rate of 4 to 5 gallons per 1,000 bushels of stored product (52).

A considerable amount of the information on control of insects in stored peanuts was developed by research on these pests in other products. Additional research is needed, particularly on the effect of fumigants, refrigeration, and heat treatment on peanuts and peanut products as well as the insects involved.

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