Stored Product Pests

Learning Objectives:

After completion of the study of Stored Product Pests, the trainee should be able to:

- Identify common stored product pests.
- Identify factors that contribute to pest infestations in stored products.
- List the key features in the life cycle and habitat of common stored product pests.
- Discuss monitoring and survey techniques for stored product pests including pheromone use.

There are over 100 species of pests found infesting dried plant and animal food materials. Excluding cockroaches, mites and ants, the majority of stored product pests belong to the orders Coleoptera (beetles) and Lepidoptera (moths), but can include birds, rodents, fungi, microorganisms and other pests. The occurrence of these pests in homes, restaurants or other structures usually originate from one of two sources. The majority of these pests originate from infested material brought into the building. This typically results when food materials are first stored for a period of time in an area, such as a warehouse, where an infestation already exists. Once a pest is introduced, it may readily spread to other suitable foods in the structure. Some infestations may also originate from the small number of these pests that naturally occur in and around areas where food is stored.

Most stored product pests are cosmopolitan or worldwide in distribution. One reason for the wide distribution of these pests is that grain, cereal, other dried foods and their pests have been shipped with little restriction all over the world. Another reason for their widespread distribution may be related to the static environmental conditions in stored products. An important factor influencing the distribution of any insect species is the range of environmental conditions within which it is capable of living. As you might expect, an insect that is capable of surviving in one geographical area will not be capable of surviving in another area if environmental conditions are not suitable.

Like other insects, stored product pests have a limited range of environmental conditions within which they are capable of moving, feeding and reproducing. However, unlike insects that develop outdoors, stored product insects are not normally exposed to the extremes in different climatic conditions of different geographical localities. For example, while the climates of southern California, Canada, Russia and France differ immensely, environmental conditions in a home or warehouse in each location are likely to be similar.

To control losses from stored product pests, (1) use management methods that prevent pest infestation, (2) eradicate existing infestations and (3) stop the spread of the pests or contamination to other food items. Establish an integrated approach that includes periodic inspection and monitoring, sanitation, exclusion and appropriate chemical and nonchemical controls. Use mechanical techniques such as aerating the stored products for moisture control, controlling storage temperature to reduce moisture condensation or uptake and to prevent development of insects, and rotating or turning the stored products to stop localized pest outbreaks. Never store pest-free items near infested products, in contaminated or infested containers or buildings.

It is beyond the scope of this manual to attempt to discuss all pests of stored products. The information presented here is limited to the four main categories of the most commonly encountered pests.

Birds

Birds can consume large quantities of grain and other items, and they may also contaminate stored food with feces and feathers. Bird feces may contain salmonella bacteria and fungal spores such as Histoplasma that can produce serious intestinal or respiratory infections in people.

The most important way to prevent bird damage is to exclude them for storage areas. Areas where birds are most apt to be a problem are warehouses with large doors kept open. If doors cannot be closed, install nets or strips of plastic or fabric at the entrances. These barriers enable people and vehicles to pass through freely but keep birds out. In all storage facilities, seal cracks and openings that are large

enough for birds to enter. Close off vents and other high-level openings with wire screen having a mesh of 1/4 inch or smaller. Remove or modify ledges that serve as roosting sites or install nets or other barriers to keep birds from roosting in or on the storage facility. Other attractive nearby roosting sites, such as large trees, may need to be eliminated.

Maintain good sanitation so storage areas do not attract birds. Clean up grains or other items spilled during loading, transfer and handling. Be sure that conveyors, railings, ledges and other parts of the storage facility are kept clean and free of food residues. Dispose of spoiled or contaminated products in covered containers and remove these promptly from the area. Be sure the outside surroundings of the facility do not provide adequate roosting and perching for birds. With persistence, certain species such as pigeons can be trapped. Trapped birds are generally released in an area distant from where they were caught.

Avicides are not generally effective in controlling birds when there is an abundance of other food in the area. If you use avicides, place them in locations where there is no risk of contaminating any stored food products. Whenever possible, use materials that repel rather than kill pest birds.

Trapping, repelling or poisoning pest birds requires considerable experience and expertise. Permits may be required from the Arkansas Game and Fish Commission and USDA Wildlife Services for some species. Extreme care is required to prevent injury of protected non-target species.

Rodents

Rodents such as rats and mice are troublesome pests of stored food. Rodents can chew through wood and other materials to get to food sources. They are good climbers and can squeeze through small openings. Rats and mice populations can rapidly build and consume or contaminate large quantities of stored food. They contaminate stored products and storage facilities with their urine, feces and hair. They also damage cloth, plastic and paper bags or cardboard boxes used to package stored products. Rodents within a storage facility may also chew on electrical wiring and cause serious fire hazards or equipment malfunction.

Exclusion

The most important control method for rodents is rodent-proofing. To exclude rodents from storage areas, seal openings with heavy-gauge sheet metal, heavy wire screen with a mesh of 1/4 inch or less or concrete with heavy wire screening embedded in it. Attach metal plates to the bottoms of doors to reduce the gap to 1/4 inch or less and prevent rodents from entering. Modify foundations of buildings with concrete or metal barriers to stop rodents from digging their way in. Eliminate dead spaces including double walls, false ceilings, enclosed staircases, boxed plumbing and voids under cabinets.

