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Stored-Grain Insects

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ABSTRACT

Five primary pests cause most of the insect damage to grain in storage and shipment. These are the granary weevil, the rice weevil, the maize weevil, the lesser grain borer or Australian wheat weevil, and the Angoumois grain moth. Other insect species or groups of species described in this handbook can cause great damage to grain if storage conditions are unusually favorable for their increase. Yet, if grain in the unbroken kernel remains unaffected by the five primary pests, it is not likely that any other insect will damage it appreciably in commercial storage or shipment, except possibly the khapra beetle, which does not occur at present in the United States. The secondary pests are mostly surface feeders in both the adult and larval stages. Some of them may eat into kernels of grain and lie hidden there, but most of them feed on grain dust or broken surfaces of kernels exposed by either mechanical injury to the grain in handling or by the feeding of the five primary grain pests with which they are usually associated. Therefore, the secondary pests can largely be removed by grain-cleaning operations.

Except for the lesser grain borer, the larvae or grubs of the primary insect pests are not ordinarily capable of a free existence outside the kernel. They live entirely within the kernel, where they feed unseen and usually unsuspected. They cannot be removed by ordinary cleaning machinery and must be controlled by other means. Key words: grain weevils, grain moths, beetles, mealworms, biology, life history, prevention, control.

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United States Department of Agriculture**

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STORED-GRAIN INSECTS

INTRODUCTION

Since the establishment of Federal standards for grain under the provisions of the Grain Standards Act, Federal grain supervisors and federally licensed grain inspectors have been required to identify the various species of "live weevils and other insects injurious to stored grain" which may be present in the grain. For accurate identification, uniform names should be used by all interested persons, including shipper, purchaser, and elevator operator.

Of the five primary insect pests, the granary weevil, the rice weevil, the maize weevil, and the lesser grain borer may well be called grain weevils. The fifth primary pest, the Angoumois grain moth, so destructive to wheat and corn, may be called a grain moth. Other insects likely to

be found in grain may be called simply beetles, moths, and mealworms. Their presence usually does not indicate a condition likely to affect the grain trade, if the grain, after it has reached the elevator, is screened and fanned to remove these insects.

This handbook briefly describes the biology, life histories, and habits of stored-grain insects and gives effective methods for the prevention and control of grain infestations.

Grain weevils, grain borers, grain moths, flour moths, grain and flour beetles, mealworms, dermestid beetles, spider beetles, miscellaneous beetles, booklice or psocids, silverfish, cockroaches, flour or grain mites, and parasites of grain pests are discussed.

GRAIN WEEVILS

Of the five true weevils that attack grain in the United States, only three are of primary importance—the granary weevil, the rice weevil, and the maize weevil. Except locally, the broadnosed grain weevil and the coffee bean weevil are of minor importance. All but the coffee bean weevil have elongated beaks or

snouts, as shown in figures 1, 3, and 4.

Granary Weevil

The granary weevil, *Sitophilus granarius* (Linnaeus),¹ is a small, moderately polished, blackish or

¹Coleoptera, Curculionidae.

chestnut-brown beetle (fig. 1A). The head extends into a long slender snout with a pair of stout mandibles or jaws at the end. This insect is not more than three-sixteenths of an inch long and often is smaller. There are no wings under the wing covers, and the thorax is well marked with longitudinal punctures, two characteristics that distinguish this insect from the closely related rice weevil with which it is often found.

The granary weevil, one of the oldest known insect pests, has been carried by commerce to all parts of the world. It prefers a temperate climate and is more frequently found in the Northern States than in the South.

Both the adults and larvae feed voraciously on a great variety of grains. The adult weevils live, on an average 7 to 8 months, and each

female lays 50 to 250 eggs during this period. Before laying, the female uses her mandibles to bore a small hole in a grain kernel. She then deposits an egg through the hole and covers it with a gelatinous fluid that seals the hole. The small, white, fleshy, legless grub or larva hatches from the egg and burrows about inside the kernel. When fully grown, the larva transforms into a pupa and then into an adult.

In warm weather, the granary weevil develops from the egg to the adult stage in about 4 weeks. Cold weather greatly prolongs the developmental period.

Rice Weevil

The rice weevil, *Sitophilus oryzae* (Linnaeus),¹ is a small snout beetle which varies in size, but it averages

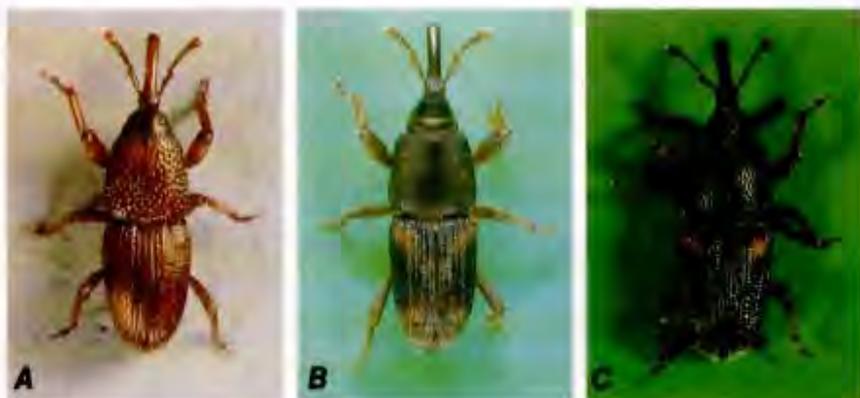


Figure 1.—Grain weevils: *Left*, Granary weevil adult; *center*, rice weevil adult; *right*, maize weevil adult.

about three thirty-seconds of an inch in length. It varies from reddish brown to nearly black and is usually marked on the back with four light-reddish or yellowish spots (fig. 1B). The rice weevil closely resembles the granary weevil in form but differs in color and markings, and it has fully developed wings beneath the wing covers. The thorax is densely pitted with somewhat irregularly shaped punctures, except for a smooth, narrow strip extending down the middle of the upper (dorsal) side.

This weevil has been known since early times. It is found in all parts of the world where grain is used and is one of the worst pests in stored grain. This insect is particularly abundant in warm countries, where it breeds continuously and rapidly destroys all unprotected grain.

The adult rice weevils live, on an average, 4 to 5 months, and each female lays 300 to 400 eggs during this period. The early life stages are almost identical in habit and appearance to those of the granary weevil. During hot weather, the egg, larval, and pupal stages may be passed in as few as 26 days. This period, of course, is greatly prolonged during cool or cold weather.

Maize Weevil

The maize weevil, *Sitophilus zeamais* Motschulsky, for a long time referred to as the larger strain or race of the rice weevil, is now recognized as a distinct species. Although

slightly larger, up to one-eighth of an inch long, and darker than the rice weevil adult, the degree of variation within each species makes them difficult to tell apart (fig. 1C). The thorax of the maize weevil is densely and uniformly pitted with round punctures.

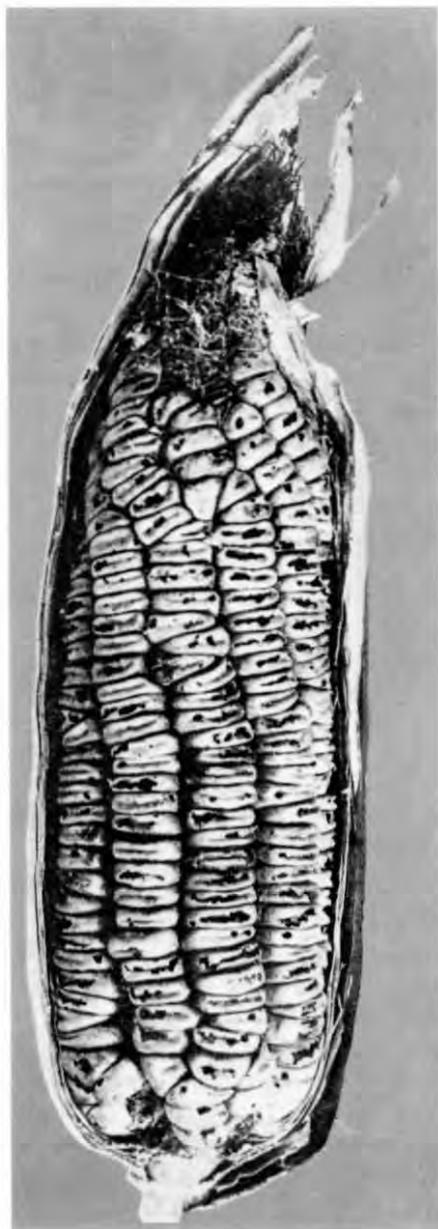
It is a common pest of a variety of grain crops and causes tremendous losses to corn in the South, reducing the kernels to dry powder and hulls (fig. 2). The adults fly from the granaries to the fields, where they start infestations that may continue after harvest and may be especially destructive in storage.

The life history and early life stages are similar to those of the rice weevil (fig. 3). The rate of development is slightly slower; a minimum of 30 days is required for passing through the egg, larval, and pupal stages.

Broadnosed Grain Weevil

The broadnosed grain weevil, *Caulophilus oryzae* (Gyllenhal),¹ is a small, dark-brown snout beetle slightly less than one-eighth of an inch long. In form and color, it resembles the granary weevil somewhat but differs from it and other grain-infesting weevils by having a shorter, broader snout (fig. 4C).

The weevil is occasionally found in Georgia and South Carolina and is widespread in Florida, where it is a serious pest of stored grains, but it is not found in northern grains. It is unable to breed in dry, hard, unin-



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Figure 2.—An ear of corn badly damaged by maize weevils. The ear was hit against a table to jar loose a dry powdery substance, or farinaceous material, to reveal the great amount of damage done.

jured grain, but it does attack soft or damaged grain or grain that has been attacked by other grain insects. It is a strong flier, and, like the maize weevil, flies to the cornfields and infests the grain before it becomes fully hardened.

The adult weevils normally live about 5 months, and, during this time, each female lays 200 to 300 small white eggs, usually in broken portions of the grain. In a few days, the eggs hatch, and the small, white, legless grubs feed on the softer portions of the grain until fully grown (fig. 4A). They then transform into white pupae (fig. 4B) and, in a few days, transform into adult weevils which cut their way out of the grain. In summer, the period from egg to adult is about 1 month.

Coffee Bean Weevil

The coffee bean weevil, *Araecerus fasciculatus* (De Geer),² is a very active, robust, dark-brown beetle two-sixteenths to three-sixteenths of an inch long. It is covered with a mottled light- and dark-brown pubescence. This insect may be easily recognized from figure 5.

This weevil is found in many countries and is extremely abundant in the Southern States, where it breeds in dried fruit, coffee berries, cornstalks, corn, and the seed and seed pods of an almost endless variety of plants. The coffee bean weevil is a strong flier and is frequently seen in the cornfields of the

²Coleoptera, Anthribidae.

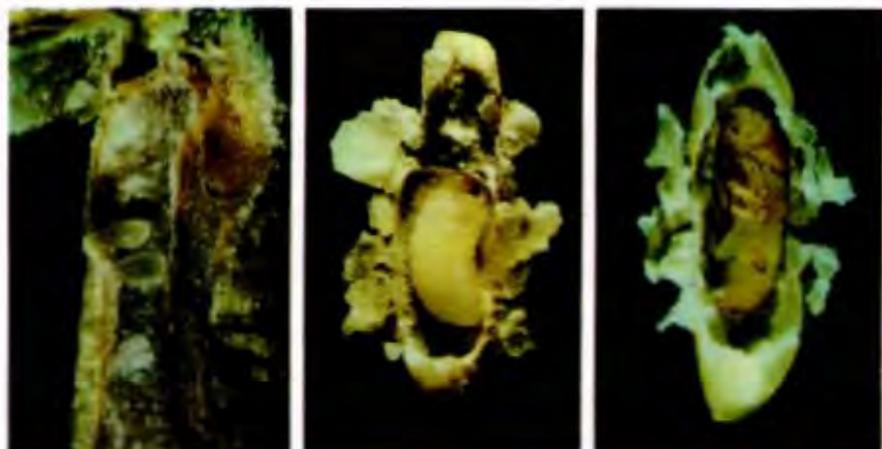
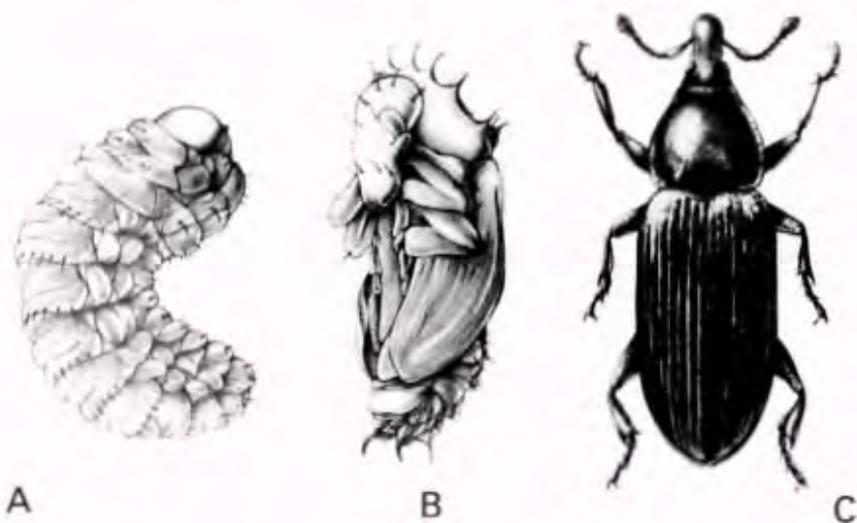


Figure 3.—Maize weevil: *Left*, eggs; *center*, larva; *right*, pupa.



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Figure 4.—Broadnosed grain weevil: *A*, Full-grown larva; *B*, pupa; *C*, adult. Adult is slightly less than one-eighth of an inch long.



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Figure 5.—Coffee bean weevil adult, about three-sixteenths of an inch long.

South on exposed and damaged ears. It lays eggs in the soft kernels of corn and continues to breed after the corn has been harvested and placed in storage. This insect does not cause much damage to corn in storage, since the corn becomes too hard to be attractive. It may, however, be very abundant locally in corn in Florida during the first 3 months of storage. This weevil reportedly caused total destruction of a sack of kafir seeds in Honolulu. Over the country, the coffee bean weevil is a minor grain pest.

GRAIN BORERS

Three species of grain borers are established in the United States. The lesser grain borer is widespread in the grain centers of this country and is a serious pest of stored grain. The larger grain borer and the bamboo powderpost beetle are confined to the Southern States and are not of commercial importance.

Lesser Grain Borer

The lesser grain borer, *Rhyzopertha dominica* (Fabricius),³ is one of the smallest beetles of those injurious to grain in this country. It is known to many grain dealers as the Australian wheat weevil because of the large supplies of infested wheat that were imported from Australia

during World War I. It is widespread in the Gulf States, and grain samples infested with this beetle are found in all large grain centers. The lesser grain borer is readily distinguished from other grain pests by its slender cylindrical form and small size. It is polished dark brown or black, with a somewhat roughened surface, and is about one-eighth of an inch long and one thirty-second of an inch wide (fig. 6A). The larval and pupal stages are illustrated in figure 7. This grain borer belongs to a family of beetles that has the head turned down under the thorax and that is armed with powerful jaws used for cutting into wood. Originally native to the Tropics, the lesser grain borer has spread through commerce to all parts of the world.

