

HAWAII AGRICULTURAL EXPERIMENT STATION,
E. V. WILCOX, Special Agent in Charge.

Bulletin No. 27.

INSECTS INJURIOUS TO CORN.

BY

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LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *March 15, 1912.*

SIR: I have the honor to submit herewith and recommend for publication as Bulletin 27 of the Hawaii Agricultural Experiment Station a paper on Insects Injurious to Corn, prepared by David T. Fullaway, entomologist of the station. The large increase in areas planted to corn, particularly on the various ranches, has called attention to certain insect pests of this crop, which are discussed in this paper with means of controlling the pests.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

DR. A. C. TRUE,
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Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

JAMES WILSON, *Secretary of Agriculture.*

CONTENTS.

	Page.
Introduction.....	7
Wireworms.....	7
Army worms and cutworms.....	7
Plant lice.....	9
Leaf hopper	10
Defoliating caterpillars.....	11
Hawaiian earworms.....	14
Grain moths and weevils.....	18

ILLUSTRATIONS.

	Page.
FIG. 1. Wireworm.....	7
2. Cutworm and moth (<i>Agrotis ypsilon</i>).....	8
3. Plant lice (<i>Aphis maidis</i>), winged and wingless females.....	9
4. <i>Amorbia emigratella</i> , larva, moth, and pupa.....	13
5. <i>Batrachedra rileyi</i> , adult, pupa, and larva.....	14
6. <i>Cryptoblabes aliena</i> , adult, pupa, and larva.....	15
7. <i>Aræcerus fasciculatus</i> , larva, beetle, and pupa.....	17
8. Angoumois grain moth (<i>Sitotroga cerealella</i>), egg, egg mass, larva, pupa, and adult.....	18

INSECTS INJURIOUS TO CORN.

INTRODUCTION.

Corn is a staple crop and finds a place along with other cereals in the agriculture of nearly all countries. Its cultivation in Hawaii dates back to the time of the early voyagers. Shortly after the discovery of gold in California the production of cereals in these islands assumed great importance, owing to the high prices commanded for the products. This importance, however, has gradually waned, especially of late years, due to the losses occasioned by cutworms and other pests, which have increased enormously with the depletion of the golden plover. With the control of the cutworm, which is now better understood than formerly, it is believed that the cultivation of corn will increase from year to year, although the acreage will still be limited by the availability of land and the small margin of profit.

For the reasons given above, the following discussion of the insects attacking the crop will undoubtedly command some interest from planters and factors engaged in its cultivation.

The insects attacking corn are wireworms, cutworms, army worms, plant lice, leaf hoppers, defoliating caterpillars, earworms, and grain feeders.

WIREWORMS.

Wireworms are the larvæ of certain common elaters or click beetles. They are found in the soil, where they feed on the roots or stems of plants near the surface (fig. 1). Two species have been



FIG. 1.—Wireworm. (From Hawaii Sta. Bul. 18.)

observed commonly about corn plantations, *Simodactylus cinnamomeus* and *Monocrepidius exsul*. They are not very injurious to corn, although they are so at times to cotton.

ARMY WORMS AND CUTWORMS.

Of the 35 or more species of native and introduced army worms and cutworms,¹ 8 are commonly present and injurious to ordinary field crops, although a few others may at times become numerous and

¹ O. H. Swezey, *Army Worms and Cutworms on Sugar Cane in the Hawaiian Islands*. Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 7.

extend their depredations from wild vegetation to cultivated plants. Most of these species will attack corn, and at certain times of the year, especially in the winter months, are highly destructive. Getting beyond the control of parasites, they increase with astonishing rapidity, and find in standing, unprotected crops an abundant and easily obtained food supply. Under normal conditions, vigorously growing corn can accommodate a few cutworms, but when these unchecked hordes of voracious half-fed caterpillars migrate to cultivated fields, they leave devastation in their wake, and continue advancing and destroying until either food supply is exhausted or parasites regain control. When crowded for food, ears and stems are also devoured. The destruction is as complete as that by fire. The commoner species attacking corn are *Agrotis ypsilon* (fig. 2), *A.*

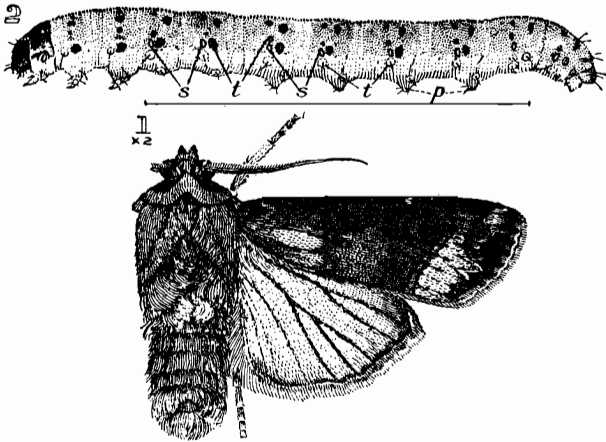


FIG. 2.—Cutworm and moth (*Agrotis ypsilon*). (From Hawaii Sta. Bul 18.)

crinigera, *Cirphis unipuncta*, and *Spodoptera mauritia*. (*Spodoptera*) *Laphygma exigua*, a common army worm here, is reported as a beet pest in the Western States, and *Feltia dislocata*, *Cirphis amblycasis*, *C. pyrrhias*, *Lycophotia margaritosa* and *Caradrina reclusa* are mentioned by Swezey ¹ as occasionally breaking out in excessive numbers and spreading to cultivated crops.