Sanitation

Sanitation is important in preventing rodent buildup. Spilled grains and other food items around the periphery of a building attract rodents and encourage them to nest nearby. Be sure all spills are cleaned up quickly and placed in rodent-proof containers or promptly destroyed. Sanitation must also include keeping all storage areas and adjacent spaces well lit, clean and orderly. Eliminate weeds, shrubs and vines that provide shelter and hiding places for rodents. Rodent activity can be more quickly spotted in clean, orderly areas, enabling early control.

Trapping, Baiting and Fumigation

Rodents infesting a storage facility are controlled by trapping, use of poison baits (rodenticides), fumigation or combinations of these methods. When controlling rodents in food storage areas, consider the following points:

1. Trapping requires daily checking for trapped animals and servicing of equipment. If traps are baited, the bait must be kept fresh by periodic replacement.

2. Poisonous baits must be kept fresh to be attractive; therefore, bait stations need to be checked and refilled frequently. If baits are the multiple-feeding anticoagulant type, rodents must feed on them continually over a period of several days.

3. Once started, bait stations must not be allowed to become empty; otherwise, rodents may recover from the toxic effects.

4. Use of rodenticides, such as poison baits, within storage facilities creates the risk of product contamination and may not be allowed in some situations.

5. Baits may not be very effective as long as the rodents have access to the stored food product.

6. Poisoned animals may wander off and die, making them difficult to find. Dead animals create smells and attract insects such as flies.

7. Fumigation may leave dead animals inaccessible.

When using rodenticides for control of rats or mice inside or around a food storage facility, it is important to identify the rodent species. You need this identification to understand the rodent's habits so you can select the right rodenticide and use it properly. Mice, for instance, tend to restrict their activities to a small area, probably no more than 30 feet from their nest, and never move beyond this area unless food or shelter is eliminated. Bait placed only a few feet away from a mouse nest will have no effect if the mouse never travels near it. Different species of rodents may inhabit different levels of a storage structure, or different colonies of the same species may even be at different levels. An effective rodenticide or trapping program requires locating all rodent colonies and placing control agents within reach of each.

Fungi and Other Microorganisms

Many microorganisms may attack and damage stored food products, including bacteria, protozoa, slime molds, yeasts and filamentous fungi. A large number of these require free water to grow and reproduce. These are only problems if the stored products become wet or are wet when put into storage. The most serious problem of stored grains and other products, however, comes from filamentous fungi adapted to conditions without free moisture. Fungi damage includes reduced germination of grain seeds, discoloration of grains and other products, microbiological heating of the stored material, caking, decay and musty odors. Some fungi produce toxic materials that contaminate stored food products and can cause poisoning if ingested; the most serious of these are the aflatoxins produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*.

Many conditions promote fungal development in stored foods. These include high moisture, low temperature, insect or mite presence, damage to the grain or other stored products, degree of fungi invasion before items are put into storage and the amount of foreign material present with the stored product. The length of time items are in storage and the amount and type of air circulation in the area also influence fungal development.

Several things should be done to reduce problems with microorganisms in stored foods. Moisture control is very important. The length of time items are to be stored influences the amount of moisture that must be removed before storing. For example, grains held for long-term storage (greater than two years) usually must have no more than a 13.5 percent moisture content. On the other hand, grains may usually be stored for four or five months at moisture levels of 18 percent without fungus problems. Differences in temperature between the stored product and the surrounding area may cause condensation of water vapor, thereby producing wet spots which favor fungal growth. To control temperature and condensation in storage containers and to provide air circulation, occasionally turn the material or transfer it from one container to another.

Some stored product insects carry in fungal spores on their bodies that may infest stored food. Moreover, insect-feeding damage makes some items more susceptible to feeding by other insects and fungi invasion. Large accumulations of insects may alter the temperature and moisture content of a stored product and may provide more ideal conditions for fungi. Therefore, controlling stored product insects can help reduce fungal problems.

Insects

Stored product insects are small and often difficult to detect. Eggs or larvae commonly pass unnoticed from one part of the food-handling system to the next. These are important economic pests that contaminate stored food with their excrement, cast skins, dead bodies and webbing. They consume or damage large quantities of food. In damaging packaging materials, they cause indirect food damage and further economic loss.

Several species of beetles, weevils and moths are common stored product insects. Descriptions of some of these follow. Management guidelines for these insects are included together, following the descriptions, as the control principles are the same.

Beetles

Sawtoothed Grain Beetle
Oryzaephilus surinamensis

Merchant Grain Beetle
Oryzaephilus mercator

The sawtoothed grain beetle and the merchant grain beetle are similar in appearance and easy to confuse (Figure 5-1). Adults are about 1/10 inch long and reddish brown to dark brown. Lateral margins of the thorax contain six sawtoothed projections on each side. These are long, narrow beetles with characteristic flattened bodies, giving them access to small cracks and crevices. Both species have well developed wings, but the sawtoothed grain beetle has not been seen flying. Adults of both species are usually seen running rapidly over stored food. Larvae have brown heads. Their bodies are yellowish, elongated and segmented with three pairs of legs. They crawl actively during feeding.

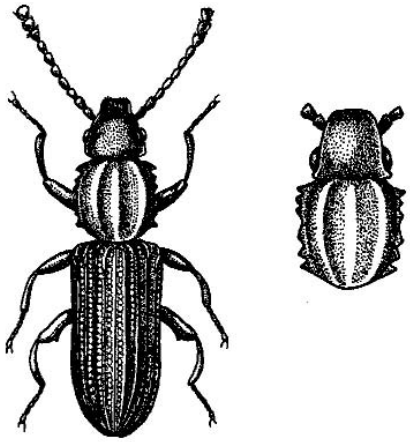


Figure 5-1. Sawtoothed grain beetle, left, and merchant grain beetle, right.