³Coleoptera, Bostrichidae.



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Figure 5.—Coffee bean weevil adult, about three-sixteenths of an inch long.

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³Coleoptera, Bostrichidae.



Figure 6.—Grain borers: *Left*, lesser grain borer adult; *right*, bamboo powderpost beetle adult.



Figure 7.—Lesser grain borer: *Left*, larvae; *right*, pupa.

Both the beetles and larvae cause serious damage in warm climates by attacking a great variety of grains. Figure 8 shows how destructive they can be to wheat kernels, which, in this case, were literally riddled by the boring of the adults and their larvae. The damaged kernels are always surrounded by powder from the chewed-up grain.

Each female lays 300 to 500 eggs and deposits them, singly or in clusters, upon the loose grain. The eggs hatch in a few days, and the small whitish grubs, or larvae, crawl actively about the grain, and feed on the flour produced by the boring beetles or bore directly into grains that have been slightly damaged. They complete their growth within the grain, transform into white pupae, and, in time, change into adult beetles, which cut their way out of the grain. In summer, the period from egg to adult is about 1 month.

Larger Grain Borer

The larger grain borer, *Prostephanus truncatus* (Horn),³ is a small, dark-brown, elongate-cylindrical beetle about one-sixth of an inch long. It is very similar in appearance to the lesser grain borer, but may be distinguished from that insect by its larger size and comparatively smooth, polished surface (fig. 9A).

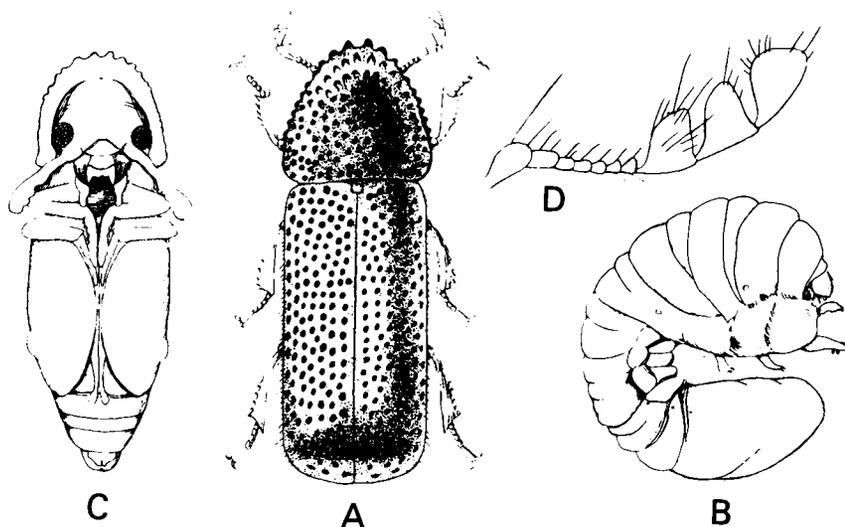
This tropical insect has limited distribution in this country. It is occasionally found infesting corn in the South and has been reported from Texas, California, and the District of Columbia. Similar to the lesser grain borer in habits, it belongs to a family of beetles that is mainly destructive to timber. Like the lesser grain borer, it has probably acquired the grain-feeding habit rather recently.

Another member of the family, the bamboo powderpost beetle, *Dinod-*



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Figure 8.—Wheat kernels thoroughly riddled and devoured by boring and feeding of lesser grain borer and its larva.



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Figure 9.—Larger grain borer: *A*, adult; *B*, larva; *C*, pupa; *D*, antenna of adult.

erus minutus (Fabricius),³ occasionally infests stored grain in the United States. It has been reported

from Louisiana and Florida. In general appearance, it resembles the larger grain borer (fig. 6*B*).

GRAIN MOTHS

The term "grain moth" includes only those moths capable of destroying sound, unbroken grain kernels. They are not as abundant as the flour moths, which are principally pests in broken, damaged kernels or milled products.

Angoumois Grain Moth

The Angoumois grain moth, *Sitotroga cerealella* (Olivier),⁴ is a small buff or yellowish-brown moth with a wing expanse of about one-half inch.

This is the moth most commonly found in infested grain in this country, and it is not likely to be confused with any other grain moth. It attacks all cereal grains, is found in all parts of the world, and is particularly injurious in the South, where it attacks grain both in the field and in storage. In the North, it survives the winter mainly in the larval form in kernels of grain in storage or in scattered wheat in litter, straw piles, and baled straw. The emerging moth flies to the wheatfields in May and deposits eggs upon the developing grain.

⁴Lepidoptera, Gelechiidae.

Under normal conditions, each female lays an average of 40 eggs; although, under favorable conditions, individual moths have been known to lay as many as 389 eggs. The eggs, which are white when first laid, soon change to a reddish color. They are laid on wheat heads, on the exposed tips of corn ears in the field, or on stored grain.

Upon hatching, each larva crawls to a kernel of grain and often spins a small entrance cocoon to assist it in boring into the hard kernel. After entering the grain, it feeds on either the endosperm or the germ until fully grown. It then eats out a channel to the outside of the seed and makes a weakly fastened flap at the exit by cutting the shell one-half to three-fourths of the circumference of a circle. The larva then spins a silken cocoon and changes to a reddish-brown pupa. Later, as a moth, it pushes its way through the flap. The period from egg to adult may be completed in 5 weeks, although development is usually slower.

Widespread use of the combine harvester has reduced wheat damage by this moth to a minimum. However, in the southern portion of the commercial corn-growing area, it periodically causes heavy losses to stored corn. Figure 10 shows an ear of corn with the external evidence of a heavy attack by the Angoumois grain moth. Figure 11 shows the successive stages in the development of this insect in a kernel of wheat, from egg to adult. Figure 12A shows the adult moth.

Pink Scavenger Caterpillar

The pink scavenger caterpillar, *Sathrobrotia rileyi* (Walsingham),⁵ is the larva, or caterpillar, of a small moth. It is pink, with a pale-brown head and thoracic shield, and is about five-sixteenths of an inch long when fully grown (fig. 12C). The moth which develops from this larva

⁵Lepidoptera, Cosmopterigidae.



Figure 10.—Ear of corn showing heavy infestation by the Angoumois grain moth. Note that certain kernels have three emergence holes, and that many kernels have served as food for two larvae.

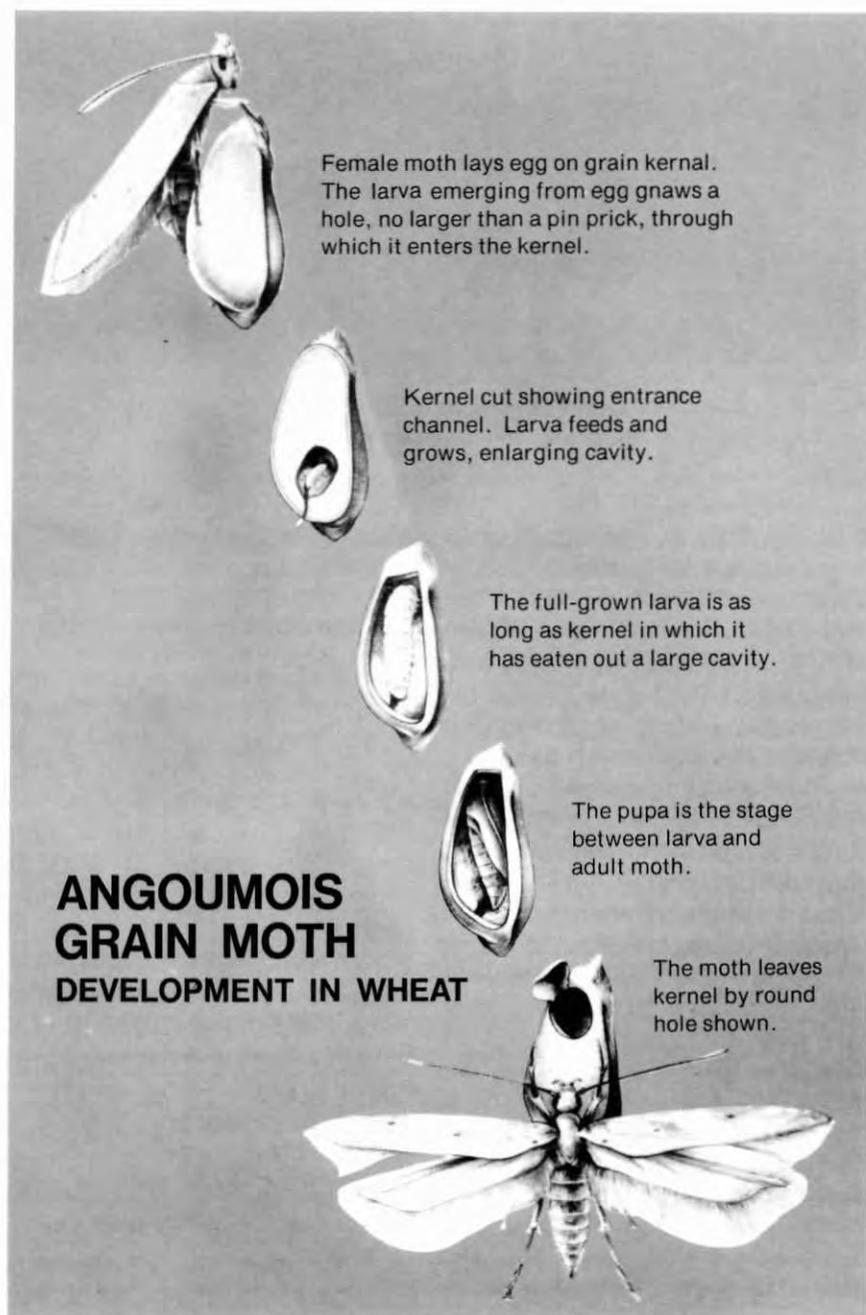


Figure 11.—Life cycle of the Angoumois grain moth on wheat.



Figure 12.—Grain moths: *Left*, Angoumois grain moth adult; *center*, pink scavenger caterpillar adult; *right*, pink scavenger caterpillar larva.

is smaller than the Angoumois grain moth, with a wing expanse of slightly less than half an inch (fig. 12*B*). The forewings are banded and mottled with yellow, reddish brown, and black. The pale-gray hindwings are very slender and are edged with long fringes.

This insect is common in the South, where it causes considerable injury to corn, both in the field and in storage. Infestation begins in the field and continues after the corn is placed in storage. Figure 13 shows corn damaged by feeding larvae. A reliable indication of the presence of this pest is the large amount of loosely webbed frass that fills the interstices between the kernels or fills the cavities of partially eaten kernels. The pearly white eggs are usually laid singly, occasionally in twos or threes. The pinkish larva feeds on the seed, husk, and cob with equal relish. The pink scavenger caterpillar is seldom a serious pest of commercial shipments, but it is capable of serious injury to corn, particularly as it comes to

maturity in the field or while in the crib on Southern farms.

European Grain Moth

The European grain moth, *Nemapogon granella* (Linnaeus),⁶ is a small moth about the size of the Angoumois grain moth and is creamy white and heavily mottled with brown (fig. 14). The mottled appearance distinguishes it from the Angoumois grain moth. It infests all kinds of grain, both in the field and in storage. The larva feeds on the grain and webs the kernels together.

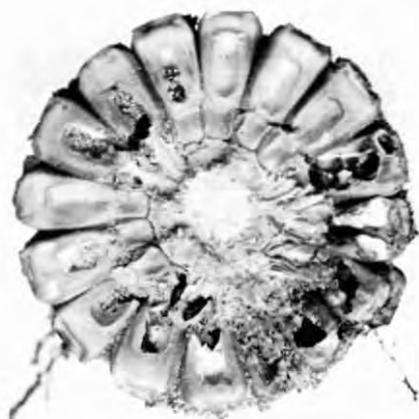
This moth is found throughout the Northern States but is not very abundant and cannot be compared with the Angoumois grain moth in destructiveness.

Rice Moth

The rice moth, *Corcyra cephalonica* (Stainton),⁷ has a wing

⁶Lepidoptera, Tineidae.

⁷Lepidoptera, Pyralidae.



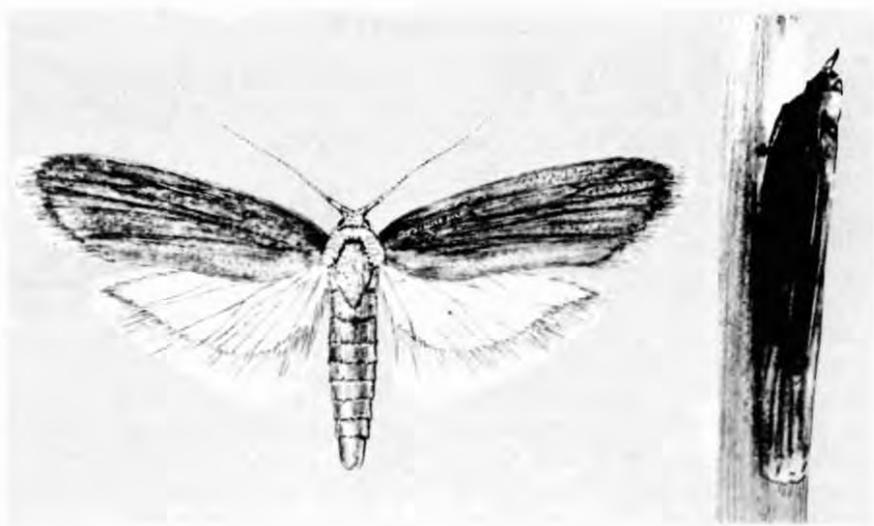
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Figure 13.—Cut ear of corn showing characteristic feeding and destruction by pink scavenger caterpillar larvae. Larvae eat from one kernel to another and often sever kernels from cob. Larvae sometimes eat into cob and transform into pupae there. Pupae are about one-third as long as the kernels shown.



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Figure 14.—European grain moth adult. Adult has a wing expanse of about one-half of an inch.



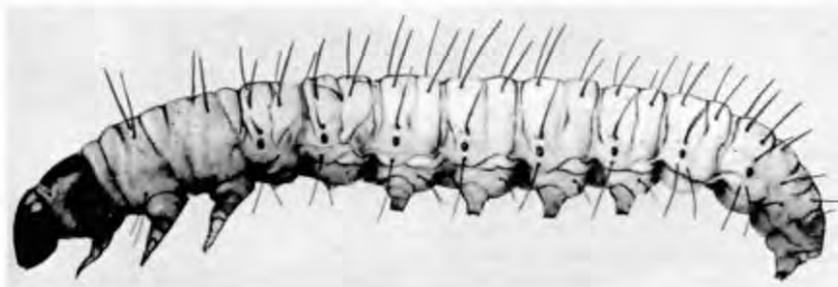
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Figure 15.—Rice moth adult: *Left*, dorsal view with wings spread; *right*, side view with wings folded to body. Adult has a wing spread of about one-half of an inch.

a dirty, slightly bluish gray with occasional tints of green (fig. 16).

Damage by this pest, as with all moth pests, is done by the larvae, which are rather general feeders. They attack such materials as rice, cocoa, chocolate, dried fruit, biscuits, and seeds. The larvae produce a dense webbing as they become fully

grown. When feeding upon grains, they spin dense silken tubes and web the grain kernels into the walls of the tubes. The moths live 1 to 2 weeks, and each female lays 100 to 200 eggs. In summer, the development period from egg to adult is about 6 weeks. The rice moth has not as yet become very widely spread in this country.