Control.—The elimination of cutworms as a factor in corn cultivation ought not to present special difficulties with the use of intelligence and thoroughness in applying remedies. Fields should be protected against migrating worms from the time of seeding with a steep furrow, the dirt being thrown out so as to leave a perpendicular wall of about 12 inches facing away from the field. Poisoned bait according to the following formula should be spread out in liberal quantities early: White arsenic, 1 pound; bran, 30 pounds; molasses,

¹ Loc. cit.

1 quart; water to moisten. Where corn is under continuous cultivation the use of light traps for the male moths is also recommended.

The natural enemies of cutworms are not as numerous as they should be, but are fairly efficient throughout most of the year. The most important are the tachinid flies *Frontina archippivora* and *Chætogædia monticola*, the ichneumon *Ichneumon koebelei*, and birds, especially the mynah, the golden plover, and the Chinese pheasant, which should receive every possible encouragement from the agriculturist.

PLANT LICE.

Corn rarely escapes attack by plant lice or aphides. The injury inflicted by these small insects results from the withdrawal of sap through the sucking beak, which is inserted in the soft tissues of the plant and rapidly drains them of their fluid contents. Plant lice

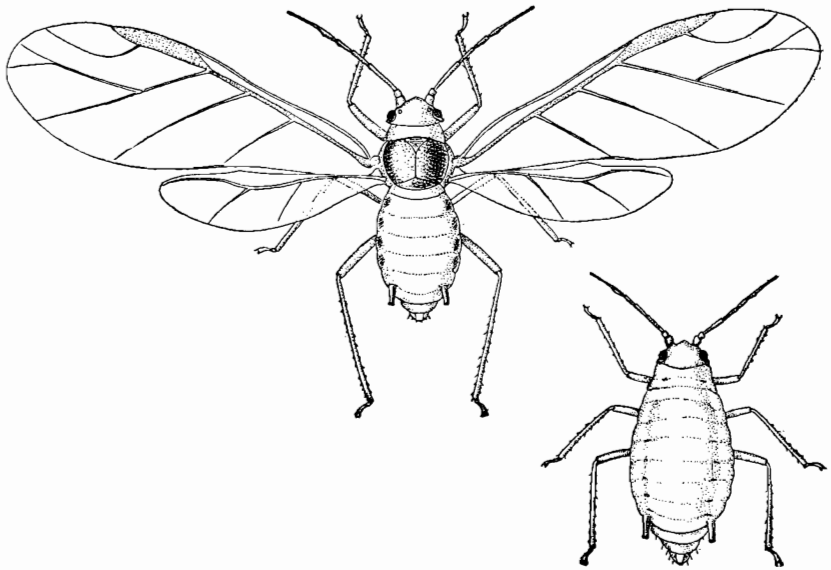


FIG. 3.—Plant lice, winged and wingless females (*Aphis maidis*). (From U. S. Dept. Agr., Bur. Ent. Cir. 86.)

flourish best under moist conditions, i. e., during the wet winter months or in irrigated fields, although in the driest situations they are able to persist in the protection of the leaf sheaths, where they find peculiarly favorable conditions of heat, moisture, and inaccessibility to enemies. The species commonly found on corn, sorghum, and other cereals is *Aphis maidis* (fig. 3). It is readily distinguished from other species by its preference for cereals to other cultivated hosts and certain peculiarities of structure and coloration. It is of moderate size, rather flat, deep green, with conspicuous black spots at the base of the cornicles. These plant lice are usually attended

by ants, which follow them for the sweet liquids secreted from the cornicles, and it is quite possible, from what we know of the symbiotic relations between other plant lice and ants, that assistance and protection are received. Where the ants harbor the plant lice in the stress of unfavorable conditions and attend to their favorable distribution on the plant, the difficulties experienced in combating this pest are greatly increased. The saccharine secretion exuded through the cornicles and the anus produces a "mussy" condition in the portions of the plant which the plant lice inhabit and attracts a host of other insects, especially the pomace fly (*Drosophila ampelophila*) and nitidulid beetles, which apparently breed in these places, and also furnishes a medium for the growth of molds and other fungi.

Control.—Aphides have many natural enemies, which tend to keep them in check and at times render them innocuous, notably the ladybird beetles *Coccinella repanda*, *C. abdominalis*, *Platyomus lividigaster*, *Scymnus notescens*, and *S. vividus*, the syrphid fly *Xanthogramma grandicornis*, the *Leucopis grandicornis* (Fam. Agromyzidæ), and minute internal parasites—cynipids, chalcids, and braconids. A small black encyrtid, first noticed by Mr. Swezey in 1906, is parasitic on *Aphis maidis*. It has been propagated by the writer for several months and is found to be highly efficient. In several lots examined, about 90 per cent of the plant lice had succumbed. The parasitized individuals become fastened to the plant and quickly turn a dull black; the integument hardens and forms a mere shell by the time the adult fly is ready to emerge. As its small size and weak powers of flight prevent the rapid spread of the parasite, it is hoped that this useful insect can be propagated and distributed in strong colonies to localities where it is needed.

The use of sprays on badly infested plants is recommended. The most economical and efficient are probably some of the proprietary tobacco mixtures on the market.

LEAF HOPPER.