Adult females lay between 45 and 285 eggs singly or in small batches in or around suitable larval food sources. Eggs hatch in about eight days. Larvae pass through two to four instars over an average of 37 days, and pupation takes another six days. Temperature and humidity affect the development time and the number of larval instars.

Sawtoothed grain beetle larvae feed on items such as rice, wheat and nutmeats. These insects probably cannot attack whole, undamaged grains, so they may be associated with other whole-grain pests and feed on the kernels damaged by the other pests. The merchant grain beetle is not a major pest of grains or cereals, preferring seeds and nuts.

Confused Flour Beetle
Tribolium confusum

Red Flour Beetle
Tribolium castaneum

The confused flour beetle and the red flour beetle are the most common and serious pests of flour, cereal and broken grains (Figure 5-2). They are closely related, similar in appearance and often occur together. Flour beetles are members of the large coleopteran family Tenebrionidae, commonly known as the darkling beetles. They emit a foul-smelling, gaseous secretion when disturbed. Adults are about 1/7 inch long, flattened and shiny reddish brown. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a club-like shape, whereas antennae of the red flour beetle abruptly terminate in three larger, club-like segments (Figure 5-3).

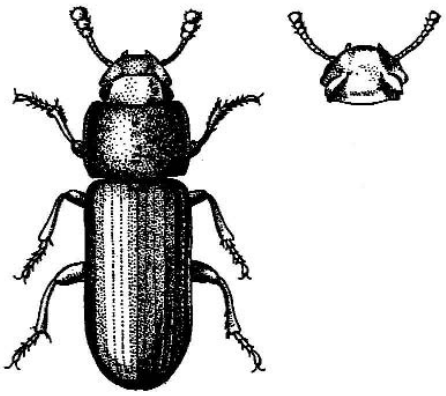


Figure 5-2. Red flour beetle, left, and confused flour beetle, right.

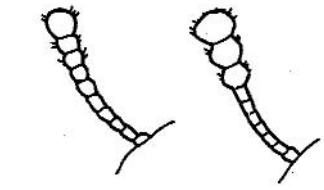


Figure 5-3. Antennae of the confused flour beetle terminate in four segments that gradually enlarge to form a club-like shape. Antennae of the red flour beetle abruptly terminate in three larger, club-like segments.

Adult flour beetles live up to two years. Females produce 400 to 500 eggs in their lifetime, laying two or three per day. Eggs hatch in five to twelve days. Larvae pass through 5 to 18 instars, typically seven or eight, over a period ranging from one to four months. Larvae are slender, wire-like and whitish-colored with yellow tinges. They are distinguished from other stored product insect larvae by the prominent, two-pointed termination of the last body segment (Figure 5-4).

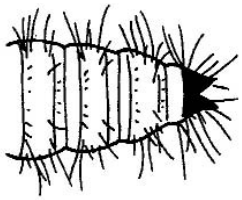


Figure 5-4. Larvae of flour beetles have a prominent two-pointed termination of the last body segment.

Like grain beetles, flour beetles usually do not attack whole grains. They feed on damaged grains, flour, cereals and other stored products. Their small size provides them access to closed containers that would normally be insect-proof. Adult beetles run quickly when disturbed. In addition to feeding damage, they produce secretions that contaminate the material they feed on giving it a disagreeable odor and taste.

Granary Weevil
Sitophilus granarius

Rice Weevil
Sitophilus oryzae

Weevils are distinguished from other beetles by the slender elongation of their heads, a feature responsible for the common name of snout beetles. The granary and rice weevils are serious grain pests (Figure 5-5).

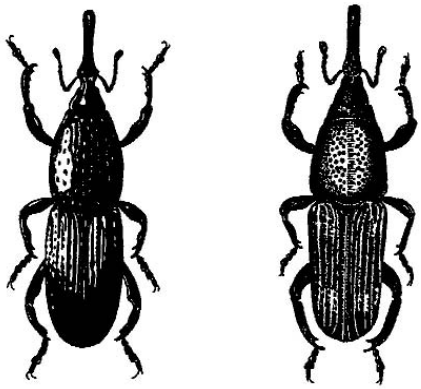


Figure 5-5. Granary weevil, left, and rice weevil, right.

Several features distinguish the granary weevil from the rice weevil. The granary weevil is about 1/8 inch long and shiny dark brown or black. The top-central area of its thorax is covered with elongated depressions or punctures. Adults have nonfunctional, vestigial wings. By contrast, the rice weevil is a good flyer and is slightly smaller. It is reddish brown to black and usually has four reddish or yellowish spots on its elytra. The top-central area of the thorax is covered with round punctures.

Both species bore holes into grain kernels to deposit their eggs. Larvae feed and pupate inside kernels and also feed on caked flour and tightly compressed cereals. Granary weevils have become adapted to living entirely in stored grains and never forage in the wild for food, hence their lack of wings. Rice weevils, however, fly to fields and infest grains such as corn, rice and wheat. After harvest, infested grain mixed with clean grain causes widespread contamination during storage.