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Figure 16.—Full-grown larva of the rice moth, about one-half of an inch long.

FLOUR MOTHS

Among the flour moths are some of the commonest and most serious pests of grain products. They are designated as flour moths, not because they feed entirely upon flour or milled products, but because they seldom attack sound kernels. These insects prefer broken grains, grains injured by major grain pests, and more especially milled cereal products such as flour, breakfast foods, and meals. All three flour moths are commonly found in grain warehouses, but the Indian meal moth and the meal moth are probably the most frequently reported. These two moths may, under exceptionally favorable conditions, become estab-

lished in whole grain and other seeds and cause injury, especially by eating out the germ.

Indian Meal Moth

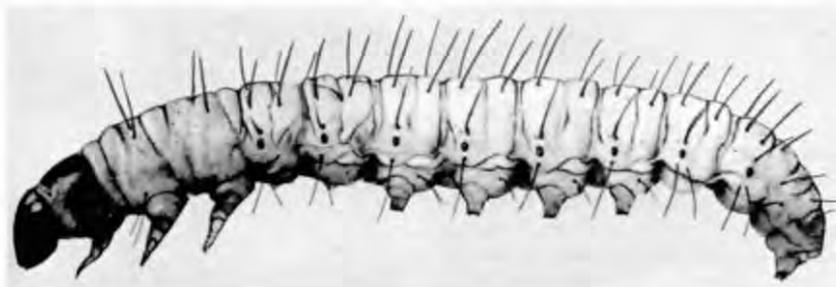
The Indian meal moth, *Plodia interpunctella* (Hubner),⁷ is a rather handsome moth with a wing expanse of nearly three-fourths of an inch (figs. 17 and 18A). It is easily distinguished from other grain pests by the peculiar markings of its forewings, which are reddish brown with a copper luster on the outer two-thirds but whitish gray on the inner or body ends.

Each female moth lays 100 to 300

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Indian Meal Moth

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Each female moth lays 100 to 300



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Figure 17.—Indian meal moth with wings spread. Adult has a wing expanse of nearly three-fourths of an inch.

eggs, singly or in groups, on food material. Within a few days, the eggs hatch and small whitish larvae, or caterpillars, emerge. These larvae feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs.

When fully grown, the larva is about half an inch long and is dirty white, sometimes varying to greenish and pinkish hues (fig. 18*B*). The larva spins a silken cocoon and transforms

into a light-brown pupa, from which the adult moth develops and later emerges. During warm weather, the Indian meal moth may pass through the egg, larval, and pupal stages in 6 to 8 weeks.

The larva of the Indian meal moth spins a web as it becomes fully grown and leaves a silken thread behind wherever it crawls. This webbing is often dense enough to attract attention when sacks of cracked corn, meal, or corn in the ear (that has been previously injured by other pests) have become heavily infested (fig. 19).

Mediterranean Flour Moth

The Mediterranean flour moth, *Anagasta kuehniella* (Zeller),⁷ has a wingspread of slightly less than 1 inch. Its hindwings are a dirty white, and the forewings—which alone show when the moth is not flying—are a



Figure 18.—Flour moths: *Left*, Indian meal moth adult; *center*, Indian meal moth larvae; *right*, almond moth adult.



BN-3077

Figure 19.—Ear of corn with characteristic loose webbing left by larvae of Indian meal moth. This moth rarely attacks sound grain but often attacks grain already injured by other grain pests, as shown here. Webbing develops only when grains are not moved for some time.

pale leaden gray with transverse, wavy, black markings (fig. 20A, B).

This flour moth is a native of Europe. It was first found in the United States in California in 1892. Since then, it has become widespread over the country and for many years was considered the most troublesome pest of flour mills. The larva spins silken thread wherever it goes and webs and mats together particles of food on which it is feeding. The matted flour sometimes clogs the

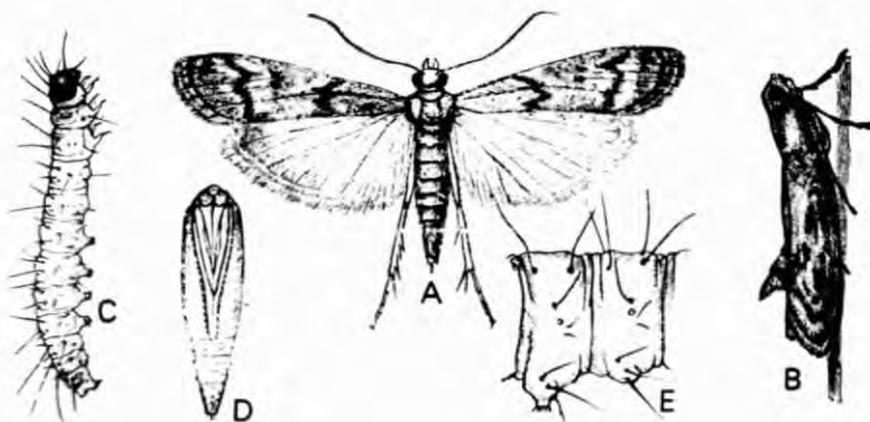
machinery in flour mills and causes milling operators to stop. In mills that have an annual fumigation, this insect is no longer a major problem. Although it prefers flour and meal, the Mediterranean flour moth attacks grain, bran, cereal products, and many other foodstuffs.

The female moth lays small white eggs in accumulations of flour, meal, or waste grain. Within a few days, a small larva emerges from each egg (fig. 20C). When fully grown, the larva is about half an inch long and is whitish or pinkish, with a few small black spots on the body. The full-grown larva spins a silken cocoon, in which the insect transforms into a reddish-brown pupa (fig. 20D). Later, the adult moth emerges from the pupa. During warm weather, the Mediterranean flour moth requires 8 to 9 weeks to pass through the egg, larval, and pupal stages.

Three other insect species occasionally infest grain or cereal products. They are the almond moth, *Cadra cautella* (Walker), the tobacco moth, *Ephestia elutella* (Hubner), and the raisin moth, *Cadra figulilella* (Gregson). Of the three, the almond moth is the most troublesome pest (fig. 18C). It is commonly found in seed stores and is a serious pest of rough rice and grain sorghum in the South.

Meal Moth

The meal moth, *Pyralis farinalis* Linnaeus,⁷ is brownish, somewhat larger than the Indian meal moth (though it varies in size), and usually has a wingspread of about 1 inch.



BN-3078

Figure 20.—Mediterranean flour moth: *A*, adult (dorsal view) with wings spread; *B*, adult (side view) in resting position; *C*, larva; *D*, pupa (enlarged); *E*, abdominal joint of larva (enlarged). Adult moth has a wing expanse of slightly less than 1 inch.

Figure 21*C* shows the characteristic markings or pattern of the forewings. They are light brown with dark-brown patches at the bases and tips, and each forewing has two wavy, transverse white lines.

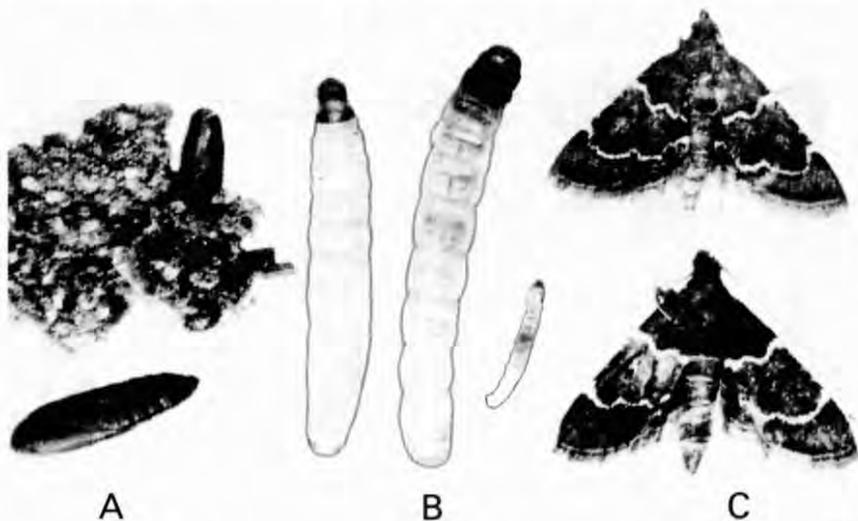
The meal moth is widely distributed and, in the larval stage, is a general feeder upon cereals, cereal products, hay, and many types of dried vegetable matter. It is usually found in damp basements or in other places where accumulations of damp, spoiled grain, bran, or meal are found. Though it prefers material that is damp and in poor condition, the meal moth may attack and severely damage sound wheat or cereal products, if these materials are stored in moist places or have a relatively high moisture content.

Meal moth larvae sometimes attract much attention because of their capacity to "web-up" and bind together seeds of various kinds. The

larvae cut through burlap sacks and can damage them greatly when heavy infestations develop in the sacked material. Figure 22 shows the characteristic "webbing together" of infested seeds (in this instance navy beans). Figure 23 shows the tendency of the larvae to spin their whitish silken cocoons on the outside of grain sacks where the sacks touch one another. When the larvae cut sacks, the seeds fall out and lodge where the sacks touch. In such places, the seeds are usually heavily infested.

The meal moth larva is whitish, and, when fully grown, is about 1 inch long (fig. 21*B*). The larva shows a contrast between the black of the head and the first body segment and the white of the remainder of the body. The body of the larva is often tinged with orange toward each end.

The larvae spin peculiar tubes of silk that contain mixed particles of food material. They rest in these



BN-3079

Figure 21.—Meal moth: *A*, pupa and (above) webbed grain mass with portion of pupa protruding; *B*, two well-grown larvae and (right) smaller larva; *C*, two adult moths. Markings on forewings easily distinguish this insect from other grain pests. Magnified about 1-1/2 times.

tubes, which are very tough, and feed from the openings at the ends. When fully grown, the larvae leave the tubes, spin silken cocoons (also often covered with food particles), and transform into pupae (fig. 21*A*) from which the adult moths later emerge.

The female moth lives about 1

week and lays 200 to 400 eggs. In summer, the period from egg to adult is 6 to 8 weeks.



BN-3080

Figure 22.—Navy beans, webbed together by meal moth larvae, adhere to sack.



BN-3118

Figure 23.—Whitish cocoons spun by meal moth larvae on side of sack previously filled with infested seed. Note dark pupae within cocoons, vetch seed webbed to sack by larvae, and (center) adult moth.

GRAIN AND FLOUR BEETLES

Cadelle

The cadelle, *Tenebroides mauritanicus* (Linnaeus),⁸ is an elongate, oblong, flattened, black or blackish beetle about one-third of an inch long (fig. 24A). It is sometimes called the bolting-cloth beetle because of its habit of cutting the silk cloths of bolting reels and redressing machines in flour mills.

The cadelle larva is one of the largest of the grain-infesting insects and is easily recognized. It is about three-fourths of an inch long, fleshy,

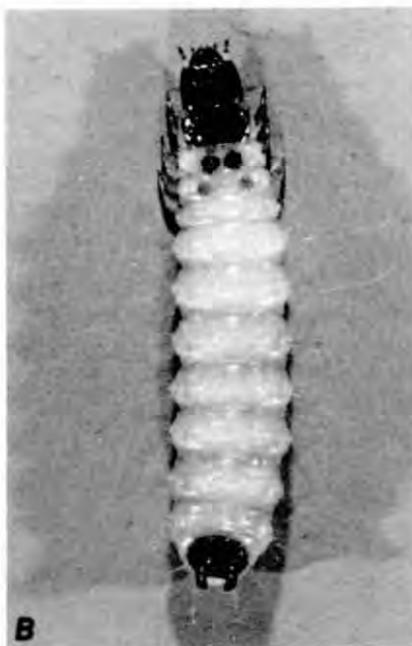
with the abdomen terminating into two dark horny points (fig. 24B). The larva body is a dirty or chalky white, and the head, thoracic shield, and two horny points are black.

This insect is widespread over the world and is frequently found in mills, granaries, and storehouses, where it infests flour, meal, and grain. Both the larva and adult feed on grain and have the destructive habit of going from kernel to kernel devouring the germs. The cadelle is one of the longest lived of the insects that attack stored grain; many of the adults live for more than 1 year and some of them for nearly 2 years.

⁸Coleoptera, Trogositidae



A



B

BN-3081 PN-5177

Figure 24.—Cadelle: *Left*, adult, about one-third of an inch long; *right*, larva, about three-fourths of an inch long.

The female beetle oviposits most of her life and, under favorable conditions, lays about 1,000 eggs.

The female lays clusters of white eggs in food material, which hatch in 7 to 10 days in warm weather.

The larvae complete their growth in 2 to 14 months and then seek some secluded place in which to transform into the pupal stage. They frequently bore into the timbers of the bin or other receptacle that holds the infested material. Both the larvae and adults can live for long periods without food and often remain hidden in the woodwork of the bin for a long time after the grain has been removed. When new grain is put into the bin, it becomes infested in a surprisingly short time.

Sawtoothed Grain Beetle

The sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus),⁹ is one of the best known of the cosmopolitan grain pests. It is a slender, flat, brown beetle about one-tenth of an inch long. It gains its name from the peculiar structure of the thorax, which bears six sawtoothlike projections on each side (fig. 25). It attacks, in both the larval and adult stages, all food of vegetable origin, especially grain and grain products such as flours, meals, breakfast foods, stock and poultry feeds, copra, nut meats, candies, and dried fruits.

The adults live, on an average, 6 to 10 months, but some adults may live as long as 3 years. The female



BN-5177

Figure 25.—Sawtoothed grain beetle adult, about one-tenth of an inch long.

beetle lays 43 to 285 eggs. She drops them loosely among the foodstuff or tucks them into a crevice in a kernel of grain. The small, slender, white eggs hatch in 3 to 5 days.

The emerging larvae do not stay within a single grain but crawl about actively and feed. During summer, they become fully grown in about 2 weeks. The mature larvae then construct delicate cocoonlike coverings by joining together small grains or fragments of foodstuffs with a sticky secretion. Within these cells, the larvae change to the pupal stage, which lasts about 1 week. In summer, the developmental period from egg to adult is 4 weeks.

⁹Coleoptera, Cucujidae.

Merchant Grain Beetle

A related species, the merchant grain beetle, *Oryzaephilus mercator* (Fauvel),⁷ is often confused with the sawtoothed grain beetle. It is less commonly found in grain than the sawtoothed grain beetle and appears to prefer oilseed products, including nuts. Cereal products are more likely to be infested with this insect than the grain itself.

In the merchant grain beetle, the eye diameter is larger than the temple region behind the eye, and the head is rectangular. A comparison with the smaller eyes and more triangular head of the sawtoothed grain beetle may be made from figure 26. The merchant grain beetle is also slightly larger and is a darker brown than the sawtoothed grain beetle.

The habits and development of the two species are similar, but the merchant grain beetle lays only one-half to two-thirds as many eggs.