Corn is almost invariably attacked by a small leaf hopper, *Peregrinus maidis*, which is often so abundant on small plants as to effect a rapid withering of the plants and ultimately their complete destruction. The injury they do results from their draining the leaves of sap and slitting the midrib for the insertion of their eggs. The secretive habits of these leaf hoppers makes it very difficult to control them by artificial means. They are usually found beneath the leaf sheaths along with the plant lice, although the mature winged individuals leap from plant to plant and are often found exposed on the leaves. The nymphs progress with a quick sidewise motion when disturbed. They are yellowish, somewhat mottled with black, with dark red eyes and short aristate antennæ. The adults are

about three-eighths of an inch long, grayish-green, with large, semi-transparent membranous wings, clouded with black at the tips. Brachypterous forms occur among both sexes of the adults. The small, white, flask-shaped eggs are laid several together in the soft tissues of the midrib. The egg period is rather protracted, occupying nearly three weeks. Thirty-five days elapsed from egg laying to adults in one generation. They apparently breed continuously throughout the year, although varying temperature and moisture conditions undoubtedly hasten or retard the development. As with the plant lice, a saccharine liquid is secreted, which spreads over the plant, and besides hindering transpiration attracts other insects and forms a medium for the growth of fungi. Leaf hoppers are also attended by ants for the sweet liquids which they exude.

Control.—Little success has been had in the control of leaf hopper with the use of sprays. Tobacco decoctions are the cheapest and most suitable, but apparently do not reach the insects. The eggs of the leaf hopper are parasitized by an *Anagrus*. It might be possible to propagate this parasite and distribute colonies to localities where needed.

DEFOLIATING CATERPILLARS.

Several caterpillars feed on the leaves of corn, notably the looping, thin, green larvæ of *Plusia chalcites*, which is especially injurious along with cutworms to young plants, and the wriggling, stout-bodied, green larvæ of *Amorbia emigratella*, which is a leaf roller, and is found on plants in all stages of growth.

The former of these two pests was studied by Swezey,¹ from whom the following account is copied:

Life history.—The eggs are white, about one-half mm. in diameter, flattened, height about half the diameter, entire surface covered with concavities like those on a thimble, arranged in regular rows radiating from the apex. They are deposited singly on the under surface of leaves. I observed a female ovipositing one evening just before it was too dark to see the eggs. She was fluttering around some bean vines, and would occasionally alight but an instant on the edge of a leaf, bending her abdomen beneath to place the egg on the under surface; then she would fly about a few moments and go to another leaf. I watched her several minutes, and she oviposited at the rate of about two eggs per minute.

Some of the eggs hatched in six days. The freshly hatched larvæ are 2 mm. long, green with black hairs situated in small black tubercles. At first they ate small patches of the substance of the leaf, leaving the opposite epidermis; but when five days old they ate small holes entirely through the leaf. Larger caterpillars ate larger holes, and ate the leaves from the margin as well.

There is very little change in the larvæ at the successive molts, except in size. The full-grown larvæ is about 36 mm. long, bright green, with a white line just above the line of spiracles, and several faint, crinkly, white lines down the back, often a black spiracular line; tubercles mostly white, except a row just above the spiracles, which are black and larger than the others. (Usually all tubercles were black previous to

¹ O. H. Swezey, Proc. Hawaiian Ent. Soc., 1 (1906), pt. 2.

the last molt.) Feet often black; head green, with black dots where the hairs are situated, and a black line on lateral margins; mandibles blackish on tip and edges. The prolegs are situated on segments 9, 10, and 13, and the caterpillar crawls by a looping motion; when at rest its back is humped up.

A caterpillar in breeding cage obtained its growth and [was] ready to pupate in 23 days. The pupa is pale green with a broad brown streak on the back, darker on the margins of the segments, the whole pupa turning brownish a little before the adult emerges; wing and leg cases extend just a little beyond the posterior margin of the fourth abdominal segment; cremaster short, with several tiny brown hooks attaching the pupa to the slight white silken cocoon, which is made between leaves fastened together, or in the fold of a single leaf; length of pupa, 19 mm.; width, 4.5 mm. The pupal period is 8 to 11 days.

Food plants.—Caterpillars of this species are quite general feeders. I have found them feeding upon the following plants: *Adenostemma viscosum*, *Ageratum conyzoides*, bean, beet, cabbage, Canna, cocklebur, Coleus, cotton, Datura, Euxolus, Ipomœa, Pelargonium, potato (both Irish and sweet), *Setaria verticillata*, Sonchus, sunflower, tomato, wild yam, and a few other undetermined wild plants.

This common moth of the Hawaiian Islands occurs also in other Pacific islands, Australia, southern Asia, Africa, and southern Europe.

The leaf roller was studied by the writer in connection with the insects attacking sweet potatoes, and the following account is taken from a previous publication of the station:¹

The tortricid leaf roller (*Amorbia emigratella*) (fig. 4) is an introduced pest which has been known in Hawaii since about 1900. It occurs also in Mexico and Costa Rica, and was probably brought here from the former country. It has increased very rapidly, as most introduced insects do which are not checked by parasites, and its great range of food plants makes it an unusually destructive form.

The larvæ are leaf rollers on many kinds of plants, shrubs, and fruit trees, and are often so numerous as to defoliate trees, on some of which they attack the fruit as well. The writer has found the leaf roller on citrus trees, cotton, avocado, guava, rose, passion flower vine, tomato, papaya, cacao, as well as on sweet potato, and on various indigenous plants in the mountains.