Females lay approximately 200 to 300 eggs during their lifetime. Rice weevils produce more eggs than granary weevils. Larvae of both species pass through four larval instars over a period of three to five weeks and usually have four generations per year. Adults of the granary weevil live from seven to eight months when food is abundant. Adults of the rice weevil live three to six months.

Cigarette Beetle
Lasioderma serricorne

Drugstore Beetle
Stegobium paniceum

Cigarette and drugstore beetles (Figure 5-6) are members of the Anobiidae family, which also includes deathwatch beetles. Adults can be distinguished by their humped appearance due to their downward-bent head and prothorax. The cigarette beetle is reddish yellow to brownish red. Adults are about 1/8 inch long. Females produce about 30 eggs over a three-week period; these usually hatch within one week. Eggs are attached to sources of stored food such as tobacco, rice, raisins, grains, pepper and many other stored products. Larvae are curved, plump, hairy and yellowish with a light brown head. The larval stage lasts from five to ten weeks, and three to six broods are produced in a year.

Adults of the drugstore beetle are almost the same size as the cigarette beetle. They are reddish brown and can be distinguished from the latter by the longitudinal striations, or ridges, on their elytra. They are also less humped.

Drugstore beetles usually have one to four generations per year. They complete a life cycle in about two months. Larvae, which resemble those of the cigarette beetle, feed on practically every type of stored product as well as spices, drugs, books and wood. They can survive on items with low food value because of yeast-like organisms in their digestive systems that produce some essential vitamins.

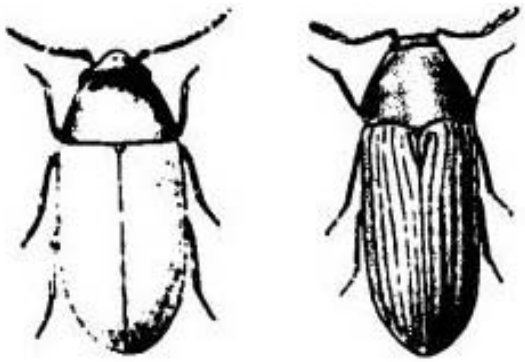


Figure 5-6. Cigarette beetle, left, and drugstore beetle, right.

Moths

Moths belong to the insect order Lepidoptera. Larvae of moths infesting stored food products may be confused with beetle or weevil larvae because of their worm-like shape. Unlike beetles and weevils, only the moth's larval stage causes damage. A telltale sign of infestation is the appearance of small- to medium-sized moths in food containers and packaging, flying around or clinging to walls in a room or storage area.

Indianmeal Moth
Plodia interpunctella

The Indianmeal moth (Figure 5-7) is the most common pest of coarsely ground flours (such as whole wheat flour) and cornmeal. It is widespread in grocery stores, warehouses, and kitchens. The Indianmeal moth also infests shelled or ear corn, broken grains, dried fruit, seeds, peas, beans, crackers, biscuits, nuts, powdered milk, chocolate, candy, red peppers, dry dog food, and other commodities. Unlike weevils and other beetle larvae, Indianmeal moths spin large amounts of webbing, further contaminating food products.

Adults of this moth have a wingspan of about 3/4 inch. Wings are pale gray with the outer two-thirds of the forewing colored reddish brown with a coppery luster.

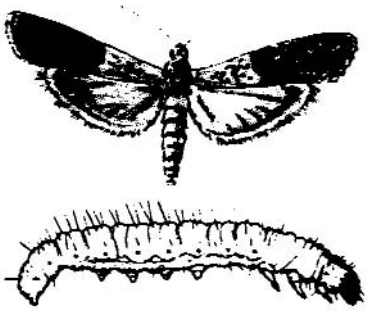


Figure 5-7. Indianmeal moth adult, top, larva, bottom.

Egg laying usually begins in April. Females lay eggs at night, either in masses or singly, and produce 200 to 400 eggs. Larvae are a dirtywhite color but may take on different hues depending on the food ingested. The larva's head and prothoracic shield are brown. Pupation takes place in a silken cocoon. The larval period varies greatly between one and ten months, depending on environmental conditions and available food. The normal complete life cycle of this pest takes about six to eight weeks.

Angoumois Grain Moth
Sitotroga cerealella

The Angoumois grain moth is considered an important pest of stored grain that prefers to lay its eggs in barley, rye, corn, oats, rice and various whole grain seeds. It prefers damp grain in preference to old, dry grain, but it will attack dry grains in storage as well as maturing in the field. The Angoumois grain moth is active at low temperatures. Infested grain has a foul smell and is unpalatable.

The adult has a wingspan of 5/8 inch and is yellowish white, with pale yellow forewings. The hind wings are gray and have a thin, finger-like projection at the tip. The female lays 40 to 300 eggs, which hatch in about a week. The life cycle in warm seasons requires from five to seven weeks. During the winter, the larva is dormant for four to five months, and the life cycle may require up to six months.

Figure 5-8. Angoumois grain moth

Management Guidelines for Stored Product Insects

Stored product insects are tiny and difficult to detect in bulk or packaged food products. They can be freely transported from processing plants to warehouses to grocery stores to restaurants and household and institutional kitchens. Even under the most carefully controlled conditions, some of these pests – in egg, larvae or adult form – will pass from one level of the food handling system to another. Eradication at any one level is virtually impossible due to the size and complexity of the food distribution industry. Once an infestation occurs in one commodity, it can quickly spread to others unless appropriate and timely control measures are taken. Each entity in the complex maze of food distribution, from the producer to the consumer, must assume a role in the management of stored product insects.