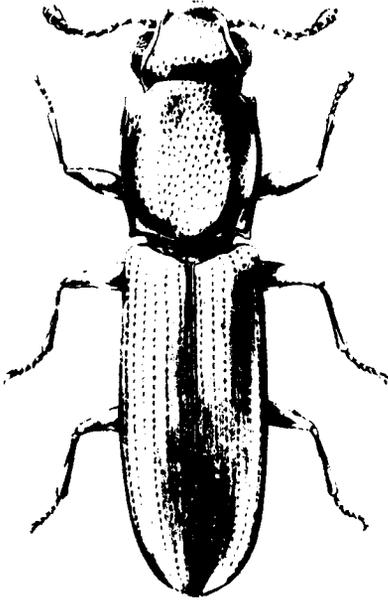
Squarenecked Grain Beetle

The squarenecked grain beetle, *Cathartus quadricollis* (Guerin-Meneville),⁸ is closely related to the sawtoothed grain beetle, which it greatly resembles in form, size, and color. It is a flattened, oblong, polished, reddish-brown beetle about one-tenth of an inch long. It differs from the sawtoothed grain beetle by its almost square thorax, which lacks the sawtoothlike projections (fig. 27).

This beetle is mainly abundant in the South, where it is found outdoors in great numbers in the seed pods of



Figure 26.—Anterior comparison of sawtoothed and merchant grain beetles: *Left*, sawtoothed grain beetle adult; *right*, merchant grain beetle adult.



BN-3085

Figure 27.—Square-necked grain beetle adult, about one-tenth of an inch long.

a great variety of plants. It is one of the most common beetles in stored corn in the South and, in the corn-fields, is always found on damaged or exposed ears.

The immature stages closely resemble those of the sawtoothed grain beetles in both form and habit. The larvae have the bad habit of devouring the germs of the seeds in which they breed. These insects develop from egg to adult in about 3 weeks.

Foreign Grain Beetle

The foreign grain beetle, *Ahasverus advena* (Waltl),⁹ is a small reddish-brown beetle somewhat sim-

ilar in appearance to the closely related square-necked grain beetle, but is shorter and stouter (fig. 28).

Though of worldwide distribution, it is not important as an enemy of stored grains. It is attracted to damp and moldy grains, where it feeds on the molds. This insect is rarely found in clean grain.

Mexican Grain Beetle

The Mexican grain beetle, *Pharaxonotha kirschi* Reitter,¹⁰ is a highly polished, deep-brown beetle about three-sixteenths of an inch long. It somewhat resembles the confused flour beetle in general appearance but can be readily distinguished from that insect by its more polished surface and longer antennae (fig. 29A).

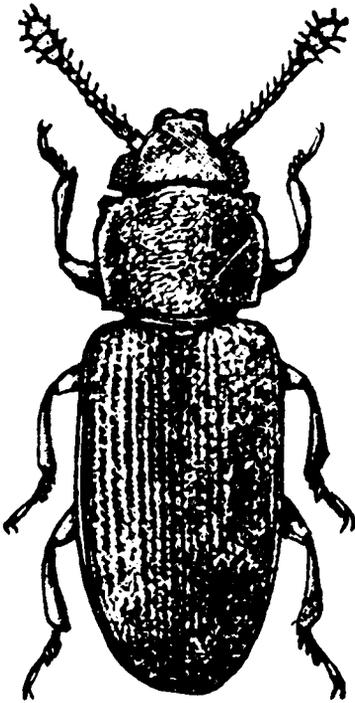
This insect is common in Mexico and Guatemala, where it breeds in grain and grain products, but it is not known to be established in the United States.

Siamese Grain Beetle

The Siamese grain beetle, *Lophocateres pusillus* (Klug),⁸ is a flattened reddish-brown beetle slightly less than one-eighth of an inch long. It is characterized by the much flattened margins of the thorax and wing covers (fig. 30A).

This insect first appeared in this country in exhibits of rice and cereal from Siam, Liberia, and Ceylon at the Columbian Exposition, and it is now well established in the Southern

¹⁰Coleoptera, Languriidae.



BN-3086

Figure 28.—Foreign grain beetle adult.

States. It is commonly found in rice mills in Texas but does not cause serious damage.

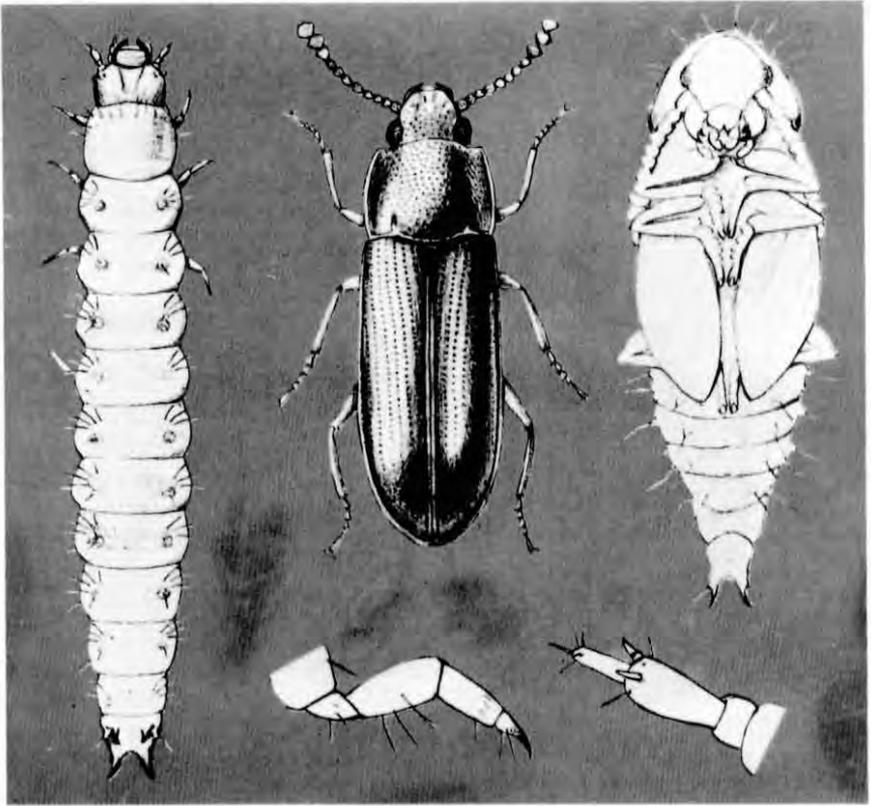
Flat Grain Beetle

The flat grain beetle, *Cryptolestes pusillus* (Schoenherr),⁹ is one of the smallest beetles commonly found in stored grain. It is a minute, flattened, oblong, reddish-brown beetle about one-sixteenth of an inch long, with elongate antennae about two-thirds as long as the body (fig. 31). It is cosmopolitan and is one of the commonest insect pests of stored grain. However, this insect is not a primary

pest of stored grain, and the adult is apparently unable to survive in sound, uninjured grain. It follows up the attack of the more vigorous grain pests and is frequently found in enormous numbers with the rice weevil. This insect is a scavenger and often infests grain and meal that are in poor condition.

The females deposit small white eggs in crevices in the grain or drop them loosely upon farinaceous material. The larvae are particularly fond of the wheat germ, and, in infested grain, many kernels are found uninjured except for the removal of the germ. The larvae also feed on dead insects. When fully grown, the larvae form cocoons of a gelatinous substance to which food particles adhere. They transform into the pupal stage in these cocoons and later emerge as adults. Under favorable conditions, this insect may develop from egg to adult in about 5 weeks, but the average period of development in summer is about 9 weeks.

A related beetle, *C. turcicus* (Grouvelle), resembles the flat grain beetle so closely in appearance and habit that it is usually confused with that insect. This beetle, also, is cosmopolitan and the females of the two species are so similar that it is almost impossible to distinguish between them. The males, however, can be distinguished from each other by the length of the antennae. The antennae of the *C. turcicus* male beetle are as long as, or longer, than the body, but the antennae of the flat grain beetle male are only two-thirds as long as the body.



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Figure 29.—Mexican grain beetle: A, adult; B, larva; C, pupa; D, leg of larva; E, antenna of larva. A, B, and C enlarged about 8 times; D and E greatly enlarged.

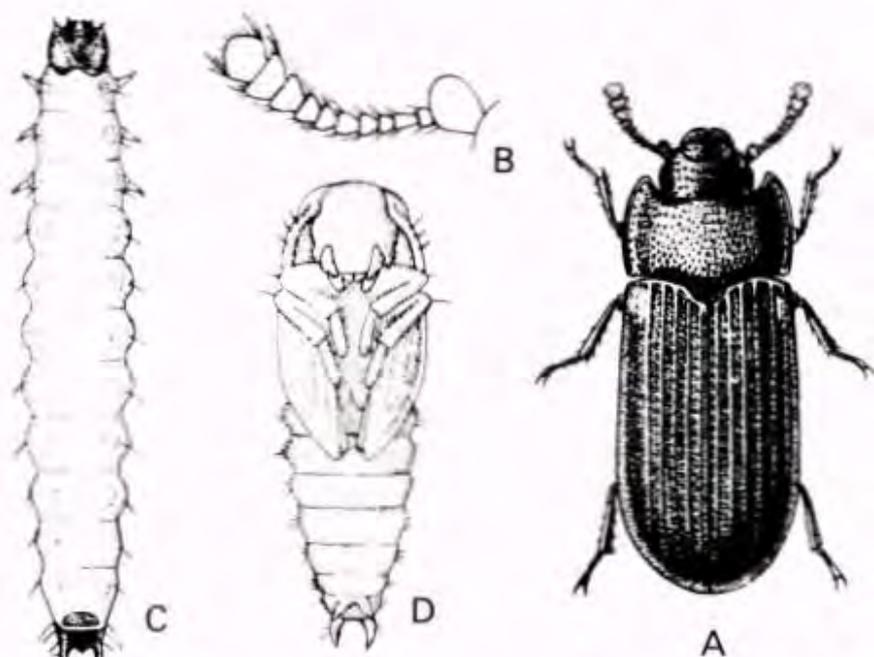
Rusty Grain Beetle

A third species, the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens),⁹ is similar to the flat grain beetle and *C. turcicus* beetle in appearance and habit, but differs from them in the antennae (fig. 32) of the male beetle, which are not more than half as long as the body. This species is more resistant to cold weather than the other two species and is more commonly found in stored grain in the Northern States.

Confused Flour Beetle

The confused flour beetle, *Tribolium confusum* Jacquelin du Val,¹¹ is a shiny, flattened, oval, reddish-brown beetle about one-seventh of an inch long. The head and upper parts of the thorax are densely covered with minute punctures. The wing covers are ridged lengthwise and are sparsely punctured between the ridges (fig. 33). This insect is distributed

¹¹Coleoptera, Tenebrionidae.



BN-3088

Figure 30.—Siamese grain beetle: *A*, adult; *B*, antenna of adult; *C*, larva; *D*, pupa enlarged.

over the world and is very abundant throughout this country. It is a general feeder on farinaceous material and is undoubtedly the most abundant and injurious insect pest of flour mills in the United States. It is found in granaries, mills, warehouses, and wherever grain or grain products are stored.

The average life of these beetles is about 1 year, but some have been known to live as long as 3 years 9 months. The female lays an average of about 450 eggs, which are small and white, loosely in flour or other food material in which the adults live. They are covered with a sticky secretion, thus becoming covered with flour or meal, and readily adhere to the sides of sacks, boxes, and other



Figure 31.—Flat grain beetle adult, showing characteristic long antennae. Body is not more than one-sixteenth of an inch long.



HN-5178

Figure 32. Rusty grain beetle adult.

containers. Consequently, fresh material placed in the containers is rapidly infested. The eggs hatch in 5 to 12 days and small, wiry, slender, cylindrical, wormlike larvae emerge. When fully grown, they are about three-sixteenths of an inch long and are white tinged with yellow. These larvae feed on flour or other material such as grain dust and the broken surfaces of grain kernels.

When fully grown, the larvae transform into small naked pupae. At first white in color, the pupae gradually change to yellow and then to brown and, shortly afterwards, transform into adult beetles. In summer, the period from egg to adult averages about 6 weeks under favorable weather conditions, but the life cycle is greatly prolonged by cold weather, as is true of all grain pests.

Red Flour Beetle

The red flour beetle, *Tribolium castaneum* (Herbst),¹¹ is almost identical in appearance to the closely related confused flour beetle. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. The segments of the confused flour beetle antennae gradually increase in size from the bases to the tips whereas the last few segments of the red flour beetle antennae are abruptly much larger than the other segments, forming enlarged tips. The head margins of the confused flour beetle are expanded and notched at the eyes, with a ridge over the eye. The pronotum is widest at the anterior third. The head margins of the red flour beetle are nearly continuous at the eyes and do not have a ridge over the eye.



Figure 33. Confusum (confused) flour beetle adult.

The pronotum is widest at the middle. The differences between the two species are shown in figure 34.

This insect is constantly associated with the confused flour beetle and has similar feeding and breeding habits. The immature stages of the two insects are so similar that it is impossible to distinguish between them. The developmental period from egg to adult is usually somewhat shorter than for the confused flour beetle. Although it is cosmopolitan, the red flour beetle is found most commonly in the Southern United States, where it causes very serious damage to grain products. In addition to the damage it causes by feeding, this insect imparts a nauseous smell and taste to the material it infests. Like the confused flour beetle, the red flour beetle

is primarily a pest of milled products. It is present in grain shipments, where it attacks only grain dust and the surfaces of broken grains; hence, it is not a primary pest of commercial shipments.

American Black Flour Beetle

The American black flour beetle, *Tribolium audax* Halstead,¹¹ is found as commonly outdoors as it is in storehouses. Until recently, it was confused with the European *T. madens* (Charpentier), which it resembles in appearance and habits (fig. 35A). Although not so well known as the confused and red flour beetles, it has similar habits and is occasionally found infesting grain and grain products in flour mills and storehouses.



Figure 34—Anterior comparison of confusum (confused) and castaneum (red) flour beetles: *Left*, confusum (confused) flour beetle adult; *right*, castaneum (red) flour beetle adult.



Figure 35.—Flour beetles: *A*, American black flour beetle adult; *B*, longheaded flour beetle adult; *C*, slenderhorned flour beetle adult; *D*, small-eyed flour beetle adult; *E*, depressed flour beetle adult.

This insect is seldom found in injurious numbers and is by no means as widespread as *T. confusum* and *T. castaneum*. It occurs in its greatest abundance in the Rocky Mountain States, but it has been reported from widely scattered points over the country. It may be readily distinguished from the confused and red flour beetles by its black color and larger size. This insect is about one-sixth of an inch long. Infestation of poultry feed by *T. destructor*

Uyttenboogaart, another species of this destructive group of flour beetles, was recently reported from Montreal, Canada. It was introduced from Europe.

Longheaded Flour Beetle

The longheaded flour beetle, *Latheticus oryzae* Waterhouse,¹¹ is a slender, flattened beetle slightly less

than one-eighth of an inch long. It is somewhat similar in form to the confused flour beetle but is narrower and is pale yellowish brown (fig. 35B). The beetle is further differentiated from the confused flour beetle by the peculiarly shaped antennae and the minute canthus behind each eye.

The longheaded flour beetle has been reported from most parts of the world as having infested wheat, rice, corn, barley, rye, flour, and similar products. It was first recognized in this country from specimens collected in Texas in 1908 and is now widespread in the Southern and Middle Western States, where it is common in rice and flour mills. This beetle infests grain and grain products in the mills and causes the same type of damage as that done by the confused flour beetle.