The young larvæ feed much as do the small caterpillars of *Phlyctœnia despecta*, working beneath a coarse web. In fruits they commence to bore inside, but soon desist and work on the surface beneath a web, or fasten the fruit to the nearest object—a leaf or another fruit. They destroy the blossom in the papaya and prevent the fruit from setting.

Life history.—There are four stages in the life cycle—the egg, larva or caterpillar, pupa, and moth.

The eggs are laid in clusters of from 65 to 120 (sometimes only a few eggs in a cluster), usually on the upper surface of a leaf, sometimes on foreign bodies. The cluster imparts a greenish color and has a whitish protective covering which extends beyond the edge of the egg mass. The eggs are flat, elliptical, 1 mm. long, slightly iridescent and finely reticulated (which becomes more apparent after hatching) and overlap a trifle. The greenish color changes to brownish as the ovum approaches maturity, and just previous to hatching the young larva may be seen coiled inside the egg. The egg stage occupies 10 days.

The larva on hatching is about 1.65 mm. long, light green, head brownish-yellow, cervical shield lemon-yellow. On each segment a pair of dorsal hairs, which are

¹ Hawaii Sta. Bul. 22.

longer on the head, cervical and anal shields. The eyes are black, mandibles dark brown, anal shield concolorous. In the course of its growth the larva molts three or four times. Full-grown larva 25 mm., head rounded, slightly bilobed, luteous, with a pair of dorsal and lateral pinkish-brown bands, a black line on lateral margin extending nearly its whole length, ocelli black, pale centered, continued caudad in a wavy black line, tips of mandibles dark brown, tips of antennæ brownish-black; body stout, cylindrical, uniform green or yellowish-green, transversely wrinkled, fat body and tracheæ showing conspicuously through thin integument; tubercles small, slightly

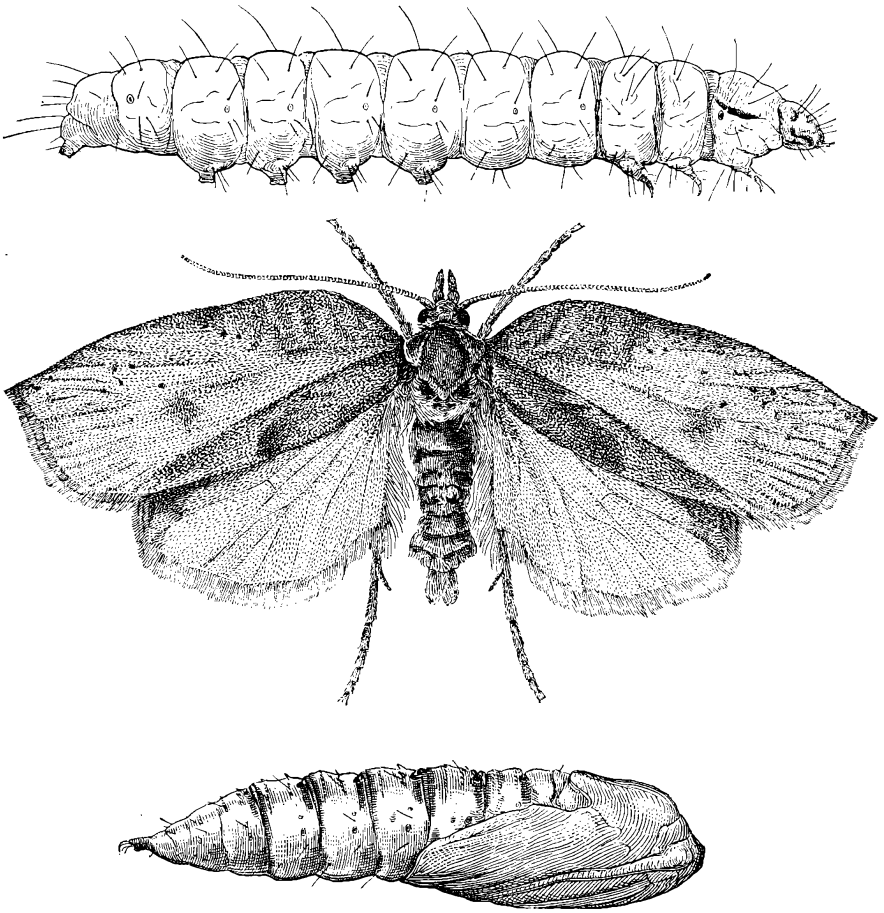


FIG. 4.—*Amorbia emigratella*: Larva, moth, and pupa. (From Hawaii Sta. Bul. 22.)

convex, concolorous with body or slightly fuscous, each bearing a seta (sometimes two), arranged in several longitudinal rows as follows: On dorsum anterior (1) and central (2) near anterior margin and center of segments 5 to 12, the former near median line—on segments 3 and 4 these tubercles double and (1) ventrad of (2); supraspiracular (3) one situated just above each spiracle (on segment 12 prespiracular); subspiracular (4+5) a double tubercle below each spiracle, composed of two tubercles united and bears two hairs—on segment 2 in front of spiracle—on segments 3 and 4 (1), (4+5) and (3) form a triangle in about median position in the segment, (1) double; lateral (6) one on each segment caudad of (4+5), nearer to posterior margin—on second segment

double and ventrad of (4+5); marginal (7) on outer side of each proleg and inner side of each true leg—on legless segments in about the same longitudinal line ventrad of (6)—each has three setæ; ventral (8) a small tubercle near median ventral line of each segment; cervical shield concolorous with body, with black line on lateral margin; feet concolorous with body, the tips black; spiracles minute, circular, rimmed with brown and center yellowish-white—those on segments 2 and 12 larger than the others. The larval period is 28 to 35 days.