Detection and control methods for stored product insects have to be ongoing, not sporadic. Management relies on inspections and monitoring to detect and identify pests, followed by an integrated program of control that includes sanitation practices, exclusion techniques, habitat modification and the careful use of insecticides.

Beetle or moth infestation of a box of cereal or a bag of flour in the home is an annoyance. The infestation may result in the loss of the cost of the product and perhaps spread of the pest to other similar products stored in the pantry or cupboard. Control can be as simple as throwing away the infested materials (or returning them to the grocery store for a refund) and storing uncontaminated food products in insect-proof containers.

Similar infestations occurring in grocery stores, warehouses, or packaging and processing plants can result in considerable loss of investment and revenue. Pest control efforts, therefore, should be proportional to the potential for loss. Major efforts involving sanitation practices, exclusion techniques, habitat modifications and insecticide applications are usually required to eliminate damage. Early detection simplifies the management program, reduces control costs and prevents extensive damage to stored food. Monitoring is used to detect, locate, and identify pests, determine the proper time to apply control techniques and evaluate the success of the management program.

Inspection and Detection

Inspection and detection are necessary parts of a stored product pest management program. They provide information, evaluate control methods used and monitor for reinfestation. Make a complete and thorough inspection of the premises to locate potential infestation sources. Carefully examine stored food such as grains, dried fruit, flour, dog food and seeds. Check around buildings because some stored product insects are attracted to certain flowers and shrubs and outdoor lighting.

Use pheromone traps inside a building or structure to monitor pest activity. Pheromones are available for most of the insects that damage stored food. Traps using mating pheromones generally catch individuals of one sex, usually males. For other stored product insects, traps containing aggregating pheromones are available that attract both sexes. Incorporating food attractants with the pheromone lures enhances the attractiveness of monitoring systems for some insect species. Food attractants can lure larvae and adults of both sexes. With some species, food attractants are used alone.

When using pheromones or food attractants for monitoring, place one trap per 250 to 500 square feet of storage space. For monitoring flying insects, locate traps near storage containers. Put traps inside containers for insects that do not normally fly.

Sometimes the use of more than one type of pheromone in an enclosed area may prevent target insects from efficiently locating traps. Before installing traps for other insect species in an area where one type of pheromone trap is already being used, check with the manufacturer or supplier to determine the effectiveness of such a combination.

Flying insects locate pheromone traps by following a trail of pheromone scent upwind, detecting its increasing concentration in the air. Enclosed areas where traps are located should have some air movement so the atmosphere does not become saturated with pheromone. Keep traps away from bright lights that may repel target insects.

Check traps regularly – daily if there is a low tolerance to stored product insects on the commodity or weekly under normal conditions. At each inspection, record the number of pest insects caught and remove from the traps. Replace pheromones

according to manufacturer's instructions. Change sticky parts of the traps whenever the coating of debris makes them ineffective.

Pheromones or attractants can sometimes be used in traps for control of stored product insects. Trapping may be a preferable control method over insecticides because foods are not exposed to residues. Put traps close to the infestation source for maximum control, and increase the density of traps to about one to each 25 to 50 square feet of storage space.

Exclusion

Prevent insect entry into the storage facility by inspecting grains, cereals, flour and other bulk and packaged products as they arrive. Check packages for holes, webbing, insect frass, eggs, living insects and insect parts. Even new, unused packaging material, such as cardboard, may be an insect source. Immediately return infested materials to the supplier or destroy them. Never store infested materials in the facility unless they can be enclosed in a tight container or refrigerated. Prevent contamination of flour, grains, cereals and dried fruit by keeping in insect-proof containers. Opened bags or boxes must be resealed securely or their contents transferred to sealable containers. Promptly remove empty boxes and bags from the building.

Keep insects out of buildings by using screens over doors and windows. Close off all other openings with wire screening or caulking. If it is not possible to exclude pests from the entire building, at least make sure the storage area is protected. Locate and close rodent holes as stored product insects can enter through these. If rodent baits are in the area, check them for infestation; even stored or unused bait may harbor insects. To keep from attracting insects into buildings, locate outdoor lighting away from doorways. Use sodium-vapor lights rather than mercury-vapor lights for outdoor lighting around warehouses and grocery stores because insects are less attracted to yellow light. Place lighting source away from doors and focus light toward doors. This will draw insects away from doors and toward the lights.

Sanitation

Sanitation is a critical part of controlling stored product insects in homes, grocery stores, warehouses and processing facilities. Clean up spilled materials to eliminate food sources for pests. Seal cracks in shelves and bulk food containers to eliminate places where pests can hide and to keep grains, flour, or other food from accumulating. Keep storage shelves far enough away from walls to leave room for cleaning. Raise shelving in warehouses and other storage areas off the floor to make cleaning underneath possible. Areas where susceptible items are stored should be well lighted for ease in cleaning and spotting pest infestation. Moths may be easier to detect during evening hours when they are active.

Environmental Modification

Manipulation of storage temperatures or humidity can be used to destroy many stored product pests. Heat treatment kills some pests outright, while cold treatment usually blocks their development. For adequate control, it may be necessary to subject products to a prescribed period of high temperatures followed by cold, after which they should be kept stored at a constant, lowered temperature. In general, a temperature of 60 degrees Fahrenheit prevents insect feeding; 40 degrees Fahrenheit kills insects over a period of time. Some products can be frozen to protect them from insect damage.