Slenderhorned Flour Beetle

The slenderhorned flour beetle, *Gnatocerus maxillosus* (Fabricius),¹¹ is closely related to the broadhorned flour beetle and is of similar form and appearance (fig. 35C). It is about one-eighth of an inch long. In addition to its smaller size, this insect may be distinguished from the broadhorned flour beetle by the slender incurved "horns" with which mandibles or jaws of the male are armed. Its habits are similar to those of the broadhorned flour beetle, but it is less common in the United States and is more or less confined to the Southern States.

Smalleyed Flour Beetle

The smalleyed flour beetle, *Palorus ratzeburgi* (Wissmann),¹¹ is the smallest of the flour beetles that infest grain and grain products in this country. It is tiny, somewhat oblong, flattened, shiny, reddish-brown beetle about one-tenth of an inch long (fig. 35D). This insect occurs throughout the world and is widely distributed in this country. It breeds in grain and milled products and is frequently found in flour-mill basements.

Depressed Flour Beetle

The depressed flour beetle, *Palorus subdepressus* (Wollaston),¹¹ is similar in appearance and habits to the smalleyed flour beetle. It is slightly larger than that species, and the sides of the front of the head are strongly reflexed and extend backward to conceal the front portions of the eyes (fig. 35E). In the smalleyed flour beetle, the sides of the front do not extend backward. The depressed flour beetle, also, is cosmopolitan but is much less common in the United States than the smalleyed flour beetle, except perhaps in the Great Plains.

Broadhorned Flour Beetle

The broadhorned flour beetle, *Gnatocerus cornutus* (Fabricius),¹¹ owes its name to the peculiar structure of the mandibles, or jaws, of the male beetle, which are armed with a pair of broad, stout "horns." It is a stout, reddish-brown beetle about

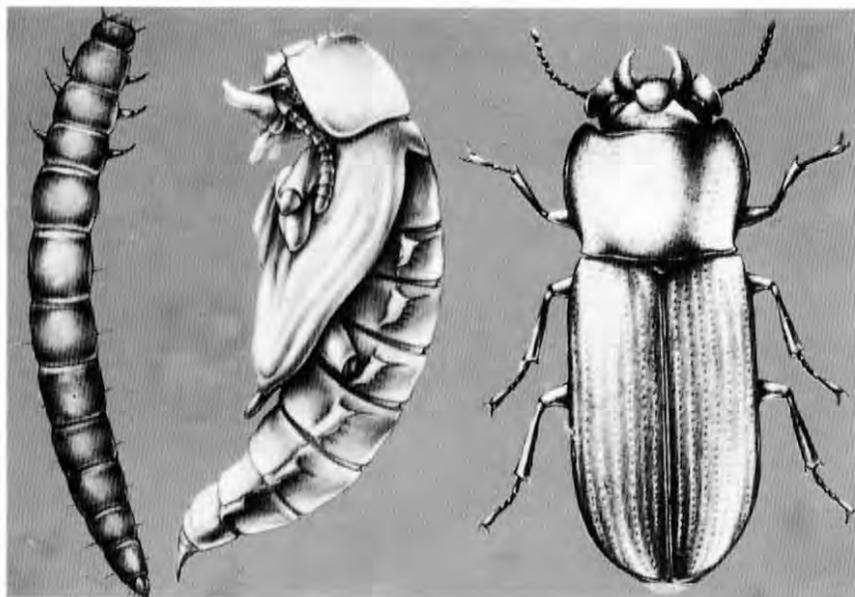
one-sixth of an inch long, and it closely resembles the other flour beetles in appearance but is easily distinguished from them by the peculiar structure of its jaws (fig. 36). It is cosmopolitan and is common in all parts of the United States, except in the Great Plains, where it is comparatively rare. This insect prefers to feed in flour and meal but is found in a variety of grains. The adult beetles frequently live for 1 year or longer. The female lays 100 to 200 small white eggs which hatch in 4 to 6 days in warm weather. The development period from egg to adult is 6 to 8 weeks.

Larger Black Flour Beetle

The larger black flour beetle, *Cynaeus angustus* (LeConte),¹² described in 1852, was little known as a pest of stored grain and grain products until 1939, when it was found in a flour mill in Seattle, in stored wheat in Kansas, and in stored corn in Iowa.

It is now fairly common in farm-stored grain in the North Central States. It is a stout, reddish-brown or black beetle about one-fourth of an inch long (fig. 37). This insect is known to live for 6 months and may

¹²Coleoptera, Tenebrionidae.



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Figure 36.—Broadhorned flour beetle: *Left*, larva; *center*, pupa; *right*, adult. Adult is about one-sixth of an inch long.



Figure 37.—Larger black flour beetle adult, about one-fourth of an inch long.

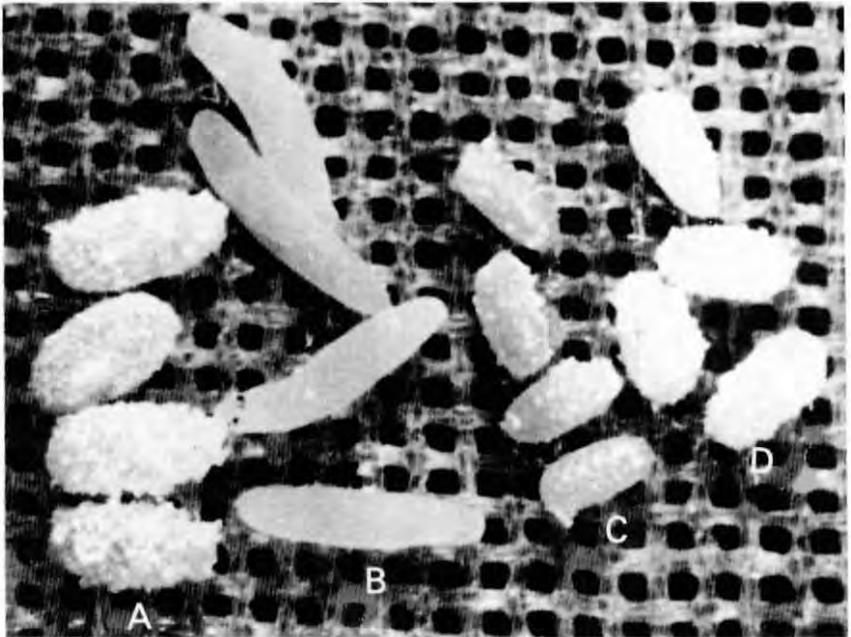
live for at least 1 year under favorable conditions. The life cycle from egg to adult can be completed in 4

weeks, but it usually requires 6 to 10 weeks. This insect prefers grain that is high in moisture.

EGGS OF FLOUR AND GRAIN INSECTS

The eggs of the common flour- and grain-infesting insects are rarely seen by the layman. They are usually white and are often covered with a sticky substance that causes particles of flour or other material to adhere to them, thus making them difficult to distinguish from the foodstuff in which they are deposited. Some eggs are oval or oblong-oval, and others are slender and spindle shaped. Their small size is well illustrated in figure 38, which shows the eggs of four different species of insects on a piece of

10XX silk bolting cloth. The eggs of the flat grain beetle are so small that, if placed side by side, they would average about 150 per inch. Those of the cadelle, which is one of the larger beetles that infest stored cereal products, if placed end to end, would average about 19 eggs per inch. During the process of milling flour and preparing it for the market, the flour is sifted through silk bolting cloth to remove insect eggs and other impurities.



BN-3098

Figure 38. Eggs of flour and grain insects: *A*, roadhorned flour beetle; *B*, cadelle; *C*, Mediterranean flour moth; *D*, confused flour beetle. Photo greatly enlarged.

MEALWORMS

The term "mealworm" applies to the larvae of several beetles of the family Tenebrionidae that are nocturnal and frequent dark places. They breed in refuse grain, coarse cereal, and mill products that accumulate in dark corners, under sacks, in bins, and in similar places. They inhabit moist places and are often found among slightly damp bags.

Yellow Mealworm

The yellow mealworm, *Tenebrio molitor* Linnaeus,¹¹ is one of the largest insects that infest stored cereal products. This insect is cosmopolitan;

in the United States, it is abundant only in the Northern States.

The adult is a polished dark-brown or black beetle somewhat more than half an inch long (fig. 39*A*). Its thorax is finely punctured, and its wing covers are longitudinally striated or grooved. The female lays bean-shaped white eggs covered with a sticky secretion that causes the flour, meal, or grain waste in which they are placed to adhere to them. The eggs hatch in about 2 weeks and slender white larvae emerge. The larvae soon turn yellow and assume the form shown in figure 39*C*. When

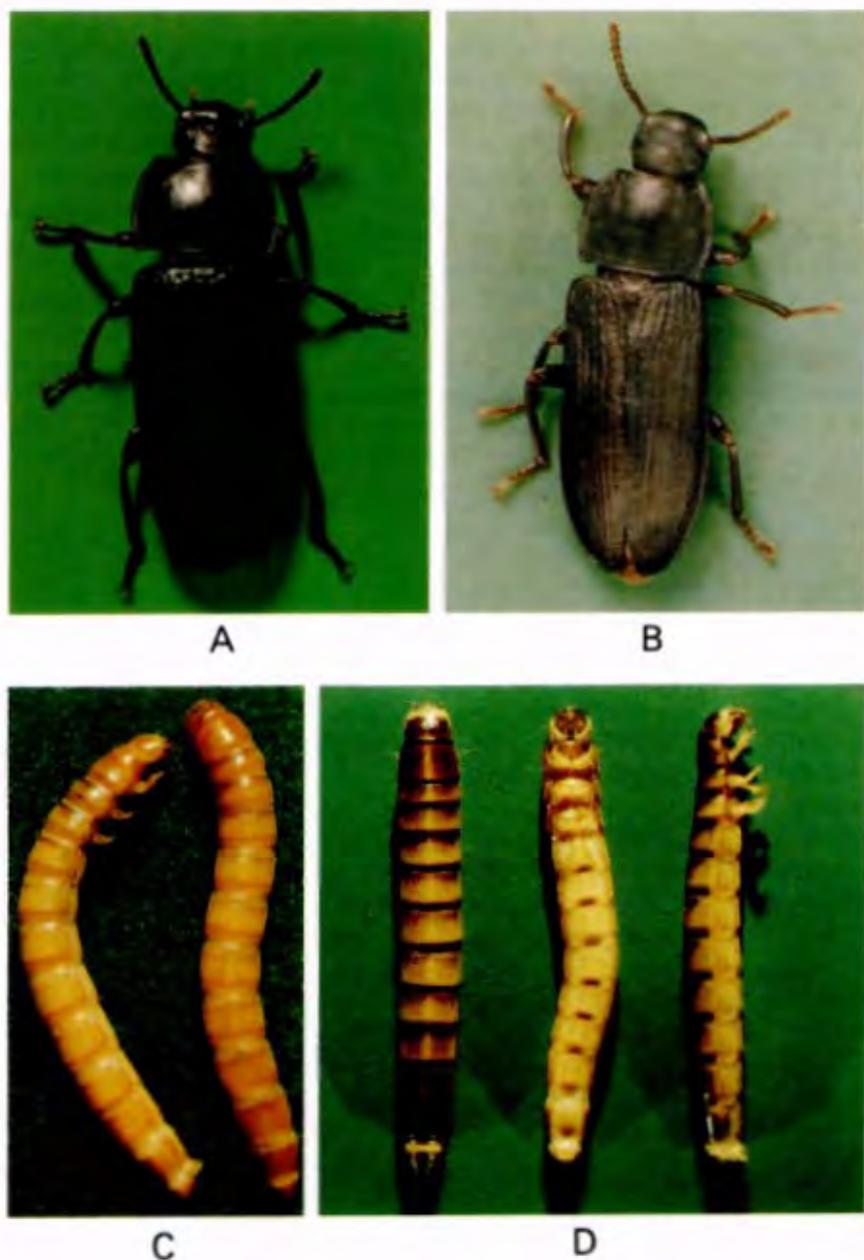


Figure 39.—Mealworms: *A*, yellow mealworm adult; *B*, dark mealworm adult; *C*, yellow mealworm larvae; *D*, dark mealworm larvae.

fully grown, the larvae are about 1 inch long and are yellowish, shading to yellowish brown toward each end and at the articulation of each segment. The yellow mealworm gets its name from the yellowish color of the larvae.

There is but one generation each year. The adults begin to appear in the latitude of Washington, D.C., in late May and early June and may be found until late in August. The female beetles are quite prolific, and each may lay as many as 500 eggs. The larvae become fully grown in about 3 months, but, instead of transforming into the pupal and adult stages, they continue to feed and molt until cold weather and then hibernate. Later on, in late spring or early summer, they transform into the pupal stage for about 2 weeks.

Because the yellow mealworm has but one generation each year and is entirely an external feeder upon grains, it is not a serious pest. Screening and fanning will easily remove it from grain shipments. The well-grown larva, however, can do serious injury to whole grains under certain conditions, when grain is held for long periods without being moved.

Dark Mealworm

The dark mealworm, *Tenebrio obscurus* Fabricius,¹¹ is very similar in form, size, and color to the closely related yellow mealworm. However, the adult is a dull, pitch-black beetle,

in contrast to the shiny or polished dark-brown or black yellow mealworm adult (fig. 39B). The dark mealworm larva so closely resembles the yellow mealworm larva that it can best be distinguished from that species by its much darker color (fig. 39D).

These two species are often found together since they have similar feeding habits. The overwintering larvae of the dark mealworm begin to pupate earlier than those of the yellow mealworms, and, in the Washington, D.C., area the adult beetles emerge during April and May.

Lesser Mealworm

The lesser mealworm, *Alphitobius diaperinus* (Panzer),¹¹ resembles the yellow and dark mealworms in form and color but is considerably smaller. It is black or very dark reddish brown and is three-sixteenths to four-sixteenths of an inch long (fig. 40A). The larva is yellowish brown and closely resembles the young larva of the yellow mealworm in form and appearance (fig. 40B). This insect is cosmopolitan and is commonly found in flour-mill basements in damp or musty flour or grain. It prefers grain and cereal products that are slightly out of condition and is commonly associated with poultry feed.

Black Fungus Beetle

The black fungus beetle, *Alphitobius laevigatus* (Fabricius),¹¹ is

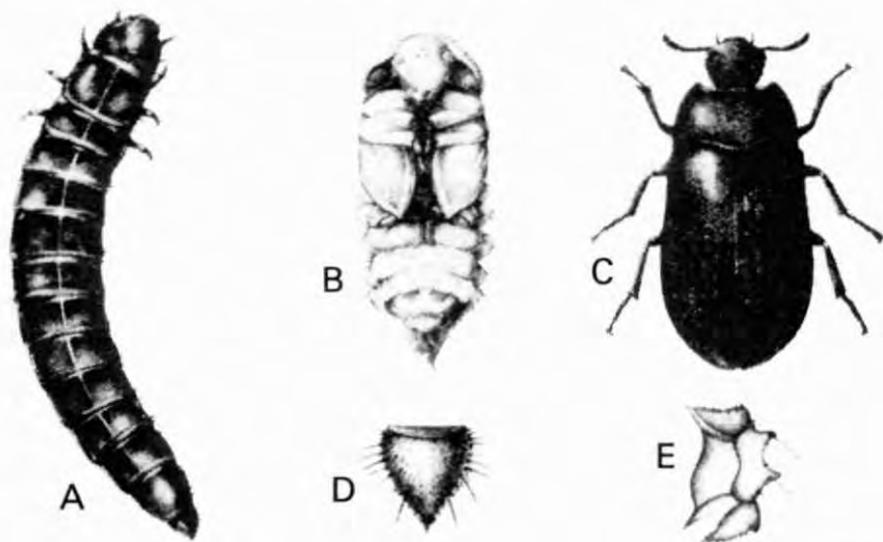


Figure 40.—Lesser mealworm: *Left*, adult; *right*, larva.

almost identical in appearance to the lesser mealworm and has similar habits. It prefers damp, moldy grain and cereal products and does not cause serious damage to sound grain. This insect may be distinguished from the lesser mealworm by the curved sides of the thorax, which are coarsely and densely punctuated on the surfaces, whereas, in the lesser mealworm, the sides are nearly straight and the surfaces are finely and sparsely punctured (fig. 41C). In the United States, the black fungus beetle is much less abundant than the lesser mealworm.