Pupation takes place within the folded leaf. Pupa 9 to 12 mm., dark brown on dorsum shading into golden-brown on venter; wing-cases luteous, and extending beyond middle of fourth abdominal segment; spiracular openings small, reddish-brown; on dorsum of abdominal segments 2 to 8 two transverse rows of minute blunt spines, near anterior and posterior margins, becoming smaller outwardly from median line and disappearing before the spiracles; posterior row a trifle more extensive than the anterior; in front of anterior row on median line of dorsum of segments 2 to 7 a pit, partially covered by narrow blackish lip extending from posterior margin of preceding segment; on segment 9 a few scattered hairs; cremaster moderately pointed with eight short recurved spines. The pupal stage covers 10 days. The moth is described by Busck.¹ The tortricid leaf roller is parasitized by *Chalcis obscurata*, which does something to mitigate its destructiveness. Unfortunately, the very valuable egg parasites (*Trichogramma* spp.), which contribute more than any others to keep this class of pest in check, are unable to penetrate the tough covering of the *Amorbia* eggs.

Neither of these two pests can be considered very destructive to corn, since they are both very general feeders. In case of serious damage to the plants they can be controlled by spraying with arsenate of lead.

HAWAIIAN EARWORMS.

The insects grouped under this heading are generally attracted to any crop presenting an abundance of decomposing or inert vegetable

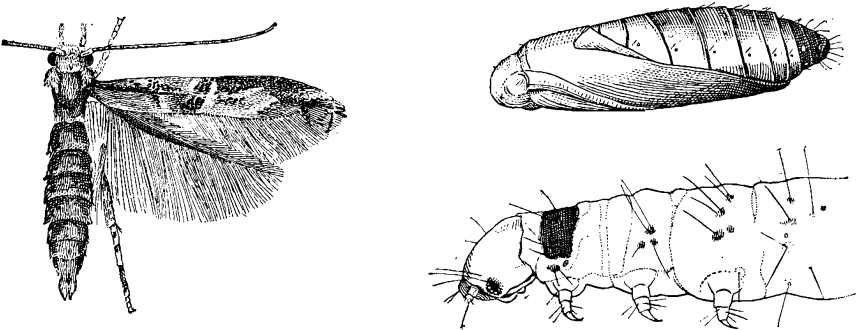


FIG. 5.—*Batrachedra rileyi*: Adult, pupa, and larva. (From Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 6.)

matter, and usually follow the work of other insects or the rotting produced by a superabundance of moisture with heat. The condi-

¹ Proc. Ent. Soc. Wash., 9 (1909), p. 201.

tion described is usually found in the outer ends of ears of corn, which are commonly infested with the larvæ or caterpillars of *Batrachedra rileyi* (fig. 5) and *Cryptoblabes aliena* (fig. 6), nitidulid larvæ, and the coffee bean weevil (*Aræcerus fasciculatus*).

The following account of *Batrachedra rileyi* is copied from Swezey:¹

The larvæ of this tiny little moth I have found feeding in various situations, most frequently on dead vegetable matter or refuse substances, hence, not particularly injurious. I have found them feeding beneath leaf sheaths of dead cane, also in bored cane sticks, and in places where the leaves are dirty and sticky from having been attacked by Aphis or leaf hoppers. I have also found them feeding in the tassels. Once I found them very numerous in sweet corn ears, feeding on the "silks," inner husks, the pith, and other parts of the cob. I have also seen them in ears of field corn, eating into the kernels of corn and into the cob. Another time I observed them numerous on a large woody twining bean vine, feeding on dying leaves and ripening pods, especially where there was an accumulation of débris, webs, frass, etc., on

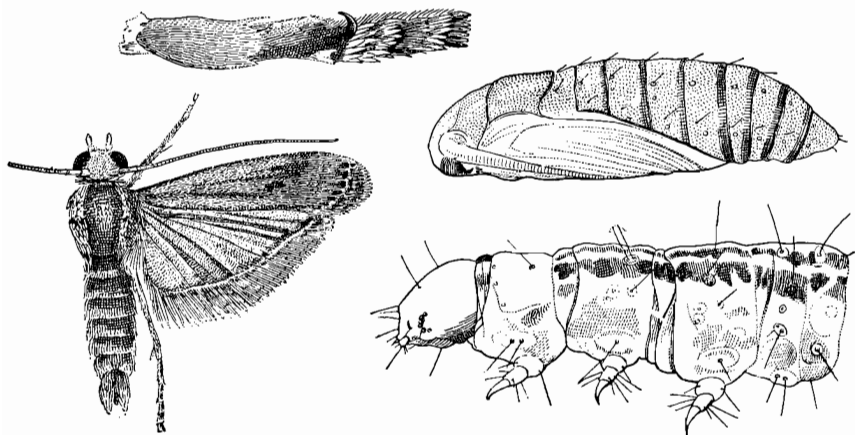


FIG. 6.—*Cryptoblabes aliena*: Adult, pupa, and larva. (From Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 6.)

account of infestation by mealy bugs, *Lecanium*, *Tortrix*, and *Cryptoblabes* larvæ. Similarly, I have found them feeding on lantana infested by *Orthezia*, and on palm leaves infested with mealy bugs and leaf rollers; also on dead leaves of pandanus, banana, and various other plants. On the banana, I have found them feeding in the bunch on the dead or injured fruit, and on the skin of the ripened fruit, which they have penetrated sometimes and eaten into the fruit inside.