Desiccants

Dusts, such as silica gel or diatomaceous earth, can be combined with certain stored grains to provide protection against insect damage. These dusts kill target insects by desiccation. Dusts are removed from grain and other stored food before processing by a cleaning operation that also removes other debris. Because sorptive dusts are inert, they do not leave any potentially harmful residues on the food if traces of the desiccant remain.

Insecticides

Insecticides vary according to the pest type and infestation situation. Because food products are involved, residues must never exceed legal tolerances. Apply only those insecticides registered for stored food product sites, and use them in strict accordance with label instructions. Insect resistance to insecticides is an increasing problem, so avoid overusing insecticides. Always employ other control methods along with insecticides. Apply insecticide when insects are most susceptible.

The safest types of insecticides for use on food items are the microbials, such as *Bacillus thuringiensis*. These organisms produce toxins fatal to certain species of insects but have no known effect on people. *Use* only microbial insecticides labeled for control of stored product *sites* that can be applied directly to the product or bulk commodity. Thorough coverage is necessary to ensure that target insects consume some of the microbial organisms.

Compared with organophosphate, carbamate and chlorinated hydrocarbon insecticides, insect growth regulators (IGRs) have a low toxicity to humans. IGRs are chemicals that alter an insect's ability to develop normally or pass through developmental stages at the proper time. For instance, some IGRs prevent larvae from becoming adults, and others force them to pass into the adult stage before they are mature enough to reproduce.

Because of the low toxicity of IGRs, they are usually safe to spray directly onto raw products. (Check the label before application.) Use an IGR where fumigation is not possible or desirable. An IGR is only effective if it contacts the targeted insect pest; therefore, thorough coverage is necessary. Spray a labeled IGR on grains, nuts or other foodstuffs during the filling of storage bins. Use enough spray to thoroughly protect all of the stored product. Spray when insects are at the correct stage of development as described on the IGR label instructions. Occasionally, the application of an IGR extends the larval period, and larvae of pest insects may feed more before they are destroyed.

Fumigants are used to control stored product insects in bulk containers and processed food areas such as truck trailers, railroad cars, warehouses and large storage areas. Fumigants are effective because they penetrate areas where pests occur or might become problems. To be effective, fumigation must take place in a well-sealed area so its concentration can build up to high enough levels. Small quantities of cereals and similar products can be fumigated in containers such as plastic pails or glass jars using dry ice (frozen carbon dioxide); however, if containers are tightly closed immediately after treatment, a vacuum will form that may cause them to implode. Tighten down the lid after the container warms to room temperature. Fumigation is covered in detail in *Classification 3, General Fumigation Training Manual.* Persons fumigating must be certified in Classification 3 – General Fumigation if performing fumigation for more than one person, company or corporation. If the person fumigating is an employee of a large scale, primarily wholesale food manufacturing, processing and storing company or corporation and fumigation is restricted to the company address or addresses, then certification under Classification 8 – Food Related Fumigation is all that is required.

Short-term residual insecticides, such as pyrethrins or pyrethroids, can be used for rapid knockdown of some types of stored product insects. Apply these materials in cracks and crevices and on surfaces that stored products contact. These materials can be applied to bulk containers before adding foodstuffs. They are also used in cupboards and on shelves and areas close to where products are stored, but usually require frequent reapplication if infestations are high.

Residual insecticides, including some persistent pyrethroids, should be selectively used. Residuals are generally applied to surfaces of empty containers to prevent infestation but are rarely applied directly to foodstuffs. Use residual insecticides as a supplement to sanitation measures. They are convenient ways to control stored product pests in inaccessible areas.

There are severe restrictions on pesticide residues on food in food-handling establishments, so be sure residual insecticides are used only according to label instruction and in compliance with federal, state and local regulations.

Mites

Mites occasionally infest stored food. They are known to feed on cheese, flour, grains, dried fruits, dried meats, cereal foods, dog and cat food and animal feeds. Insects or fungi must first damage grains before certain mite species invade. There are over 112 species of mites commonly associated with stored foods. Because mites are extremely small, their presence goes unnoticed. The damage they can cause is sometimes very serious. Infested items become contaminated with living and dead mites, cast skins and fecal material.

Feeding by some mite species alters the nutritional quality of grains and other food. Mites often attack the germ of grains. Flour from mite-damaged grain may become sour and have poor color, and bread made from it does not rise properly.

Some mites are fungus feeders. They invade moldy commodities, bringing spores of certain fungi, and feed on the fungi once they become established. Even after the mites are controlled, the fungi persist and continue to cause damage.

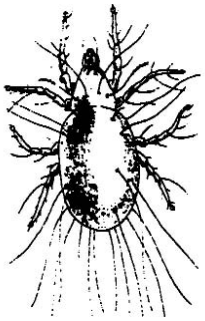


Figure 5-9. Grain mite

Management Guidelines for Stored Product Mites

The most difficult part of managing stored product mites is detecting infestation. Large populations can develop before being discovered and may have already done considerable damage. The stored food may have an odor described as minty, sweetish or musty when it is infested with mites. This odor may be the first indication mites are present.

Use a microscope or hand lens to inspect stored products for moving mites that are small and colorless or cream-colored. Take several samples throughout the stored product and examine each carefully. Check for moldy areas and for mites associated with the fungus. Avoid attracting mites by using sanitation to eliminate residues around the storage facility. Clean storage containers before use to remove debris, mites and mite eggs. Inspect materials before storage to be sure they are pest-free. Maintain proper storage conditions, including moisture-control and air circulation to prevent fungi growth. Keeping the stored product at or below a moisture content of 12 percent also retards development of many species of mites.