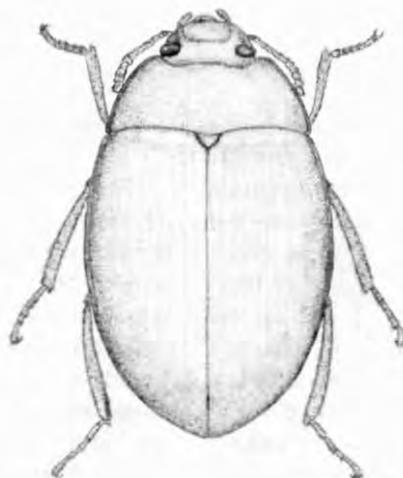
Redhorned Grain Beetle

The redhorned grain beetle, *Platydema ruficorne* (Sturm),¹¹ is a broadly oval beetle slightly less than one-fourth of an inch long. It is velvety black with a purplish tinge and has reddish-yellow antennae (fig. 42). Reported to be common on fleshy fungi and underneath tree bark, it was found in abundance in shelled corn in Missouri in 1940 and was also found in shelled corn in Illinois and Iowa. This insect is particularly attracted to damp and moldy grain.



BN-3100

Figure 41.—Black fungus beetle: *A*, larva; *B*, pupa; *C*, adult; *D*, caudal segment of larva; *E*, lateral plate of pupa. Larva is about 1 inch long.



BN-5179

Figure 42—Redhorned grain beetle adult, about one-fourth of an inch long.

DERMESTID BEETLES

In general, the dermestids are a group of beetles that scavenge and feed on animal matter. Certain species, however, belonging to the genera *Trogoderma*, *Anthrenus*, and *Attagenus*, vary their diet by feeding on farinaceous materials. They are frequently present in flour mills, farm granaries, warehouses, and similar places where grain and grain products are stored.

Black Carpet Beetle

The black carpet beetle, *Attagenus megatoma* (Fabricius),¹² is a small, oval beetle two-sixteenths to three-sixteenths of an inch long (fig. 43A). The head and thorax are black, but the wing covers are black or dark-reddish brown and are covered with short hairs. Its legs and antennae are dark yellow. The larva is very characteristic and can be easily recognized. It is reddish or golden brown, is covered with short, scalelike, appressed hairs, and has a tuft of long hairs at the end of the body (fig. 44).

The larvae are often found in abundance in cracks in the floors of warehouses where foodstuffs have accumulated. In the spring, these larvae transform into adults, which swarm over bagged material stored there. Because the larvae of the black carpet beetle develop slowly, there is only one generation each year. If conditions are unfavorable, the life cycle may be prolonged to 2 or 3 years. The adults, which emerge in the spring and early summer, live 2 to 4

weeks, and each female lays about 100 eggs. This beetle is cosmopolitan.

Trogoderma Beetles¹²

The best known member of this group is *Trogoderma inclusum* LeConte,¹² which is a common pest of grain, seed, and other stored products in the Great Plains States. The adult beetle is one-fourteenth to one-sixth of an inch long. The female is about 1-1/3 times the size of the male. The beetle is reddish brown to black with indistinct pale markings on the wing covers.

The larva is stout, and, at rest, the back is yellowish brown (fig. 45). However, the areas between the segments, which are visible during movement, and the underside are very pale yellow. The last three segments of the body are almost covered by tufts of dense, specialized hairs. The fully grown larva may attain a length of one-fourth of an inch. This insect larva is difficult to distinguish from the larvae of related species.

The adult female beetle lays up to 96 eggs. The life cycle varies from 7 weeks to several years, depending upon the temperature and the food supply.

Trogoderma glabrum (Herbst) is very similar to *T. inclusum* and is found in similar situations. The adult lacks the longitudinal pale markings on the midportion of the wing covers, and differences in the eyes and antennae of the two species can nor-

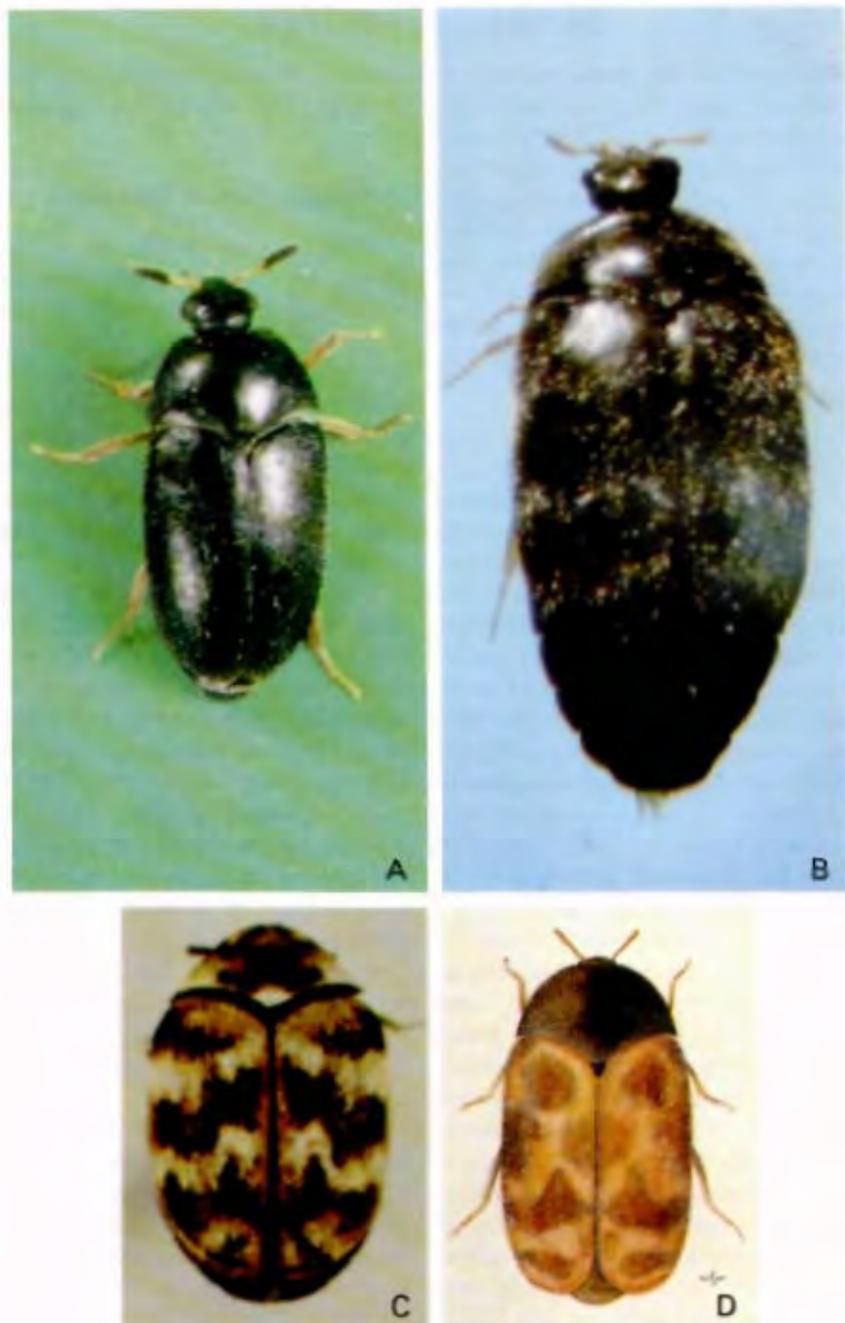


Figure 43.—Dermestid beetles: A, black carpet beetle adult female; B, *Trogoderma glabrum* (H.) adult; C, varied carpet beetle adult; D, khapra beetle adult. (Drawing of khapra beetle adult courtesy of California Department of Food and Agriculture.)



Figure 44.—Larva of black carpet beetle (with tuft of hairs), about two-fifths of an inch long.

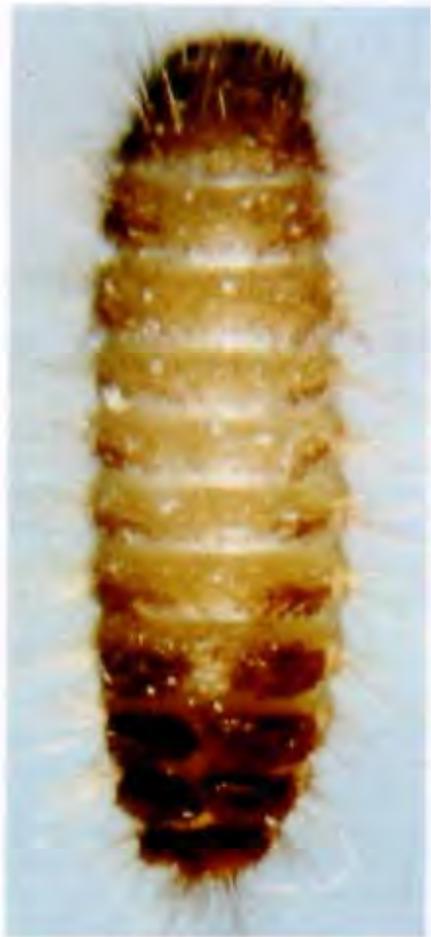


Figure 45.—Larva of *Trogoderma inclusum* LeC.

mally be determined only in the laboratory (fig. 43*B*). The larvae are also very similar, but *T. glabrum* larvae are generally darker, or more reddish brown than yellowish brown.

The so-called warehouse beetle, *Trogoderma variabile* Ballion (*T. parabile* Beal), is widespread but difficult to recognize because of its variable appearance.

Worldwide, the khapra beetle, *Trogoderma granarium* Everts, is the most destructive of this group (fig.

43*D*). It was discovered in Tulare County, Calif., in 1953 and is thought to have been present in the San Joaquin Valley since 1939.

Before its discovery, this insect had spread to other points in California and into Arizona, New Mexico, Texas, and Baja California, Mexico. A Federal quarantine was invoked in February 1955 to deter the spread of this pest to other areas, and

an eradication program was started. By 1961, active infestations were eliminated, and strict quarantine measures have kept the beetle from becoming reestablished in the United States.

This beetle prefers dried vegetable matter to animal matter as food but will attack almost any kind of either material. Grain damaged by the khapra beetle has somewhat the same appearance as grain attacked by the lesser grain borer.

Under favorable conditions, the khapra beetle breeds so rapidly that the larvae often appear in large numbers in the surface layers of binned

grain. The larvae crowd into the crevices of building, bins, and so forth, and are difficult to reach with insecticides. Since this beetle has limited mobility, it spreads principally through the agency of man.

Other species of *Trogoderma* in this country that may be confused with those mentioned here are *T. grassmani* Beal, *T. ornatum* (Say), *T. simplex* Jayne, and *T. sternale* Jayne. All these species are sometimes confused with the *Anthrenus* species, which are not grain pests. The varied carpet beetle, *A. verbasci* (Linnaeus), however, has been found in mills and storage facilities (fig. 43C).

SPIDER BEETLES¹³

Several species of beetles belonging to the family Ptinidae are occasionally found infesting grain and cereal products. They attract attention by their peculiar, spiderlike form. These insects are rather widespread in distribution but are rarely abundant enough in the United States to cause serious damage.

Hairy Spider Beetle

The hairy spider beetle *Ptinus viliger* (Reitter),¹³ is a reddish-brown beetle marked with four irregular white patches. It is about one-seventh of an inch long (fig. 46). This insect is a rather common pest in the Prairie Provinces of Canada and is occasionally destructive in the adjoining Northern United States. It attacks

stored grain and all types of ground-cereal products. The adult beetle appears in warehouses in the spring and lays eggs in flour, feed, or other cereal products. The female lays about 40 eggs. Under favorable conditions, the development period from egg to adult is about 3-1/2 months. The full-grown larvae construct characteristic silken pupal cases, which are covered with food particles from the food material in which they occur.

An allied species, *P. raptor* Sturm, is about as common in Canada as the hairy spider beetle.

Whitemarked Spider Beetle

The whitemarked spider beetle, *Ptinus fur* (Linnaeus), is also found in the Northern States and is some-

¹³Coleoptera, Ptinidae.

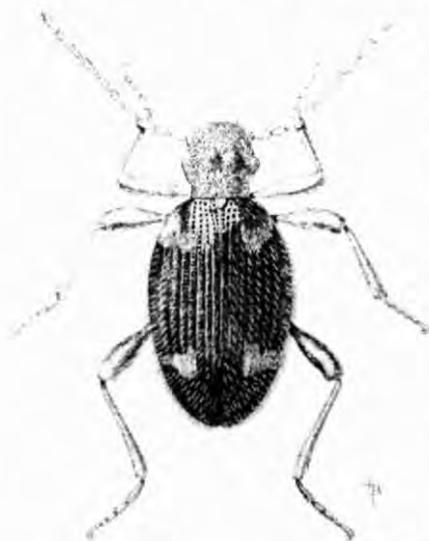


Figure 46.—Hairy spider beetle adult, about one-seventh of an inch long.

what more abundant than the hairy spider beetle, which it closely resembles in appearance and habits (fig. 47). It feeds on both animal and plant matter and attacks flour, feed, grain, and miscellaneous foodstuffs. It is rarely abundant enough to cause serious damage.

Brown Spider Beetle

The brown spider beetle, *Ptinus clavipes* (Panzer), closely resembles the whitemarked spider beetle in size, color, general appearance, and habits. It may be distinguished from that beetle by the absence of white markings on the wing covers.

Other Spider Beetles

The Australian spider beetle, *Ptinus ocellus* Brown, has been reported from

the United States but is rarely found here. It is very similar in general appearance and habits to the brown spider beetle.

The American spider beetle, *Mezium americanum* (Laporte), is a small spider beetle of striking appearance. It has a shiny, subglobular body that distinguishes it from the preceding spider beetles (fig. 48). It is somewhat of a scavenger and feeds on dried animal products and plant matter. It is not an important pest of stored grain or grain products, but it is occasionally found in mills, warehouses, and dwellings.

A closely related species, *Gibbium psylloides* (Czenpinski), resembles the American spider beetle in appearance and habits and is found in similar situations. It may be distinguished from that insect by the head and thorax, which are densely covered with small



Figure 47.—Whitemarked spider beetle adult female. The elongate-oval male is not so conspicuously marked as the female.