Mr. D. T. Fullaway has reported it from cotton infested with mealy bugs. The original description of the species is from specimens bred from rotten cotton bolls in the United States. It has been present in these islands for a number of years no doubt, as they were found by Dr. Perkins when he first came (1892), though it is not included in the *Fauna Hawaiiensis*.

The other species of this genus show a variety of habits so far as these are known. Some breed in heads of *Juncus* and sedges, catkins, and seeds of poplar and willow, in plant galls (though not producing them), pine needles, others in webs of other larvæ and of spiders; and one Australian species feeds on the San José scale and other scale insects. A Hawaiian species feeds on ferns.

¹ O. H. Swezey, The Hawaiian Sugar Cane Bud Moth (*Ercunctis flavistriata*), with an Account of Some Allied Species and Natural Enemies. Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 6.

Life history.—Eggs are deposited mostly singly, occasionally two together; about 0.5 mm. long, roundish-ovate, flattened below where in contact with surface of object, convex above and coarsely reticulate. They hatch in a few days. The freshly hatched larvæ are about 1 mm. long, pinkish, with black head and cervical shield. The full-grown larva is about 7 to 8 mm. in length, pinkish except head which is pale brown, and cervical shield which is dark brown; tubercles concolorous, 2 wider apart than 1, 3 above spiracle, 4 + 5 below. The larva pupates in a whitish cocoon among the frass where it has fed. The pupa is 4 to 5 mm., uniform medium brown; wing cases and antenna cases extend to apex of sixth abdominal segment; abdominal segments apparently immovable; terminal segment with numerous slender hooked bristles, a few also on the two preceding segments. The pupal period is 11 to 13 days.

Microdus hawaiiicola is recorded as a parasite.

In regard to *Cryptoblabes aliena*, Mr. Swezey says:¹

The larvæ of this phycitid moth were first noticed in 1905 on sorghum, cotton, and sugar cane. In each case the plants were considerably attacked by Aphis. On sugar cane they often hide within a retreat made by the margin of the leaf being rolled down and fastened beneath with silk. Often several larvæ may be in the same place. They eat off the substance of the leaf, leaving the opposite epidermis, which makes the leaf look dead on the margin. They often feed near the base of the leaf, adjacent to the sheath.

The larvæ feed on leaves of sorghum in the same way. They also feed in the tops, eating the flowers, bracts, and young seeds. In 1906 larvæ were found very abundantly feeding on sweet corn, which was badly attacked by corn hoppers (*Pergandus maidis*). They were beneath leaf sheaths and husks and in the ears, eating the silks, young grains, and even the bracts or chaff of the cob; they were also in the tassels. They spin slight silken tunnels wherever they feed.

More recently I have found the larvæ quite abundant among the flower clusters of algaroba, both fresh clusters and the withered and dried-up ones. I have also found them on orange, mulberry, and some other plants, feeding where there has been infestation by Aphis or mealy bugs, and in the dried capsules of the castor-oil plant.

In May, 1908, I found them abundant on lantana, where it was being killed by being attacked by *Orthesia*, the "Maui blight;" and in the same year found them on coffee trees among the berries, an occasional one being eaten by them. In all cases where these larvæ occur along with Aphis, mealy bugs, etc., they do not feed on these latter insects themselves, although they may be attracted by the more or less sweetish excretions of these insects; they feed, however, largely on the tissues of the plants themselves, either the fresh tissues or else the dead or dying tissues.

It is thus seen that the larvæ of this moth are quite general feeders. They are not to be considered very injurious, however; the other insects with which they are usually associated being far more injurious. They have not as yet become injurious to sugar cane, but are generally distributed, as I have occasionally observed the larvæ in cane fields of various districts of the islands.

Larva is about 12 mm. long; nearly cylindrical, narrowing toward each end; olivaceous, yellowish, reddish, or fuscous, with several longitudinal darker stripes, brownish or fuscous; most conspicuous is a broad, somewhat double brownish or fuscous stripe just above line of tubercles 3; head yellowish-brown to dark fuscous, eyes black; cervical shield concolorous, darker on anterior margin; tubercles small, concolorous or pale, with a black dot in center at base of hair; tubercle 3 on segments 3 and 12 surrounded by a darker ring; tubercles 1 and 2 in straight longitudinal line, 3 just above spiracle, 4+5 below spiracle and a little more anteriorly; hairs very pale

¹ Loc. cit.

brown; spiracles pale yellow. Larvæ taken from sweet corn and algaroba blossoms were paler, usually yellowish or reddish; those from lantana, orange, and other trees where *Orthezia*, *Aphis*, mealy bugs, etc., had been feeding, were mostly very dark fuscous, often almost black, and nearly uniformly colored.

Pupa is 5 to 6 mm. long; bright light brown, paler below, greenish on wing and leg cases; punctured all over the back; fine hairs in two dorsal, two lateral, and two ventral rows; spiracles slightly raised; wing and leg cases extend to near apex of fourth abdominal segment; cremaster with two stout straight spines close together, touching, hooked at tip, firmly fastened into silk of cocoon, a few short hooked spines near their base. Formed in a slight cocoon among the web where the larva fed.