Desiccants, fumigants and some types of residual sprays effectively control mites as long as the commodity has been uniformly treated. Treatment of the commodity or storage container for insect control usually destroys mites. Periodic retreatment may be necessary because mite eggs may not have been destroyed. Check the label of the pesticide for permitted uses and follow label instructions carefully.

Table 5-1. Biology of Stored Product Pests

Pest Species	Feeding Damage	Developmental Biology	Food Infested
Angoumois grain moth, *Sitotroga cerealella*	Very important grain pest in the South. Commonly found emerging from decorative corn in home. Internal feeder.	40-400 eggs per female. Six to seven generations per year. Larval and pupal stage found within host.	Mainly attacks whole grain.
Mediterranean flour moth, *Anagasta kuehniella*	Larvae spin large amounts of silk in and over food. Surface feeder.	360-600 eggs per female. Three to four generations per year. Larvae typically leave area of host to pupate.	Prefers flour; also infests wheat, bran, nuts, chocolate, seeds, beans, dried fruits and others.
Indianmeal moth, *Plodia interpunctella*	Larvae spin large amounts of silk in and over food. Most commonly encountered food infesting moth in home and grocery store. Surface feeder.	40-400 eggs per female. Five to six generations per year.	Same host range as Mediterranean flour moth.

Table 5-1. Biology of Stored Product Pests (cont.)			
Pest Species	**Feeding Damage**	**Developmental Biology**	**Food Infested**
Rice weevil*, *Sitotroga oryzae,* and, Granary weevil*, *Sitotroga granarius*	Most important whole grain infesting insects in world. Internal feeders.	50-400 eggs per female. Six to eight generations per year. Larvae and pupae found within host.	Attacks whole grain or pieces of grain large enough for larvae to develop.
Drugstore beetle*, *Stegobium paniceum,* and, Cigarette beetle*, *Lasioderma serricorne*	Most common pantry pest in United States. External feeders.	20-200 eggs per female. Six generations per year.	Very general feeders, attacking almost all dried plant and animal material including drugs and tobacco.
Saw-toothed grain beetle, *Oryzaephilus surinamensis*	Feeding consists of scarring and roughening of surface of food. Very common household pest.	50-300 eggs per female. Eight to nine generations per year.	Very general feeding. Attacks almost all dried plant products.
Confused flour beetle*, *Tribolium confusum,* and Red flour beetle*, *Tribolium castaneum*	Feedings consist of scarring and roughening of surface of food. Usually brought into home in flour.	400 eggs per female. Six to seven generations per year.	Common in flour, also infests cereals, nuts, chocolate, spice, peas and many others.
*These beetles have almost identical life cycles.			

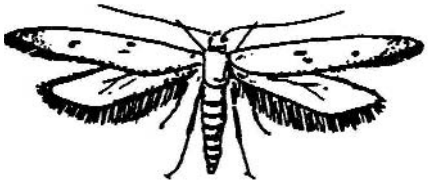
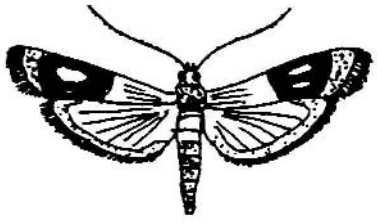
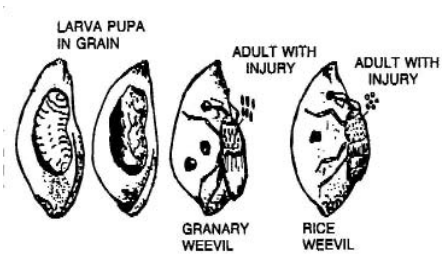
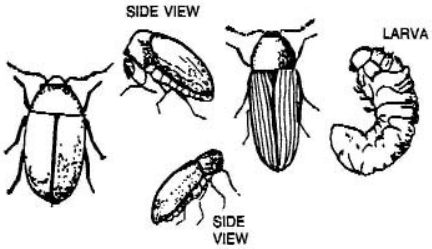
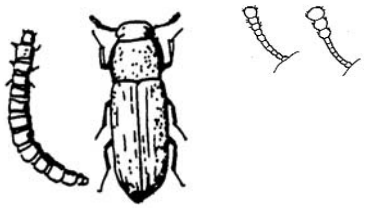
Table 5-2. Identification of Adult Stored Product Pests		
Pest Species		**Identifying Characteristics**
Angoumois grain moth, *Sitotroga cerealella*		Wingspread 1/2 inch. Pale yellow forewings. Gray hind wings which are pointed at end resembling a pointed finger.
Mediterranean flour moth, *Anagasta kuehniell*a		Wingspread 3/4 inch. Front wings gray with wavy transverse bars. When at rest head and thorax raised above abdomen protruding between and above wings.
Indian meal moth, *Plodia interpunctella*		Wingspread 3/8 inch. Basal 1/2 forewing grayish with outer 1/2 as well as head and thorax reddish.