BN-3053

Figure 48.—American spider beetle adult.
Photo enlarged.

scales and scalelike hairs. This species reportedly occurs only in the extreme southern portion of the United

States, whereas *M. affine* (Boieldieu) is the common form in the Northern States and Canada.

MISCELLANEOUS BEETLES

Twobanded Fungus Beetle

The twobanded fungus beetle, *Alphitophagus bifasciatus* (Say),¹¹ is a small, handsome, elongate-oval beetle slightly less than one-eighth of an inch long. It is reddish brown with two broad black bands across the wing covers (fig. 49). This insect is distributed over the world and, as a scavenger, generally feeds on such materials as fungi and molds in refuse grain and grain products, and decaying vegetable matter. It is frequently found around mills and storehouses where waste material is allowed to accumulate and in wet or damaged grain in the holds of grain ships. The larvae have been reared in moist cornmeal and in spoiled cereals.

Hairy Fungus Beetle

The hairy fungus beetle, *Typhaea stercorea* (Linnaeus),¹⁴ is frequently found in cornfields, where it is apparently attracted to the decaying kernels of exposed ears. After corn is harvested and shelled, it is often heavily infested by this insect, but there is little feeding on undamaged grain. This beetle is cosmopolitan and is found in all parts of the United States in dwellings, warehouses, stores, flour mills, granaries, and similar places.

It is a small brownish beetle about one-tenth of an inch long and is covered with hairs (fig. 50). It rather closely resembles the drugstore beetle

¹⁴Coleoptera, Mycetophagidae.



BN-3104

Figure 49.—Two-banded fungus beetle adult.
Photo enlarged about 20 times.

in general appearance but is smaller (fig. 50). This insect can also be easily distinguished from the drugstore beetle by the shape of its antennae, which are clavate instead of irregularly serrate.

Corn Sap Beetle

The corn sap beetle, *Carpophilus dimidiatus* (Fabricius),¹⁵ may be readily recognized by its peculiar wing covers, which are short and truncate, leaving the tip of the abdomen exposed. It is a small, oblong, ovoid, dark-brown beetle, with lighter colored wing covers and is one-tenth to one-eighth of an inch long (fig. 51).

This insect normally feeds in rot-

ting or decaying fruit and other vegetative forms and in the sap exuding from injured plants. It is quite numerous in cornfields in the South, where it swarms over the damaged ears and feeds and breeds in the decaying kernels. The corn sap beetle is attracted to damp, decaying grain, and, not infrequently, it is found in rice mills breeding in accumulations of broken rice. It is often seen in swarms, crawling over bags of rice.

A closely related beetle, *Carpophilus* (*Urophorus*) *humeralis* (F.), which was introduced from abroad, is becoming more and more abundant in this country. It is similar in form to the corn sap beetle but is slightly larger and is a uniform, shiny, dark



Figure 50.—Hairy fungus beetle adult, about one-tenth of an inch long.

¹⁵Colcoptera, Nitidulidae.

brown all over. Its habits are very similar to those of the corn sap beetle.

Cigarette Beetle

The cigarette beetle, *Lasioderma serricorne* (Fabricius),¹⁶ is a small, stout, oval, reddish yellow or brownish-red beetle, with the head bent down nearly at a right angle to the body. This gives the beetle a humped appearance when viewed from the side, as shown in figure 52C. It varies in size, but is usually about one-tenth of an inch long. This insect, found in all temperate, subtropical regions, infests tobacco and many other stored products. It breeds in a variety of seeds and may occasionally be found attacking grains left in storage in the original sacks for long periods.

The adult beetles live 2 to 4 weeks, and, during this time, each female

may lay as many as 100 eggs. The developmental period from egg to adult is quite variable but, under favorable conditions, is 6 to 8 weeks.



Figure 51.—Corn sap beetle adult. Photo enlarged.

¹⁶Coleoptera, Anobiidae.



Figure 52.—Cigarette beetle: *Left*, larva; *center*, adult (dorsal view); *right*, adult (side view). Adult is about one-tenth of an inch long.

Drugstore Beetle

The drugstore beetle, *Stegobium paniceum* (Linnaeus),¹⁶ is very similar in appearance to the closely related cigarette beetle but is more elongate in proportion to width and has distinctly striated wing covers. The adult insect is about one-tenth of an inch long and has a cylindrical, uniformly light-brown body covered with a fine, silky pubescence (fig. 53A, B). The larva, or grub, is considerably less hairy than that of the cigarette or tobacco beetle (fig. 53C). It is known as the drugstore beetle from its habit of feeding on pharmaceutical drugs. This insect is a very general feeder that attacks a great variety of stored foods, seeds, and other materials, and

it reportedly "eats anything except cast iron." It is frequently found in storehouses and granaries around the world.

This beetle lays eggs in almost any dry organic substance. The small white grubs emerge from the eggs and then tunnel through these substances. When fully grown, they pupate in small cocoons. The entire life cycle may be passed in less than 2 months.

Catorama Beetles

Members of the genus *Tricorynus*,¹⁶ formerly *Catorama*, are closely related to the drugstore and cigarette beetles. This group includes *T. herbarius* (Gorham), known as the



Figure 53. Drugstore beetle: A, adult (dorsal view); B, adult (side view); C, larva. Adult is about one-tenth of an inch long. This insect attacks only undisturbed grain that has been in storage for long periods.

Mexican book beetle, *T. confusus* (Fall), and *T. tabaci* (Guerin-Meneville). *T. herbarius* is about one-eighth of an inch long. *T. confusus* (fig. 54) is slightly smaller, and *T. tabaci* is slightly larger. These insects are only occasionally found in stored grain and do not cause serious damage.

Murmidius Beetle¹⁷

The minute beetle, *Murmidius ovalis* (Beck),¹⁷ is sometimes found in stored grain or cereal products. It is shiny, dark-reddish brown and is less than one-sixteenth of an inch long (fig. 55). This insect lays sculptured eggs, which are fastened in place on their sides.



Figure 54.—Catorama beetle (*Tricorynus confusus* (F.)) adult.



Figure 55.—Murmidius beetle (*Murmidius ovalis* (B.)) adult.

The larvae, which are unusual in appearance, are pale yellow, oval in outline (with the head invisible from above), flattened, with bristly appendages around the margins and boathook-shaped setae on their back. These insects pupate in a hemispherical cocoon, which is fastened down on its flat base. They require a high humidity and, under hot conditions, can complete development in less than 2 months. Under cooler conditions, they may require more than 7 months for development.

BOOKLICE OR PSOCIDS

Grain and grain products are sometimes found to be swarming with minute insects scarcely larger than a pinhead. Flour and grain samples are particularly attractive to them. They are known as psocids, or

booklice, owing to their resemblance to lice and their occasional presence in books. These insects belong to several closely related species of the genus *Liposcelis*.¹⁸ They are tiny, pale gray or yellowish white, wingless, soft

¹⁷Coleoptera, Cerylonidae.

¹⁸Psocoptera, Liposcelidae.

Mexican book beetle, *T. confusus* (Fall), and *T. tabaci* (Guerin-Meneville). *T. herbarius* is about one-eighth of an inch long. *T. confusus* (fig. 54) is slightly smaller, and *T. tabaci* is slightly larger. These insects are only occasionally found in stored grain and do not cause serious damage.

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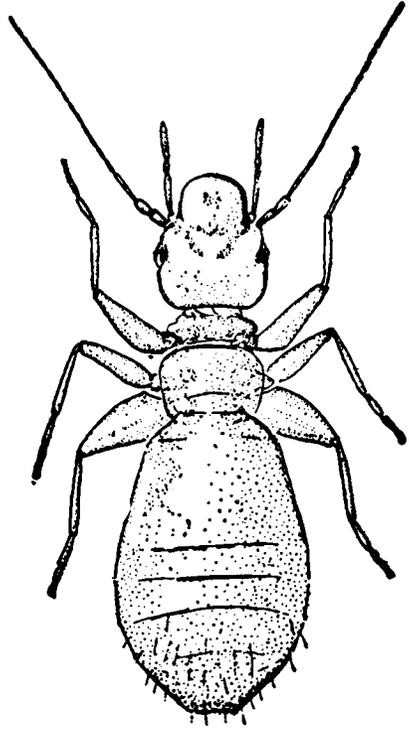
¹⁷Coleoptera, Cerylonidae.

¹⁸Psocoptera, Liposcelidae.

bodied, louselike insects with fairly large heads, poorly developed eyes, and long slender antennae (fig. 56). These insects are about one twenty-fifth of an inch long. They feed on a great variety of organic matter, both of plant and animal origin, but are troublesome through their presence alone, not because of the actual damage they cause.

Some females are believed to reproduce without mating, but males are sometimes found with them. Each female may lay as many as 100 eggs, and, in summer, the developmental period from egg to adult is about 3 weeks. The newly hatched young resemble the adults in form and general appearance but are smaller and lighter in color. These insects are widely distributed in North America and Europe.

A closely related species, the larger pale booklouse, *Trogium pulsatorium* (Linnaeus), known as "the death watch," is similar in appearance and habits and is found under the same circumstances. It may be distinguished from the common booklouse by its slightly larger size, diminutive wing covers, and well-developed eyes. This insect, also, is widely dis-



BN-3109

Figure 56.—Booklouse or psocid adult. Enlarged.

tributed over North America and Europe but is not quite so common or abundant as the preceding species.

SILVERFISH

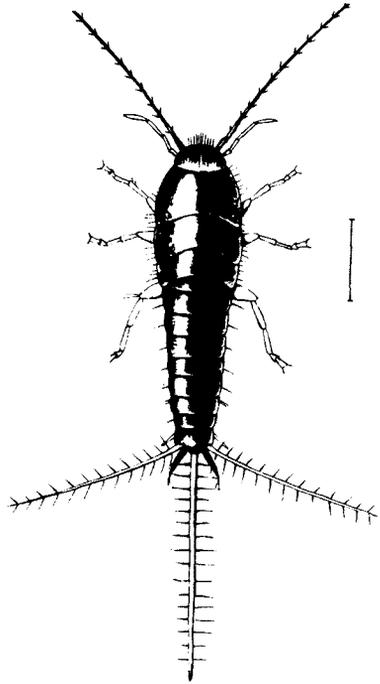
The silverfish or slicker, *Lepisma saccharina* Linnaeus,¹⁹ is commonly found in mills, warehouses, and dwellings. It is a shiny, silver or pearl-gray insect with three long, tail-like appendages, which make it easy

to recognize. It is cosmopolitan and feeds on starchy foods of all kinds. It is particularly found in dark, moist, warm situations.

A closely related species, the firebrat, *Thermobia domestica* (Packard), is found in similar situations and closely resembles the sil-

¹⁹Thysanura, Lepismatidae.

verfish in appearance and habits (fig. 57). This insect may be differentiated from the silverfish by its broader body. It is pearly white and is heavily mottled along the back, with dusky scales that give it a banded appearance when some of the scales have rubbed off. It is cosmopolitan and, in some areas of the world, is more abundant than the silverfish. The developmental period from egg to adult is 11 to 12 weeks.



BN-3110

Figure 57.—Firebrat adult, about 2-1/4 times natural size.

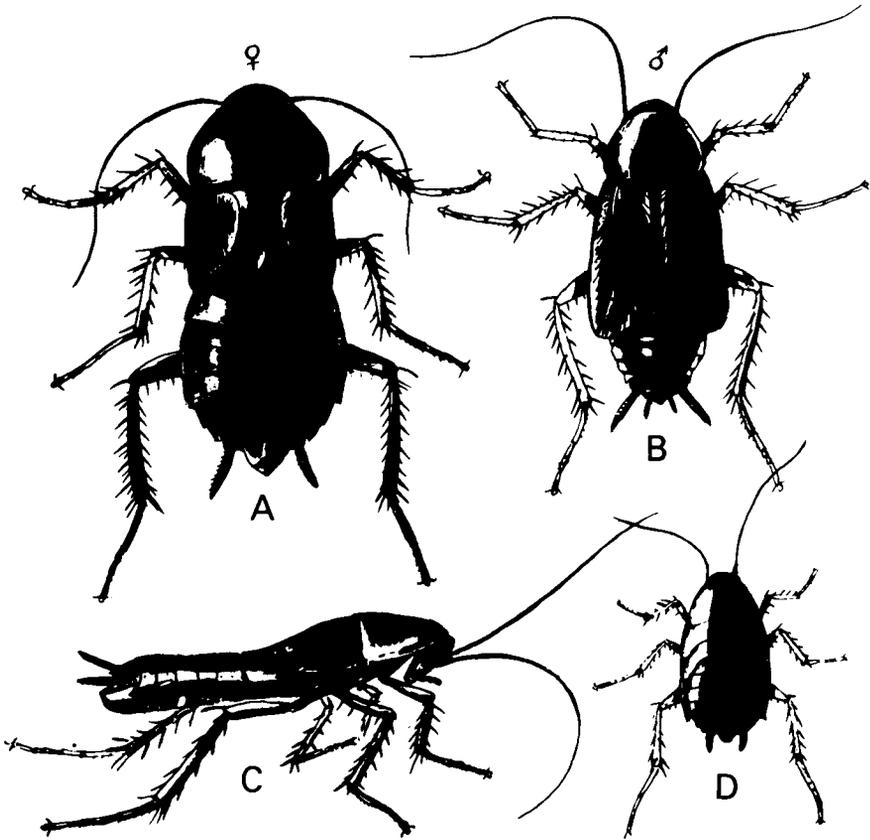
COCKROACHES²⁰

The familiar cockroaches are frequently found in establishments that contain cereal products. They are particularly abundant in the basements of buildings in dark, moist situations, and, when lights are suddenly turned on, it is not uncommon to see the floors almost black with them. The oriental cockroach, *Blatta orientalis* Linnaeus, is probably the commonest species found in flour mills and food establishments in

North America. It is a large, dark-brown or black roach, about 1 inch long at maturity (fig. 58). The females are unique because they have short wing pads but no functional wings (fig. 58A). The males have fully developed wings (fig. 58B).

A closely related species, the American cockroach, *Periplaneta americana* (Linnaeus), is also quite abundant and is the predominant form in many flour mills in the Southwestern and Midwestern States. It is larger than the oriental cock-

²⁰Orthoptera, Blattidae.