I have bred no parasites from the larvæ, nor have I ever found any of them stored up for food in wasps' nests. Specimens of the moth were sent to Dr. Dyar, Washington, D. C., for determination. He informed me that they did not agree with any described species; hence I have described it as new.

Nitidulid beetles are the small, stout, flat, short-winged, usually dark-colored insects found around decaying vegetable matter. They are very common in the waste piles of pineapple canneries and under any decaying fruit.

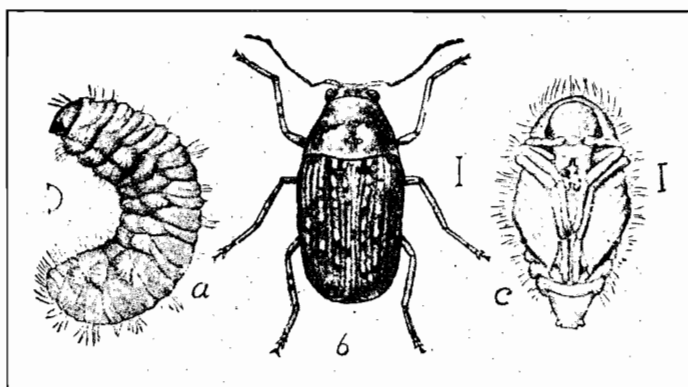


FIG. 7.—*Aræcerus fasciculatus*: Larva, beetle, and pupa. Copied from Chittenden.
(From Hawaii Sta. Bul. 18.)

Dr. L. O. Howard, entomologist of the United States Department of Agriculture, writes ¹ as follows in regard to *Aræcerus fasciculatus* (fig. 7):

It is a cosmopolitan insect living in the pods of various plants, among others in those of the coffee plant in Brazil, but is never known to attack healthy plants. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once distinguish it from the latter species.

This insect, however, has recently been reported by Mr. E. S. Tucker, of the Bureau of Entomology, United States Department of Agriculture, to bore cornstalks in Louisiana, attacking the green stalks before the corn matured and causing stunted ears. It is parasitized by a *Eupelmus*.

¹ In litt.

GRAIN MOTHS AND WEEVILS.

The insects feeding on dried and stored grains comprise a numerous and heterogeneous group of great economic importance because of the losses sustained by producers and handlers of grain before the products can be put into use. This class of pest is represented here by a number of species, some of which damage corn and cause considerable loss. They are mostly cosmopolitan insects, which have been spread by commercial operations from center to center and from port to port in the products on which they feed.

The most important, perhaps, are the Angoumois grain moth (*Sitotroga cerealella*) (fig. 8) and the rice weevil (*Calandra oryza*).

The Angoumois grain moth is an insect of comparatively recent introduction. The first record of its presence here, to my knowledge,

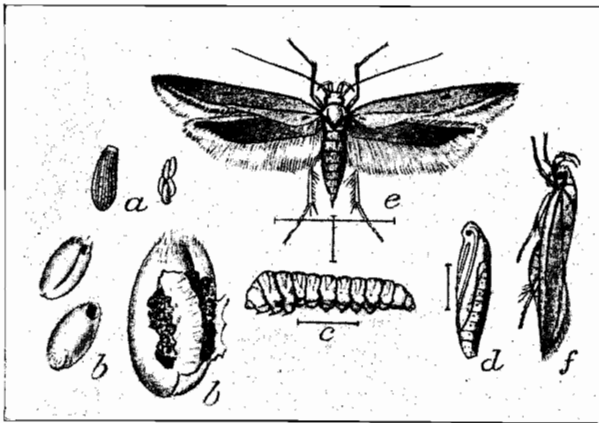


FIG. 8.—Angoumois grain moth (*Sitotroga cerealella*): Egg, egg mass, larva, pupa, and adult. (From U. S. Dept. Agr., Bur. Ent. Cir. 118.)

was made by D. L. Van Dine,¹ who bred it from rice taken in the field and from the stored product. It is now well established on Maui and Oahu and is probably also in the other islands of the group. The following account of the life history is copied from Swezey, who investigated a serious outbreak of the pest in the Kula and Makawao districts of Maui in 1910:

The eggs are somewhat elongate oval, slightly pinkish-iridescent, and are deposited on the outside of grains or kernels of corn. On ears of corn, the eggs are placed in the crevices between the kernels, and are thrust so far down as to easily escape observation. On hatching, the tiny larva burrows into the kernel and feeds on the substance, making a burrow scarcely larger than it can conveniently occupy. In wheat there is just about enough material in one grain for the nourishment of one larva; but a kernel of corn may furnish food for three or four. When full grown the larva is plump and white, and occupies nearly all the space it has eaten in the grain. It may be distinguished from weevil larvæ, as it is straight while the latter are shorter and more or less curved or curled up.

¹ Hawaii Sta. Rpt. 1907, p. 43.

Before spinning its slight white cocoon inside the kernel, the larva eats to the skin or epidermis of the grain and cuts an accurate circular piece, which is not removed but held lightly in position by a little silk from its cocoon, and can be readily pushed away by the moth when ready to emerge.

The pupa is pale, yellowish-brown, and is formed inside the white cocoon inside of the kernel, with its head directed outward for convenience of the emerging moth. There are a few delicate hairs on the back and at the apex, also a pair of short curved spines dorsally at apex.

The moth is about three-eighths of an inch long with wings folded at rest; with wings expanded, it has a width of about five-eighths inch. It is of a pale yellowish-brown color, with a few fuscous dots and markings on the forewings.