Table 5-2. Identification of Adult Stored Product Pests (cont.)		
Pest Species		**Identifying Characteristics**
Rice weevil, *Sitophilus oryzae,* and Granary weevil, *Sitophilus granarius*		Length 1/8 inch and dark to reddish brown in coloration. Mouthparts drawn into elongate snout or beak. Rice weevils have 4 faint reddish or yellowish spots on the elytra and round or irregularly shaped punctures on the prothorax. Granary weevils lack the pale markings on the elytra, and the pits on the thorax are elongated.
Drugstore beetle, *Stegobium paniceum,* and Cigarette beetle, *Lasioderma serricorne*		Squatty, 1/8 inch in length and reddish brown in coloration. Head retracted into thorax and not visible from a dorsal angle. Elytra of drugstore beetle with parallel lines. Cigarette beetle elytra smooth.
Saw-toothed grain beetle, *Oryzaephilus surinamensis*		Approximately 1/8 inch long, elongate, dark brown and flat. Readily recognized by six sawtoothed like projections, located on the lateral margins of each side of thorax.
Confused flour beetle, *Tribolium confusum,* and Red flour beetle, *Tribolium castaneum*. These beetles are very similar in appearance and have similar biologies.		Elongate flattened, shiny reddish brown and about 1/8 inch in length. Antennae gradually enlarged to form a club. The antennae of the Confused flour beetle are gradually enlarged toward the tip, ending in a club of 4 segments. The antennae of the Red flour beetle are abruptly club-like with the club consisting of 3 segments. Also the sides of the thorax of the Confused flour beetle are almost straight, while those of the Red flour beetle are curved.

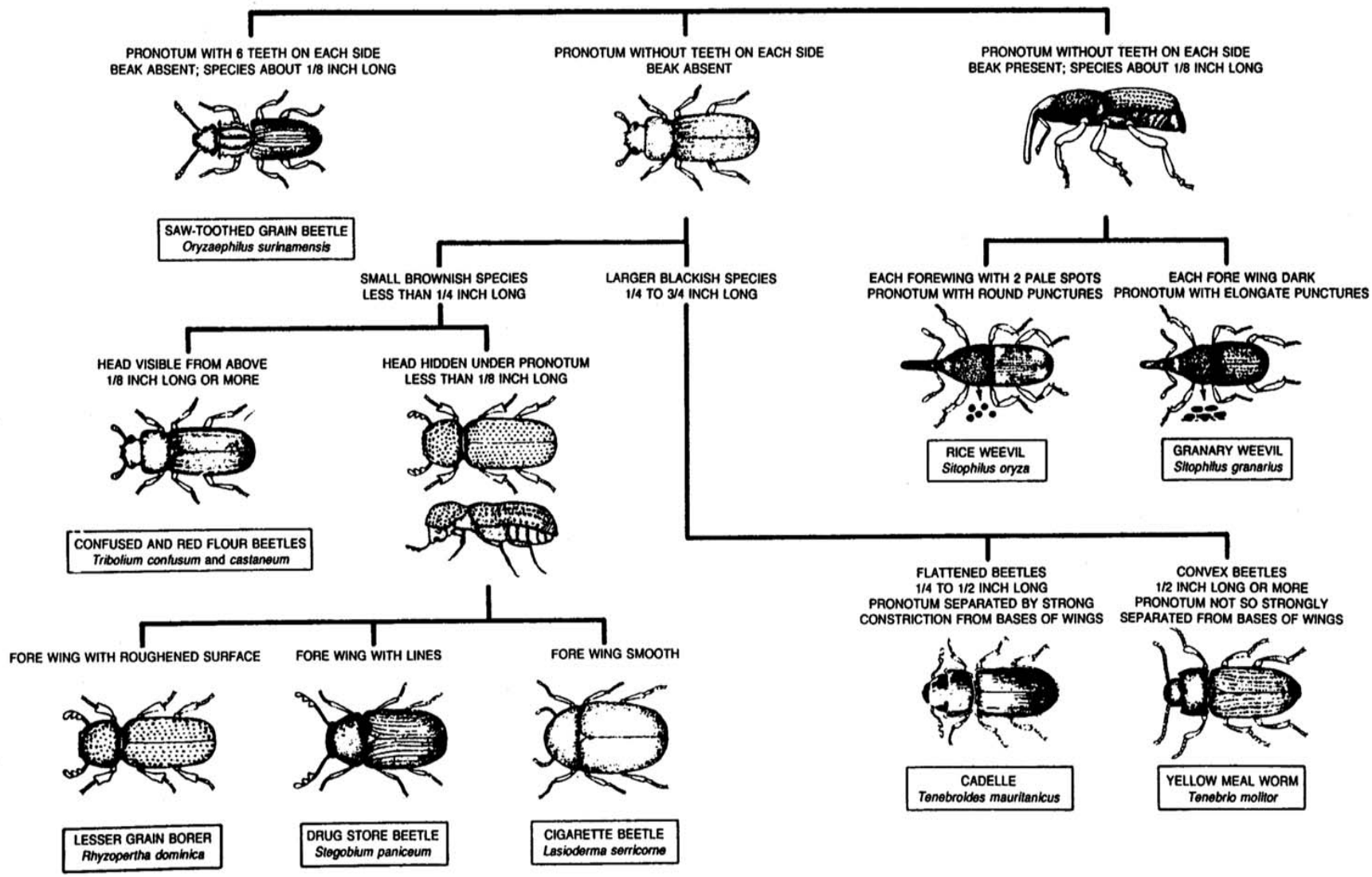


Figure 5-10. Beetles: Pictorial key to some species commonly associated with stored foods