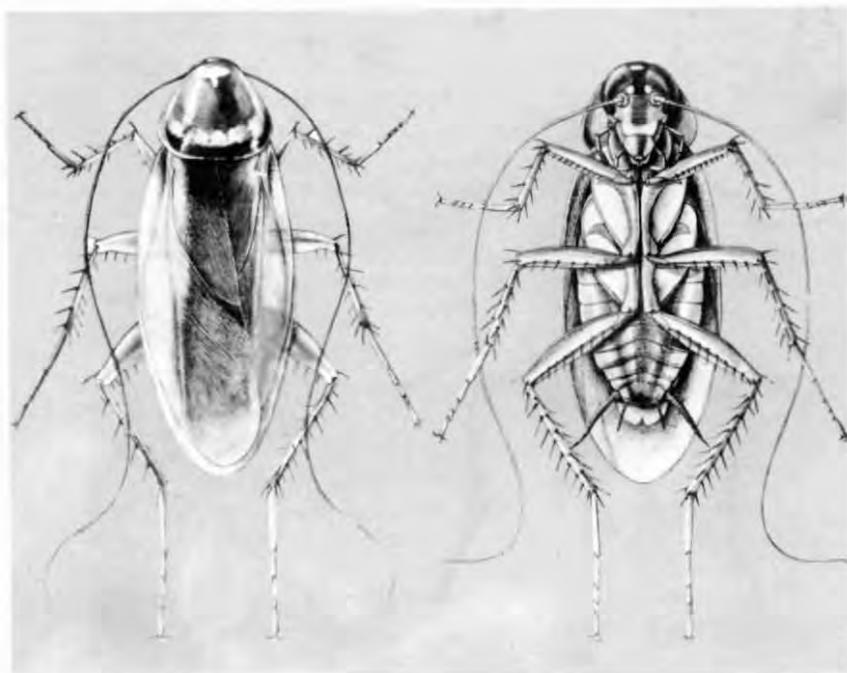


BN-3055

Figure 58.—Oriental cockroach: *A*, adult female; *B*, adult male; *C*, adult female (side view); *D*, half-grown cockroach. Enlarged.

roach and frequently is 1-1/2 inches long. This insect is bright sienna brown, except for the brownish-yellow pronotum, which encloses the

characteristic, irregularly shaped, reddish-brown double spot in the center (fig. 59).



BN-3111

Figure 59.—American cockroach: *Left*, adult (dorsal view); *right*, adult (ventral view). Enlarged.

FLOUR OR GRAIN MITES²¹

The flour or grain mites are pale, grayish white, smooth, wingless, soft-bodied creatures. They are microscopic in size and have numerous long hair on the legs and back (fig. 60). Mites are not true insects because the adults have eight legs and the body is indistinctly divided into two parts. The flour or grain mites, usually less than one-fiftieth of an inch long, are much smaller than the booklice.

They are often found in stored grain and occasionally increase in numbers so rapidly that the grain seems to be quite alive with them. During heavy infestations, their cast skins and dead bodies accumulate into fluffy, light-brown masses beneath the sacks of grain. If these accumulations are on a warehouse floor, they roll up into piles, which move about with each gust of wind. No other group of grain pests produces these masses. When present in large numbers, the flour or grain mites promote sweating, impart a dis-

²¹Acarina, Acaridae.

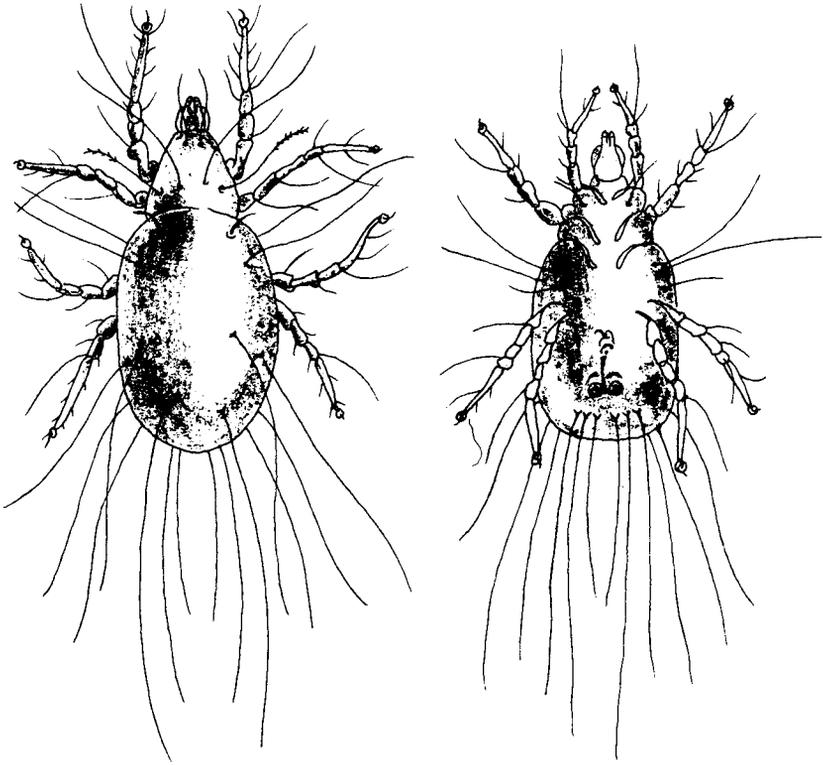


Figure 60.—Grain mites. Greatly enlarged.

BN-5180

agreeable odor to the grain, and may cause damage by feeding.

Fortunately, the mites that attack grain are preyed upon by predaceous mites, which usually become abundant enough to kill the grain mites in a comparatively short time. If not, screening and fanning the grain will usually reduce grain mite infestations to a point where no injury occurs.

Acarus siro Linneaus, known as the flour mite, common forage mite,

or grain mite, is the most injurious species of mite found in flour, grain, and cereal products in North America. It multiplies very rapidly under favorable conditions and may complete its life cycle, from egg to adult, in slightly over 2 weeks.

Species of the genus *Tyrophagus* and other related genera, also known as flour mites or cheese mites, are common in grain. They are similar in appearance and habits to *A. siro*.

PARASITES OF GRAIN PESTS

Swarms of small wasplike insects, of the size and appearance shown in figure 61, are sometimes found in bulk grain. Similar insects may also be seen on the windows of flour mills and other establishments where cereal products are handled. These insects are not harmful to grain but are beneficial because they attack and destroy the insects that infest grain and grain products.

The small parasite shown resting on a kernel of wheat in figure 61 is the adult of *Anisopteromalus calandrae* (Howard),²² the most important parasite of the rice and granary weevils. The female wasp can detect the presence of the grain-weevil grub hidden from sight within the grain and paralyzes it with a few thrusts of the ovipositor. She then deposits one egg

on the exterior of the grub or in close proximity to it. The egg hatches, and the parasite grub feeds on the paralyzed weevil grub and destroys it. The developmental period from egg to adult is about 2 weeks. One female parasite wasp is known to lay as many as 283 eggs, but the help usually comes too late to prevent damage to the crop. A related species, *Choetospila elegans* Westwood,²² is somewhat less commonly found as a parasite of the same insects.

Figure 62 shows another fairly common parasite of the grain beetles. This insect, *Cephalonomia tarsalis* (Ashmead),²³ has habits quite similar to those of the preceding species.

Figure 63 shows the adult of *Bracon hebetor* Say,²⁴ attacking flour moth larvae. This little wasp is one of the most important parasites of these

²²Hymenoptera, Pteromalidae.

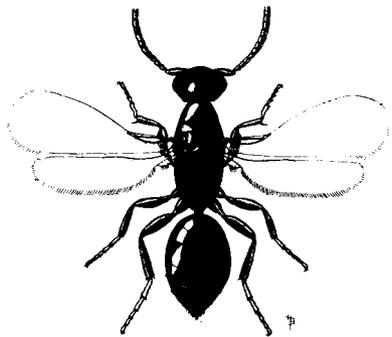
²³Hymenoptera, Bethyridae.

²⁴Hymenoptera, Braconidae.



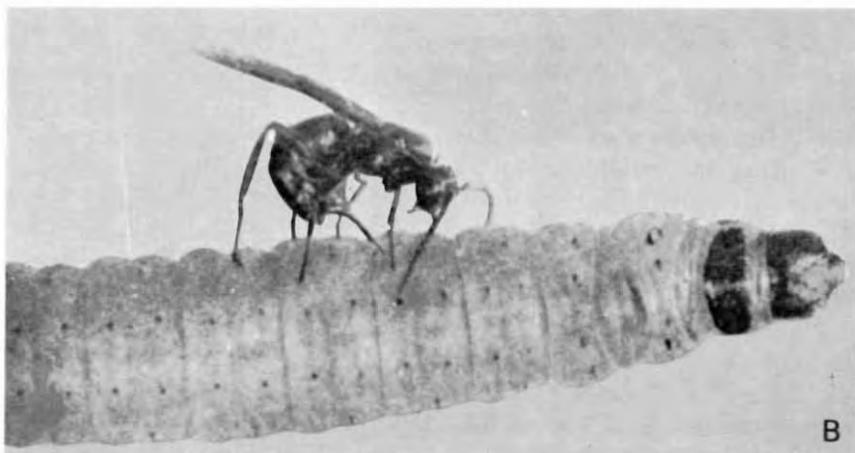
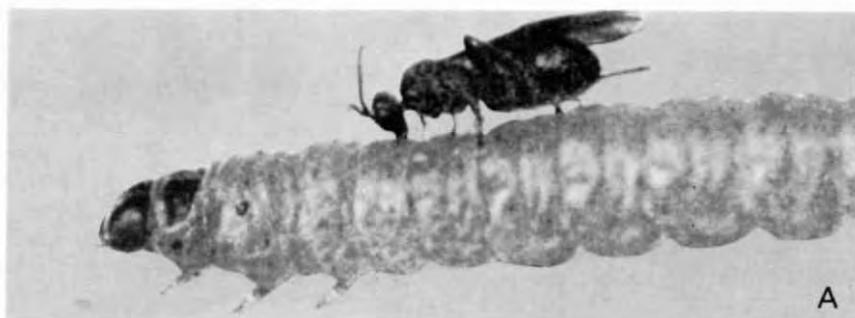
BN-3056

Figure 61.—*Anisopteromalus calandrae* (H.) adult, a hymenopterous parasite of grain pests, resting on a wheat kernel.



BN-3113

Figure 62.—*Cephalonomia tarsalis* (A.) adult. Enlarged.



BN-3114

Figure 63.—*Bracon hebetor* S. adult female, in three poses: *A*, feeding on body fluids of Mediterranean flour moth larva, with straight ovipositor protruding behind; *B*, in position for puncturing body of larva preparatory to laying an egg; *C*, with ovipositor well inserted in larva, just before laying an egg.

moths. It first paralyzes the flour moth caterpillar by stinging it several times. It then deposits several eggs on the paralyzed caterpillar. These eggs hatch into small, white, footless, grublike larvae that suck the body juices of the caterpillar. Under favorable circumstances, this parasite develops from egg to adult wasp in less than 2 weeks.

The species *Venturia canescens* (Gravenhost),²⁵ is even more important as a beneficial parasite of the flour and meal moths. This slender wasp has a reddish-brown abdomen, black head and thorax, and reddish-brown to yellow legs (fig. 64).

The habits of this parasite are somewhat different from all the above-mentioned parasites of grain pests. The adult wasp deposits eggs inside the body of the flour moth caterpillar, and the entire development of the parasitic larvae, until just before pupation, takes place within the host. The host caterpillar is not paralyzed and continues feeding until the parasitic larva has become nearly full grown. The developmental period from egg to adult is 3 to 4 weeks.



BN-3115

Figure 64.—*Venturia canescens* adult
Enlarged.

Grain dealers and millers not infrequently find a small, threadlike, white worm, about three-fourths of an inch long, in accumulations of flour or grain dust (fig. 65). This worm is the larvae of a small black fly, *Scenopinus fenestralis* (L.)²⁶ known as the windowpane fly because it frequents the windows of mills and similar establishments (fig. 66). This worm does not injure grain or cereal products but is a predator on other insects found in mills and warehouses. A closely related species, *Scenopinus glabrifrons* Meigen,²⁶ is also known as a windowpane fly.

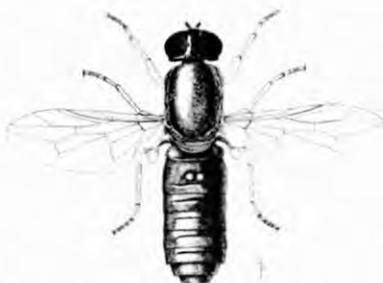
²⁵Hymenoptera, Ichneumonidae.

²⁶Diptera, Scenopinidae.



BN-3116

Figure 65.—Larva of windowpane fly, *Scenopinus fenestralis* (L.), about three-fourths of an inch long. Larva preys upon grain beetles and mites.



BN-3117

Figure 66.—Windowpane fly, *Scenopinus fenestralis* (L.), adult.

HOW GRAIN BECOMES INFESTED

Grain may become infested in a number of ways. In many grain-growing regions, infestation starts in the field before the crops are harvested. This is, of course, particularly true in the South, where the rice weevil and other insects are abundant in the field at harvesttime, and in the soft red winter wheat region of the Eastern States, where the Angoumois

grain moth is often extremely destructive. In the more northern States that experience severe winters, field infestation is negligible.

In addition to field infestation, which may be important (depending on the region or the season), there are several other sources of infestation of stored grain that are of considerable importance.

In all regions, it is customary to store grain year after year in the same bins. If these bins are made of wood, cracks and crevices become filled with grain dust and broken grain and afford places of concealment for many insects. Insects such as the cadelle burrow into the wooden sides or floors to pupate and later emerge in enormous numbers. Grain bins are not always properly cleaned; hence, fresh grain stored in them quickly becomes infested.

Storing bran, shorts, and other milled feeds in or near the granary is another cause of infestation, since these products are invariably infested. Many bins, too, are located in barns that normally contain products in which insects breed.

Temporary storage of grain in country or crib elevators frequently adds to the danger of infestation. Such storage is difficult to keep free from infestation, and clean grain often becomes contaminated by infested grain brought to the same place.

Grain may also become infested while moving it in railroad boxcars to terminal elevators. Many grain-infesting insects live in the grain dust and waste grain that accumulate in cracks of the floors or woodwork and in the linings of the boxcars.

Storage of clean grain in warehouses and elevators that already contain infested grain also results in contamination through the movement of insects from the infested grain to the clean grain.

Before shipment, uninfested grain should not be placed in sacks previously used for grain storage because these old sacks often harbor insects, as shown in figure 21, unless they have been sterilized by heat or fumigation. Certain extensive and costly infestations have been traced directly to the use of secondhand, infested, untreated grain sacks.

Grain stored in open or poorly constructed cribs or bins may become infested by insects flying in from the outside.

HOW TO PREVENT OR REDUCE PRIMARY INFESTATION

Adoption of the combine harvester has reduced field infestation of small grain to a negligible amount. To prevent infestation after harvest, it is recommended that producers take the following steps: (1) Store only dry grain in weathertight, rodent-proof bins, preferably made of steel; (2) clean out all bins before loading with grain; (3) spray the walls and floors of wooden bins and

around the door frames of metal bins; (4) clean up and dispose of litter, waste grain, and feed accumulations in and around farm buildings; (5) apply protective powder, or spray, directly to grain as it is binned, or fumigate promptly after binning; and (6) inspect the bins monthly and fumigate if an infestation is discovered.

In the North Central States,

exposure to winter weather in most years kills off infestations in ear corn stored on the farm; hence, the loss from insect attack is not significant if the corn is to be used for feed during the ensuing season. Following mild winters, the Angoumois grain moth may be destructive, so under such conditions, it is well to shell corn in May and store it in tight bins. In the Southern States, field infestation can be reduced by: (1) Growing corn varieties with tight shucks that are semi-resistant to field infestation; (2) dis-

posing of infested grain in farm storages before the corn reaches the silking stage; (3) early harvesting; (4) applying a protectant; (5) drying and shelling; and (6) storing the corn in tight bins suitable for fumigation.

Information regarding the prevention or reduction of grain infestation is contained in other publications of the Department of Agriculture, copies of which can be obtained from the Office of Governmental and Public Affairs, U.S. Department of Agriculture, Washington, D.C. 20250.