The rice weevil (*Calandra oryza*) is a common pest of corn as well of rice and other stored products and is generally distributed throughout the islands. It is mentioned in the Fauna and in the annual reports of the station since 1905. It is probably not as injurious as the grain moth, but when abundant it does considerable damage. The life history of this pest has recently been elaborated in the Southern States by Hinds and Turner,¹ from whose account the following excerpts have been made:

The egg.—The egg of the rice weevil is always deposited within the kernel of some grain. It is regularly elliptical or sometimes rather "pear-shaped," with the larger end outward as it rests in the grain. The covering membranes are thin and of an opaque white color. The average length of eggs is about 0.665 mm. by about 0.295 mm. thickness at the larger part. The young larva can be seen through the egg covering shortly before it is ready to hatch. Hatching occurs in an average of three days from deposition of the egg with a mean temperature of between 60° and 65° F. There appears to be a considerable mortality during the egg stage as not nearly as many larvæ develop in corn as there are eggs deposited, but the exact proportions have not been determined. It appears to be fully 50 per cent, however.

The larva.—This stage has been figured by a few writers. * * * The grub is of a creamy white color except the head which is brownish shading to nearly black at the tips of the mouth parts. It is very thick bodied, with the ventral line approximately straight while the dorsum is almost semicircular. There are three larval stages, as shown distinctly by the measurements of heads. In the first stage the head averages approximately 0.22 mm. in breadth at its widest part; in the second stage, 0.33 mm., and in the third stage 0.64 mm. The first larval stage requires about 3 days, the second 4 days, and the third 9 days on the average, with mean temperature of between 60° and 65° F. There is then a distinct prepupal stage in which the forming pupa is plainly visible through the unshed larval skin lasting for usually 1 day. The entire larval stage, therefore, requires between 16 and 17 days on the average, with a common range of between 15 and 19 days under usual temperature conditions. The pupal cell is always formed within the kernel and may be either in the heart of the kernel or near its exterior.

The pupa.—This instar is somewhat longer and more slender than was the grub before it. There seems to be considerable variation in length of this stage at the same period, with the average at about 6 days and the range between 3 and 9 days. Considerable brown coloration appears before the pupal skin is shed. After the insect has become adult it still remains within the kernel for several days to harden and fully mature before it makes any attempt to escape.

¹ W. E. Hinds and W. F. Turner. Life History of the Rice Weevil (*Calandra oryza* L.) in Alabama. Jour. Econ. Ent., 4 (1911), No. 2, pp. 230-236.

Naturally, with all of the immature instars, the duration of the stage is very largely determined by prevailing temperature conditions. The records that have been given relate to observations ranging from about the middle of August to the early part of November in the latitude of Auburn, Ala. The breeding of weevils continues more or less steadily throughout the winter, provided the temperature remains sufficiently high. The occurrence of a particularly cold snap, as when temperature falls to below 10° above zero, while it does not exterminate the weevils, still appears to destroy a large part of the immature stages and many adults and thus greatly retards subsequent multiplication and injury by the pests later in the winter. As a rule, the greatest damage by these weevils is done before the end of December in this State, and thereafter to corn that is stored beyond the following April.

During the winter season, as from December 15 to March 15, the larval stage has been known to be extended to beyond 115 days, or about four months, in spite of the fact that the infested corn was kept in a heated building where the day temperature averaged nearly 60° with the night temperature probably 10° to 15° lower.

The adult.—As has been said, the adult remains in the pupal cell for several days, usually three to four, for hardening and maturing before it starts to cut its way out of the kernel. Much feeding may then be done within the kernel without any attempt at emergence, so that we can not reckon the life cycle from observations based solely upon the time between oviposition and the emergence of the adult. Many weevils perish in their effort to escape from the kernel, being found wedged in the exit hole, usually with only the head, prothorax, and forelegs free.

At an average temperature of about 63°, development from oviposition to the emergence of the adult may take place in about 32 days. The general average, however, is rather longer than this, and for the first field generation appears to be about 6 weeks, and for the second field generation between 7 and 8 weeks. This is between about the first week of August and the last of October.

The adult rice weevil, or "black weevil," as it is often called in the South, is a rather slender, cylindrical beetle, averaging in length of body from the front margin of the prothorax to the tip of the body, about 3.5 mm. and for the length of head and snout about 1.6 mm. The normal color is a very dark brown or nearly black and is uniform except for four reddish spots located one at each corner of the wing covers. The prothorax is densely and uniformly punctured as are the elytra. The reddish spots and the punctation serve to distinguish this species from *C. granaria*. The average weight per weevil is approximately 0.003 gram, or more than 150,000 weevils per pound.

A pteromalid is doubtfully reported by Swezey as parasitic on the rice weevil.

The following insects have also been bred from the stored grain: *Catorama mexicana*, *Plodia interpunctella*, *Ephestia elutella*, and *Seta-morpha dryas*, although they are not as injurious as the others.

Control.—As these insects damage chiefly stored grain, they are best controlled by fumigation with carbon bisulphid. Corn should be stored in air-tight bins and fumigated at the time of storing. If the corn is to be retained some time the cribs must naturally be more or less open to allow a free circulation of air, but frequent handling is necessary to prevent infestation by weevils. Tightness lessens the cost of fumigation, and a specially constructed bin for this purpose in connection with the crib is very desirable.